United States Patent [19]

Bradley

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[54] **APPARATUS AND METHOD FOR READING AND WRITING TEXT CHARACTERS IN A GRAPHICS DISPLAY**

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Related U.S. Patent Documents

Reissue of:

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Appl. No.: **292,084**
Filed: **Aug. 12, 1981**

[51] **Int. Cl.**[4] **G09G 1/28**

[52] **U.S. Cl.** **340/747**; 340/703; 340/750

[58] **Field of Search** 340/825.3, 747, 750, 340/703; 382/56

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,778,810	12/1973	Hayashi	340/747
3,906,480	9/1975	Schwartz et al.	340/747 X
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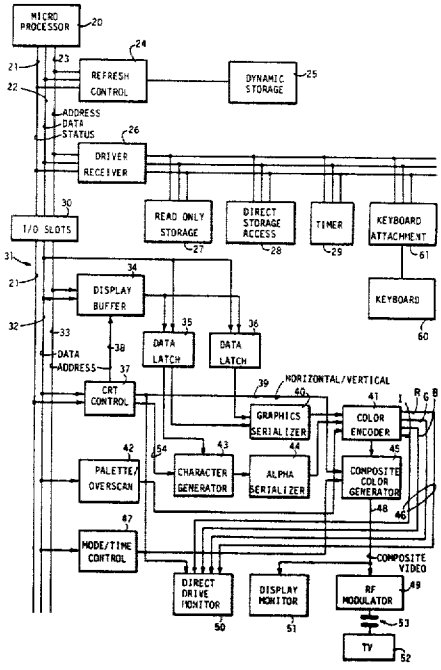
4,225,861	9/1980	Langdon et al.	340/703
4,283,724	8/1981	Edwards	340/731

Primary Examiner—David L. Trafton
Attorney, Agent, or Firm—Sughrue, Mion, Zinn, Macpeak, and Seas

[57] **ABSTRACT**

Apparatus and method for writing text characters to a raster scan video display operted in an all-points-addressable, or graphics, mode, and for reading characters thus written. A graphic video display buffer directly refreshes the display with graphics data received from a microprogrammed processor. The processor writes a character to the display by selecting and loading into the graphics video display buffer a text character dot pattern retrieved from main storage, and reads a character previously written by comparing a dot pattern retrieved from the display buffer with dot patterns retrieved from main storage. To write a character to the display in color, the graphic dot image of a selected character retrieved from main storage is expanded to a selected pixel and color format, and stored in the graphics video display buffer. Text characters thus written in color are read by retrieving from the display buffer the expanded dot image, restoring the expanded dot image to its original form, and comparing the restored dot image with graphic dot images retrieved from storage.

18 Claims, 13 Drawing Figures



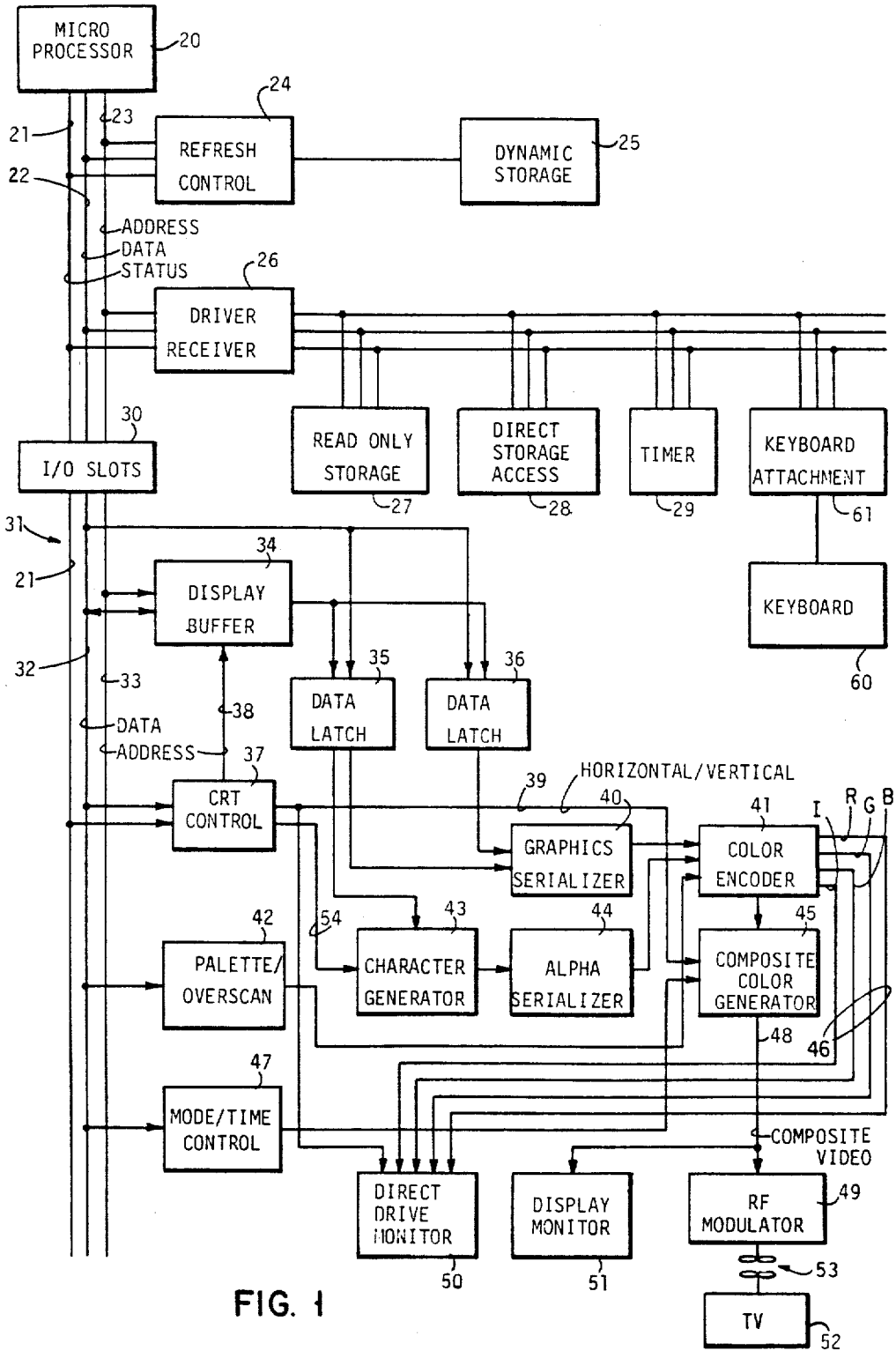

MICRO PROCESSOR
20
24
23
21
22
REFRESH CONTROL
DYNAMIC STORAGE
25
ADDRESS
DATA
STATUS
26
DRIVER RECEIVER
30
I/O SLOTS
READ ONLY STORAGE
27
DIRECT STORAGE ACCESS
28
TIMER
29
KEYBOARD ATTACHMENT
61
KEYBOARD
60
31
21
34
DISPLAY BUFFER
32
33
38
DATA
ADDRESS
37
35
DATA LATCH
36
DATA LATCH
39
HORIZONTAL/VERTICAL
40
41
I
R
G
B
CRT CONTROL
GRAPHICS SERIALIZER
COLOR ENCODER
42
54
43
44
45
PALETTE/ OVERSCAN
CHARACTER GENERATOR
ALPHA SERIALIZER
COMPOSITE COLOR GENERATOR
48
46
47
MODE/TIME CONTROL
COMPOSITE VIDEO
DIRECT DRIVE MONITOR
50
DISPLAY MONITOR
51
RF MODULATOR
49
53
TV
52

FIG. 1

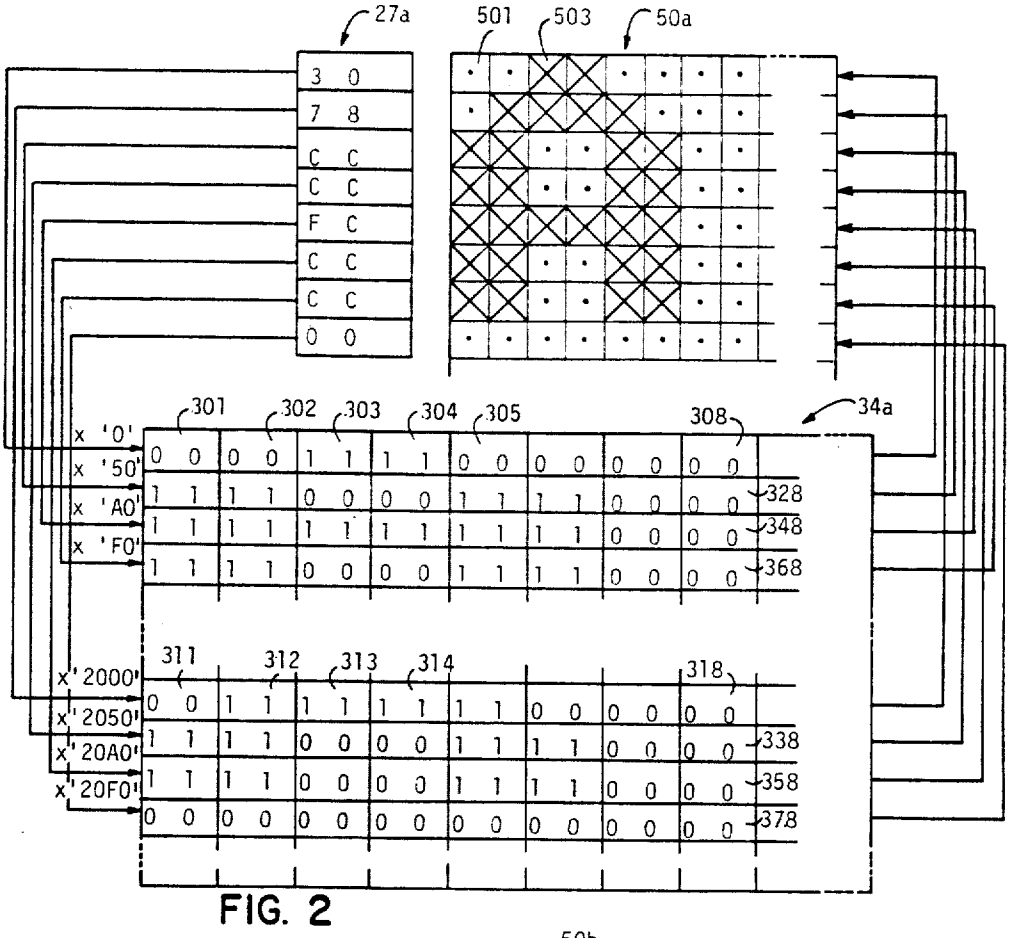

27a
501
503
50a
3 0
7 8
C C
C C
F C
C C
C C
0 0
301
302
303
304
305
308
34a
x '0'
x '50'
x 'A0'
x 'F0'
328
348
368
311
312
313
314
318
x'2000'
x'2050'
x'20A0'
x'20F0'
338
358
378

FIG. 2

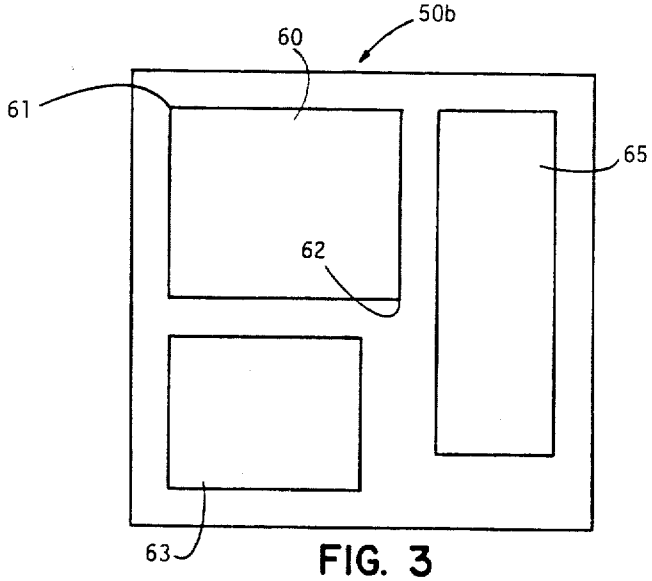

50b
60
61
65
62
63

FIG. 3

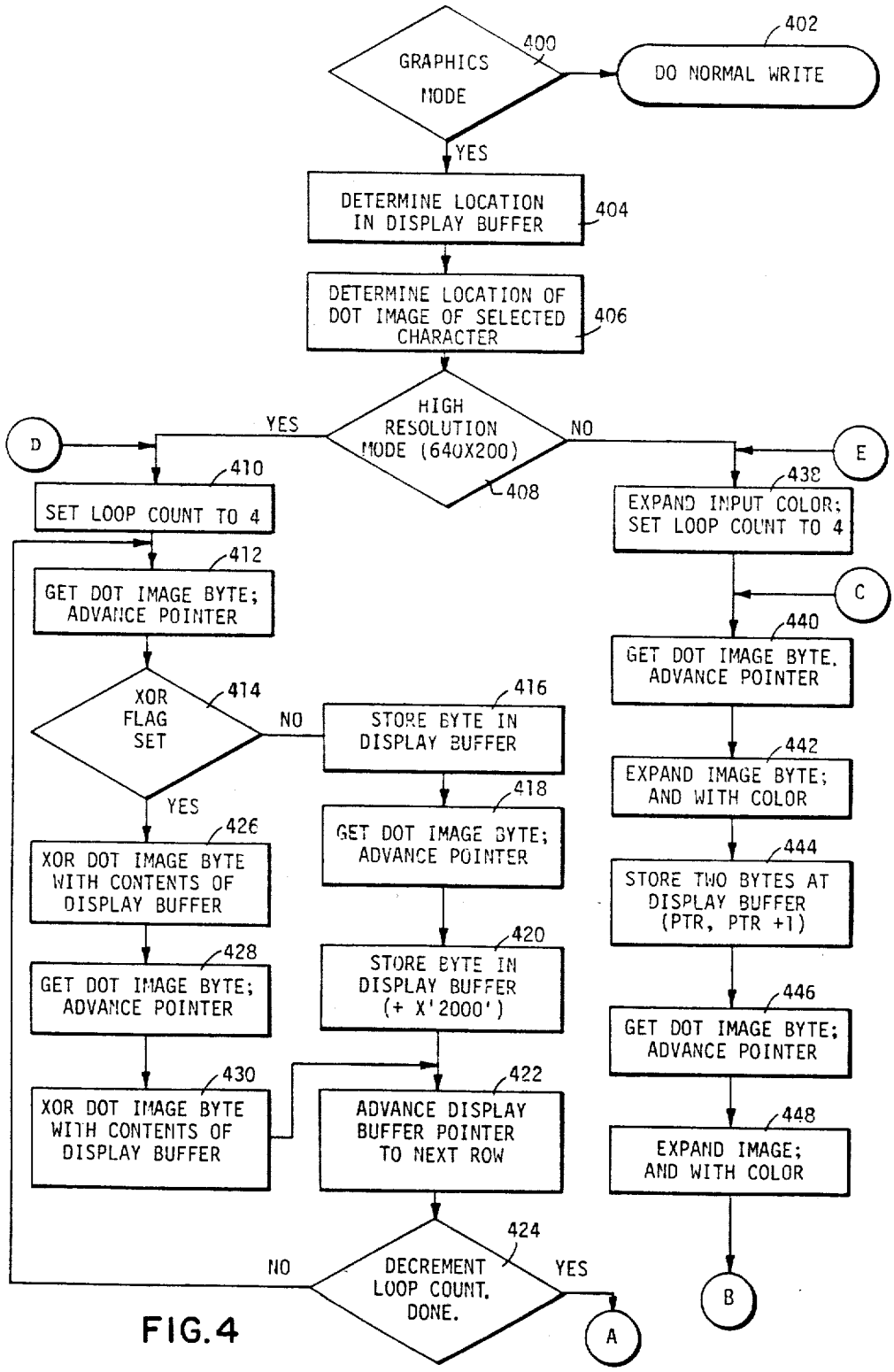

GRAPHICS MODE
400
402
DO NORMAL WRITE
YES
DETERMINE LOCATION IN DISPLAY BUFFER
404
DETERMINE LOCATION OF DOT IMAGE OF SELECTED CHARACTER
406
HIGH RESOLUTION MODE (640X200)
408
YES
NO
D
E
SET LOOP COUNT TO 4
410
EXPAND INPUT COLOR; SET LOOP COUNT TO 4
438
GET DOT IMAGE BYTE; ADVANCE POINTER
412
C
GET DOT IMAGE BYTE, ADVANCE POINTER
440
XOR FLAG SET
414
NO
STORE BYTE IN DISPLAY BUFFER
416
EXPAND IMAGE BYTE; AND WITH COLOR
442
YES
GET DOT IMAGE BYTE; ADVANCE POINTER
418
STORE TWO BYTES AT DISPLAY BUFFER (PTR, PTR +1)
444
XOR DOT IMAGE BYTE WITH CONTENTS OF DISPLAY BUFFER
426
GET DOT IMAGE BYTE; ADVANCE POINTER
446
GET DOT IMAGE BYTE; ADVANCE POINTER
428
STORE BYTE IN DISPLAY BUFFER (+ X'2000')
420
EXPAND IMAGE; AND WITH COLOR
448
XOR DOT IMAGE BYTE WITH CONTENTS OF DISPLAY BUFFER
430
ADVANCE DISPLAY BUFFER POINTER TO NEXT ROW
422
B
DECREMENT LOOP COUNT. DONE.
424
NO
YES
A

FIG.4

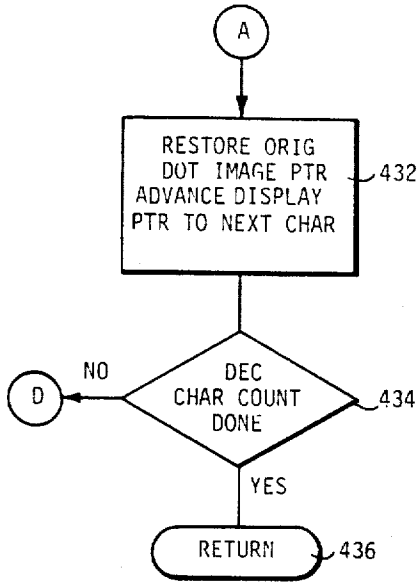

A
RESTORE ORIG
DOT IMAGE PTR
ADVANCE DISPLAY
PTR TO NEXT CHAR
432
NO
D
DEC
CHAR COUNT
DONE
434
YES
RETURN
436

FIG. 5

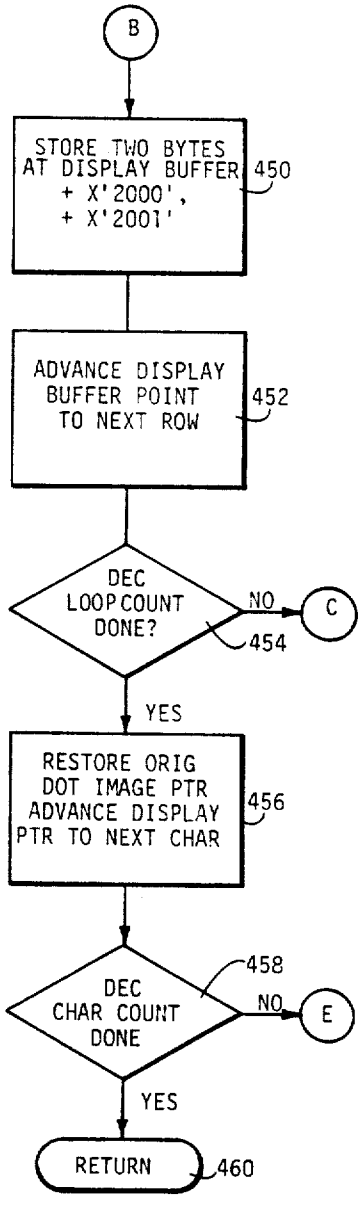

B
STORE TWO BYTES
AT DISPLAY BUFFER
+ X'2000',
+ X'2001'
450
ADVANCE DISPLAY
BUFFER POINT
TO NEXT ROW
452
DEC
LOOP COUNT
DONE?
NO
C
454
YES
RESTORE ORIG
DOT IMAGE PTR
ADVANCE DISPLAY
PTR TO NEXT CHAR
456
458
DEC
CHAR COUNT
DONE
NO
E
YES
RETURN
460

FIG. 6

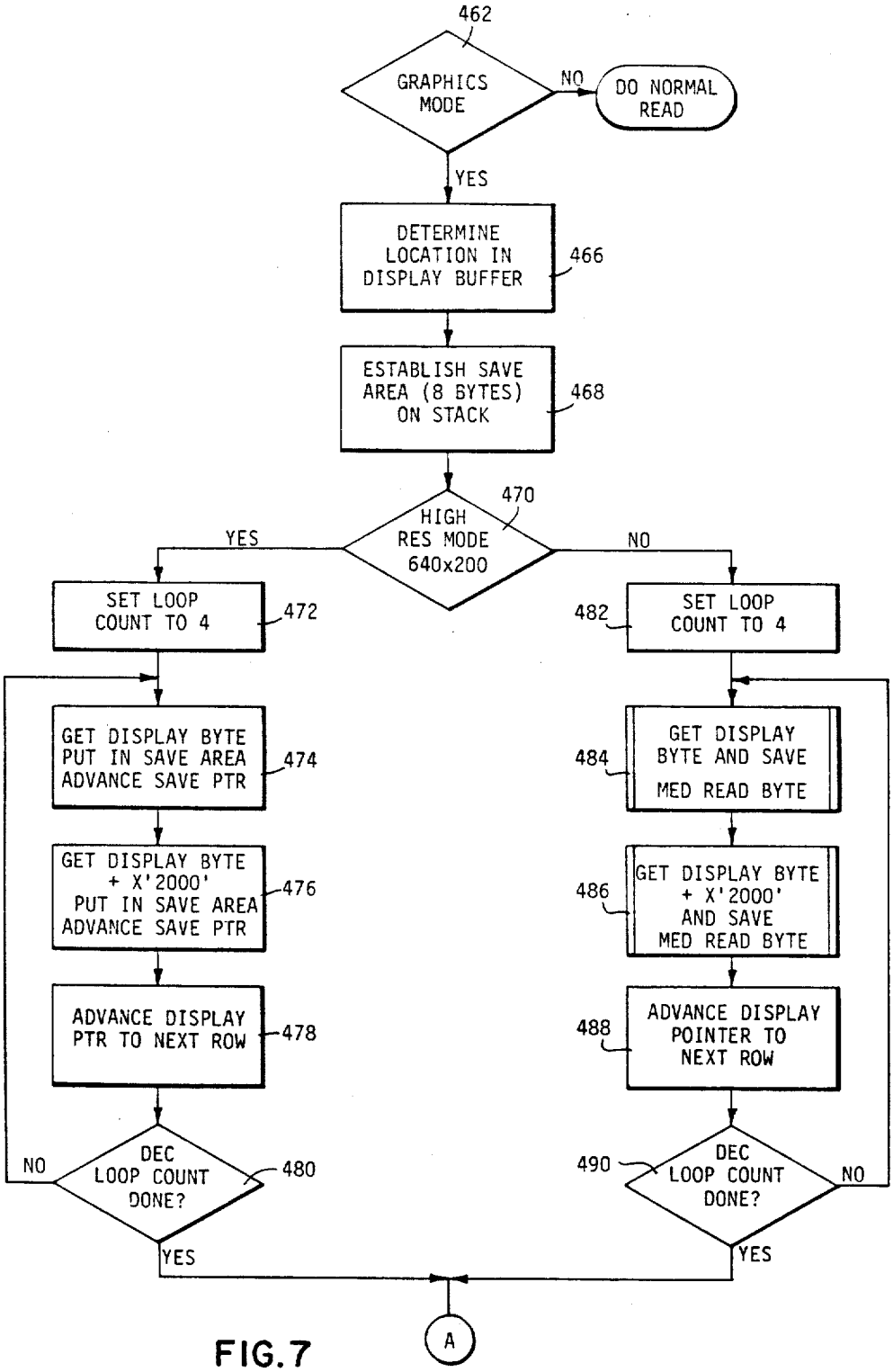

462
GRAPHICS MODE
NO
DO NORMAL READ
YES
DETERMINE LOCATION IN DISPLAY BUFFER
466
ESTABLISH SAVE AREA (8 BYTES) ON STACK
468
470
HIGH RES MODE 640x200
YES
NO
SET LOOP COUNT TO 4
472
GET DISPLAY BYTE PUT IN SAVE AREA ADVANCE SAVE PTR
474
GET DISPLAY BYTE + X'2000' PUT IN SAVE AREA ADVANCE SAVE PTR
476
ADVANCE DISPLAY PTR TO NEXT ROW
478
DEC LOOP COUNT DONE?
480
NO
YES
482
SET LOOP COUNT TO 4
484
GET DISPLAY BYTE AND SAVE MED READ BYTE
486
GET DISPLAY BYTE + X'2000' AND SAVE MED READ BYTE
488
ADVANCE DISPLAY POINTER TO NEXT ROW
490
DEC LOOP COUNT DONE?
NO
YES
A

FIG. 7

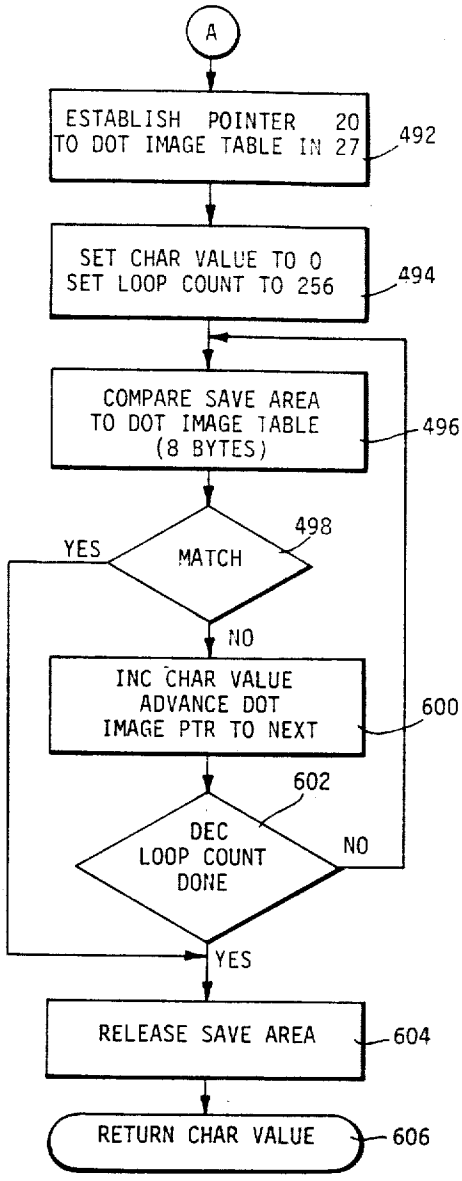

A
ESTABLISH POINTER 20 TO DOT IMAGE TABLE IN 27
492
SET CHAR VALUE TO 0 SET LOOP COUNT TO 256
494
COMPARE SAVE AREA TO DOT IMAGE TABLE (8 BYTES)
496
498
YES
MATCH
NO
INC CHAR VALUE ADVANCE DOT IMAGE PTR TO NEXT
600
602
DEC LOOP COUNT DONE
NO
YES
RELEASE SAVE AREA
604
RETURN CHAR VALUE
606

FIG.8

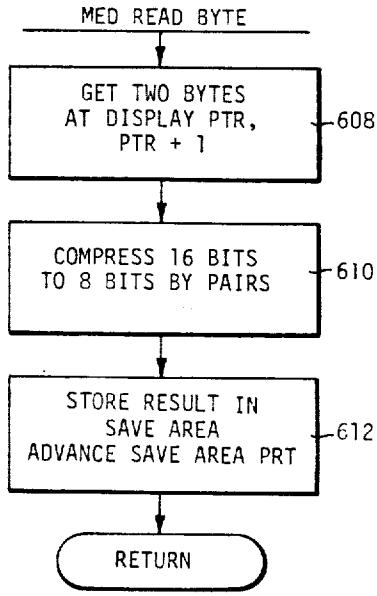

MED READ BYTE
GET TWO BYTES AT DISPLAY PTR, PTR + 1
608
COMPRESS 16 BITS TO 8 BITS BY PAIRS
610
STORE RESULT IN SAVE AREA ADVANCE SAVE AREA PRT
612
RETURN

FIG.9

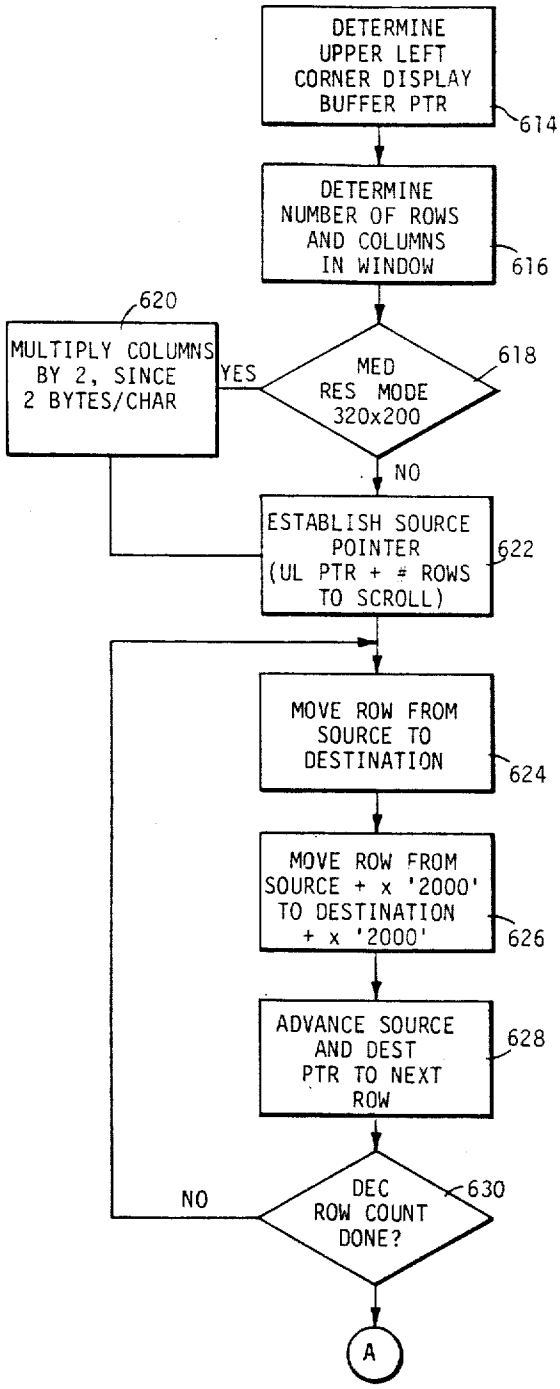

DETERMINE UPPER LEFT CORNER DISPLAY BUFFER PTR
614
DETERMINE NUMBER OF ROWS AND COLUMNS IN WINDOW
616
620
MULTIPLY COLUMNS BY 2, SINCE 2 BYTES/CHAR
YES
MED RES MODE 320x200
618
NO
ESTABLISH SOURCE POINTER (UL PTR + # ROWS TO SCROLL)
622
MOVE ROW FROM SOURCE TO DESTINATION
624
MOVE ROW FROM SOURCE + x '2000' TO DESTINATION + x '2000'
626
ADVANCE SOURCE AND DEST PTR TO NEXT ROW
628
NO
DEC ROW COUNT DONE?
630
A

FIG. 10

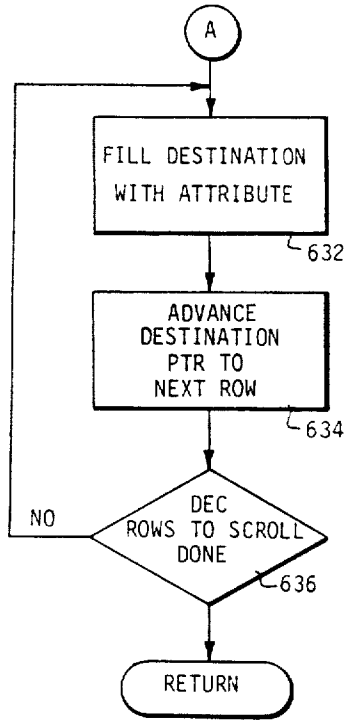

A
FILL DESTINATION WITH ATTRIBUTE
632
ADVANCE DESTINATION PTR TO NEXT ROW
634
NO
DEC ROWS TO SCROLL DONE
636
RETURN

FIG. 11

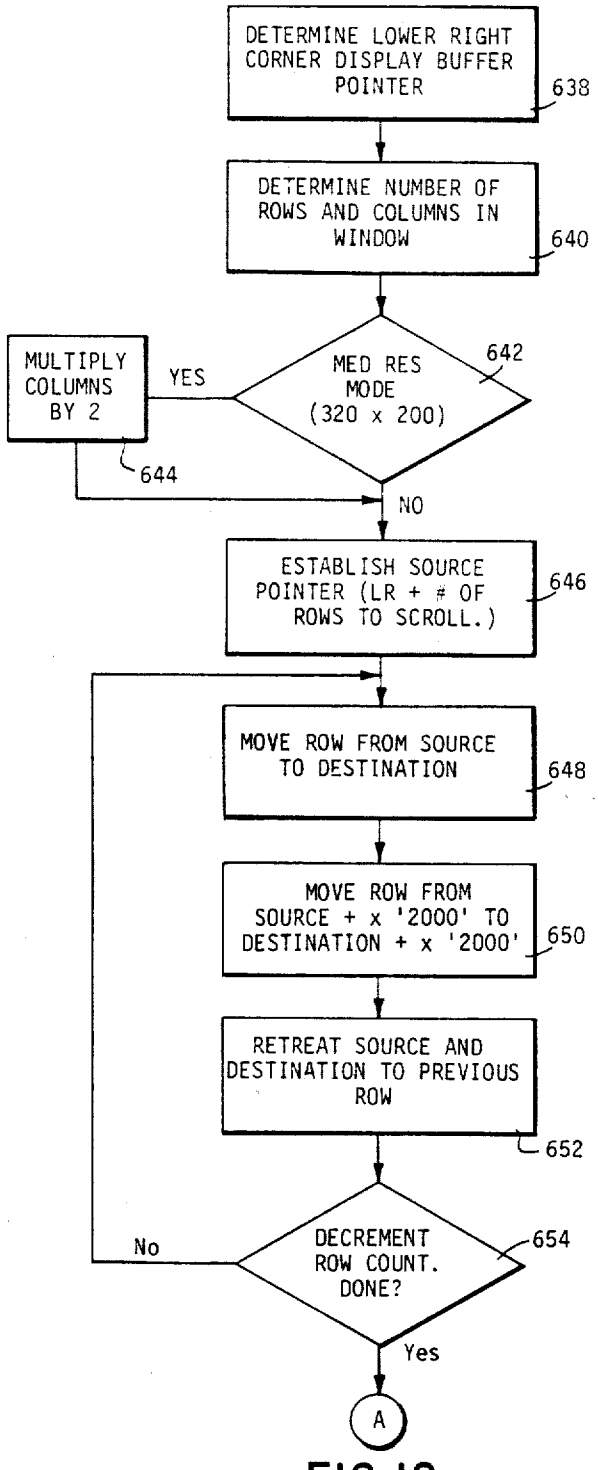

DETERMINE LOWER RIGHT CORNER DISPLAY BUFFER POINTER
638
DETERMINE NUMBER OF ROWS AND COLUMNS IN WINDOW
640
MED RES MODE (320 x 200)
642
YES
MULTIPLY COLUMNS BY 2
644
NO
ESTABLISH SOURCE POINTER (LR + # OF ROWS TO SCROLL.)
646
MOVE ROW FROM SOURCE TO DESTINATION
648
MOVE ROW FROM SOURCE + x '2000' TO DESTINATION + x '2000'
650
RETREAT SOURCE AND DESTINATION TO PREVIOUS ROW
652
DECREMENT ROW COUNT. DONE?
654
No
Yes
A

FIG. 12

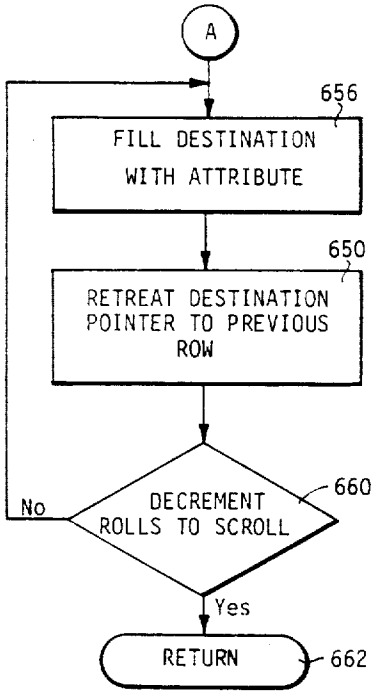

A
FILL DESTINATION WITH ATTRIBUTE
656
RETREAT DESTINATION POINTER TO PREVIOUS ROW
650
DECREMENT ROLLS TO SCROLL
660
No
Yes
RETURN
662

FIG. 13

APPARATUS AND METHOD FOR READING AND WRITING TEXT CHARACTERS IN A GRAPHICS DISPLAY

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to display systems and, more particularly, to a system for reading and writing text characters in a color graphics raster scan, all points addressable video display.

2. Discussion of the Prior Art

A video display typically provides an interface between a data processing machine and a user. Generally, a video image may comprise either strings of characters or of graphics, each of which requires different storage and, heretofore, processing requirements. Because of these differing requirements, many prior art video display systems do not permit the combining of text and graphic data on the same screen. However, many applications of graphic displays would be greatly enhanced by the provision of character data, such as legends on charts or graphs.

U.S. Pat. No. 4,149,145 describes a video display permitting the placement of character data within the region of display of graphic information. This is done by combining both graphic and character data in a video register. Each of the graphic and character data are separately developed, with a character generator providing the character image components and a graphic generator providing the graphic image components. These two components are merged or superimposed to provide a composite video signal. However, in the system of U.S. Pat. No. 4,149,145, there is no provision for reading text characters from the composite signal, and unnecessary complexity is required by the use of separate text character and graphics generators.

SUMMARY OF THE INVENTION

The invention provides apparatus and method for writing text characters to a raster scan video display operated in the graphics mode, and for reading characters thus written.

The apparatus of the invention includes a graphic video display buffer operable in an all points addressable mode for refreshing the display with graphics data, and a processor for loading the graphic data into said graphics video display buffer. The improvement comprises programmable control means referenced by said processor for writing by selecting and loading into said graphics video display buffer a text character dot pattern from main storage, and for reading by comparing dot patterns read from said display buffer with dot patterns in said main storage.

According to the method of the invention, text characters are written to a raster scan, all points addressable video display by retrieving from storage the graphic dot image of a selected character, expanding the graphic dot image to a selected pixel and color format, and storing the expanded dot image in a graphics video display buffer. Text characters are read by retrieving from the display buffer expanded dot images, restoring the expanded dot image to its original form, and comparing the restored dot image with graphic dot images selected from storage.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a logic schematic illustrating the video display control apparatus of the invention.

FIG. **2** is a schematic illustration of the relationships between pixel display and storage locations.

FIG. **3** is a schematic illustration of a segmented display screen for use in describing the scrolling features of the invention.

FIGS. **4–6** are logic flow diagrams of the graphics write steps of the method of the invention.

FIGS. **7–9** are logic flow diagrams of the graphics read steps of the invention.

FIGS. **10–11** are logic flow diagrams of the graphics scroll up steps of the invention.

FIGS. **12–13** are logic flow diagrams of the graphics scroll down steps of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. **1**, a description will be given of the apparatus of the invention for reading and writing text characters in a color graphics display.

The display of the invention is particularly suited for use in connection with a microcomputer including microprocessor **20**, dynamic storage **25**, read only storage **27**, display **50**, and keyboard **60**. In this embodiment, microprocessor **20** may comprise an Intel 8088 CPU, which utilizes the same 16-bit internal architecture as the Intel 8086 CPU but has an external 8-bit data bus **22**. For a description of the Intel 8086, and consequently of the 8086 instruction set used in the microprogram assembly language descriptions of the invention set forth hereafter, reference is made to Stephan P. Morse, The 8086 Primer, Hayden Book Company Inc., Rochelle Park, N.J., copyright 1980, Library of Congress classification QA76.8.1292M67 001.6'4'04 79-23932 ISBN 0-8104-5165-4, the teachings of which are herein incorporated by reference.

Processor **20** communicates with devices external to its integrated circuit chip via status and control line **21**, data bus **22**, and address bus **23**. Such external devices include dynamic storage **25** (for example, Texas Instruments 4116 RAM) with refresh control **24** (for example, an Intel 8237 DMA driven by an Intel 8253 Timer); and, connected by drivers/receivers **26** (for example, a TTL standard part 74LS245), read only storage **27** (for example, a MOSTEK 36000), direct storage access (or DMA) chip **28** (for example, and Intel 8237 DMA), timer **29** (for example, an Intel 8253 Timer implemented as described in "Refresh Circuit for Dynamic Memory of Data Processor Employing a Direct Memory Access Controller," by James A. Brewer, et al, U.S. patent application Ser. No. 292,075, filed Aug. 12, 1981) and keyboard attachment **66** with keyboard **67**.

Input/Output slots **30** provide for the attachment of a further plurality of external devices, one of which, the color graphic display attachment **31** is illustrated. Color graphics display adapter **31** attaches one or more of a wide variety of TV frequency monitor **50**, **51** and TV sets **52**, with an RF modulator **49** required for attaching a TV via antenna **53**. Adapter **31** is capable of operating in black and white or color, and herein provides these video interfaces: a composite video port on line **48**, which may be directly attached to display monitor **51** or

to RF modulator **49**, and a direct drive port comprising lines **39** and **46**.

Herein, display buffer **34** (such as an Intel 2118 RAM) resides in the address space of controller **20** starting at address X'**B8000**'. It provides in 16K bytes of dynamic RAM storage a raster scan bit map. A dual-ported implementation allows CPU **20** and graphics control unit **37** to access buffer **34**.

An APA mode, two resolution modes will be described: APA color 320×200 (320 pixels per row, 200 rows per screen) mode and APA black and white 640×200 mode. In 320×200 mode, each pixel may have one of four colors. The background color (color **00**) may be any of the sixteen possible colors. The remaining three colors come from one of two palettes in palette **42** selected by microprocessor **20** under control of read only storage **27** program: one palette containing red (color **01**), green (color **10**), and yellow (color **11**), and the other palette containing cyan (color **01**), magenta (color **10**), and white (color **11**). The 640×200 mode is, in the embodiment described, available only in two colors, such as black and white, since the full **16KB** of storage in display buffer **34** is used to define the pixels on or off state.

In A/N mode, characters are formed from ROS character generator **43**, which herein may contain dot patterns for **254** characters. These are serialized by alpha serializer **44** into color encoder **41** for output to port lines **46** or via lines **48** to composite color generator **48** for output to composite video line **48**.

Display adapter **31** includes a CRT control module **37**, which provides the necessary interface to processor **20** to drive a raster scan CRT **50–52**. Herein, CRT control module **37** comprises a Motorola MC6845 CRT controller (CRTC) which provides video timing on horizontal/vertical line **39** and refresh display buffer addressing on lines **38**. The Motorola MC6845 CRTC is described in MC6845 MOS (N-channel, Silicon-Gate) CRT controller, Motorola Simiconductor's publication ADI-465, copyright Motorola, Inc., 1977.

As shown in FIG. **1**, the primary function of CRTC **37** is to generate refresh addresses (MA0–MA13) on line **38**, row selects (RAO–RA4) on line **54**, video monitor timing (HSYNC, VSYNC) on line **39**, and display enable (not shown). Other functions include an internal cursor register which generates a cursor output (not shown) when its content compares to the current refresh address **38**. A light-pen strobe input signal (not shown) allows capture of refresh address in an internal light pen register.

All timing in CRTC **37** is derived from a clock input (not shown). Processor **20** communicates with CRTC **37** through buffered 8-bit data bus **32** by reading/writing into an 18-register file of CRTC **37**.

The refresh memory **34** address is multiplexed between processor **20** and CRTC **37**. Data appears on a secondary bus **32** which is buffered from the processor primary bus **22**. A number of approaches are possible for solving contentions for display buffer **34**:

(1) Processor **20** always gets priority.

(2) Processor **20** gets priority access any time, but can be synchronized by an interrupt to perform accesses only during horizontal and vertical retrace times.

(3) Synchronize process by memory wait cycles.

(4) Synchronize processor **20** to character rate.

The secondary data bus concept in no way precludes using the display buffer **34** for other purposes. It looks like any other RAM to processor **20**. For example, using approach **4**, a 64K RAM buffer **34** could perform refresh and program storage functions transparently.

CRTC **37** interfaces to processor **20** on bidirectional data bus **32** (DO–D7) using Intel 8088 CS, RS, E, and R/W control lines **21** for control signals.

The bidirectional data lines **32** (DO–D7) allow data transfers between the CRTC **37** internal register file and processor **20**.

The enable (E) signal on lines **21** is a high impedance TTL/MOS compatible input which enables the data bus input/output buffers and clocks data to and from CRTC **37**. This signal is usually derived from the processor **20** clock.

The chip select (CS) line **21** is a high impedance TTL/MOS compatible input which selects CRTC **37** when low to read or write the CRTC **37** internal register file. This signal should only be active when there is a valid stable address being decoded on bus **33** from processor **20**.

The register select (RS) line **21** is a high impedance TTL/MOS compatible input which selects either the address register (RS='0') or one of the data registers (RS='1') of the internal register file of CRTC **37**.

The read/write (R/W) line is a high impedance TTL/MOS compatible input which determines whether the internal register file in CRTC **37** gets written or read. A write is active low ('0').

CRTC **37** provides horizontal sync (HS/vertical sync (VS) signals on lines **39**, and display enable signals.

Vertical sync is a TTL compatible output providing an active high signal which drives monitor **50** directly or is fed to video processing logic **45** for composite generation. This signal determines the vertical position of the displayed text.

Horizontal sync is a TTL compatible output providing an active high signal which drives monitor **50** directly or is fed to video processing logic **45** for composite generation. This signal determines the horizontal position of the displayed text.

Display enable is a TTL compatible output providing an active high signal which indicates CRTC **37** is providing addressing in the active display area of buffer **34**.

CRTC **37** provides memory address **38** (MA0–MA13) to scan display buffer **34**. Also provided are raster addresses (RA0–RA4) for the character ROM.

Refresh memory **34** address (MA0–MA13) provides **14** outputs used to refresh the CRT screen **50–52** with pages of data located within a 16K block of refresh memory **34**.

Raster addresses **54** (RA0–RA4) provides 5 outputs from the internal raster counter to address the character ROM **43** for the row of a character.

Palette/overscan **42** and mode select **47** are implemented as a general purpose programmable I/O register. Its function in attachment **31** is to provide mode selection and color selection in the medium resolution color graphics mode.

Time control **47** further generates the timing signals used by CRT controller **37** and by dynamic RAM **34**. It also resolves the CPU **20** graphic controller **37** contentions for accessing display buffer **34**.

An A/N mode, attachment **31** utilizes ROS (for example, a MOSTEK 36000 ROS) character generator **43**, which consists of 8K bytes of storage which cannot be read/written under software control. The output of character generator is fed to alpha serializer **44** (such as a standard 74 LS 166 shift register), and thence to color

encoder **41**. As elements **43**, **44** are included only for completeness, they are not utilized in the invention and will not be further described.

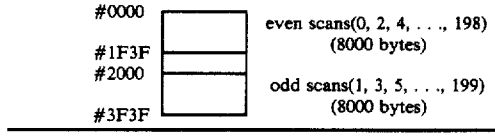
The output of display buffer **34** is alternatively fed for every other display row in a ping pong manner through data latches **35**, **36** to graphics serializer **40**, and thence to color encoder **41**. Data latches **35**, **36** may be implemented as standard TTL 74 LS 244 latches, graphics serializer **40** as a standard TTL 74 LS 166 shift register. Color encoder **41** may be implemented in logic such as is described in M. A. Dean, et al, "Composite Video Color Signal Generator From Digital Color Signals", assignees Ser. No. 292,074, 8-1981, of common assignee as the present invention. Composite color generator **45** provides logic for generating composite video **48**, which is base band video color information.

The organization of display buffer **34** to support the 200×320 color graphics mode is illustrated in FIG. **2** for generating, by way of example, a capital A in the upper left-hand position **50a** of monitor **50**. Read only storage **27** stores for each character displayable in graphics mode an eight byte code, shown at **27a** as sixteen hexidecimal digits **3078CCCCFCCCCCOO**. In FIG. **2**, these are organized in pairs, each pair describing one row of an 8×8 matrix on display **50a**. In display **50a**, an "X" in a pixel location denotes display of the foreground color (herein, code **11**) and a "." denotes display of the background color (code **00**).

When the character "A" is to be displayed, the sixteen digit hex code from read only storage **27** (or, equivalently, from dynamic storage **25**) is, in effect converted to binary. Thus, the first 8 pixel row, 30 hex, becomes 00110000, in binary. This eight bit binary code is then expanded to specify color, with each "0" becoming "00" to represent the background color, and each "1" becoming 10, 01, or 11 to specify one of the three foreground colors from the selected palette. In FIG. **2**, each "1" in the binary representation of the character code from storage **27** becomes "**11**" (which for palette two represents yellow; see below). Thus, the hex **30** representation of the first 8-pixel row of character "A", is expanded to 00 00 11 11 00 00 00 00 in display buffer **34a**, shown at location '0' (in hexidecimal notation, denoted as x '0'). Graphics storage **34** is organized in two banks of 8000 bytes each, as illustrated in Table 1, where address x '0000' contains the pixel information (**301–304**) for the upper left corner of the display area, and address x '2000' contains the pixel information for the first four pixels (**311–314**) of thesecond row of the display (in this case, the first 8 bit byte of the two byte binary expansion 00 11 11 11 11 00 00 00 of hex **78**).

TABLE 1

DISPLAY BUFFER 34 ADDRESSING



For the 200×640 mode (black and white), addressing and mapping of display buffer **34** to display **50** is the same as for 200×320 color graphics, but the data format is different: each bit in buffer **34** is mapped to a pixel on screen **50** (with a binary 1 indicating, say, black; and binary 0, white).

Color encoder **41** output lines **46I** (intensity), R (red), G (green), B (blue), provide the available colors set forth in Table 2:

TABLE 2

COLOR ENCODER OUTPUT 46				
I	R	G	B	COLOR
0	0	0	0	Black
0	0	0	1	Blue
0	0	1	0	Green
0	0	1	1	Cyan
0	1	0	0	Red
0	1	0	1	Magenta
0	1	1	0	Brown
0	1	1	1	Light Gray
1	0	0	0	Dark Gray
1	0	0	1	Light Blue
1	0	1	0	Light Green
1	0	1	1	Light Cyan
1	1	0	0	Light Red
1	1	0	1	Light Magenta
1	1	1	0	Yellow
1	1	1	1	White

Referring now to FIGS. **4–9**, in connection with the Intel 8086 assembly language (ASM-86) listings embedded in microcode in read only storage **27**, executed in microprocessor **20** to control the operation of video attachment **31**, and set forth in Tables 3 through 12, a description will be given of the method of the invention for writing text characters to a video screen operating in APA, or graphics mode. The Intel 8086 architecture and ASM-86 language is explained in Morse, The 8088 Primer, supra.

In Table 3 is set forth the preamble and various initialization procedures to the Graphics Read/Write Character microprogram in ROS **27**. While the control program, in this embodiment, is shown stored in a read only store **27**, it is apparent that such could be stored in a dynamic storage, such as storage **25**.

In step **400**, a data location in RAM **25** is tested to determine if the system is graphics write mode. If not, and a character is to be written, a branch to normal A/N character mode **402** is taken and the method of the invention bypassed.

Table 4 sets forth the 8086 assembly language listing for the graphics write steps, Table 5 the high resolution (black and white, or 640×200) mode thereof, and Table 6 the medium resolution (color, or 320×200) mode.

In step **404**, lines **53–57** of Table 4, addressability to the display buffer is established: the location in display buffer (REGEN) **34** to receive the write character is determined and loaded into register DI of processor **20**. In step **406**, lines **58–83**, addressability to the stored dot image is established: the location in read only storage (ROM) **27** or dynamic storage (USER RAM) **25** of the dot image of the character to be displayed is determined. After execution of Table 4, line 92, processor **20** registors DS, SI are pointing at the location in ROM **27** or RAM **25** where the character dot image is stored, and DS, SI define addressability of the dot image. At step **408**, line 93 the test is made for high resolution (640×200) or medium resolution (320×200) mode, (JC means jump on carry, and is an old Intel 8080 operation code which is the same as JB/JNAE in ASM-86, which works, amazingly enough, even though JC is not a documented operation code in ASM-86.) In high resolution mode, control passes to step **410**, line 95 (Table 5). For medium resolution mode, it passes to step **438**, line 124 (Table 6).

For high resolution mode (640×200, black and white), the procedure of steps **412–424** (**426–430** included, if pertinent) is performed for each of the four bytes required to provide the dot image for a character in graphics mode. Step **410** (line 99) sets the loop counter register DH to four, and in steps **412** (step **101**) a dot image byte from ROM **27** or RAM **25** pointed to by processor **20** registers DS, SI is loaded into the processor **20** string. The LODSB and STOSB instructions at lines 101, 120 and 104, 119, etc. perform the following actions:

LODSB: MOV AL, [DS:SI]; SI←SI+1

STOSB: MOV [ES.DI], AL; DI←DI+1

At step **414** (line 102) a test is made to determine whether or not the application requesting the display of the character wants the character to replace the current display, or to be exclusive OR'd with the current display. In steps **416–422**, (lines 104–115) the current display is replaced by storing this and the next dot image bytes in display buffer **34**, with the next byte offset or displaced by X'2000' from the location of this byte in buffer **34**. In steps **426–430** (lines 117–122), the alternative operation of exclusive ORing those two bytes into display buffer **34** is performed. If more than one identical character is to be written to display screen **50** in this operation, steps **432–434** of FIG. **5** (lines 112–114) condition the procedure for executing steps **410** through **434** for each such character.

Table 6 sets forth the 8086 assembly language listing in ROM **27** executed by processor **20** to control display attachment **31** to display a text character in the medium resolution (320×200) mode, and corresponds to steps **438** (FIG. **4**) to **460** (FIG. **6**).

In steps **438** (lines 128, Table 6, and Table 8) the input color (two bits, 01, 10 or 11) is expanded to fill a 16-bit word by repeating the two bit code. In step **440** (line 134), a byte of character code points are loaded into the AL register of processor **20** from storage **25, 27**. In step **442**, (line 135) each bit in the 1 byte AL register (character code points) is doubled up by calling EXPAND BYTE, Table 9; and the result is AND'd to the expanded input color (at line 136).

In step **444** (lines 142–143) the resulting word (2 bytes) of step **442** is stored in display buffer **34**. This is shown, by way of example, at location X'O' in FIG. **2**, the stored word comprising fields **301–308**. (In FIG. **4**, the XOR procedures of Table 6, lines 137–140 and 147–150 are not shown, but are analygous to the XOR procedure of steps **414–430** for the high resolution mode.)

In step **446** (line 144) the next dot image byte is retrieved from storage **25, 27**, and at step **448** it is expanded (line 145) and AND'd with color (line 146). In step **450** (lines 152–153) the resulting word is stored in display buffer **34**, offset from the word stored at step **444** by x '2000'.

At step **452** (line 154) the display buffer pointer is advanced to the next row of the character to be displayed, and processing returns (step **454**, line 156) to complete the character or proceeds (step **456, 458, 460**, lines 156–160) to repeat the completed character as many times as required.

Referring now to logic flow diagrams **7–9** in connection with the 8086 assembly language listings of Tables 10–12, an explanation will be given of the graphic read steps of the invention. In this process, a selected character dot image from display buffer **34** is compared against dot image code points retrieved from storage **25, 27**, a match indicating that the character in buffer **34** has been identified, or read.

In step **462** it is first determined if video attachment **31** is being operated in the graphics mode. If not, in step **464** the read operation is performed in character mode, and the method of the invention is not involved.

In step **466** (line 171) the location in display buffer **34** to be read is determined by calling procedure POSITION, as set forth in Table 7. In step **468** (line 173) an 8-byte save area is established on a stack within the address space of processor **20**.

In step **470** (lines 176–181) the read mode is determined. Control passes to step **482** (Table 11) for medium resolution (color, or 320×200) mode. For high resolution (black/white, or 640×200 mode, at step **472**, line 187) the loop count is set to 4 (there being 4 two-byte words per character), and in steps **474–480** (lines 189–197) eight bytes are retrieved from display buffer **34** and put into the save area reserved on the stack in step **468**. For medium resolution mode, at step **482** (line 203), the loop count is set equal to 4, and in steps **484–490** (lines 204–210) the character to be read is retrieved from display buffer **34**. The procedure MED READ BYTE called at lines 205, 207 is set forth in Table 12 in connection with FIG. **9**.

Referring to FIG. **8**, at step **492** (Table 11, line 214) processing continues to compare the character, either high or medium resolution mode, read from display buffer **34** with character code points read from storage **25, 27**. In step **492** (line 214) the pointer to the dot image table in ROM **27** is established. (The processing of lines 238–250 is executed if the character is not found in ROM **27** and the search must be extended into dynamic storage **25** where the user supplied second half of the graphic character points table is stored.)

In step **494** (lines 220–224) the character value is initialized to zero (it will be set equal to 1 when a match is found), and the loop count set equal to 256 (line 224 sets DX=128, and this is again, at line 249, reestablished for a total of 256 passes through the loop of steps **496–602**, if required).

In step **496** (line 229), the character read from display buffer **34** into the save area is compared with the dot image read from storage **25, 27**, and the match tested at step **498** (line 232). Loop control steps **600, 602** (lines 233–236) are executed until a match is found, or until all 256 dot images in storage **25, 27** have been compared with a match. In step **604** (line 255) the save area is released, and in step **606** (line 256) the procedure ends. If a character match has occurred in step **498**, the character thus read is located in storage **25, 27** at the location pointed to by register AL. AL=0 if the character was not found (a not unexpected result if a character had been exclusively OR'd into the display buffer **24** at the location being read, such as at steps **426–450**).

Referring now to FIG. **9** in connection with Table 12, the procedure MED READ BYTE, called at steps **484** and **486**, will be described. This procedure compresses 16 bits previously expanded from eight to encode the color (see step **442**) and stored in display buffer **34** (at step **444**) back to the original dot image (obtained previously from storage **25, 27** at step **440**). Step **608** (lines 330–331) gets two eight-bit bytes, which in step **610** (lines 332–343) is compressed two bits at a time to recover the original dot image. In step **612** (lines 344–346)

the results are saved in the area pointed to by register BP.

Referring now to FIG. **3**, in connection with FIGS. **10–13** and Table 13, a description will be given of the graphic scrolling facility provided for separate discrete areas **60**, **63**, **65** of display screen **506**. This invention is described and claimed in U.S. patent application Ser. No. 6/292,081, filed Aug. 12, 1981 for "Apparatus and Method for Scrolling Text Characters and Graphic Data in Selected Portions of a Graphic Display", by David J. Bradley. In accordance with this invention, a user may define a plurality of windows on the screen in which graphic information blocks may be scrolled. The designation of a scroll section or window **60** requires address of opposite corners, such as the address of the upper left corner **61** and the lower right corner **62**, and the number of lines to scroll. The difference in corner addresses sets the window. The color of the newly blanked line is established by a blanking attribute. Within these parameters, the graphic scrolling procedure of FIGS. **10–13** is performed. By this approach, both text (graphic) and display may be scrolled within separate windows **60**, **63**, and **65**.

In Table 13, certain 8086 assembly language parameters are initialized. (Reference to graphics R/W dot does not pertain to the present invention.)

In Tables 14 and 15, the scroll up assembly language statements corresponding to FIGS. **10** and **11** are set forth. (The line numbers of Tables 13–19 overlap those of previous tables, but the step numbers of the figures do not.)

In step **614** (line 161) the pointer to the display buffer **34** location corresponding to upper left corner **61** of the display window **60** to be scrolled is placed in processor **20** register AX. In step **616** (lines 169–174) is determined the number of rows and columns in window **60**. In step **618** (lines 178–179) the mode is determined, and if 320×200 mode is detected, in step **620** (lines 182–183) the number of columns in the window is adjusted to handle two bytes per character.

In step **622** (lines 185–200 of Table 15), the source pointer is established equal to upper left (UL) pointer plus the number of rows (from register AL) to scroll, the result placed in register **S1**.

In steps **624**, **626** (line 203) a call is made to procedure ROW MOVE (Table 18) to move a row from source (pointed to by SI) to destination (pointed to by DI). Line 314 performs the move of step **624**, line 322 of step **626**, and lines 317–318 adjust the pointers (note line 17, Table 13—ODD FLD is equal to X'2000').

In step **628** (lines 204–205), the source (SI) and destination (DI) pointers are advanced to the next row of the screen window. In step **630** (lines 206–207) the row count is decremented and, if the process is not complete, the procedure of steps **624–630** repeated.

In step **632** (FIG. **11**; line 213) procedure ROW CLEAR (Table 19) is called to clear a row by filling it with the fill value for blanked lines specified in processor **20** register BH and transferred to the AL register at line 211. The REP STOSB instruction at lines 333, 338 stores the byte contained in AL into the byte whose offset is contained in DI, increments DI, and repeats to fill every byte of the row with the blanking attribute (which may be the screen background color, for example.)

In step **634** (line 214) destination pointer DI is advanced to the next row, and in step **636** (lines 215, 216) the number BL of rows to scroll is decremented, and the loop of steps **632–636** executed for each row to be scrolled.

The procedure for scroll down is set forth in FIGS. **12** and **13**, in connection with the 8086 assembly language source code instructions of Tables 16–19. The procedure is analogous to that for scroll up, wherever step **638** corresponds to lines 239–242, step **640** to lines 250–256, step **642** to lines 257–261, step **644** to lines 263–265, step **646** to lines 267–283, steps **648** and **650** to line 286, step **652** to lines 287–288, step **654** to lines 289–290, step **656** to line 296, step **658** to line 297, step **660** to lines 298, 299 and step **662** to line 301.

The assembly language code listings of Tables 3 through 19 are Copyrighted by IBM Corporation, 1981, and are reproduced herein by consent of IBM.

TABLE 3: GRAPHICS READ/WRITE CHARACTER INITIALIZATION

```
LINE    SOURCE

   1    $TITLE('VIDEO1 GRAPHICS READ/WRITE CHARACTER')
   2    $PAGELENGTH(43)
   3    ;-----------------------------------------------
   4    ; GRAPHICS WRITE
   5    ;  THIS ROUTINE WRITES THE ASCII CHARACTER TO THE CURRENT
   6    ;  POSITION ON THE SCREEN.
   7    ; ENTRY --
   8    ;  AL = CHARACTER TO WRITE
   9    ;  BL = COLOR ATTRIBUTE TO BE USED FOR FOREGROUND COLOR
  10    ;       IF BIT 7 IS SET, THE CHAR IS XOR'D INTO THE REGEN BUFFER
  11    ;       (0 IS USED FOR THE BACKGROUND COLOR)
  12    ;  CX = NUMBER OF CHARS TO WRITE
  13    ;  DS = DATA SEGMENT
  14    ;  ES = REGEN SEGMENT
  15    ; EXIT --
  16    ;  NOTHING IS RETURNED
  17    ;
  18    ; GRAPHICS READ
  19    ;   THIS ROUTINE READS THE ASCII CHARACTER AT THE CURRENT CURSOR
  20    ;   POSITION ON THE SCREEN BY MATCHING THE DOTS ON THE SCREEN TO THE
```

```
21      ;   CHARACTER GENERATOR CODE POINTS
22      ; ENTRY —
23      ;  NONE  ( 0 IS ASSUMED AS THE BACKGROUND COLOR
24      ; EXIT —
25      ;  AL = CHARACTER READ AT THAT POSITION (0 RETURNED IF NONE FOUND)
26      ;
27      ; FOR BOTH ROUTINES, THE IMAGES USED TO FORM CHARS ARE CONTAINED IN ROM
28      ;  FOR THE 1ST 128 CHARS.  TO ACCESS CHARS IN THE SECOND HALF, THE USER
29      ;  MUST INITIALIZE THE VECTOR AT INTERRUPT 1FH (LOCATION 0007CH) TO
30      ;  POINT TO THE USER SUPPLIED TABLE OF GRAPHIC IMAGES (8X8 BOXES).
31      ;  FAILURE TO DO SO WILL CAUSE IN STRANGE RESULTS
32      ;-----------------------------------------------
33
34      DUMMY   SEGMENT AT 0
35              ORG     01FH*4          ; LOCATION OF POINTER
36      EXT_PTR LABEL   DWORD           ; POINTER TO EXTENSION
37      DUMMY   ENDS
38
39      DATA    SEGMENT BYTE PUBLIC
40              EXTRN   CRT_COLS:WORD,CRT_MODE:BYTE,CURSOR_POSN:WORD
41      DATA    ENDS
42
43      CODE    SEGMENT BYTE PUBLIC
44              ASSUME  CS:CODE,DS:DATA,ES:DATA
45              EXTRN   CRT_CHAR_GEN:BYTE
46              EXTRN   VIDEO_RETURN:NEAR
47              PUBLIC  GRAPHICS_WRITE
48
                TABLE 4:  GRAPHICS WRITE CHARACTER
49      GRAPHICS_WRITE  PROC    NEAR
50              MOV     AH,0            ; ZERO TO HIGH OF CODE POINT
51              PUSH    AX              ; SAVE CODE POINT VALUE
52
53      ;------ DETERMINE POSITION IN REGEN BUFFER TO PUT CODE POINTS
54
55              CALL    POSITION        ; FIND LOCATION IN REGEN BUFFER
56              MOV     DI,AX           ; REGEN POINTER IN DI
57
58      ;------ DETERMINE REGION TO GET CODE POINTS FROM
59
60              POP     AX              ; RECOVER CODE POINT
61              CMP     AL,80H          ; IS IT IN SECOND HALF
62              JAE     EXTEND_CHAR     ; YES
63
64      ;------ IMAGE IS IN FIRST HALF, CONTAINED IN ROM
65
66              MOV     SI,OFFSET CRT_CHAR_GEN  ; OFFSET OF IMAGES
67              PUSH    CS                      ; SAVE SEGMENT ON STACK
68              JMP     SHORT DETERMINE_MODE
69
70      ;------ IMAGE IS IN SECOND HALF, IN USER RAM
71
72      EXTEND_CHAR:
73              SUB     AL,80H                  ; ZERO ORIGIN FOR SECOND HALF
74              PUSH    DS                      ; SAVE DATA POINTER
75              SUB     SI,SI
76              MOV     DS,SI                   ; ESTABLISH VECTOR ADDRESSING
```

```
77          ASSUME  DS:DUMMY
78          LDS     SI,EXT_PTR              ; GET THE OFFSET OF THE TABLE
79          MOV     DX,DS                   ; GET THE SEGMENT OF THE TABLE
80          ASSUME  DS:DATA
81          POP     DS                      ; RECOVER DATA SEGMENT
82          PUSH    DX                      ; SAVE TABLE SEGMENT ON STACK
83
84      ;------ DETERMINE GRAPHICS MODE IN OPERATION
85
86      DETERMINE_MODE:
87          SAL     AX,1                    ; MULTIPLY CODE POINT
88          SAL     AX,1                    ;  VALUE BY 8
89          SAL     AX,1
90          ADD     SI,AX                   ; SI HAS OFFSET OF DESIRED CODES
91          CMP     CRT_MODE,6
92          POP     DS              ; RECOVER TABLE POINTER SEGMENT
93          JC      MED_RES_WRITE   ; TEST FOR MEDIUM RESOLUTION MODE
94
```

TABLE 5: GRAPHICS WRITE CHARACTER 640x200 BLACK/WHITE MODE

```
95      ;------ HIGH RESOLUTION MODE
96      HIGH_CHAR:
97          PUSH    DI              ; SAVE REGEN POINTER
98          PUSH    SI              ; SAVE CODE POINTER
99          MOV     DH,4            ; NUMBER OF TIMES THROUGH LOOP
100     L10:
101         LODSB                   ; GET BYTE FROM CODE POINTS
102         TEST    BL,80H          ; SHOULD WE USE THE FUNCTION
103         JNZ     XOR_HIGH        ;  TO PUT CHAR IN
104         STOSB                   ; STORE IN REGEN BUFFER
105         LODSB
106     L10A:                       ;
107         MOV     ES:[DI+2000H-1],AL      ; STORE IN SECOND HALF
108         ADD     DI,79           ; MOVE TO NEXT ROW IN REGEN
109         DEC     DH              ; DONE WITH LOOP
110         JNZ     L10
111         POP     SI
112         POP     DI              ; RECOVER REGEN POINTER
113         INC     DI              ; POINT TO NEXT CHAR POSITION
114         LOOP    HIGH_CHAR               ; MORE CHARS TO WRITE
115         JMP     VIDEO_RETURN
116
117     XOR_HIGH:                   ;
118         XOR     AL,ES:[DI]      ; EXCLUSIVE OR WITH CURRENT
119         STOSB                   ; STORE THE CODE POINT
120         LODSB                   ; AGAIN FOR ODD FIELD
121         XOR     AL,ES:[DI+2000H-1]      ;
122         JMP     L10A            ; BACK TO MAINSTREAM
123
```

TABLE 6: GRAPHICS WRITE CHARACTER 320X200 COLOR MODE

```
124     ;------ MEDIUM RESOLUTION WRITE
125     MED_RES_WRITE:
126         MOV     DL,BL           ; SAVE HIGH COLOR BIT
127         SAL     DI,1            ; OFFSET*2 SINCE 2 BYTES/CHAR
128         CALL    EXPAND_MED_COLOR        ; EXPAND BL TO FULL WORD OF COLOR
129     MED_CHAR:
130         PUSH    DI              ; SAVE REGEN POINTER
131         PUSH    SI                      ; SAVE THE CODE POINTER
```

```
132             MOV     DH,4            ; NUMBER OF LOOPS
133     L20:
134             LODSB                   ; GET CODE POINT
135             CALL    EXPAND_BYTE     ; DOUBLE UP ALL THE BITS
136             AND     AX,BX           ; CONVERT THEM TO FOREGROUND COLOR ( 0 BACK )
137             TEST    DL,80H          ; IS THIS XOR FUNCTION
138             JZ      L20A            ; NO, STORE IT IN AS IT IS
139             XOR     AH,ES:[DI]      ; DO FUNCTION WITH HALF
140             XOR     AL,ES:[DI+1]    ;  AND WITH OTHER HALF
141     L20A:                           ;
142             MOV     ES:[DI],AH      ; STORE FIRST BYTE
143             MOV     ES:[DI+1],AL    ; STORE SECOND BYTE
144             LODSB                   ; GET CODE POINT
145             CALL    EXPAND_BYTE
146             AND     AX,BX           ; CONVERT TO COLOR
147             TEST    DL,80H          ; AGAIN, IS THIS XOR FUNCTION
148             JZ      L20B            ; NO, JUST STORE THE VALUES
149             XOR     AH,ES:[DI+2000H]        ; FUNCTION WITH FIRST HALF
150             XOR     AL,ES:[DI+2001H]        ; AND WITH SECOND HALF
151     L20B:                           ;
152             MOV     ES:[DI+2000H],AH
153             MOV     ES:[DI+2000H+1],AL      ; STORE IN SECOND PORTION OF BUFFER
154             ADD     DI,80           ; POINT TO NEXT LOCATION
155             DEC     DH
156             JNZ     L20             ; KEEP GOING
157             POP     SI              ; RECOVER CODE POINTER
158             POP     DI              ; RECOVER REGEN POINTER
159             ADD     DI,2            ; POINT TO NEXT CHAR POSITION
160             LOOP    MED_CHAR        ; MORE TO WRITE
161             JMP     VIDEO_RETURN
162
163     GRAPHICS_WRITE  ENDP
```

TABLE 7: POSITION

```
349     ;--------------------------------
350     ; POSITION
351     ;  THIS ROUTINE TAKES THE CURSOR POSITION CONTAINED IN
352     ;  THE MEMORY LOCATION, AND CONVERTS IT INTO AN OFFSET
353     ;  INTO THE REGEN BUFFER, ASSUMING ONE BYTE/CHAR.
354     ;  FOR MEDIUM RESOLUTION GRAPHICS, THE NUMBER MUST
355     ;  BE DOUBLED.
356     ; ENTRY -- NO REGISTERS,MEMORY LOCATION CURSOR_POSN IS USED
357     ; EXIT--
358     ;  AX CONTAINS OFFSET INTO REGEN BUFFER
359     ;--------------------------------
360
361             PUBLIC  GRAPH_POSN
362     POSITION        PROC    NEAR
363             MOV     AX,CURSOR_POSN          ; GET CURRENT CURSOR
364     GRAPH_POSN      LABEL   NEAR
365             PUSH    BX                      ; SAVE REGISTER
366             MOV     BX,AX                   ; SAVE A COPY OF CURRENT CURSOR
367             MOV     AL,AH                   ; GET ROWS TO AL
368             MUL     BYTE PTR CRT_COLS       ; MULTIPLY BY BYTES/COLUMN
369             SHL     AX,1                    ; MULTIPLY * 4 SINCE 4 ROWS/BYTE
370             SHL     AX,1
371             SUB     AH,AH                   ; ISOLATE COLUMN VALUE
372             ADD     AX,BX                   ; DETERMINE OFFSET
```

```
373         POP     BX                  ; RECOVER POINTER
374         RET                         ; ALL DONE
375     POSITION    ENDP
376     CODE    ENDS
377         END
```

TABLE 8: EXPAND MED COLOR

```
259     ;-------------------------------------------
260     ; EXPAND_MED_COLOR
261     ;  THIS ROUTINE EXPANDS THE LOW 2 BITS IN BL TO
262     ;  FILL THE ENTIRE BX REGISTER
263     ; ENTRY --
264     ;  BL = COLOR TO BE USED ( LOW 2 BITS )
265     ; EXIT --
266     ;  BX = COLOR TO BE USED ( 8 REPLICATIONS OF THE 2 COLOR BITS )
267     ;-------------------------------------------
268
269     EXPAND_MED_COLOR        PROC    NEAR
270         AND     BL,3            ; ISOLATE THE COLOR BITS
271         MOV     AL,BL           ; COPY TO AL
272         PUSH    CX              ; SAVE REGISTER
273         MOV     CX,3            ; NUMBER OF TIMES TO DO THIS
274     EXPAND_MED:
275         SAL     AL,1
276         SAL     AL,1            ; LEFT SHIFT BY 2
277         OR      BL,AL           ; ANOTHER COLOR VERSION INTO BL
278         LOOP    EXPAND_MED      ; FILL ALL OF BL
279         MOV     BH,BL           ; FILL UPPER PORTION
280         POP     CX              ; REGISTER BACK
281         RET                     ; ALL DONE
282     EXPAND_MED_COLOR        ENDP
283
```

TABLE 9: EXPAND BYTE

```
284     ;-------------------------------------------
285     ; EXPAND_BYTE
286     ;  THIS ROUTINE TAKES THE BYTE IN AL AND DOUBLES ALL
287     ;  OF THE BITS, TURNING THE 8 BITS INTO 16 BITS.
288     ;  THE RESULT IS LEFT IN AX
289     ;-------------------------------------------
290
291     EXPAND_BYTE     PROC    NEAR
292         PUSH    DX              ; SAVE REGISTERS
293         PUSH    CX
294         PUSH    BX
295         MOV     DX,0            ; RESULT REGISTER
296         MOV     CX,1            ; MASK REGISTER
297     EXPAND_BYTE_LOOP:
298         MOV     BX,AX           ; BASE INTO TEMP
299         AND     BX,CX           ; USE MASK TO EXTRACT A BIT
300         OR      DX,BX           ; PUT INTO RESULT REGISTER
301         SHL     AX,1
302         SHL     CX,1            ; SHIFT BASE AND MASK BY 1
303         MOV     BX,AX           ; BASE TO TEMP
304         AND     BX,CX           ; EXTRACT THE SAME BIT
305         OR      DX,BX           ; PUT INTO RESULT
306         SHL     CX,1            ; SHIFT ONLY MASK NOW, MOVING TO NEXT BASE
307         JNC     EXPAND_BYTE_LOOP        ; USE MASK BIT COMING OUT TO TERMINATE
308         MOV     AX,DX           ; RESULT TO FARM REGISTER
309         POP     BX
```

```
310             POP     CX              ; RECOVER REGISTERS
311             POP     DX
312             RET                     ; ALL DONE
313     EXPAND_BYTE     ENDP
```

TABLE 10: GRAPHICS READ CHARACTER (HIGH RESOLUTION)

```
164
165     ;--------------------------------
166     ; GRAPHICS READ
167     ;--------------------------------
168             PUBLIC  GRAPHICS_READ
169     GRAPHICS_READ   PROC    NEAR
170
171             CALL    POSITION        ; CONVERTED TO OFFSET IN REGEN
172             MOV     SI,AX           ; SAVE IN SI
173             SUB     SP,8            ; ALLOCATE SPACE TO SAVE THE READ CODE POINT
174             MOV     BP,SP           ; POINTER TO SAVE AREA
175
176     ;------ DETERMINE GRAPHICS MODES
177
178             CMP     CRT_MODE,6
179             PUSH    ES
180             POP     DS              ; POINT TO REGEN SEGMENT
181             JC      MED_RES_READ    ; MEDIUM RESOLUTION
182
183     ;------ HIGH RESOLUTION READ
184
185     ;------ GET VALUES FROM REGEN BUFFER AND CONVERT TO CODE POINT
186     HIGH_READ:
187             MOV     DH,4            ; NUMBER OF PASSES
188     L100:
189             MOV     AL,[SI]         ; GET FIRST BYTE
190             MOV     [BP],AL         ; SAVE IN STORAGE AREA
191             INC     BP              ; NEXT LOCATION
192             MOV     AL,[SI+2000H]   ; GET LOWER REGION BYTE
193             MOV     [BP],AL         ; ADJUST AND STORE
194             INC     BP
195             ADD     SI,80           ; POINTER INTO REGEN
196             DEC     DH              ; LOOP CONTROL
197             JNZ     L100            ; DO IT SOME MORE
198             JMP     FIND_CHAR       ; GO MATCH THE SAVED CODE POINTS
199
```

TABLE 11: GRAPHICS READ CHARACTER (MEDIUM RESOLUTION)

```
200     ;------ MEDIUM RESOLUTION READ
201     MED_RES_READ:
202             SAL     SI,1            ; OFFSET*2 SINCE 2 BYTES/CHAR
203             MOV     DH,4            ; NUMBER OF PASSES
204     L110:
205             CALL    MED_READ_BYTE   ; GET PAIR BYTES FROM REGEN INTO SINGLE SAVE
206             ADD     SI,2000H        ; GO TO LOWER REGION
207             CALL    MED_READ_BYTE   ; GET THIS PAIR INTO SAVE
208             SUB     SI,2000H-80     ; ADJUST POINTER BACK INTO UPPER
209             DEC     DH
210             JNZ     L110            ; KEEP GOING UNTIL ALL 8 DONE
211
212     ;------- SAVE AREA HAS CHARACTER IN IT, MATCH IT
```

```
213  FIND_CHAR:
214          MOV     DI,OFFSET CRT_CHAR_GEN  ; ESTABLISH ADDRESSING TO CODE POINTS
215          PUSH    CS
216          POP     ES                      ; CODE POINTS IN CS
217          SUB     BP,8            ; ADJUST POINTER TO BEGINNING OF SAVE AREA
218          MOV     SI,BP
219          CLD                     ; ENSURE DIRECTION
220          MOV     AL,0            ; CURRENT CODE POINT BEING MATCHED
221  L190:
222          PUSH    SS              ; ESTABLISH ADDRESSING TO STACK
223          POP     DS              ; FOR THE STRING COMPARE
224          MOV     DX,128          ; NUMBER TO TEST AGAINST
225  L200:
226          PUSH    SI              ; SAVE SAVE AREA POINTER
227          PUSH    DI              ; SAVE CODE POINTER
228          MOV     CX,8            ; NUMBER OF BYTES TO MATCH
229          REPE    CMPSB           ; COMPARE THE 8 BYTES
230          POP     DI              ; RECOVER THE POINTERS
231          POP     SI
232          JZ      FOUND           ; IF ZERO FLAG SET, THEN MATCH OCCURRED
233          INC     AL              ; NO MATCH, MOVE ON TO NEXT
234          ADD     DI,8            ; NEXT CODE POINT
235          DEC     DX              ; LOOP CONTROL
236          JNZ     L200            ; DO ALL OF THEM
237
238  ;------ CHAR NOT MATCHED, MIGHT BE IN USER SUPPLIED SECOND HALF
239
240          CMP     AL,0            ; AL<> 0 IF ONLY 1ST HALF SCANNED
241          JE      FOUND           ; IF = 0, THEN ALL HAS BEEN SCANNED
242          SUB     AX,AX
243          MOV     DS,AX           ; ESTABLISH ADDRESSING TO VECTOR
244          ASSUME  DS:DUMMY
245          LES     DI,EXT_PTR      ; GET POINTER
246          MOV     AX,ES           ; SEE IF THE POINTER REALLY EXISTS
247          OR      AX,DI           ; IF ALL 0, THEN DOESN'T EXIST
248          JZ      FOUND           ; NO SENSE LOOKING
249          MOV     AL,128          ; ORIGIN FOR SECOND HALF
250          JMP     L190            ; GO BACK AND TRY FOR IT
251          ASSUME  DS:DATA
252
253  ;------ CHARACTER IS FOUND ( AL=0 IF NOT FOUND )
254  FOUND:
255          ADD     SP,8            ; READJUST THE STACK, THROW AWAY SAVE
256          JMP     VIDEO_RETURN    ; ALL DONE
257  GRAPHICS_READ   ENDP
258
```

TABLE 12: MED READ BYTE

```
314
315  ;--------------------------------------------
316  ; MED_READ_BYTE
317  ; THIS ROUTINE WILL TAKE 2 BYTES FROM THE REGEN BUFFER,
318  ;  COMPARE AGAINST THE CURRENT FOREGROUND COLOR, AND PLACE
319  ;  THE CORRESPONDING ON/OFF BIT PATTERN INTO THE CURRENT
```

```
320     ;  POSITION IN THE SAVE AREA
321     ; ENTRY --
322     ;  SI,DS = POINTER TO REGEN AREA OF INTEREST
323     ;  BX = EXPANDED FOREGROUND COLOR
324     ;  BP = POINTER TO SAVE AREA
325     ; EXIT --
326     ;  BP IS INCREMENT AFTER SAVE
327     ;-----------------------------------------------
328
329     MED_READ_BYTE   PROC    NEAR
330             MOV     AH,[SI]         ; GET FIRST BYTE
331             MOV     AL,[SI+1]       ; GET SECOND BYTE
332             MOV     CX,0C000H       ; 2 BIT MASK TO TEST THE ENTRIES
333             MOV     DL,0            ; RESULT REGISTER
334     L300:
335             TEST    AX,CX           ; IS THIS SECTION BACKGROUND?
336             CLC                     ; CLEAR CARRY IN HOPES THAT IT IS
337             JZ      L310            ; IF ZERO, IT IS BACKGROUND
338             STC                     ; WASN'T, SO SET CARRY
339     L310:
340             RCL     DL,1            ; MOVE THAT BIT INTO THE RESULT
341             SHR     CX,1
342             SHR     CX,1            ; MOVE THE MASK TO THE RIGHT BY 2 BITS
343             JNC     L300            ; DO IT AGAIN IF MASK DIDN'T FALL OUT
344             MOV     [BP],DL         ; STORE RESULT IN SAVE AREA
345             INC     BP              ; ADJUST POINTER
346             RET                     ; ALL DONE
347     MED_READ_BYTE   ENDP
348
```

TABLE 13: VIDEO3 GRAPHICS

```
LINE    SOURCE
  1     $TITLE('VIDEO3 GRAPHICS R/W DOT -- SCROLL UP/DOWN')
  2     $PAGELENGTH(43)
  3     ;-----------------------------------------
  4     ; THIS MODULE CONTAINS THE ROUTINES USED DURING GRAPHICS OPERATIONS
  5     ; THE ROUTINES INCLUDE:
  6     ;  READ/WRITE DOT
  7     ;  SCROLL UP/DOWN
  8     ;-----------------------------------------
  9
 10     DATA    SEGMENT BYTE PUBLIC
 11             EXTRN   CRT_MODE:BYTE,CRT_COLS:BYTE
 12     DATA    ENDS
 13
 14     CODE    SEGMENT BYTE PUBLIC
 15             ASSUME  CS:CODE,DS:DATA,ES:DATA
 16             EXTRN   VIDEO_RETURN:NEAR
 17     ODD_FLD EQU     2000H           ; OFFSET TO ODD FIELD OF GRAPHICS
 18
```

TABLE 14: SCROLL UP - PART 1

```
142     ;-----------------------------------------------
143     ; SCROLL UP
144     ;  THIS ROUTINE SCROLLS UP THE INFORMATION ON THE CRT
145     ; ENTRY --
```

```
146     ;  CH,CL = UPPER LEFT CORNER OF REGION TO SCROLL
147     ;  DH,DL = LOWER RIGHT CORNER OF REGION TO SCROLL
148     ;   BOTH OF THE ABOVE ARE IN CHARACTER POSITIONS
149     ;  BH = FILL VALUE FOR BLANKED LINES
150     ;  AL = # LINES TO SCROLL (AL=0 MEANS BLANK THE ENTIRE FIELD)
151     ;  DS = DATA SEGMENT
152     ;  ES = REGEN SEGMENT
153     ; EXIT --
154     ;  NOTHING, THE SCREEN IS SCROLLED
155     ;--------------------------------------------------------
156             PUBLIC  GRAPHICS_UP,GRAPHICS_DOWN
157             EXTRN   GRAPH_POSN:NEAR
158
159     GRAPHICS_UP     PROC    NEAR
160             MOV     BL,AL   ; SAVE LINE COUNT IN BL
161             MOV     AX,CX   ; GET UPPER LEFT POSITION INTO AX REG
162
163     ;------ USE CHARACTER SUBROUTINE FOR POSITIONING
164     ;------ ADDRESS RETURNED IS MULTIPLIED BY 2 FROM CORRECT VALUE
165
166             CALL    GRAPH_POSN
167             MOV     DI,AX           ; SAVE RESULT AS DESTINATION ADDRESS
168
169     ;------ DETERMINE SIZE OF WINDOW
170
171             SUB     DX,CX
172             ADD     DX,101H         ; ADJUST VALUES
173             SAL     DH,1            ; MULTIPLY # ROWS BY 4 SINCE 8 VERT DOTS/CHAR
174             SAL     DH,1            ;  AND EVEN/ODD ROWS
175
176     ;------ DETERMINE CRT MODE
177
178             CMP     CRT_MODE,6      ; TEST FOR MEDIUM RES
179             JNC     FIND_SOURCE
180
181     MED_RES_UP:
182             SAL     DL,1            ; # COLUMNS * 2, SINCE 2 BYTES/CHAR
183             SAL     DI,1            ; OFFSET *2 SINCE 2 BYTES/CHAR
184
```

TABLE 15: SCROLL UP - PART 2

```
185     ;------ DETERMINE THE SOURCE ADDRESS IN THE BUFFER
186     FIND_SOURCE:
187             PUSH    ES              ; GET SEGMENTS BOTH POINTING TO REGEN
188             POP     DS
189             SUB     CH,CH           ; ZERO TO HIGH OF COUNT REG
190             SAL     BL,1            ; MULTIPLY NUMBER OF LINES BY 4
191             SAL     BL,1
192             JZ      BLANK_FIELD     ; IF ZERO, THEN BLANK ENTIRE FIELD
193             MOV     AL,BL           ; GET NUMBER OF LINES IN AL
194             MOV     AH,80           ; 80 BYTES/ROW
195             MUL     AH              ; DETERMINE OFFSET TO SOURCE
196             MOV     SI,DI           ; SET UP SOURCE
197             ADD     SI,AX           ;  ADD IN OFFSET TO IT
198             MOV     AH,DH           ; NUMBER OF ROWS IN FIELD
199             SUB     AH,BL           ; DETERMINE NUMBER TO MOVE
200
201     ;------ LOOP THROUGH, MOVING ONE ROW AT A TIME, BOTH EVEN AND ODD FIELDS
```

```
202     ROW_LOOP:
203             CALL    ROW_MOVE                ; MOVE ONE ROW
204             SUB     SI,ODD_FLD-80   ; MOVE TO NEXT ROW
205             SUB     DI,ODD_FLD-80
206             DEC     AH              ; NUMBER OF ROWS TO MOVE
207             JNZ     ROW_LOOP        ; CONTINUE TILL ALL MOVED
208
209     ;------ FILL IN THE VACATED LINE(S)
210     CLEAR_ENTRY:
211             MOV     AL,BH           ; ATTRIBUTE TO FILL WITH
212     CLEAR_LOOP:
213             CALL    ROW_CLEAR       ; CLEAR THAT ROW
214             SUB     DI,ODD_FLD-80   ; POINT TO NEXT LINE
215             DEC     BL              ; NUMBER OF LINES TO FILL
216             JNZ     CLEAR_LOOP
217             JMP     VIDEO_RETURN    ; EVERYTHING DONE
218
219     BLANK_FIELD:
220             MOV     BL,DH           ; SET BLANK COUNT TO EVERYTHING IN FIELD
221             JMP     CLEAR_ENTRY     ; CLEAR THE FIELD
222     GRAPHICS_UP     ENDP
223 +1  $EJECT
```

TABLE 16: SCROLL DOWN - PART 1

```
LINE    SOURCE

224     ;--------------------------------------------------
225     ; SCROLL DOWN
226     ;  THIS ROUTINE SCROLLS DOWN THE INFORMATION ON THE CRT
227     ; ENTRY --
228     ;  CH,CL = UPPER LEFT CORNER OF REGION TO SCROLL
229     ;  DH,DL = LOWER RIGHT CORNER OF REGION TO SCROLL
230     ;    BOTH OF THE ABOVE ARE IN CHARACTER POSITIONS
231     ;  BH = FILL VALUE FOR BLANKED LINES
232     ;  AL = # LINES TO SCROLL (AL=0 MEANS BLANK THE ENTIRE FIELD)
233     ;  DS = DATA SEGMENT
234     ;  ES = REGEN SEGMENT
235     ; EXIT --
236     ;  NOTHING, THE SCREEN IS SCROLLED
237     ;--------------------------------------------------
238
239     GRAPHICS_DOWN   PROC    NEAR
240             STD             ; SET DIRECTION
241             MOV     BL,AL   ; SAVE LINE COUNT IN BL
242             MOV     AX,DX   ; GET LOWER RIGHT POSITION INTO AX REG
243
244     ;------ USE CHARACTER SUBROUTINE FOR POSITIONING
245     ;------- ADDRESS RETURNED IS MULTIPLIED BY 2 FROM CORRECT VALUE
246
247             CALL    GRAPH_POSN
248             MOV     DI,AX           ; SAVE RESULT AS DESTINATION ADDRESS
249
250     ;------- DETERMINE SIZE OF WINDOW
251
252             SUB     DX,CX
```

```
253             ADD     DX,101H         ; ADJUST VALUES
254             SAL     DH,1            ; MULTIPLY # ROWS BY 4 SINCE 3 VERT DOTS/CHAR
255             SAL     DH,1            ;  AND EVEN/ODD ROWS
256
257     ;------ DETERMINE CRT MODE
258
259             CMP     CRT_MODE,6      ; TEST FOR MEDIUM RES
260             JNC     FIND_SOURCE_DOWN
261
262     MED_RES_DOWN:
263             SAL     DL,1            ; # COLUMNS * 2, SINCE 2 BYTES/CHAR (OFFSET OK)
264             SAL     DI,1            ; OFFSET *2 SINCE 2 BYTES/CHAR
265             INC     DI              ; POINT TO LAST BYTE
266
```

TABLE 17: SCROLL DOWN - PART 2

```
267     ;------ DETERMINE THE SOURCE ADDRESS IN THE BUFFER
268     FIND_SOURCE_DOWN:
269             PUSH    ES              ; BOTH SEGMENTS TO REGEN
270             POP     DS
271             SUB     CH,CH           ; ZERO TO HIGH OF COUNT REG
272             ADD     DI,240          ; POINT TO LAST ROW OF PIXELS
273             SAL     BL,1            ; MULTIPLY NUMBER OF LINES BY 4
274             SAL     BL,1
275             JZ      BLANK_FIELD_DOWN        ; IF ZERO, THEN BLANK ENTIRE FIELD
276             MOV     AL,BL           ; GET NUMBER OF LINES IN AL
277             MOV     AH,80           ; 80 BYTES/ROW
278             MUL     AH              ; DETERMINE OFFSET TO SOURCE
279             MOV     SI,DI           ; SET UP SOURCE
280             SUB     SI,AX           ;  SUBTRACT THE OFFSET
281             MOV     AH,DH           ; NUMBER OF ROWS IN FIELD
282             SUB     AH,BL           ; DETERMINE NUMBER TO MOVE
283
284     ;------ LOOP THROUGH, MOVING ONE ROW AT A TIME, BOTH EVEN AND ODD FIELDS
285     ROW_LOOP_DOWN:
286             CALL    ROW_MOVE        ; MOVE ONE ROW
287             SUB     SI,ODD_FLD+80   ; MOVE TO NEXT ROW
288             SUB     DI,ODD_FLD+80
289             DEC     AH              ; NUMBER OF ROWS TO MOVE
290             JNZ     ROW_LOOP_DOWN   ; CONTINUE TILL ALL MOVED
291
292     ;------ FILL IN THE VACATED LINE(S)
293     CLEAR_ENTRY_DOWN:
294             MOV     AL,BH           ; ATTRIBUTE TO FILL WITH
295     CLEAR_LOOP_DOWN:
296             CALL    ROW_CLEAR       ; CLEAR A ROW
297             SUB     DI,ODD_FLD+80   ; POINT TO NEXT LINE
298             DEC     BL              ; NUMBER OF LINES TO FILL
299             JNZ     CLEAR_LOOP_DOWN
300             CLD                     ; RESET THE DIRECTION FLAG
301             JMP     VIDEO_RETURN    ; EVERYTHING DONE
302
303     BLANK_FIELD_DOWN:
```

```
304             MOV     BL,DH           ; SET BLANK COUNT TO EVERYTHING IN FIELD
305             JMP     CLEAR_ENTRY_DOWN        ; CLEAR THE FIELD
306     GRAPHICS_DOWN   ENDP
307
```

TABLE 18: ROW MOVE

```
308     ;------ ROUTINE TO MOVE ONE ROW OF INFORMATION
309
310     ROW_MOVE        PROC    NEAR
311             MOV     CL,DL           ; NUMBER OF BYTES IN THE ROW
312             PUSH    SI
313             PUSH    DI              ; SAVE POINTERS
314             REP     MOVSB           ; MOVE THE EVEN FIELD
315             POP     DI
316             POP     SI
317             ADD     SI,ODD_FLD
318             ADD     DI,ODD_FLD              ; POINT TO THE ODD FIELD
319             PUSH    SI
320             PUSH    DI              ; SAVE THE POINTERS
321             MOV     CL,DL           ; COUNT BACK
322             REP     MOVSB           ; MOVE THE ODD FIELD
323             POP     DI
324             POP     SI              ; POINTERS BACK
325             RET                     ; RETURN TO CALLER
326     ROW_MOVE        ENDP
```

TABLE 19: ROW CLEAR

```
327
328     ;------ CLEAR A SINGLE ROW
329
330     ROW_CLEAR       PROC    NEAR
331             MOV     CL,DL           ; NUMBER OF BYTES IN FIELD
332             PUSH    DI              ; SAVE POINTER
333             REP     STOSB           ; STORE THE NEW VALUE
334             POP     DI              ; POINTER BACK
335             ADD     DI,ODD_FLD              ; POINT TO ODD FIELD
336             PUSH    DI
337             MOV     CL,DL
338             REP     STOSB           ; FILL THE ODD FILELD
339             POP     DI
340             RET                     ; RETURN TO CALLER
341     ROW_CLEAR       ENDP
342     CODE    ENDS
343             END
```

65

While the invention has been described with respect to preferred embodiments thereof, it is to be understood that the foregoing and other modifications and variations may be made without departing from the scope and spirit thereof.

I claim:

[1. A raster scan video display control apparatus of the type including a graphic video display refresh buffer operable in an all points addressable mode for refreshing said display with graphics data, a processor for writing graphic data into said display refresh buffer, and a character storage for storing the character dot patterns of a display character font, characterized by:

means for selecting a character to be displayed; and

programmable control means referenced by said processor for

(1) loading from said storage into said graphic video display refresh buffer a character dot pattern corresponding to the character to be displayed;

(2) expanding the selected character dot pattern into a predetermined pixel format and then color encoding the expanded dot pattern to establish a resultant expanded/encoded dot pattern; and

(3) loading said expanded/encoded dot pattern into said graphic video display refresh buffer.]

[2. A raster scan video display control apparatus of the type including a graphic video display refresh buffer operable in an all points addressable mode for refreshing said display with graphics data, a processor for writing graphic data into said display refresh buffer, and a character storage for storing the character dot patterns of a display character font, characterized by:

means for selecting a character to be displayed; and

programmable control means referenced by said processor selectively for loading from said storage into said graphic video display refresh buffer a character dot pattern corresponding to the character to be displayed and for reading a previously displayed character by comparing a character dot pattern previously loaded into said graphic video display buffer with successive character dot patterns selected from said character storage.]

3. A method for writing a text character on a raster scan all points addressable video display, comprising the steps of:

retrieving from storage the graphic dot image of the character to be written;

expanding said graphic image to a selected pixel and color format; and

storing the expanded dot image in a display refresh buffer.

4. A method for reading a selected text character previously written as an expanded dot image into a display refresh buffer from a graphic dot image stored in a storage associated with an all points addressable video display, comprising the steps of:

retrieving from said display refresh buffer the expanded dot image of the selected character to be read;

converting the expanded dot image to be read to a converted dot image corresponding to the format of graphic dot image in the storage;

obtaining from storage the graphic dot image of a comparison character;

comparing the dot image of the comparison character with said converted dot image; and

repeating the obtaining and comparing steps until the dot image of the comparison character matches said converted dot image.

5. A method for operating a computing apparatus that controls a graphics display to write a text character onto a display screen, the computing appartus including a processor referencing a store, and a display refresh buffer, characterized in that the method comprises the steps of:

establishing addressability to the location in said display refresh buffer to receive a selected display text character;

establishing addressability to the location in said store containing a dot image of said selected display text character;

fetching one portion of said dot image from said store;

expanding said portion of said dot image according to a selected pixel format to provide an expanded dot image portion;

modifying said expanded dot image portion to encode a desired color; and

storing the expanded dot image portion as modified in said display refresh buffer; and

repeating said fetching, expanding, modifying and storing steps for each portion of said dot image to load into said display refresh buffer the selected display text character.

6. The method of claim [7,] *5*, characterized by the steps of:

refreshing a raster scan display with alternate raster scan lines refreshed from offset locations of said display refresh buffer; and

storing alternating dot image portions in offset locations of said display refresh buffer as part of said storing step.

7. The method of claim [7,] *5*, characterized in that said storing step is performed by exclusive 'ORing each dot image portion with a corresponding portion of said modified expanded dot image previously stored in said display refresh buffer.

8. The method of claim 5, characterized in that said expanding step and said modifying step are for the purpose of writing a text character in color and said expanding step and modifying step are eliminated when writing the text character in black and white.

9. A method for operating a computing apparatus that controls a graphics display to read a text character previously written onto said graphics display, the computing apparatus including a processor referencing a store, and a display refresh buffer, comprising the steps of:

retrieving from said display refresh buffer a dot image of the character to be read;

storing the dot image of the character to be read in a save area in said store;

sequentially retrieving from said store respective dot images of possible display text characters and comparing each respective dot image with the dot image in the save area; and

repeating the retrieving and comparing steps until a respective dot image matches the dot image in said save area, thereby concluding reading of the text characters.

10. A raster scan video display control apparatus of the type including a graphic video display refresh buffer operable in an all points addressable mode for refreshing said display with graphics data, a processor for writing graphics data into said display refresh buffer, and a character storage for storing the character dot patterns of a display character font, comprising means for selecting a character to be displayed, and means for loading from said storage into said graphic video display refresh buffer a character dot pattern corresponding to the character to be displayed and for reading a previously displayed character by comparing

a character dot pattern previously loaded into said graphic video display buffer with successive character dot patterns selected from said character storage.

11. A raster scan video display control apparatus of the type including a graphic video display refresh buffer for refreshing said display with graphics data, a processor for writing graphics data into said display refresh buffer, and a character storage for storing the character dot patterns of a display character font, comprising means for selecting a character to be displayed, means for reading out said character from said character storage in a first format, means for expanding the selected character dot pattern into a predetermined pixel format and then color encoding the expanded dot pattern to establish a resultant expanded/encoded dot pattern, and loading said expanded/encoded dot pattern into said graphic video display refresh buffer.

12. In a display apparatus for writing a text character onto a video display and including a means for retrieving the graphic dot image of the character to be written from a character storage, the improvement comprising means for expanding a retrieved graphic dot image into a selected pixel and color format, and means for storing the expanded dot image in a display refresh buffer.

13. Video display control apparatus of the type including a video display buffer for holding information patterns directly specifying the tracing of patterns on a display screen, a processor for writing information patterns into said buffer, and font storage means for storing a font of displayable information patterns, characterized by:

means for selecting code representations of patterns to be displayed;

means responsive to said selected representations for extracting first information patterns corresponding to said patterns extracted from said font storage means;

means for converting said extracted first patterns into corresponding second information patterns for producing the same display patterns as said first patterns but with a different image characteristic; and

means for entering said second information patterns into said display buffer.

14. Video display control apparatus of the type including a video display buffer for holding information patterns directly specifying the tracing of image patterns on a display screen, a processor for writing information patterns, into said buffer, and font storage means for storing a font of displayable information patterns, characterized by:

means for selecting code representations of image patterns to be displayed;

means responsive to said selected representations for extracting corresponding information patterns from said font storing means;

means responsive to said extracting means for storing information patterns corresponding to said extracted patterns in said display buffer;

means for reading information pattern patterns from said display buffer; and

means coupled to said reading means and said font storage means for converting information patterns read from said buffer into corresponding code representations.

15. Video display control apparatus in accordance with claim 14 wherein said converting means comprises:

means for comparing each information pattern read from said display buffer with patterns stored in said font storage means; and

means responsive to a match between patterns compared by said comparing means for developing a code representation corresponding to the matched pattern.

16. Video display control apparatus in accordance with claim 14 wherein said means for storing corresponding patterns in said display buffer comprises:

means for converting each pattern extracted from said font storage into a corresponding pattern having a different display image characteristic than the extracted pattern; and

means for writing such corresponding patterns into said display buffer.

17. A method for creating image displays of information patterns comprising:

forming code representations of information patterns to be displayed;

converting said code representations into corresponding first information patterns corresponding to images to be displayed;

converting said first information patterns into second information patterns for directly controlling the tracing of associated image patterns on an image display; said second information patterns having associated image characteristics different from those of the respective first information patterns; and

storing said second information patterns in a display buffer capable of directly controlling the formation of images on an image display.

18. A method for creating image displays of information patterns comprising:

forming code representations of information patterns to be displayed;

converting said code representations into corresponding information patterns to be displayed;

storing said information patterns in a display buffer capable of directly controlling the formation of images on an image display;

reading information patterns from said display buffer; and

converting said information patterns read from said display buffer into corresponding code representations.

19. The display formation method of claim 18 wherein:

said step of converting said code representations into corresponding information patterns comprises:

converting each code representation into a first associated information pattern having a first associated image formation characteristic; and

converting each first associated information pattern into a different second information pattern having an associated second image formation characteristic different from the respective first characteristic.

20. The display formation method of claim 19 wherein said step of converting said information patterns into code representations comprises:

converting each information pattern into a corresponding standardized information pattern having a different image formation characteristic; and

converting each said corresponding pattern into a corresponding standardized code representation.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : Re 32,201

DATED : July 8, 1986

INVENTOR(S) : David J. Bradley

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 34, line 32, in claim 7, line 3, change "said" to --a--;

Column 35, line 56, in claim 14, line 15, delete "pattern".

Signed and Sealed this

Twelfth Day of February, 1991

Attest:

Attesting Officer

HARRY F. MANBECK, JR.

Commissioner of Patents and Trademarks

REEXAMINATION CERTIFICATE (1108th)

United States Patent [19]

Bradley

[11] **B1 Re. 32,201**

[45] Certificate Issued **Aug. 1, 1989**

[54] **APPARATUS AND METHOD FOR READING AND WRITING TEXT CHARACTERS IN A GRAPHICS DISPLAY**

[75] Inventor: **David J. Bradley**, Boca Raton, Fla.

[73] Assignee: **International Business Machines Corp.**, Armonk, N.Y.

Reexamination Request:
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[56] **References Cited**

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[57] **ABSTRACT**

Apparatus and method for writing text characters to a raster scan video display operted in an all-points-addressable, or graphics, mode, and for reading characters thus written. A graphic video display buffer directly refreshes the display with graphics data received from a microprogrammed processor. The processor writes a character to the display by selecting and loading into the graphics video display buffer a text character dot pattern retrieved from main storage, and reads a character previously written by comparing a dot pattern retrieved from the display buffer with dot patterns retrieved from main storage. To write a character to the display in color, the graphic dot image of a selected character retrieved from main storage is expanded to a selected pixel and color format, and stored in the graphics video display buffer. Text characters thus written in color are read by retrieving from the display buffer the expanded dot image, restoring the expanded dot image to its original form, and comparing the restored dot image with graphic dot images retrieved from storage.

REEXAMINATION CERTIFICATE ISSUED UNDER 35 U.S.C. 307

THE PATENT IS HEREBY AMENDED AS INDICATED BELOW.

Matter enclosed in heavy brackets [ ] appeared in the patent, but has been deleted and is no longer a part of the patent; matter printed in italics indicates additions made to the patent.

AS A RESULT OF REEXAMINATION, IT HAS BEEN DETERMINED THAT:

The patentability of claims **4, 9, 10, 14–16** and **18–20** is confirmed.

Claims **1** and **2** were previously cancelled.

Claims **3, 5, 11–13** and **17** are determined to be patentable as amended.

Claims **6–8**, dependent on an amended claim are determined to be patentable.

3. A method for writing a text character on a raster scan all points addressable video display, comprising the steps of:

retrieving from storage the graphic dot image of the *text* character to be written, *each dot being represented by a single bit;*

expanding said graphic *dot* image to a selected pixel and color format *by duplicating each bit and logically combining the bits representing each dot with encoded color information*; and

storing the expanded dot image *by placing the bits representing each dot* in *contiguous address memory locations in* a display refresh buffer.

5. A method for operating a computing apparatus that controls a graphics display to write a text character onto a display screen, the computing apparatus including a processor referencing a store, and a display refresh buffer *comprising a plurality of memory locations*, characterized in that the method comprises the steps of:

establishing addressability to the location in said display refresh buffer to receive a selected display text character;

establishing addressability to the location in said store containing a dot image of said selected display text character;

fetching one portion of said dot image from said store, *each dot being represented by a single bit;*

expanding said portion of said dot image according to a selected pixel format *by duplicating each bit* to provide an expanded dot image portion;

modifying said expanded dot image portion *by logically combining the bits representing each dot with encoded color information to provide an encoded color dot image portion* [to encode a desired color]; and

storing the [expanded] *bits representing each dot in the encoded color* dot image portion [as modified] in *contiguous address memory locations in* said display refresh buffer; and

repeating said fetching, expanding, modifying and storing steps for each portion of said dot image to load into said display refresh buffer the selected display text character.

11. A raster scan video display control apparatus of the type including a graphic video display refresh buffer *comprising a plurality of memory locations* for refreshing said display with graphics data, a processor for writing graphics data into said display refresh buffer, and a character storage for storing the character dot patterns of a display character font, comprising means for selecting a character to be displayed, means for reading out said character from said character storage in a first *dot* format *comprising one bit per dot*, means for expanding *by duplicating* the selected character dot pattern into a predetermined pixel format *comprising two identical bits per pixel* and then color encoding the expanded dot pattern *by logically combining encoded color information with said expanded dot pattern* to establish a resultant expanded/encoded dot pattern, and loading *the bits representing each dot of* said expanded/encoded dot pattern into *contiguous address memory locations in* said graphic video display refresh buffer.

12. In a display apparatus for writing a text character onto a video display and including a means for retrieving the graphic dot image of the character to be written from a character storage, *each dot in said image being represented by a single bit*, the improvement comprising means forexpanding a retrieved graphic dot image into a selected pixel and color format *by duplicating each bit n times and logically combining the n bits representing each dot with n bits of encoded color infomation, where n is an integer*, and

means for storing the expanded dot image in a display refresh buffer *by entering the n bits representing each dot of said expanded dot image into n contiguous address memory locations.*

13. Video display control apparatus of the type including a video display buffer *having a plurality of memory locations* for holding information patterns directly specifying the tracing of *multi-element* patterns on a display screen, a processor for writing information patterns into said buffer, and font storage means for storing a font of displayable information patterns, characterized by:

means for selecting code representations of patterns to be displayed;

means responsive to said selected representations for extracting first *multi-element* information patterns corresponding to said *multi-element* patterns extracted from said font storage means, *each element of said first patterns being represented by a first number of bits n, where n is an integer;*

means for converting said extracted first patterns into corresponding second *multi-element* information patterns, *each element of said second patterns being represented by a second number of bits 2n*, for producing the same display patterns as said first patterns but with a different image characteristic; and

means for entering said second *multi-element* information patterns into said display buffer *by storing the 2n bits representing each element of said second patterns in 2n contiguous address memory locations.*

17. A method for creating image displays of *multi-element* information patterns comprising:

forming code representations of *said multi-element* information patterns to be displayed, *each element being represented by a first number of bits;*

converting said code representations into corresponding first *multi element* information patterns

corresponding to images to be displayed, *each element being represented by a second number of bits greater than said first number of bits;*

converting said first *multi-element* information patterns into second *multi-element* information patterns for directly controlling the tracing of associated image patterns on an image display *by logically combining attribute information encoded in a second number of bits with the bit representation for each element of said second multi-element information*

patterns; said second information patterns having associated image characteristics different from those of the respective first information patterns; and

storing said second information patterns in *contiguous address memory locations of* a display buffer capable of directly controlling the information of images on an image display.

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