# United States Patent [19]

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[54] **APPARATUS FOR VISUAL DISPLAY OF ALPHA-NUMERIC DATA IN COLOURS**


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[73] Assignee: **Redifon Limited,** London, England



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[30] **Foreign Application Priority Data**

Sept. 16, 1971 Great Britain .................... 38357/71

[52] **U.S. Cl.** ........................ **340/172.5,** 340/324 AD

[51] **Int. Cl.** ........................ **G06f 3/14,** G06k 15/18

[58] **Field of Search** .......... 340/172.5, 225, 324 AD; 178/7.85



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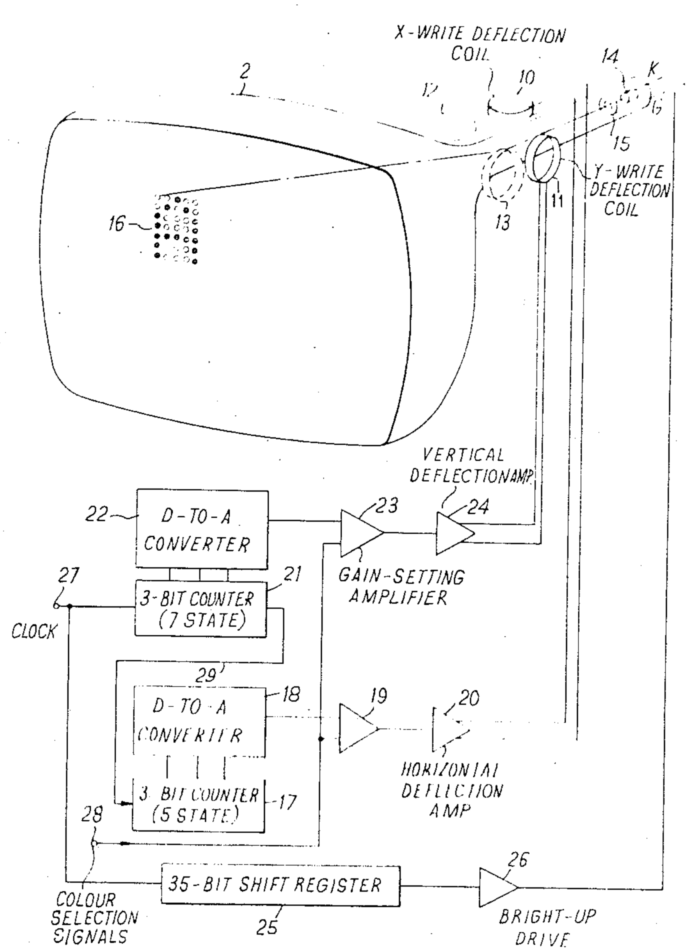
*Assistant Examiner*—Melvin B. Chapnick
*Attorney, Agent, or Firm*—Larson, Taylor & Hinds



[57] **ABSTRACT**

Apparatus for the visual display of alpha-numerical data in a plurality of colours using a multiple-colour cathode ray tube of the beam-penetration type. The apparatus is used particularly for the real-time display of up-dated data during a ground-based flight simulator exercise. Data from the associated flight simulator digital-computer is selected by an address generator and stored in an auxiliary buffer memory store. Data comprises character data and control data. Character data defines specific characters by selective dot bright-up during dot-matrix scan. Control data determines position, line and colour of the associated character. Data selection may be automatic or manual. Data colour display reserves Red for abnormal data.


**4 Claims, 7 Drawing Figures**



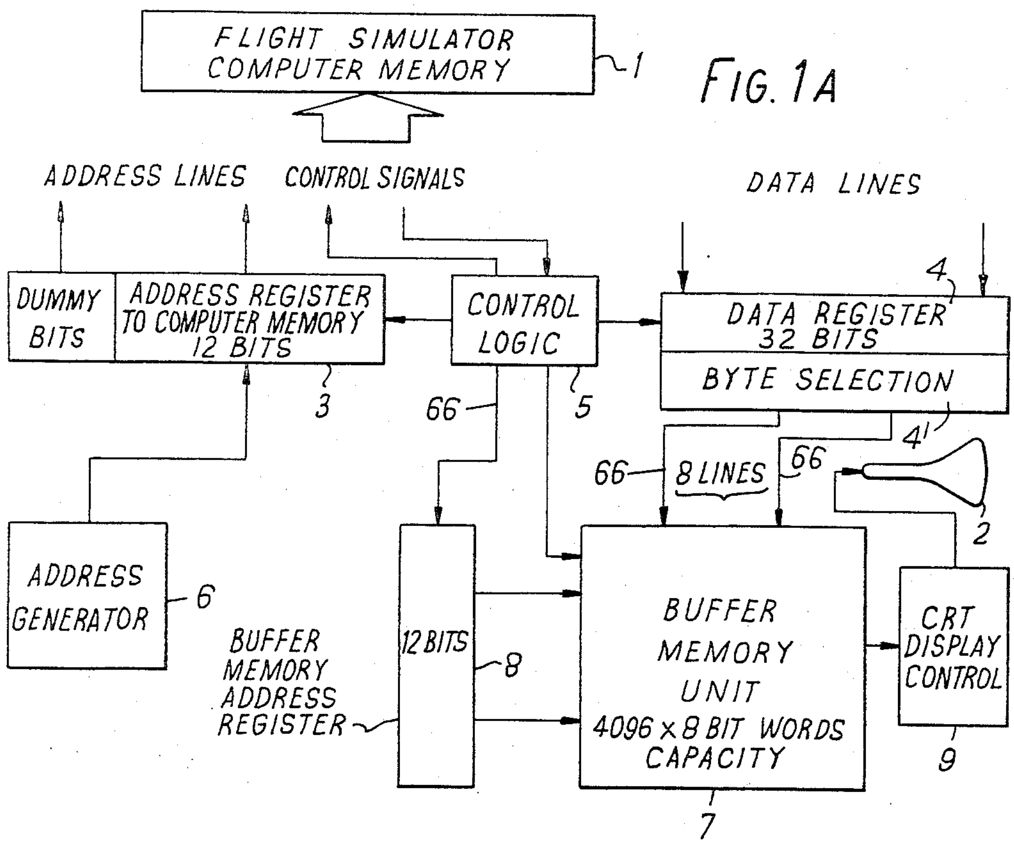

FLIGHT SIMULATOR COMPUTER MEMORY
1
ADDRESS LINES
CONTROL SIGNALS
DATA LINES
DUMMY BITS
ADDRESS REGISTER TO COMPUTER MEMORY 12 BITS
3
CONTROL LOGIC
5
66
DATA REGISTER 32 BITS
BYTE SELECTION
4
4'
8 LINES
66
2
ADDRESS GENERATOR
6
BUFFER MEMORY ADDRESS REGISTER
12 BITS
8
BUFFER MEMORY UNIT 4096 x 8 BIT WORDS CAPACITY
7
CRT DISPLAY CONTROL
9

FIG. 1A

FIG. 1B

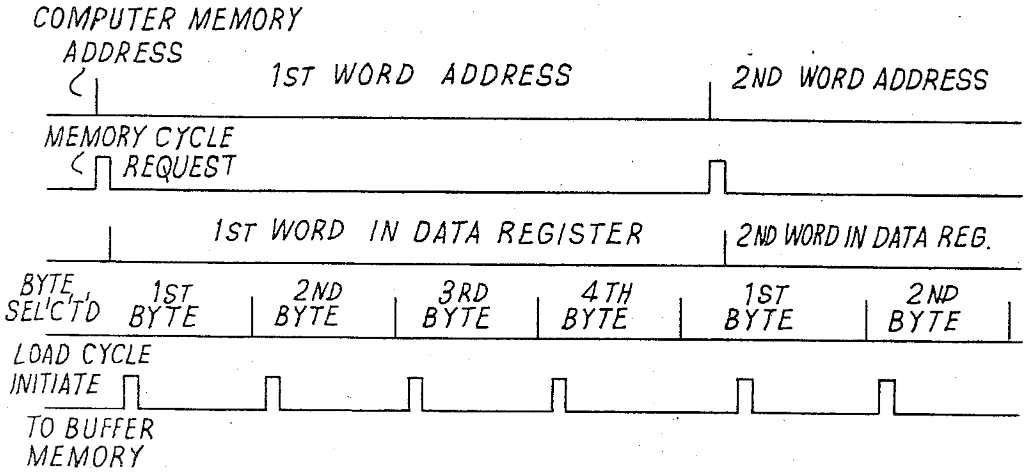

COMPUTER MEMORY ADDRESS
1ST WORD ADDRESS
2ND WORD ADDRESS
MEMORY CYCLE REQUEST
1ST WORD IN DATA REGISTER
2ND WORD IN DATA REG.
BYTE SEL'CT'D
1ST BYTE
2ND BYTE
3RD BYTE
4TH BYTE
1ST BYTE
2ND BYTE
LOAD CYCLE INITIATE TO BUFFER MEMORY

FIG. 2

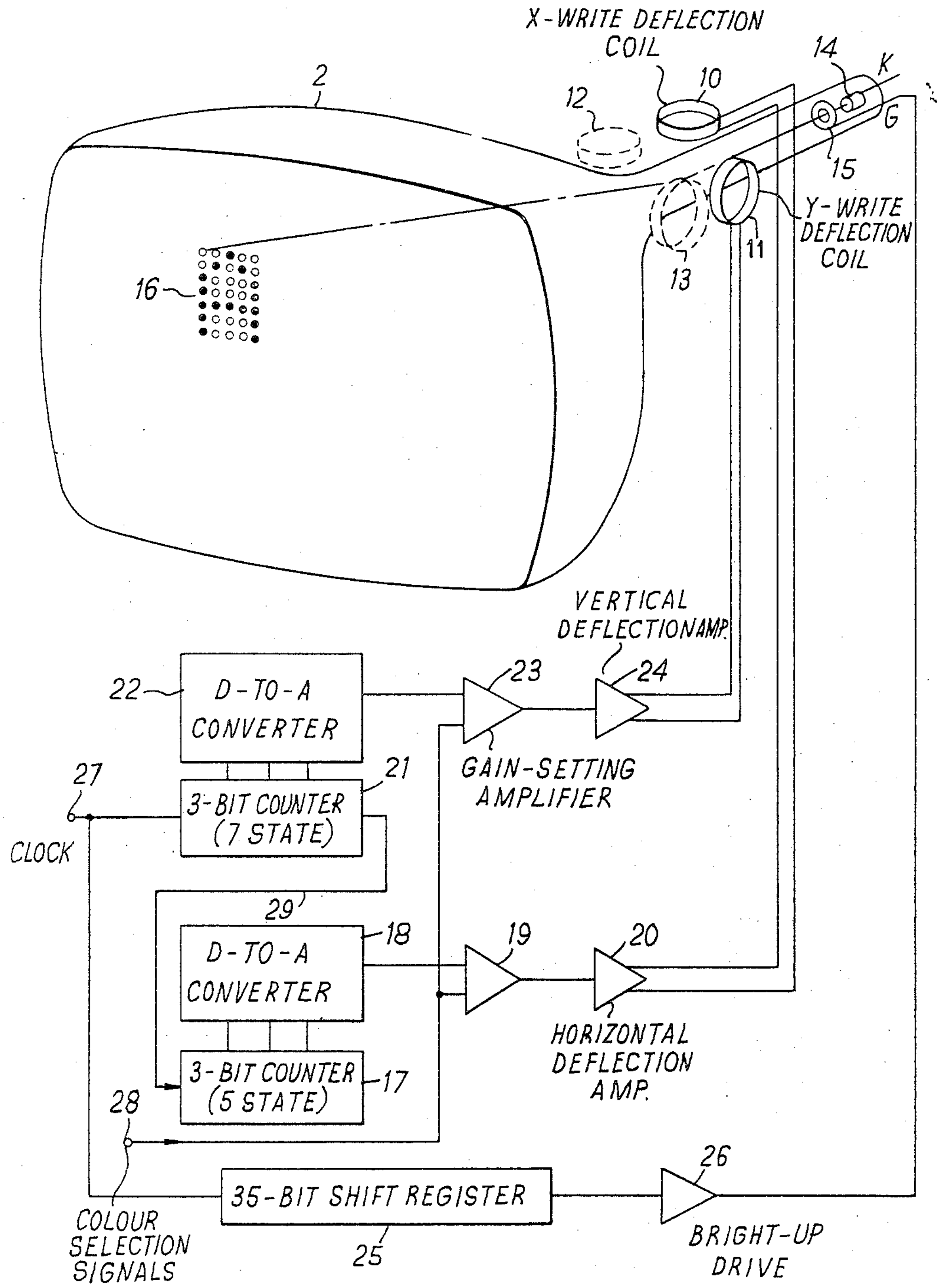

X-WRITE DEFLECTION COIL
2
10
12
14
K
G
15
Y-WRITE DEFLECTION COIL
11
13
16
VERTICAL DEFLECTION AMP.
22
D-TO-A CONVERTER
23
24
GAIN-SETTING AMPLIFIER
27
21
3-BIT COUNTER (7 STATE)
CLOCK
29
18
D-TO-A CONVERTER
19
20
HORIZONTAL DEFLECTION AMP.
3-BIT COUNTER (5 STATE)
17
28
26
35-BIT SHIFT REGISTER
COLOUR SELECTION SIGNALS
25
BRIGHT-UP DRIVE

FIG. 3

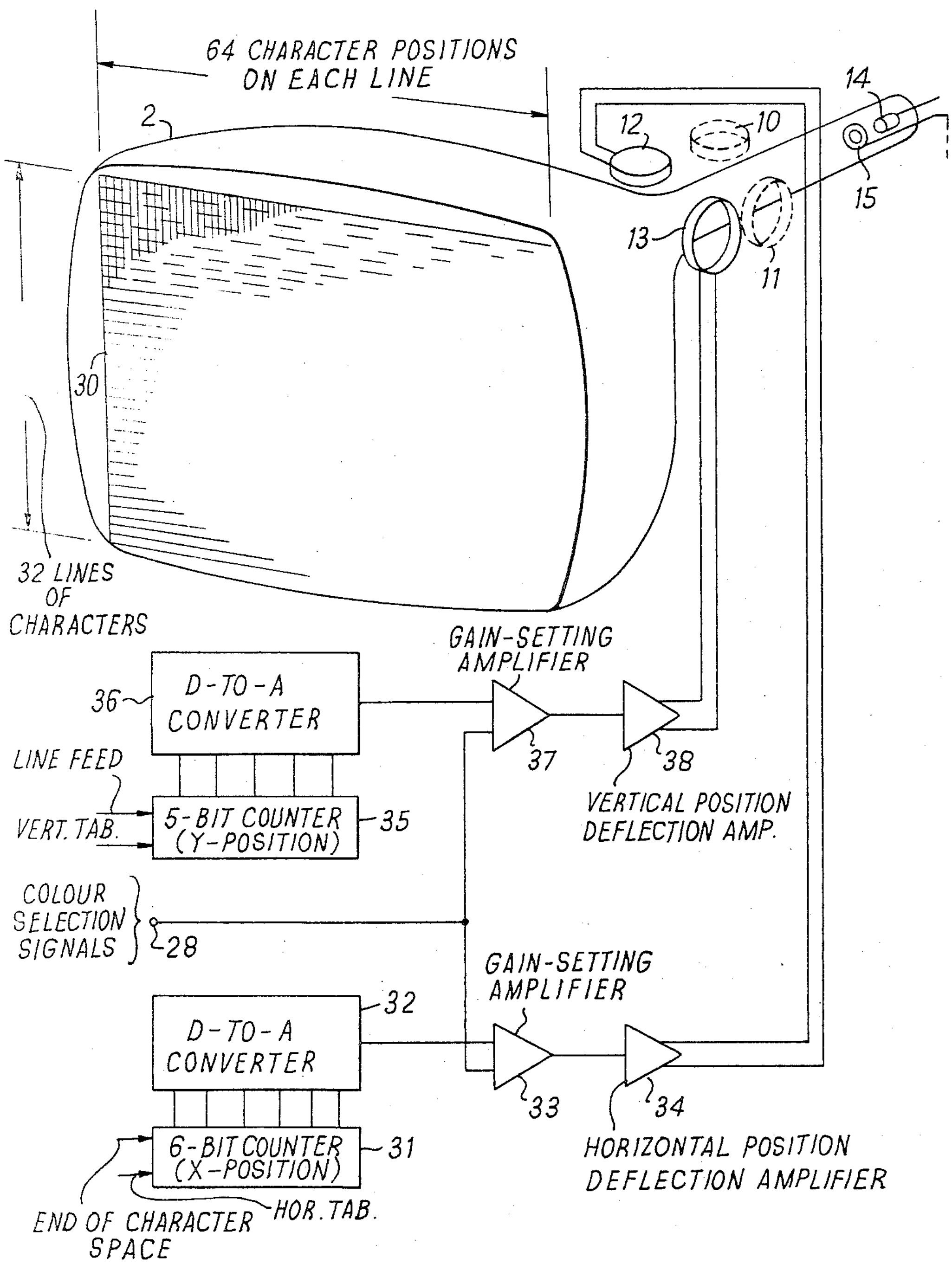

64 CHARACTER POSITIONS ON EACH LINE
2
12
10
14
15
13
11
30
32 LINES OF CHARACTERS
GAIN-SETTING AMPLIFIER
D-TO-A CONVERTER
36
37
38
LINE FEED
VERT. TAB.
5-BIT COUNTER (Y-POSITION)
35
VERTICAL POSITION DEFLECTION AMP.
COLOUR SELECTION SIGNALS
28
GAIN-SETTING AMPLIFIER
32
D-TO-A CONVERTER
33
34
6-BIT COUNTER (X-POSITION)
31
HORIZONTAL POSITION DEFLECTION AMPLIFIER
END OF CHARACTER SPACE
HOR. TAB.

FIG. 4

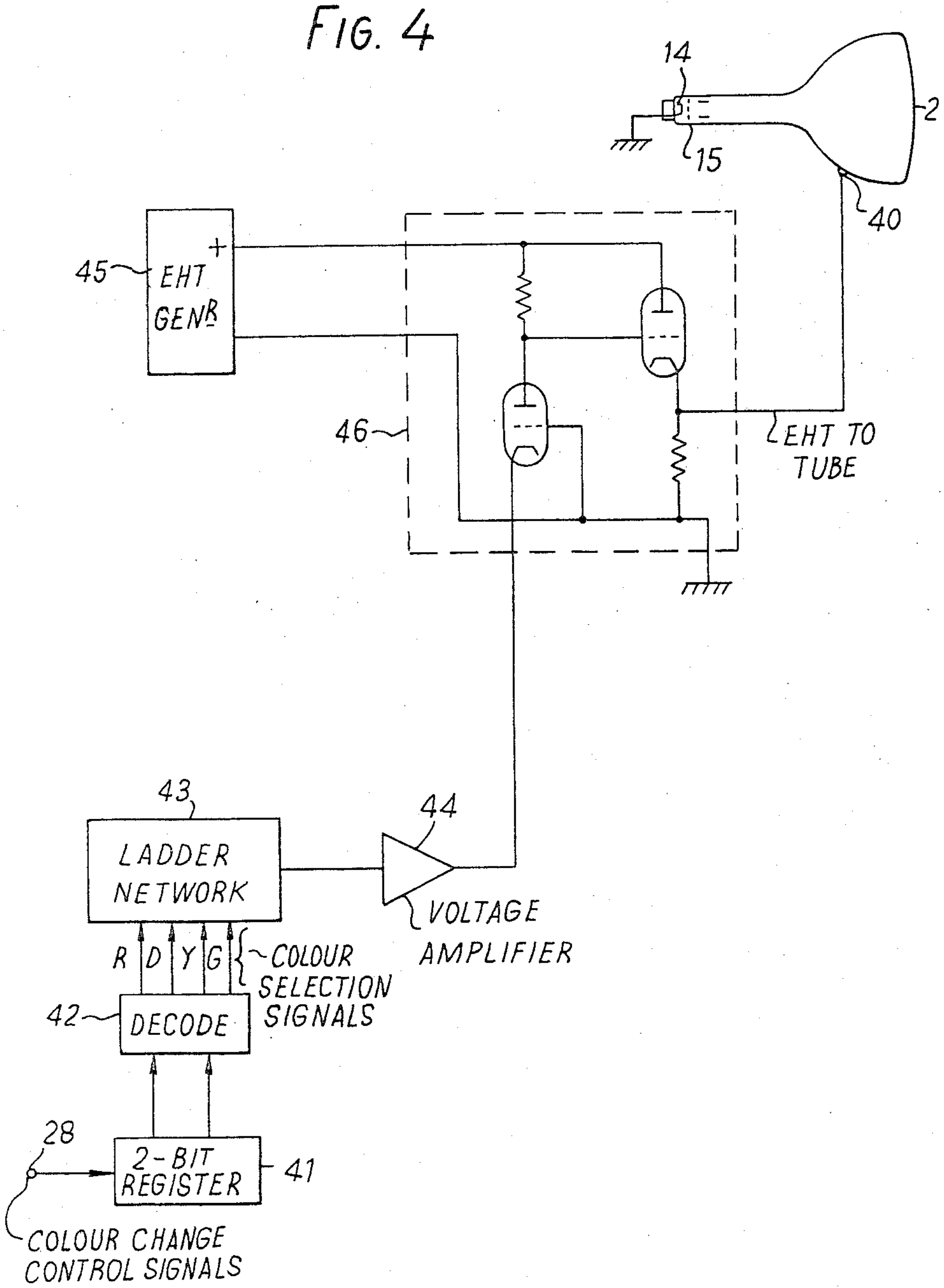
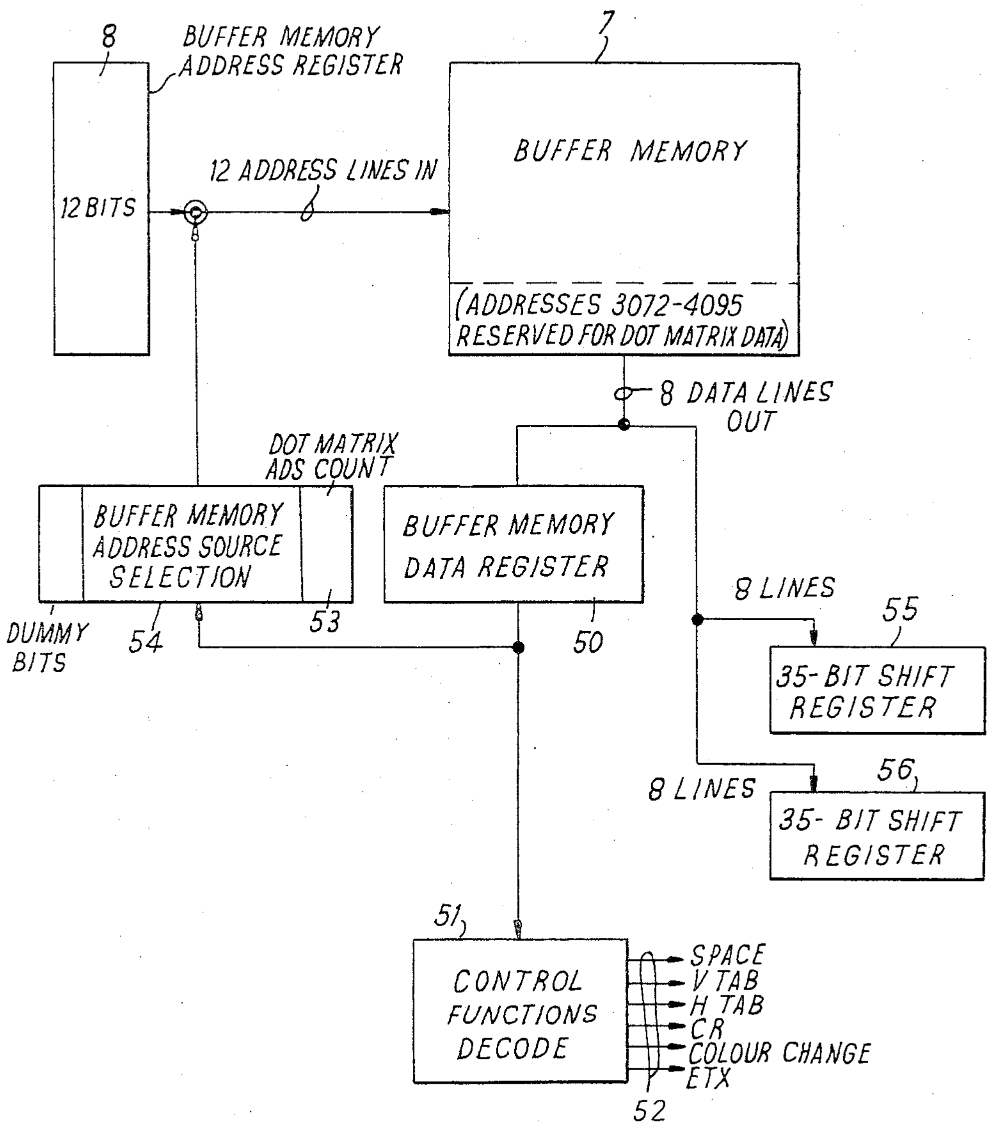

14
2
15
40
45
EHT GENR
+
46
EHT TO TUBE
43
LADDER NETWORK
44
VOLTAGE AMPLIFIER
R
D
Y
G
COLOUR SELECTION SIGNALS
42
DECODE
28
2-BIT REGISTER
41
COLOUR CHANGE CONTROL SIGNALS

FIG. 5


8
BUFFER MEMORY ADDRESS REGISTER
12 BITS
12 ADDRESS LINES IN
7
BUFFER MEMORY
(ADDRESSES 3072-4095 RESERVED FOR DOT MATRIX DATA)
8 DATA LINES OUT
DOT MATRIX ADS COUNT
BUFFER MEMORY ADDRESS SOURCE SELECTION
DUMMY BITS
54
53
BUFFER MEMORY DATA REGISTER
50
8 LINES
55
35-BIT SHIFT REGISTER
8 LINES
56
35- BIT SHIFT REGISTER
51
CONTROL FUNCTIONS DECODE
SPACE
V TAB
H TAB
CR
COLOUR CHANGE
ETX
52

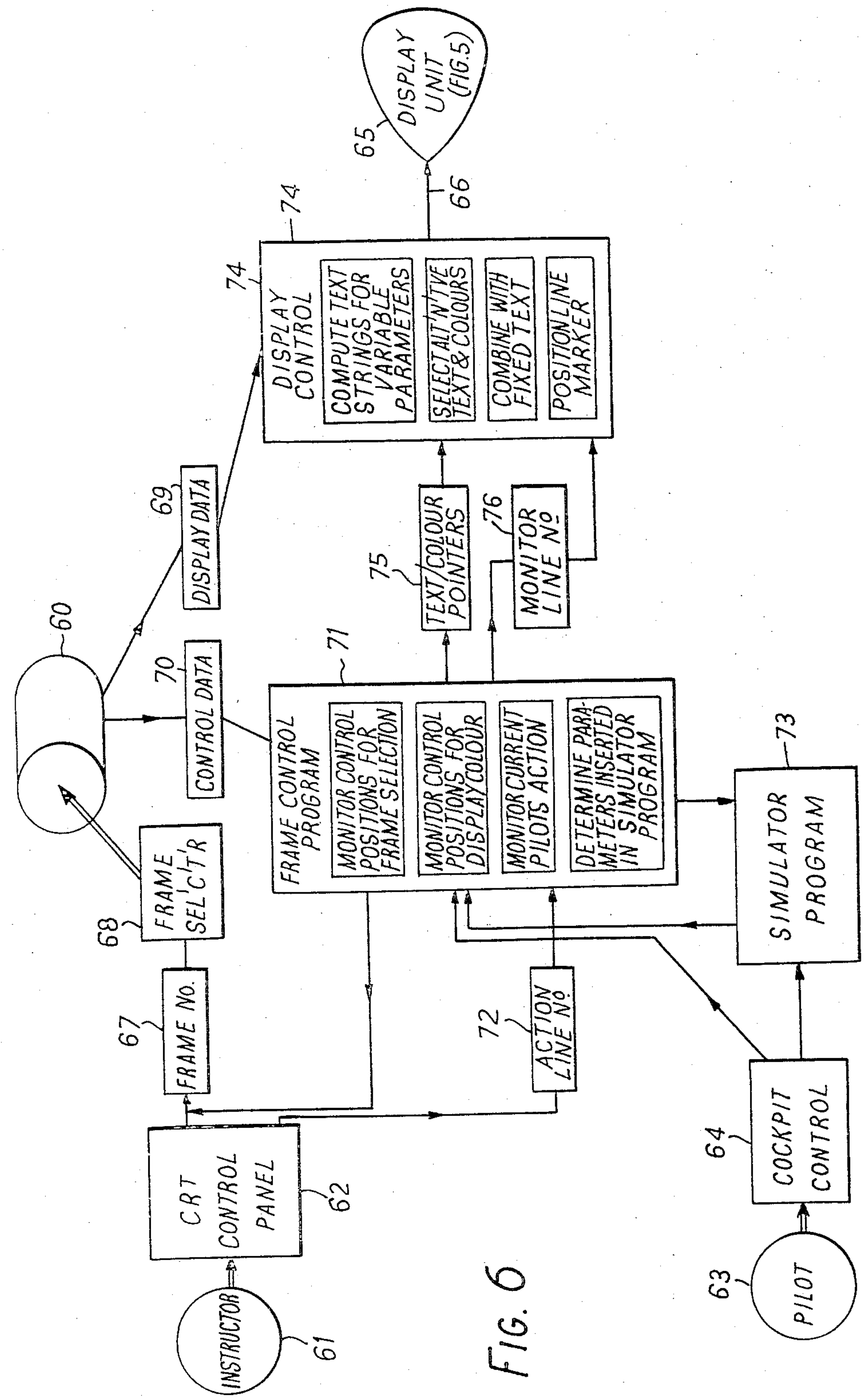

65
DISPLAY UNIT (FIG.5)
66
74
DISPLAY CONTROL
COMPUTE TEXT STRINGS FOR VARIABLE PARAMETERS
SELECT ALT'N'TVE TEXT & COLOURS
COMBINE WITH FIXED TEXT
POSITION LINE MARKER
60
69
DISPLAY DATA
70
CONTROL DATA
71
FRAME CONTROL PROGRAM
MONITOR CONTROL POSITIONS FOR FRAME SELECTION
MONITOR CONTROL POSITIONS FOR DISPLAY COLOUR
MONITOR CURRENT PILOTS ACTION
DETERMINE PARAMETERS INSERTED IN SIMULATOR PROGRAM
75
TEXT/COLOUR POINTERS
76
MONITOR LINE No
73
SIMULATOR PROGRAM
68
FRAME SEL'C'T'R
67
FRAME No.
72
ACTION LINE No
62
CRT CONTROL PANEL
61
INSTRUCTOR
64
COCKPIT CONTROL
63
PILOT

FIG. 6

# APPARATUS FOR VISUAL DISPLAY OF ALPHA-NUMERIC DATA IN COLOURS

## FIELD OF THE INVENTION

This invention relates to apparatus for the visual display of alpha-numerical data, using a multiple-colour cathode ray tube.

## BACKGROUND OF THE INVENTION

Data display systems are known which provide a display in alternative colours, some using cathode ray tubes of a type developed for colour television and other systems using beam penetration colour tubes. The present invention relates to systems using beam penetration colour tubes.

Cathode ray tube alpha-numerical data display systems are known in which characters are formed by beam shaping, using suitable masks, by raster scanning, as in the creation of a television image, or by selective scanning to create each character individually, as by curves, strokes or dots. The present invention relates to display systems in which characters are formed by selective scanning to form a configuration of dots.

The object of the present invention is to provide an improved system for alpha-numerical data display in colour.

## SUMMARY OF THE INVENTION

Accordingly, the present invention provides apparatus for the visual display of selected alpha-numerical data in a plurality of colours using a multiple-colour cathode ray tube, said data being progressively updated in real time as the data changes, including means for effecting a first selection from available data to determine which of said data shall be displayed and means for effecting a second selection to determine which of the said selected data shall be displayed in which of the plurality of available colours, in accordance with a predetermined colour classification signifying the status of data items displayed.

Conveniently, all characters selected for display in one colour are displayed at one time and subsequently all characters selected for display in a second colour are displayed.

Apparatus according to the invention will have many practical applications, but one use envisaged is in association with ground-based flight simulation apparatus to provide a continuous display of data to a Flight Instructor during a simulated flight exercise. It will therefore be convenient to describe the present invention in relation to this particular use.

In order that the invention may be readily carried into practice, one embodiment will now be described in detail, by way of example, with reference to the accompanying drawings, in which:

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a block schematic diagram showing the memory unit and associated units of display apparatus according to the present invention for providing a display in colour of alpha-numeric data derived from a flight simulator computer;

FIG. 1B is a pulse-time diagram relating to the arrangement of FIG. 1A;

FIG. 2 is a block schematic diagram showing the arrangement of apparatus for writing characters upon the display cathode ray tube screen of FIG. 1A;

FIG. 3 is a block schematic diagram showing thearrangement of apparatus for composing a frame of characters upon the face of the cathode ray tube of FIG. 1A;

FIG. 4 is a schematic diagram of apparatus for controlling the colour of the display by the cathode ray tube of FIG. 1A;

FIG. 5 is a schematic diagram of apparatus concerned with the composition of a frame of display data as shown in FIG. 3; an

FIG. 6 is a diagram showing the flow of data within the system of FIG. 1A for displaying data and selecting the colour of display of specific data items.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiment of the invention will now be particularly described is associated with a ground-based aircraft flight simulator and operates to display a frame of alpha-numeric data to the flight instructor controlling a simulated flight exercise. The display serves to inform the flight instructor of the up-to-date state of simulated aircraft parameters according to the relevant data updated and stored in a flight simulator digital computer throughout the flight exercise.

Thus, FIG. 1A shows the apparatus which links the memory 1 of the flight simulator computer with a display CR tube 2.

There is a limit to the amount of information which can be displayed by the tube 2 at any one time. There is also a limit to the amount of information which can be assimilated by the flight instructor in the time available. Hence, a first selection of available data is made to display different frames of data from time to time, so that the display may include parameters which are relevant at any particular time.

Further, colour is employed to indicate the status of specific items of data according to a predetermined colour classification. Thus, in the present example, a Yellow display is used for unchanging information, such as titles and headings. Green is used to dsiplay parameters which are normal and Red is used to display parameters which are abnormal, so that data displayed in Red draws the flight instructor's attention to simulated conditions which are abnormal. Orange is used only to provide a line-marker cursor on the tube screen.

The CR tube 2 is of the beam penetration type and is provided with a Red phosphor and a Green phosphor in two layers, so that the four colours: Red, Orange, Yellow and Green are provided, in sequence, as th tube final anode voltage is progressively increased stepwise.

Characters are formed on the screen of tube 2 by scanning a 7 high by 5 wide dot matrix in each character area of the screen and selectively brightening-up the beam at selected dot positions to form the character desired.

A display frame comprises 32 lines each line having up to 64 characters or spaces.

The characters are not usually formed one by one along each line in sequence. As will be more particularly described, it is preferred first to form all characters required in Red, next the line required in Orange, next all characters required in Yellow and finally all those required in Green, because of the time delay required to change the final anode potential to provide a changed colour.

As will later be described in detail, operation of the display apparatus is in two phases. The first phase is a Memory Cycle, during which data is transferred from the flight computer memory into the display buffer memory. The second phase is a Display Cycle, during which the display on the CR tube screen is effected and repeated at a rate of 40 times per second, to avoid flicker.

Referring now to the drawings, the Memory Cycle will first be described with reference to FIG. 1A. The display system there shown comprises a 12-bit address register **3**, a 32-bit data register **4** and a logic unit **5**.

The address register **3** has supplied to it from an address generator **6** a sequence of addresses each of which specifies the location within the computer memory **1** from which it is desired to read a word of data. The logic unit **5** then generates a signal which causes the computer to present the addressed word at its output, so that the specified word is entered into the register **4**.

In the register **4**, each entered word is divided into four bytes each of eight bits. These are selected in sequence at **4'** and loaded, one byte at a time, into four successive locations in a buffer memory **7**. The actual locations used are specified by a buffer memory address register **8**, starting with address zero for the first byte of the first word transferred to buffer memory **7**.

When all four bytes of the first word have been loaded into memory **7**, the address register **3** is incremented, so that the 32-bit word from the next location of memory **1** is transferred to the data register **4** and then loaded into the buffer memory **7**, in the same way.

This process is continued until all the data required to be displayed in a whole frame selected has been loaded into the buffer memory **7**.

The selection of a frame of data, which may for example consist of Engine Data or Hydrualics Data, is performed by the address generator unit **6**. This may be effected manually by the flight instructor, as by the depression of selector buttons or by the positioning of a selector switch, or it may be effected automatically by the computer flight program.

When all the relevant data for the selected frame has been assembled in the memory **7**, the fact is signalled by the computer by transfer of a word consisting of all "**1**"'s from memory **1** to memory **7**. Upon receipt of this end-of-transmission code word, the system of FIG. 1A changes to the Display Cycle phase of operation.

FIG. 1B is a timing diagram relating to the operation of the system of FIG. 1A showing, in the first line, the initiating memory **1** address transmission and, subsequently, the timing of a memory cycle request, transfer of the first word into register **4**, selection of the four bytes and loading into the buffer memory **7**.

The total time taken to perform a Memory Cycle and to transfer all data for a selected frame depends on the frame size and the amount of data concerned. It is normally of the order of 3 to 4 milliseconds and never in excess of 12 milliseconds.

A following Display Cycle relates to the CRT display control apparatus **9** of FIG. 1 and will be described with reference to FIGS. 2 to 5.

Referring first to FIG. 2, the display CR tube **2** employs electromagnetic deflection and has separate coil yokes, the first comprising X-Write and Y-Write deflection coils **10** and **11**, respectively, and X-Position and Y-Position deflection coils **12** and **13**, respectively, the latter pair being shown in broken lines.

The view of FIG. 2 also shows the cathode **14** and spot-brightness control grid **15** of tube **2**.

In the view of FIG. 3, the same elements as in FIG. 2 are indicated by the same reference numerals. In FIG. 3, the "Position" deflection coils **12** and **13** are shown in full lines and the "Write" deflection coils **10** and **11** are shown in broken lines.

The "Position" deflection system is relatively slow and serves to position a particular character within the frame of the display. The "Write" deflection system is relatively fast and serves to scan the tube beam over the dot matrix of an individual character.

Referring to FIG. 2, there is shown a 5 × 7 dot matrix **16** over which the tube beam is scanned by coils **10** and **11**. Bright-up potentials applied to the grid **15** from the letter "A," in the example illustrated.

All four deflection coils **10** to **14** are fed from an associated register, each by way of a digital-to-analogue converter, a gain-setting amplifier and a deflection current amplifier, so that, by each coil, the tube beam is positioned on the tube face according to the weight of the binary number held in the associated register.

Thus, X-Write coil **10** is controlled from a 3-bit, 5-state, counter **17**, by way of a digital-to-analogue converter **18**, gain-setting amplifier **19** and horizontal deflection current amplifier **20**. Similarly, Y-Write coil **11** is controlled from a 3-bit, 7-state, counter **21**, by way of a digital-to-analogue converter **22**, gain-setting amplifier **23** and vertical deflection current amplifier **24**.

The counter **21** is controlled by a clock pulse from terminal **27**. The dot matrix **16** is scanned, in this example, in columns, so that each column sweep is indicated by a pulse from counter **21** to counter **17** by way of line **29**.

A character is formed on the screen of tube **2** by deflecting the tube beam to each of the seven dot positions in each of the five columns in sequence. A positive voltage pulse to grid **15** is applied at each dot position requiring a written dot in the particular character.

A 35-bit register **25** holds a pattern of "**1**"s and "**0**"s, which define a character. The end bit in the register defines whether a dot is to be bright or not, in the dot matrix position selected by the deflection counters at the time, according to whether the end bit is "**1**" or "**0**," respectively.

Two 35-bit shift registers are in fact used, so that one may be used to display a character while the other is being loaded with data for the next character. Each register is thus used for alternate characters.

As already stated, the final anode voltage of tube **2** is changed for the purpose of display colour selection. The tube deflection sensitivity is changed in consequence. A colour selection signal at terminal **28** controls the gain of amplifiers **19** and **23**, so that the beam deflection is identical for all the display colours, and so that similar characters in different colours are the same size.

In FIG. 3, a display frame 30 is shown on the screen of tube 2 consisting of 32 lines each of 64 character (or space) positions for 5 × 7 dot characters such as character 16 of FIG. 2. In the figure, X- Position coil 12 is controlled from a 6-bit, X-Position, counter 31, by way of a digital-to-analogue converter 32, gain-setting amplifier 33 and horizontal deflection current amplifier 34. Similarly, Y-Position coil 13 is controlled from a 5-bit, Y-Position, counter 35, by way of a digital-to-analogue converter 36, gain-setting amplifier 37 and vertical position deflection current amplifier 38. The gain-setting amplifiers 33 and 37 are similarly controlled by the colour selection signals at terminal 28.

The position of each character on the screen is defined by insertion of Vertical Tab. and Horizontal Tab. control functions into the frame data before the code for the character itself.

A Vertical Tab. instruction consists of the VT code followed by a 5-bit binary number defining the line on which the character is to be written. This number is loaded into the Y-position counter 35 to control amplifier 37 to deflect the beam of the required line of character positions.

A Horizontal Tab. instruction consits of the HT code followed by a 6-bit binary number defining the character position in which the character is to be written. This charcter position, together with the selected line, defines a single one of the 32 × 64 available character positions. This number is loaded into the X-position counter 31 to control amplifier 34 to deflect the tube beam to that character position.

After each character has been written, the X-position counter 31 is incremented to the next character position, whether or not a character is to be written. The feeding of a "Space" control function similarly increments the X-position counter 31.

The execution of a "Carriage Return/Line Feed" control function clears the X-position counter 31 to zero, corresponding to a left-hand character position, and increments the Y-counter 35 to the next line below.

Colour selection in the display of the CR tube 2 will now be described with reference to FIG. 4 and consists in varying the final anode voltage of the tube, at terminal 40 thereof, in accordance with the colour control signal fed to terminal 28. The signal at terminal 28 sets the state of a 2-bit, four-state register 41, which state is decoded by a decoder 42 to provide a colour enable signal on a selected one of four lines. The colour enable signal controls a voltage ladder network 43, according to the line on which it is applied, to provide an output voltage at a selected one of four levels. The output voltage is fed to a voltage amplifier 44 and the amplifier output is used to control correspondingly a high-speed, high-gain, valve voltage amplifier 46 supplied from an EHT voltage generator 45. The output of amplifier 46 provides the final anode voltage of tube 2 at terminal 40.

The form and manner of operation of the ladder network 43, amplifier 44 and amplifier 46 are more fully described in the sepcification of British Pat. application No. 39,373/70.

As described, the colour selection signals at terminal 28 are used to set the gains of amplifiers 19,23,33 and 37 in the two deflection systems of FIGS. 2 and 3. The same signals are also used to control the amplitude and duration of the "Bright-UP" pulses from amplifier 26 of FIG. 2, to compensate for the different sensitivities and persistence of the two tube phosphors. However, it is considered unnecessary to describe this function in any greater detail.

The sequence of Display Cycle operations will now be described in greater detail with reference to FIG. 5. In FIG. 5 there is shown the buffer memory 7 and its address register 8 already described with reference to FIG. 1A.

During a frame display cycle, each 8-bit word of frame composition data is read in sequence from the buffer memory 7 and loaded into a memory data register 50. The contents of register 50 are decoded by a decoder 51 to identify the control function codes which are selectively supplied to the control function signal output lines 52.

Any data code which is not a control function code is treated as a display character code.

Every control function code causes a frame composition function to be executed, as described with reference to FIG. 3.

Every character code causes the corresponding character to be written, at the specified character position, as described with reference to FIG. 2.

At the beginning of each frame display cycle, the buffer memory address register 8 is set to zero and the first word of data is read from memory 7. In general, this is a colour selection code and provides a corresponding signal at terminal 28, not shown in FIG. 5. The address register 8 is then incremented to the next address and the word from this next location is read from memory 7. This second word is normally a horizontal or vertical tab. function and is decoded by decoder 51 to provide a signal on the corresponding line 52.

When all the control functions have been executed, a character code is read from memory 7 into the data register 50.

Five 8-bit words of data are used to provide the dot matrix scan/bright-up information for each character. The top 1,024 words in the buffer memory 7 comprise dot matrix bright-up data for 128 different characters.

When a particular display character code has been loaded into data register 50, that code is used to address the locations in the memory 7 where the corresponding bright-up data is stored.

The two most significant bits of an address are "1"s. The next seven bits form part of the 8-bit character code referred to. The three least significant bits are provided by a 3-bit dot matrix address counter 53. These last three bits are initially zero and are incremented for each successive word of bright-up data.

The function of buffer memory address source selection is performed by a selection unit 54 of which the counter 53 forms a part.

When the address of memory 7 has thus been selected, the first word of character bright-up data at that location is read from the buffer memory 7 on eight parallel lines and loaded into the first eight stages of one or other of two 35-bit shift registers 55 and 56. Eight shift pulses are then applied to shift the data into the second eight stages of the register used.

The dot matrix address counter **53** is then incremented and the next word of character bright-up data is then read from the buffer memory **7**. This data is located into the first eight stages of the same shift register **55** or **56**. A further eight shift pulses moves both words forward in the shift register leaving the first eight stages free.

The third and fourth words are entered into the register in the same way and all four words shifted by eight places. The fifth word is then entered into the free first eight stages.

The register now holds the entire dot matrix data for a selected single character and a flip-flop is set as a result.

Address selection of buffer memory **7** now reverts from unit **54** to the buffer memory address reigster **8**. This is incremented and the next word of frame composition data is read from the buffer memory **7** and loaded into the data register **50**, in similar manner as before. The corresponding control functions are similarly executed and the next character data is loaded into the other one of the two registers **55** and **56**.

This address selection, data load, control function execution and character formation process is repeated until an End-of-Text, ETX, control function is received by register **50** and decoded by decoder **51**.

This ETX control function indicates the end of a single display iteration and the buffer memory address register **8** is reset to zero ready for the next display interation, which may or may not be identical with the last, depending upon whether or not new frame data is to be transferred from the flight computer.

An external line is used to indicate the condition. The state of this line is examined after each ETX control function. If new datais to be transferred from the flight computer, the system of FIG. **1** is set to perform a Memory Cycle. If no new data is to be transferred, the system may commence a further display interation.

The process of colour selection, according to data status, and the provision of the required colour change control signal at terminal **28** will now be described in greater detail with reference to FIG. **6**.

FIG. **6** is a diagram showing the flow of data within the overall system including the flight simulator computer, the display unit and the other sources of data. In FIG. **6**, the heavy-lined rectangles denote program blocks, represented physically by computer software, and the light-lined rectangles denote the form of data in the locations indicated.

Thus, in FIG. **6**, the main source of display data and control data is the computer memory store **60**. An instructor **61** is able to enter or control data or control the selection of data displayed, by means of manual controls provided in a control panel. The relevant program block is shown at **62**.

A trainee crew member, exemplified by the trainee pilot **63** will by manual control of the aircraft controls provide, or modify, data in the computer store **60**. The relevant program block is shown at **64**.

The display unit of the system, which has been particularly described with reference to FIG. **1A** and FIG. **5** is shown in FIG. **6** at reference **65**. The data input channel to the display unit **65**, referenced **66** in FIG. **6**, is similarly referenced in FIG. **5** and FIG. **1A**, in order to make these figures compatible, insofar as this is possible with the hardware diagrams of FIG. **1A** and FIG. **5** and the data flow diagram of FIG. **6**.

Following, say, a data display selection by the instructor **61** by means of his control panel, the control panel program is correspondingly controlled by supply "frame number select" data **67**. This data controls a frame selector program **68** so that, when the frame selector program **68** recognises the request for a change of display frame, it requests a transfer of the relevant frame data from the backing store **60**.

The data selected from sotre **60** comprises "display data" **69**, that is fixed and alternative frame text springs, and "control data" **70**.

The control data **70** includes details of flight simulator controls and parameters to be measured and the criteria for selection of display frame changes and display colours within the chosen frame.

A frame control panel **71** further has data inputs of "action line number select" **72**, corresponding to the display selection by the instructor **61**.

The frame control program **71** further has data inputs from the main flight-simulator program **73** and from the cockpit controls program **64**, both of which are modified according to the actions of the pilot **63**.

Thus, the frame control program **71** examines the simulator controls and parameters and determines the display colour required according to display data status, as described. The frame control program further determines, from the input data at any instant, the position in the sequence of events during a simultated flight and any change of display frame necessary. Further, it may directly set simulator parameters according to action line number data **72**, under control of the instructor **61**.

A display control program **74** receives data inputs of display data **69** from the backing store **60** and "text and colour pointer" data **75** and "monitor line number" data **76**, both from the frame control program **71**. The display control program selects the necessary text strings and their required display colour and combines these to form the display data supplied by channel **66** to the display **65**.

The operation will be further clarified by considering actual cases.

Consider the case when the instructor **61** selects on his control panel, one of the malfunctions displayed on the current frame. Referring to FIG. **6**, the package of software "action line number" **72** triggers a program **71** which determines the parameter which is to be inserted into the simulator program **73**. The simulated malfunction will thence appear on the appropriate crew member's control panel. At the same time, the software concerned with the "text/color pointers" **75** changes the appropriate lines of text on the display **65** to indicate to the instructor **61** that this particular malfunction has been selected. The display control **74** thence selects the appropriate colour and outputs a further string of characters, both control and display, to the buffer memory **7**.

The crew member will now normally take some action as a result of the malfunction which has been introduced. Again referring to FIG. **6**, we see than any change in the cockpit controls **64** is sensed both by the simulator program **73** and the frame control program **71** and will have an effect on the current frame being displayed. That part of the frame control program **71** which is monitoring the control positions changes the colour of a text string via the display control **74**, to indicate to the instructor what action the crew member has taken to deal with the malfunction. The frame control program 71 may also measure the speed of response of the crew member and generate the appropriate text string on the display unit for the instructor's attention. In this case, the colour of the display information can be varied according to whether or not the performance of the crew is within predetermined tolerance limits.

As a specific example, take the case of the instructor 61 selecting an "engine fire" malfucntion upon take-off. In this case, on the "take-off" data frame which is displayed concurrently with the take-off manoeuvre being performed by pilot 63, the instructor will be able to select "engine fire" via his control panel. In the manner described above, his action will cause the apprpriate indications to the pilot and first officer and the frame control program 71 will measure the response time for them to operate the fire bottles.

In a case where the engine is required to be shut down, it can also measure the deviation of the aircraft from the predetermined take-off course for the duration of the emergency. The information required by the instructor 61 for this training exercise is presented to the instructor on the CRT display screen, in the correct sequence and in the colours appropriate to its nature, as described earlier herein.

The description with reference to FIG. 6 has been somewhat simplified for clarity. It will be understood that many modifications and elaborations of the operation described are practicable by the specific choice of software or built-in programs.

Thus, more than one type of data frame may be displayed by a single CRT at the same time. Multiple displays may be provided, for example for the instructor and for different members of the trainee crew, and the display of different data may be appropriate to the different displays. Such multiplication of displays merely requires corresponding multiplication of the program elements 71, 74 and 65 shown in FIG. 6.

In one form of actual flight-simulator display, four different types of data frame may be displayed at one time. These display frame types correspond to the following:

a. Program control frames which link together individual training task frames into comprehensive training exercises;

b. Training task frames themselves, which operate in the nature of the malfunction example given above;

c. Ancillary frames that contain lists of malfunction, read out parameters, etc; and

d. Performance comparison frames, which are used to summarise comparison of a crew's performance for particular emergency and normal aircraft manoeuvres against a predetermined set of parameters.

Further, hardware and software facilities, not shown in the figures, are provided so that selected display data, instead of being supplied to a display memory unit 7, is supplied to an equivalent print-out memory unit. From this store, the data is printed out by a known form of line-printer, so that specific data may be available as hard copy for instructor and trainee crew, at the completion of an exercise.

What we claim is:

1. Apparatus for visual display of alpha-numerial data in a plurality of colours using a multiple-colour cathode ray tube of the beam-penetration type in which successive characters of alpha-numerical data displayed are formed by controlling a first tube beam deflection system for positioning a rectangular dot matrix laterally and vertically in lines within the tube display frame, by controlling a second tube beam deflection system for scanning the tube beam over an individual dot matrix and by supplying to the tube bright-up pulses for writing the required dots in each dot matrix, said data being progressively up-dated in real time as the data changes, said apparatus comprising means for effecting a first selection from available data to determine which of said available data shall be selected for display and means for effecting a second selection to determine which of the said data selected for display shall be displayed in which of the plurality of available colours, in accordance with a predetermined colour classification signifying the status of data items displayed, the said means for effecting the second selection of data so as to determine the colour of display thereof, selectively controlling the final anode potential of the tube for the display of data in different colours, said apparatus further comprising means for providing that all characters selected for display in one colour are displayed at one time and that subsequently all characters selected for display in a second colour are displayed.

2. Apparatus as claimed in claim 1, including a digital-computer having data processing means and a memory in which computer data is processed, up-dated and stored in the said memory as said available data, a subsequent buffer memory data register, and a control function signal decode unit having a plurality of output lines means for supplying the data selected for display to the buffer memory data register such that each word of data is loaded in sequence, identified as display character code or control function code, and, when identified as the latter, decoded to selectively provide a control signal on one of the plurality of output lines of the control function signal decode unit so as to control the location and colour of display of the associated display character.

3. Apparatus as claimed in claim 2, in which the means for effecting the selection of data for display includes an address generator unit which supplies addresses to an address register which specify locations within the computer memory of data selected for display, said address generator unit being capable of generating addresses for the selection of data for display both automatically under control of a computer program and manually under control of an operator.

4. Apparatus as claimed in claim 3, in which the vertical deflection circuit and the horizontal deflection circuit of both the said first and the said second tube beam deflection system each include a gain-setting amplifier the gain of which is controlled, together with the final anode potential of the tube, so that substantially uniform data character size is maintained despite the change of deflection sensitivity resulting from change of final anode potential.

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