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(54) **APPARATUS AND METHOD FOR HANDLING SPECIAL WINDOWS IN A DISPLAY**

(75) Inventors: **Richard D. Cappels, Sr.**, San Jose, CA (US); **Christoph H. Krah**, San Jose, CA (US); **Johanna M. Andrews**, Sunnyvale, CA (US)

(73) Assignee: **Apple, Inc.**, Cupertino, CA (US)

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G09G 5/00 (2006.01)

(52) **U.S. Cl.** **715/726**; 715/719; 715/720; 715/722; 715/721; 345/204; 345/690; 345/698; 348/742; 348/254

(58) **Field of Classification Search** 345/116, 345/432, 10, 340, 20, 115, 327, 118, 147, 345/112, 113, 114, 565, 11, 341, 342, 343, 345/146, 780–795, 802, 803, 596–599, 629, 345/634, 635, 638, 204, 102, 656, 440, 690, 345/698; 348/380–382, 460, 511, 528, 596, 348/678, 682, 712, 565, 742, 254, 100; 715/634, 715/635, 638, 780, 795, 802, 719, 720, 721, 715/722, 726
See application file for complete search history.

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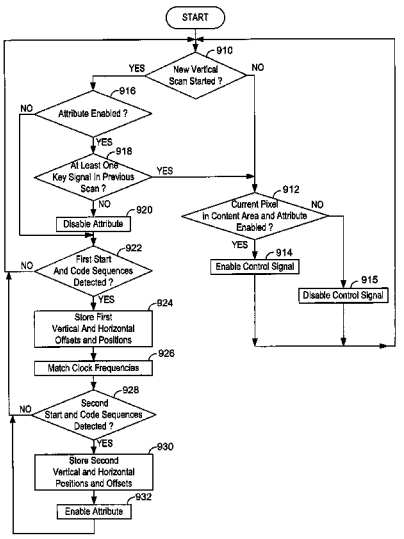
Primary Examiner—Weilun Lo
Assistant Examiner—Mylinh Tran
(74) *Attorney, Agent, or Firm*—Morrison & Foerster LLP

(57) **ABSTRACT**

An apparatus and method for handling special windows in a display comprises a window manager in an operating system that is called by application programs to create special windows. The window manager embeds static key signals including encoded special window information, such as the coordinates of a window area to be specially processed, into a video RAM. An existing video interface scans the video RAM and transmits display information, including the key signals, to the display. The present invention further comprises a window decoder in the display, that detects the key signals, extracts the encoded special window information, and controls display circuitry performing the desired special processing. The key signal encoding scheme does not create visually discernible display aberrations that could distract the user or interfere with normal window management.

35 Claims, 9 Drawing Sheets



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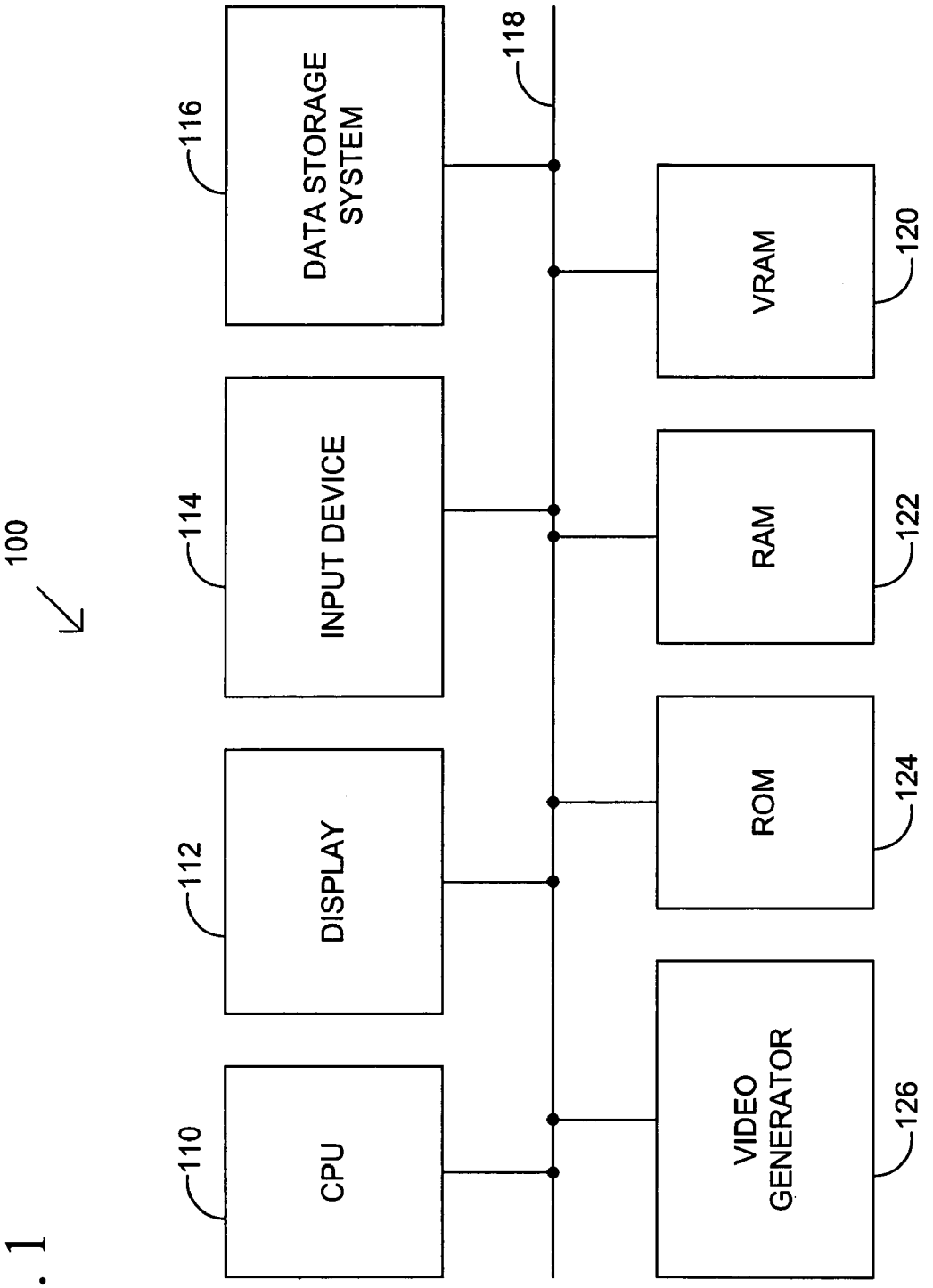

100
110
CPU
112
DISPLAY
114
INPUT DEVICE
116
DATA STORAGE SYSTEM
118
120
VRAM
122
RAM
124
ROM
126
VIDEO GENERATOR

FIG. 1

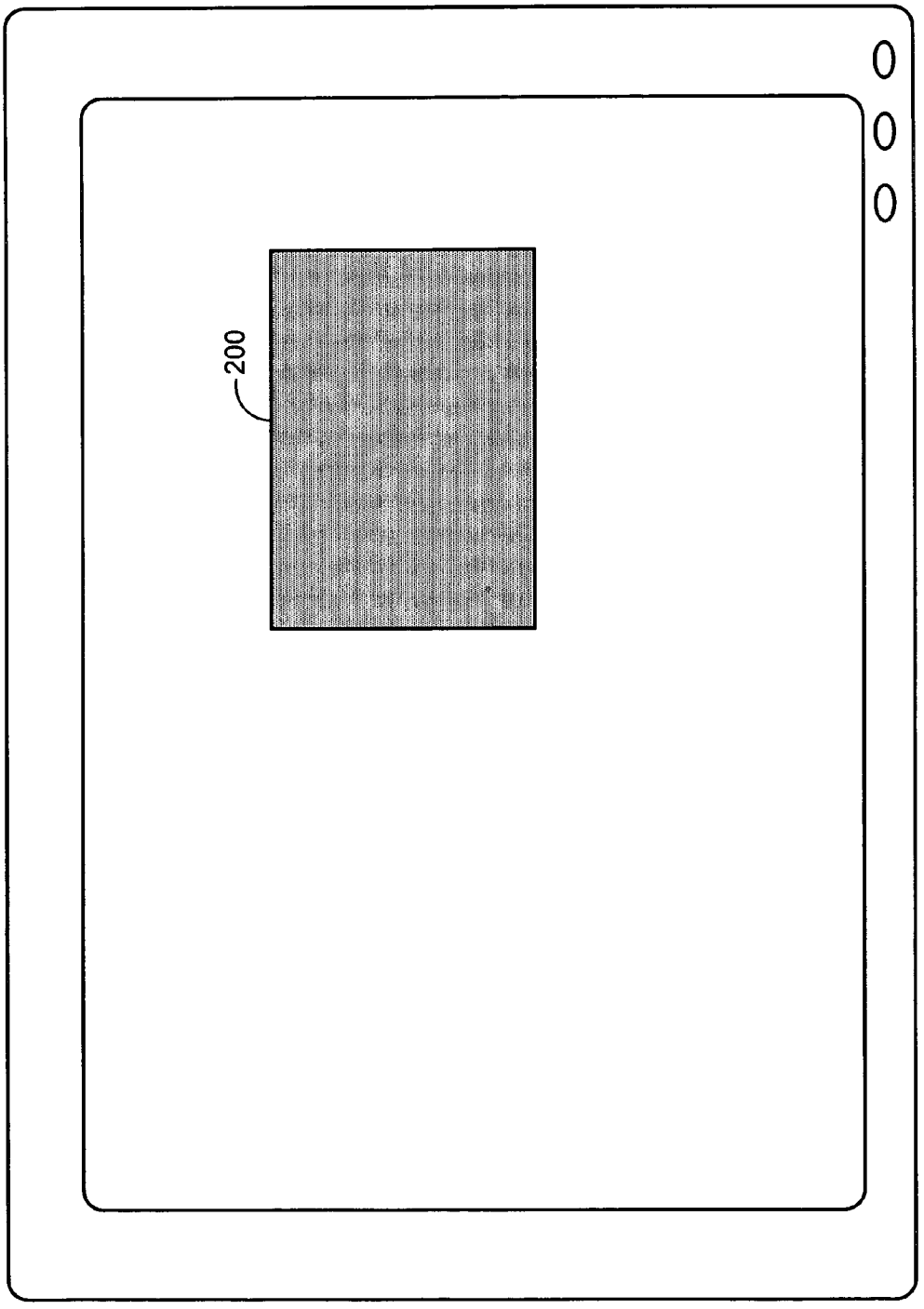


FIG. 2

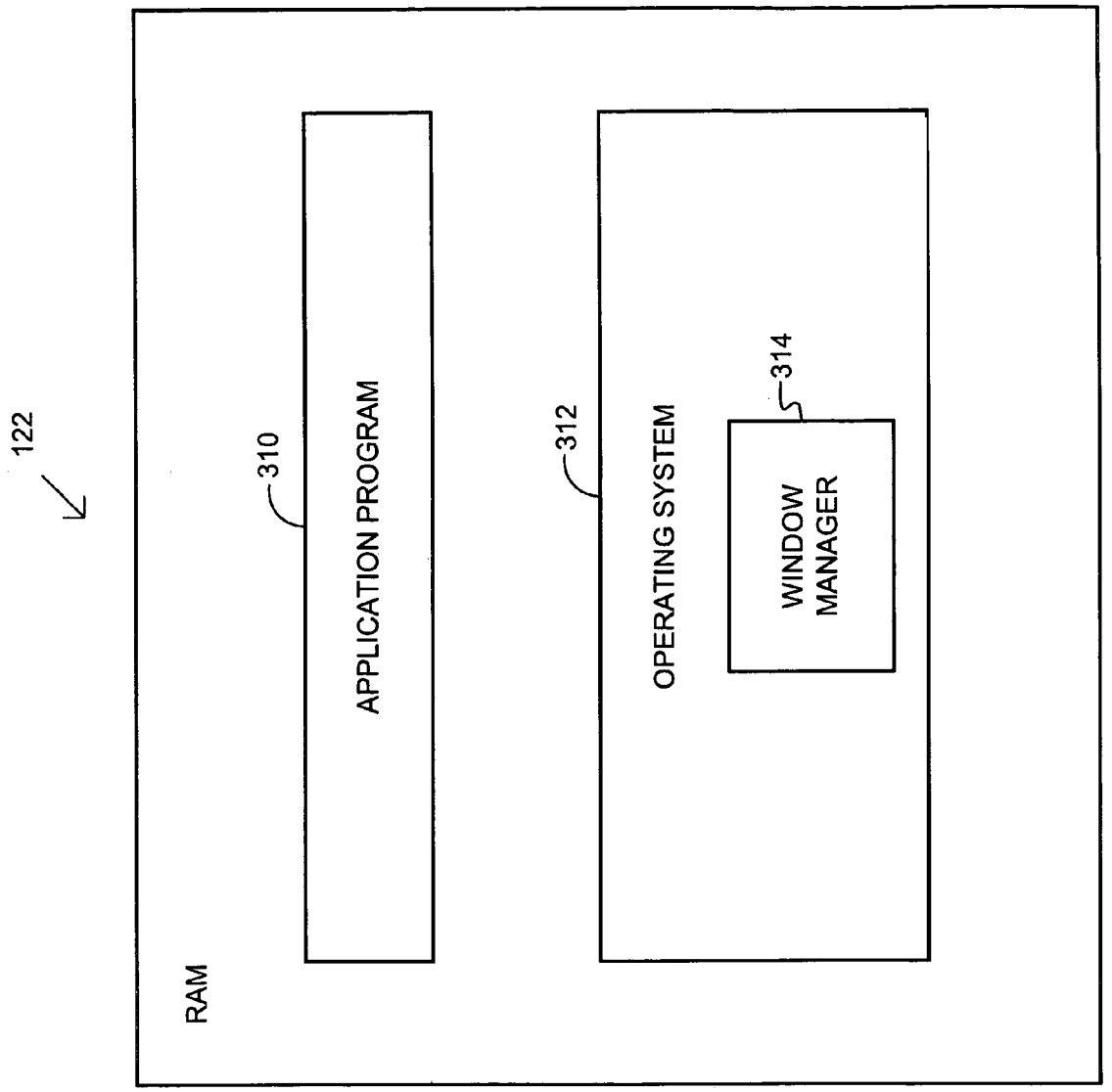

122
RAM
310
APPLICATION PROGRAM
312
OPERATING SYSTEM
314
WINDOW MANAGER

FIG. 3

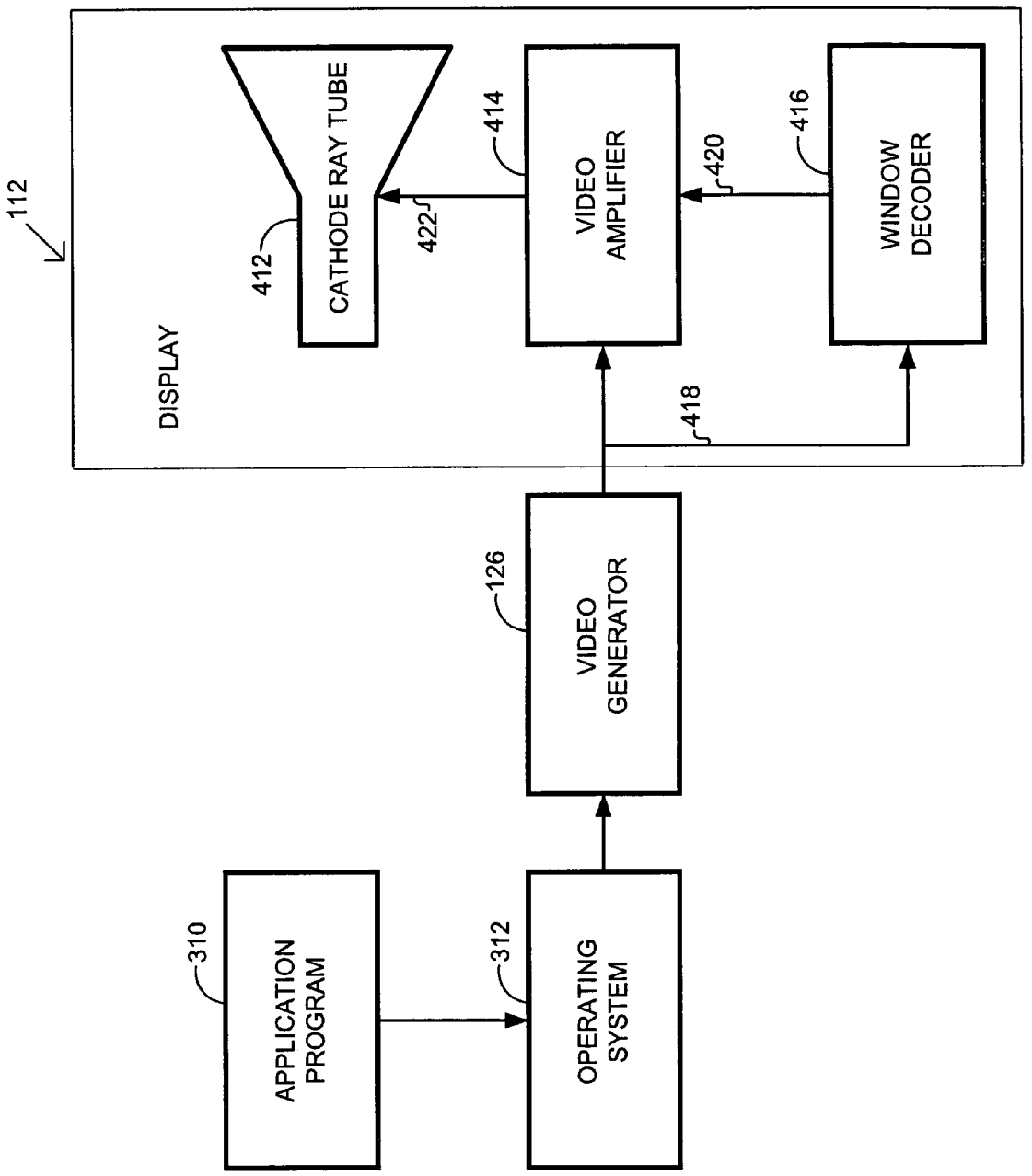

112
DISPLAY
412
CATHODE RAY TUBE
422
414
VIDEO AMPLIFIER
420
416
WINDOW DECODER
418
126
VIDEO GENERATOR
310
APPLICATION PROGRAM
312
OPERATING SYSTEM

FIG. 4

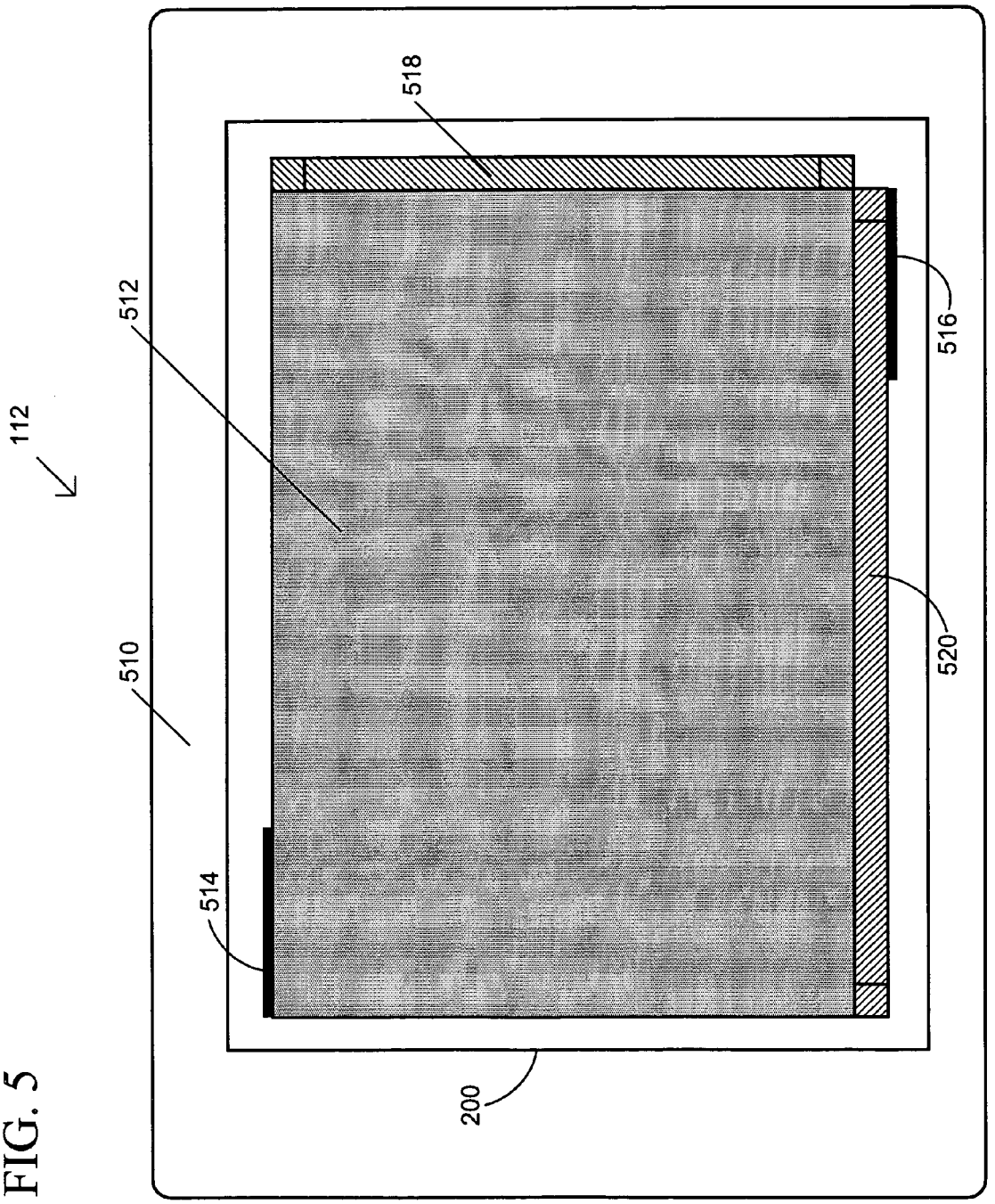


FIG. 5

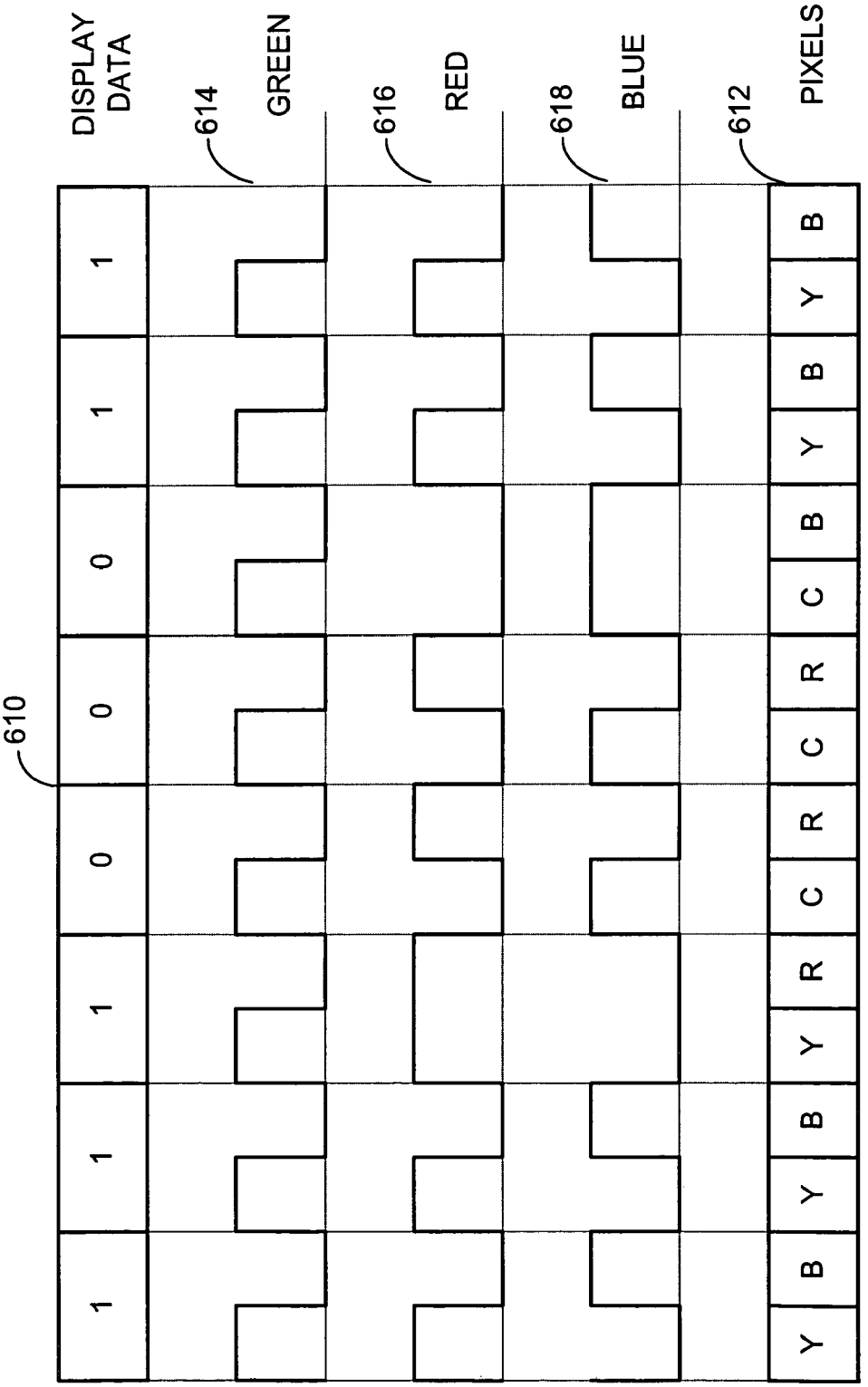

DISPLAY DATA
610
614
GREEN
616
RED
618
BLUE
612
PIXELS
1
1
0
0
1
1
1
Y
B
Y
B
Y
B
C
R
C
R
C
R
Y
B
Y
B
Y
B

FIG. 6

FIG. 7A

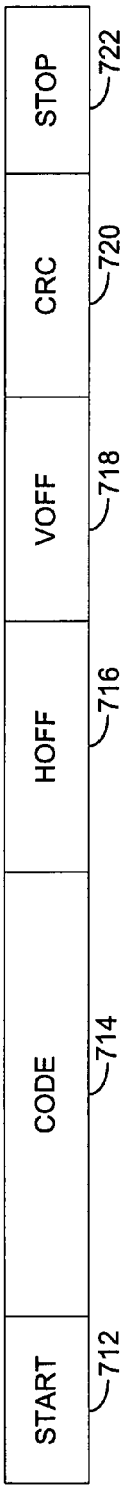


FIG. 7B

SYMBOL	MEANING	DATA LENGTH
START	START SEQUENCE INDICATED BY BLUE=RED	6 BITS
CODE	UNIQUE DATA PATTERN TO DISTINGUISH KEY SIGNALS FROM OTHER DATA	16 BITS
HOFF	HORIZONTAL OFFSET WITH SIGN BIT INDICATING LEFT/RIGHT OFFSET	9 BITS
VOFF	VERTICAL OFFSET	8 BITS
CRC	CRC CHECKSUM FOR HOFF AND VOFF	8 BITS
STOP	STOP SEQUENCE INDICATED BY BLUE=RED	6 BITS

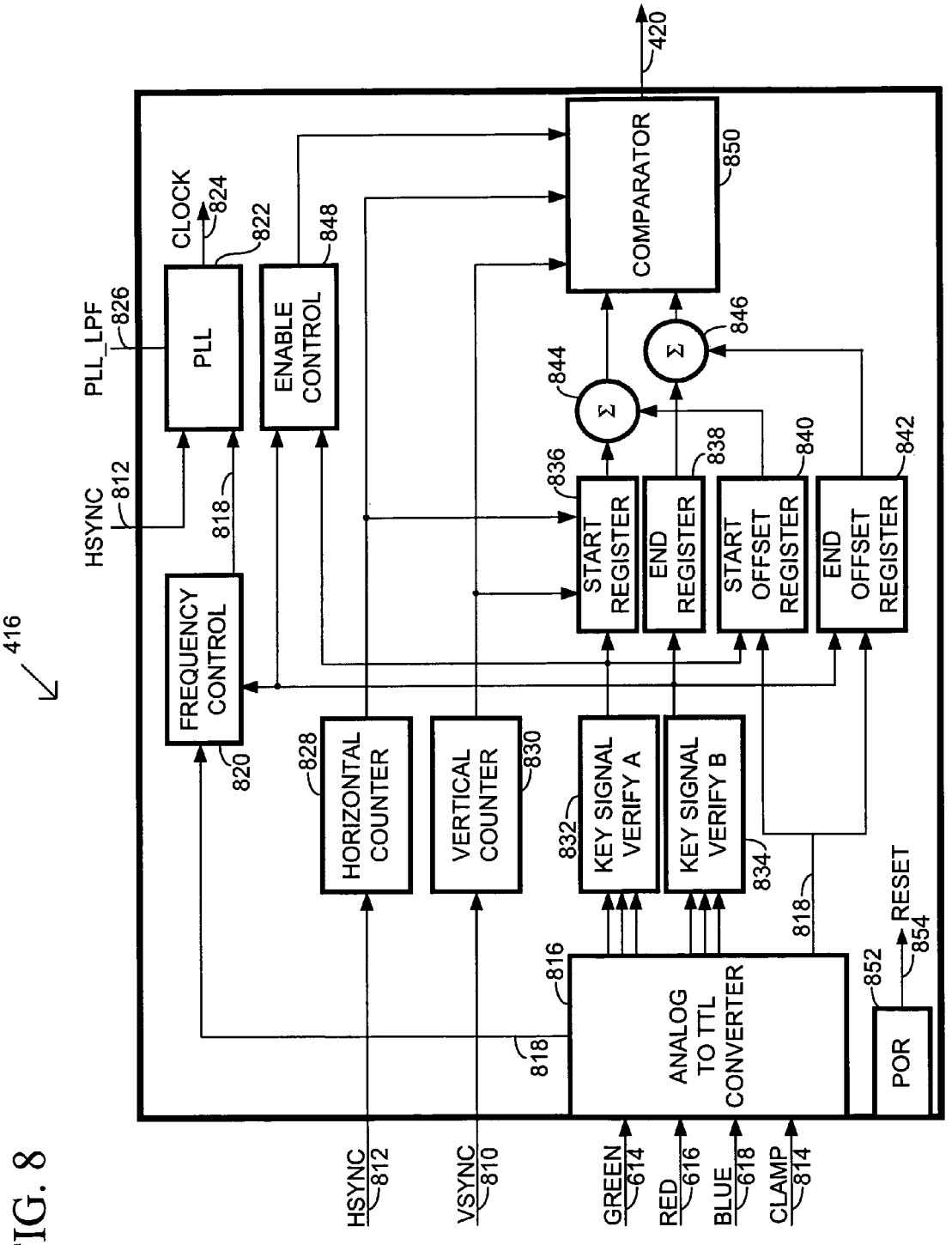
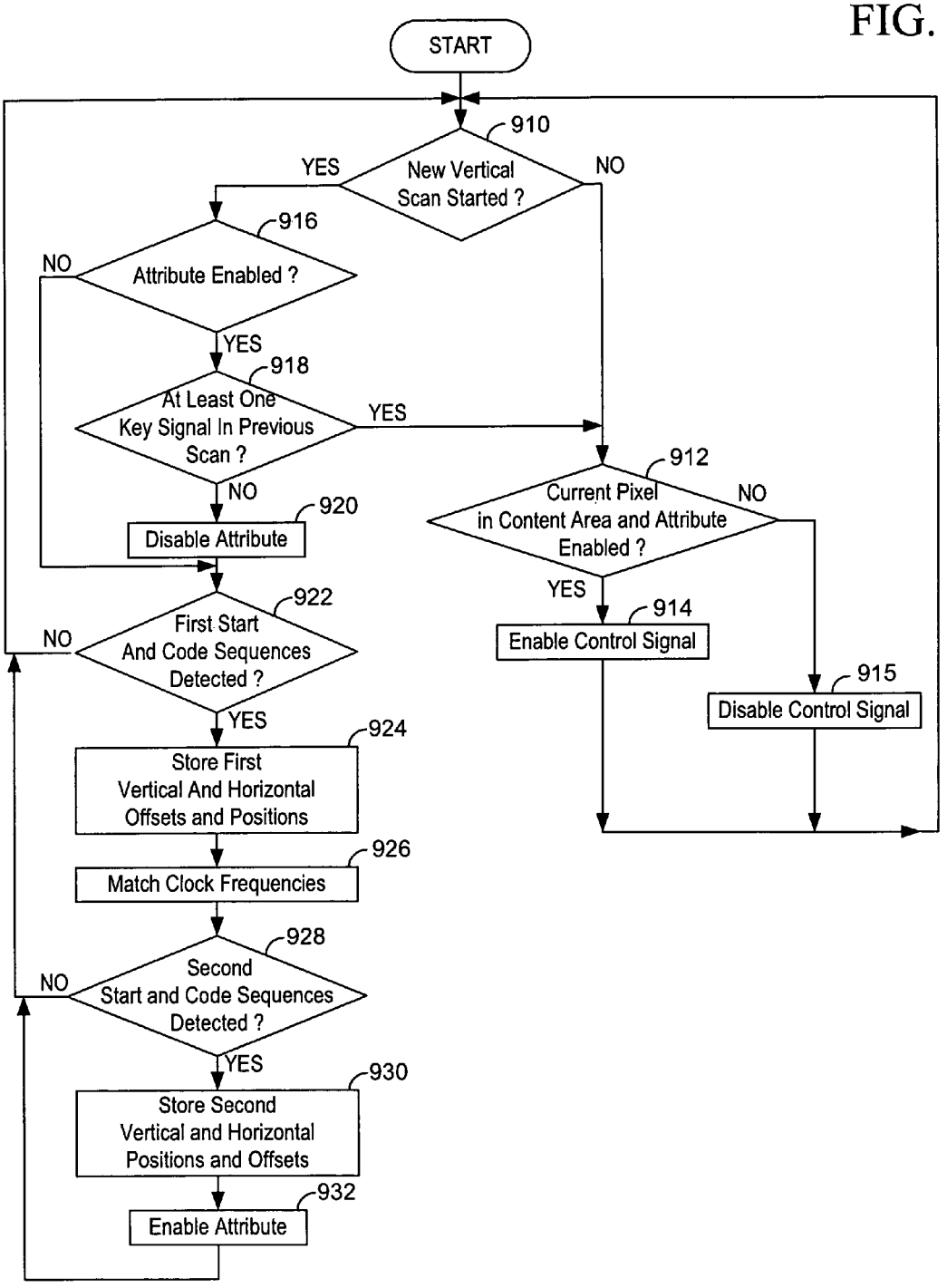

416
420
COMPARATOR
850
CLOCK
824
822
848
PLL_LPF
826
PLL
ENABLE CONTROL
HSYNC
812
818
844
846
Σ
Σ
836
838
840
842
START REGISTER
END REGISTER
START OFFSET REGISTER
END OFFSET REGISTER
FREQUENCY CONTROL
820
828
HORIZONTAL COUNTER
VERTICAL COUNTER
830
832
KEY SIGNAL VERIFY A
KEY SIGNAL VERIFY B
834
818
816
ANALOG TO TTL CONVERTER
818
852
RESET
854
POR
HSYNC
812
VSYNC
810
GREEN
614
RED
616
BLUE
618
CLAMP
814

FIG. 8

FIG. 9


START
910
New Vertical Scan Started ?
YES
NO
916
Attribute Enabled ?
NO
YES
918
At Least One Key Signal In Previous Scan ?
YES
NO
920
Disable Attribute
912
Current Pixel in Content Area and Attribute Enabled ?
NO
YES
914
Enable Control Signal
915
Disable Control Signal
922
First Start And Code Sequences Detected ?
NO
YES
924
Store First Vertical And Horizontal Offsets and Positions
926
Match Clock Frequencies
928
Second Start and Code Sequences Detected ?
NO
YES
930
Store Second Vertical and Horizontal Positions and Offsets
932
Enable Attribute

APPARATUS AND METHOD FOR HANDLING SPECIAL WINDOWS IN A DISPLAY

CROSS-REFERENCE TO RELATED APPLICATION

This application is related to co-pending U.S. patent application Ser. No. 08/900,964, entitled "System And Method For Generating High-Luminance Windows On A Computer Display Device", filed on Jul. 25, 1997, which is incorporated by reference. These related applications are commonly assigned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to display devices, and relates more particularly to an apparatus and method for handling special windows in a display.

2. Description of the Background Art

Effective presentation of visual information is an important consideration for manufacturers, designers, and users of displays. Such displays are commonly used for interfacing with computers. Many modern computer operating systems use graphical user interfaces that enclose information from application programs in separate viewing areas or windows in a display to simplify information management.

These special windows in a display may be used for presentation of different types of information than are typically shown in the remainder of the display. In some applications, use of a special window in a display may be desirable to help distinguish or differently process information. For example, a computer system may present video information from a video source (such as a video camera or video tape recorder) in a special window, while simultaneously presenting more traditional computer-generated information such as text and graphics in the rest of the display.

Conventional computer displays are designed to present text and graphics, but are not specifically designed to present video information. Luminance levels in conventional computer displays are usually considerably lower than the luminance levels used in conventional video monitors or television screens. Video information presented in conventional computer displays thus appears to have less contrast between bright and dark areas, and tends to look rather murky. Raising luminance levels is one possible way to enhance the presentation of video information in computer displays, but problems may arise from indiscriminately raising luminance levels over the entire display surface.

For example, text or graphics outside the special window may become blurred, decreasing the overall effectiveness of the display. Furthermore, continuously raising luminance levels over the entire display surface may unacceptably accelerate the aging of the display tube. These problems could be avoided with an effective means for identifying and locating the limited portions of a special display window to be advantageously processed.

The coordinates of a special display window may be transmitted to a display via a separate data channel. For example, the serial interface available on most modern computers may be dedicated to this purpose. However, this potential solution presents a number of difficulties. First, such a system would demand significant additional hardware within a computer system; a second serial interface card would have to be managed by the computer system. Second, the signals generated by such serial interface hardware would have to be precisely calibrated with the horizontal and vertical video synchronization signals going to the display. Finally, significant software development would be required to coordinate such a dual-channel interface system.

Therefore, for the foregoing reasons, an improved apparatus and method for handling special windows in a display is needed, in accordance with the present invention.

SUMMARY OF THE INVENTION

In accordance with the present invention, an apparatus and method are disclosed to handle special windows in a display.

In one embodiment of the present invention, windows comprise frames that are created by an operating system, and content areas that are created by an application program. The windows are special if they include content areas or portions of content areas that are to be specially processed, such as being displayed with higher than normal luminance. Software developers preferably trigger special window creation by calling a window manager, which includes operating system functions specifically designed to simplify special window use.

In accordance with the present invention, special windows include key signals that enable display circuitry to identify windows to be specially processed. The key signals also include information needed by display circuitry to locate the boundaries of the portion of the content area to be specially processed. The key signals are preferably static patterns in a special window, so that no separate signals or second communication channel beyond the existing video interface are required to trigger special processing. The operating system places digital representations of all display information, including special windows, into a video RAM in the preferred embodiment. The existing video interface circuitry scans the video RAM and produces video signals to be sent to the display. A window decoder in the display detects the key signals, extracts the embedded special window information from the key signals and controls the display circuitry performing the special processing desired.

Key signals are patterns of colored pixel (picture element) pairs. A color coding scheme enables storage of key signal information in a manner that is easily detectable by the window decoder, yet is not visually discernible, given the limited acuity of the human eye. In additive color display systems, primary colors (red, green, blue) can be mixed to produce secondary colors (yellow, cyan, magenta). If a pixel of a primary color is placed next to a pixel of an opposite secondary color (that is, one not including the primary color) of equal luminance, the resulting pixel pair resembles a single pixel that is an achromatic gray in color. This enables the key signal to be plainly displayed in a gray window frame without causing visual distraction. One primary color channel serves as the data signal, and another is used as a complement to produce the achromatic gray color of pixel pairs.

The key signal color coding scheme preferably uses the remaining primary color channel in the existing video interface as a video clock signal. A separate clock in the window decoder is synchronized to the video clock signal when a key signal is present. The separate but synchronous internal clock is continuously available to the window decoder, and enables the use of a precise but relative (versus absolute) display coordinate system. The location of any pixel in the display can be determined and controlled by the time elapsed since the last horizontal and vertical synchronization pulses in the existing video interface. No second communications channel for transmission of external timing pulses for precise pixel location is required. The window decoder can use key signal information and existing synchronization pulses to control

the timing, and thus location, of special processing for desired portions of the display with respect to the upper left corner of the display.

Key signal information includes start and stop sequences, code sequences to distinguish a key signal from other display data, horizontal and vertical offset values, and a CRC checksum. The horizontal and vertical position of the key signal and the horizontal and vertical offset values can be summed by the window decoder to yield the coordinates of the portion of the content area to be specially processed. The window decoder uses the other sequences in a variety of means for verifying the presence of a window intended to be specially processed. Accidental special processing could be very distracting to the user and should be avoided. For example, key signals preferably identifying upper left and lower right corners of the portion of the content area to be specially processed should be detected in one scan, and should persist for a set number of scans. Similarly, code sequences should match a pair of preset sequences, and three bits of unchanging color, as in a gray frame, should be present prior to the start sequence of each key signal. Many other conditions used to avoid accidental special processing are described in the detailed description of the present invention. Once the window decoder enables special processing, the window decoder disables special processing only when no special windows exist, or when the special window is occluded by another window.

The present invention therefore handles special windows in a display, enabling more effective presentation of visual information.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram for one embodiment of a computer system, in accordance with the present invention;

FIG. **2** is a diagram for one embodiment of the display of FIG. **1**, including a window, in accordance with the present invention;

FIG. **3** is a block diagram for one embodiment of the RAM of FIG. **1**, in accordance with the present invention;

FIG. **4** is a block diagram showing one embodiment for the processing of display data, in accordance with the present invention;

FIG. **5** is a diagram for one embodiment of a window in the FIG. **1** display, in accordance with the present invention;

FIG. **6** is a timing diagram for one embodiment of display data encoded into exemplary pixels, in accordance with the present invention;

FIG. **7**A is a block diagram for the preferred embodiment of the FIG. **5** key signals, in accordance with the present invention;

FIG. **7**B is a table describing one embodiment for components of the FIG. **7**B key signals;

FIG. **8** is a block diagram for the preferred embodiment of the FIG. **4** window decoder, in accordance with the present invention; and

FIG. **9** is a flowchart for one embodiment of method steps to process special windows, in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention relates to an improvement in displays, including computer displays. The following description is presented to enable one of ordinary skill in the art to make and use the invention and is provided in the context of a patent application and its requirements. Various modifications to the preferred embodiment will be readily apparent to those skilled in the art and the generic principles herein may be applied to other embodiments. Thus, the present invention is not intended to be limited to the embodiment shown but is to be accorded the widest scope consistent with the principles and features described herein.

The present invention comprises an apparatus and method for handling special windows in a display. The invention uses a modified display window frame created by a window manager from an operating system, and transmitted to the display over a video interface. This window frame includes key signals with unique characteristics that are visually unobtrusive, and yet are easily detected and processed by display circuitry to identify and locate special windows for advantageous processing, in accordance with the present invention.

Referring now to FIG. **1**, a block diagram for one embodiment of a computer system is shown, in accordance with the present invention. Computer system **100** preferably comprises a central processing unit (CPU) **110**, a display **112**, an input device **114**, a data storage system **116**, a video random access memory (VRAM) **120**, a random access memory (RAM) **122**, a read-only memory (ROM) **124**, and a video generator **126**. Each element of computer system **100** is preferably coupled to a common data bus **118**. Input device **114** may alternatively comprise various configurations, including elements such as a keyboard or a mouse. Data storage system **116** may also alternatively comprise various configurations, including elements such as a floppy disk or a hard disk. Computer system **100** of the present invention may include, but is not limited to, an Apple Macintosh® computer system.

Referring now to FIG. **2**, a diagram for one embodiment of display **112** of FIG. **1**, including a window **200**, is shown, in accordance with the present invention. Display **112** of the preferred embodiment may include, but is not limited to, a cathode-ray-tube based video monitor. However, other types of commonly used displays including liquid-crystal-based displays may alternatively be encompassed by the present invention. Information is preferably updated on display **112** in a rastered manner, i.e., display **112** is periodically scanned horizontally from left to right and then vertically from top to bottom with sufficient speed that the eye will not perceive the scanning process. Display contents are thus depicted as picture elements or pixels. Each pixel corresponds to a specific time with respect to the start of a scan. Window **200** contains information related to a specific task being performed by computer system **100**. The size and location of window **200** in display **112** may be modified by the user as needed, usually via input device **114**. A particular window **200** in display **112** is activated when first displayed or selected by the user as the active window **200**.

Referring now to FIG. **3**, a block diagram for one embodiment of RAM **122** of FIG. **1** is shown, in accordance with the present invention. In the FIG. **3** embodiment, RAM **122** includes an application program **310** and an operating system **312**. Application program **310**, often created by an independent software developer, enables computer system **100** to perform a specific task, such as word processing, communication via the Internet, processing of numerical data in a spreadsheet, or playback of a multimedia file. A modern computer system **100** can simultaneously run multiple application programs **310**. Operating system **312** performs a multitude of tasks to simplify use of computer system **100**. These tasks usually include installation and coordination of the various hardware components of computer system **100**, creation and management of files, and operations relating to a graphical user interface in display **112**. Window manager **314** is a subset of operating system **312** that simplifies creation and

management of windows **200**. Creators of application programs **310** need only include calls to window manager **314** to inform operating system **312** that a particular size and type window **200** is required. Window manager **314** is specifically intended to minimize the software development burden faced by creators of application programs **310**.

Referring now to FIG. **4**, a block diagram showing one embodiment for the processing of display data is shown, in accordance with the present invention. In the FIG. **4** embodiment, application program **310** and operating system **312** share responsibility for managing windows **200**. Application program **310** instructs operating system **312** to create window **200** and thereafter supplies window content information to operating system **312**. In one embodiment, video RAM **120** (FIG. **1**) contains the information to be placed onto display **112**, including text, graphics, and window information from operating system **312** as well as window content information from application program **310**. Video generator **126** repeatedly scans through video RAM **120** (FIG. **1**) and produces appropriate video signals to be passed to display **112** to enable visual depiction of the contents of video RAM **120**.

In the FIG. **4** embodiment, display **112** comprises a cathode ray tube **412**, a video amplifier **414**, and a window decoder **416**. Video signals **418** from video generator **126** are passed to video amplifier **414** and to window decoder **416**. Window decoder **416** selectively generates a control signal **420** to indicate to video amplifier **414** that a given picture element or pixel in display **112** is to be processed differently than other pixels. Video amplifier **414** includes circuitry to responsively implement the desired special attribute, such as increased luminance, by responsively generating output signals **422** for cathode ray tube **412** based on video signals **418** from video generator **126** and the presence or absence of control signal **420** from window decoder **416**. In the event that window decoder **416** does not produce control signal **420** denoting the existence of a pixel to be specially processed, video amplifier **414** produces output signals **422** for cathode ray tube **412** that result in a regular depiction of video information. In the event that window decoder **416** does produce control signal **420** denoting the existence of a pixel to be specially processed, video amplifier **414** produces different output signals **422** for cathode ray tube **412** that will result in that pixel being specially displayed. For example, a pixel might be displayed with a relatively higher luminance level whenever window decoder **416** generates control signal **420**. Synchronization of special pixel processing with the rastering process in display **112** results in the correct target areas of a special window **200** being specially processed.

Referring now to FIG. **5**, a diagram for one embodiment of a window **200** in the FIG. **1** display **112** is shown, in accordance with the present invention. The window **200** in display **112** includes a frame **510**, a content area **512**, a first key signal **514**, a second key signal **516**, a vertical scroll bar **518**, and a horizontal scroll bar **520**.

Operating system **312** creates and manages frame **510**, while application program **310** provides information to be displayed in content area **512** to operating system **312**. Frame **510** contains depictions of first key signal **514** and second key signal **516**, which each contain information regarding the dimensions of the portion of content area **512** in display **112** to be specially processed. Frame **510** also includes window control tools, such as vertical scroll bar **518**, and horizontal scroll bar **520**. In an alternate embodiment, scroll bars **518** and **520** may help control special processing. For example, the position of a slide in horizontal scroll bar **520** might denote the relative degree to which luminance levels are to be raised. The first key signal **514** preferably identifies and locates the upper left corner of the portion of content area **512** to be specially processed. The second key signal **516** preferably identifies and locates the lower right corner of the portion of content area **512** to be specially processed.

Alternate key signal embodiments may include other information, such as a field to denote the selection of different types of special processing that display **112** can perform. Window manager **314** of operating system **312** preferably creates both first key signal **514** and second key signal **516**. Key signals should not interfere with normal window **200** operation, and should not distract the user. Display **112** depicts the information contained in first key signal **514** and second key signal **516** in a visually unobtrusive manner to be further described in connection with FIG. **6** below. Alternate embodiments of the present invention may handle multiple windows **200** to be specially processed. Similarly, windows **200** to be specially processed are not necessarily required to be rectangular in shape. A minimum size for windows **200** is determined by the size of key signals; in other words, key signals should not protrude beyond the frame **510** of windows **200**.

In the preferred embodiment, video RAM **120** stores a digital representation of all pixels to be depicted on display **112**. Window manager **314** in operating system **312** encodes and stores both first key signal **514** and second key signal **516** in video RAM **120**, in the preferred embodiment. Application programs **310** define data to be displayed in content area **512** and supply such data to operating system **312**. The operating system **312** defines all other data to be displayed. Video generator **126** then, in the preferred embodiment, scans video RAM **120**, and produces video signals **418** transmitting the entire contents of video RAM **120** to display **112**. First key signal **514** and second key signal **516** are thus passed to display **112** along with all other contents of video RAM **120**, in the preferred embodiment.

A second communications channel, such as a separate serial interface, is therefore not required. However, since the entire contents of video RAM **120** will be depicted on display **112**, the information in first key signal **514** and in second key signal **516** should be encoded in a manner that will not be visually distinctive to the viewer when both key signals are depicted on display **112**. Furthermore, key signals transmitted to conventional video monitors, i.e. those not equipped to perform special processing, should not cause malfunctions or display aberrations.

Referring now to FIG. **6**, a timing diagram for one embodiment of display data **610** encoded into exemplary pixels **612** is shown, in accordance with the present invention. Display data **610** represents an arbitrary sequence of bits to be encoded into pixels **612** in a manner that will produce an unobtrusive achromatic gray when depicted on display **112**. Display data **610** is presented for purposes of illustration, and other embodiments may readily contain different sequences of binary data. Each bit of display data **610** is represented by two pixels **612**. Each pixel **612** has green, red, and blue content of various values. A return-to-zero encoding scheme is used so that a pair of up/down transitions occurs in one or two pixels **612**.

Green content is shown in a green waveform **614**, red content is shown in a red waveform **616**, and blue content is shown in a blue waveform **618**. In the FIG. **6** embodiment, window manager **314** uses green waveform **614** as a clock to clearly define the duration of individual pixels **612**, which is analogous to individual pixel **612** width in a rastered display **112**. Use of pixel **612** color data, represented in the preferred embodiment by green waveform **614**, as a clock renders use of a second clock communicated via a second communication

channel (such as a serial interface card) unnecessary. In the preferred embodiment, a rising edge of green waveform **614** clocks in preceding data. Red waveform **616** carries display data **610**. A transition from a high to a low display data **610** value or vice-versa causes red waveform **616** to alter its phase with respect to green waveform **614** as shown. The blue waveform **618** is the logical inverse of red waveform **616**.

The mixture of the green, red, and blue content as given in green waveform **614**, red waveform **616**, and blue waveform **618**, respectively, determines the overall perceived color of each resulting pixel **612**. In all figures, these letters denote the following colors: R=red, G=green, B=blue, C=cyan, M=magneta, Y=yellow. In additive color systems, cyan results from an equal mixture of green and blue, magenta results from an equal mixture of red and blue, and yellow results from an equal mixture of red and green. Mixing a secondary color with an opposing primary color (one not contained in the secondary color) of equal luminance generally results in a mixture that appears gray to the viewer. When a pixel **612** of a primary color (red, green, or blue) is located next to a pixel **612** of a corresponding secondary color (cyan, magenta, or yellow, respectively) of proper brightness, the resulting pair of pixels **612** approximates a single achromatic gray pixel **612** in appearance, given the limited spatial acuity of the human eye. Display **112** thus depicts display data **610** without notable visual aberration when display data **610** is encoded into pixels **612** colored in this manner. In the preferred embodiment, a binary logic value of "1" is denoted by a yellow pixel **612** neighboring a blue pixel **612**, and a binary logic value of "0" is denoted by a cyan pixel **612** neighboring a red pixel **612**. The first key signal **514** and the second key signal **516** of the FIG. **6** embodiment are patterns of data display **610** bits that have been accordingly color-coded into pixels **612**, forming embedded instructions to trigger special window processing. Modifications to this particular embodiment using configurations other than those described above are intended to be covered by the present invention. For example, in some display systems it may be preferable to use red waveform **616** as a clock signal and blue waveform **618** as the data signal.

Referring now to FIG. **7**A, a block diagram for the preferred embodiment of a key signal format **710** for FIG. **5** key signals **514** and **516** is shown, in accordance with the present invention. Referring also to FIG. **7**B, a table describing one embodiment for components **712** through **722** of the FIG. **7**A key signal format **710** is shown. First key signal **514** and second key signal **516** each include fields of display data **610** bits as shown in key signal format **710**. The data fields or key signal components include a start sequence (START) **712**, a code sequence (CODE) **714**, a horizontal offset (HOFF) **716**, a vertical offset (VOFF) **718**, a CRC checksum (CRC) **720**, and a stop sequence (STOP) **722**, as shown in FIG. **7**A and described in FIG. **7**B. These foregoing key signal components enable window decoder **416** to detect key signals **514** and **516**, and to extract special window information reliably. Definition of special window coordinates relative to the beginning of vertical or horizontal scans of display **112** is more efficient than definition of absolute special window coordinates from a clock signal transmitted via an additional communications channel. Alternate embodiments may include other key signal components. Similarly, alternate embodiments may use more complex key signals, such as a hidden watermark or a highly visible copyright or trademark logo.

Start sequence **712** of the preferred embodiment is a 6-bit pattern in which the data on blue waveform **618** is equal to the data on red waveform **616**, i.e., logical inversion is not performed. This distinguishes start sequence **712** from code sequence **714**, horizontal offset **716**, vertical offset **718**, and CRC checksum **720**, enabling window decoder **416** to reliably discern the presence of start sequence **712**. Start sequence **712** clears registers and resets counters in window decoder **416**, as will be detailed below.

Code sequence **714** of the preferred embodiment is a unique 16-bit pattern used to distinguish the presence of first key signal **514** or second key signal **516** from other display data **610**. Use of a unique pattern for code sequence **714** substantially reduces the likelihood that other display data **610** will accidentally be misconstrued as either first key signal **514** or second key signal **516** and trigger unintended special window processing. Different code sequences **714** are used for first key signal **514** and second key signal **516**, with one preferably the logical inverse of the other. In the preferred embodiment, code sequence **714** for first key signal **514** is 0001101111100100, and code sequence **714** for second key signal **516** is 1110010000011011. Both key signals should be found by window decoder **416** during a single scan of display **112** in order to determine the presence of a window **200** to be specially processed. Use of a static pattern for first key signal **514** or for second key signal **516** enables a static image of a special window alone to trigger special window processing whenever the static image is displayed. No separate signals are required to activate special window processing because the key signals are contained within the static image.

Horizontal offset **716** of the preferred embodiment is a 9-bit pattern denoting the horizontal distance in pixels **612** from the beginning of a reference point to the horizontal edge of content area **512** that is to be differently processed. One bit of horizontal offset **716**, preferably the ninth, is used as a sign bit indicating an offset to the left of the reference point if set, and an offset to the right of the reference point if not set. For first key signal **514**, the reference point is the end of start sequence **712** of first key signal **514**, so that the left border of the portion of content area **512** to be specially processed is located at the end of start sequence **712** plus or minus horizontal offset **716**. For second key signal **516**, the reference point is the beginning of stop sequence **722** of second key signal **516**, so that the right border of the portion of content area **512** to be specially processed is located at the beginning of stop sequence **722** plus or minus horizontal offset **716**. Summation of horizontal key signal reference positions and horizontal key signal offsets thus determines the horizontal coordinates of the portion of content area **512** to be specially processed.

Vertical offset **718** of the preferred embodiment is an 8-bit pattern denoting the vertical distance in pixels **612** from the beginning of a reference point to the vertical edge of the content area **512** to be differently processed. For first key signal **514**, the reference point is the vertical line on which first key signal **514** begins, and the offset is counted downward. For second key signal **516**, the reference point is the vertical line on which second key signal **516** begins, and the offset is counted upward. Summation of vertical key signal reference positions and vertical key signal offsets thus determines the vertical coordinates of the portion of content area **512** to be specially processed.

Horizontal offsets **716** and vertical offsets **718** are necessary. Application programs **310** control the display data **610** to be depicted inside content area **512**, while operating system **312** controls frame **510** and the key signals located in frame **510**. In the preferred embodiment, both horizontal offsets **716** and vertical offsets **718** are set to default values that select entire content area **512** but not frame **510** elements such as scroll bars for special processing. Different offset values select a subset of content area **512** for special processing.

CRC checksum **720** for horizontal offset **716** and vertical offset **718** is preferably an 8-bit polynomial data pattern, 10011001, used to reduce the possibility of error in the offsets. Stop sequence **722** of the preferred embodiment is a 6-bit data pattern in which the data on blue waveform **618** is equal to the data on red waveform **616**, i.e., logical inversion is not performed. As with start sequence **712**, this distinguishes stop sequence **722** from code sequence **714**, horizontal offset **716**, vertical offset **718**, and CRC checksum **720**, enabling window decoder **416** to confirm the presence of stop sequence **722**.

Referring now to FIG. **8**, a block diagram for the preferred embodiment of the FIG. **4** window decoder **416** is shown, in accordance with the present invention. In the preferred embodiment, window decoder **416** is intended to be fabricated onto a single low-cost ASIC (application-specific integrated circuit). In operation, video generator **126** (FIG. **4**) creates a vertical synchronization pulse **810** to indicate the beginning of a new vertical scan of display **112** and a horizontal synchronization pulse **812** to indicate the beginning of a new scan of a horizontal line of pixels **612** on display **112**. Video generator **126** also produces green waveform **614**, red waveform **616**, and blue waveform **618** as well as a signal from which clamp signal **814** is generated to indicate the black level of the incoming video waveforms.

Incoming waveforms **614**, **616**, **618**, and **814** are fed into an analog-to-TTL converter **816**, which produces digital signals from each color waveform based on the respective signal levels at the time the clamp signal is asserted. In the preferred embodiment, if a color waveform is at the clamp voltage level, a logical zero is assigned to the digital signal corresponding to that color waveform. If a color waveform is at 700 millivolts with respect to the clamp signal voltage level, preferably, a logical one is assigned to the digital signal corresponding to that color waveform. In the preferred embodiment, the green signal from the analog-to-TTL converter **816** is used as a video clock signal **818**. Video clock signal **818** is present only when first key signal **514** or second key signal **516** are being processed. A frequency control unit **820** selectively passes video clock signal **818** to a phase-locked loop (PLL) **822** to generate a separate but synchronous internal clock signal **824**. Internal clock signal **824** is necessary for clocking data into logic circuitry of window decoder **416**; video clock signal **818** is not always available and thus cannot be used directly for this purpose. Internal clock signal **824** is available for use by all logic circuitry of window decoder **416**, its connection to each logic circuitry element is omitted for clarity. An external low pass filter **826** is connected to the phase-locked loop (PLL) **822** which serves as an analog memory of the phase-frequency relationship between internal clock signal **824** and video clock signal **818**.

The coordinates of the current pixel **612** in display **112** are tracked by window decoder **416**. Each pulse of internal clock signal **824** denotes a single pixel **612** and increments horizontal counter **828**. Horizontal synchronization pulse **812** indicates the beginning of a scan of a new horizontal line, and resets horizontal counter **828** and increments vertical counter **830**. Vertical synchronization pulse **810** denotes the beginning of a new scan of display **112** and resets vertical counter **830**. The location of any current pixel **612** can thus be determined by the contents of horizontal counter **828** and vertical counter **830**.

Logic circuitry referred to as key signal verify A **832** in window decoder **416** detects and verifies the first key signal **514**. Identical circuitry referred to as key signal verify B **834** in window decoder **416** detects and verifies the second key signal **516**. Video clock signal **818** and TTL-level versions of red waveform **616** and blue waveform **618** are fed into the key signal verification circuits **832** and **834**. Start sequence **712** triggers the key signal verification process of matching immediately following display data **710** with code sequences **714**. If key signal verify A **832** successfully matches display data **710** with code sequence **714** corresponding to first key signal **514**, then window decoder **416** loads the first key signal **514** coordinates from horizontal counter **828** and vertical counter **830** into start register **836**. Similarly, if key signal verify B **834** successfully matches display data **710** with code sequence **714** corresponding to second key signal **516**, then window decoder **416** loads the second key signal **516** coordinates from horizontal counter **828** and vertical counter **830** into end register **838**.

Window decoder **416** performs additional checks to ensure the validity of key signals to prevent incorrect detection of windows **200** requiring special processing. Both key signals should be present for a number of scans of display **112** to enable special processing. The number of bits in the key signal data, that is, excluding start sequence **712** and stop sequence **722**, should match the preferred number of key signal data bits. Additionally, the duration of key signals measured in terms of internal clock signal **824** periods is checked by window decoder **416**. If the number of bits in the first half of a key signal does not match the number of bits in the second half of a key signal in a period of time determined by a number of internal clock signal **824** periods, the key signal is deemed invalid. The duration matching and bit counting described above helps to verify that internal clock signal **824** is properly synchronized to video clock signal **818**, further preventing errors.

Key signal verify A **832** and key signal verify B **834** also extract horizontal offset **716**, vertical offset **718**, and CRC checksum **720** for first key signal **514** and second key signal **516**, respectively. If no CRC error is found, window decoder **416** stores offset information for first key signal **514** in start offset register **840**. Similarly, if no CRC error is found, window decoder **416** stores offset information for second key signal **516** in end offset register **842**. Contents of start register **836** and start offset register **840** are summed by an adder **844** to compute the upper left coordinates of the portion of content area **512** to be specially processed. Similarly, the contents of end register **838** and end offset register **842** are summed by a second adder **846** to compute the lower right coordinates of the portion of content area **512** to be specially processed. When key signal verify A **832** detects and verifies first key signal **514** and key signal verify A **834** detects and verifies second key signal **516**, enable control **848** sets an attribute denoting the presence of a window to be specially processed. Window decoder **416** monitors this attribute, and disables the attribute if no key signals are detected, indicating that there are no windows to be specially processed or that a special window exists but is occluded.

Comparator **850** selectively generates control signal **420** based on the values of its inputs, which are the coordinates of current pixel **612** from horizontal counter **828** and vertical counter **830**, the coordinates of the portion of content area **512** to be specially processed from adders **844** and **846**, and the attribute denoting the presence of a window to be specially processed from enable control **848**. If the current pixel **612** is within the portion of content area **512** to be specially processed and a special window is present, then comparator **850** generates control signal **420**. Power-on reset **852** produces reset signal **854** to initialize window decoder **416** when display **112** is first turned on.

Referring now to FIG. **9**, a flowchart for one embodiment of method steps to process special windows is shown, in accordance with the present invention.

Initially, in step **910**, window decoder **416** determines whether a new vertical scan of display **112** has started. Window decoder **416** accomplishes this by checking for the presence of vertical synchronization pulse **810**. If a new vertical scan has started, then window decoder **416** proceeds to step **916** to begin the process of identifying and locating special windows. If a new vertical scan has not started, then window decoder **416** proceeds to step **912**.

In step **912**, window decoder **416** determines whether the current pixel **612** is located within the portion of content area **512** to be specially processed, and whether an attribute denoting the activation of a special window is enabled. If the current pixel **612** is located within the portion of content area **512** to be specially processed and the attribute denoting the activation of a special window is enabled, then, in step **914**, window decoder **416** enables control signal **420**. Control signal **420** is passed to video amplifier **414** to indicate the presence of a pixel **612** to be specially processed. For example, if control signal **420** is enabled, video amplifier **414** may responsively increase the luminance of the current pixel **612**. However, if the current pixel **612** is not located within the portion of content area **512** to be specially processed or the attribute denoting the activation of a special window is not enabled, window decoder **416** disables control signal **420** in step **915**. Window decoder **416** then returns to step **910** to either process the next pixel **620** in step **912** or to begin the process of identifying and locating special windows in step **916**.

In step **916**, window decoder **416** determines whether the attribute denoting the activation of a special window is enabled. If the attribute denoting the activation of a special window is enabled, then window decoder **416** proceeds to step **918**. If the attribute denoting the activation of a special window is not enabled, then window decoder **416** proceeds to step **922** to look for first key signal **514**.

In step **918**, window decoder **416** determines whether at least one key signal (either first key signal **514** or second key signal **516**) was detected in the previous scan of display **112**. If at least one key signal was detected in the previous scan of display **112**, window decoder **416** proceeds to step **912** to selectively process the current pixel **612**, since at this point it is known that a special window has been activated but it is not yet known whether the current pixel **612** is within that special window. If no key signals were detected in the previous scan of display **112**, window decoder **416** proceeds to step **920** to disable the attribute denoting the activation of a special window. Disabling the attribute denoting the activation of a special window may be required because there are no special windows to be processed, or because a special window exists, but is now occluded by a standard window.

In step **922**, window decoder **416** determines whether both first start sequence **712'** and first code sequence **714** have been detected, signifying that first key signal **514** has been found. If both first start sequence **712** and first code sequence **714** have been detected, then window decoder **416** proceeds to step **924**. If either first start sequence **712** or first code sequence **714** have not been detected, then window decoder **416** returns to step **910** to either process the next pixel **612** in step **912** or to begin the process of identifying and locating special windows in step **916**.

In step **924**, window decoder **416** stores information about the location of the upper left corner of the portion of content area **512** to be specially processed. Specifically, window decoder **416** stores horizontal offset **716**, and vertical offset **718** from first key signal **514**, and uses CRC checksum **720** to validate these values. Window decoder **416** also stores the vertical and horizontal position of current pixel **612** with respect to the upper left corner of display **112**. The vertical position of current pixel **612** is computed from the count of the horizontal lines scanned since vertical synchronization pulse **810** triggered a new scan of display **112**. The horizontal position of current pixel **612** is computed from the count of pixels **612** scanned since horizontal synchronization pulse **812** triggered a scan of a new horizontal line of display **112**.

Then, in step **926**, window decoder **416** matches the frequency of video clock signal **818** with the internal clock signal **824**. This is accomplished via frequency control block **820** and phase-locked loop **822**. Video clock signal **818** is known to be present because first key signal **514** has been detected in step **922** above, and one waveform of first key signal **514** (preferably green waveform **614**) is used specifically for clocking purposes. The synchronization of video clock signal **818** and internal clock signal **824** guarantees that the intended width and duration of pixels **612** to be specially processed matches the actual width and duration of pixels **612** that are specially processed. The matching of pixel **612** widths prevents problems of horizontal pixel blurring that may occur in display systems using dual, versus single, communications channels.

Then, in step **928**, window decoder **416** determines whether both second start sequence **712** and second code sequence **714** have been detected, signifying second key signal **516** has been found. If both second start sequence **712** and second code sequence **714** have been detected, then window decoder **416** proceeds to step **930**. If either second start sequence **712** or second code sequence **714** have not been detected, then window decoder **416** returns to step **910** to either process the next pixel **612** in step **912** or to begin the process of identifying and locating special windows in step **916**.

Next, in step **930**, window decoder **416** stores information about the lower right corner of the portion of content area **512** to be specially processed. Specifically, window decoder **416** stores horizontal offset **716**, and vertical offset **718** from second key signal **516** and uses CRC checksum **720** to validate these values. Window decoder **416** also stores the vertical and horizontal position of current pixel **612** with respect to the upper left corner of display **112**. The vertical position of current pixel **612** is computed from the count of the horizontal lines scanned since vertical synchronization pulse **810** triggered a new scan of display **112**. The horizontal position of current pixel **612** is computed from the count of pixels **612** scanned since horizontal synchronization pulse **812** triggered a scan of a new horizontal line of display **112**.

Finally, in step **932** window decoder **416** enables the attribute denoting the activation of a special window. By this point, window decoder **416** has located both first key signal **514** and second key signal **514** to identify the presence of a non-occluded special window. Window decoder **416** has also extracted all of the information regarding the location of the special window. The window decoder **416** then returns to step **910** to either process the next pixel in step **912** or to begin the process of identifying and locating special windows in step **916**.

The invention has been explained above with reference to a preferred embodiment. Other embodiments will be apparent to those skilled in the art in light of this disclosure. For example, the present invention may readily be implemented using configurations other than those described in the preferred embodiment above. Additionally, the present invention may effectively be used in conjunction with systems other

than the one described above as the preferred embodiment. Therefore, these and other variations upon the preferred embodiments are intended to be covered by the present invention, which is limited only by the appended claims.

What is claimed is:

1. An apparatus for generating an image on a display, wherein said image includes one or more special windows, comprising:

a window manager to embed special window information in a video signal comprised of a first color signal, a second color signal, and a third color signal with said first color signal including said special window information, wherein said video signal characterizes said image to be generated on said display and said first and second color signals are used to display said special window information on said display; and

a window decoder to extract said special window information from said video signal and responsively generate a display control signal, wherein said display control signal enables special processing of portions of said video signal associated with said one or more special windows, and wherein said special processing results in said one or more special windows being produced on said display with one or more display attributes that differ from non-processed portions of said video signal.

2. The apparatus of claim **1**, wherein said window manager is included in an operating system.

3. The apparatus of claim **1**, wherein said window decoder is implemented as an application-specific integrated circuit.

4. The apparatus of claim **1**, further comprising:

a target area in said special windows to be specially processed in response to said display control signal, wherein said special processing results in said target area being produced on said display with one or more display attributes that differ from non-target areas; and

a video interface to transmit data including said special window information to said display.

5. The apparatus of claim **4**, wherein:

said third color signal serves as a video clock signal for said special window information.

6. The apparatus of claim **5**, further comprising:

key signals including a pattern of bits of said special window information to encode a target area position, and corresponding to a pattern of pixels depicted in said display.

7. The apparatus of claim **6**, wherein components of said key signals include:

a start sequence indicating a beginning of said key signals;

a code sequence distinguishing said key signals from said data;

a horizontal offset sequence indicating a boundary of said target area relative to a horizontal position of said key signals;

a vertical offset sequence indicating a second boundary of said target area relative to a vertical position of said key signals;

a CRC checksum verifying said horizontal offset sequence and said vertical offset sequence; and

a stop sequence indicating an end of said key signals.

8. The apparatus of claim **7**, further comprising:

nondifferential key signal data indicating said start sequence and said stop sequence; and

differential key signal data indicating remaining components of said key signals.

9. The apparatus of claim **7**, further comprising:

a number sequence indicating a number of special windows.

10. The apparatus of claim **7**, further comprising:

a shape sequence indicating a shape of said target area when said target area is not rectangular.

11. The apparatus of claim **7**, further comprising:

a selection sequence indicating a selection from among a plurality of available special processes.

12. The apparatus of claim **5**, further comprising:

pixel pairs in said display, each member pixel of said pixel pairs being proximately located, said pixel pairs being colored according to said first color signal, said second color signal, and said third color signal in an additively complementary manner to visually approximate a single pixel of a mixed color.

13. The apparatus of claim **1**, wherein the special window information is embedded in the video signal so as to be visually indistinctive to a viewer.

14. A method for generating an image on a display, wherein said image includes one or more special windows, comprising the steps of:

embedding special window information in a video signal comprised of a first color signal, a second color signal, and a third color signal with said first color signal including said special window information, wherein said video signal characterizes said image to be generated on said display and said first and second color signals are used to display said special window information on said display;

extracting said special window information from said video signal; and

generating a display control signal in response to said window information to enable different processing of portions of said video signal associated with said one or more special windows, wherein said different processing results in said one or more special windows being produced on said display with one or more display attributes differing from non-processed portions of said video signal.

15. The method of claim **14**, wherein said step of embedding is performed by a window manager that is included in an operating system.

16. The method of claim **14**, wherein said step of extracting is performed by a window decoder implemented as an application-specific integrated circuit.

17. The method of claim **14**, further comprising the steps of:

specially processing a target area in said special windows in response to said display control signal, wherein said special processing results in said target area being produced on said display with one or more display attributes that differ from non-target areas; and

transmitting data including said special window information to said display using a video interface.

18. The method of claim **17**, further comprising the steps of:

depicting pixels in said display; and

using the third color signal as a video clock signal for said special window information.

19. The method of claim **18**, further comprising the steps of:

transmitting key signals including a pattern of bits of said special window information to encode a target area position, and

corresponding to a pattern of said pixels depicted in said display.

20. The method of claim **19**, wherein said step of transmitting said key signals further comprises the step of concurrently transmitting within said key signals:

a start sequence indicating a beginning of said key signals;
a code sequence distinguishing said key signals from said data;
a horizontal offset sequence indicating a boundary of said target area relative to a horizontal position of said key signals;
a vertical offset sequence indicating a second boundary of said target area relative to a vertical position of said key signals;
a CRC checksum verifying said horizontal offset sequence and said vertical offset sequence; and
a stop sequence indicating an end of said key signals.

21. The method of claim **20**, further comprising the steps of:
transmitting nondifferential key signal data indicating said start sequence and said stop sequence; and
transmitting differential key signal data indicating remaining components of said key signals.

22. The method of claim **20**, further comprising the step of:
transmitting a number sequence indicating a number of special windows.

23. The method of claim **20**, further comprising the step of:
transmitting a shape sequence indicating s shape of said target area when said target area is not rectangular.

24. The method of claim **20**, further comprising the step of:
transmitting a selection sequence indicating a selection from among a plurality of available special processes.

25. The method of claim **18**, further comprising the step of:
depicting pixel pairs in said display, each member pixel of said pixel pairs being proximately located, said pixel pairs being colored according to said first color signal, said second color signal, and said third color signal in an additively complementary manner to visually approximate a single pixel of a mixed color.

26. The method of claim **19**, wherein said step of transmitting said key signals further comprises the steps of:
transmitting a start sequence indicating a beginning of said key signals;
transmitting a code sequence distinguishing said key signals from said data;
transmitting a horizontal offset sequence indicating a boundary of said target area relative to a horizontal position of said key signals;
transmitting a vertical offset sequence indicating a second boundary of said target area relative to a vertical position of said key signals;
transmitting a CRC checksum verifying said horizontal offset sequence and said vertical offset sequence; and
transmitting a stop sequence indicating an end of said key signals.

27. The method of claim **14**, wherein the special window information is embedded in the video signal so as to be visually indistinctive to a viewer.

28. A system for generating an image on a display, wherein said image includes one or more special windows, comprising:
means for embedding special window information in a video signal comprised of a first color signal, a second color signal, and a third color signal with said first color signal including said special window information, wherein said video signal characterizes said image to be generated on said display and said first and second color signals are used to display said special window information on said display;
means for extracting said special window information from said video signal; and
means for generating a display control signal in response to said window information to enable different processing of portions of said video signal associated with said one or more special windows, wherein said different processing results in said one or more special windows being produced on said display with one or more display attributes differing from non-processed portions of said video signal.

29. The system of claim **28**, wherein the special window information is embedded in the video signal so as to be visually indistinctive to a viewer.

30. A computer-readable medium comprising program instructions for generating an image comprised of one or more special windows on a display by performing the steps of:
embedding a special window information in a video signal comprised of a first color signal, a second color signal, and a third color signal with said first color signal including said special window information, wherein said video signal characterizes said image to be generated on said display and said first and second color signals are used to display said special window information on said display;
extracting said special window information from said video signal; and
generating a display control signal in response to said window information to enable special processing of portions of said video signal associated with said one or more special windows, wherein said special processing results in said one or more special windows being produced on said display with one or more display attributes that differ from non-processed portions of said video signal.

31. The computer-readable medium of claim **30**, wherein the special window information is embedded in the video signal so as to be visually indistinctive to a viewer.

32. A method for displaying an image on a display, wherein said image includes one or more special windows, comprising the steps of:
receiving a video signal that represents said image to be generated on said display, wherein said video signal is comprised of a first color signal, a second color signal, and a third color signal with said first color signal including at least one key signal embedded therein;
extracting said at least one key signal from said video signal;
selectively generating a display control signal in response to said at least one key signal, wherein said display control signal indicates a target area within said one or more special windows is to be specially processed in order to display said target area with one or more display attributes that differ from non-target areas; and
generating an output signal based on said video signal and the presence or absence of said display control signal, wherein said output signal produces said image including said one or more special windows on said display and said first and second color signals are used to display said at least one key signal to be displayed on said display.

33. The method of claim **32**, further comprising the step of disabling special processing when a special window is covered by another window.

34. An apparatus for displaying an image on a display, wherein said image includes one or more special windows, comprising:
means for receiving a video signal that represents said image to be generated on said display, wherein said

video signal is comprised of a first color signal, a second color signal, and a third color signal with said first color signal including at least one key signal embedded therein;

means for extracting said at least one key signal from said video signal;

means for selectively generating a display control signal in response to said at least one key signal, wherein said display control signal indicates a target area within said one or more special windows is to be specially processed in order to display said target area with one or more display attributes that differ from non-target areas; and

means for generating an output signal based on said video signal and the presence or absence of said display control signal, wherein said output signal produces said image including said one or more special windows on said display and said first and second color signals are used to display said at least one key signal to be displayed on said display.

35. The apparatus of claim **34**, further comprising means for disabling special processing when a special window is covered by another window.

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