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METHOD AND APPARATUS FOR FILLING AN OBJECT BASED RASTERISED IMAGE

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WO 83/02510

(57) Claim

1. A method of filling an object based rasterised image comprising a plurality of graphic objects, said method comprising the steps of:

comparing a (first) pixel position in a raster line with pixel edge intersection data of the plurality of graphic objects to determine if an edge exists at said first pixel position;

in the case that no edge exists at said first pixel position, moving to a next pixel position along the raster line while maintaining a currently displayed pixel fill level at said first pixel position; and

in the case an edge exists at said first pixel position, selecting fill level data for each possible one of said plurality of graphic objects able to be represented at said first pixel position, and then displaying at said first pixel position the fill level data corresponding to the highest priority of said plurality of graphic objects as the current pixel fill level.

2. Apparatus for filling an object based rasterised image comprised of a plurality of graphic objects, said apparatus comprising:

comparator means for comparing a pixel position in a line of said rasterised image with a pixel position of an edge intersection of said plurality of graphic objects to determine if an edge exists at said pixel position;

selector means for selecting, in the case an edge exists at said pixel position,

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fill level data for each possible one of said plurality of graphic objects able to be represented at said pixel position; and

a priority encoder means for determining a priority fill level of each of said plurality of graphic objects and for displaying the fill level data corresponding to the highest priority fill level as the current pixel fill level at said pixel position.

3. Apparatus for filling an object based rasterised image, said apparatus comprising:

pixel location means for producing a current pixel value or a pre pixel start value;

comparator means for receiving said values from said pixel location means and edge position values and outputting an edge display signal when said edge position value is greater than or equal to said current pixel value or said pre pixel start value;

combination means for receiving said edge display signal and a pre edge start signal and combining said signals to produce a toggle signal;

toggle means for receiving fill level values corresponding to said edge position values and toggling a corresponding fill level state from a first state to a second state; and

priority determination means for receiving said fill level states from said toggle means and producing a priority output level corresponding to the highest fill level in said second state.

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COMPLETE SPECIFICATION

FOR A STANDARD PATENT

ORIGINAL

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ASSOCIATED PROVISIONAL APPLICATION DETAILS

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PL2148	AU	29 April 1992

The following statement is a full description of this invention, including the best method of performing it known to me/us:-

METHOD AND APPARATUS FOR FILLING AN OBJECT BASED RASTERISED IMAGE

The present invention relates to object based graphics systems, and, in particular, discloses a method and apparatus for providing hidden surface removal by filling an object based rasterised image prior to displaying that image either on a video display or by means of printing.

Most object based graphics systems utilise a frame store or page buffer to hold a pixel based image of the page or screen. The outlines of the objects are calculated, filled and written into the frame store. For two-dimensional graphics, objects which appear in front of other objects are simply written into the frame store after the background object, thereby replacing the background on a pixel-by-pixel basis. This is commonly known in the art as "Painter's algorithm". Images are calculated in object order, from the rearmost object to the foremost object. However, real-time image generation for raster displays requires the calculation of images in raster order. This means that each scan-line must be calculated as it is reached, thus requiring that the intersection points of each scan line with each object outline are calculated and then subsequently filled.

Although it is possible, with a line buffer rather than a page buffer, to use the Painter's algorithm within a scan-line to fill the objects, image generation in real-time, at video data rates is expensive using this method.

It is an object of the present invention to substantially overcome the abovementioned difficulties through provision of a means by which overlying objects in an image can be filled on a line-by-line basis, without the need for a frame or line store.

In accordance with one aspect of the present invention there is disclosed A method of filling an object based rasterised image comprising a plurality of graphic objects, said method comprising the steps of:

comparing a (first) pixel position in a raster line with pixel edge intersection data of the plurality of graphic objects to determine if an edge exists at said first pixel position;

in the case that no edge exists at said first pixel position, moving to a next pixel position along the raster line while maintaining a currently displayed pixel fill level at said first pixel position; and

in the case an edge exists at said first pixel position, selecting fill level data for each possible one of said plurality of graphic objects able to be represented at said first pixel position, and then displaying at said first pixel position the fill level data corresponding to the highest priority of said plurality of graphic objects as the current pixel fill level.

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In accordance with another aspect of the present invention there is disclosed apparatus for filling an object based rasterised image comprised of a plurality of graphic objects, said apparatus comprising:

comparator means for comparing a pixel position in a line of said rasterised image with a pixel position of an edge intersection of said plurality of graphic objects to determine if an edge exists at said pixel position;

selector means for selecting, in the case an edge exists at said pixel position, fill level data for each possible one of said plurality of graphic objects able to be represented at said pixel position; and

a priority encoder means for determining a priority fill level of each of said plurality of graphic objects and for displaying the fill level data corresponding to the highest priority fill level as the current pixel fill level at said pixel position.

In accordance with another aspect of the present invention there is disclosed apparatus for filling an object based rasterised image, said apparatus comprising:

pixel location means for producing a current pixel value or a pre pixel start value;

comparator means for receiving said values from said pixel location means and edge position values and outputting an edge display signal when said edge position value is greater than or equal to said current pixel value or said pre pixel start value;

combination means for receiving said edge display signal and a pre edge start signal and combining said signals to produce a toggle signal;

toggle means for receiving fill level values corresponding to said edge position values and toggling a corresponding fill level state from a first state to a second state; and

priority determination means for receiving said fill level states from said toggle means and producing a priority output level corresponding to the highest fill level in said second state.

A preferred embodiment of the present invention will now be described with reference to the drawings in which:

Fig. 1 is a schematic block diagram representation of an object based graphics system which includes the preferred embodiment;

Fig. 2 illustrates the outlines of an image formed of a number of objects;

Fig. 3 illustrates the image of Fig. 2 when viewed in priority order;

Fig. 4 is a view similar to Fig. 3, in which each of the objects is fully coloured;

Fig. 5 is a view similar to Fig. 4 after hidden surfaces are removed;

Fig. 6 is a view of the image of Fig. 5;

Fig. 7 is a simple embodiment of the present invention; and

Fig. 8 is a preferred embodiment configured for use in an object based graphic system.

Referring firstly to Fig. 1, a data flow diagram of a real time object based graphic system 1 is shown which is characterised by the absence of an image frame store. The system 1 generally includes an image creation workstation 2 which permits a user to select various images either using a drawing tablet, image scanner, database of images, or the like. The user can input specific commands via a command console 3 to a processor 4 which acts to divide the images into objects and to create a page display list of those objects.

As indicated earlier, where an image frame store is available, the objects need only be stored in the frame store on a one-by-one basis so to form the entire image. However, in real time image generation, the processing required to calculate, store, as well as overwrite pixel data within such a memory is excessive and therefore not suitable for low cost systems.

Specifically, it is required that each of the objects of the final image be processed on a line-by-line basis. This is performed initially by forming, translating and scaling of portions of the objects (object fragments) 5 for each object of the image. The various sub-objects are then sorted 6 into the order into which they will appear in each raster line of the

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display. Edge calculation 7 then occurs which determines the intersection between all object fragments of the image such that the image need only be represented by edge pixel data, and the colour level into which the image changes after crossing each edge. This data is then output to a fill calculator 8 which, using the edge pixel data and the colour level, and in synchronisation with a display 10, outputs pixel level data for each pixel of the raster line for the image. This pixel level data is then input to a colouring device 9 which outputs specific colour information either in RGB (red, green, blue) or CMYK (cyan, magenta, yellow and black) or other colour data formats to an image display 10 such as a video display or a printer respectively.

As illustrated in Fig. 1, the data flow stages 5, 6, 7, and 8 can be combined into a single real time objects graphics processor 11 such as that disclosed in Australian Patent Application No. 38244/93 (Attorney Ref: (RTO7)(202788)) entitled "A Real-Time Object Based Graphics System", claiming priority from Australian Patent Application No PL2147 of 29 April, 1993, lodged concurrently herewith and the disclosure of which is hereby incorporated by cross-reference.

Figs. 2 to 6 show the image generation process, termed "rasterisation" just described. In this case, an image 12 is formed by a background 13 which acts as a first object, a character "A" 14 which acts as a second object, a rectangle 16 which acts as a third object, and a circle 15 which acts as a fourth object.

Fig. 2 shows the outline information of the image 12 which is a series of numbers which describe each fragment of the outline of the curves and the priority level of each curve fragment. The priority level is analogous to the level each object takes in the resultant image and the manner in which the objects overlie each other. This complements the arrangement obtained through the use of Painter's algorithm. Also seen in Fig. 2 is a sectional line 18-18 representing a single scan-line which is used with reference to Figs. 3, 4 and 5.

As seen in Fig. 3, edge calculation of the intersection of each scan line with the outline fragments to be rendered is involved. This results in a sorted list of the pixel position of each fragment intersection, along with the priority level. Fig. 3 shows a cross-section through the line 18-18 of Fig. 2 which represents a single scan line of the image and in which the priority level is represented by the height of each of the layers in Fig. 3.

In Fig. 4, the regions to be filled are generated. These regions are filled by the "even/odd rule". This involves, where the first intersection encountered turns the fill of colour ON, the second intersection turns the fill OFF, and third turns the fill ON and so on. This

fill method allows holes in objects, such as in the character A 14, to allow the background 13 to appear there through.

Next, as seen in Fig. 5, hidden surfaces are removed. Objects that are obscured by other objects of a higher priority order are removed thereby creating a string of data for a single scan line which is divided by blocks of varying pixel colour level.

Fig. 6 shows the resultant image 12 as printed or displayed in which the circle 15 has the highest priority and the background 13 the lowest.

The present invention is concerned specifically with a method and apparatus by which the results of Figs. 4 and 5 are achieved.

Referring now to Fig. 7, a fill calculator 20 is shown which receives pixel edge position data 21 and colour level data 24 from an edge calculator 7 such as that seen in Fig. 1. A further input relating to the pixel position in the raster line 22 arrives synchronously from the display, such as the display 10 in Fig. 1, such that pixel data can be output in a synchronous fashion thereto. The level data 24 for each edge is fully decoded using a decoder 30 to output individual bit level data 25 to the inputs of a plurality of toggle latches 26, one latch for each value of decoded level data 25.

A comparator 23 is provided to compare the pixel edge position 21 with the pixel position in the line 22. If the pixel edge value is negative or if it is less than or equal to the value of the pixel position in the line, the toggle latches 26 are clocked simultaneously. This causes the toggle latch corresponding to the particular object's level to toggle, whilst all the other latches remain unaffected. This implements the even/odd rule as previously stated. The outputs of the toggle latches 26 correspond to all of the currently active objects in the display. This operation is equivalent to the level fill provided in Fig. 4.

A priority encoder 28 connects to the output of the toggle latches 26 and selects the highest level output that is asserted. This is then encoded and output as the fill level 29. Accordingly, the priority encoder 28 performs hidden surface removal as seen in Fig. 5. For example, if the priority level of the just clocked level, is less than that being output by the priority encoder 28, the colour level output 29 remains unchanged. Alternatively, if the just clocked level is higher than that being output by the priority encoder, the level output 29 is changed to that of the just clocked level. Also, if the just clocked level is the same as the current highest priority level, the output will change to the highest active level below the current level. This causes the output image to change in accordance with the transition of an edge between two objects in which it is intended that the second object have higher priority and overlie the first. The output level data 29 is then used to select a colour which is displayed in the pixel position in the raster line on the display.

Referring now to Fig. 8, the preferred embodiment of a fill calculator 40 is shown in which the pixel position of object edges in the current line are input and comprise 16 bits of edge position data (EP) 41 and 6 bits of fill level (FL) 49. A pixel clock (PCLK) 43 in synchronism with the display, inputs to a pixel counter 45, which, together with an initialised number of pixels 44, output from the pixel counter 45 the current pixel position in the present raster line which is input to an "A" input of a comparator 46. The edge position data (EP) 41 is provided to a "B" input of the comparator 46 which has an output 47 connected to one input of a NOR gate 48. The NOR gate 48 is also input with the most significant bit (EP15) 42 of the pixel data 41. The NOR gate 48 outputs to a clock input 52 of a bank of 64 J-K flip-flops 51 connected as toggle latches. Each of the flip-flops 51 is enabled with a single decoded fill level 49 supplied via a 6-to-64 decoder 50. When the flip-flops 51 are clocked via the clock input 52, those flip-flops corresponding to enabled levels change state (toggle) to implement the even/odd rule. The toggle flip-flops 51 are reset at the beginning of each line by a line sync 56. The output of the toggle flip-flops 51 are connected to a priority circuit 53, which only allows the highest of the 64 input states to be represented on its output states. This "highest state" is then encoded into a 6- bit binary number by the encoder 54, providing the output level 55.

The output level data 55 can then be input to a colour look-up table (not illustrated but known in the art) to output a 24-bit block of actual colour data for the pixel being displayed.

The fill calculators of Figs. 7 and 8 provide a means by which a result equivalent to painter's algorithm can be achieved without incurring the necessary expense and time loss found with a full page store. In the specific implementations as described in the aforementioned Australian Patent Application No. PL2147 (Attorney Ref: 202788), the graphic objects are processed as quadratic polynomial fragments which, in view of their simpler mathematical representation when compared to (Bezier) spline based object data, permit rapid processing up to and including edge calculation 7. However, the present invention is not limited to graphics systems which operate on quadratic polynomial fragments.

The foregoing describes a number of embodiments of the present invention, and modifications obvious to those skilled in the art can be made thereto without departing from the scope of the present invention.

The claims defining the invention are as follows:

1. A method of filling an object based rasterised image comprising a plurality of graphic objects, said method comprising the steps of:

comparing a (first) pixel position in a raster line with pixel edge intersection data of the plurality of graphic objects to determine if an edge exists at said first pixel position;

in the case that no edge exists at said first pixel position, moving to a next pixel position along the raster line while maintaining a currently displayed pixel fill level at said first pixel position; and

in the case an edge exists at said first pixel position, selecting fill level data for each possible one of said plurality of graphic objects able to be represented at said first pixel position, and then displaying at said first pixel position the fill level data corresponding to the highest priority of said plurality of graphic objects as the current pixel fill level.

2. Apparatus for filling an object based rasterised image comprised of a plurality of graphic objects, said apparatus comprising:

comparator means for comparing a pixel position in a line of said rasterised image with a pixel position of an edge intersection of said plurality of graphic objects to determine if an edge exists at said pixel position;

selector means for selecting, in the case an edge exists at said pixel position, fill level data for each possible one of said plurality of graphic objects able to be represented at said pixel position; and

a priority encoder means for determining a priority fill level of each of said plurality of graphic objects and for displaying the fill level data corresponding to the highest priority fill level as the current pixel fill level at said pixel position.

3. Apparatus for filling an object based rasterised image, said apparatus comprising:

pixel location means for producing a current pixel value or a pre pixel start value;

comparator means for receiving said values from said pixel location means and edge position values and outputting an edge display signal when said edge position value is greater than or equal to said current pixel value or said pre pixel start value;

combination means for receiving said edge display signal and a pre edge start signal and combining said signals to produce a toggle signal;

toggle means for receiving fill level values corresponding to said edge position values and toggling a corresponding fill level state from a first state to a second state; and

priority determination means for receiving said fill level states from said toggle means and producing a priority output level corresponding to the highest fill level in said second state.

4. Apparatus as claimed in claim 3 wherein said toggle means is adapted to receive a toggle reset signal, said signal is activated at least once per input line of the rasterised image.

5. Apparatus as claimed in claim 3 or 4 further comprising:

decoder means for receiving an encoded fill signal and outputting a corresponding fill level value to said toggle means, and

encoder means for receiving said priority output level and outputting a corresponding encoded priority output level.

6. Apparatus as claimed in claim 2, wherein said selector means includes a toggle latch for each fill level.

7. Apparatus as claimed in claim 4 or 5 wherein said toggle means includes a toggle latch for each fill level.

8. Apparatus as claimed in claim 7 wherein said toggle latch alternates between a first state and a second state upon each occurrence of an edge.

9. A method as claimed in claim 1 wherein said edge intersection data is derived from processing objects described by quadratic polynomial fragments.

10. Apparatus as claimed in claim 2, wherein said edge intersection is derived from processing objects described by quadratic polynomial fragments.

11. Apparatus as claimed in any one of claims 3 to 8 wherein said edge position values are derived from processing objects described by quadratic polynomial fragments.

12. A method for filling an object based rasterised image substantially as hereinbefore described with reference to the accompanying drawings.

13. Apparatus for filling an object based rasterised image, substantially as hereinbefore described with reference to the accompanying drawings.

DATED this First Day of February 1996

Canon Information System Research Australia Pty Ltd

Canon Kabushiki Kaisha

Patent Attorneys for the Applicant

SPRUSON & FERGUSON

ABSTRACT

Method and Apparatus for Filling an Object Based Rasterised Image

A method and apparatus (20) for performing hidden surface removal of an object based rasterised image is disclosed. The apparatus (20) receives pixel edge data (21) which is compared with a pixel position (22) in the rasterised seam line. The result is used to toggle an array of latches (26) which are input (25) with a decoder (30) arrangement of fill level data (24). Only those levels (25) that are active are output therefrom to be priority encoded (28) thereby outputting (29) only the highest active level.

Fig. 7.

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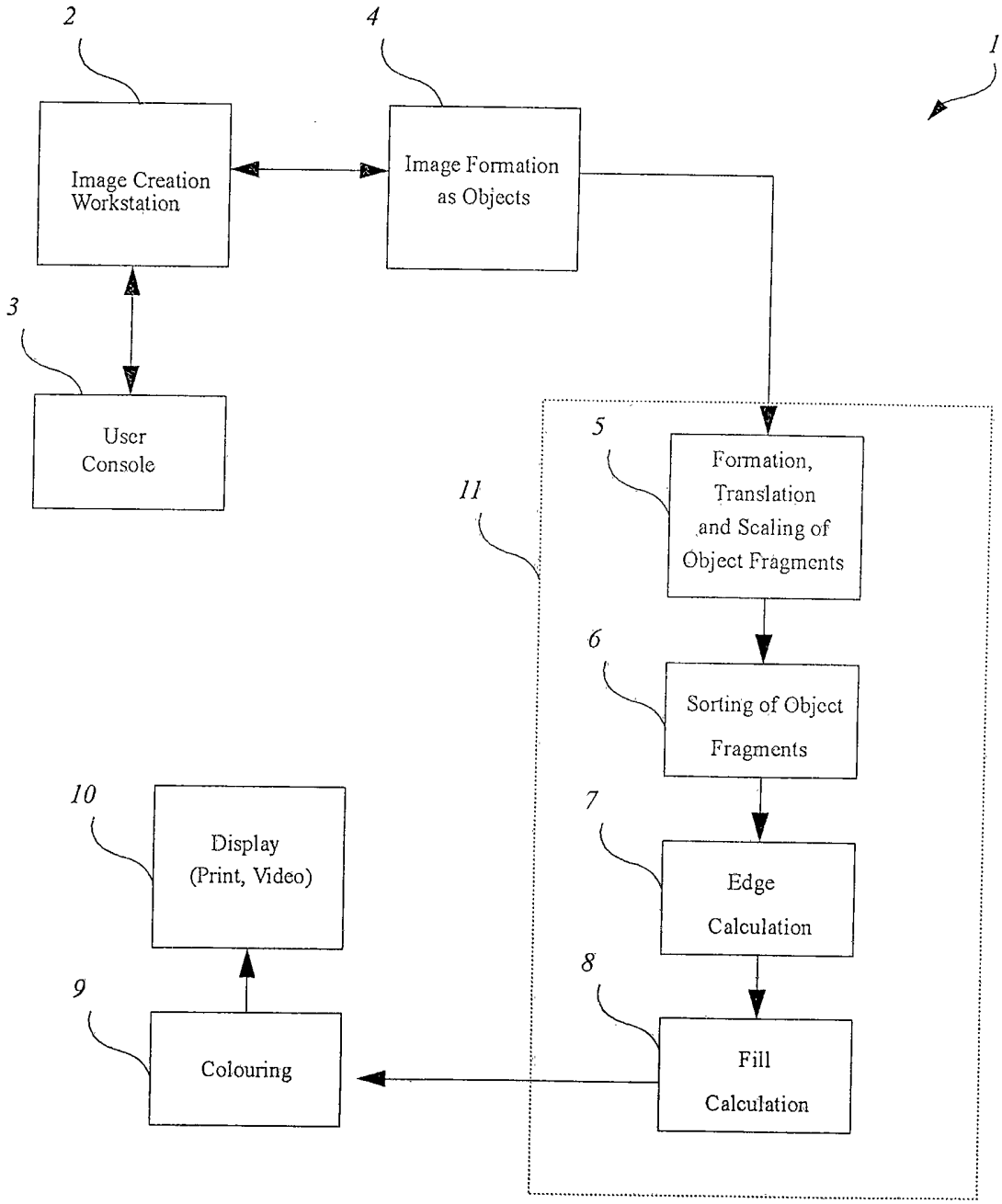

Fig. 1

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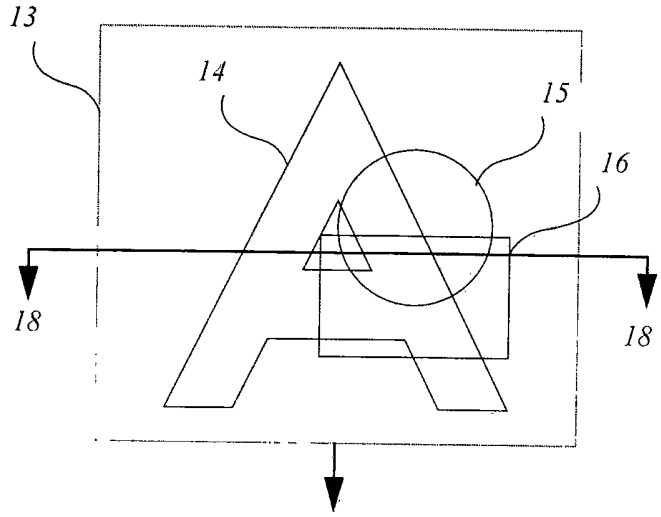

Fig. 2

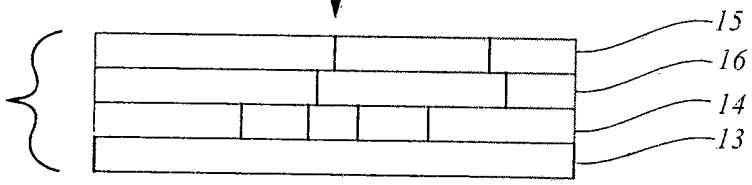

Fig. 3

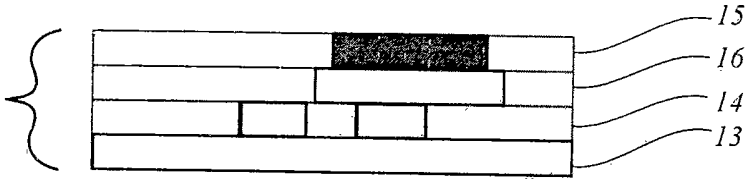

Fig. 4

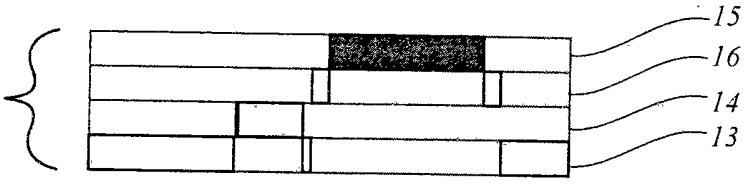

Fig. 5

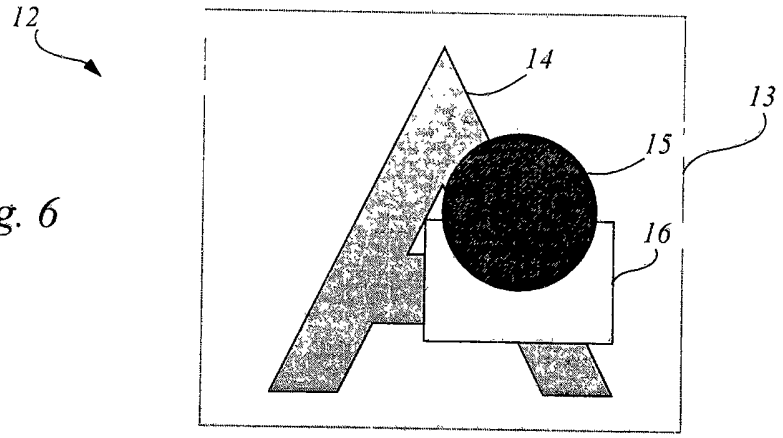

Fig. 6

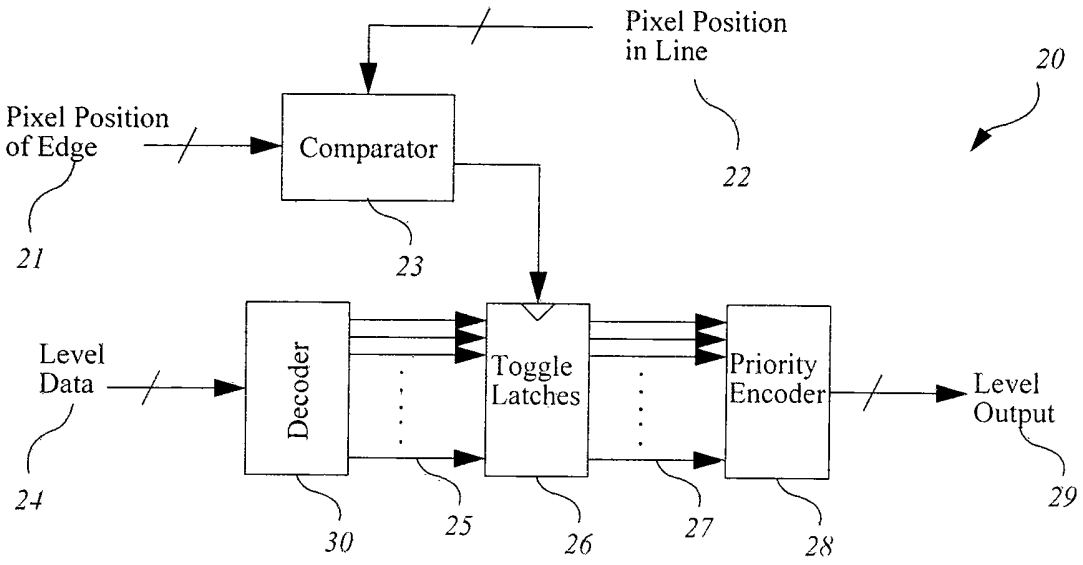
Pixel Position in Line
20
Pixel Position of Edge
Comparator
22
21
23
Level Data
Decoder
Toggle Latches
Priority Encoder
Level Output
24
30
25
26
27
28
29

Fig. 7

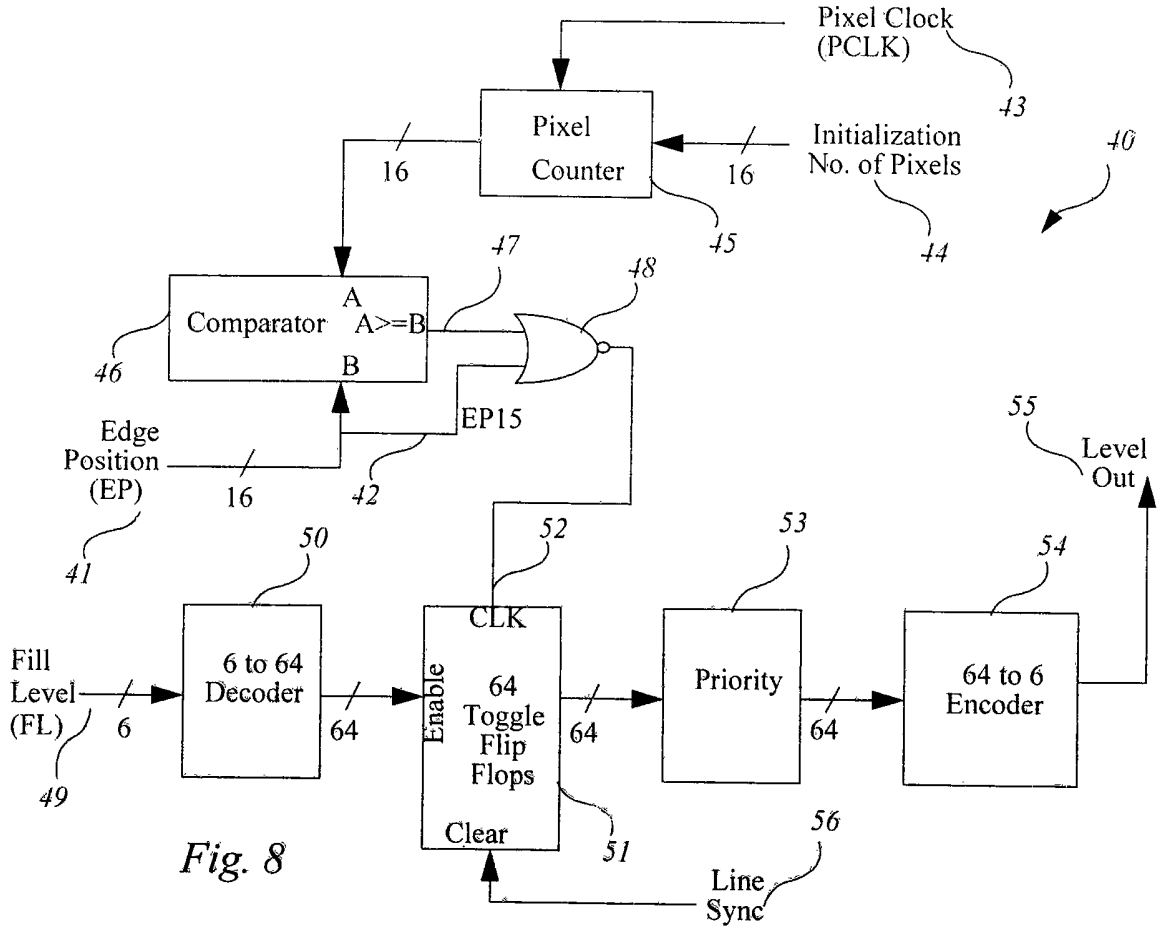
Pixel Clock (PCLK)
43
Pixel Counter
16
16
Initialization No. of Pixels
40
45
44
47
48
Comparator
A
A>=B
B
46
EP15
Edge Position (EP)
16
42
41
55
Level Out
50
52
53
54
CLK
Fill Level (FL)
6
6 to 64 Decoder
64
Enable
64 Toggle Flip Flops
64
Priority
64
64 to 6 Encoder
49
Clear
51
56
Line Sync

Fig. 8