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An agency of Industry Canada

CA 2221429 C 2005/08/30

(11)(21) 2 221 429

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(22) Date de dépôt/Filing Date: 1997/11/19

(41) Mise à la disp. pub./Open to Public Insp.: 1998/05/21

(45) Date de délivrance/Issue Date: 2005/08/30

(30) Priorité/Priority: 1996/11/21 (8-327769) JP

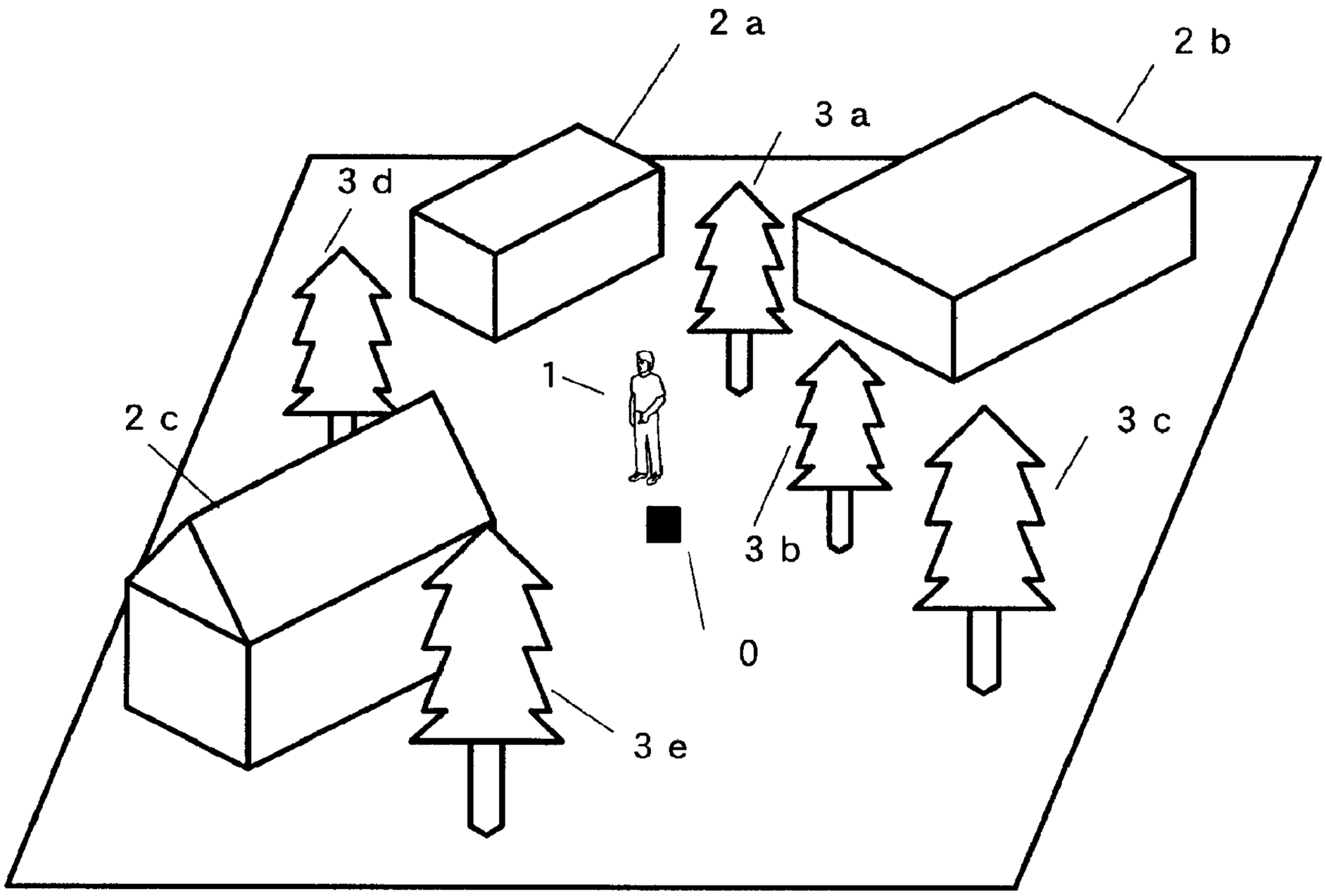
(51) Cl.Int.^{6}/Int.Cl.^{6} G06T 15/20

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(54) Titre : APPAREIL D'IMAGERIE ET APPAREIL D'AFFICHAGE D'IMAGES
(54) Title: IMAGE CREATING APPARATUS AND IMAGE DISPLAY APPARATUS



(57) Abrégé/Abstract:
An image creating apparatus, adapted to create an image constituted by of a plurality of dots for each of a plurality of background scenes that are visually perceived as viewed in different two or more directions from a certain view point existing in a three-dimensional space, is provided with a memory which stores polygon image data composed of three-dimensional coordinate data and texture data for each of a plurality of polygons representative of an object, color data for each dot of the plurality of background scenes and depth data for each dot of the plurality of background scenes. In converting the polygon image data into dot image data, the color data and the depth data are, for each dot, written in the memory on the basis of the texture data and the three-dimensional coordinate data, respectively.

ABSTRACT OF THE DISCLOSURE

An image creating apparatus, adapted to create an image constituted by of a plurality of dots for each of a plurality of background scenes that are visually perceived as viewed in different two or more directions from a certain view point existing in a three-dimensional space, is provided with a memory which stores polygon image data composed of three-dimensional coordinate data and texture data for each of a plurality of polygons representative of an object, color data for each dot of the plurality of background scenes and depth data for each dot of the plurality of background scenes. In converting the polygon image data into dot image data, the color data and the depth data are, for each dot, written in the memory on the basis of the texture data and the three-dimensional coordinate data, respectively.

TITLE OF THE INVENTION

Image Creating Apparatus and Image Display Apparatus

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to image creating apparatuses and image display apparatuses. More particularly, this invention relates to an image creating apparatus and image display apparatus for generating and/or displaying image data approximated for representing realistic three-dimensional images, particularly when the images are displayed using polygon representation.

Description of the prior art

In conventional games of three-dimensional representation (3D), images of background objects and moving objects are merely displayed through three-dimensional image data involving three-dimensional coordinate data and textures (patterns and material feelings including colors) as if the images were photographed in a predetermined direction by a camera located at a predetermined distance.

Meanwhile, conventional games of two-dimensional representation can display images, in combination, of the background object (or background character or background picture) and the moving object (moving character or game hero character, etc.). However, the relation in position between the background object and the moving object is determined only either one of at the front or the rear of the background object with reference to the moving object. It is therefore impossible to display the background objects depicted between a plurality of background objects (e.g. between a house and a mountain or between a car and a building, or the like) in one background scene by merely setting the backward-forward relation for each background object. To this end, the

conventional background image is nothing more than a mere planar image with no depth data, so that the moving object (e.g. hero character) thus depicted, upon passing between a plurality of other background objects, cannot be represented as if it passed behind or in front of or between the objects in a way of perspective representation with depth given for the objects.

Figure 1 is a view showing an on-screen space for displaying background objects and a moving object due to a conventional technique. The example of Figure 1 shows a case that, when rendering a person as a moving object 1 and depicting a building 2 and a tree 3 as background objects, the moving object 1 is represented in preference to the background objects. That is, the moving object 1 is set at a higher order of priority than the background objects 2 and 3. In this case, the moving object 1 is displayed as if it existed in front of the building 2 during movement from a position (a) to a position (b) and from the position (b) to the position (c), whereas it is represented at the front of the tree 3 during movement from a position (c) to a position (d). The moving object 1 in movement from the position (d) to a position (e) is displayed (solely) without superposition over the background.

Figure 2 is a view showing an on-screen space for displaying background objects and a moving object due to the conventional technique. In an example of Figure 2, a person is depicted as a moving object 1 and a building 2 and a tree 3 are drawn as background objects, wherein the moving body 1 is set in lower priority than the background objects 2 and 3. In this case, when the moving object 1 in movement from a position (a) to a position (b) comes to a position that is overlapped with the building 2, no representation is made for the portion overlapped with the building 2, thereby displaying the person as if he was behind the building. During movement from the position (b) to a position (d), display is similarly done. Thereafter, when the moving object 1 passes past

an left end of the building 2 and further moves from the position (d) to a position (e), it is solely displayed because of the absence of the building 2 or the tree 3 there.

In the conventional art, when the moving object 1 becomes overlapped with the background object 2 or 3, nothing is done more than display only with either one of the moving object 1 or the background object 2 and 3 which is higher in priority order. This is because the data defining the depth (depth data) is not assigned to each of the background objects and the moving object.

Where a three-dimensional image is displayed on a display depending upon three-dimensional data (or polygon data; i.e. coordinate data at polygon corners X, Y, Z) for representing an object (including background objects and/or moving objects; background characters, also referred to as moving characters) constituted by gathering of a plurality of polygons, there is a necessity of representing a greater number of polygons in order to display an image with higher reality and precision. However, it takes long time for computation, as the number of polygons increases greater. There often encountered is a case where the computation for representing one frame of a three-dimensional image becomes impossible for one frame (or during vertical blanking), resulting in overburdening of processing. The resulting display image might be unnatural of movement just like frame-basis feeding. Thus, there has been a difficulty of smoothly changing in real time the three-dimensional image.

On the other hand, where the background object is displayed by combining with a moving object (hero character), there has been no setting in the forward-backward relation between the background object depicted in the background scene and the moving object. As a result, the forward-backward relation as to the background object and the moving object can not be met with the actual movement.

SUMMARY OF THE INVENTION

Illustrative embodiments of the present invention may provide an image creating apparatus which is capable of creating images utilizable for three-dimensional display with reality by providing depth data to each dot constituting for pixels (picture elements) for background objects being displayed on a display, when background objects are displayed depending upon three-dimensional data for representing the object constituted by a plurality of polygons.

Illustrative embodiments of the present invention may also provide an image creating apparatus which is capable of creating images utilizable for realistic three-dimensional display by providing depth data to each dot constituting for background objects and pixels being displayed on a display when the background object and the moving object are synthetically displayed depending upon three-dimensional data for representing the object constituted by a plurality of polygons.

Illustrative embodiments of the present invention may also provide an image display apparatus effective for realistic three-dimensional display by providing depth data to each dot constituting for pixels for background objects to be displayed on a display where background objects are displayed on three-dimensional data for representing the object constituted by a plurality of polygons.

Illustrative embodiments of the present invention may also provide an image creating apparatus and/or an image display apparatus that are free from overburdening or overloading on the CPU even where there are a number of objects existing in the three-dimensional space for being displayed.

An image creating apparatus according to one illustrative embodiment is adapted to create an image constituted by gathering of dots for a plurality of scenes visually perceived as viewed in three-dimensional different two or more directions from a certain view point

existing in a three-dimensional space. The apparatus includes: a polygon image data generating means for generating polygon image data constituted by three-dimensional data and texture data so as to represent, for each polygon, an object existing in the three-dimensional space by a plurality of polygons; a color data storing means having a storing capacity corresponding to the number of the dots for a plurality of background scenes, to temporarily store color data on each background scene on a dot-by-dot basis; a depth data storing means having a storing capacity corresponding to the number of the dots for the plurality of the background scenes, to temporarily store depth data on the background scene on a dot-by-dot basis; a color data writing means for converting into dot image data the polygon image data obtained upon being directed in different two or more directions in the three-dimensional space at the certain view point, to write the color data on the dot-by-dot basis into a corresponding storing position of the color data storing means depending upon the texture data of the polygon; and a depth data writing means for determining, by computation, the depth data on the dot depending upon the three-dimensional coordinate data of the polygon when converting into the dot image data the polygon image data obtained upon being directed in the different two or more directions in the three-dimensional space at the certain view point, to write the depth data on the dot-by-dot basis into a corresponding storing position of the color data storing means.

The color data storing means and the depth data storing means may respectively have storing capacities for storing, on the dot-by-dot basis, the color data and the depth data of the object existing in the background scene obtained by dividing a 360-degree range through parallel rotation about the view point, the color data writing means writing, on the dot-by-dot basis, the color data on the object existing in the divided background scene into a corresponding storing position of the color data storing means to the background scene, and the depth data writing means writing, on the dot-by-dot basis, the depth data on

the object existing in the divided background scene into a corresponding storing position of the depth data storing means to the background scene.

The color data storing means and the depth data storing means may respectively have storing areas of six faces for the background scenes, and the color data writing means and the depth data writing means respectively writing the color data and the depth data into a corresponding face of the six faces, on the left, right, front, rear, upper and lower, as viewed from the view point, in the color data storing means and the depth data storing means at a storing position corresponding to the dot of the object.

The polygon image data generating means may include a first polygon image data generating means for generating background polygon image data constituted by three-dimensional coordinate data and texture data on the polygon for the background object in order to represent by the plurality of the polygons the background object existing in the three-dimensional space, a second polygon image data generating means for generating moving polygon image data constituted by three-dimensional coordinate data and texture data on the polygon for the moving object to be displayed in order to synthesize the moving object with the background polygon image generated by the first polygon image data generating means and represent the moving object by the plurality of the polygons, wherein the color data writing means converts the background polygon image data for the background object generated by the first polygon image data generating means into dot image data for the background object, and the polygon image data for the moving object generated by the second polygon image data generating means into dot image data for the moving object, and writes color data on one of the background object and the moving object which is closer to the view point into the corresponding storing position of the color data storing means depending upon the respective depth data of the background polygon and the moving object polygon, and the depth data writing means writing the

depth data of the one of the background object and the moving object which is closer to the view point into the storing position corresponding to the depth data depending upon the depth data of the background object polygon and the moving object polygon when the color data writing means writes the color data of the background object polygon and the moving object polygon into the corresponding storing position of the color data storing means.

An image display apparatus according to an illustrative embodiment is adapted to display on a raster scan display means the image, and further comprises a reading means for reading the color data written in the color data storing means in synchronism with raster scanning over the raster scan display.

According to certain embodiments, various objects, such as background objects and/or moving objects depicted by polygons, can be represented by a variety of combinations of overlapping manners in the three-dimensional space where the background objects and/or the moving objects are present, thus realizing realistic image representation.

According to some illustrative embodiments, visual effects may be exhibited in a manner just like the processing, in real time, of all the polygons in the three-dimensional space. Moreover, if the polygons for a multiplicity of objects to be displayed by a plurality of background scenes around the camera position are converted beforehand into the color data on a dot-by-dot basis, there is obtained an advantage that the processing is possible without lowering the capability of image processing, even if the number of objects to be represented by polygons is considerably increased.

Furthermore, even where the moving object is displayed by the combination with the background scene, since the representation is possible for the forward-backward relations to the background object depicted in the background scene and the moving

object, there is further provided an advantage that the representation of the moving object can be displayed as if it was entering into a picture book to move around therein.

In addition, since the background scene is provided with depth data for each dot, it is possible to designate the forward-backward relation to the dots between the background scene and the moving object, offering an advantage of more realistic three-dimensional image representation.

In accordance with another aspect of the present invention, there is provided an image creating apparatus adapted to create an image constituted by gathering of dots for a plurality of scenes visually perceived as viewed in two or more different three-dimensional directions from a current view point existing in a three-dimensional space. The apparatus includes a polygon image data generator for generating polygon image data constituted by three-dimensional coordinate data and texture data of polygons representing objects existing in the three-dimensional space, the three-dimensional space accommodating at least one moving object which is moved by a user and one or more background objects as background to the moving object, the background being divided into a plurality of background scenes represented by six planes, including left, right, front, rear, upper and lower planes, as viewed from the current view point. The apparatus further includes color data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store color data of each of the six planes on a dot-by-dot basis. The apparatus further includes depth data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store depth data of each of the six planes on a dot-by-dot basis. The apparatus further includes a color data writer for converting, into dot image data including color data and depth data, the polygon image data

generated for objects existing in a selected one of the background scenes represented by a corresponding plane as viewed from the current view point, and writing, on a dot-by-dot basis, color data of a closest object of the moving object and a background object existing at each dot to the current view point into corresponding storing positions in the color data storage depending on depth data of the dot image data of the closest object and depending upon the texture data of a polygon forming the closest object. The apparatus further includes a depth data writer for determining, by computation, the depth data of the dot image data for each dot depending upon the three-dimensional coordinate data of the polygon forming the closest object, and the depth data writer writing, on a dot-by-dot basis, depth data of the closest object into corresponding storing positions in the depth data storage.

In accordance with another aspect of the invention, there is provided an image display apparatus adapted to display on a raster scan display an image constituted by gathering of a plurality of dots for a plurality of scenes visually perceived as viewed in two or more different three-dimensional directions from a current view point existing in a three-dimensional space. The apparatus includes a polygon image data generator for generating polygon image data constituted by three-dimensional coordinate data and texture data of polygons representing objects existing in the three-dimensional space, the three-dimensional space accommodating at least one moving object which is moved by a user and one or more background objects as background to the moving object, the background being divided into a plurality of background scenes represented by six planes, including left, right, front, rear, upper and lower planes, as viewed from the current view point. The apparatus further includes color data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store color data of each of the six planes on a dot-by-dot basis. The apparatus further includes depth data storage having a storing capacity corresponding to the number of

the dots for the six planes of the background, and having storing positions, each position to temporarily store depth data of each of the six planes on a dot-by-dot basis. The apparatus further includes a color data writer for converting, into dot image data including color data and depth data, the polygon image data generated for objects existing in a selected one of the background scenes represented by a corresponding plane as viewed from the current view point, and writing, on a dot-by-dot basis, color data of a closest object of the moving object and a background object existing at each dot to the current view point into corresponding storing positions in said color data storage depending on depth data of the dot image data of the closest object and depending upon the texture data of a polygon forming the closest object. The apparatus further includes a depth data writer for determining, by computation, the depth data of the dot image data for each dot depending upon the three-dimensional coordinate data of the polygon forming the closest object, and the depth data writer writing, on a dot-by-dot basis, depth data of the closest object into corresponding storing positions in the depth data storage. The apparatus further includes a reader for reading the color data written in the color data storage in synchronism with raster scanning over the raster scan display. The apparatus further includes an input for changing a range of display of the background scenes viewed from the current view point. The reader changes a readout address in the color data storage so as to change the range of the background scene in response to the operation of the input.

In accordance with another aspect of the invention, there is provided an image creating apparatus adapted to create an image for displaying based on a current scene viewed from a current view point existing in a three-dimensional space. The apparatus includes a polygon image data generator for generating polygon image data constituted by three-dimensional coordinate data and texture data of polygons representing objects existing in the three-dimensional space, the three-dimensional space accommodating at least one moving

object which is moved by a user and one or more background objects as background to the moving object, the background being divided into a plurality of background scenes represented by six planes, including left, right, front, rear, upper and lower planes, as viewed from the current view point. The apparatus further includes background color data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store color data of each of the six planes on a dot-by-dot basis. The apparatus further includes background depth data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store depth data of each of the six planes on a dot-by-dot basis. The apparatus further includes a background writer for converting, into dot image data, the polygon image data generated for background objects existing in each background scene represented by each plane as viewed from the current view point, the dot image data including color data depending on the texture data of polygons forming the background objects and depth data calculated based on the coordinate data of the polygons forming the background objects, and writing, on a dot-by-dot basis, the color data of the background objects in each plane into corresponding storing positions in the background color data storage and the depth data of the background objects in each plane into corresponding storing positions in the background depth data storage. The apparatus further includes display dot image data storage for temporarily storing, on a dot-by-dot basis, dot image data of objects existing in a current scene to be displayed. The apparatus further includes a display dot image data writer for converting into dot image data the polygon image data generated for the moving object in a current scene selected from the six planes, the dot image data of the moving object including color data and

depth data of the moving object, and for each dot occupied by the moving object, comparing the depth data of the moving object and the background objects existing in the current scene to determine a closest object to the current view point and writing the dot image data of the closest object into the display dot image data storage.

In accordance with another aspect of the invention, there is provided an image display apparatus adapted to display on a raster scan display an image based on a current scene viewed from a current view point existing in a three-dimensional space. The apparatus includes a polygon image data generator for generating polygon image data constituted by three-dimensional coordinate data and texture data of polygons representing objects existing in the three-dimensional space, the three-dimensional space accommodating at least one moving object which is moved by a user and one or more background objects as background to the moving object, the background being divided into a plurality of background scenes represented by six planes, including left, right, front, rear, upper and lower planes, as viewed from the current view point. The apparatus further includes background color data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store color data of each of the six planes on a dot-by-dot basis. The apparatus further includes background depth data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store depth data of each of the six planes on a dot-by-dot basis. The apparatus further includes a background writer for converting, into dot image data, the polygon image data generated for background objects existing in each background scene represented by each plane as viewed from the current view point, the dot image data including color data depending on the texture data of polygons forming the background objects and depth data calculated based on the coordinate data of the polygons forming the background objects, and writing, on a dot-by-dot

basis, the color data of the background objects in each plane into corresponding storing positions in the background color data storage and the depth data of the background objects in each plane into corresponding storing positions in the background depth data storage. The apparatus further includes display dot image data storage for temporarily storing, on a dot-by-dot basis, dot image data of objects existing in a current scene to be displayed. The apparatus further includes a display dot image data writer for converting into dot image data the polygon image data generated for the moving object in a current scene selected from the six planes, the dot image data of the moving object including color data and depth data of the moving object, and for each dot occupied by the moving object, comparing the depth data of the moving object and the background objects existing in the current scene to determine a closest object to the current view point and writing the dot image data of the closest object into the display dot image data storage. The apparatus further includes a reader for reading the color data written in the color data storage in synchronism with raster scanning over the raster scan display. The apparatus further includes an input for changing a range of display of the background scenes viewed from the current view point. The reader changes a readout address in the color data storage so as to change the range of the background scene in response to the operation of the input.

In accordance with another aspect of the invention, there is provided a method for creating an image for displaying based on a current scene viewed from a current view point existing in a three-dimensional space. The method includes generating polygon image data constituted by three-dimensional coordinate data and texture data of polygons representing objects existing in the three-dimensional space, the three-dimensional space accommodating at least one moving object which is moved by a user and one or more background objects as background to the moving object, the background being divided into a plurality of background scenes represented by six planes, including left, right, front, rear,

upper and lower planes, as viewed from the current view point. The method further includes converting, into dot image data, the polygon image data generated for background objects existing in each background scene represented by each plane as viewed from the current view point, the dot image data including color data depending on the texture data of polygons forming the background objects and depth data calculated based on the coordinate data of the polygons forming the background objects. The method further includes writing, on a dot-by-dot basis, the color data of the background objects in each plane into corresponding storing positions in a background color data storage, and writing, on a dot-by-dot basis, the depth data of the background objects in each plane into corresponding storing positions in a background depth data storage. The method further includes converting, into dot image data, the polygon image data generated for the moving object in a current scene selected from the six planes, the dot image data of the moving object including color data and depth data of the moving object. The method further includes comparing, for each dot occupied by the moving object, the depth data of the moving object and the background objects existing in the current scene as stored in the background depth data storage to determine a closest object to the current view point. The method further includes temporarily storing, for each dot occupied by the moving object, the dot image data of the closest object into a display dot image data storage for displaying.

The above described features, aspects, and advantages of the present invention will become more apparent from the following detailed description of illustrative embodiments of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a view showing one example of an on-screen space where background objects and a moving object are displayed by a prior art;

Figure 2 is a view showing another example of an on-screen space where the background objects and the moving object are displayed by the prior art;

Figure 3 is a perspective view showing one example of an object (three-dimensional) space for explaining the principle of illustrative embodiments of this invention;

Figure 4 is an external view showing a system configuration of an image processing apparatus according to one embodiment of the present invention;

Figure 5 is a block diagram of the image processing apparatus according to the one embodiment of the present invention;

Figure 6 is a memory map illustratively showing memory spaces in an external ROM 21;

Figure 7 is a memory map illustratively showing memory spaces in a RAM 15;

Figure 8 is a detailed circuit diagram of a controller control circuit 18;

Figure 9 is a block diagram of a controller 40;

Figure 10 is a main flowchart for game processing;

Figure 11 is an external perspective diagram for a case that a building as one example of a background object is represented by polygons;

Figure 12 is a plan diagram the composingly showing the polygons constituting certain one of the building as the one example of the background object;

Figure 13 is a plan view of one-example three-dimensional space, as built from the above, represented by the embodiment of the present invention;

Figure 14 is a flowchart for a case that background image data is taken as if photographed in six directions by a camera;

Figure 15 is a view visually demonstrating a result of transformation of a three-dimensional space into a two-dimensional background images;

Figure 16 is a subroutine flowchart for the processing of combining with the background object and the moving object;

Figure 17 is a subroutine flowchart for operations of determining operating state data who on the controller;

Figure 18 is a flowchart for explaining the operation of combining the moving object with the background image;

Figure 19 is a view showing one example of synthetic representation with the background object and the moving object of the present embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 3 is a perspective view illustrating an object space (three-dimensional space) as one example for explaining the principle of the present embodiment.

A moving object 1 is an object that moves in a three-dimensional space depending upon the data supplied from a controller 40 (in Figure 4 hereinafter stated) manipulated by an operator (player). This may be a hero character, animal, automobile (or opponent character and ally character as viewed relative to the hero character) or the like.

Background objects may be various objects involving foregrounds such as buildings 2a - 2c and trees 3a - 3e that are displayed stationary at a given coordinate position according to a program, and a background such as a mountain, sea and clouds and the like, as the game type and/or the scene may be. These background objects are gathered in plurality of number to constitute a background scene.

The display of a composite or synthetical image of background objects and/or moving objects, which is to be displayed on the display during playing a game, is carried out by generating data of images that would be taken by a hypothetical camera located at a view point O with respect to a hero, etc. for example, so that the background object and/or the moving object existing in a limited hypothetical three-dimensional space are taken by the camera directed in a certain direction and rotated in parallel by 360 degrees.

Specifically, the background objects are each constituted by gathering of a plurality of polygons. Each polygon is defined by three-dimensional coordinate data (X, Y, Z coordinate data), and texture data for determining the textures affixed to polygon faces to represent colors, patterns, material feelings, etc. The view point O (or the hypothetical camera photographing position) and the direction of camera eye (the photographing direction by the hypothetical camera) are varied depending upon operational data generated upon operation of the controller by the operator. The hypothetical camera takes a photograph for the background object and/or the moving object with reference to the view point and the direction of camera eye. The three-dimensional coordinate data on the polygons for the background object (or the

background object and the moving object) to be projected in the three-dimensional space upon photographing by the hypothetical camera is determined by computation and subjected to texture mapping for each polygon, thereby forming a three-dimensional image. The image data on each dot in the three-dimensional space is written into a buffer memory (RAM 15 shown in Figure 5), hereinafter stated, based on the polygon three-dimensional coordinate data and texture data, thus obtaining image data for display. In the embodiment of the present invention, the formation of image data is realized by using the image buffer for storing color data on a dot-by-dot basis, and the Z buffer for storing depth data on a dot-by-dot basis. The detailed operation of the same will be described later.

Now explanations will be made for an image processing system as one example of the image creating apparatus and/or the image display apparatus according to the present invention. Figure 4 is an external view showing a system structure of the image processing apparatus according to one embodiment of the invention. The image processing system is for example a video game system, and includes an image processing apparatus main body 10, an ROM cartridge 20 as one example of an external memory device, a CRT display 30 as one example of a display means to be connected to the image processing apparatus main body 10, a controller 40 as one example of an operating means, and an RAM cartridge 50 as one example of an extension device detachably attached to the controller 40. Incidentally, the operating means may employ an input device such as a keyboard, mouse, etc. where the image creating apparatus of the present invention is applied to a personal computer.

Figure 5 is a block diagram of the image processing apparatus as one embodiment of this invention. The image processing apparatus 10 incorporates therein a central processing unit (hereinafter abbreviated as "CPU") 11 and a coprocessor (reality media

coprocessor: hereinafter abbreviated as "RCP") 12. The RCP 12 includes an image processing unit (reality signal processor; hereinafter abbreviated as "RSP") 122 for carrying out coordinate transformation and shading for the polygon, an image processing unit (reality display processor; hereinafter abbreviated as "RDP") 123 for rasterizing the polygon data into an image to be displayed and converting it into a data format (dot data) memorable by a frame memory, and a bus control circuit 121 for controlling the bus. The RCP 12 is connected with a cartridge connector 13 for detachably mounting the ROM cartridge 20 thereon, a disc drive connector 14 for detachably attaching a disc drive 22, and a RAM 15. The RCP 12 is also connected with an audio signal generating circuit 16 for outputting audio signals processed by the CPU 11 and an image signal generating circuit 17 for outputting video signals processed by the same. Furthermore, the RCP 12 is connected with a controller control circuit 18 for serially transferring operational data on one or a plurality of controllers 40 and/or data on RAM cartridge 50.

The audio signal generating circuit 16 is connected with a connector 195 provided at the rear face of the image processing apparatus 10. The image signal generating circuit 17 is connected with a connector 196 provided at the rear face of the image processing apparatus 10. The connector 195 is dismountably connected with a connecting portion of a sound generating device 32 such as a TV speaker, or the like. The connector 196 is dismountably connected with a connecting portion of a display 31 such as a TV CRT or the like. Incidentally, although in the Figure 5 example there is shown a case that the connector 195 and the connector 196 are separately provided from each other, they may be formed in one single connector having the number of terminals for both connectors 195 and 196.

The controller control circuit 18 is connected with controller connectors (hereinafter abbreviated as "connector") 191 - 194 provided at the front face of the image

processing apparatus 10. The connector 191 - 194 is detachably connected with the controller 40 through a connecting jack 41. The connection of the connector 191 - 194 with the controller 40 in this manner places the controller 40 into electrical connection to the image processing apparatus 10, thereby enabling data transmission and reception therebetween.

The ROM cartridge 20 is structured by mounting on a board an external ROM 21 stored with data for processing a game, wherein the board is accommodated within a housing. The external ROM 21 is stored with image data for image processing for a game, etc. or program data, and, as required, audio data such as music sounds or effect sounds and so on. Incidentally, various memory mediums such as CD-ROMs and magnetic disc may be used as the external memory device, in place of the ROM cartridge 20.

The external ROM 21 has roughly a program memory area 200, an image data area 210 and a sound memory area 220, as shown in Figure 6, to previously store with various programs in a fixed manner. The program memory area 200 is stored with programs (e.g. a control program for achieving the function of flowcharts in Figure 10, Figure 14, Figure 16, Figure 17 and Figure 18 referred to later, and a game program conforming to the consent of a game, etc.) required for carrying out image processing for a game or the like. The detail of the program will be hereinafter referred to. The image data area 210 is stored with image data including coordinate data on a plurality of polygons and texture data on each of the background objects and/or the moving object. The sound memory area 220 is stored with sound data such as effect sounds, musics, etc. for use in a game or the like.

Specifically, the program area 200 includes program areas 201 - 207 for previously memorize operational programs for the CPU 11 in a fixed manner. That is, a

main program area 201 is stored with main program data for a game, etc. An operational state determining program memorizing area 202 is stored with a program for processing data indicative of an operating state, etc. of the controller 40. A writing program memorizing area 203 is stored with a writing program by which the CPU 11 causes the RCP 12 to perform writing operation. That is, the area is stored for example with a writing program for writing color data into an image buffer area (152 shown in Figure 7) and depth data into a Z buffer area (153 in Figure 7) as image data based on texture data of a plurality of background objects to be displayed in one background scene, a writing program for writing into the image buffer area (152) color data corresponding to any of the background scenes of the areas 1-6 in a background image buffer area 154, and a writing program for writing into the Z buffer area (153 depth data corresponding to any of the background scenes of the areas 1-6 in a background Z buffer area 155. A combining program memorizing area 204 is stored with a composite program by which the CPU causes the RCP 12 to combine the background object with the moving object. A moving control program memorizing area 205 is stored with a control program by which the CPU 11 causes the RCP 12 to vary the location of the moving object in the three-dimensional space. A background scene creating program memorizing area 206 is stored with a background picture creating program by which the CPU 11 causes the RCP 12 to create an all-directional background picture. A camera control program memorizing area 207 is stored with a camera control program by which the CPU 11 causes the RCP 12 to control the location and direction of photographing in the three-dimensional space by the hypothetical camera (or for determining a background scene to be read into the object space).

The disc drive 22 is used in place of the ROM cartridge 20 or in addition to the ROM cartridge 20. The disc drive 22 is a record reproducing device for reading data out

of an optical-type or magnetic disc form memory medium that is stored with various data (including program data and image processing data) for a game. When a magnetic disc or the like is attached to, the disc drive 22 reads out the data memorized on the magnetic disc and transfers the data to the RAM 15.

Figure 7 is a memory map for the RAM 15, illustratively showing memorizing areas thereof. The RAM 15 includes a program area 151, an image buffer area 152, a Z buffer area 153, a background image buffer area 154 as one example of a color data storing means, a background Z buffer area 155 as one example of a depth data storing means, an image data area 156, a sound memory area 157, an operating state data storing area 158, and an operating (working) memory area 159. The areas 151 - 159 of the RAM 15 are memory spaces which are accessible by the CPU through the bus control circuit 121 or by the RCP 12 directly, which have an arbitrary capacity (or memory space) assigned depending upon the game used.

Specifically, the program area 151 is to memorize, by transferring thereto, part of the program for a game, etc. stored in the ROM cartridge 20. The image buffer area 152 has a memory capacity corresponding to the number of picture elements (pixels or dots) on the display 31 $\times$ the number of bits of color data per picture element, so that it memorizes color data on a dot-by-dot basis in a manner corresponding to the picture element on the display 31. This image buffer area 152, in an image processing mode, temporarily stores with dot color data on an object viewed from the view point, based on the three-dimensional coordinate data for representing in gathering of polygons for one or more background objects and/or moving objects to be displayed in one background scene memorized by the image data area 156. The image buffer area 152, in a display mode, temporarily stores with color data on a dot-by-dot basis for any of the planes of the background scene memorized in the background image buffer area 154, when the plane

of the background scene is displayed. The Z buffer area 153 has a memory capacity corresponding to the number of picture elements (pixels or dots) on the display 31 × the number of bits of depth data, so that it memorizes depth data on a bit-by-bit basis in a manner corresponding to the picture element on the display 31. This Z buffer area 153, in the image processing mode, temporarily stores with depth data on a dot-by-dot basis for an object that can be seen from the view point, based on the three-dimensional coordinate data for representing in gathering of polygons for one or more background objects and/or the moving objects, in a manner similar to the image buffer area 152. The Z buffer area 153, in the display mode, temporarily stores with depth data on a dot-by-dot basis for any plane of the background scene stored in the background Z buffer area 155. The background image buffer area 154 and the background Z buffer area 155 have respective memory capacities for storing with color data and depth data of 6 planes of background images that are obtained by dividing a range of 360 degrees over which the hypothetical camera is parallel moved from the view point into a plurality of scenes (e.g. 4 scenes of the front, rear, left and right), together with the upper plane and a lower plane (bottom plane), to have memory sites (addresses) corresponding to the number of screen picture elements (or the number of dots) for each plane of the background scene. The background image buffer area 154 memorizes, as a background image, color data on a dot-by-dot basis for the background scene (image created by the RSP 122 and the RDP 123 included in the RCP 12) to be projected through photographing by the hypothetical camera directed in a certain direction in the three-dimensional space. The background Z buffer area 155 memorizes depth data on a dot-by-dot basis constituting the background image correspondingly to the color data memorized by the background image buffer area 154. The image data area 156 memorizes coordinate data and texture data constituted by gathering of polygons for each object of the background objects and/or moving objects

for display a game stored by the ROM cartridge 20, so that at least one screen of data is transferred thereto from the ROM cartridge 20 prior to image processing operations. The sound memory area 157 is transferred with audio data stored in the ROM cartridge 20, memorizing audio data of the sound to be generated through the sound generating device 32. The operating state data storing area 158 memorizes operating state data indicative of a state of operation that is read out of the controller 40. The working memory area 159 temporarily memorizes data such as parameters upon executing a program by the CPU 11.

The bus control circuit 121 included in the RCP 12 parallel-serial converts a command given in a parallel signal form via the bus from the CPU 11, so that the same command is supplied as a serial signal to the controller control circuit 18. The bus control circuit 121 converts a serial signal inputted from the controller control circuit 18 into a parallel signal, to output the same signal via the bus to the CPU 11. The data, read from the controller 40 and representative of a state of scanning, is subjected to processing, i.e. processed by the CPU 11 and written into the RAM 15 for temporary storage. In other words, the RAM 15 includes a storing area for temporarily storing the data to be processed by the CPU 11, so that it is utilized for smoothening the reading and writing of data through the bus control circuit 121.

Figure 8 is a detailed circuit diagram of the controller control circuit 18. The controller control circuit 18 is provided to transmit and receive data in serial between the RCP 12 and the controller connectors 191 - 194, so that it includes a data transfer control circuit 181, a transmitting circuit 182, a receiving circuit 183 and a RAM 184 for temporarily storing transmitting and received data. The data transfer control circuit 181 includes a parallel-serial converting circuit and a serial-parallel converting circuit for converting data formats during data transfer, to perform control on writing into and

reading out of the RAM 184. The serial-parallel converting circuit converts the serial data supplied from the RCP 12 into parallel data to be delivered to the RAM 184 or the transmitting circuit 182. The parallel-serial converting circuit converts the parallel data supplied from the RAM 184 or the receiving circuit 183 into serial data to be delivered to the RCP 12. The transmitting circuit 182 converts into serial data a command for controlling the reading of a controller 40 signal supplied from the data transfer control circuit 181 as well as writing data (parallel data) into the RAM cartridge 50, and delivers these data to channels CH1 - CH4 corresponding respectively to a plurality of the controllers 40. The receiving circuit 183 receives in serial the data representative of operating state of the controllers 40 inputted through the channels CH1 - CH4 respectively corresponding to a plurality of the controllers 40, and converts the data into parallel data to be delivered to the data transfer control circuit 181. The data transfer control circuit 181 controls the writing into the RAM 184 for the data transferred from the RCP 12, the operating state data on the controller 40 received by the receiving circuit 183 or the data read out of the RAM cartridge 50, and operates to read data out of the RAM 184 to transfer the same to the RCP 12 depending upon instructions from the RCP 12.

The RAM 184 includes memory area. The first area is stored with a command for the first channel, while the second area is stored with transmission data and reception data for the first channel. Similarly, the third area is stored with a command for the second channel, while the fourth area is stored with transmission data and reception data for the second channel. The fifth area is stored with a command for the third channel, and the sixth area is stored with transmission data and reception data for the third channel. The seventh area is stored with a command for the fourth channel, and the eighth area is stored with transmission data and reception data for the fourth channel.

Figure 9 is a detailed circuit diagram of the controller 40 and the RAM cartridge 50 as one example of an extension device. The controller 40 has a housing incorporating therein electronic circuits such as an operating signal processing circuit 44, in order to detect operating states of switches 403 - 407 or a joystick 45, etc. and transfer the detected data to the controller control circuit.

The operating signal processing circuit 44 includes a receiving circuit 441, a control circuit 442, a switch signal detecting circuit 440, a counter circuit 444, a joyport control circuit 446, a reset circuit 447 and a NOR gate 448. The receiving circuit 441 converts serial signals, such as the control signal, transmitted from the controller control circuit 18 and writing data to the RAM cartridge 50 into a parallel signal, delivering the same to the control circuit 442. When the control signal transmitted from the controller control circuit 18 is a signal to reset X, Y coordinates for the joystick 45, the control circuit 442 generates a reset signal to reset (0) the count values of an X-axis counter 444X and a Y-axis counter 444Y within the counter 444 via the NOR gate.

The joystick 45 includes X-axis and Y-axis photo-interrupters in order to decompose the inclination of the lever into X-axis and Y-axis direction components to generate pulses in number proportional to the inclination, to deliver respective pulse signals to the counter 444X and the counter 444Y. When the joystick 45 is inclined in the X-axis direction, the counter 444X counts the number of pulses generated in response to the magnitude of inclination. When the joystick 45 is inclined in the Y-axis direction, the counter 444Y counts the number of pulses generated responsive to the amount of inclination. Accordingly, the moving direction and the coordinate position for a hero character or a cursor are determined by a resultant vector of the X-axis and Y-axis components that are determined by the count values of the counter 444X and the counter 444Y. Incidentally, the counter 444X and the counter 444Y are reset of their count values

by a reset signal supplied from a reset signal generating circuit 447 upon turning on the power or a reset signal supplied from a switch signal detecting circuit when predetermined two switches are simultaneously depressed by a player.

The switch signal detecting circuit 443 responds to an output command signal on a switch state supplied at a constant period (e.g. at an interval of 1/30 seconds of a TV frame period) from the control circuit 442, to read thereinto a signal depending upon the state of depressions of a cross switch 403, switches 404A - 404F, 405, 406L, 406R and 407, delivering the same to the control circuit 442. The control circuit 442 responds to a readout command signal for the operating state data from the controller control circuit 18, to supply operating state data concerning the switches 403-407 and the count values of the counters 444X, 444Y to the transmitting circuit 445 in a predetermined data format sequence. The transmitting circuit 445 converts these parallel signals outputted from the control circuit 442 into serial data, to transfer the same data to the controller control circuit 18 via a converting circuit 43 and a signal line 42. The control circuit 442 is connected with a port control circuit 446 via an address bus and a data bus as well as a port connector 46. The port control circuit 446 controls on data inputting and outputting (or transmission and reception control) according to instructions by the CPU 11, when the RAM cartridge 50 is connected to the port connector 46.

The RAM cartridge 50 has the RAM 51 connected to the address bus and the data bus, and connected to an electric for supplying power to the RAM 51. The RAM 51 is a RAM having a capacity less than a half of the maximum memory capacity accessible using the address bus, and formed for example by a 256k-bit RAM. The RAM 51 stores with backup data concerning a game so that it keeps data storage due to supply of power from the cell 52 even if the RAM cartridge 50 is removed off from the port connector 46.

Figure 10 is a flowchart showing a principal operation of the video game apparatus

as one example according to the present invention. At a step (in the figure "S" is affixedly shown) 10, the CPU 11 performs initial setting to set the image processing apparatus 10, in a state immediately after turning on the power, to a predetermined initial state. For example, of the game programs memorize in the program areas of the ROM cartridge 20, a predetermined game program is transferred to the program area 151 of the RAM 15, and the parameters are set to their initial values.

At a step 20, the RSP 122 performs coordinate transforming processing under the control of the CPU 11, based on coordinate data and texture data on polygons for each object stored in the image data area 156 of the RAM 15.

First explanations will be made in detail for the case that the RSP 122 performs coordinate transformation for the polygon. Figure 11 is a diagram representing a building as one of the background objects in Figure 3. The building 2 is in a cubic form formed by six parallelogram faces. Each of the parallelograms is divided into two triangles, i.e. triangles abd and bcd. The coordinates at three apexes of the triangle are numerical data represented by polygon three-dimensional coordinate data P1(X1, Y1, Z1), P2(X2, Y2, Z2), and P3(X3, Y3, Z3). In a similar manner, the moving object 1 operable by another controller 40 and the background objects representing a building 2 and a tree 3 are also constituted by gathering of a plurality of triangles, each of which is to be represented by polygon coordinate data.

In the meanwhile, the polygon texture data is data for designating on what color, pattern or material feeling is affixed to the inside of a triangle defined by the three-dimensional coordinate data for the polygon. Incidentally, the texture data, if an eye is fixed onto one dot among a gathering of dots existing in a region encompassed by the triangle, will be color data for designating a color.

Figure 13 is a plan view, as viewed from the right above, of the three-dimensional

space (object space) shown in Figure 3. For example, when four planes on the front, rear, left and right, as viewed from a view point O, are photographed by a camera as shown in Figure 13, it is satisfactory to deal with coordinate data on polygons defining portions opposed to the camera, as to the moving object (hero character) 1, the buildings 2a, 2b and 2d and the tree 3a visible from the camera 4. In this case, it is determined on whether or not each object exists within a range being in sight from the camera 4 position (i.e. whether the polygon for the object should be represented or not). Thereafter, two-dimensional image data is read in as if a hatched portion in sight from the camera 4 was photographed as a foreground scene depending upon the coordinate data of the polygon to be displayed.

Then, the RDP 123 performs image rendering processing with the image buffer and the Z buffer under the control of the CPU 11. This image rendering process involves transformation into color data on a dot-by-dot basis based on the texture data and the two-dimensional data created by the coordinate transformation, determining by competition depth data, writing color data into the image buffer 152, and writing the depth data into the Z buffer 153. By thus carrying out coordinate transformation and image rendering for each polygon, the image to be displayed is created.

Incidentally, a moving object inoperable by the controller 40 may exist in the three-dimensional space, though not shown in Figure 3. The moving object in this case is displayed as an opponent character or an ally character, simultaneous with the aforesaid hero character, thus being utilized as an object that automatically moves according to a program.

At a step 30, the CPU 11 determines to which direction and how much the joystick is inclined. Based on the result of the determination, the moving object is moved at a speed commensurate with the amount of inclination as to the direction of joystick

inclination. This process is achieved by gradually varying the three-dimensional coordinate data for the polygon constituting the moving object in the three-dimensional space, depending upon the count values of the X counter 444X and the Y counter 444Y.

At a step 40, the CPU 11 determines whether or not the moving object exists at a predetermined location in the three-dimensional space. If it is determined that the moving object does not exist at the predetermined location, the process repeats the operations of the steps 20 and 30, while if the moving object exists at the predetermined location is determined the process of a step 50 is executed.

At a step 50, the background scenes, in the 6 directions, of on the front, rear, left, and right and the upper and lower are photographed in order from a predetermined photographing position. The detail thereof is given in a subroutine of Figure 14. With reference to Figure 14, at a step 51 a variable S representing the number of plane being photographed is set to 1. The variable S is temporarily written into a part of the working memory area 159 of the RAM 15. At a step 52, the location and direction to be photographed (to be written by image data) are determined. The location of photographing is at a position where the moving object has existed at the step 30 or a location convenient for photographing that background scene, which is determined according a game program and in compliance with the situation in the game. The direction of photographing is determined by sequentially setting as to the directions of not yet photographed of the six direction, i.e. the front, rear, left, right, upper and lower, with respect to the point where the moving object exists. At a step S53, the RCP 12 performs similar processing to that of the step 20 in Figure 10. When the writing of the color data into the memory site corresponding to the dot for the one background scene is completed for all the dots, the CPU transfers at a step 54 the color data on the two-dimensional image created in the image buffer to an area corresponding to the photographed background

scene among the areas 1-6 contained in the background image buffer 154, temporarily memorizing the same there. At a step 55, the CPU 11 transfers and writes the depth data on the dot of a certain background scene (e.g. the front scene, at first) created on the Z buffer 153 to an area corresponding to the photographed background scene among a plurality of background Z buffer 154 areas 1-6 (e.g. the area 1 corresponding to the front scene, at first), temporarily memorizing the same there. At a step 56, the CPU 11 increments the variable S by one, and then designates a direction to be photographed. At a subsequent step 57, the CPU 11 determines whether or not the value of the variable S is greater than 6, thereby judging whether the transfer/writing of image data to the 6 planes of the background scene is completed or not.

If the variable S is not greater than 6 (5 or the smaller), the process returns to the step 52 to repeat the steps 52 to 56, thus continuing the similar process until image data have been written for the 6 planes of the background scene. Meanwhile, when the variable S is 6 or the greater is determined, the subroutine of Figure 14 (step 50) is ended.

When all the processes in the subroutine at the step 50 have been ended in this manner, the background image buffer 154 at its area 1-6 are temporarily stored with color data on each dot of the background images of 6 planes representing the front, rear, left, right, upper and lower as viewed from the photograph position, while the the background Z buffer 155 at its areas 1-6 are stored with the depth data on each dot of the background images of 6 planes representing the front, rear, left, right, upper and lower as viewed from the photograph position.

In a state that all the processing of the subroutine at the step 50 has been completed, where the color data and the depth data have been created for background scenes, in four directions, of the front, rear, left and right from the photograph position, the sight of the background scenes on the front, rear, left and right with respect to the hero

character moving object 1 is equivalent to a three-dimensional background scene as shown in Figure 15. Explaining in greater detail by referring to Figure 15, the above sight is equivalent to the background scene 5F put onto the front wall, wherein the scene 5F has been photographed by the camera that is at the view point and directed frontward (forward) in the object space shown in Figure 3. Similarly, the above sight is equivalent to the background scene 5B photographed by the camera directed rearward is putting onto a rear wall, the background scene 5R photographed by the camera directed rightward is put onto a right wall, and the background scene 5R photographed by the camera directed leftward is put onto a left wall. Incidentally, the background scene 5R photographed by the camera directed upward is put onto a ceiling plane, while the background scene 5R photographed by the camera directed downward (toward the bottom) is put onto a lower plane (or floor plane), as similar to the above. In practical image data processing, the color data on each dot constituting these background scenes 5F, 5B, 5R, 5L, 5U, 5 is temporarily written into the area 1 - area 6 of the background image buffer 154, and the depth data thereof is temporarily written into the area 1 - area 6 of the background Z buffer 155.

In an actual game is carried out a process for displaying in combination of the background object and the moving object at a step 60 shown in Figure 10, based on the image data of the aforesaid 6 planes on the front, rear, left, right, upper and lower of the background scenes. This synthesizing process is achieved by a subroutine flowchart shown in Figure 16. Referring to Figure 16, the RDP 122 performs reading of operating state data out of the controller under the control of the CPU 11, at a step 61.

The detail of the step 61 is shown in an operating state data processing subroutine in Figure 17. Referring to Figure 17, at a step 611 the CPU 11 reads operating state data out of the operating state data area 158, and thereafter carries out the processes as given

below. At a step 612, it is determined on whether the count value X of the X counter 444X is greater than zero or not. If the count value X of the X counter 444X is greater than zero is determined, the RSP 122 performs at a step 613 a process of varying the three-dimensional coordinate data for the polygon constituting the moving object 1 (e.g. process of increasing minus values of the X coordinate data for the polygons constituting the moving object 1) such that the moving object 1 is displayed in a rightward-directed position. At a subsequent step 614, the moving object 1 in the three-dimensional space is moved rightward. In interacting with this, at a step 615 the camera 4 is gradually rotated through 360 degrees by being parallel moved from the front to the right about the photograph position, thereby scrolling the background scene from the right to the left (leftward scroll). This process is achieved by setting a range of the background scene to be displayed (e.g. 5F and 5R) among a plurality of areas of the background image buffer 154 and the background Z buffer 155, for example, and thereafter shifting rightward the background scene to be displayed little by little with the set range kept constant. Then, the process proceeds to a step 616.

Meanwhile, if it is determined at the aforesaid step 612 that the count value X of the X counter 444X is smaller than zero, the process proceeds to a step 617. At the step 617, the RSP 122 performs the process of varying the three-dimensional coordinate data for the polygon constituting the moving object 1 (e.g. process of increasing the minus value of the X coordinate data), so that the moving object 1 is in a leftward-directed position. At a step 618, the displayed position of the moving object 1 in the three-dimensional space is gradually moved to the left. At a step 619, the camera 4 is parallel moved from the front to the left about the photograph position, to be gradually rotated in the left direction through 360 degrees, thereby scrolling the background scene from the left to the right (rightward scroll). This process is achieved by setting the range of

background scene to be displayed (e.g. 5F and 5L) among the background image buffer areas and the background Z buffer areas, and thereafter gradually shifting to the left the background scene to be displayed with the range setting kept constant. Then, the process proceeds to a step 620.

Incidentally, at the step 616, when it is determined that the count value X of the X counter 444X is not smaller than zero (i.e. greater), then the process proceeds to the step 620.

At the step 620, the CPU 11 determines whether the count value Y of the Y counter is greater than zero or not. This determination is to determine whether the moving object 1 is to be moved in a depth direction or not, in order to provide displaying such that it advances forward when the joystick 45 is inclined forward and it retreats when inclined backward. If the count value Y of the Y counter 444Y is determined greater than 0, the three-dimensional coordinate data for the polygon constituting the moving object 1 is subjected to transformation processing at a step 621 so as to display the moving object 1 in a backward-directed position. In response to this coordinate transformation, the moving object 1 is displayed moving in the depth direction of the three-dimensional space, at a step 622. Specifically, the coordinate transformation is made such that the Z coordinate data in the three-dimensional coordinate data for the polygon constituting the moving object 1 is increased to represent the moving object 1 to go away from the camera 4 (advance in the depth direction). As a result, the moving object 1 is displayed in a manner advancing in the depth direction on the screen. Thereafter, the process proceeds to a step 623.

Meanwhile, when the count value Y of the Y counter 444Y is determined not greater (smaller) than zero at the step 620, the process also proceeds to the step 623.

At the step 623, the CPU 11 determines whether the count value Y of the Y

counter 444Y is smaller than zero or not. If the count value Y of the Y counter 444Y is determined smaller than 0, at a subsequent step 624 the coordinate data for the polygons constituting the moving object 1 is transformed (e.g. processing of setting the Z coordinate data for the polygon on a breast side smaller than the Z coordinate data for the polygon on a back side of the moving object 1) in order to display the moving object 1 in a frontward-direct position (directed toward the player). At a step 625, processing is carried out so as to display the moving object 1 to move toward the front of the three-dimensional space. Thereafter, the process proceeds to a step 63.

Incidentally, the amount of change in a position of the moving object 1 in the three-dimensional space varies depending upon the magnitude of the respective count values of the X counter 444X and the Y counter 444Y. For example, if the count value of the X counter 444X is great, the moving object 1 is largely moved toward the right, while if the count value of the Y counter 444Y is great, the moving object 1 is greatly moved in the depth direction.

Referring again to Figure 16, at the step 63 the color data on the background scene to be displayed (e.g. the area 1 corresponding to the background scene 5F when the camera 4 is directed frontward), which scene has been set at the step 61, is transferred from the background image buffer 154 to the image buffer 152. At a step 64, the depth data of the background scene to be displayed (e.g. the area 1 corresponding to 5F), that has been set at the step 61, is transferred from the background Z buffer area 155 to the Z buffer area 153. Thereafter, the process proceeds to a step 65.

At the step 65 is performed an image synthesizing process for representing the moving object in combination with the background scene. The detail of this image synthesizing process is shown in an image combining process subroutine in Figure 18. Referring to Figure 18, at a step 651 the RCP 12 coordinate-transforms the three-

dimensional coordinate data for the polygon constituting the moving object 1 into on-screen coordinate, to determine on-screen coordinates and depth values on a dot-by-dot basis for the moving object 1 to be taken (viewed) by the camera 4. Here, the "on-screen coordinate" refers to the display screen coordinates corresponding to the screen of the display 30, wherein the respective dot positions of display on the screen correspond to addresses in the image buffer 152 and the Z buffer 153. At a step 652, the RDP 123 reads the depth data on a certain dot position of the moving object 1 determined at the step 151 and the depth data of the background scene corresponding (i.e. common in both X coordinate data and Y coordinate data) to the dot position, to thereby compare at a step 653 the respective depth data in the same X, Y coordinate position of the moving object 1 and the background scene. As a result of the comparison, where the depth data of the moving object one is smaller (on the front of the background scene), the color data on the same dot is written into the corresponding address in the image buffer 152 at a step 654, and the dept data on the same dot of the moving object one is written into the corresponding address in the Z buffer 153.

On the other hand, when comparing the respective depth data in the same X, Y coordinate dot position of the moving object 1 and the background scene, if the depth data of the moving object 1 is determined greater, neither of the color data nor the depth data on the moving object 1 is written into the image buffer 152/Z buffer 153 because the depth position of the moving object 1 is farther than that of the background scene 5F and accordingly invisibly hidden by any background object in the background scene. Then, at the step 656, it is determined whether or not the processes of the above steps 651 - 655 have been ended for all the dot positions of the on-screen coordinate. If not-ended is determined, the process returns to the step 651 to repeat the processes of the above steps 651 - 656. If ended is determined, the process proceeds to a step 66.

At the step 66, the bus control circuit 121 outputs an image signal to the image signal generating circuit 17 based on the color data on each dot stored in the image buffer 152. Due to this, the image signal generating circuit 17 generates a signal, for example, for color representation such as video signals or RGB signals, etc. to supply the same to the display 31, thereby enabling the user to see three-dimensionally represented images on the display 31.

Thereafter, the CPU 11 determines, at a step 67, whether the combining processing subroutine is ended or not. If the combining process is determined not ended, the process to returns to the step 61 to repeat the operations of the above steps 61 - 67. On the other hand, if the combining process is determined ended, the process proceeds to a step 70. At the step 70, it is determined whether the game is ended or not. When the determination is not game-over, the process returns to the step 20 to repeat the aforesaid operations. Meanwhile, the CPU ends the game based on conditions if the game program stores on the game program area 151 in the RAM 15 has been executed (or if the game program stored in the external ROM 21 has entirely executed), if the player makes mistakes to a number permitted in one time of the game, or game-over conditions such as servicing over the life set by the game program.

Now, explanations will be made on operational principle by using an embodiment wherein the moving object 1 is displayed with its forward-backward relations relative to the background objects varied in a free manner.

Figure 19 is an illustrative view showing the outcome of display where the moving object 1 is controlled of display so as to pass through between a building 2 and a tree 3. The plurality of background objects appearing in the background scene are modeled in the three-dimensional space, to be rendered as two-dimensional planar images, being presented as a background image. In this case, the image buffer 152 and the Z buffer 153

are respectively written with color data on each dot based on the texture data for the background objects 2, 3 and the depth data on the dots.

For example, when the moving object 1 is displayed in a manner passing through between the building 2 and the tree 3, the building 2 is placed at the most distant location and the moving object 1 passes in front thereof and the tree 3 is displayed at a forward location relative to the location the moving object 1 passes through. In this case, the depth data (Z data) on the dots for the polygons constituting the building 2 is selected to the largest (farthest), the depth data on the dots for the polygons constituting the tree 3 is selected to the smallest (nearest), and the depth data on the dots for the polygons constituting the moving object 1 is selected to an intermediate value of those of the both objects. When the moving object 1 moves from a position (a) through a position (b) to the left, until it reaches a position (c) before the tree 3, the depth data on the moving object 1 is smaller (frontward) than the depth data on the building 2. Accordingly, in the processing of combining the moving object and the background object, the color data on the dots for the moving object 1 is overwritten to the corresponding address of the image buffer 152 to the X and Y coordinates of the dot for each predetermined frame on the display 31. At the same time, the depth data on the dot for the moving object 1 is overwritten to the corresponding address of the Z buffer 153 to the X and Y coordinates of the dot. By virtue of this, when displayed on the display 31, the moving object 1 can be seen as if it was moving through in front of the building 2 by reading out color data stored by the image buffer 152.

When the moving object 1 comes to a position (c) beside the tree 3, it passes on a deeper side of the tree 3 so that its portion hidden by leaves of the tree 3 (the portion of the moving object 1 of above the breast) has the depth data greater than the depth data of the tree 3. Consequently, the color data on that portion is not overwritten to the image buffer

152, but the color data for the lower half of the moving object 1 body only is overwritten to the dot-corresponding address of the image buffer 152. Thereupon, the depth data on the dot or the moving object 1 is also written to the corresponding address of the Z buffer 153. As a result, the moving object 1 at the lower half thereof is displayed to be seen from the side of a trunk of the tree 3. Furthermore, when the moving object 1 passes behind the trunk of the tree 3, the color data for that portion is not written to the image buffer 152 so that the lower half portion of the moving object 1, upon being displayed, is invisibly hidden by the trunk. If the moving object 1 is further moved to the left, the lower half portion thereof appears from behind the trunk. After passing past a position (d), the color data on the entire body is written into the image buffer 152, displaying the entire portion of the moving object 1.

On the other hand, in order to display an image to pass the moving object 1 through the front of the building 2 and the tree 3, program setting may be made such that the Z coordinate data on the dots for all the polygons constituting the moving object 1 is determined smaller than the Z coordinate data on the dots for the polygons respectively constituting the building 2 and the tree 3. This causes the color data of the dots for all the polygons constituting the moving object 1 is written into the image buffer 152 in order during the entire time period that the moving object 1 is moving from the position (a) to the position (e), and the depth data on the dots is written into the Z buffer 153 in order. As a result, when the color data stored in the image buffer 152 is read out in synchronism with raster scanning over the display 31, an image as shown in Figure 1 is displayed.

Conversely, in order to display the image to pass the moving object 1 behind the building 2 and the tree 3, program setting may be made such that the Z coordinate data on the dots for all the polygons constituting the moving object 1 is determined greater than the Z coordinate data on the dots for the polygons respectively constituting the building 2

and the tree 3. This causes the color data on the dots for all the polygons constituting the moving object 1 not to be written into the image buffer 152 over the duration that the moving object 1 is moving from the right end to the left end. The writing-in of the moving object 1 is made only when it is positioned at a location where there is no background objects present. As a result, when the color data stores by the image buffer 152 is read out in synchronism with raster scanning over the display 31, an image as shown in Figure 2 is displayed.

As explained above, according to the present embodiment, even where a plurality of objects are overlapped, the background scene can be three-dimensionally represented at overlapped and non-overlapped portions by temporarily storing depth data into the Z buffer during image rendering in a manner similar to actual perspectives, despite utilizing with only one scene of the image buffer.

Incidentally, although in the above embodiment explanations have been made for the case that a plurality of background objects and at least one moving object are displayed overlapped, the principle of this invention is also applicable for displaying preferentially a nearer background object based on the depth-directional relations to only the background objects. Furthermore, although in the above embodiment explanations have been made for the case that the background object and the moving object are combined with and the color data stored by the image buffer 152 is read out in synchronism with raster scanning, if a CPU with a high process capability is utilized, the image data for only the background scene may be stored in the image buffer 152 to output the color data for either one of the background scene or the moving object based on the order of priority when the color data is read out of the image buffer 152.

Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to

be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

What is claimed is:

1. An image creating apparatus adapted to create an image constituted by gathering of dots for a plurality of scenes visually perceived as viewed in two or more different three-dimensional directions from a current view point existing in a three-dimensional space, said apparatus comprising:

a polygon image data generator for generating polygon image data constituted by three-dimensional coordinate data and texture data of polygons representing objects existing in the three-dimensional space, the three-dimensional space accommodating at least one moving object which is moved by a user and one or more background objects as background to the moving object, the background being divided into a plurality of background scenes represented by six planes, including left, right, front, rear, upper and lower planes, as viewed from the current view point;

color data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store color data of each of the six planes on a dot-by-dot basis;

depth data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store depth data of each of the six planes on a dot-by-dot basis;

a color data writer for converting, into dot image data including color data and depth data, the polygon image data generated for objects existing in a selected one of the background scenes represented by a corresponding plane as viewed from the current view point, and writing, on a dot-by-dot basis, color data of a closest object of the moving object and a background object existing at each dot to the current view point into corresponding storing positions in said color data storage depending on depth data of the dot image data of the closest object and depending upon the texture data of a polygon forming the closest object; and

a depth data writer for determining, by computation, the depth data of the dot image data for each dot depending upon the three-dimensional coordinate data of the polygon forming the closest object, and the depth data writer writing, on a dot-by-dot basis, depth data of the closest object into corresponding storing positions in said depth data storage.

2. An image creating apparatus according to claim 1,

wherein said polygon image data generator includes:

a first polygon image data generator for generating background polygon image data for each background object;

a second polygon image data generator for generating moving polygon image data for the moving object;

wherein said color data writer converts the background polygon image data and moving polygon image data into background color data and moving color data respectively,

said depth data writer determines background depth data and moving depth data based on the current view point, and

said color data writer writes the moving color data into the corresponding positions in said color data storage when the moving depth data is smaller than the background depth data, and writes the background color data into the corresponding positions in said color data storage when the background depth data is smaller than the moving depth data.

3. An image display apparatus adapted to display on a raster scan display an image constituted by gathering of a plurality of dots for a plurality of scenes visually perceived as viewed in two or more different three-dimensional directions from a current view point existing in a three-dimensional space, said apparatus comprising:

a polygon image data generator for generating polygon image data constituted by three-dimensional coordinate data and texture data of polygons representing objects existing in the three-dimensional space, the three-dimensional space accommodating at least one moving object which is moved by a user and one or more background objects as background to the moving object, the background being divided into a plurality of background scenes represented by six planes, including left, right, front, rear, upper and lower planes, as viewed from the current view point;

color data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store color data of each of the six planes on a dot-by-dot basis;

depth data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store depth data of each of the six planes on a dot-by-dot basis;

a color data writer for converting, into dot image data including color data and depth data, the polygon image data generated for objects existing in a selected one of the background scenes represented by a corresponding plane as viewed from the current view point, and writing, on a dot-by-dot basis, color data of a closest object of the moving object and a background object existing at each dot to the current view point into corresponding storing positions in said color data storage depending on depth data of the dot image data of the closest object and depending upon the texture data of a polygon forming the closest object; and

a depth data writer for determining, by computation, the depth data of the dot image data for each dot depending upon the three-dimensional coordinate data of the polygon forming the closest object, and the depth data writer writing, on a dot-by-dot basis, depth data of the closest object into corresponding storing positions in said depth data storage;

a reader for reading the color data written in said color data storage in synchronism with raster scanning over said raster scan display; and

an input for changing a range of display of the background scenes viewed from the current view point,

wherein said reader changes a readout address in said color data storage so as to change the range of the background scene in response to the operation of said input.

4. An image display apparatus according to claim 3,

wherein said polygon image data generator includes:

a first polygon image data generator for generating background polygon image data for each background object;

a second polygon image data generator for generating moving polygon image data for the moving object;

wherein said color data writer converts the background polygon image data and moving polygon image data into background color data and moving color data respectively,

said depth data writer determines background depth data and moving depth data based on the current view point, and

said color data writer writes the moving color data into the corresponding positions in said color data storage when the moving depth data is smaller than the background depth data, and writes the background color data into the corresponding positions in said color data storage when the background depth data is smaller than the moving depth data.

5. An image creating apparatus adapted to create an image for displaying based on a current scene viewed from a current view point existing in a three-dimensional space, said apparatus comprising:

a polygon image data generator for generating polygon image data constituted by three-dimensional coordinate data and texture data of polygons representing objects existing in the three-dimensional space, the three-dimensional space accommodating at least one moving object which is moved by a user and one or more background objects as background to the moving object, the background being divided into a plurality of background scenes represented by six planes, including left, right, front, rear, upper and lower planes, as viewed from the current view point;

background color data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store color data of each of the six planes on a dot-by-dot basis;

background depth data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store depth data of each of the six planes on a dot-by-dot basis;

a background writer for converting, into dot image data, the polygon image data generated for background objects existing in each background scene represented by each plane as viewed from the current view point, the dot image data including color data depending on the texture data of polygons forming the background objects and depth data calculated based on the coordinate data of the polygons forming the background objects, and writing, on a dot-by-dot basis, the color data of the background objects in

each plane into corresponding storing positions in said background color data storage and the depth data of the background objects in each plane into corresponding storing positions in said background depth data storage;

display dot image data storage for temporarily storing, on a dot-by-dot basis, dot image data of objects existing in a current scene to be displayed; and

a display dot image data writer for converting into dot image data the polygon image data generated for the moving object in a current scene selected from the six planes, the dot image data of the moving object including color data and depth data of the moving object, and for each dot occupied by the moving object, comparing the depth data of the moving object and the background objects existing in the current scene to determine a closest object to the current view point; and writing the dot image data of the closest object into the display dot image data storage.

6. An image creating apparatus according to claim 5, wherein the display dot image data storage having:

a display color data storage for temporally storing the color data of the closest object, and

a display depth data storage for temporally storing the depth data of the closest object.

7. An image creating apparatus according to claim 5 or 6 further comprising:

a dot image data reader for reading the dot image data stored in the display dot image data storage for displaying.

8. An image display apparatus adapted to display on a raster scan display an image based on a current scene viewed from a current view point existing in a three-dimensional space, said apparatus comprising:

a polygon image data generator for generating polygon image data constituted by three-dimensional coordinate data and texture data of polygons representing objects existing in the three-dimensional space, the three-dimensional space accommodating at least one moving object which is moved by a user and one or more background objects as background to the moving object, the background being divided into a plurality of

background scenes represented by six planes, including left, right, front, rear, upper and lower planes, as viewed from the current view point;

background color data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store color data of each of the six planes on a dot-by-dot basis;

background depth data storage having a storing capacity corresponding to the number of the dots for the six planes of the background, and having storing positions, each position to temporarily store depth data of each of the six planes on a dot-by-dot basis;

a background writer for converting, into dot image data, the polygon image data generated for background objects existing in each background scene represented by each plane as viewed from the current view point, the dot image data including color data depending on the texture data of polygons forming the background objects and depth data calculated based on the coordinate data of the polygons forming the background objects, and writing, on a dot-by-dot basis, the color data of the background objects in each plane into corresponding storing positions in said background color data storage and the depth data of the background objects in each plane into corresponding storing positions in said background depth data storage;

display dot image data storage for temporally storing, on a dot-by-dot basis, dot image data of objects existing in a current scene to be displayed; and

a display dot image data writer for converting into dot image data the polygon image data generated for the moving object in a current scene selected from the six planes, the dot image data of the moving object including color data and depth data of the moving object, and for each dot occupied by the moving object, comparing the depth data of the moving object and the background objects existing in the current scene to determine a closest object to the current view point; and writing the dot image data of the closest object into the display dot image data storage;

a reader for reading the color data written in said color data storage in synchronism with raster scanning over said raster scan display; and

an input for changing a range of display of the background scenes viewed from the current view point,

wherein said reader changes a readout address in said color data storage so as to change the range of the background scene in response to the operation of said input.

9. A method for creating an image for displaying based on a current scene viewed from a current view point existing in a three-dimensional space, said method comprising the steps of:

generating polygon image data constituted by three-dimensional coordinate data and texture data of polygons representing objects existing in the three-dimensional space, the three-dimensional space accommodating at least one moving object which is moved by a user and one or more background objects as background to the moving object, the background being divided into a plurality of background scenes represented by six planes, including left, right, front, rear, upper and lower planes, as viewed from the current view point;

converting, into dot image data, the polygon image data generated for background objects existing in each background scene represented by each plane as viewed from the current view point, the dot image data including color data depending on the texture data of polygons forming the background objects and depth data calculated based on the coordinate data of the polygons forming the background objects;

writing, on a dot-by-dot basis, the color data of the background objects in each plane into corresponding storing positions in a background color data storage;

writing, on a dot-by-dot basis, the depth data of the background objects in each plane into corresponding storing positions in a background depth data storage;

converting, into dot image data, the polygon image data generated for the moving object in a current scene selected from the six planes, the dot image data of the moving object including color data and depth data of the moving object;

comparing, for each dot occupied by the moving object, the depth data of the moving object and the background objects existing in the current scene as stored in the background depth data storage to determine a closest object to the current view point; and

temporarily storing, for each dot occupied by the moving object, the dot image data of the closest object into a display dot image data storage for displaying.

10. A method according to claim 9, wherein the temporarily storing step comprises the steps of:

temporarily storing the color data of the closest object into a display color data storage, and

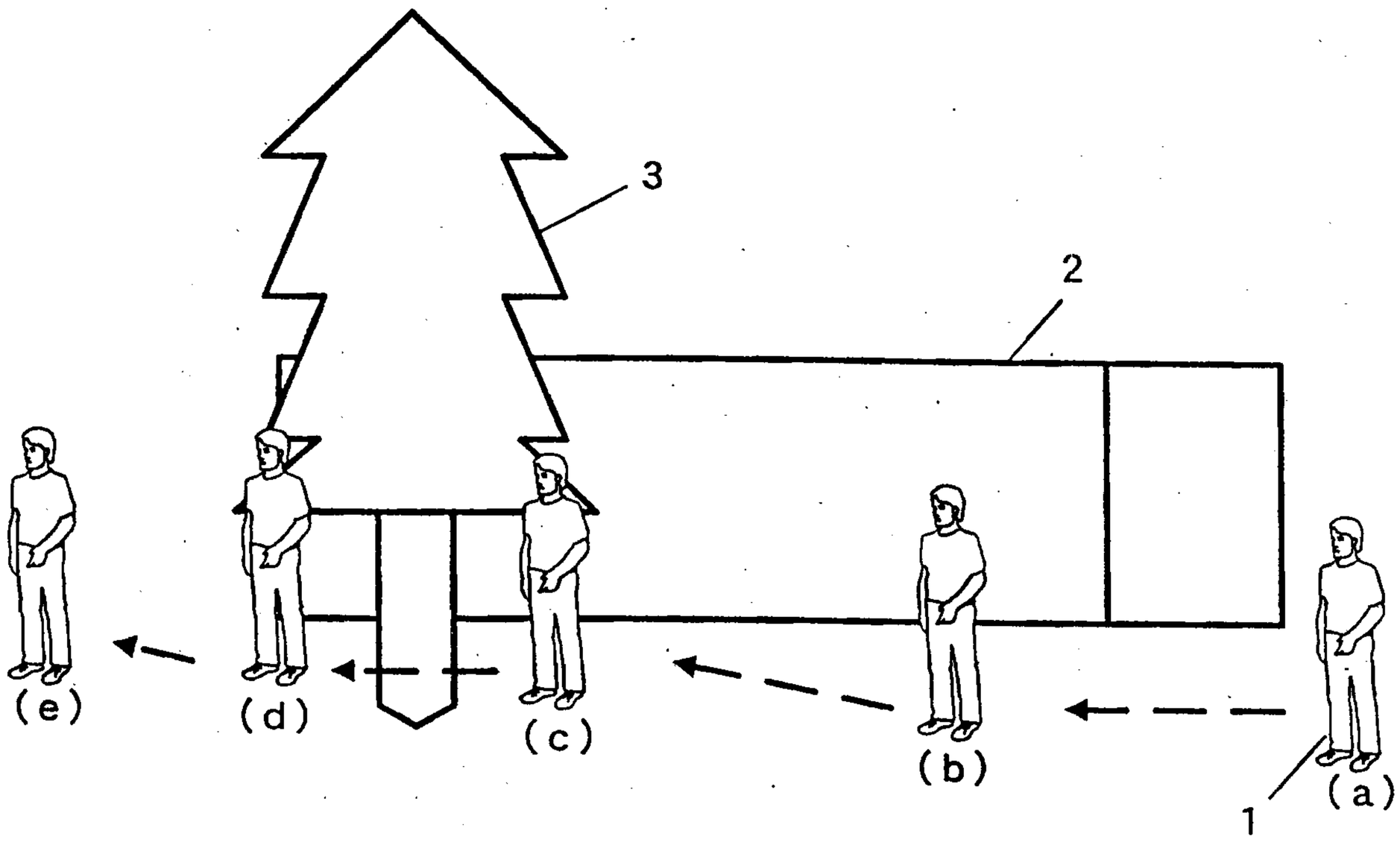
temporarily storing the depth data of the closest object into a display depth data storage.

11. A method as claimed in claim 9 or 10 further comprising the steps of:

reading the dot image data stored in the display dot image data storage; and

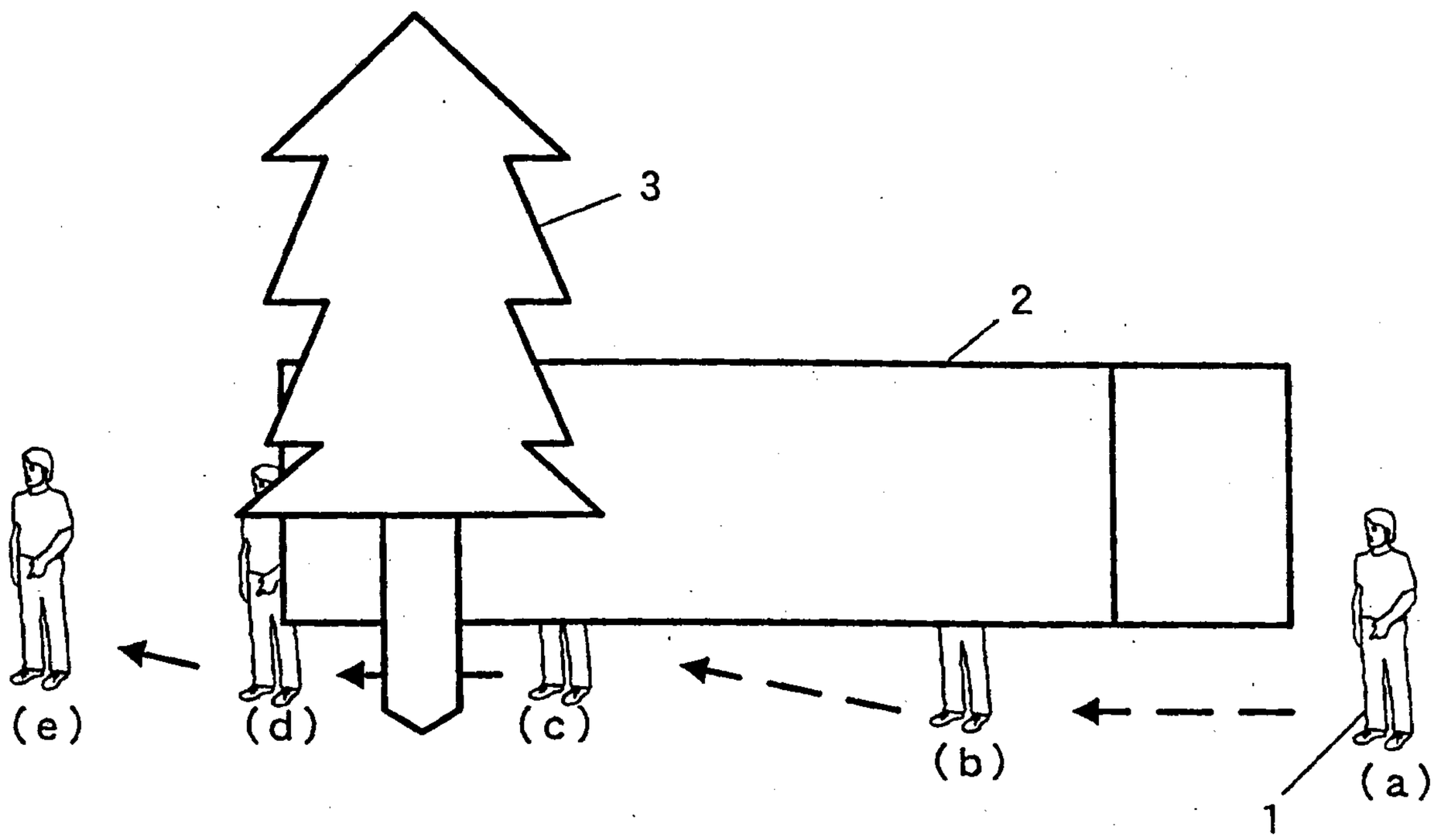
displaying the dot image data.

FIG. 1



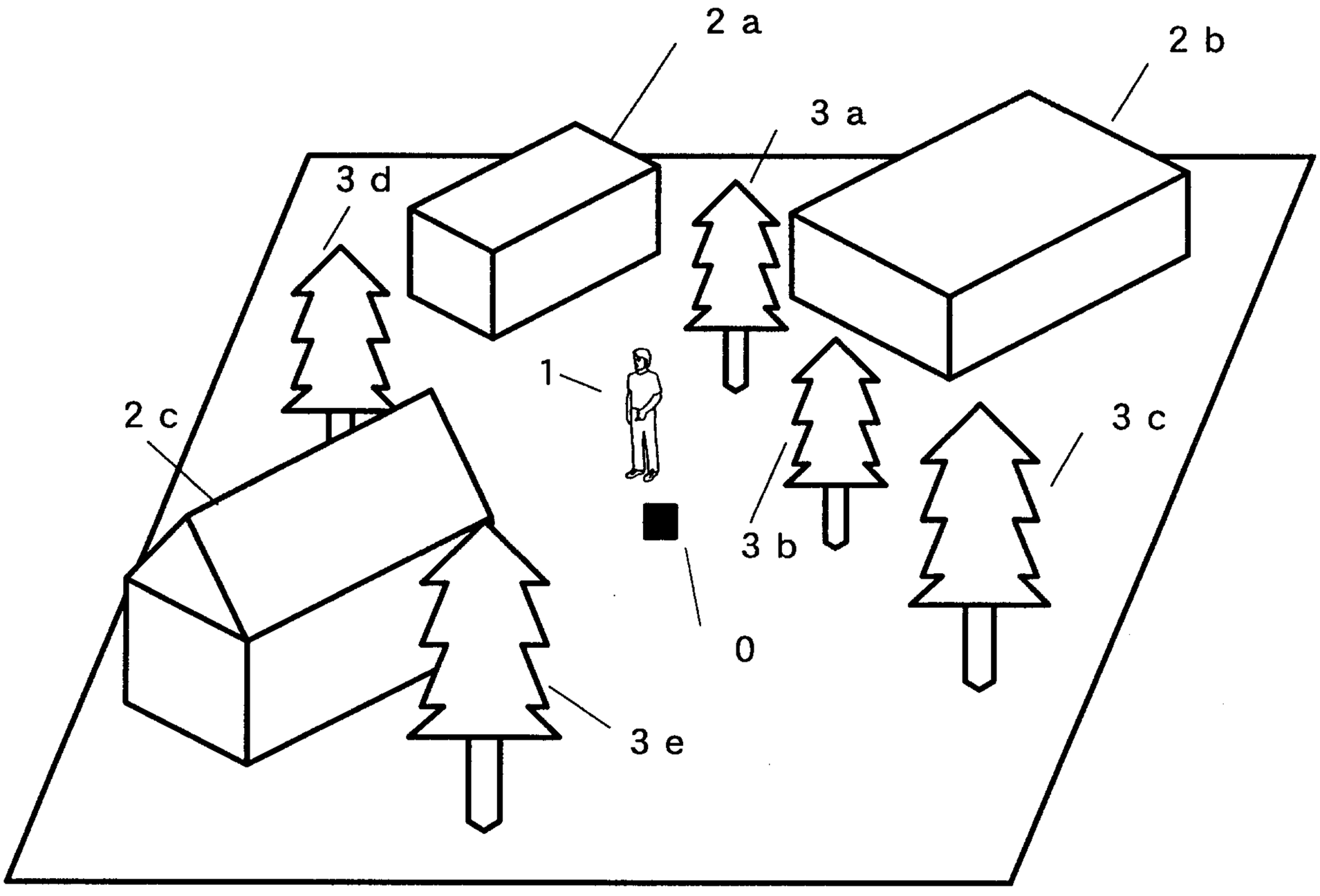
PRIOR ART

FIG. 2



PRIOR ART

FIG. 3



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FIG. 4

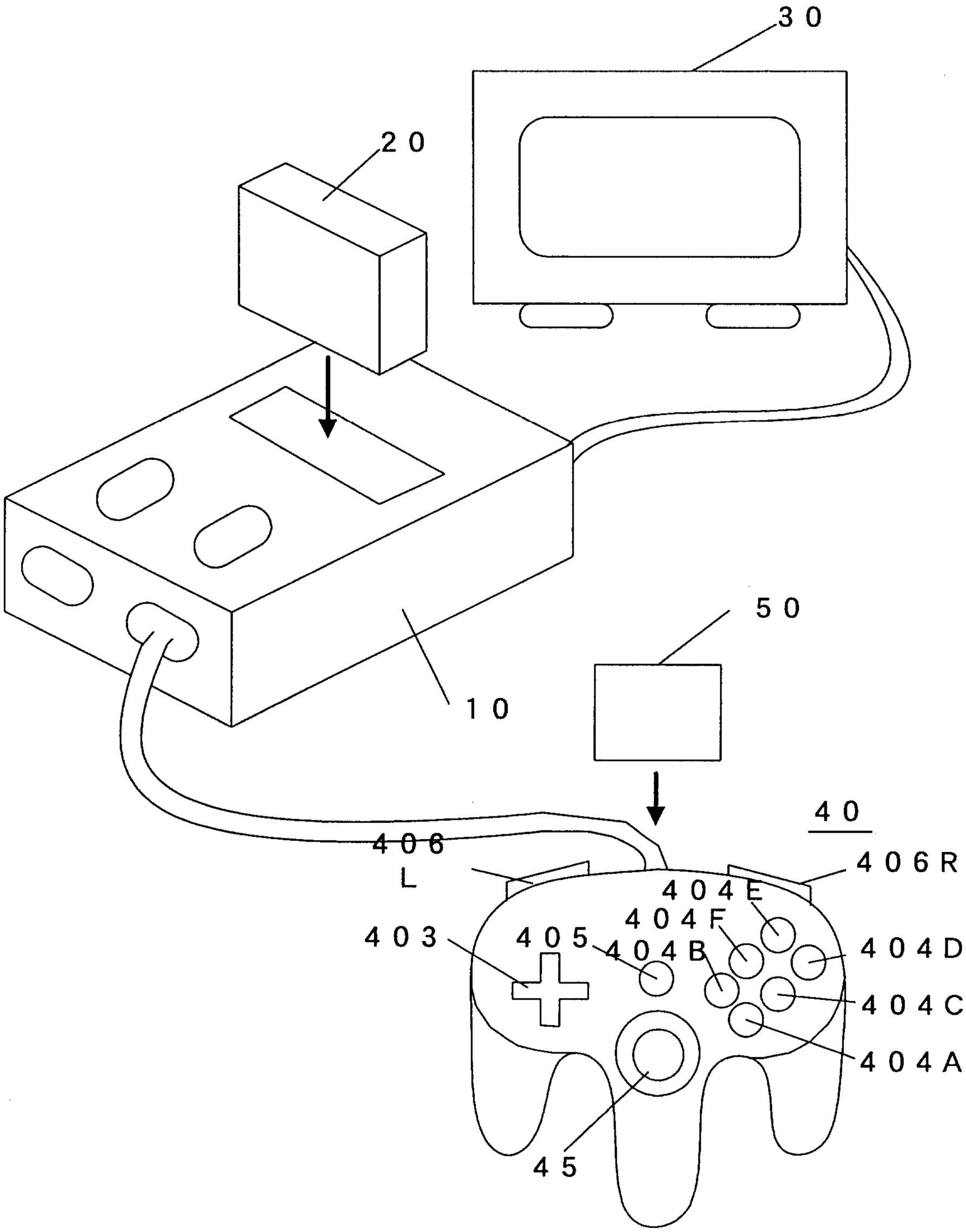
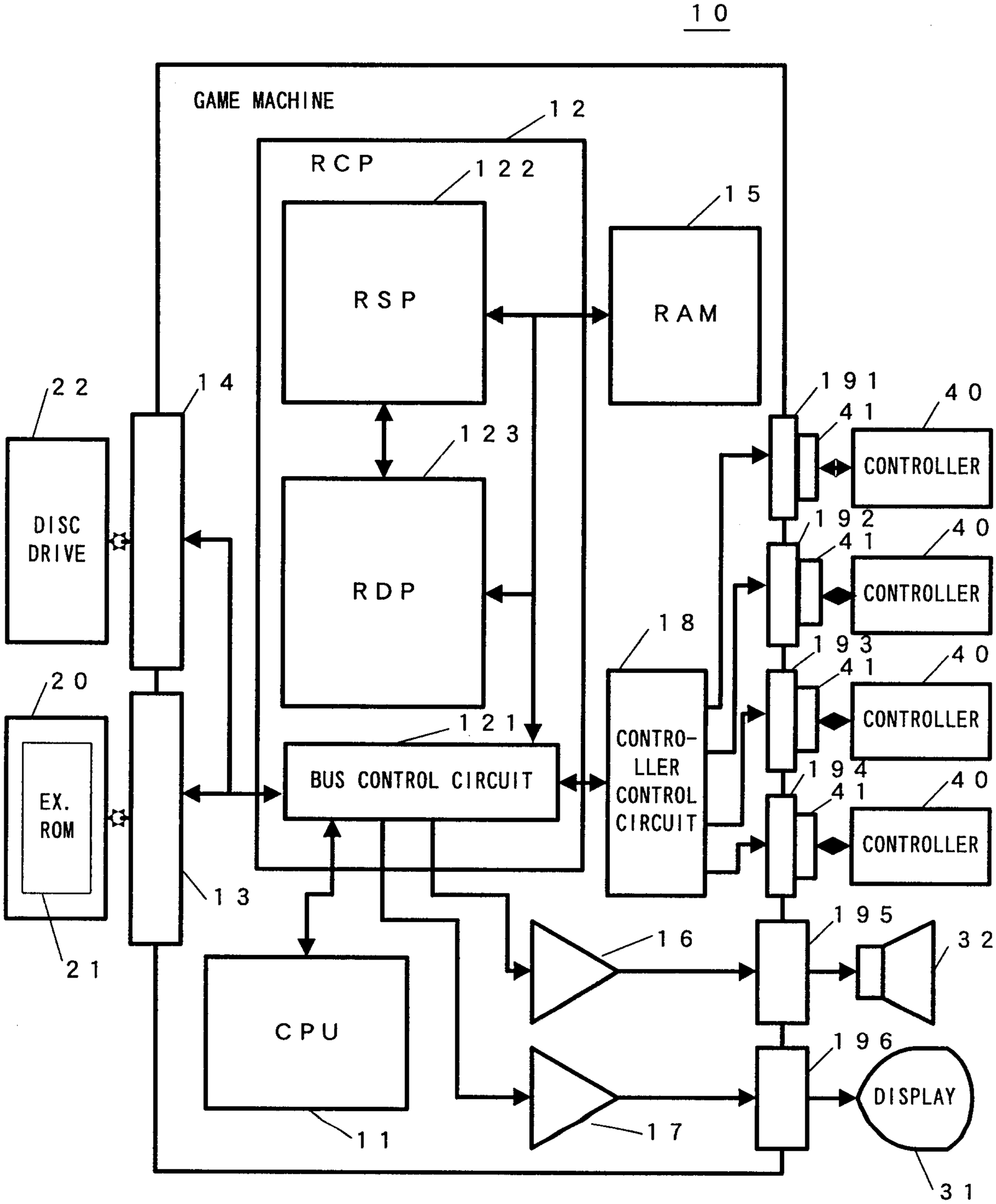

30
20
10
50
40
406L
406R
404E
404F
403
405
404B
404D
404C
404A
45

FIG. 5



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FIG. 6

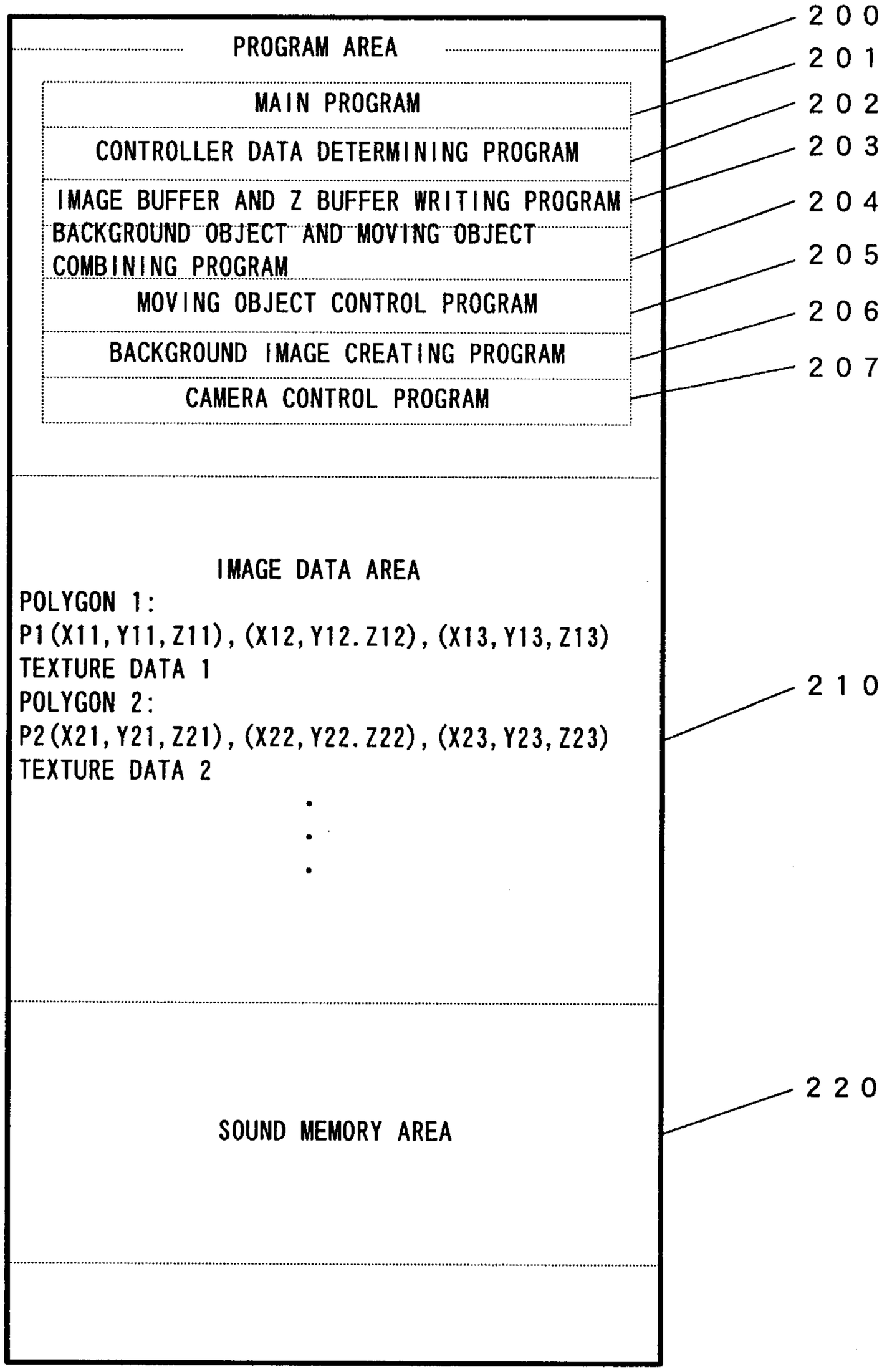

PROGRAM AREA
MAIN PROGRAM
CONTROLLER DATA DETERMINING PROGRAM
IMAGE BUFFER AND Z BUFFER WRITING PROGRAM
BACKGROUND OBJECT AND MOVING OBJECT COMBINING PROGRAM
MOVING OBJECT CONTROL PROGRAM
BACKGROUND IMAGE CREATING PROGRAM
CAMERA CONTROL PROGRAM
200
201
202
203
204
205
206
207
IMAGE DATA AREA
POLYGON 1:
P1(X11,Y11,Z11),(X12,Y12.Z12),(X13,Y13,Z13)
TEXTURE DATA 1
POLYGON 2:
P2(X21,Y21,Z21),(X22,Y22.Z22),(X23,Y23,Z23)
TEXTURE DATA 2
210
SOUND MEMORY AREA
220

FIG. 7

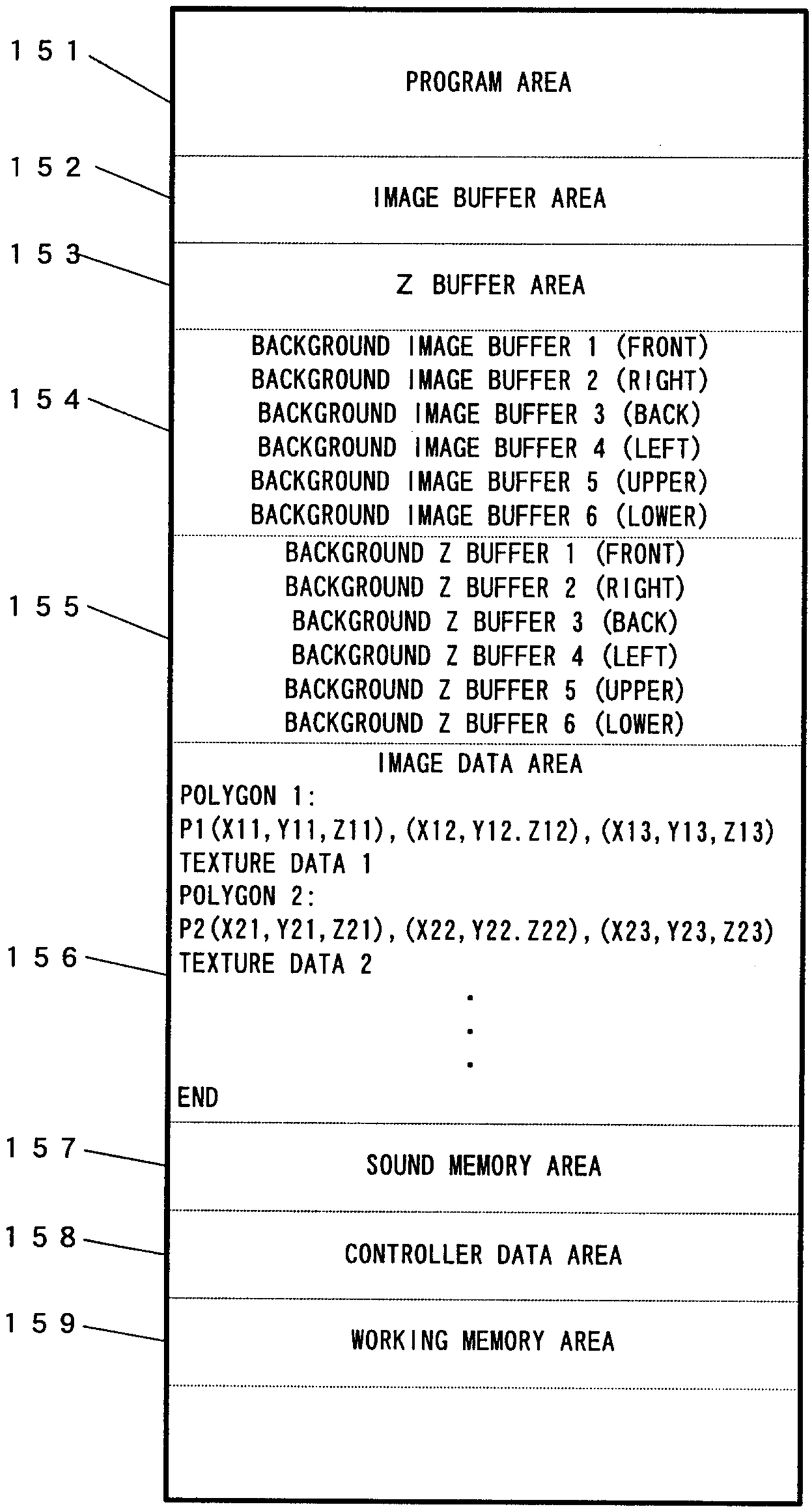

151
PROGRAM AREA
152
IMAGE BUFFER AREA
153
Z BUFFER AREA
154
BACKGROUND IMAGE BUFFER 1 (FRONT)
BACKGROUND IMAGE BUFFER 2 (RIGHT)
BACKGROUND IMAGE BUFFER 3 (BACK)
BACKGROUND IMAGE BUFFER 4 (LEFT)
BACKGROUND IMAGE BUFFER 5 (UPPER)
BACKGROUND IMAGE BUFFER 6 (LOWER)
155
BACKGROUND Z BUFFER 1 (FRONT)
BACKGROUND Z BUFFER 2 (RIGHT)
BACKGROUND Z BUFFER 3 (BACK)
BACKGROUND Z BUFFER 4 (LEFT)
BACKGROUND Z BUFFER 5 (UPPER)
BACKGROUND Z BUFFER 6 (LOWER)
156
IMAGE DATA AREA
POLYGON 1:
P1(X11,Y11,Z11),(X12,Y12.Z12),(X13,Y13,Z13)
TEXTURE DATA 1
POLYGON 2:
P2(X21,Y21,Z21),(X22,Y22.Z22),(X23,Y23,Z23)
TEXTURE DATA 2
END
157
SOUND MEMORY AREA
158
CONTROLLER DATA AREA
159
WORKING MEMORY AREA

FIG. 8

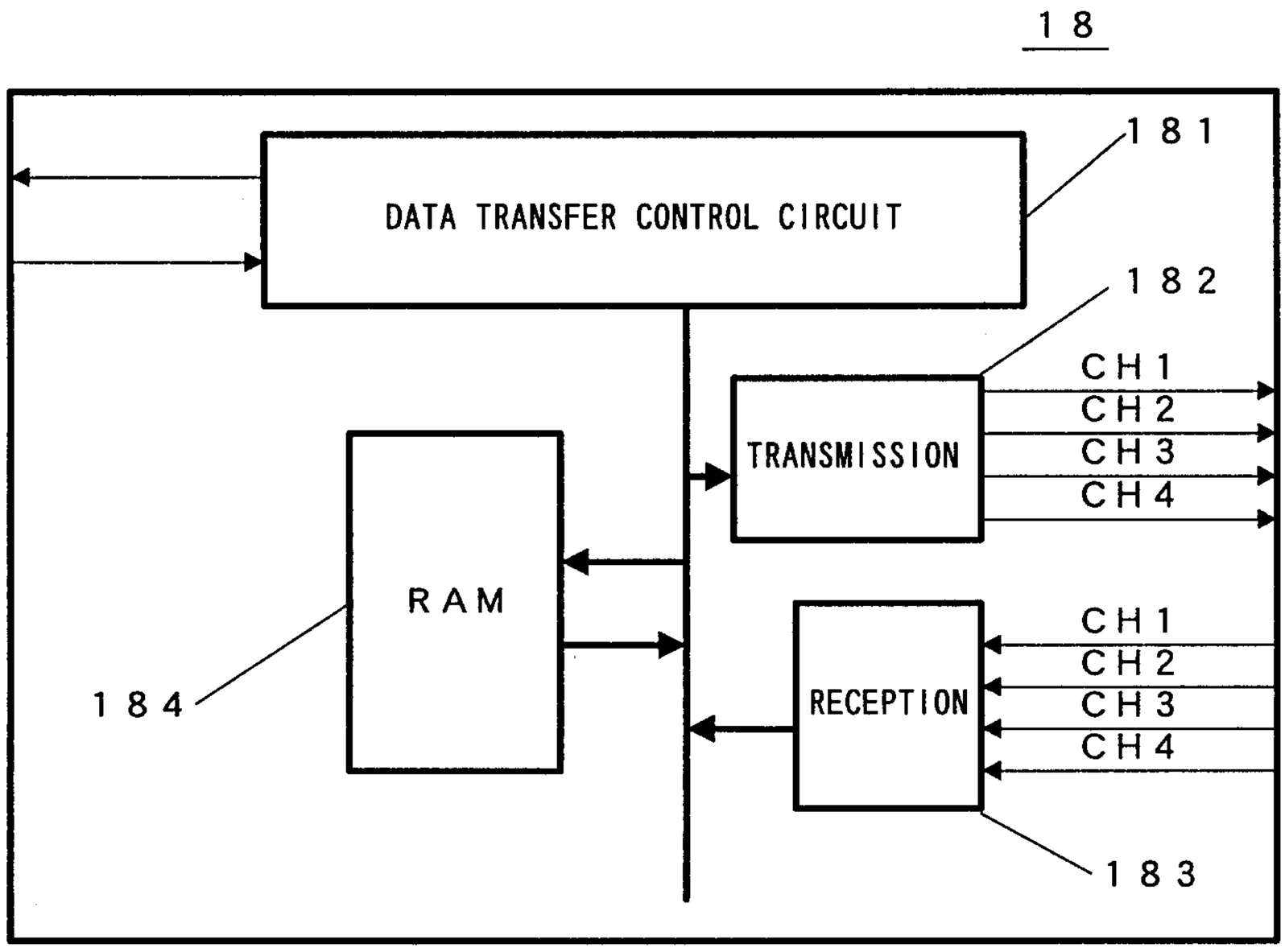

18
181
DATA TRANSFER CONTROL CIRCUIT
182
CH1
CH2
CH3
CH4
TRANSMISSION
RAM
184
CH1
CH2
CH3
CH4
RECEPTION
183

FIG. 9

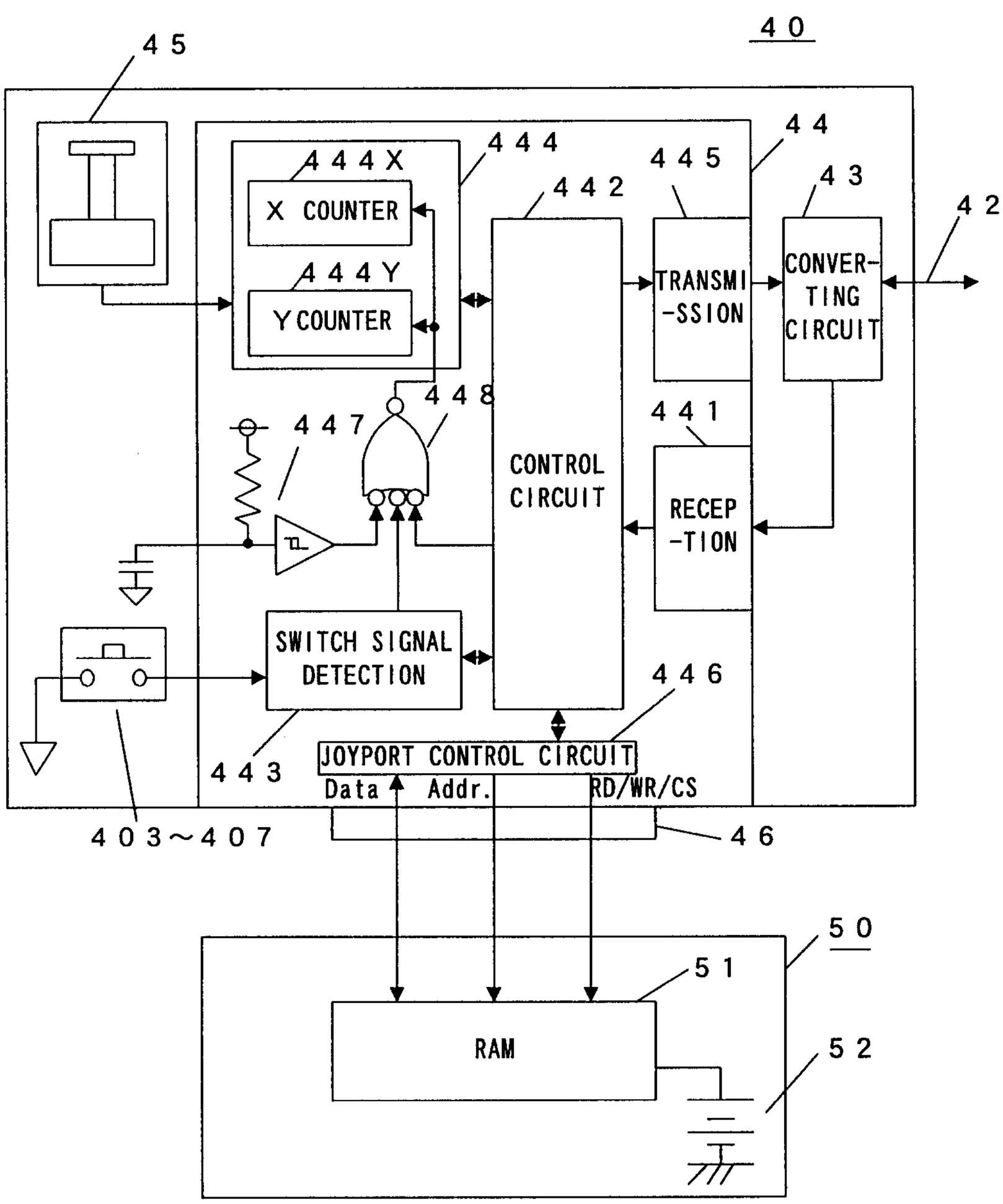

45
40
444
444X
X COUNTER
444Y
Y COUNTER
442
445
44
43
42
TRANSMI
-SSION
CONVER-
TING
CIRCUIT
448
447
441
CONTROL
CIRCUIT
RECEP
-TION
SWITCH SIGNAL
DETECTION
446
443
JOYPORT CONTROL CIRCUIT
Data
Addr.
RD/WR/CS
403～407
46
50
51
RAM
52

FIG. 10

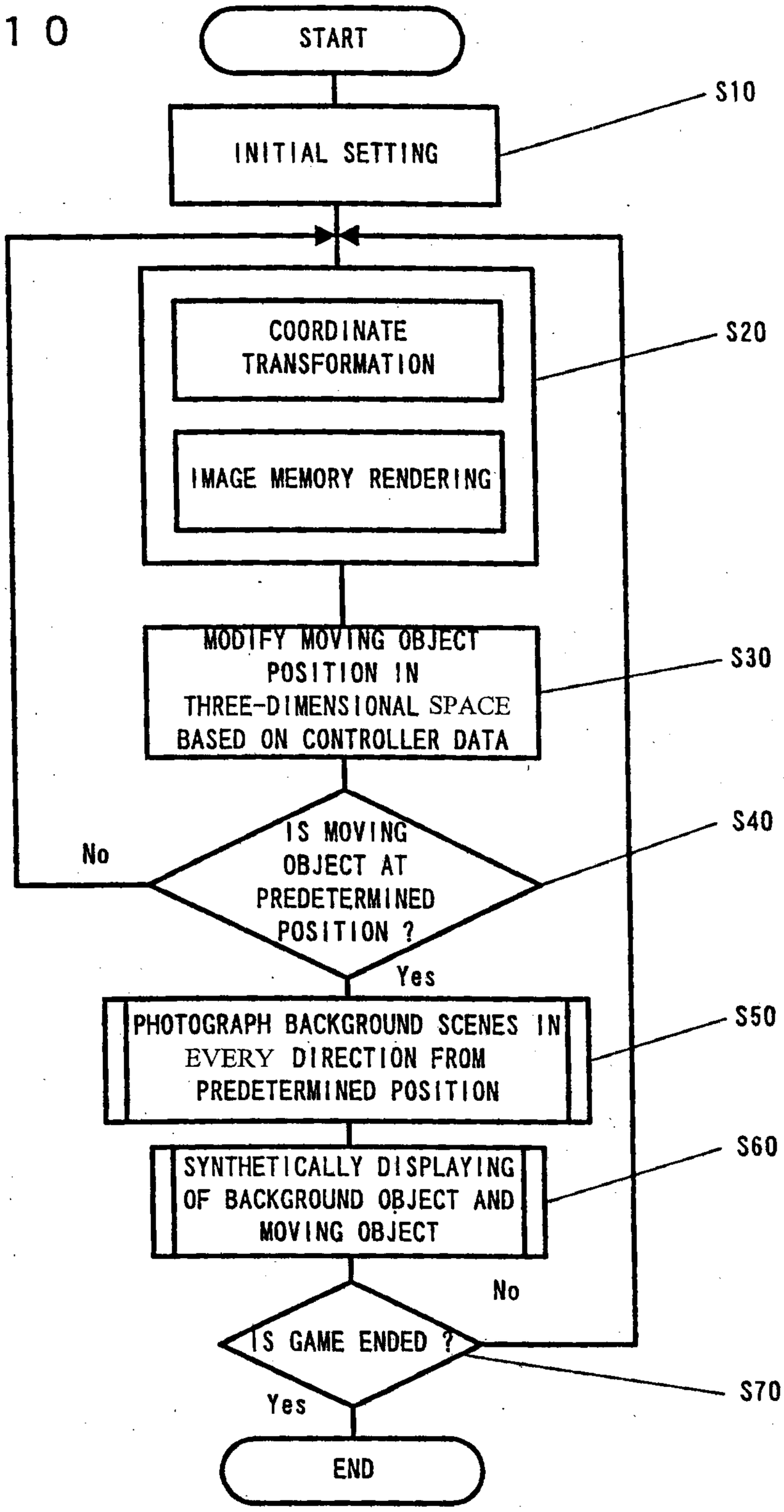

START
INITIAL SETTING
S10
COORDINATE TRANSFORMATION
IMAGE MEMORY RENDERING
S20
MODIFY MOVING OBJECT POSITION IN THREE-DIMENSIONAL SPACE BASED ON CONTROLLER DATA
S30
IS MOVING OBJECT AT PREDETERMINED POSITION ?
No
S40
Yes
PHOTOGRAPH BACKGROUND SCENES IN EVERY DIRECTION FROM PREDETERMINED POSITION
S50
SYNTHETICALLY DISPLAYING OF BACKGROUND OBJECT AND MOVING OBJECT
S60
No
IS GAME ENDED ?
S70
Yes
END

FIG. 11

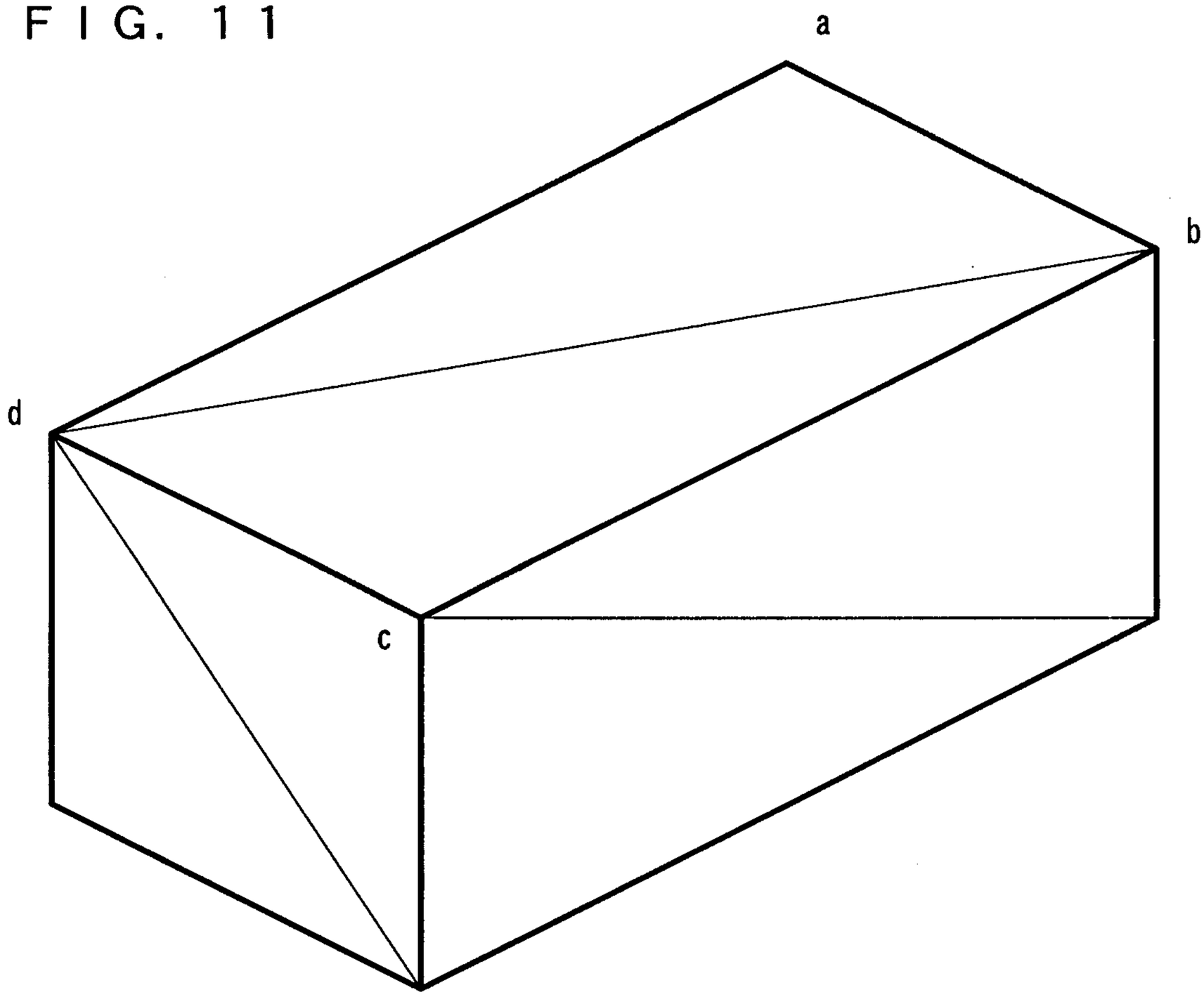
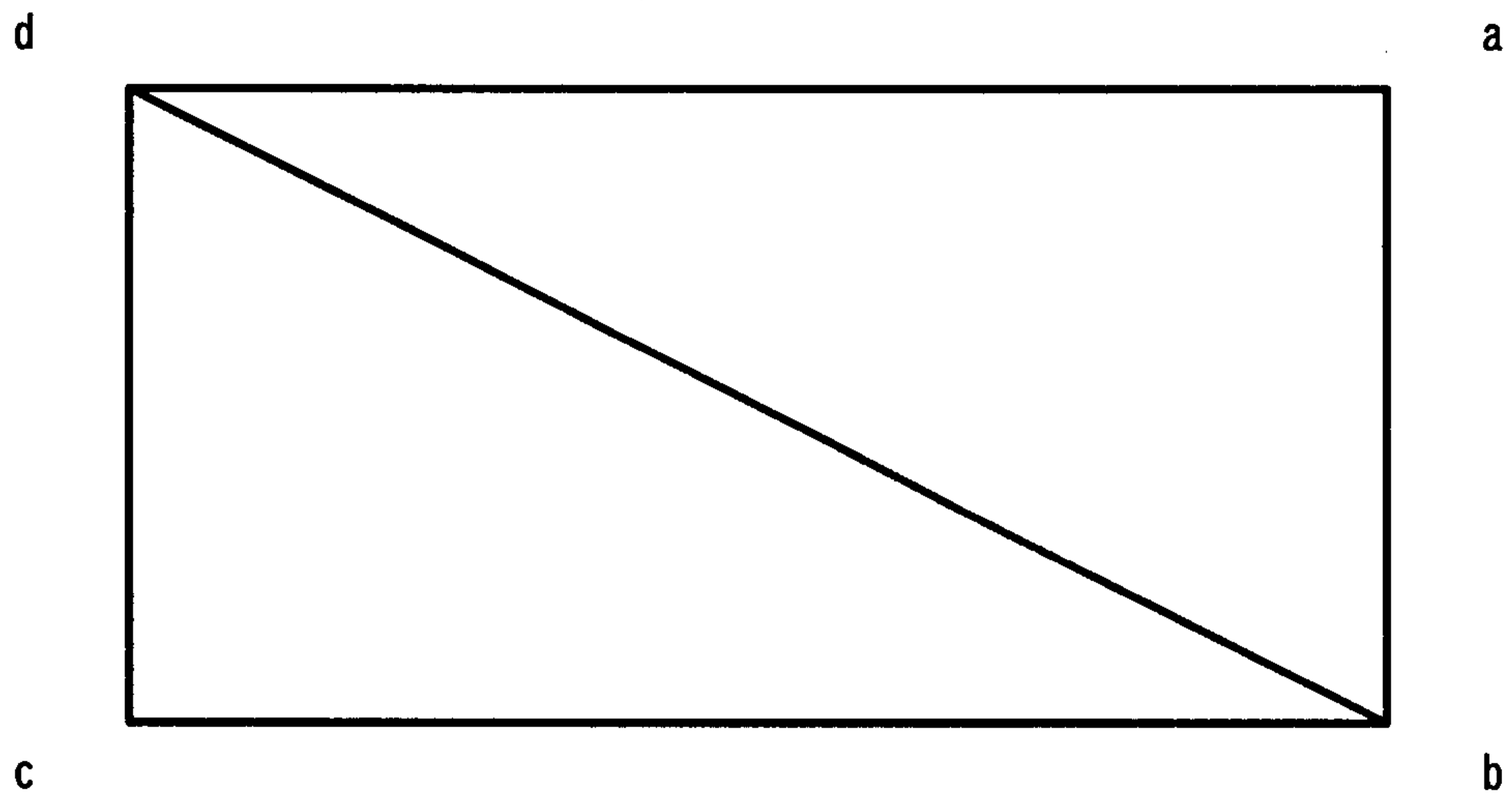


FIG. 12



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FIG. 13

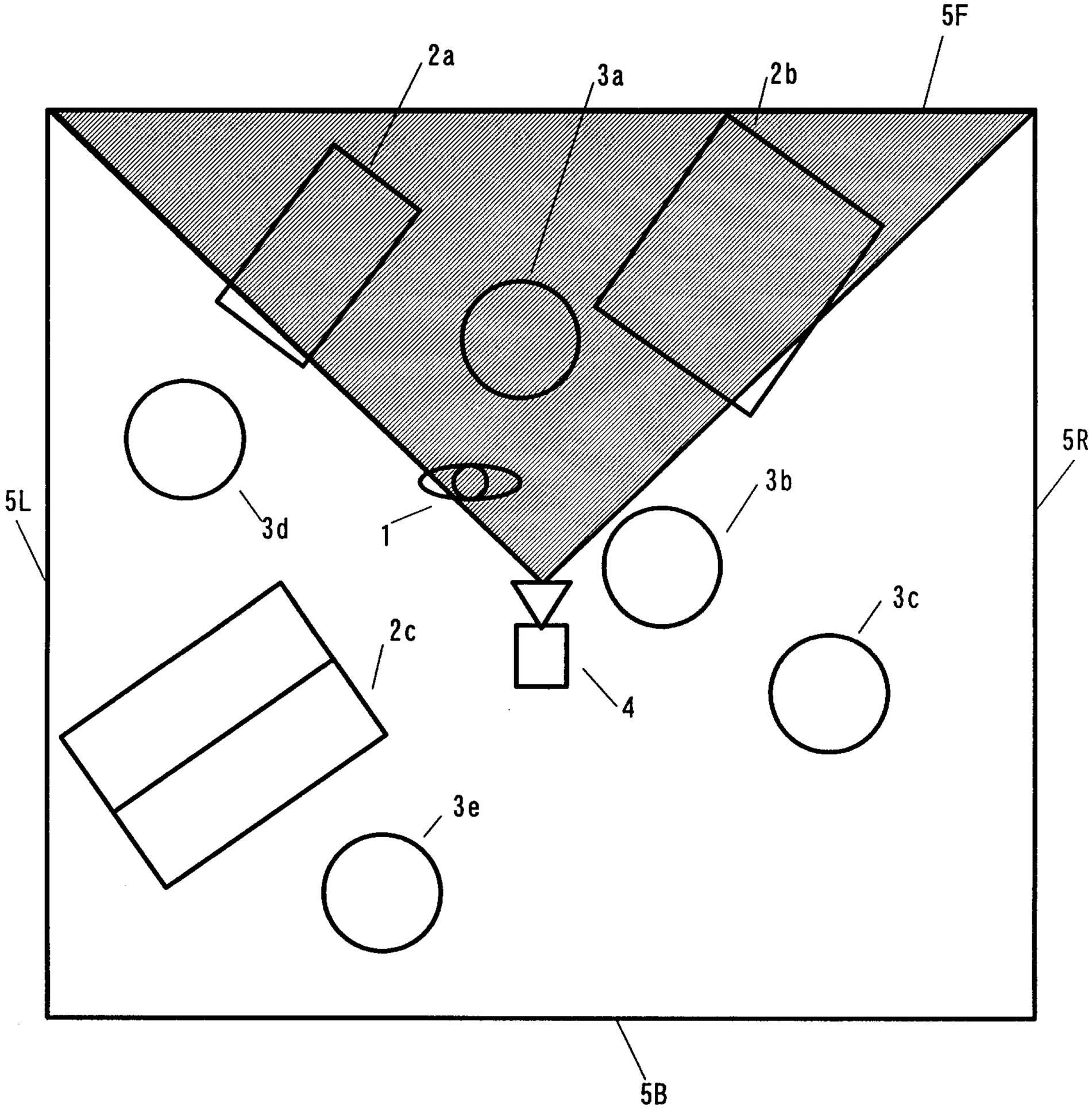


FIG. 14

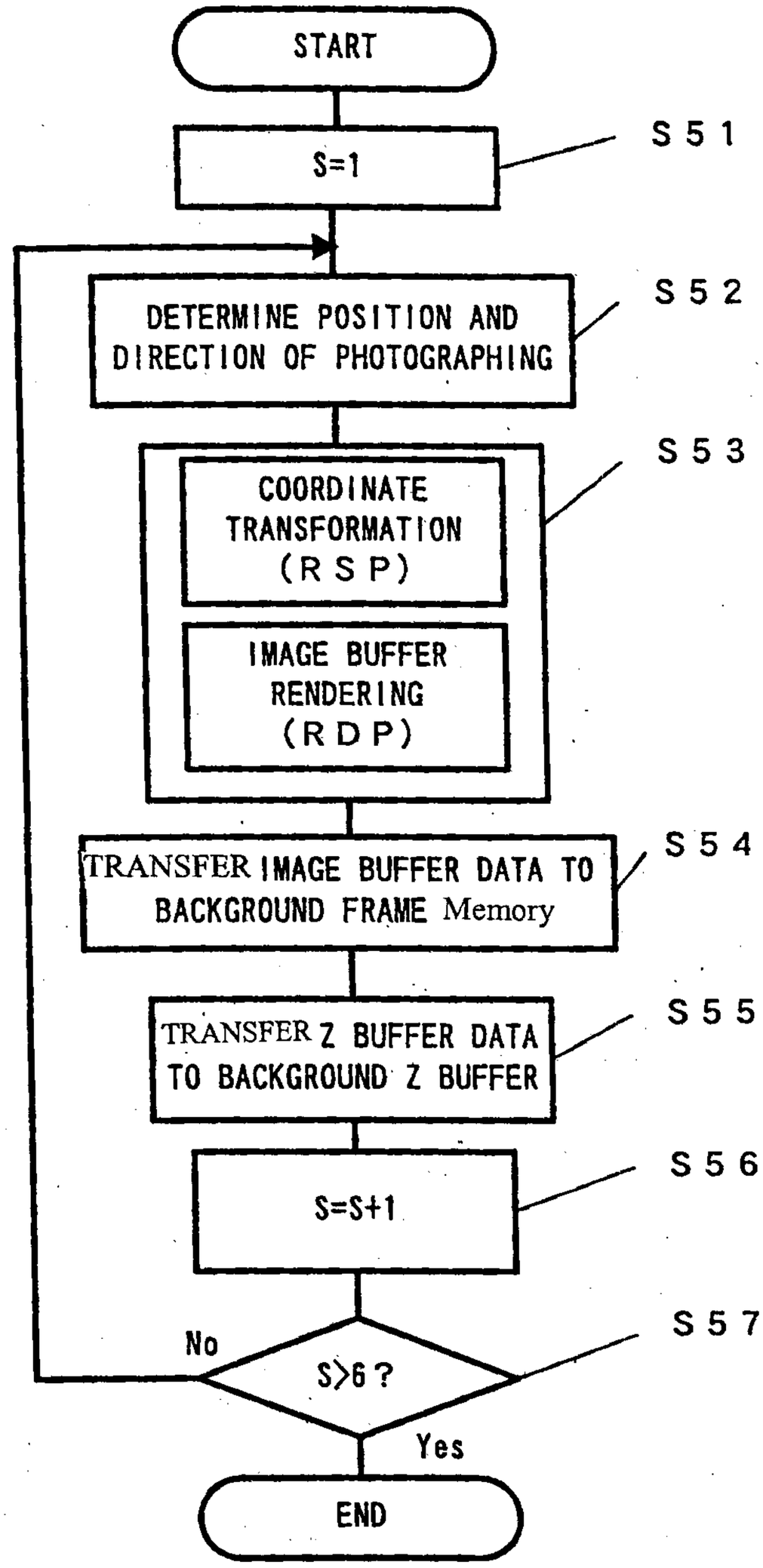
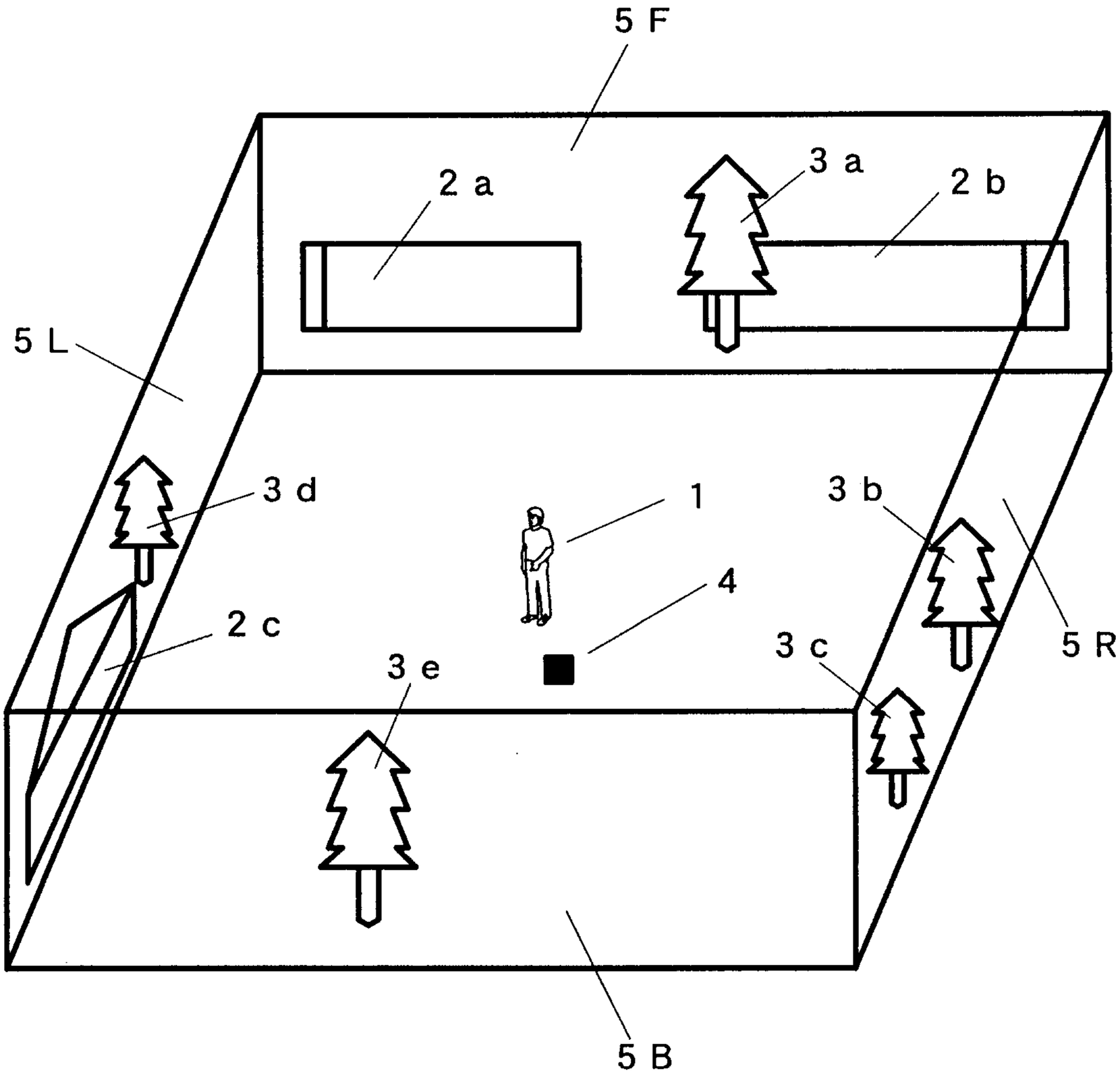

START
S=1
S51
DETERMINE POSITION AND DIRECTION OF PHOTOGRAPHING
S52
COORDINATE TRANSFORMATION (RSP)
IMAGE BUFFER RENDERING (RDP)
S53
TRANSFER IMAGE BUFFER DATA TO BACKGROUND FRAME Memory
S54
TRANSFER Z BUFFER DATA TO BACKGROUND Z BUFFER
S55
S=S+1
S56
No
S>6?
S57
Yes
END

FIG. 15



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FIG. 16

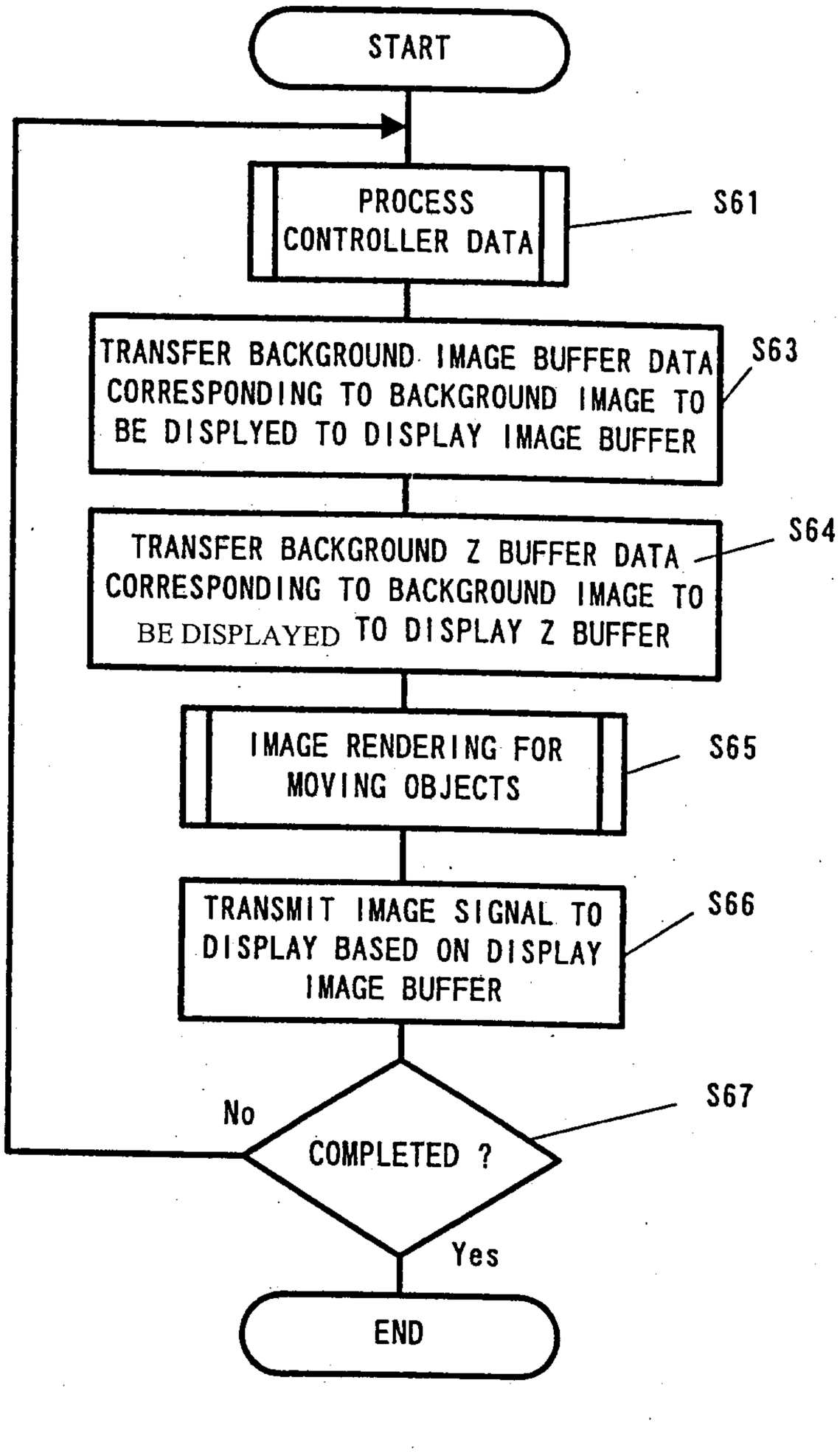

START
PROCESS CONTROLLER DATA
S61
TRANSFER BACKGROUND IMAGE BUFFER DATA CORRESPONDING TO BACKGROUND IMAGE TO BE DISPLYED TO DISPLAY IMAGE BUFFER
S63
TRANSFER BACKGROUND Z BUFFER DATA CORRESPONDING TO BACKGROUND IMAGE TO BE DISPLAYED TO DISPLAY Z BUFFER
S64
IMAGE RENDERING FOR MOVING OBJECTS
S65
TRANSMIT IMAGE SIGNAL TO DISPLAY BASED ON DISPLAY IMAGE BUFFER
S66
No
COMPLETED ?
S67
Yes
END

FIG. 17

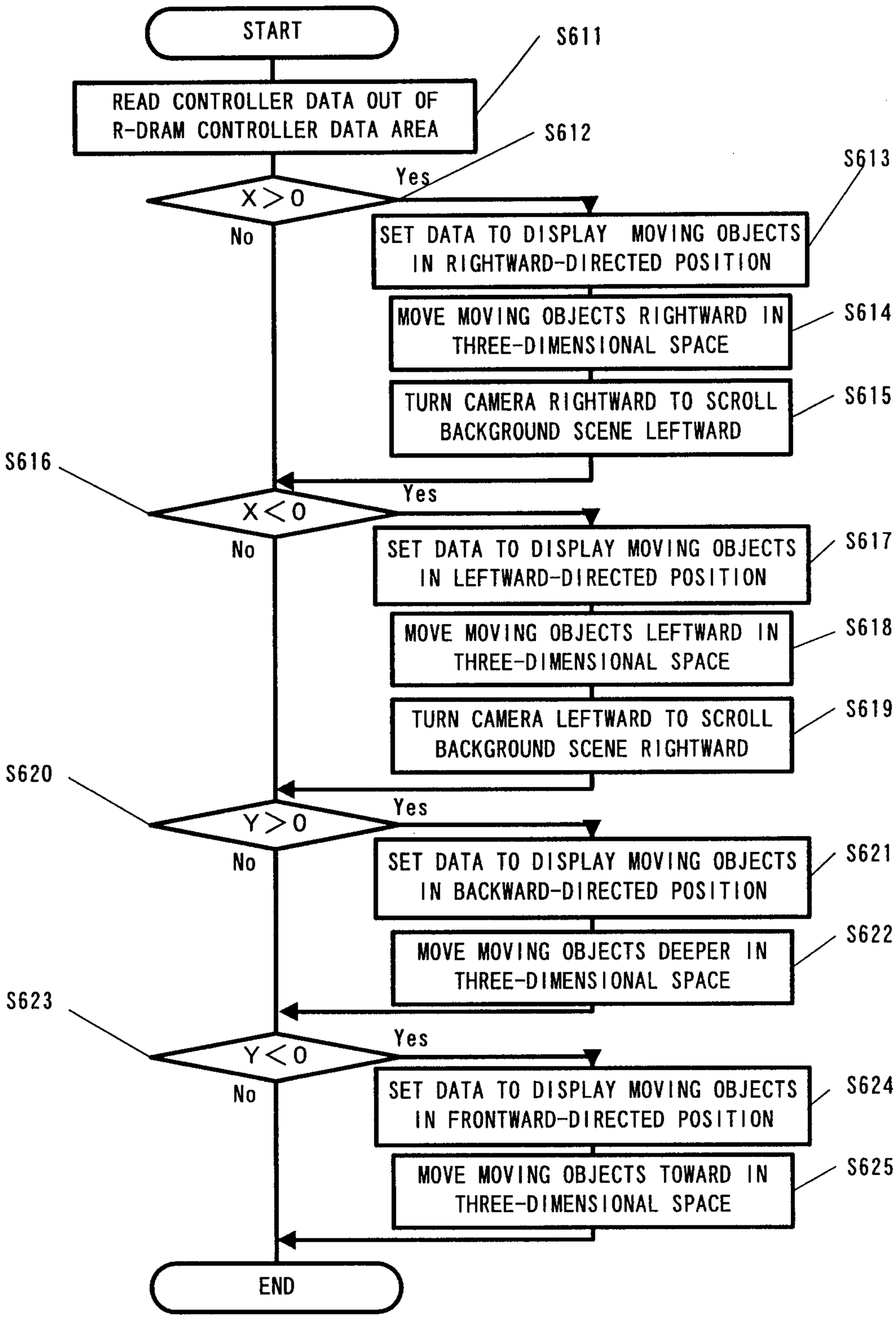

START
READ CONTROLLER DATA OUT OF R-DRAM CONTROLLER DATA AREA
S611
X > 0
Yes
S612
No
SET DATA TO DISPLAY MOVING OBJECTS IN RIGHTWARD-DIRECTED POSITION
S613
MOVE MOVING OBJECTS RIGHTWARD IN THREE-DIMENSIONAL SPACE
S614
TURN CAMERA RIGHTWARD TO SCROLL BACKGROUND SCENE LEFTWARD
S615
S616
X < 0
Yes
No
SET DATA TO DISPLAY MOVING OBJECTS IN LEFTWARD-DIRECTED POSITION
S617
MOVE MOVING OBJECTS LEFTWARD IN THREE-DIMENSIONAL SPACE
S618
TURN CAMERA LEFTWARD TO SCROLL BACKGROUND SCENE RIGHTWARD
S619
S620
Y > 0
Yes
No
SET DATA TO DISPLAY MOVING OBJECTS IN BACKWARD-DIRECTED POSITION
S621
MOVE MOVING OBJECTS DEEPER IN THREE-DIMENSIONAL SPACE
S622
S623
Y < 0
Yes
No
SET DATA TO DISPLAY MOVING OBJECTS IN FRONTWARD-DIRECTED POSITION
S624
MOVE MOVING OBJECTS TOWARD IN THREE-DIMENSIONAL SPACE
S625
END

FIG. 18

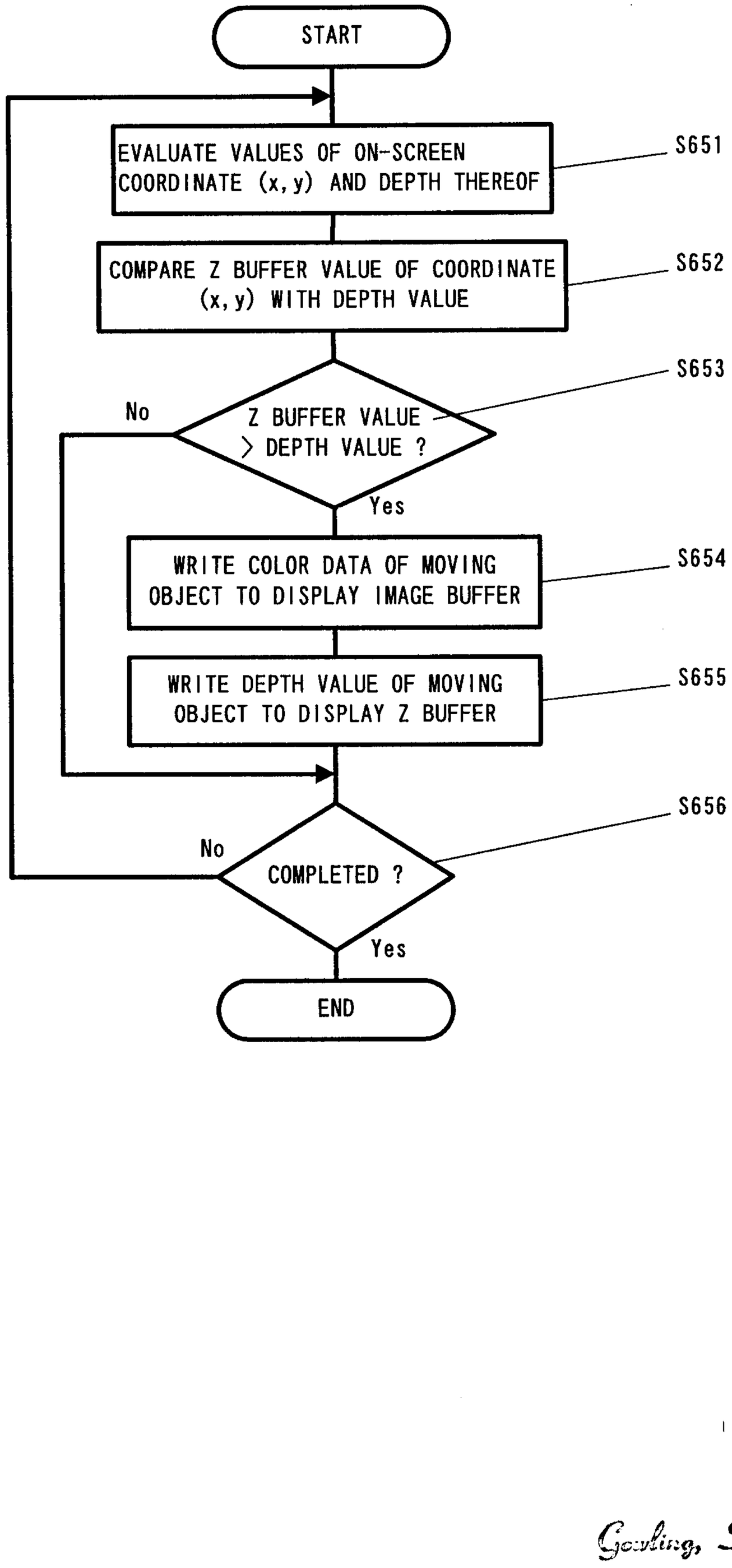
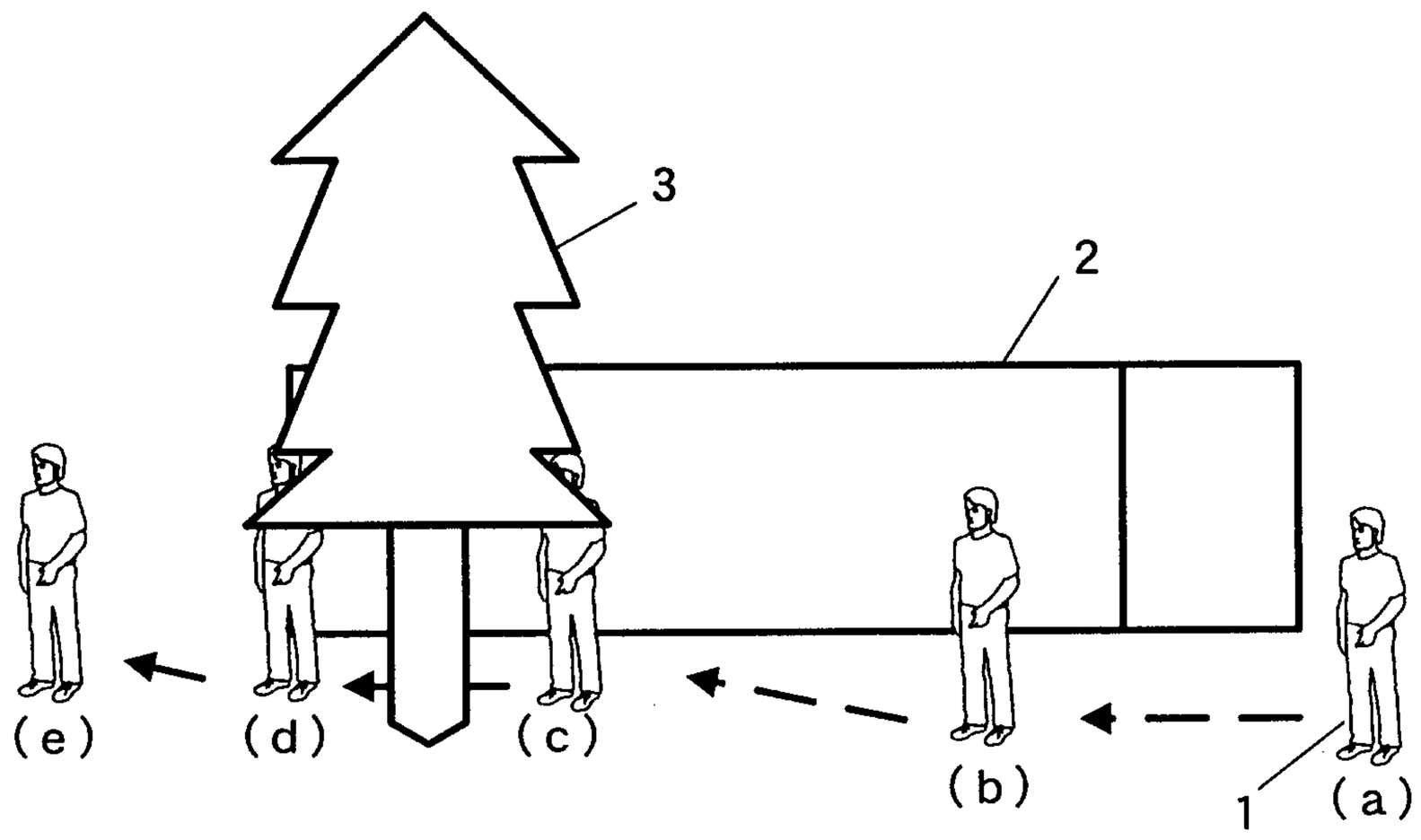
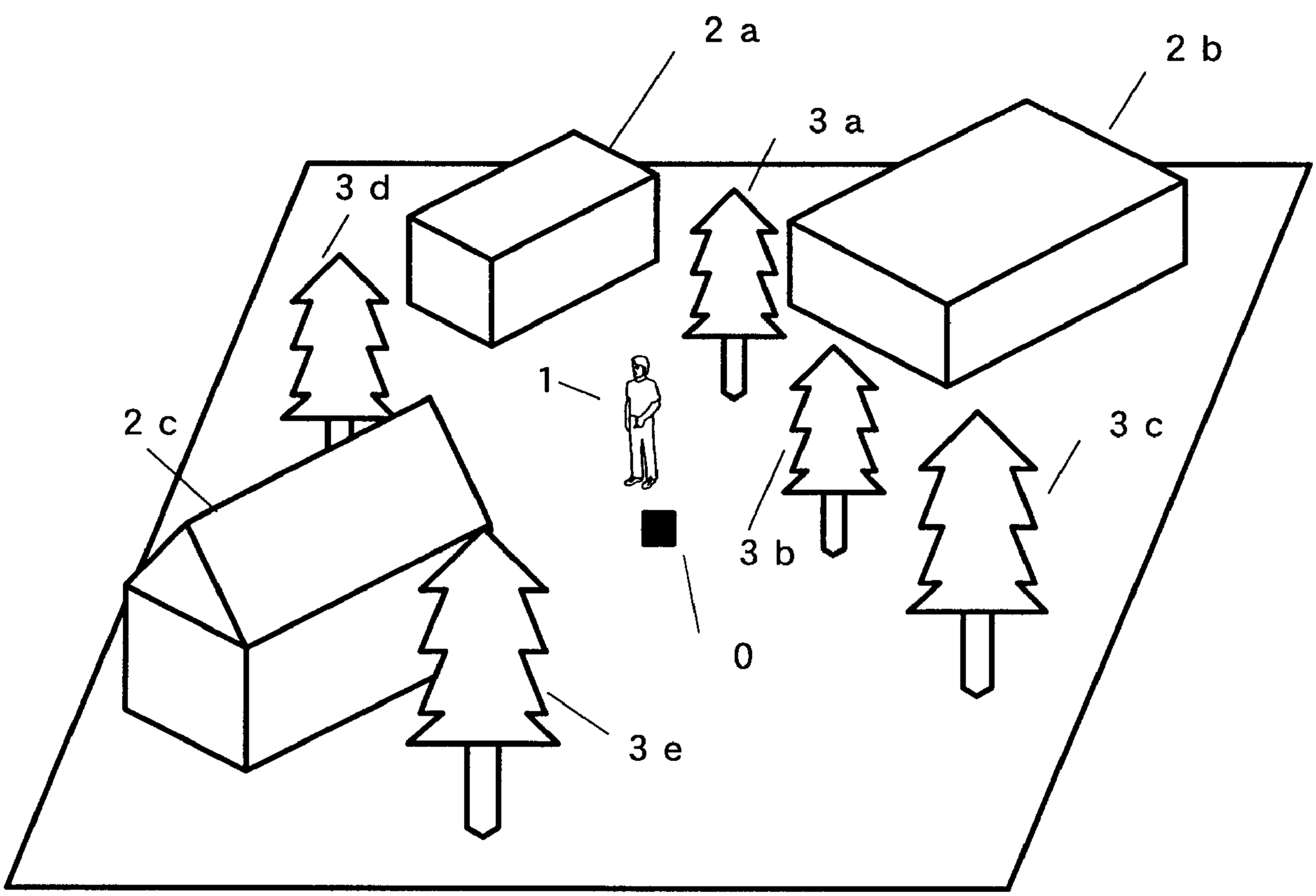

START
EVALUATE VALUES OF ON-SCREEN COORDINATE (x, y) AND DEPTH THEREOF
S651
COMPARE Z BUFFER VALUE OF COORDINATE (x, y) WITH DEPTH VALUE
S652
Z BUFFER VALUE > DEPTH VALUE ?
S653
No
Yes
WRITE COLOR DATA OF MOVING OBJECT TO DISPLAY IMAGE BUFFER
S654
WRITE DEPTH VALUE OF MOVING OBJECT TO DISPLAY Z BUFFER
S655
COMPLETED ?
S656
No
Yes
END

FIG. 19




2 a
2 b
3 a
3 d
1
2 c
3 c
3 b
0
3 e