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(54) **IMAGE PROCESSOR AND GAME MACHINE USING THE SAME**

BILDPROZESSOR UND SPIELGERÄT ZUR VERWENDUNG DESSELBEN

PROCESSEUR D'IMAGES ET MACHINE DE JEU FAISANT INTERVENIR CE DERNIER

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- **PATENT ABSTRACTS OF JAPAN vol. 096, no. 001, 31 January 1996 & JP 07 244743 A (SEGA ENTERP LTD), 19 September 1995,**

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Description

TECHNICAL FIELD

[0001] The present invention relates to a picture processing device. Particularly, this invention relates to a picture processing device used for a game device. More particularly, this invention relates to a game device for an air battle game which imitates battle techniques of a plurality of aircraft.

BACKGROUND ART

[0002] With the progress of computer graphics technology in recent years, picture processing devices, such as game devices and simulation devices, have become widely popular in general. A game device comprises, for example, peripherals such as joysticks (operation sticks), buttons and monitor, and a main game device for conducting data communication with the peripherals or for executing picture processing or sound processing. Since the picture processing of this game device weighs very heavily in enhancing the product value, the technique of animation reproduction has become precise in these days.

[0003] In this type of game device, the main game device has a computer device built-in for executing previously stored game programs and is designed to give operation signals, which command the movement of characters, background and objects, etc. expressed in a game, from the peripherals to the computer device. The game device also comprises a display for displaying a picture in accordance with game developments as a game program is executed by the computer device, and a sound device for generating sounds in accordance with game developments.

[0004] As one field of the game device having such structure, there is a game device which performs a game of air battle between a player's aircraft and opponents' aircraft. This air battle game simulates a situation in which a game player controls the joystick (or operation stick) to move the player's aircraft to a position behind the opponent's aircraft to attack the opponent's aircraft.

[0005] In this type of air battle game, aircraft appear which can move in free directions in a three-dimensional space. Accordingly, aircraft and background are composed of a plurality of polygons in a three-dimensional coordinate space, and picture processing means of the main game device executes picture processing to express an image, as seen from a predetermined viewpoint, of the aircraft, background, etc. in this coordinate space.

[0006] However, when controlling the player's aircraft in the three-dimensional space, a very high skill is required to control the course and direction of the player's aircraft at the aimed route, and it is very difficult to adjust the player's aircraft at the moving direction of the opponent's aircraft and to make the player's aircraft appear behind the opponent's aircraft. Therefore, an air battle game device is provided which is designed to move the player's aircraft and the opponent's aircraft in almost the same direction to make the player's aircraft easily appear behind the opponent's aircraft (for example, "WING WAR (Trademark)" manufactured by SEGA ENTERPRISES LTD.).

[0007] However, since such a conventional game device gives speeds to move in the three-dimensional space respectively to the opponent's aircraft and to the player's aircraft, there is a problem that when the game enters the picture processing state where the player's aircraft and the opponent's aircraft oppose to each other, for example, by flying past each other, such a state is over in an instant and the player cannot deal with this state. In conclusion, with the conventional game device, it is impossible to provide a game device which enables easy operation of objects and realizes superior attractiveness and interest.

[0008] Accordingly, this invention aims to provide a picture processing device which enables the player or operator to sufficiently deal with the state in which a plurality of objects fly past each other.

[0009] According to a first aspect of the invention, there is provided a picture processing device, comprising picture processing means for executing picture processing to display on a displaying means an image, as seen from a predetermined viewpoint, of a plurality of virtual flying objects existing in a three-dimensional virtual coordinate space, said picture processing means executing picture processing to move said objects in said coordinate space at respective speeds in accordance with operation signals from operating means for operating said objects, wherein said picture processing means comprises: first means for executing a picture processing mode in which first and second objects appear to fly in opposite directions in said virtual coordinate space; and second means operable in said picture processing mode for processing coordinate values of the first and second objects in said three-dimensional virtual coordinate space so as to reduce the relative speed of the first and second objects appearing to fly in said directions opposite to each other in said virtual coordinate space; said first means being arranged to execute picture processing in said picture processing mode to cause the first and second objects to appear to approach one another substantially head-on and to fly past each other, and said second means being operable on detection that the processing is in said picture processing mode to set the direction and speed of the first and second objects so that they fly in the same direction in said virtual coordinate space and with a predetermined relative speed.

[0010] In the described embodiment, the second means is operable to set said relative speed so that the time required for the first and second objects to fly past each other in the virtual three-dimensional coordinate space corresponds with a predetermined time.

[0011] In the embodiment, the picture processing means includes: means for determining base coordinate values of the objects flying in accordance with the operating signals in the three-dimensional space; means for converting said base coordinate values into a coordinate system corresponding to said visual field of display by the displaying means; means operable in said picture processing mode to compute from the base coordinate values of said first and second objects the distance between said objects in said three-dimensional space, to reset the direction of flight of one of said first and second objects in said three-dimensional space to be the same as the direction of flight of the other of said first and second objects, and to reset the speed of flight of said one of said first and second objects in said reset direction to be lower than the speed of the flight of the other of said first and second objects, so that the distance between said first and second objects reduces with time, but at a slower rate than that associated with the directions and speeds of the respective first and second objects prior to said resetting thereof by said computing and resetting means.

[0012] According to a second aspect of the invention, there is provided a game device, comprising displaying means and a picture processing device according to the first aspect.

[0013] According to a third aspect of the invention, there is provided a storage medium for storing a computer program comprising code means adapted so that when loaded into a computer the combination of the computer and program operates to provide the functionality of the picture processing device according to the first aspect or the game device according to the second aspect.

[0014] According to this invention, the first means executes the processing to move the first and second objects in directions opposite to each other in the three-dimensional space. The second means detects that this processing is executed and then sets a relative speed of the first and second objects flying in mutually opposite directions at a reduced value. Accordingly, although the opposing flying past action of the first and second objects would terminate in a short time if they were to move in the opposite directions at the same speeds as if they were not moving in opposite directions, the time required for such opposing action is extended when the relative speed is reduced as described above. Therefore, the player or operator can deal with this situation properly and provide the necessary operation inputs to the operating means.

[0015] The second means detects that the first and second objects are in the picture processing mode where these objects are approaching each other in opposite directions along substantially the same course. The second means then causes the objects to fly in the same direction in the coordinate space on the basis of the detection results, that is, causes one object to fly backward in the coordinate space and sets a predetermined reduced relative speed to these objects.

[0016] Thus, the second means sets the relative speed of the objects so that the time required for the first and second objects to pass by each other in the three-dimensional coordinate space becomes a predetermined time, thereby making the time required until these objects pass by each other a desirable figure.

[0017] In the third aspect of the invention, the storage medium may comprise, for example, a floppy disk, magnetic tape, photomagnetic disk, CD-ROM, DVD, ROM cartridge, RAM cartridge with battery back-up, and non-volatile RAM cartridge. The storage medium stores information (mainly digital data and programs) by some physical means and is capable of having a processing device such as computers and private processors perform a certain function.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Figure 1 is a full perspective view of a game device according to one embodiment of the present invention.

Figure 2 is a block diagram of this game device.

Figure 3 is a main flowchart of this game device.

Figure 4 is a flowchart of a subroutine which describes the player's aircraft movement processing.

Figure 5 is a conceptional view showing the range within which the player's aircraft J existing at a certain point in an absolute coordinate system (in three dimensions) of X, Y and Z axes can move.

Figure 6 is a flowchart of another subroutine which describes the player's aircraft movement processing.

Figure 7 is a model view which describes a round course set by the player's aircraft line changing processing in the three-dimensional coordinate space.

Figure 8 is a flowchart of a subroutine which describes the appearance of the opponent's aircraft and the control of the appeared opponent's aircraft.

Figure 9 is a conceptional view which shows a plurality of objects (the opponent's aircraft and the player's aircraft) being set in the same direction.

Figure 10 shows an image taken from the viewpoint which is set behind the player's aircraft.

Figure 11 shows conceptional views which describe the content of relative speed control of the objects in the opposing processing.

Figure 12 is a detailed flowchart which describes a shell firing processing.

Figure 13 shows conceptional views describing that firing tracks are left by the shell firing processing.

Figure 14 is a detailed flowchart which explains a collision determination processing.

Figure 15 is an example of the appearance of explosion polygon images in the collision determination processing.

Figure 16 is another example of the appearance of the explosion polygon images.

BEST MODE FOR CARRYING OUT THE INVENTION

[0019] An embodiment of the present invention is hereinafter explained by referring to the attached drawings. In this embodiment, an explanation is given about an example where the picture processing device of this invention is applied to an air battle game device. Figure 1 is a full perspective view of this game device. Housing 1 is substantially in a box shape, and substrates and the like are provided within housing 1. On the front face of the housing, a CRT-type display 1a and an operation panel 2 are provided.

[0020] On this operation panel, an operation stick 2a, which serves as a joystick, throttle 2b, and joypad 2c for commanding the start of a game, etc. are provided.

[0021] The game player sits on a chair (not shown) which is set integrally with housing 1 in front of housing 1, and operates an aircraft (player's aircraft: first object) displayed on display 1a against other aircraft (opponent's aircraft: second object) by operating the operation stick 2a, etc. The flying course and flying direction of the player's aircraft can be controlled by using the operation stick 2a and the speed of the player's aircraft can be controlled by using a throttle lever 2b. The opponent's aircraft are caused to appear and are controlled by a microcomputer on the game device side in accordance with a predetermined program. It is possible to cause the opponent's aircraft to be controlled by an opponent game player by, for example, connecting two game devices.

[0022] Figure 2 shows a block structure of this game device. This game device comprises, as its basic elements, a main game device 10 composed of a microcomputer, input device 11, output device 12, TV monitor 13 and speaker 14.

[0023] The input device (or operating means) 11 has the operation stick and the throttle lever as described above and also has a view change (or viewpoint changing) switch 2d, etc. as necessary. This viewpoint changing switch provides a selection of viewpoints to the player. For example, either an image of the player's aircraft against the opponent's aircraft as seen from the viewpoint at the cockpit of the player's aircraft or an image of the player's aircraft against the opponent's aircraft as seen from the viewpoint close to upper behind the player's aircraft off to the right or left can be selected. This game device may comprise a kickback mechanism to adjust the operation power of the operation stick, and an output device 13 which comprises various types of lamps, as necessary. A projector may be used instead of the TV monitor 13.

[0024] The main game device 10 has CPU (central processing unit) 101 and also comprises ROM 102, RAM 103, sound device 104, input/output interface 106, scroll data computing device 107, co-processor (auxiliary processing unit) 108, landform data ROM 109, geometrizer 110, shape data ROM 111, drawing device 112, texture data ROM 113, texture map RAM 114, frame buffer 115, picture synthesizing device 116, and D/A converter 117.

[0025] CPU 101 is connected via bus lines to ROM 102, which stores predetermined programs and the like, RAM 103 for storing various data, sound device 104, input/output interface 106, scroll data computing device 107, co-processor 108 and geometrizer 110.

[0026] RAM 103 functions as the RAM for the buffer, so various commands (including a command to display characters such as the player's aircraft and the opponent's aircraft) to geometrizer 110 are written thereon and a matrix at the time of conversion matrix computation is written thereon.

[0027] The input/output interface 106 is connected to the input device 11 and the output device 12, thereby operation signals of the operation stick, etc. of the input device 11 are taken in CPU 101 as digital quantity and signals generated by CPU 101 and other elements can be outputted to the output device 12. The sound device 104 is connected to speaker 14 via the power amplifier 105, and sound signals generated by the sound device 104 are amplified and then given to speaker 14.

[0028] According to this embodiment, CPU 101 reads in, based on the program installed in ROM 102, operation signals from the input device 11 and landform data from the landform data ROM 109 or shape data (three-dimensional data of, for example, characters such as the player's aircraft and the opponent's aircraft, landform, and background such as sky) from the shape data ROM 111, and then executes various processing as described later in Figure 3.

[0029] Aircraft behavior calculation is conducted to simulate the movements of the aircraft in a virtual space according to the operation signals sent by the player from the input device 11. After a coordinate value in the three-dimensional space is determined, a conversion matrix for converting this coordinate value into a visual field coordinate system and the shape data (such as those concerning the aircraft and landform) are specified at geometrizer 110.

[0030] The landform data ROM 109 stores the landform data as well as the shape data of shells to be fired by the player's aircraft, the opponent's aircraft, and the player's aircraft or the opponent's aircraft. In this embodiment, ROM 109 is referred to as the landform data ROM for convenience. Co-processor 108 is connected to the landform data ROM 109 and, therefore, the shape data including the predetermined landform and the aircraft (the player's aircraft and the opponent's aircraft) are given to co-processor 108 (and to CPU 101).

[0031] Co-processor 108 is designed mainly to make a collision determination concerning the player's aircraft and the opponent's aircraft (for example, whether or not a shell has hit the aircraft, or whether or not the aircraft has collided with the ground), and to assume mainly the operation of floating points during this determination and the aircraft behavior computation. As result, the determination of contact concerning the aircraft is performed by co-processor 108, and the determination results are given to CPU 101, thereby reducing the computation load on CPU and enabling more rapid performance of this contact determination as well as more rapid picture processing (for example, formation of an explosion picture as described later) at CPU based on the determination results.

[0032] Geometrizer 110 is connected to the shape data ROM 111 and the drawing device 112. The shape data ROM 111 has previously stored thereon the polygon shape data (three-dimensional data of plural polygons consisting of respective vertexes, which compose the player's aircraft and the opponent's aircraft, or the background such as landform), and this shape data is delivered to geometrizer 110. Geometrizer 110 radioscopically converts the shape data designated by the conversion matrix and sent from CPU 101, thereby obtaining data converted from the coordinate system of the virtual space consisting of three-dimensional coordinates to the visual field coordinate system.

[0033] The drawing device 112 pastes textures onto the converted shape data of the visual field coordinate system, and outputs such data to the frame buffer 115. In order to paste the textures, the drawing device 112 is connected to the texture data ROM 113 and the texture map RAM 114, and also to the frame buffer 115. Polygon data means a group of data of relative or absolute coordinates of respective vertexes of polygons (polygons: mainly triangles or quadrangles) which are made of an aggregate of a plurality of vertexes. A plurality of these polygons are combined to compose the shape data of the aircraft and background. CPU 101 composes an image as seen from a predetermined viewpoint position on the basis of the shape data defined in the three-dimensional coordinate space and provides picture signals to the TV monitor 13.

[0034] The landform data ROM 109 stores polygon data, which are set comparatively rough to satisfy the performance of the collision determination concerning the player's aircraft, the opponent's aircraft, or the ground. In contrast, the shape data ROM 111 stores polygon data which are set in more details.

[0035] The scroll data computing device 107 computes scroll picture data such as letters. This computing device 107 and the above-mentioned frame buffer 115 are connected to the picture synthesizing device 116 and D/A converter 117 and then to the TV monitor 13. This allows the polygon picture (simulation results), including the aircraft and ground (background), which is temporarily stored in the frame buffer 115, and the scroll picture with letter information, such as a speed value, to be synthesized in accordance with a designated priority, thereby generating a final frame picture data. This picture data is converted by the D/A converter 117 into analog signals and sent to the TV monitor 13, and the picture of the air battle game is displayed on a real time basis.

[0036] Actions of this game device are hereinafter explained by referring to Figure 3. Figure 3 shows these actions as a main flowchart of CPU 101. As the game device is activated, CPU 101 starts the processing shown in Figure 3 by means of a timer interruption processing executed at regular intervals (t).

[0037] CPU 101 repeatedly executes at predetermined intervals until the termination of the game: processing to move the player's aircraft (S100); processing to make the opponent's aircraft appear and to control the appeared opponent's aircraft (S200); shell firing processing to execute a processing to fire shells or guided missiles from the player's aircraft or the opponent's aircraft and to move these shells (S400); collision processing to execute an explosion picture appearing processing, etc. as described later on the basis of the results of collision determination executed by co-processor 108 concerning a collision between the aircraft (the player's aircraft or the opponent's aircraft) and the ground or a collision between the aircraft and the shell (S500); and processing to produce a radioscopic conversion matrix for radioscopically converting the respective three-dimensional shape data based on the above respective processing into the visual field coordinate system, and to specify this matrix as well as the shape data at the aforementioned geometrizer 110 via RAM 103, thereby obtaining a picture of the processing results (S600).

[0038] The respective processing S100 through S500 are programmed, for example, in the form of subroutines and will be explained later in more details.

[0039] Figure 4 is a detailed flowchart which explains one subroutine of the above-described player's aircraft moving processing (S100). CPU 101 reads in, through the input/output interface 106, the operation information about the player's aircraft as the digital quantity, which is given by operation by the game player of the input device 11 such as the operation stick or throttle, and detects the moving direction of the player's aircraft (S102).

[0040] As shown in Figure 5, in this embodiment, the moving range of the player's aircraft J, which exists at a certain position in the absolute coordinate system (in three dimensions) of X, Y and Z axes, is limited to the range defined by height H along the Y-axis direction through that position, angle θ formed on the X-Z plane, and angle θ' formed on the Y-X plane.

[0041] Accordingly, CPU 101 determines whether or not the input amount from the input device is within the above-described range of limiting value (S104), and if the input amount exceeds the limiting value, the input amount is reduced to the limiting value and the player's aircraft is moved in the three-dimensional coordinate space (S106 and S108). Instead of reducing the input amount, the moving range of the player's aircraft according to the input amount may be limited by a relevant program.

[0042] A subroutine other than the player's aircraft moving processing (S100) is hereinafter explained based on Figure 6. CPU 101 reads in the coordinates of the player's aircraft in the three-dimensional space (S202) and also determines whether or not the read coordinates have reached the appearing range of a boss aircraft, one of the opponent's aircraft, which is the specific object of the present invention (S204).

[0043] If the coordinates of the player's aircraft have reached within a predetermined distance from the coordinates of the boss aircraft, for example, the above determination is affirmed and then CPU 101 sets "1" in a course change processing mode flag Fa in a predetermined area of RAM (S206), which shows that it has proceeded from the standard moving processing as described in Figure 5 to move the player's aircraft described in Figure 4, to the course change processing mode. On the other hand, if this determination is denied, CPU 101 returns to the processing of Figure 4 and the standard moving processing state continues.

[0044] CPU 101 executes a processing to change the moving direction or course of the player's aircraft to a round course 902 to fly around the boss aircraft 900 as shown in Figure 7. The round course to fly around the boss aircraft consists of a plurality of points P1 through P5, and coordinate values in the absolute coordinate system and the approach angle of the player's aircraft are set for every point. These data are stored in the shape data ROM 111.

[0045] CPU 101 then moves the player's aircraft to coordinates of the starting point of the round course (for example, P1), reads in the coordinates of the remaining points successively, and moves the player's aircraft around these points (S208). When the player's aircraft moves along the round course around the boss aircraft and reaches the starting point again, it is considered as one round.

[0046] Since the course change flag Fa is designed to keep "1" until the player's aircraft completes flying around the course for predetermined times, CPU determines the value of this flag and causes the player's aircraft to move around the round course until the flag value changes to "0" (S210) and then returns to the main routine as shown in Figure 3.

[0047] S102 through S108 as shown in Figure 4 constitute a moving direction controlling means, S102 and S104 constitute a moving direction detecting means, and S104 and S106 constitute a moving range regulating means. S202 to S210 as shown in Figure 6 constitute a moving direction control releasing means, a moving direction control resetting means and an object movement controlling means.

[0048] According to the processing of the player's aircraft moving subroutine as shown in Figure 6, an image of the boss aircraft, as seen from the viewpoint at the player's aircraft flying around the boss aircraft, is displayed on the TV monitor as shown in Figure 7. Therefore, a varied image generated by different viewpoints is provided to the player.

[0049] For example, if the aforementioned points of the respective points in the round course are taken as representative examples for explanation, the picture processing to display the following images on the TV monitor 13 is executed: image 9(a) as seen at P1 from behind the boss aircraft; image 9(b) as seen at P2 from under the bottom of the boss aircraft; image 9(c) as seen at P3 from just above the boss aircraft; image 9(d) as seen at P4 from just beside the boss aircraft; and image 9(e) as seen at P5 from above the wing of the boss aircraft. This course change processing may move the player's aircraft around the boss aircraft without passing through a predetermined point on the round course.

[0050] Next, one of the subroutines concerning the appearance of the opponent's aircraft and the control of the opponent's aircraft (S200) is hereinafter explained by referring to Figure 8. CPU 101 reads in the coordinate value of the player's aircraft successively and executes this processing when this coordinate value reaches within a predetermined distance from the coordinate point where the opponent's aircraft starts to appear.

[0051] According to this processing, if the opponent's aircraft moves in the same direction as that of the player's aircraft, CPU 101 executes the processing of standard moving state as shown in Figure 4 and then sets the moving direction or course of the opponent's aircraft T at a predetermined distance from the player's aircraft along the X' direction which is the moving direction of the player's aircraft in the absolute coordinate system (X', Y', Z') which is set concerning the player's aircraft J, as shown in Figure 9 (S301).

[0052] As a result, the game device of this embodiment moves the player's aircraft and the opponent's aircraft in the same direction in the absolute coordinate virtual space in three dimensions as shown in Figure 9. The same direction herein used does not necessarily mean completely the same direction. For example, such a situation includes the case where the opponent's aircraft T moves, according to the operation signals from the operation stick 2a, within plane S which is virtually set as being perpendicular to the X' axis.

[0053] According to this S301, since the viewpoint is set behind the player's aircraft, even if the operation stick is operated randomly, the image of the player's aircraft J located behind the opponent's aircraft T1 through T6 as shown in Figure 10 is displayed on the TV monitor 13. By setting the virtual plane S shown in Figure 9 within, or in a space extremely wider, than the display range of the TV monitor in the display coordinate system, it is possible to make the opponent's aircraft T appear in the space within, or in a space extremely wider, than the display range of the TV monitor even if the operation stick 2a is moved violently. In Figure 10, numeral 700 indicates a target set by the player's aircraft at the opponent's aircraft.

[0054] Consequently, it is possible to move the player's aircraft and the opponent's aircraft in the same direction by means of the standard moving processing as shown in Figure 4 and the above-described S301. In this course control processing, the movable range of the player's aircraft is limited to a predetermined range in the absolute coordinate system as shown in Figure 5, because the opponent's aircraft would have to be moved violently in accordance with the movements of the player's aircraft and the movements of the opponent's aircraft would become unnatural if the opponent's aircraft is located in the relative coordinate system of the player's aircraft without limiting the movable range of the player's aircraft as described above and, for example, if the player's aircraft is moved at a large angle in the absolute coordinate system.

[0055] If the opponent's aircraft is the boss aircraft, the processing of S301 is not applied, and the boss aircraft is set at a programmed coordinate position and the standard moving state of the player's aircraft as shown in Figure 4 is changed to the course to fly around the boss aircraft as shown in Figure 6.

[0056] If the opponent's aircraft is programmed to advance in a direction opposite to the player's aircraft, the nose of the opponent's aircraft T is set at a direction facing to the player's aircraft J, as schematically and conceptionally shown in two dimensions in Figure 11, and the opponent's aircraft is set in the X' direction, as shown in Figure 9, which is the moving direction of the player's aircraft (S302), and then the opponent's aircraft is moved in the same direction, the X' direction, as that of the player's aircraft (in other words, the opponent's aircraft which is going to pass by the player's aircraft is made to move backward). Namely, the relative speed between the player's aircraft J and the opponent's aircraft T would become a large value if the respective moving speeds of the player's aircraft and the opponent's aircraft, which are going to pass by each other in opposite directions, are simply added. However, this processing considerably reduces the relative speed between the player's aircraft J and the opponent's aircraft T by causing the opponent's aircraft to move backward in the three-dimensional coordinate space.

[0057] CPU 101 reads in the respective coordinate values of the player's aircraft and the opponent's aircraft and computes a distance between them (S304) and sets the speed of the opponent's aircraft (VT) at a lower value than the speed of the player's aircraft (VJ) so that the player's aircraft passes the opponent's aircraft ahead in the virtual coordinate space in a predetermined time (S306). Accordingly, as the picture processing proceeds, the distance (L2) between the player's aircraft and the opponent's aircraft at a certain point becomes gradually shorter than the distance (L1) between these aircraft before that point, as shown in Figure 11(1) and then in Figure 11 (2).

[0058] CPU 101 reads in the coordinate values of the player's aircraft and the opponent's aircraft successively, and if the player's aircraft passes the opponent's aircraft ahead in the coordinate system or if the collision determination (described later) between a shell fired by the player's aircraft and the opponent's aircraft is affirmed, CPU 101 determines whether or not a processing to extinguish the opponent's aircraft has been executed (S309). If this determination is denied, the processing of S304 and the following steps is executed again. If this determination is affirmed, it returns to the main routine.

[0059] S302 shown in Figure -8 constitutes the first means as defined in the claims, and S304 and S306 constitute the second means.

[0060] According to the processing described above, since the relative speed of the player's aircraft and the opponent's aircraft is reduced when these aircraft are passing by each other in opposite directions in the three-dimensional coordinate space (opposite movement state), it is possible to extend the state of picture processing to make the player's aircraft and the opponent's aircraft pass by each other. Accordingly, the player can deal with this situation with certainty and can operate the input device, for example, in order to avoid shells fired by the opponent's aircraft or to avoid a collision with the opponent's aircraft.

[0061] Next, Figure 12 explains one of the subroutines for a shell firing processing. This processing mode is activated when a shell firing switch on the operation stick on the player's aircraft side is pushed down, or depending on whether or not the opponent's aircraft has moved into a shell firing point. CPU 101 reads in a shell type flag (S402), and if the shell is not a guided missile (flag = "0": S404 through S406), the shell is moved in a straight line along the firing direction of the shell. If the shell is a guided missile (flag = "1"), CPU 101 reads in the coordinate value of the object and moves the guided missile toward this coordinate value (S408).

[0062] If a shell is fired by the opponent's aircraft moving backward (S410), CPU 101 reads in the absolute speed of the opponent's aircraft from RAM 103 (S412) and sets the speed of the shell at a value no higher than the absolute speed of the player's aircraft (S414). As a result, an image is formed in which the shell fired by the opponent's aircraft passing by the player's aircraft rushes toward the player's aircraft (S416). If the opponent's aircraft is not moving backward at S410, the shell is moved at a predetermined speed (S416).

[0063] According to the processing explained above, if the shell is a guided missile D as shown in Figure 13 (1) and moves in an arrow direction, CPU 101 can display a polygon image D2 of smoke, which is a firing track, between the shell and a firing point D1 by storing the coordinates of the firing point D1 in RAM 103. If the guided missile is fired by the opponent's aircraft moving backward, both the guided missile D and the firing point D1 move backward together with the opponent's aircraft in the three-dimensional space as shown in Figure 13 (2). At this point, the moving speed of the firing point D1 is made lower than the moving speed of the guided missile D. As a result, the firing point D1 does not move closer to the player's aircraft, which virtually exists at a coordinate position on the left side of the figure, than to the guided missile D, thereby it is possible to keep a distance between the firing point D1 and the guided missile D and to produce the smoke polygon image between them.

[0064] Figure 14 explains one of the subroutines for the aforementioned collision determination processing. This collision determination processing determines a collision between the aircraft (the player's aircraft or the opponent's aircraft) and the shell or ground and executes a predetermined picture processing by utilizing the above determination results.

[0065] CPU 101 reads in coordinates of these aircraft, shell and ground from ROM 111 or RAM 103 (S502). On the basis of these coordinate positions, co-processor 108 computes a distance between the aircraft and the shell, a distance between the aircraft and the ground, and a distance between the player's aircraft and the opponent's aircraft by using data from ROM 108 and makes the collision determination between them (S504). If the distance (m) is shorter than a predetermined value (M), the co-processor affirms the collision determination. If the collision determination is denied, the co-processor terminates this processing and returns to the main routine in Figure 3.

[0066] After the collision determination is affirmed, CPU 101 sets "1" in a collision determination flag Fc respectively at the player's aircraft and the opponent's aircraft concerning which the collision has been affirmed (S506). CPU reads in the flag value of each character (the player's aircraft or the opponent's aircraft) in the visual field coordinate system and displays a polygon image of explosion on the character with the flag value "1" (S508). Figure 15 shows that it is determined that the opponent's aircraft T1, T4 and T6 shown in Figure 7 have collided with the guided missiles and then the explosion polygon images V1 through V3 are displayed with priority over the characters in the visual field system.

[0067] CPU 101 determines whether or not any opponent's aircraft without the collision determination flag being set exist in the explosion polygon area to be displayed in the visual field coordinate system (S510), and if this determination is affirmed, color pallet data of the explosion polygons are set only for alternate picture elements. In other words, the opponent's aircraft can be recognized through the explosion polygon image by executing a mesh processing to define colors for alternate picture elements within the polygon area. Figure 16 shows this state. CPU 101 executes this mesh processing concerning the explosion polygons V1 and V3, thereby enabling the player to recognize the opponent's aircraft T2, T3 and T5, which are not the objects of explosion, through the picture elements to which the color data of the explosion polygons are not given (S512).

[0068] On the other hand, concerning the polygons for which the above-described determination is denied, no opponent's aircraft without the collision determination flag being set exist within the explosion polygon image and, therefore, the explosion image polygon (V2) is composed without executing the mesh processing.

[0069] As a result, when a see-through processing such as the mesh processing is not executed concerning the explosion image as shown in Figure 14, if the player tries to display the explosion image polygon in a large size or to make multiple explosion images appear at once, the image of the aircraft is covered with the explosion image in the visual field coordinate system. On the other hand, if the explosion image is always expressed with the meshed polygon data, a strong appeal of the explosion image will be diminished. However, according to this embodiment, the explosion image is composed of meshed polygons only when necessary. Therefore, as shown in Figure 16, the explosion image composed of meshed polygon data and the explosion image composed of polygon data which are not meshed (the data with all the picture elements within the polygon area being colored as appropriate) are made to coexist and, therefore, it is possible to recognize the aircraft without the collision determination flag being set without diminishing a strong appeal of the image.

[0070] As described above, since the processing of Figure 3 is executed according to this embodiment, the game device is provided which can easily operate the aircraft in the air battle game and which gives images with a strong appeal and with superior attractiveness and interest. Moreover, according to this embodiment, it is possible to provide the game device capable of providing images with a strong appeal by changing viewpoints.

[0071] The structure to control the player's aircraft and the opponent's aircraft to fly in the same direction is not limited to the above-described structure, and other known methods or structures may be applied.

[0072] The aforementioned ROM 102 corresponds to the aforementioned storage medium. ROM 102 is not only mounted on the main game device 10, but also can be newly connected or applied to the main game device from outside the device. Moreover, the picture processing device of the present invention can be materialized even without the operating means or the displaying means. Furthermore, this invention provides a picture processing method for executing the above-described picture processing. Moreover, the picture processing device of the present invention can be materialized even without the operating means or the displaying means. Furthermore, this invention provides a picture processing method for executing the above-described picture processing.

Claims

1. A picture processing device, comprising picture processing means (10) for executing picture processing to display on a displaying means (13) an image, as seen from a predetermined viewpoint, of a plurality of virtual flying objects (J, T) existing in a three-dimensional virtual coordinate space, said picture processing means executing picture processing to move said objects in said coordinate space at respective speeds in accordance with operation signals from operating means (11, 102) for operating said objects,

wherein said picture processing means comprises:

first means (101, 302) for executing a picture processing mode in which first and second objects (J, T) appear to fly in opposite directions in said virtual coordinate space; and

second means (101, 304, 306) operable in said picture processing mode for processing coordinate values of the first and second objects in said three-dimensional virtual coordinate space so as to reduce the relative speed of the first and second objects appearing to fly in said directions opposite to each other in said virtual coordinate space;

said first means being arranged to execute picture processing in said picture processing mode to cause the first and second objects to appear to approach one another substantially head-on and to fly past each other, and

said second means being operable on detection that the processing is in said picture processing mode to set the direction and speed of the first and second objects so that they fly in the same direction (x') in said virtual coordinate space and with a predetermined relative speed.

2. A device according to claim 1, wherein said second means is operable to set said relative speed so that the time required for the first and second objects to fly past each other in the virtual three-dimensional coordinate space corresponds with a predetermined time.

3. A device according to claim 2, wherein said picture processing means includes:

means (101) for determining base coordinate values of the objects flying in accordance with the operating signals in the three-dimensional space;

means (110) for converting said base coordinate values into a coordinate system corresponding to said visual field of display by the displaying means;

means (101, 304) operable in said picture processing mode to compute from the base coordinate values of said first and second objects the distance (L_1) between said objects in said three-dimensional space, to reset the direction of flight of one of said first and second objects (T) in said three-dimensional space to be the same as the direction (x') of flight of the other of said first and second objects (J), and to reset the speed of flight (VT) of said one of said first and second objects in said reset direction to be lower than the speed of the flight (VJ) of the other of said first and second objects, so that the distance between said first and second objects (L_2) reduces with time, but at a slower rate than that associated with the directions and speeds of the respective first and second objects prior to said resetting thereof by said computing and resetting means.

4. A game device, comprising displaying means and a picture processing device according to any one of claims 1 to 3.

5. A storage medium for storing a computer program comprising code means adapted so that when loaded into a computer the combination of the computer and program operates to provide the functionality of the picture processing device according to any of claims 1 to 4.

Patentansprüche

1. Bildverarbeitungsvorrichtung, welche eine Bildverarbeitungseinrichtung (10) zum Ausführen einer Bildverarbeitung enthält, um auf einer Anzeigeeinrichtung (13) ein Bild, wie es von einem vorbestimmten Standpunkt aus gesehen wird, von mehreren virtuellen fliegenden Objekten (J, T), welche in einem dreidimensionalen virtuellen Koordinatenraum vorhanden sind, darzustellen, wobei die Bildverarbeitungseinrichtung eine Bildverarbeitung ausführt, um die Objekte in dem Koordinatenraum mit entsprechenden Geschwindigkeiten gemäß Bedienungssignalen von einer Bedienungseinrichtung (11, 102) für die Bedienung der Objekte zu bewegen, wobei die Bildverarbeitungseinrichtung aufweist:

eine erste Einrichtung (101, 302) zum Ausführen eines Bildverarbeitungsmodus, in welchem erste und zweite Objekte (J, T) in dem virtuellen Koordinatenraum in entgegengesetzte Richtungen zu fliegen scheinen; und

eine zweite Einrichtung (101, 304, 306) die in dem Bildverarbeitungsmodus bedienbar ist, um Koordinatenwerte der ersten und zweiten Objekte in dem dreidimensionalen virtuellen Koordinatenraum zu verarbeiten, um so die relative Geschwindigkeit der ersten und zweiten Objekte zu reduzieren, die in dem virtuellen Koordinatenraum in entgegengesetzten Richtungen zueinander zu fliegen scheinen;

wobei die erste Einrichtung so angeordnet ist, daß sie eine Bildverarbeitung in dem Bildverarbeitungsmodus ausführt, um zu bewirken, daß die ersten und zweiten Objekte sich einander im wesentlichen frontal anzunähern und aneinander vorbei fliegen zu scheinen, und

die zweite Einrichtung nach der Detektion, daß sich die Verarbeitung in dem Bildverarbeitungsmodus befindet so bedienbar ist, daß sie die Richtung und Geschwindigkeit der ersten und zweiten Objekte so einstellt, daß sie in derselben Richtung (x') in dem virtuellen Koordinatenraum und mit einer vorbestimmten relativen Geschwindigkeit fliegen.

2. Vorrichtung nach Anspruch 1, wobei die zweite Einrichtung so bedienbar ist, daß sie die relative Geschwindigkeit so einstellt, daß die Zeit, die erforderlich ist, daß die ersten und zweiten Objekte aneinander in dem virtuellen dreidimensionalen Koordinatenraum vorbeifliegen, einer vorbestimmten Zeit entspricht.

3. Vorrichtung nach Anspruch 2, wobei die Bildverarbeitungseinrichtung enthält:

eine Einrichtung (101) für die Ermittlung von Basiskoordinatenwerten der gemäß den Bedienungssignalen in dem dreidimensionalen Raum fliegenden Objekte;

eine Einrichtung (110) zum Umwandeln der Basiskoordinatenwerte in ein Koordinatensystem, das dem Sichtfeld der Anzeige entspricht, durch die Anzeigeeinrichtung;

eine Einrichtung (101, 304), die in dem Bildverarbeitungsmodus bedienbar ist, um aus den Basiskoordinatenwerten der ersten und zweiten Objekte den Abstand (L_1) zwischen den Objekten in dem dreidimensionalen Raum zu berechnen, um die Richtung des Fluges von einem der ersten und zweiten Objekte (T) in dem dreidimensionalen Raum zurückzusetzen, so daß sie dieselbe wie die Richtung (x') des Fluges des anderen von den ersten und zweiten Objekten (J) ist, und um die Geschwindigkeit des Fluges (VT) des einen von den ersten und zweiten Objekten in der zurückgesetzten Richtung zurückzusetzen, so daß sie langsamer als die Fluggeschwindigkeit (VJ) des anderen von den ersten und zweiten Objekten ist, so daß sich der Abstand zwischen den ersten und zweiten Objekten (L_2) mit der Zeit verringert, jedoch mit einer langsameren Rate als die, die den Richtungen und Geschwindigkeiten der jeweiligen ersten und zweiten Objekte vor deren Zurücksetzen durch die Berechnungs- und Rücksetzeinrichtung zugeordnet ist.

4. Spielvorrichtung, welche eine Anzeigeeinrichtung und eine Bildverarbeitungseinrichtung nach einem der Ansprüche 1 bis 3 aufweist.

5. Speichermedium zum Speichern eines Computerprogramms, welches eine Codeeinrichtung aufweist die so angepasst ist, daß, wenn sie in einem Computer geladen wird, die Kombination des Computers und des Programms so arbeitet, daß sie die Funktionalität der Bildverarbeitungsvorrichtung gemäß einem der Ansprüche 1 bis 4 bereitstellt.

Revendications

1. Dispositif de traitement d'image, comportant un moyen de traitement d'image (10) pour effectuer un traitement d'image pour afficher sur un moyen d'affichage (13) une image, telle qu'on la voit d'un point de vue déterminé, d'une pluralité d'objets volants virtuels (J,T) existant dans un espace de coordonnées virtuel à trois dimensions, ledit moyen de traitement d'image effectuant un traitement d'image pour déplacer lesdits objets dans ledit espace de coordonnées à des vitesses respectives en fonction de signaux de manoeuvre générés par un moyen de manoeuvre (11, 102) pour manoeuvrer lesdits objets,

dans lequel ledit moyen de traitement d'image comporte:

un premier moyen (101, 302) pour exécuter un mode de traitement d'image dans lequel un premier et un deuxième objets (J,T) semblent voler en sens contraire dans ledit espace de coordonnées virtuel; et

un deuxième moyen (101, 304, 306) pouvant fonctionner dans ledit mode de traitement d'image pour traiter des valeurs de coordonnées du premier et du deuxième objet dans ledit espace de coordonnées virtuel de façon à réduire la vitesse relative du premier et du deuxième objets semblant voler dans ledit sens contraire dans ledit espace de coordonnées virtuel;

ledit premier moyen étant conçu pour effectuer un traitement d'image dans le dit mode de traitement d'image pour donner l'impression que le premier et le deuxième objet se rapprochent sensiblement en se faisant face et se croisent en volant, et

ledit deuxième moyen fonctionnant lors de la détection du fait que le traitement est dans ledit mode de traitement d'image pour définir la direction et la vitesse du premier et du deuxième objets de façon à ce qu'ils volent parallèlement à la même direction (x') dans ledit espace de coordonnées virtuel et avec une vitesse relative prédéterminée.

2. Dispositif selon la revendication 1, dans lequel ledit deuxième moyen peut fonctionner pour définir ladite vitesse relative de façon telle que le durée nécessaire pour que le premier et le deuxième objets se dépassent en volant dans l'espace de coordonnées virtuel à trois dimensions corresponde à une durée prédéterminée.

3. Dispositif selon la revendication 2, dans lequel ledit moyen de traitement d'image comprend:

un moyen (101) de définition de valeurs de coordonnées de base des objets volants en fonction des signaux de manoeuvre dans l'espace à trois dimensions;

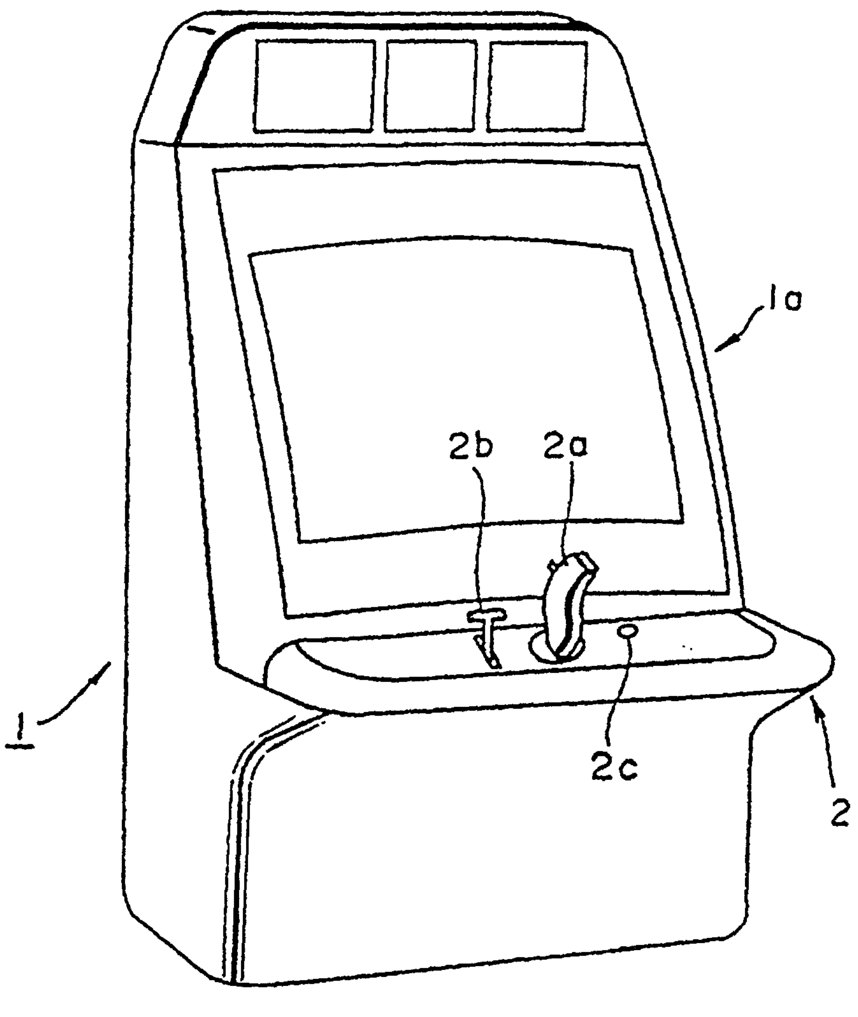
un moyen (110) de conversion desdites valeurs de coordonnées de base en un système de coordonnées correspondant audit champ visuel d'affichage par le moyen d'affichage;

un moyen (101, 304) pouvant fonctionner dans ledit mode de traitement d'image pour calculer à partir des valeurs de coordonnées de base dudit premier et dudit deuxième objets la distance (L_1) les séparant dans ledit espace à trois dimensions, pour redéfinir la direction de vol de l'un des dits premier et deuxième objets (T) dans ledit espace à trois dimensions pour qu'elle soit parallèle à celle (x') de l'autre desdits premier et deuxième objets (J) , et pour redéfinir la vitesse de vol (VT) de l'un desdits premier et deuxième objets dans ladite direction redéfinie afin qu'elle soit inférieure à la vitesse de vol (VJ) de l'autre desdits premier et deuxième objets afin que la distance qui les sépare (L_2) se réduise avec le temps mais d'un facteur moins important que celui associé aux directions et aux vitesses des premier et deuxième objets respectifs avant ladite redéfinition de celles-ci par ledit moyen de calcul et de redéfinition.

4. Dispositif de jeu comportant un moyen d'affichage et un dispositif de traitement d'image conforme à l'une quelconque des revendications 1 à 3.

5. Support d'enregistrement pour enregistrer un programme informatique comportant un moyen de codage adapté pour que, lorsqu'il est chargé dans un ordinateur, la combinaison de l'ordinateur et du programme assure la fonction du dispositif de traitement d'image conforme à l'une quelconque des revendications 1 à 4.

FIG. 1



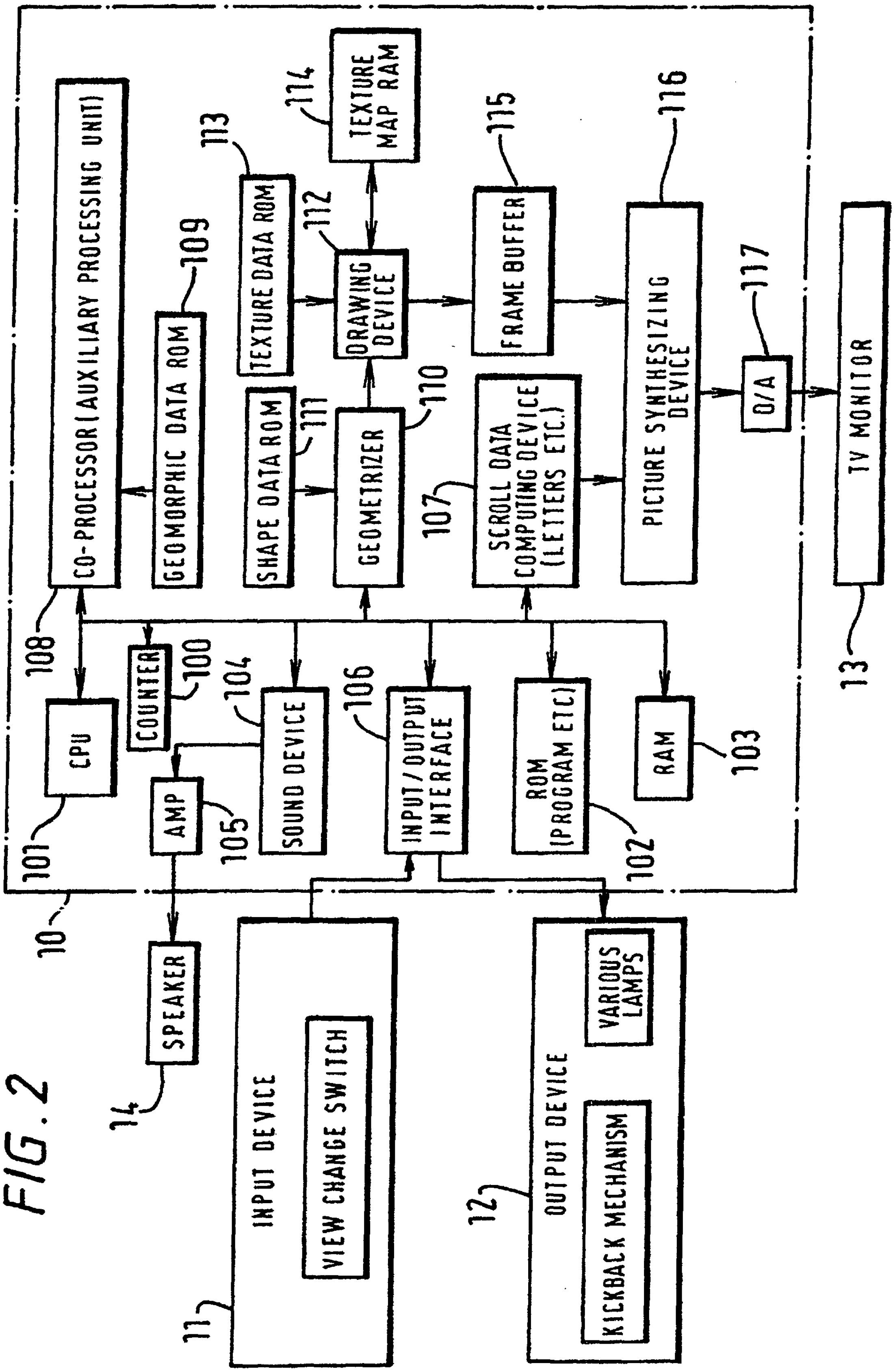

CO-PROCESSOR (AUXILIARY PROCESSING UNIT)
GEOMORPHIC DATA ROM
SHAPE DATA ROM
TEXTURE DATA ROM
TEXTURE MAP RAM
DRAWING DEVICE
GEOMETRIZER
FRAME BUFFER
SCROLL DATA COMPUTING DEVICE (LETTERS ETC.)
PICTURE SYNTHESIZING DEVICE
D/A
TV MONITOR
CPU
COUNTER
AMP
SOUND DEVICE
INPUT/OUTPUT INTERFACE
ROM (PROGRAM ETC)
RAM
SPEAKER
INPUT DEVICE
VIEW CHANGE SWITCH
OUTPUT DEVICE
KICKBACK MECHANISM
VARIOUS LAMPS
10
11
12
13
14
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117

FIG. 2

FIG. 3

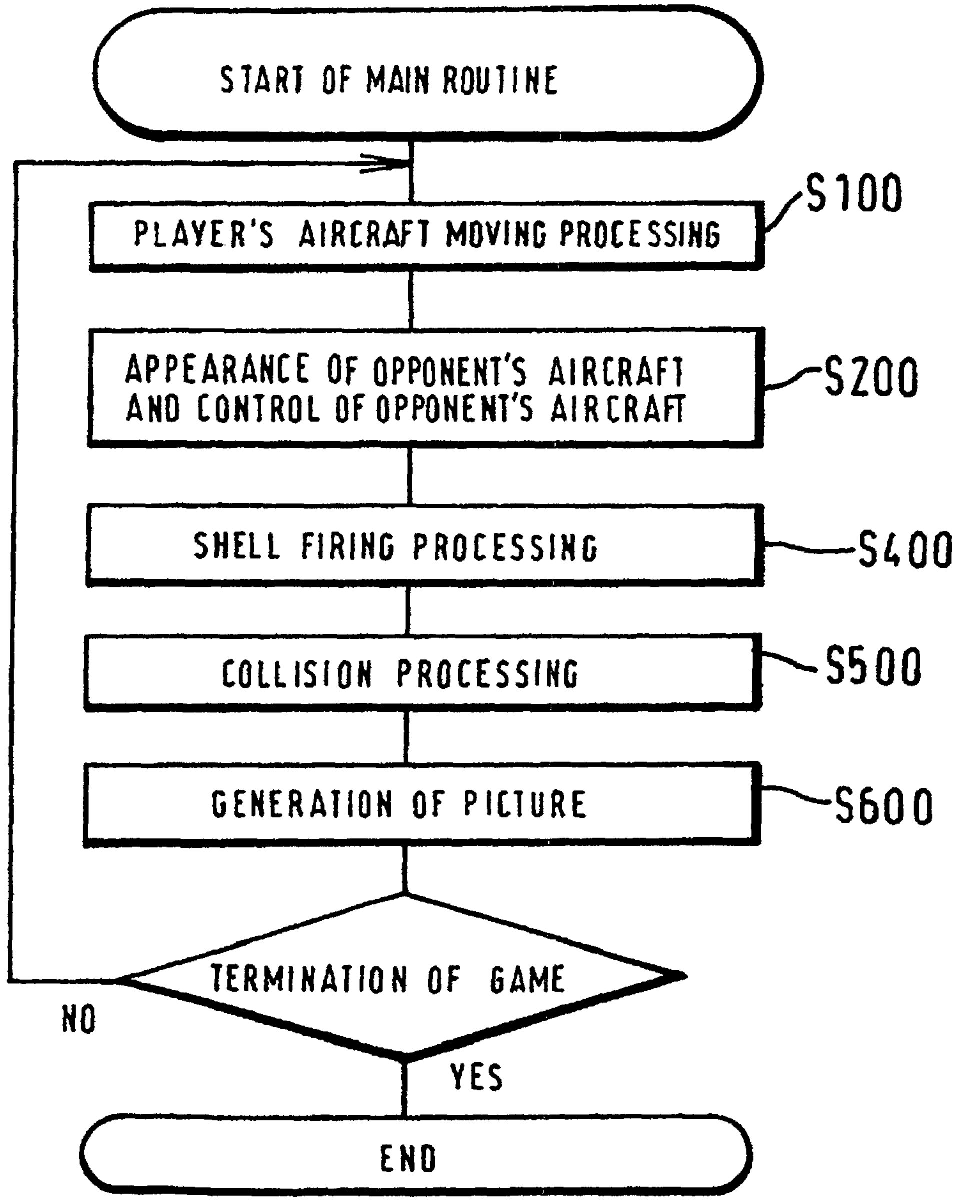

START OF MAIN ROUTINE
PLAYER'S AIRCRAFT MOVING PROCESSING
S100
APPEARANCE OF OPPONENT'S AIRCRAFT AND CONTROL OF OPPONENT'S AIRCRAFT
S200
SHELL FIRING PROCESSING
S400
COLLISION PROCESSING
S500
GENERATION OF PICTURE
S600
TERMINATION OF GAME
NO
YES
END

FIG. 4

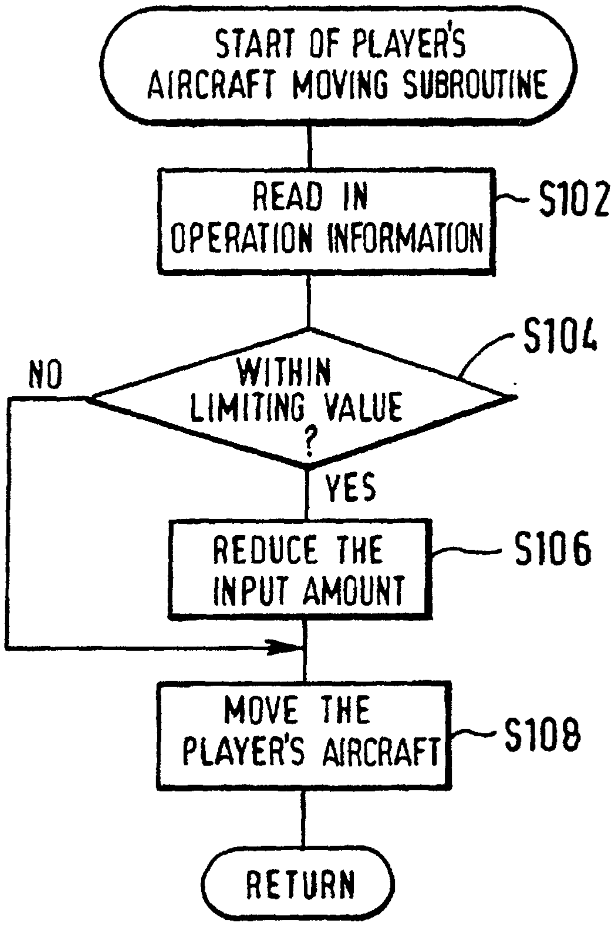

START OF PLAYER'S AIRCRAFT MOVING SUBROUTINE
READ IN OPERATION INFORMATION
S102
WITHIN LIMITING VALUE ?
S104
NO
YES
REDUCE THE INPUT AMOUNT
S106
MOVE THE PLAYER'S AIRCRAFT
S108
RETURN

FIG. 5

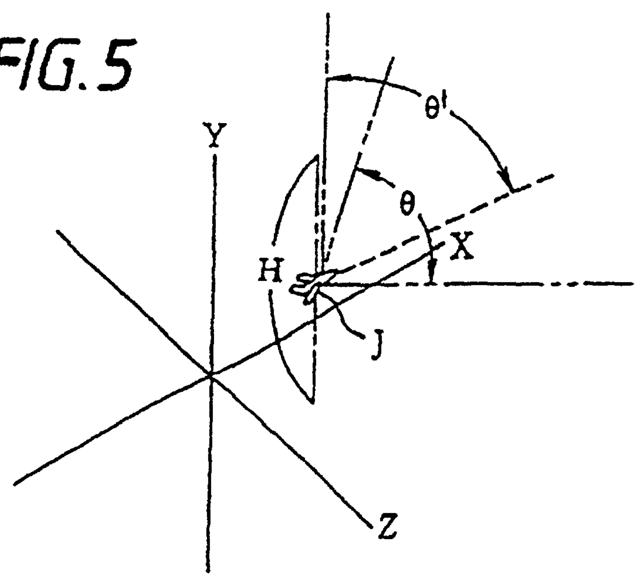

Y
θ'
θ
X
H
J
Z

FIG. 6

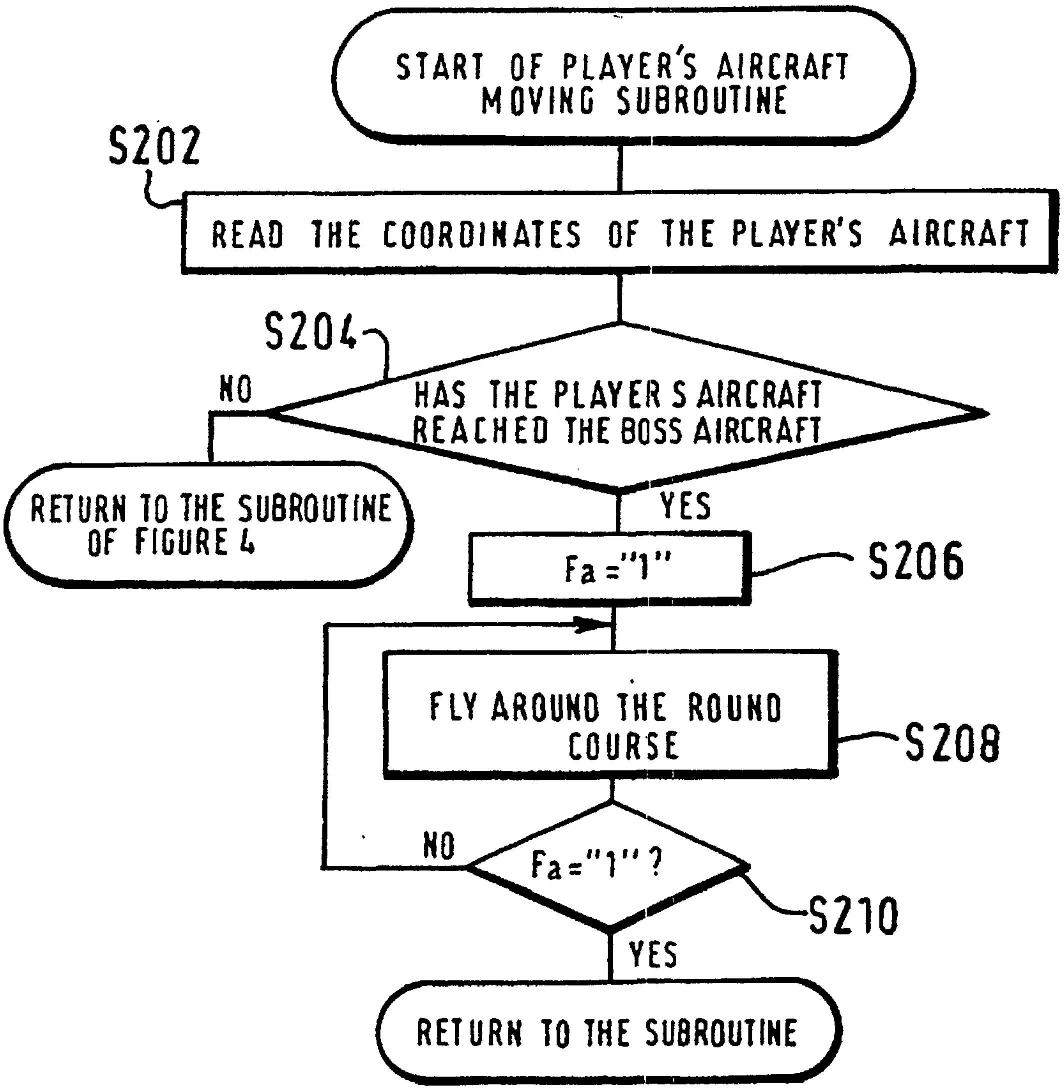

START OF PLAYER'S AIRCRAFT MOVING SUBROUTINE
S202
READ THE COORDINATES OF THE PLAYER'S AIRCRAFT
S204
HAS THE PLAYER S AIRCRAFT REACHED THE BOSS AIRCRAFT
NO
RETURN TO THE SUBROUTINE OF FIGURE 4
YES
Fa="1"
S206
FLY AROUND THE ROUND COURSE
S208
NO
Fa="1"?
S210
YES
RETURN TO THE SUBROUTINE

FIG.7

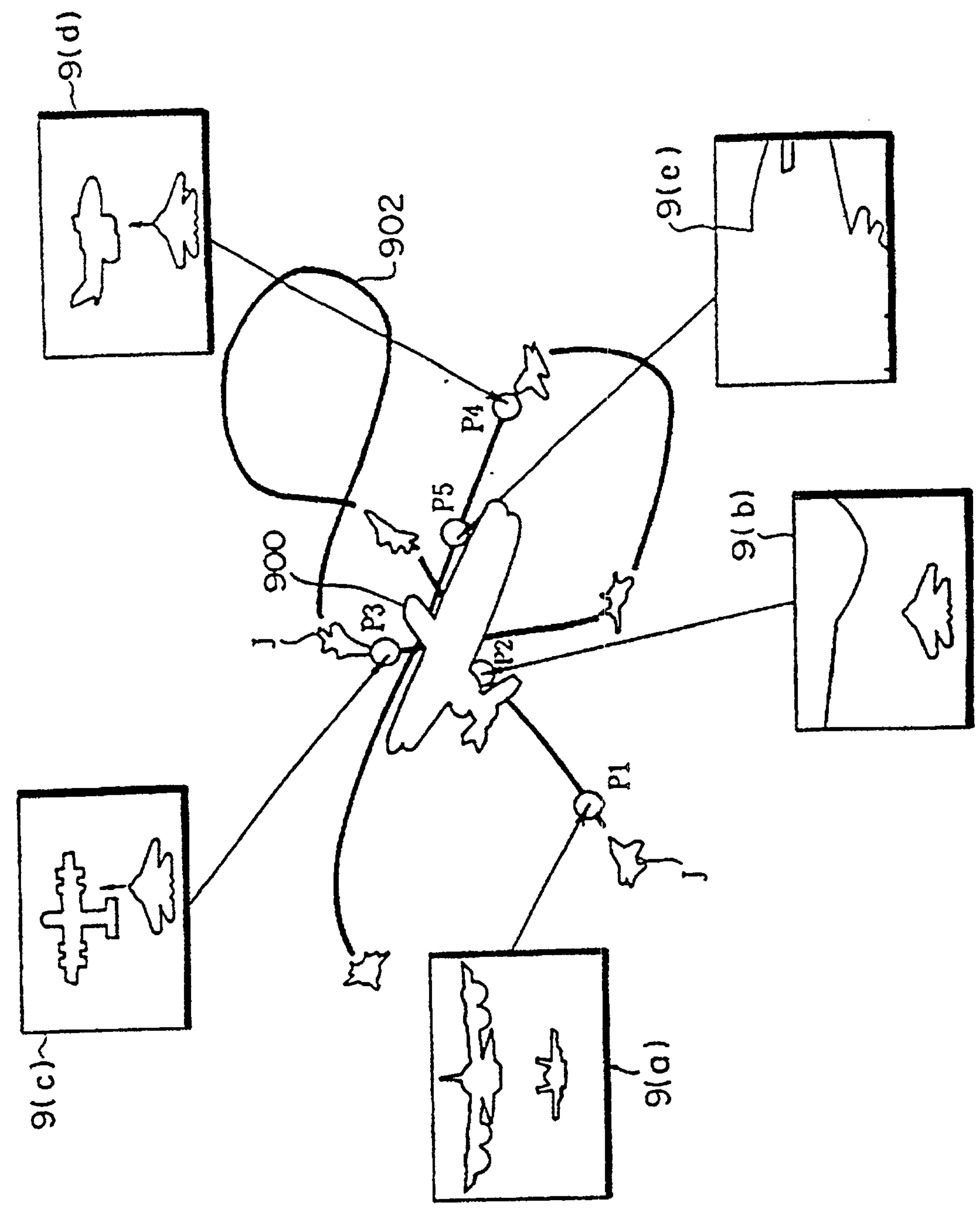


FIG.8

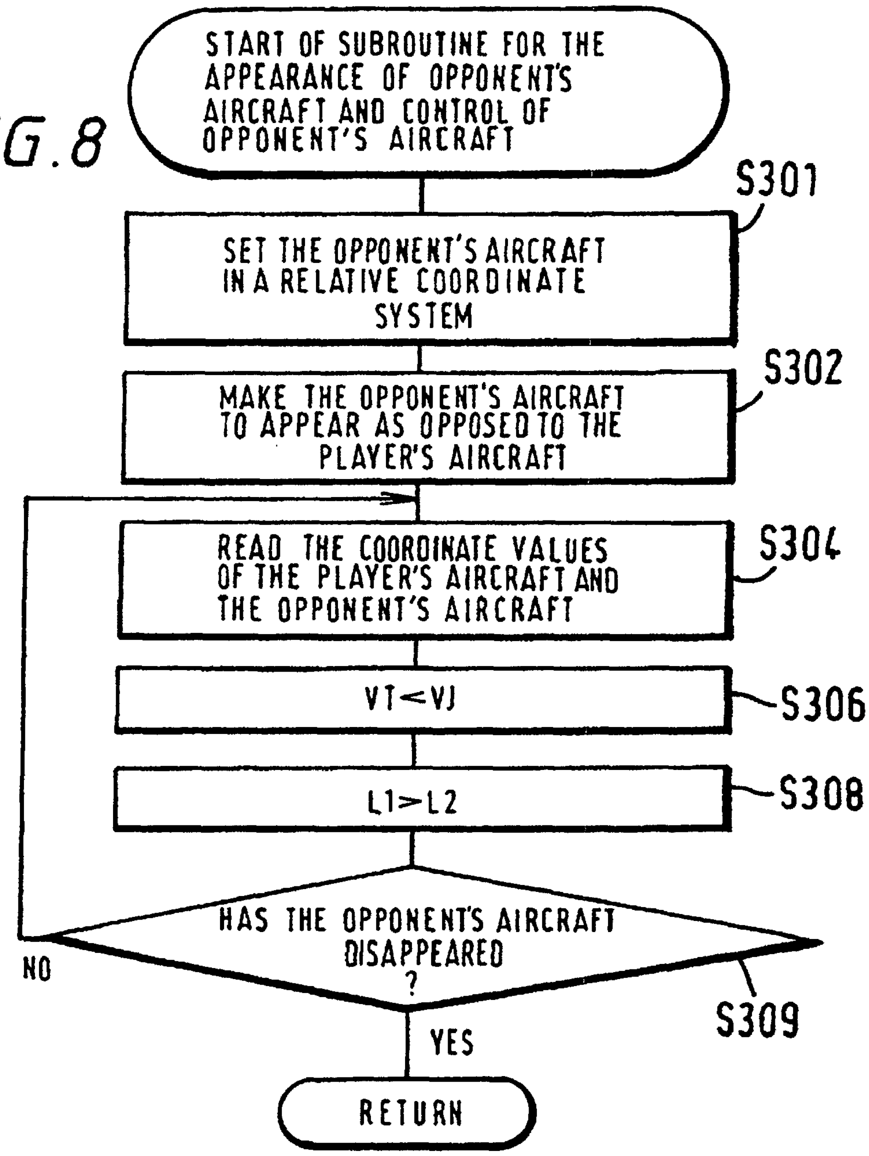

START OF SUBROUTINE FOR THE APPEARANCE OF OPPONENT'S AIRCRAFT AND CONTROL OF OPPONENT'S AIRCRAFT
S301
SET THE OPPONENT'S AIRCRAFT IN A RELATIVE COORDINATE SYSTEM
S302
MAKE THE OPPONENT'S AIRCRAFT TO APPEAR AS OPPOSED TO THE PLAYER'S AIRCRAFT
S304
READ THE COORDINATE VALUES OF THE PLAYER'S AIRCRAFT AND THE OPPONENT'S AIRCRAFT
VT<VJ
S306
L1>L2
S308
HAS THE OPPONENT'S AIRCRAFT DISAPPEARED ?
NO
S309
YES
RETURN

FIG.9

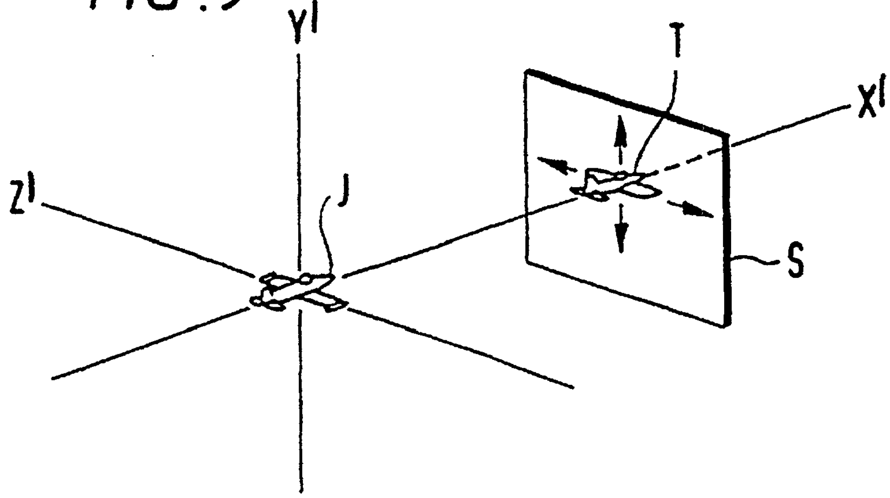

Y'
T
X'
Z'
J
S

FIG. 10

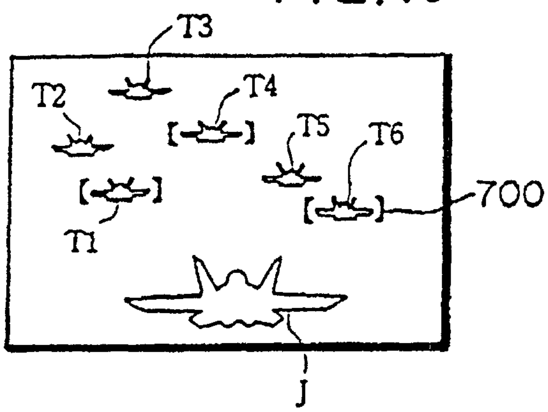


FIG. 11

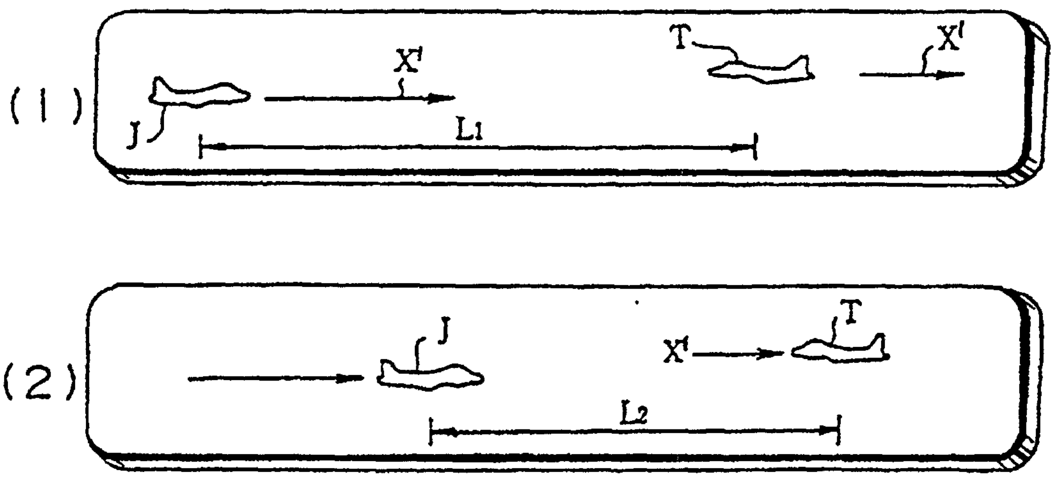


FIG. 12

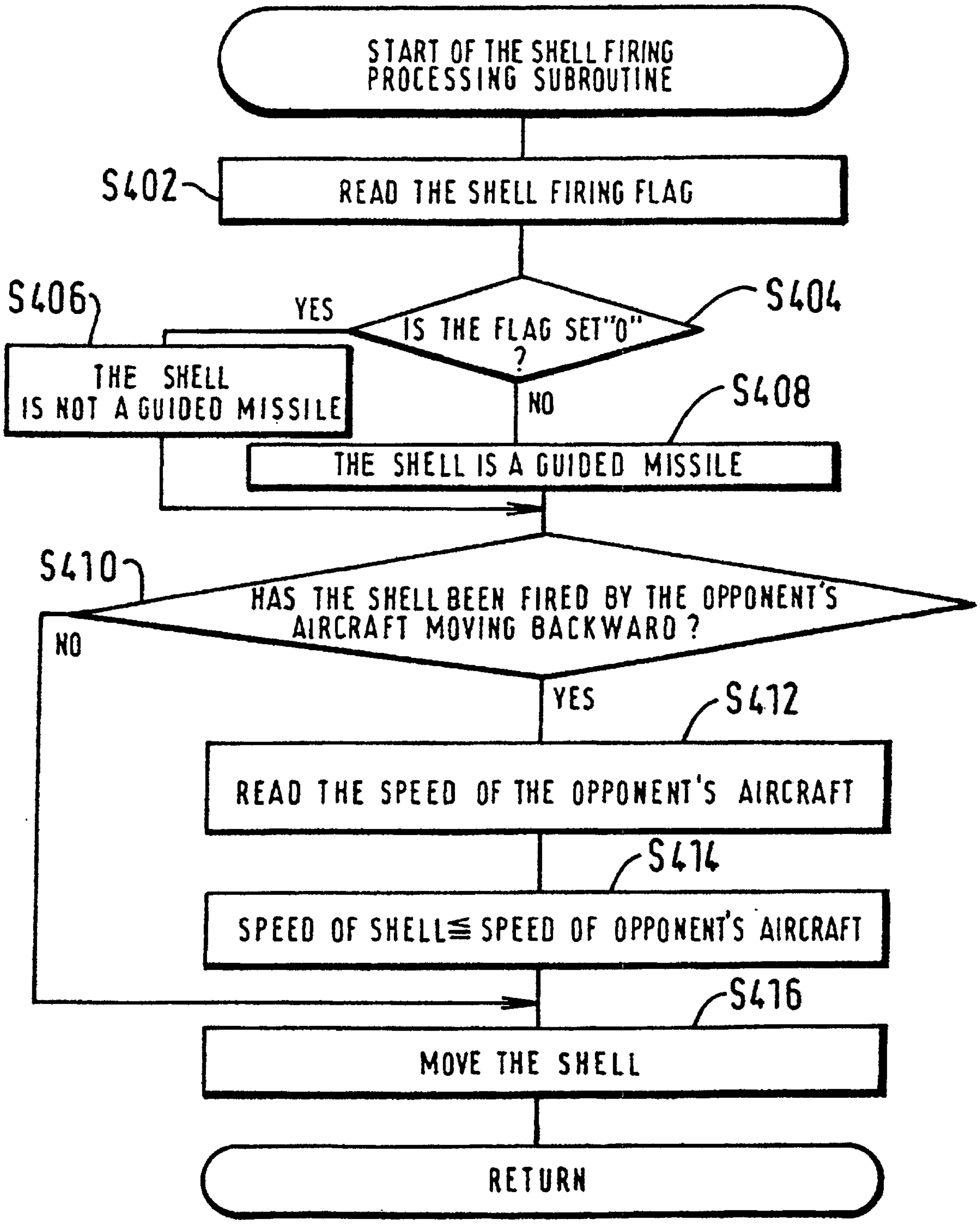

START OF THE SHELL FIRING PROCESSING SUBROUTINE
S402
READ THE SHELL FIRING FLAG
S404
IS THE FLAG SET "0" ?
YES
S406
THE SHELL IS NOT A GUIDED MISSILE
NO
S408
THE SHELL IS A GUIDED MISSILE
S410
HAS THE SHELL BEEN FIRED BY THE OPPONENT'S AIRCRAFT MOVING BACKWARD ?
NO
YES
S412
READ THE SPEED OF THE OPPONENT'S AIRCRAFT
S414
SPEED OF SHELL ≦ SPEED OF OPPONENT'S AIRCRAFT
S416
MOVE THE SHELL
RETURN

FIG. 13

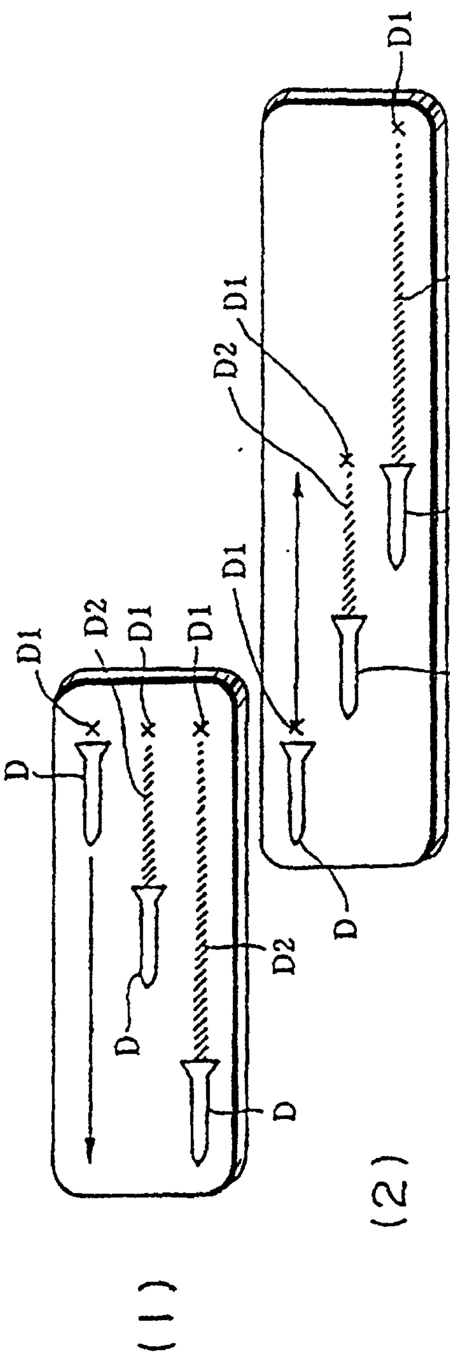


FIG. 14

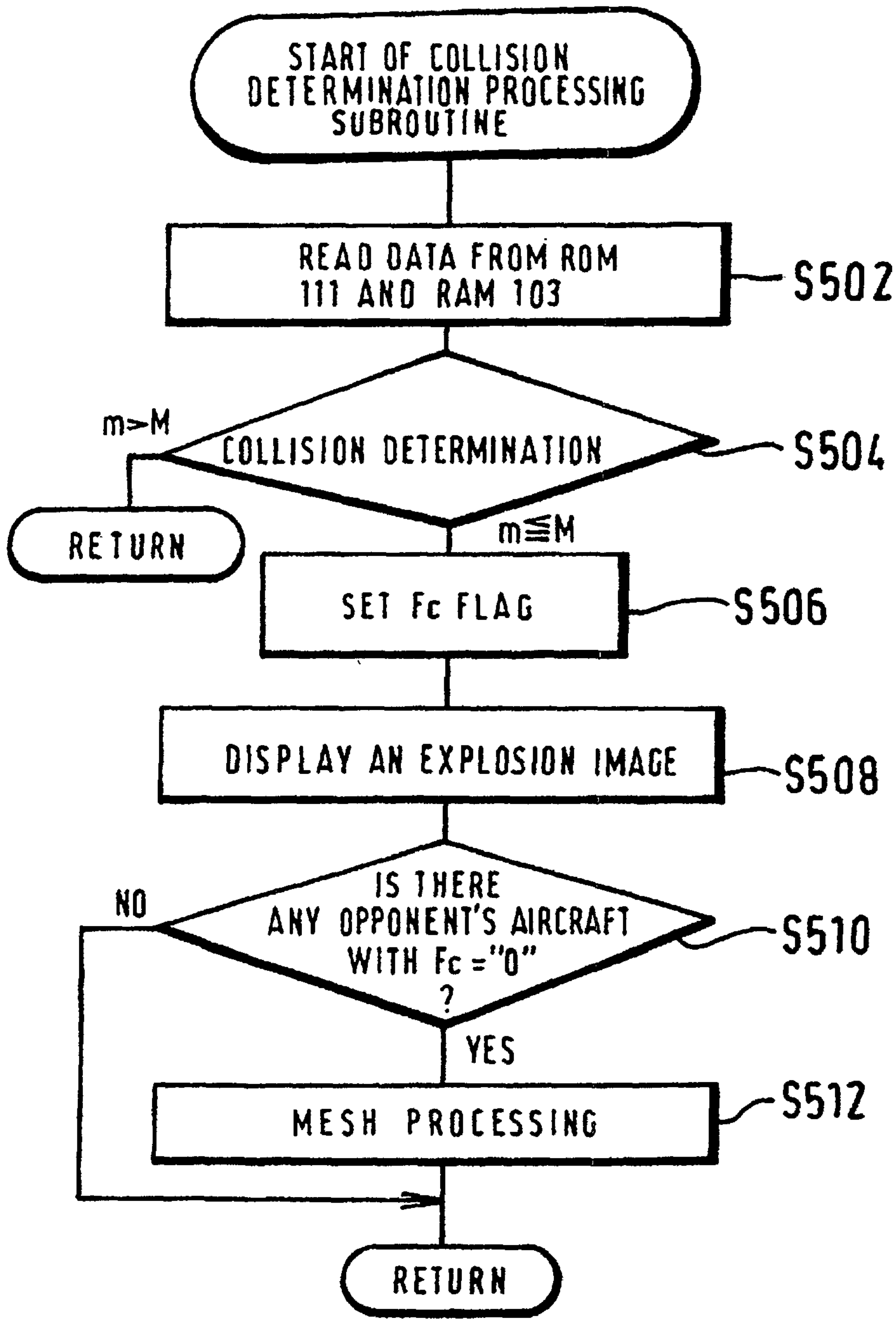

START OF COLLISION DETERMINATION PROCESSING SUBROUTINE
READ DATA FROM ROM 111 AND RAM 103
S502
COLLISION DETERMINATION
S504
m>M
RETURN
m≦M
SET Fc FLAG
S506
DISPLAY AN EXPLOSION IMAGE
S508
IS THERE ANY OPPONENT'S AIRCRAFT WITH Fc ="0" ?
S510
NO
YES
MESH PROCESSING
S512
RETURN

FIG. 15

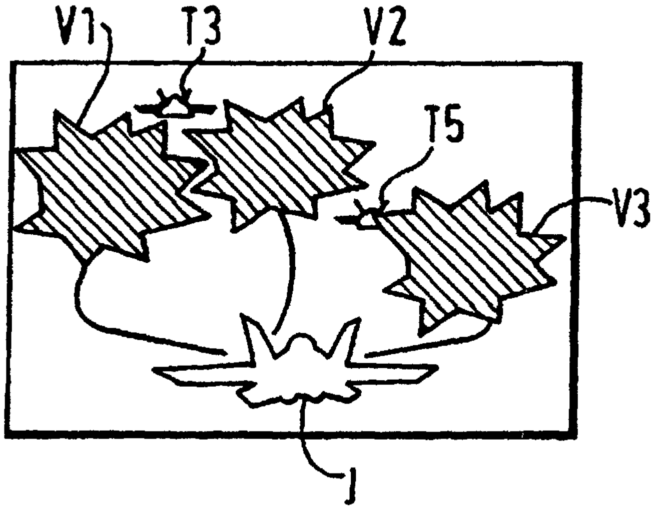


FIG. 16