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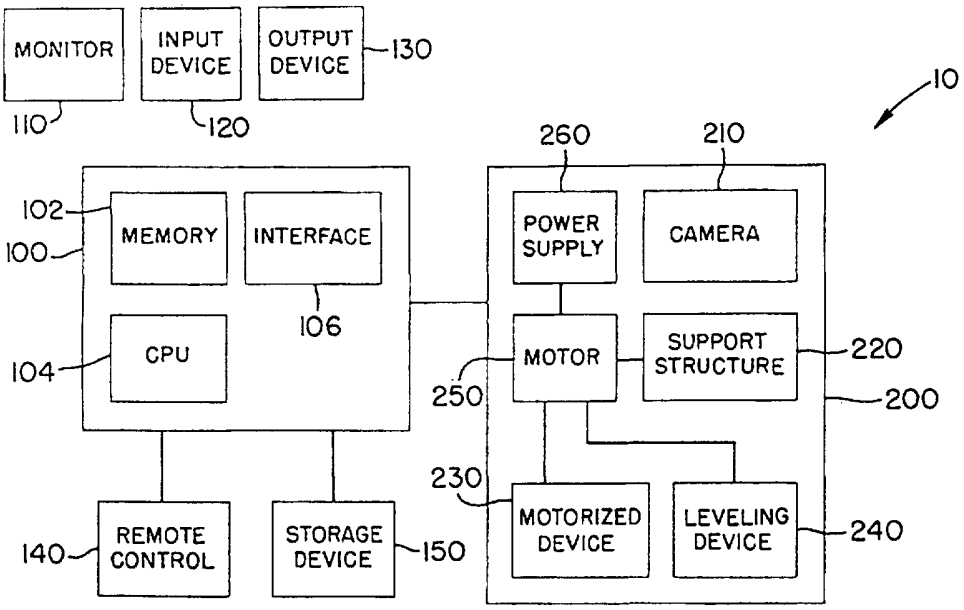
(54) Title: COMPUTER-CONTROLLED SYSTEM FOR PRODUCING THREE-DIMENSIONAL NAVIGABLE PHOTOGRAPHS OF AREAS AND METHOD THEREOF



(57) Abstract

A computer-controlled system (10) for producing and combining photographic images to create a virtual reality environment includes a moveable camera apparatus (200) for creating at least one digital photographic image and a computer (100) including a memory (102), a CPU (104) and an interface (106) for controlling the moveable camera to move to a select location and produce a select number of digital photographic images at the select location. The computer (100) then combines the digital photographic images together to form the virtual reality environment.

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COMPUTER-CONTROLLED SYSTEM FOR PRODUCING THREE-DIMENSIONAL NAVIGABLE PHOTOGRAPHS OF AREAS AND METHOD THEREOF

Field of the Invention

This invention relates generally to computer-controlled systems and pertains more particularly to a computer-controlled system for producing three-dimensional navigable photographs of areas and the method thereof.

Background of the Invention

Computer technology has developed so that particular areas, such as retail establishments, homes and other spaces, can be displayed on personal computers in a realistic three-dimensional form or in a "virtual reality" environment.

Apple Computer, Inc. of Cupertino, California has developed technology under its QuickTime VR® trademark which allows users to create such realistic areas which are then playable on a personal computer. This technology permits the user to create a "node" by stitching and blending together a series of side-by-side still-life digital photographs to form one long panoramic photograph. This created panoramic photograph results in a single "node" which is a 360° panorama of the area around the user.

Each node can then be combined with other nodes to create a fully navigable multi-node "movie." With a multi-node movie, a user can not only spin around a room, for example, and "see" a 360° panorama of the viewing area, but also "walk" through the room shown in the panoramic multi-node movie and explore different rooms of a store, for example, simply by branching from one node to another. The connection between nodes is accomplished by photographing intermediate non-panoramic step frames animating the transition from one node to another.

In order to create this multi-node movie, a photographer must photograph each node one at a time. A camera must be set on a tripod which must be perfectly level at all times during the photography session, the center plane of the camera lens must be precisely bisected by the vertical axis

in the center of the tripod which rotates the camera, the lens plane must be situated at exactly a 90 degree angle to level ground and the camera must be rotated precisely and uniformly between each shot.

This filming of a multi-node movie is extremely exacting and tedious since in order to provide the appearance of smooth and continuous motion, each incremental movement of the camera from one node to the next node must be precisely measured and cannot have any bias from left to right. In addition, great accuracy must be maintained and duplicated each time a node is to be photographed. Thus if the same parameters are not maintained during the photography session of each node, then the session would have to be re-shot because the movie would appear to be disjointed and unconnected and would not correctly produce a feeling of three-dimensionality or virtual reality. Such action is very time consuming and can become a very expensive process if mistakes are made.

Accordingly, other systems are being developed to create digital photographic images for producing a multi-node movie which have increased accuracy while also being simple and easy to use.

It is therefore an object of the present invention to provide a computer-controlled system and method for producing three-dimensional navigable photographs of areas which is accurate and precise.

It is an additional object of the present invention to provide a computer-controlled system and method for producing three-dimensional navigable photographs of areas which is simple and easy to use.

It is a further object of the present invention to provide a computer-controlled system and method for producing three-dimensional navigable photographs of areas which is economical to manufacture and is not labor intensive.

These and further objects and advantages of the present invention will become clearer in light of the following detailed description of an illustrative embodiment of this invention described in connection with the drawings.

Summary of the Invention

In accordance with the principles of the present invention, the above and other objectives are realized in a computer-controlled system for producing and combining photographic images to create a virtual reality environment which includes a movable camera apparatus for creating at least one digital photographic image and a computer for controlling the movable camera apparatus to move to a select location and produce a select number of digital photographic images at the select location. The computer then combines the digital photographic images together to form the virtual reality environment.

Brief Description of the Drawings

The above and other features and aspects of the present invention will become more apparent upon reading the following detailed description in conjunction with the accompanying drawings, in which:

FIG. 1 shows a block diagram of the components of the computer-controlled system and method for producing three-dimensional navigable photographs of areas in accordance with the principles of the present invention; and

FIG. 2 shows an illustrative diagram of a digital map for use in the computer-controlled system and method of FIG. 1.

All of the figures are drawn for ease of explanation of the basic teachings of the present invention only; the extension of the figures with respect to a particular application of the present invention will be within the skill of a practitioner of the art after the teachings of the present invention have been read, followed and understood.

Detailed Description

The present invention is directed to a computer-controlled system 10 and method which provides three-dimensional navigable photographs for selected areas to create a virtual reality environment. The computer-controlled system and method of the present invention

comprises a movable camera apparatus for creating at least one digital photographic image and computing means for controlling the movable camera apparatus to move to a select location and produce a select number of digital photographic images at the select location. Computing means then combines the digital photographic images together to form a three-dimensional virtual reality environment.

The computer-controlled system 10 produces three-dimensional navigable digital photographs in order to create a multi-node movie to allow a user to see a selected particular area, such as a retail establishment, home, etc., in a three-dimensional or virtual reality environment. The computer-controlled system 10 allows a user to capture quickly, efficiently and automatically all necessary photographic components of each node of the movie, automatically process the digital photographs into a single-node to create the panoramic image by stitching and dicing these images together, and automatically capture the intermediate, non-panoramic step-frames. In addition, the computer-controlled system 10 allows users to quickly add "hot spots" or selection items which can themselves be selected and viewed. These images and hot spots are then automatically combined and compressed into a composite multi-node movie.

The computer-controlled system 10 in its preferred embodiment comprises a hardware and software system as illustrated in FIG. 1.

In the present illustrative case, it is assumed that computing means 100 or Apple Macintosh® computers which are commercially available from Apple Computer, Inc. of Cupertino, California are used in the computer-controlled system 10. In the present embodiment, The computer 100 includes memory 102, a central processing unit 104 and interface 106 for interfacing between the computer 100 and other components. In the present embodiment, the other components comprise display means or monitor 110 for viewing information, input means or input device 120 such as a terminal, pointing device, mouse, bar code reader, etc., for

inputting information, and output means or printer 130 for printing information.

In the present embodiment, a movable camera apparatus 200 comprises camera means or a computer-controlled digital camera 210 for creating digital photographic images and specifically configured to photograph 360° panoramas, moving means or a computer-controlled motorized device 230 which rotates the camera in precise, programmable increments for a total of 360° while ensuring that the lens plane remains centered over the vertical rotational axis, leveling means or a computer-controlled motorized leveling device 240 which ensures that the camera lens is stationed at all times at a 90° angle to level ground, support structure or a motorized base 220 which transports the entire system linearly from one point to another, driving means or motor 250 for driving the motorized device 230, leveling device 240 and the support structure 220 and supply means or battery 260 for supplying power to the motor 250 to drive the various devices of the movable camera apparatus 200.

In the present embodiment, the computer 100 is a low-energy consumption CPU such as an Apple Macintosh® PowerPC 603 computer which is commercially available from Apple Computer, Inc. of Cupertino, California with 64MB or 128MB of RAM and 2GB or 4GB of hard disk space, an interchangeable battery-pack capable of powering the system for up to eight hours or more and a portable battery recharging station.

In the present embodiment, the system 10 also comprises remote control means or a remote controller 140 for controlling the functioning and movement of the camera apparatus 200 through the computer 100 as well as storing means or storage device 150, such as an internal hard disk, CD-ROM disk, magnetic tape, etc. for storing the application software, work-in-progress and final photographic images.

Although the present embodiment utilizes cabling to communicate between the computer 100 and the camera apparatus 200, infrared networking technology can also be used to operate the camera apparatus 200 as well as permit viewing by the user of what the camera apparatus 200 is photographing.

Such infrared networking technology, which is commercially available from a variety of vendors, helps to free the camera apparatus 200 from the difficult task of transporting heavy computer hardware thereon in order to store data. Rather the data would be transmitted to and from a remote computing system from and to the camera apparatus 200.

In order to create this multi-node movie, the camera apparatus 200 of the system 10 is controlled by the computer 100. The computer 100 has stored therein control commands for controlling the movement of the camera. The computer 100 also has stored therein a "digital map" or path set up by the user prior to the beginning of the photography session for the camera apparatus 200 to follow a particular route in order to create the multi-node movie.

This digital map is inputted to the computer 100 to outline the route the user wants the camera apparatus 200 to follow to create each node of the movie and ultimately to form the multi-node movie. The camera apparatus 200 and the movement thereof is then controlled by the computer 100 based upon the information input to form the digital map.

As shown in FIG. 2, for example, which illustrates a digital map for a retail establishment, the computer 100 can be programmed so as to control the camera apparatus 200 to follow any particular path in the store. As illustrated, for example, each aisle of the store, as indicated by "A", "B", "C", "D", "E" and "F" in FIG. 2, having shelves therebetween, can represent a "leg" of the digital map which when combined forms the "journey" of the camera apparatus 200. Each "N" on the map represents a select location for the camera apparatus 200 to create a node for the movie. Arrows as illustrated in FIG. 2 represent the direction the camera apparatus 200 can travel in order to create the multi-node movie. Select locations for creating a primary non-panoramic step frame and/or a secondary non-panoramic step frame are also illustrated. As illustrated on FIG. 2, a "START" point, an "END" point and arrows indicated thereon define the path which the camera apparatus 200 can be controlled to follow in order to create the multi-node movie. However, this digital

map is merely illustrative in that the camera apparatus 200 can follow a variety of different paths to create the desired multi-node movie. In addition, a digital map can also be generated which allows for random movement of the camera apparatus 200 and its spacing in order to create a multi-node movie with maximum navigational freedom and flexibility.

This digital map can be generated in a variety of ways, such as pictorially by drawing it using a graphical interface, or generating a map by "walking" or powering the system to each leg's beginning and ending point, etc. in a trial run. For example, two store aisles might be composed of three "legs": one leg down the first aisle, a second leg across and around the end of shelves of the aisle and a third leg returning the camera apparatus 200 almost to the original point of departure at the end of the second aisle. A fourth leg would be added to return the camera apparatus 200 precisely to its starting point.

However, the system 10 is not limited to the above described digital map, but can be an infinite variety of different legs and journeys which can be programmed in order to create the multi-node movie.

In an illustrative embodiment, the system 10 can operate as follows: 1) at a first node, the camera 210 of the camera apparatus 200 is instructed by the computer 100 to digitally capture a photograph at point zero, to save the photograph to memory 102 or the storage device 150 using a three or four digit sequential number as its name, to rotate the camera 210 on its vertical axis a predefined and uniform number of degrees to the right or left by driving the motor 250 which in turn drives the motorized device 230, and to repeat the process until enough photographs or a select number of photographs to prepare a 360° photographic panorama have been completed.

Once all the necessary photographs have been taken, the computer 100 of the system 10 begins to automatically process, i.e., stitch, dice and compress, the photographs for a single node. In what could be a simultaneous process, the computer 100 instructs the camera apparatus 200 of the system

10 to move a specified increment towards the next node by sending instructions to the power supply 250 to drive the motor 250 which in turn drives the motorized device 230. At each specified increment or select location, the camera apparatus 200 is also instructed to capture a single intermediate, non-panoramic step-frame.

Upon the arrival of the camera apparatus 200 at its next node, for example three to four feet from the first node, the computer 100 instructs the camera 210 of the camera apparatus 200 to capture another 360° panorama and controls the functioning of the motorized device 230 and the leveling device 240 to produce the desired images. The computer 100 can then begin processing the step-frames and the node panoramas into a linear multi-node movie.

When the digital map stored in the computer 100 has been completed by the camera apparatus 200, the computer 100, based on the programming set by the user, can either wait for further operation instructions, for example, adjustments to the stitching, programming of "hot spots", etc., or automatically complete assembly of the multi-node "movie."

If, however, the user chooses to add "hot spots," the system 10 displays on the monitor 130 the completed multi-node movie creating the three-dimensional or virtual reality environment. Using an input device 120, such as a mouse, "touch" screen or electronic "pen" capability by drawing directly on the monitor 110, etc., the user chooses a hot spot or selection item on display in the panoramic image by "sketching" over the entire area of the item. This sketching occurs by tracing an outline of the entire area of the item and filling the space therein. Other methods of item identification can be implemented as well. For example, the user can also select one point on the computer's monitor 110 within the desired selection item and then allow the computer 100 to define the appropriate area of the selection item by selecting all contiguous, similarly colored screen pixels.

Once the area of the selection item within the panorama image has been defined, the user uses an input device 120 such as a bar-code reader to collect selection item

identification information (SKU number, manufacturer, product description, list price, etc.) from labeling on the item's packaging or other reference. The computer 100 then permanently associates this item identification information (SKU number or other unique identification number) with the area in the panorama image. The computer 100 also gives the user the opportunity to associate any other existing graphics or data such as a photograph, a video clip, a spreadsheet or a text file with this selection item. This association process is completed for any or all items in each panorama image which the user wishes to be "interactive," that is, subject to user selection, viewing and/or further action within the panorama image.

For example in the present embodiment, the hot spot or selection item can be a photographic image of a toy on a shelf in a store. While viewing the panoramic images taken by the camera apparatus 200 in store, the user can choose the toy, outline the shape of the toy and fill in its definition. A bar code reader 120 can then be used to input information to the computer 100 concerning this toy. Thus when the multi-node movie is viewed by a customer, the customer can select the toy and receive a variety of information concerning the toy as well as purchase the toy based upon the information stored in the computer 100.

Once this information has been developed, retrieved and stored, the system 10 then completes the panoramic "movie" by combining, compressing, compiling and saving all elements into one final, finished data file.

The system 10 as identified is intended to be used for the cost-effective development of navigable virtual reality PC-based movies specifically to create a selected area, such as a shopping environment, which enables the user to explore an almost unlimited number of stores in a "virtual" shopping mall. These movies could be distributed through a variety of storage devices, such as floppy diskette or CD-ROM, or communication means, such as the Internet, Interactive TV and Interactive Cable TV.

The system 10 is not limited to the above, but can be

used to create movies so that realtors could let potential buyers "tour" a home via the Internet, travel packages can be shown to let potential customers "tour" an ocean liner or hotel room before making reservations, manufacturers could show their facilities to people in distant locations, etc. In addition, the system 10 can be used to allow computer game designers to significantly reduce the expense incurred by rendering or photographing individual photographic frames in producing an interactive game.

Although Fig. 1 is directed to a computer-controlled system 10 with a camera apparatus 200, an infinite number of apparatuses 200 could be used in various areas of a store, for example, one apparatus in each aisle of a retail establishment, to yield even greater efficiencies. Nor is the present embodiment limited to digital cameras 210 but can also include a slit camera which can be used to produce one continuous, seamless panorama which would avoid having to stitch the photographs together to form a panorama.

Although the system 10 of the present embodiment uses a Macintosh® computer, the system 10 is implementable in other embodiments on computers other than Macintosh® computers. Further, the present invention is implementable in other graphical user interface environments, such as Windows 95, IBM OS/2, Sun Solaris, as well as World Wide Web Browsers such as Netscape, etc. Also the system 10 is not limited to use with QuickTime VR but can be used in other navigable movie or photograph format applications which have been developed to form single node panoramas or multi-node movies. Further, the system 10 as illustrated in FIG. 1, is not limited to the components as shown, but can comprise a variety of different hardware and software configurations in order to create navigable three-dimensional photographs for selected areas.

In all cases it is understood that the above-described arrangements are merely illustrative of the many possible specific embodiments which represent applications of the present invention. Accordingly numerous and varied other arrangements, can be readily devised in accordance with the

principles of the present invention without departing from the spirit and scope of the invention. For example, the present invention while directed to retail establishments can also be applied to viewing homes, travel promotions, etc., where three-dimensional viewing or a virtual reality environment is desired to be photographed.

What Is Claimed Is:

1. A computer-controlled system for producing and combining photographic images to create a virtual reality environment, comprising:

a movable camera apparatus for creating at least one digital photographic image; and

computing means for controlling said movable camera apparatus to move to a select location and produce a select number of digital photographic images at the select location, said computing means combining the digital photographic images together to form the virtual reality environment.

2. A computer-controlled system according to claim 1, wherein said computing means includes a memory for storing a path along which the movable camera apparatus is to be moved.

3. A computer-controlled system according to claim 2, wherein said path comprises a number of select locations to which the computing means moves the movable camera apparatus and instructs the movable camera apparatus to produce a select number of digital photographic images at each select location.

4. A computer-controlled system according to claim 3, wherein at a select number of select locations, a plurality of digital photographic images are taken and combined to form a panoramic image.

5. A computer-controlled system according to claim 4, wherein at a select number of select locations, a primary non-panoramic step frame is taken.

6. A computer-controlled system according to claim 5, wherein at a select number of select locations, a secondary non-panoramic step frame is taken.

7. A computer-controlled system according to claim 1, wherein said computing means is located on the movable camera apparatus.

8. A computer-controlled system according to claim 1, wherein said movable camera apparatus is controllable by remote-control means.

9. A method for producing and combining photographic images to create a virtual reality environment, comprising

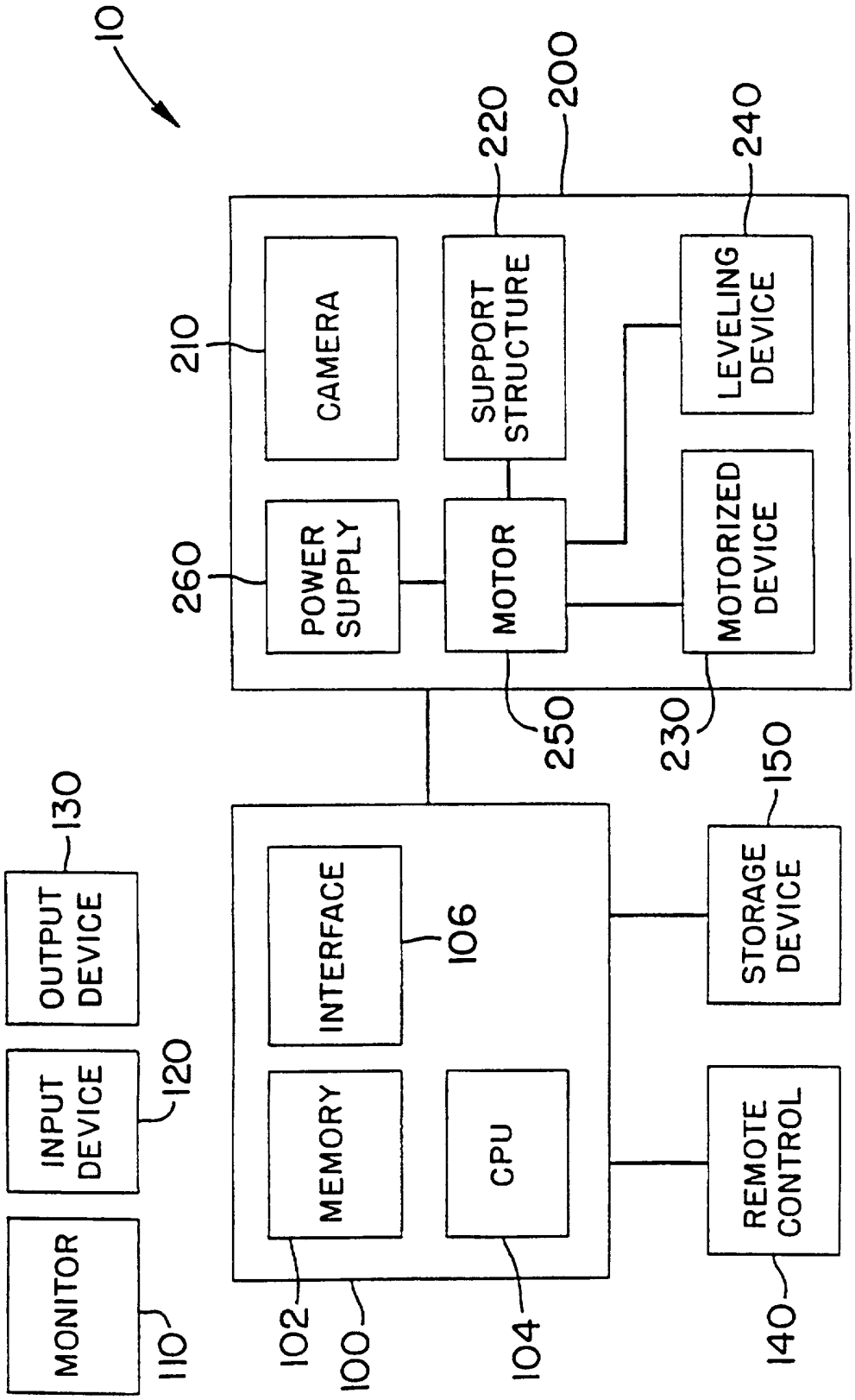
the steps of:

moving a movable camera apparatus to a select location by means of computing means and controlling the movable camera apparatus to produce a select number of digital photographic images at the select location by means of the computing means; and

combining the digital photographic images together by means of the computing means to form the virtual reality environment.

10. A method according to claim 9, wherein said moving step further comprises moving the movable camera apparatus along a path stored in a memory of the computing means.

11. A computer-controlled system according to claim 10, wherein said path comprises a number of select locations to which the computing means moves the movable camera apparatus to each of the number of select locations and instructs the movable camera apparatus to produce a select number of digital photographic images at each select location.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200
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240
210
CAMERA
SUPPORT STRUCTURE
LEVELING DEVICE
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POWER SUPPLY
MOTOR
MOTORIZED DEVICE
250
230
150
130
OUTPUT DEVICE
INTERFACE
106
STORAGE DEVICE
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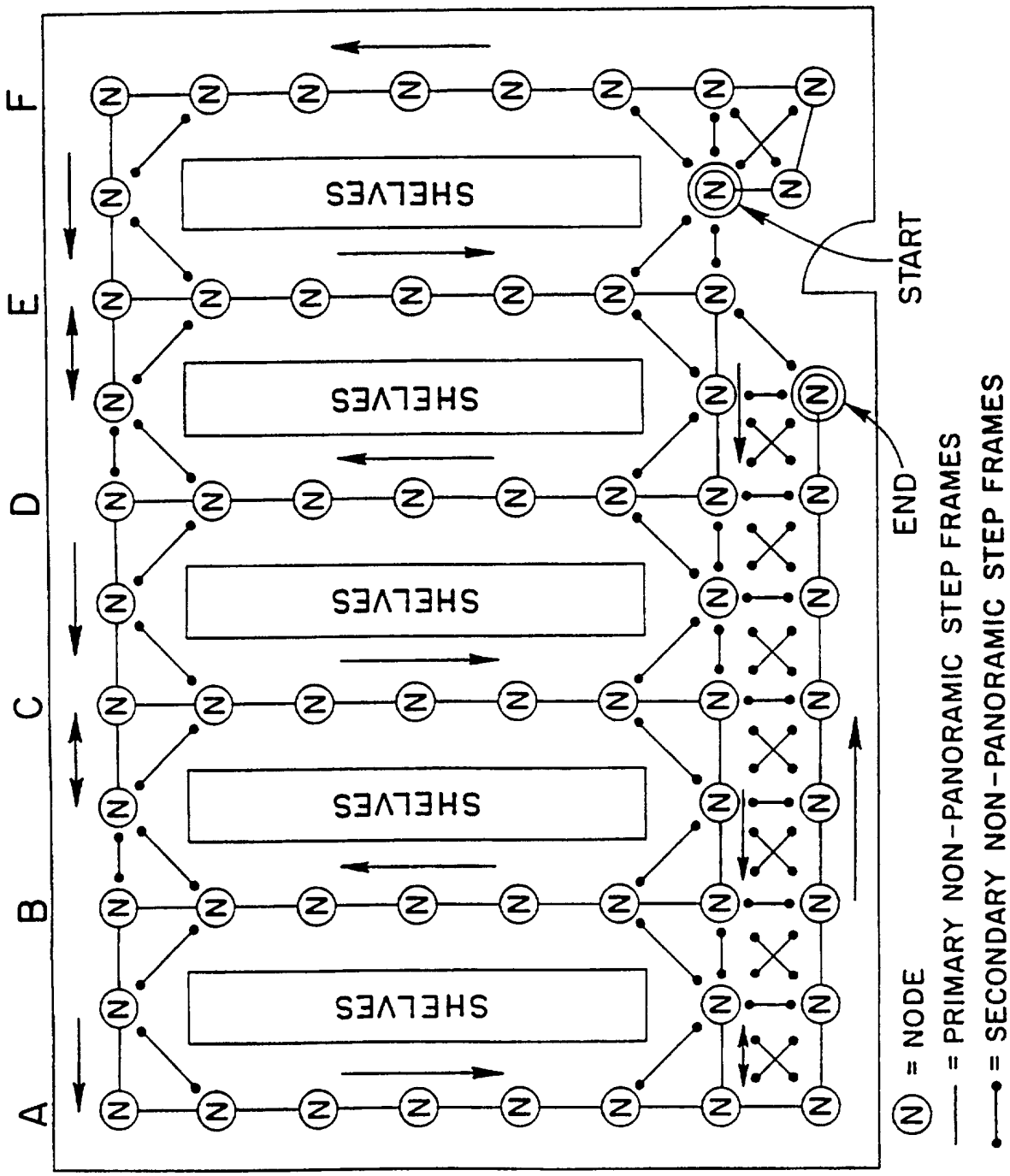
INPUT DEVICE
MEMORY
CPU
REMOTE CONTROL
MONITOR
110
102
100
104
140

FIG. 1

FIG. 2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= PRIMARY NON-PANORAMIC STEP FRAMES
= SECONDARY NON-PANORAMIC STEP FRAMES

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/20039

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.
US CL :Please See Extra Sheet.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 395/119, 129, 133, 135, 500, 329; 348/15, 36, 39, 52, 61, 95, 233, 383, 744

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS, DIALOG, STN, IEEE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,P	US, A, 5,526,041 (GLATT) 11 JUNE 1996, cols. 1-16 and figures.	1-11
Y,P	US, A, 5,531,227 (SCHNEIDER) 02 JULY 1996, cols. 1-18 and figures.	1-11
X,P	US, A, 5,497,188 (KAYE) 05 MARCH 1996, cols 1-12 and figures.	1-11
X,P	US, A, 5,479,597 (FELLOUS) 26 DECEMBER 1995, cols 1-10 and figures.	1-11
Y,P	US, A, 5,572,248 (ALLEN ET AL) 05 NOVEMBER 1996, cols. 1-24 and figures.	1-11
Y,P	US, A, 5,566,280 (FUKUI ET AL) 15 OCTOBER 1996, cols. 1-10 and figures.	1-11

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 10 MARCH 1997	Date of mailing of the international search report 01 APR 1997
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer JACQUES H. LOUIS-JACQUES Telephone No. (703) 308-9600

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/20039

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 5,255,096 (BOYLE) 10 OCTOBER 1993, cols. 1-12 and figures	1-11
Y	US, A, 5,159,458 (MURATA ET AL) 27 OCTOBER 1992, cols. 1-12 and figures	1-11
X	US, A, 5,422,653 (MAGUIRE, Jr.) 06 JUNE 1995, cols. 1-46 and figures	1-11
X	US, A, 5,130,794 (RITCHEY) 14 JULY 1992, cols. 1-46 and figures	1-11
Y	US, A, 5,394,517 (KALAWSKY) 28 FEBRUARY 1995, cols. 1-8 and figures	1-11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/20039

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

G06F 3/00, 15/00, 9/455; G09B 5/00; G09C 1/00; HO1J 31/00; HO4N 7/00, 7/14, 7/18, 9/47, 13/04, 15/00

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

395/119, 129, 133, 135, 500, 329; 348/15, 36, 39, 52, 61, 95, 233, 383, 744