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Steven N.; One Microsoft Way, Redmond, Washington
98052-6399 (US).

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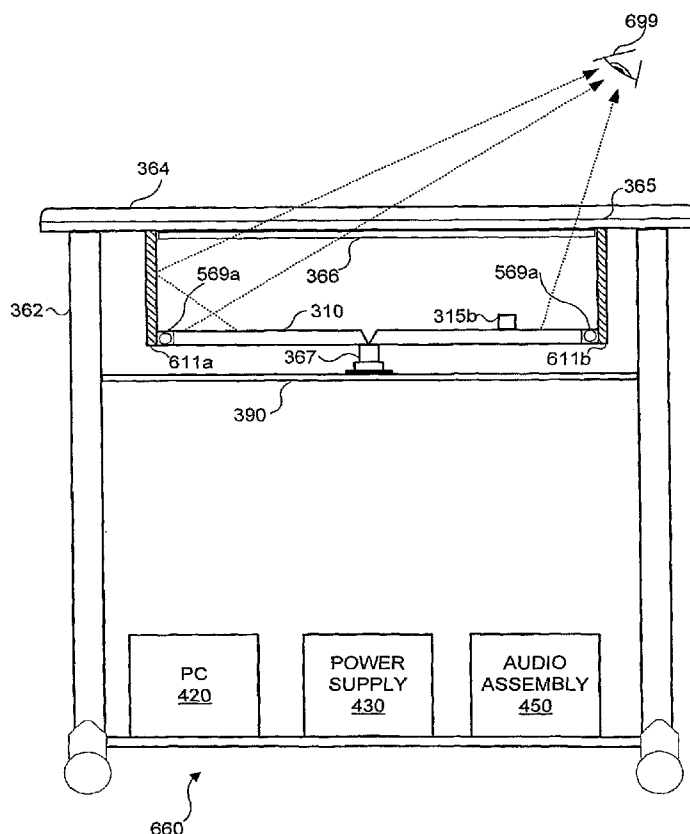
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(71) Applicant (*for all designated States except US*): MICROSOFT CORPORATION [US/US]; One Microsoft Way, Redmond, Washington 98052-6399 (US).

(72) Inventors: KEAM, Nigel S.; One Microsoft Way, Redmond, Washington 98052-6399 (US). BATHICHE,

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(54) Title: UNIFORM ILLUMINATION OF INTERACTIVE DISPLAY PANEL



(57) Abstract: An interactive display device employing a flat panel display (FPD). The interactive display device includes a housing, a flat panel display, a light diffusing layer, a visible light illumination system, and a non-visible light illumination system that is used for detecting objects adjacent to the FPD. Techniques are also described for providing uniform illumination of the FPD with visible light, when viewed from a plurality of viewing angles by a user, and for diffusing the visible illumination at a surface boundary of the FPD, such that a coherent image of an interior of the housing is at least partially obscured from view by the user. Non-visible light that has passed through the FPD is reflected from objects adjacent to the display, passes back through the FPD, and is detected within the housing.

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UNIFORM ILLUMINATION OF INTERACTIVE DISPLAY PANEL

Background

The utility and enjoyment of computer systems can be enhanced by providing better user interfaces. User interfaces for computers systems have evolved significantly since the personal computer (PC) first became widely available. Early PCs were limited to user input devices, such as the keyboard and serial mouse, and were primarily text-based. However, a vast improvement in the speed and the power of microprocessors, a much greater available low-cost memory, and improved programming functionality have all contributed to the advancement of much more sophisticated user interface designs and the development of user-friendly graphic operating systems and hardware.

One particular area of advancement in user interface technology pertains to the recent development of an interactive display, to which a number of commonly assigned patent applications have been directed. An interactive display presents graphic images to a user on a flat surface, such as the top of a table or other housing format. In addition, this surface is responsive to input by a user. A PC is coupled to the interactive display to provide the processing power that yields a rich user interactive experience, offering more sophisticated command and interface features, and a far more natural interactive approach in providing input to the system, particularly as related to displayed images.

Interactive display systems that have been developed typically employ an optical system for generating images, and for detecting user input. However, such optical systems usually require an image projection system, which is relatively expensive, requires a relatively large housing, and which must be maintained in close alignment relative to the optical components that sense input. One alternative developed to address the inherent problems of a projection system for image display is the use of a liquid crystal display (LCD) panel. LCD displays work by changing the polarization of incident light and by filtering out light which is not polarized in the same orientation as the LCD. This function is typically achieved using a sandwich of fixed polarizing sheets and active liquid crystal elements. The activation of the liquid crystal elements controls the amount of light that is able to pass through each part of the display. Additionally, a mosaic of color filters is overlaid or embedded within the LCD panel so that individual elements only transmit specific ranges of visible light, thus achieving a full color display. However, an interactive display must also be configured to detect objects placed on or near the surface upon which images are displayed. For example, a camera can be placed behind the surface to sense light reflected from an object on or immediately adjacent to the surface. Unfortunately, using visible light illumination for object detection would interfere with an image displayed on the LCD panel.

A typical illumination source for an LCD panel is a thin fluorescent tube that produces light input to the edge of a sheet of transparent material, such as acrylic, that comprises the panel. Light from the fluorescent tube travels within this acrylic sheet light guide, bouncing off the surfaces due to internal reflection until it reaches a point on the surface which has been

deliberately roughened, enabling the light to escape the light guide. Other light guide techniques include the use of scattering of bumps or an angled wedge. However, many LCD panels are quite translucent and if the illumination of the LCD panel is not uniform within the enclosure that houses the LCD panel, darkened areas can appear when the display is viewed at certain angles.

Therefore, there is current interest in finding solutions to the above problems with LCD panels for use with an interactive display that can provide detection of items on a display surface, while also providing uniform surface illumination when viewed by users, regardless of the viewing angle. The solution should enable the display of graphic images on the panel while not interfering with the detection of objects on or near the surface of the panel. Thus, it will be important to avoid using an illumination source for detecting objects that produces light visible to the user, since that would interfere with the displayed image. Of course, it is also important that items on the display surface be detected, regardless of the currently displayed image.

Summary

Several implementations of an interactive display are described below in detail. One aspect of these implementations that are described relates to a method for configuring an interactive display that employs a flat panel display for displaying images to a user. The described method includes the step of providing a visible light illumination for the flat panel display. The illumination is configured to provide a substantially uniform illumination of the surface of the display when viewed from a plurality of viewing angles by a user, in order to avoid darkened areas of the display due to parallax. The method further describes the step of providing a diffusion of the illumination at a surface boundary of the display such that a coherent image of an object below a viewing plane of the display is at least partially obstructed from view by the user. The method then describes a step of providing user input detection. The user input detection can be based on detecting infrared illumination reflected from objects adjacent to the surface boundary of the display and wherein the display is configured to be substantially transparent to the infrared illumination. Any user input detection components within the interactive display that are positioned beneath the display panel are at least partially obscured from view by the step of diffusing the visible illumination.

This Summary has been provided to introduce a few concepts in a simplified form that are further described in detail below in the Description. However, this Summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

Drawings

Various aspects and attendant advantages of one or more exemplary embodiments and modifications thereto will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a cross-sectional view illustrating internal components of an interactive display table system that includes an integral PC, but does not employ the present approach discussed below;

FIGURE 2 is an isometric view of an embodiment in which an LCD-based interactive display table, which may include an embodiment of the present IR detection system, is connected to an external PC;

FIGURE 3 is a schematic cross-sectional illustration of an LCD panel-based interactive display table that includes an exemplary embodiment of an illumination system that is spaced apart from the LCD panel;

FIGURE 4 is another schematic cross-sectional illustration of an LCD panel-based interactive display table that includes an exemplary embodiment of an illumination system that is spaced apart from the LCD panel;

FIGURE 5 is yet another schematic cross-sectional illustration of an LCD panel-based interactive display table that includes an exemplary embodiment of an illumination system that is spaced apart from the LCD panel;

FIGURE 6 is still another schematic cross-sectional illustration of an LCD panel-based interactive display table that includes an exemplary embodiment of an illumination system that is spaced apart from the LCD panel;

FIGURE 7 is another schematic cross-sectional illustration of an LCD panel-based interactive display table that includes an exemplary embodiment of an illumination system that is spaced apart from the LCD panel;

FIGURE 8 is a schematic cross-sectional illustration of an LCD panel-based interactive display table that includes an exemplary embodiment of an illumination system that is immediately adjacent to the LCD panel; and

FIGURE 9 is a schematic cross-sectional illustration of an LCD panel-based interactive display table that includes an exemplary embodiment of an illumination system that directly illuminates the LCD panel.

Description

Interactive Display System

In FIGURE 1, an exemplary interactive display table 60 is shown that includes a personal computer (PC) 20 within a frame 62 and which serves as both an optical input and video display device for the PC. This embodiment of the interactive display table does not include a flat panel display, such as an LCD panel. This embodiment is shown for comparison to the exemplary embodiments of FIGURES 2 through 9 that do include an LCD panel. Also, this Figure should help to clarify how the interactive display system operates to both display images on an interactive display surface, as well as detecting objects that are on or adjacent to the interactive display surface.

In this cut-away Figure of interactive display table 60, rays of light 82a-82c used for displaying text and graphic images are generally illustrated using dotted lines, while rays of

infrared (IR) light used for sensing objects on or just above a user interface surface 64 of interactive display table 60 are illustrated using dash lines. The perimeter of the table surface around the actual display area in the center is useful for supporting a user's arms or other objects, including objects that may be used to interact with the graphic images or virtual environment being displayed on user interface surface 64.

IR light sources 66 preferably comprise a plurality of IR light emitting diodes (LEDs) and are mounted on the interior side of frame 62. The IR light that is produced by IR light sources 66 is directed upwardly toward the underside of user interface surface 64, as indicated by dash lines 78a, 78b, and 78c. The IR light from IR light sources 66 is reflected from any objects that are atop or proximate to the display surface after passing through a translucent layer 65 of the table, comprising a sheet of vellum or other suitable translucent material with light diffusing properties. As used herein and in the description that follows in connection with objects positioned on or proximate to the interactive display surface, the term "adjacent to" is used with the intention that this term encompass both an object that is actually touching the interactive display surface as well as one that is just above the interactive display surface. Although only one IR source 66 is shown, it will be appreciated that a plurality of such IR sources may be mounted at spaced-apart locations around the interior sides of frame 62 to provide an even illumination of user interface surface 64. The IR light produced by the IR sources may:

- exit through the table surface without illuminating any objects, as indicated by dash line 78a;
- illuminate objects on the table surface, as indicated by dash line 78b; or
- illuminate objects a short distance above the table surface but not touching the table surface, as indicated by dash line 78c.

Objects above user interface surface 64 include a "touch" object 76a that rests atop the display surface and a "hover" object 76b that is close to but not in actual contact with the display surface. Thus, both touch and hover objects are "adjacent to" the display surface, as that term is used herein. As a result of using translucent layer 65 to diffuse the IR light passing through the display surface as an object approaches the top of user interface surface 64, the amount of IR light that is reflected by the object increases to a maximum level that is achieved when the object is actually in contact with the display surface.

A digital video camera 68 is mounted to frame 62 below user interface surface 64 in a position appropriate to receive IR light that is reflected from any touch object or hover object disposed above user interface surface 64. Digital video camera 68 is equipped with an IR pass filter 86a that transmits only IR light and blocks ambient visible light traveling through user interface surface 64 along dotted line 84a. In the illustrated implementation, a baffle 79 is disposed between IR source 66 and digital video camera 68 to prevent IR light that is directly emitted from the IR source from entering the digital video camera. It is preferable that the digital video camera should produce an output signal that is only responsive to the IR light

reflected from objects that are a short distance above or in contact with user interface surface 64. In this manner, only light that corresponds to an image of IR light reflected from objects on or above the display surface will be detected. It will be apparent that digital video camera 68 will also respond to any IR light included in the ambient light that passes through user interface surface 64 from above and into the interior of the interactive display, including ambient IR light that also travels along the path indicated by dotted line 84a.

IR light reflected from objects on or above the table surface may be reflected back through translucent layer 65, through IR pass filter 86a and into the lens of digital video camera 68, as indicated by dash lines 80a and 80b or reflected or absorbed by other interior surfaces within the interactive display without entering the lens of digital video camera 68, as indicated by dash line 80c.

Translucent layer 65 diffuses both incident and reflected IR light. Thus, as explained above, "hover" objects such as hover object 76b that are closer to user interface surface 64 will reflect more IR light back to digital video camera 68 than objects of the same reflectivity that are farther away from the display surface. Digital video camera 68 senses the IR light reflected from "touch" and "hover" objects within its imaging field and produces a digital signal corresponding to images of the reflected IR light that is input to the PC 20 for processing to determine a location of each such object, and optionally, the size, orientation, and shape of the object. It should be noted that a portion of an object, such as a user's forearm, may be above the table while another portion, such as the user's finger, is in contact with the display surface. In addition, an object may include an IR light reflective pattern or coded identifier, such as a bar code, on its bottom surface that is specific to that object or to a class of related objects of which that object is a member. Accordingly, the imaging signal from the digital video camera 68 can also be used for detecting each such specific object, as well as determining its orientation, based on the IR light reflected from its reflective pattern, in accord with the present invention.

The illustrated interactive display table is operable to recognize an object and/or its position relative to the user interface surface 64 by detecting its identifying characteristics using the IR light reflected from the object. The logical steps implemented to thus detect and identify an object and its orientation are explained in the commonly-assigned patent applications, including application serial number 10/814,577 entitled "Identification Of Object On Interactive Display Surface By Identifying Coded Pattern," and application serial number 10/814,761 entitled "Determining Connectedness And Offset Of 3D Objects Relative To An Interactive Surface," both of which were filed on March 31, 2004.

PC 20 may be integral to interactive display table 60 as shown in FIGURE 1, or alternatively, may instead be external to the interactive display table, as shown in the embodiment of FIGURE 2. In FIGURE 2, an interactive display table 60' is connected through a data cable 63 to an external PC 20 (which includes optional monitor 47, as mentioned above). The embodiment of FIGURE 2 may include a flat panel display such as a liquid crystal display

(LCD) panel or an organic light emitting diode (OLED) display panel, details of which are discussed below in connection with FIGURES 3-9. External PC 20 can be connected to interactive display table 60' via a wireless link (i.e., WiFi or other appropriate radio signal link). As also shown in this Figure, a set of orthogonal X and Y axes are associated with user interface surface 64, as well as an origin indicated by "0." While not discretely shown, it will be appreciated that a plurality of coordinate locations along each orthogonal axis can be employed to specify any location on user interface surface 64.

If an interactive display table 60' is connected to an external PC 20 (as in FIGURE 2) or to some other type of external computing device, such as a set top box, video game, laptop computer, or media computer (not shown), then interactive display table 60' comprises an input/output device. Power for interactive display table 60' is provided through a power lead 61, which is coupled to a conventional alternating current (AC) source (not shown). Data cable 63, which connects to interactive display table 60', can be coupled to a USB 2.0 port, an Institute of Electrical and Electronics Engineers (IEEE) 1394 (or Firewire) port, or an Ethernet port on PC 20. It is also contemplated that as the speed of wireless connections continues to improve, interactive display table 60' might also be connected to a computing device, such as PC 20 via such a high speed wireless connection, or via some other appropriate wired or wireless data communication link. Whether included internally as an integral part of the interactive display, or externally, PC 20 executes algorithms for processing the digital images from the digital video camera used for sensing objects on or adjacent to the display surface and executes software applications that are designed to employ the more intuitive user interface functionality of the interactive display table to good advantage, as well as executing other software applications that are not specifically designed to make use of such functionality, but can still make good use of the input and output capability of the interactive display table. As yet a further alternative, the interactive display can be coupled to an external computing device, but include an internal computing device for doing image processing and other tasks that would then not be done by the external PC.

An important and powerful feature of the interactive display table is its ability to display graphic images or a virtual environment for games or other software applications and to enable an interaction between the graphic image or virtual environment visible on user interface surface 64 and identify objects that are resting atop the display surface, such as an object 76a, or are hovering just above it, such as an object 76b.

Again referring to FIGURE 1, interactive display table 60 includes a video projector 70 that is used to display graphic images, a virtual environment, or text information on user interface surface 64. In this implementation, the video projector is preferably of a liquid crystal display (LCD) or digital light processor (DLP) type, or a liquid crystal on silicon (LCoS) display type, with a resolution of at least 640x480 pixels. An IR cut filter 86b is mounted in front of the projector lens of video projector 70 to prevent IR light emitted by the video projector from entering the interior of the interactive display table where the IR light might

interfere with the IR light reflected from object(s) on or above user interface surface 64. Video projector 70 projects light along dotted path 82a toward a first mirror assembly 72a. First mirror assembly 72a reflects projected light from dotted path 82a received from video projector 70 along dotted path 82b through a transparent opening 90a in frame 62, so that the reflected projected light is incident on a second mirror assembly 72b. Second mirror assembly 72b reflects light from dotted path 82b along dotted path 82c onto translucent layer 64b, which is at the focal point of the projector lens, so that the projected image is visible and in focus on user interface surface 64 for viewing.

Alignment devices 74a and 74b are provided and include threaded rods and rotatable adjustment nuts 74c for adjusting the angles of the first and second mirror assemblies to ensure that the image projected onto the display surface is aligned with the display surface. In addition to directing the projected image in a desired direction, the use of these two mirror assemblies provides a longer path between projector 70 and translucent layer 64b to enable a longer focal length (and lower cost) projector lens to be used with the projector.

The foregoing discussions describe an interactive display device in the form of interactive display table 60 (or alternatively, of interactive display table 60'). Nevertheless, it should be understood that the interactive display surface need not be in the form of a generally horizontal table top and need not be formed as a table that rests on the floor, but instead can be formed as a device that sits on a table or other surface and which can include a display surface that can face in directions other than vertical. The principles employed for the approach described herein suitably also include and apply to display surfaces of different shapes and curvatures and that are mounted in orientations other than horizontal. Further, although the following description refers to placing physical objects "on" the interactive display surface, physical objects may be placed adjacent to the interactive display surface by placing the physical objects in contact with the display surface or otherwise adjacent the display surface. It should be appreciated that the exemplary display systems described above in connection with FIGURES 1 and 2 are not limited to any specific type of display or sensing technology, and are merely provided as exemplary implementations of various interactive display systems in order to demonstrate an operating environment and common components used with other interactive display implementations.

FIGURE 3 is a schematic cross-sectional illustration of a flat panel display (FPD) based interactive display table 360, which includes an exemplary embodiment of an illumination system 310 that is spaced apart from the FPD. It should be noted that while the following descriptions that refer to FIGURES 3-9 each employ an LCD panel, any suitable flat panel display having the desired characteristics can be also employed in any of the described implementations. Non-limiting examples of usable flat-panel displays include: LCD panels, plasma displays, and organic light emitting diode (OLED) displays. However, LCD displays have certain properties that enable such displays to readily transmit infrared light. In particular, the polarizers in many LCD panels do not polarize in the non-visible infrared range. In fact,

infrared illumination passes through both the fixed polarization layers of the LCD panel and the active liquid crystal elements regardless of their activation state. A further point of note is that many of the color filters used in color LCD displays are also semi-transparent to infrared illumination.

5 As illustrated in FIGURE 3, display table 360 includes a user interface surface 364 that is coupled to LCD panel 366 via a diffusing layer 365. Although diffusing layer 365 is shown in FIGURE 3 as extending along the length of user interface surface 364, in other implementations (not shown), diffusing layer 365 can be coupled to LCD panel 366, which can then be coupled to user interface surface 364. Diffusing layer 365 generally prevents objects
10 below the viewing plane of the LCD panel from being clearly visible to a user, i.e., the slight diffusion of visible illumination provided by the diffusing layer prevents a clear view through the LCD panel, into the interior of interactive display table 360, where various user input detection components and LCD illumination components reside and might otherwise be visible to a user.

15 An interactive table chassis 362 supports user interface surface 364. Illumination system 310 is shown supported by supports 391a and 391b. A support 390 is shown supporting a camera 367 configured for detecting non-visible light (e.g., rays 378a and 378b of IR light) reflected from objects on or adjacent to user interface surface 364, such as "touch" object 376a and "hover" object 376b. Non-visible light illuminants 315a and 315b are shown
20 coupled to chassis 362. It should be understood that any number of illuminants such as 315a and 315b can be employed within interactive display table 360 in order to fully illuminate user interface surface 364 with non-visible light. Furthermore, it should be noted that non-visible illuminants can be placed in any suitable location within the housing, between illumination system 310 and LCD panel 366.

25 As illustrated in FIGURE 3, illumination system 310 includes several components. A diffusing layer 363 is coupled to a light guide assembly 368 that includes a visible light illuminant 369 for generating a homogeneous or uniform illumination of LCD panel 366 (e.g., as provided by a ray 380). A backplane 370 is also illustrated coupled to light guide assembly 368. Backplane 370 can be formed of any material suitable for substantially
30 reflecting visible light. In some implementations, backplane 370 can be an opaque white acrylic sheet. In other implementations, diffusing layer 363 can be one or more (or a combination of) light diffusing layers and collimating lenses, for example, Fresnel lenses. Light diffusing layer 363 is generally configured to condition visible light emitted from light guide assembly 368 in order to most effectively illuminate LCD panel 366.

35 Visible light assembly 368 can include a light guiding layer formed of a suitable material, such as an acrylic sheet. In other implementations, visible light illuminant 369 can be a cold cathode fluorescent tube configured to edge light an acrylic sheet that is included in the LCD panel. In yet another implementation, illuminant 369 can be white light LEDs that are optically coupled to edge of the acrylic light guide. The implementation and operation of light

guides for backlighting LCD panels will be well known to those skilled in the art, and therefore, need not be discussed in further detail.

In this exemplary configuration of interactive table 360, illumination system 310 and LCD panel 366 are spaced apart. The spacing between illumination system 310 and LCD panel 366 can range from a few centimeters to several inches depending upon the specific implementation and materials used for these components. Although not illustrated in FIGURE 3, interactive table 360 can include additional components such as a PC, a power supply, and an audio subsystem. There are several specific exemplary embodiments of the interactive table using the configuration that is illustrated in FIGURE 3, which are described below in connection with FIGURES 4-7. As appropriate, components common to the exemplary embodiment illustrated in FIGURE 3 share the same reference numbers in the Figures that follow.

Turning now to FIGURE 4, a schematic cross-sectional illustration of an interactive display table 460 is depicted that includes illumination system 310, as shown in FIGURE 3. Interactive display table 460 again includes display chassis 362, user interface surface 364 coupled to diffusing layer 365, and LCD display 366. Non-visible light illuminant 315b (e.g., an IR light source) is coupled to display chassis 362. It should be understood that while only one non-visible light illuminant is depicted in FIGURE 4, any suitable number of the non-visible light illuminants can be employed to adequately illuminate user interface surface 364. FIGURE 4 further includes a PC 420, a power supply 430 and an audio assembly 450.

PC 420 can be any computing device suitable for enabling the operation of interactive table 460, such as PC 20, which was described in connection with FIGURES 1 and 2. Power supply 430 can be any suitable supply for providing power to components of interactive table 460, at an appropriate voltage/current level. Audio assembly 450 can be any combination of audio input and output devices including, but not limited to, power amplifiers, speakers, microphones, sound processing hardware, and the like, and can also be coupled to a sound card (not separately shown) included in PC 420.

The configuration of the exemplary embodiment shown in FIGURE 4 is notable for providing a surface area for illumination system 310 is substantially greater than the surface area of LCD panel 366. As a result of this greater area of the illumination system, a user 499 will perceive a uniform illumination of LCD panel 366 from a wide variety of viewing angles relative to the LCD panel, since the illumination provided by illumination system 310 extends sufficiently outside the outer boundaries of LCD panel 366 to prevent user 499 from perceiving dark areas on the LCD panel due to parallax.

FIGURE 5 is a schematic cross-sectional illustration of yet another LCD panel-based interactive display table 560 that includes illumination system 310 that is again spaced apart from the LCD panel, just as in FIGURE 3. Interactive display table 560 includes display chassis 362, user interface surface 364 coupled to diffusing layer 365 and LCD display 366. Non-visible light illuminant 315a is again illustrated. However, illuminant 315a is now

illustrated as being coupled to illumination system 310. In one example, illuminant 315a can be one of a plurality of infrared emitting LEDs that are disposed at regular intervals upon a surface of illumination system 310. FIGURE 5 again includes PC 420, power supply 430, and an audio assembly 450.

5 The embodiment shown in FIGURE 5 further provides illumination system 310 with side panels 511a and 511b, that are respectively illuminated with visible light illuminants 569a and 569b that introduce light into the edges of the side panels. As illustrated in FIGURE 5, the side panels extend perpendicularly from each edge of the upper surface of illumination system 310 to a lower surface of user interface surface 364, forming a closed illumination box with LCD panel 366 forming the top of the closed illumination box. In one implementation
10 (not shown), side panels 511a and 511b can be coupled to interactive display chassis 362, such that the interior side walls of interactive display 560 are illuminated. As a result of adding these side panels, a user 599 will perceive a uniform illumination of LCD panel 366 from a wide variety of viewing angles relative to the LCD panel, since the illumination provided by
15 illumination system 310 and the addition of panels 511a and 511b prevents user 599 from perceiving dark areas on LCD panel 366 due to parallax. In one implementation, side panels 511a and 511b can be light guides such as acrylic sheets. In another implementation, side panels 511a and 511b can include component layers, such as one or more diffusers, one or more lenses, a light guide and a backplane reflective of visible light. In one example, side
20 panels 511a and 511b are identical in structure to illumination system 310, sharing the same configuration of diffusing layers, lenses, light guides and reflected back planes. In this example, visible light illuminants 569a and 569b can be configured to concurrently illuminate side panels 511a and 511b as well as the light guide of illumination system 310. It should be noted that the implementation of interactive table 560 is shown in cross section, and therefore,
25 can include additional components that are not illustrated, including additional side panels that are illuminated, such that each side of illumination system 310 will have an side panel illuminated to further improve the uniformity of illumination provided for LCD panel 366.

A simplified configuration, illustrated by an interactive table 660 in FIGURE 6, replaces the side panels 511a and 511b of FIGURE 5 with side panels 611a and 611b that
30 simply reflect visible light, saving materials cost compared to the exemplary implementation illustrated in FIGURE 5. As with each of the previously described embodiments, a user 699 will perceive a uniform illumination of LCD panel 366 from a wide variety of viewing angles relative to the LCD panel, since the illumination provided by illumination system 310 and reflected by side panels 611a and 611b prevents user 699 from perceiving dark areas on LCD
35 panel 366 due to parallax.

Still another simplified configuration, illustrated by an interactive table 760 in FIGURE 7, employs an illumination system 770 that is formed as a curvilinear panel that is spaced apart from LCD panel 366 at a central point, but having edges that curve up to meet user interface surface 364 around a perimeter of LCD panel 366. This implementation is

functionally similar to the embodiment illustrated in FIGURE 4, since the practical effect of curving illumination system 770 up to meet user interface surface 364 is the same as extending the area of illumination system 310 substantially beyond the area of LCD panel 366. As a result of this curved configuration, a user 799 will perceive a uniform illumination of LCD panel 366 from a wide variety of viewing angles relative to the LCD panel, since the illumination provided by curved illumination system 310 will prevent user 799 from perceiving dark areas on LCD panel 366 due to parallax.

FIGURE 8 is a schematic cross-sectional illustration of an LCD panel-based interactive display table 860 that includes an exemplary embodiment of an illumination system 810 that is disposed immediately adjacent to the LCD panel. The implementation illustrated in FIGURE 8 shares many components and features that are included in the embodiment illustrated in FIGURE 3, and therefore, functionally similar components have the same reference numbers in each Figure. As illustrated in FIGURE 8, display table 860 includes user interface surface 364, LCD panel 366, and diffusing layer 365. Although diffusing layer 365 is again shown extending along the length of user interface surface 364, in other implementations (not shown), diffusing layer 365 can be coupled to LCD panel 366, which can then be coupled to user interface surface 364.

Interactive table chassis 362 supports user interface surface 364. Illumination system 810 is shown immediately adjacent to LCD display 366 and user interface surface 364. Support 390 is shown supporting camera 367 in a suitable position for detecting non-visible light (e.g., IR light) reflected from objects on or adjacent to user interface surface 364, such as "touch" object 376a and "hover" object 376b. Notably, and unlike the embodiment illustrated in FIGURE 3, rays 378a and 378b are shown in FIGURE 8 passing through illumination system 810. Non-visible light illuminants 315a and 315a are now shown coupled to support 390. It should again be understood that any number of illuminants like illuminants 315a and 315b can be employed within interactive display table 860 in order to fully illuminate user interface surface 364 with non-visible light. Furthermore, it should be noted that non-visible illuminants can be placed in any suitable location within interactive display chassis 362 such that user interface surface 364 is effectively illuminated with the non-visible light.

As illustrated in FIGURE 8, illumination system 810 includes several components. Diffusing layer 363 is coupled to light guide assembly 368, which includes visible light illuminant 369 for generating a homogeneous uniform illumination of LCD panel 366 (e.g., as indicated by ray 380). A reflective backplane 870 is also illustrated coupled to light guide assembly 368. Backplane 870 can be formed any material suitable for substantially reflecting visible light while also permitting non-visible illumination to pass through. In one implementation, backplane 870 is implemented as a "cold mirror." As discussed above, diffusing layer 363 can be one or more (or a combination of), light diffusing layers and collimating lenses, including Fresnel lenses. Visible light assembly 368 can again include a

light guiding layer formed of any suitable material, such as an acrylic sheet. In other implementations, visible light illuminant 369 can be a cold cathode fluorescent tube configured to edge light an acrylic sheet. It should be noted that in contrast to the embodiments of FIGURES 3-7, in the configuration of interactive table 860, illumination system 810 and LCD panel 366 are immediately adjacent to each other. Indeed, in some implementations, illumination system 810 and LCD panel 366 can be in direct contact, and in other implementations illumination system 810 and LCD panel 366 can be separated by up to several millimeters. As a result of disposing the illumination system immediately adjacent to the LCD panel, a user will again perceive a uniform illumination of LCD panel 366 from a wide variety of viewing angles, since the illumination provided by illumination system 310 will be continuous across LCD panel 366 due to the close proximity of the illumination source.

FIGURE 9 is a schematic cross-sectional illustration of an LCD panel-based interactive display table 960 that includes an exemplary embodiment of an illumination system that directly illuminates the LCD panel. The implementation illustrated in FIGURE 9 again shares many components and features with the embodiment illustrated in FIGURE 3, and therefore, the same reference numbers are used in both Figures for the same components. As illustrated in FIGURE 9, interactive display table 960 includes user interface surface 364, LCD panel 366, and diffusing layer 365. Although diffusing layer 365 is again shown extending along the length of user interface surface 364, in other implementations (not shown), diffusing layer 365 can be coupled to LCD panel 366, which can then be coupled to user interface surface 364.

Interactive table chassis 362 supports user interface surface 364. Support 390 is shown supporting camera 367, which is employed for detecting non-visible light (e.g., IR light) reflected from objects on or adjacent to user interface surface 364, such as "touch" object 376a and "hover" object 376b (e.g., as indicated by rays 378a and 378b). Non-visible light illuminants 315a and 315a are shown coupled to support 390. It should again be understood that any number of non-visible light illuminants of this type can be employed within interactive display table 960 in order to fully uniformly illuminate user interface surface 364 with non-visible light. Furthermore, it should be noted that non-visible illuminants can be placed in any suitable location within interactive display chassis 362, such that user interface surface 364 is effectively illuminated with the non-visible light.

Unlike the embodiments illustrated in FIGURES 3-8, interactive display 960 includes a direct illumination system in the form of visible light illuminants 971a and 971b. In the simplified exemplary embodiment illustrated in FIGURE 9, visible light illuminants 971a and 971b flood the underside of LCD panel 366 with visible light in such a manner that a substantially uniform illumination of the LCD panel is achieved. It should be understood, however, that visible light illuminants 971a and 971b are merely exemplary, and in other implementations, any suitable number of visible light illuminants can be employed to directly illuminate LCD panel 366. As a result of this direct illumination of LCD panel 366, a user will perceive a uniform illumination of LCD panel 366 from a wide variety of viewing angles, since

the illumination provided by the direct lighting will prevent the user from perceiving dark areas on LCD panel 366 due to parallax. This direct illumination is diffused by diffusing layer 365, which evens out the intensity of the direct illuminants and prevents a clear view of objects below the viewing plane of the LCD panel.

5 Although the present invention has been described in connection with the preferred form of practicing it and modifications thereto, those of ordinary skill in the art will understand that many other modifications can be made to the present invention within the scope of the claims that follow. Accordingly, it is not intended that the scope of the invention in any way be
10 limited by the above description, but instead be determined entirely by reference to the claims that follow.

The invention in which an exclusive right is claimed is defined by the following:

1. A method for illuminating an interactive display to display images, and for detecting objects that are in contact with or in close proximity to the interactive display, comprising the steps of:

(a) illuminating a first surface of the interactive display with visible light that is substantially uniform when a second surface of the interactive display is viewed by a user from a plurality of substantially different viewing angles, wherein the second surface is opposite the first surface;

(b) diffusing the visible light such that a coherent image of an object below a viewing plane of the interactive display is at least partially obscured from view by the user; and

(c) uniformly illuminating the first surface of the interactive display with non-visible light for use in detecting objects disposed in contact with or adjacent to the second surface of the interactive display and wherein the interactive display is configured to be substantially transparent to the non-visible light.

2. The method of claim 1, wherein the step of illuminating a first surface of the interactive display with visible light comprises directly illuminating of the first surface of the interactive display with an illumination source.

3. The method of claim 1, wherein the step of illuminating a first surface of the interactive display with visible light comprises indirectly illuminating of the first surface of the interactive display with an illumination source coupled to a light guide.

4. The method of claim 1 wherein the step of uniformly illuminating the first surface of the interactive display with non-visible light further comprises detecting non-visible light that has passed from the first surface to the second surface of the interactive display, been reflected from the objects disposed in contact with or adjacent to the second surface and then passed back through the interactive display to the first surface.

5. An interactive display, comprising:

(a) an interactive display housing;

(b) a flat panel display (FPD) configured to display images;

(c) a light diffusing layer;

(d) an illumination system configured to substantially uniformly illuminate the FPD with visible light;

(e) a non-visible light illumination system for illuminating objects adjacent to the FPD with non-visible light that has passed through the FPD; and

(f) a sensor for detecting non-visible light reflected from the objects that are adjacent to the FPD.

6. The interactive display of claim 5, wherein the illumination system comprises at least one visible light illuminant configured to directly illuminate the FPD.

7. The interactive display system of claim 5, wherein the illumination system comprises a main portion within the interactive display housing, including:

- (a) a light guiding assembly that includes at least one visible light illuminant;
- (b) at least one light diffuser; and
- (c) a backplane reflective of visible light.

8. The interactive display system of claim 7, wherein the light diffuser is a Fresnel lens configured to condition visible light emitted from the light guide in order to provide uniform illumination to the FPD.

9. The interactive display system of claim 7, wherein the light guiding assembly comprises:

- (a) an acrylic sheet; and
- (b) at least one of a fluorescent tube and an LED positioned along an edge of the acrylic sheet such that light emitted from the fluorescent tube is caused to be guided by the acrylic sheet.

10. The interactive display of claim 7, wherein the illumination system is disposed immediately adjacent to the FPD.

11. The interactive display system of claim 7, wherein the illumination system is substantially spaced apart from the FPD.

12. The interactive display system of claim 11, wherein a main portion surface area is substantially greater than an FPD surface area such that illumination of the FPD is substantially uniform when viewed from a plurality of viewing angles by a user.

13. The interactive display system of claim 11, wherein the illumination system further comprises side portions being reflective of visible light and being disposed perpendicular to the main portion and extending from the main portion to the user interface surface thereby forming a closed illumination system with the FPD and the user interface surface such that illumination of the FPD is substantially uniform when viewed from a plurality of viewing angles by a user.

14. The interactive display system of claim 11, wherein the main portion of the illumination system is substantially curvilinear such that a continuous surface is formed extending to the user interface surface from a center point of the main portion thereby forming a closed illumination system with the FPD and user interface surface such that illumination of the FPD is substantially uniform when viewed from a plurality of viewing angles by a user.

15. The interactive display system of claim 10, wherein the illumination system further comprises illuminated side portions disposed substantially perpendicular to the main portion and extending to the user interface surface from the main portion to form a closed illumination system with the FPD such that illumination of the FPD is substantially uniform when viewed from a plurality of viewing angles by a user, wherein the illuminated side portions each comprise an illuminated light guide, at least one light diffuser and a reflective backplane.

16. The interactive display system of claim 5, wherein non-visible light illumination system comprises a plurality of infrared illuminants disposed within the interactive display housing for illuminating the interactive display surface with infrared illumination and wherein the sensor for detecting non-visible light comprises a digital camera sensitive to infrared illumination.

17. An interactive display system, comprising:

- (a) an interactive display housing including an interactive display chassis and a user interface surface coupled to the chassis;
- (b) a liquid crystal display (LCD) panel coupled to the user interface surface of the interactive display housing;
- (c) a light diffusing layer coupled to the LCD panel;
- (d) an illumination system disposed within the interactive display housing and configured for substantially uniformly illuminating the LCD panel with visible light; and
- (e) a user input detection system for sensing objects disposed adjacent to the user interface surface in response to non-visible light that has passed through the LCD panel, been reflected from the objects, passed back through the LCD panel, and been detected within the interactive display housing.

18. The interactive display of claim 17, wherein the illumination system comprises at least one illuminant configured to directly illuminate the bottom LCD surface of the LCD panel from within the interactive display housing.

19. The interactive display of claim 17, wherein at least a portion of the illumination system is spaced apart from the LCD panel and comprises:

- (a) a light guide having an illuminant configured to illuminate at least one edge of the light guide with visible light;
- (b) at least one Fresnel lens;
- (c) at least one light diffuser; and
- (d) a backplane substantially reflective of visible light.

20. The interactive display of claim 17, wherein the illumination system is substantially adjacent and coupled to the LCD panel and comprises:

- (a) a light guide having an illuminant configured to illuminate at least one edge of the light guide with visible light;
- (b) at least one Fresnel lens;
- (c) at least one light diffuser; and
- (d) a cold mirror.

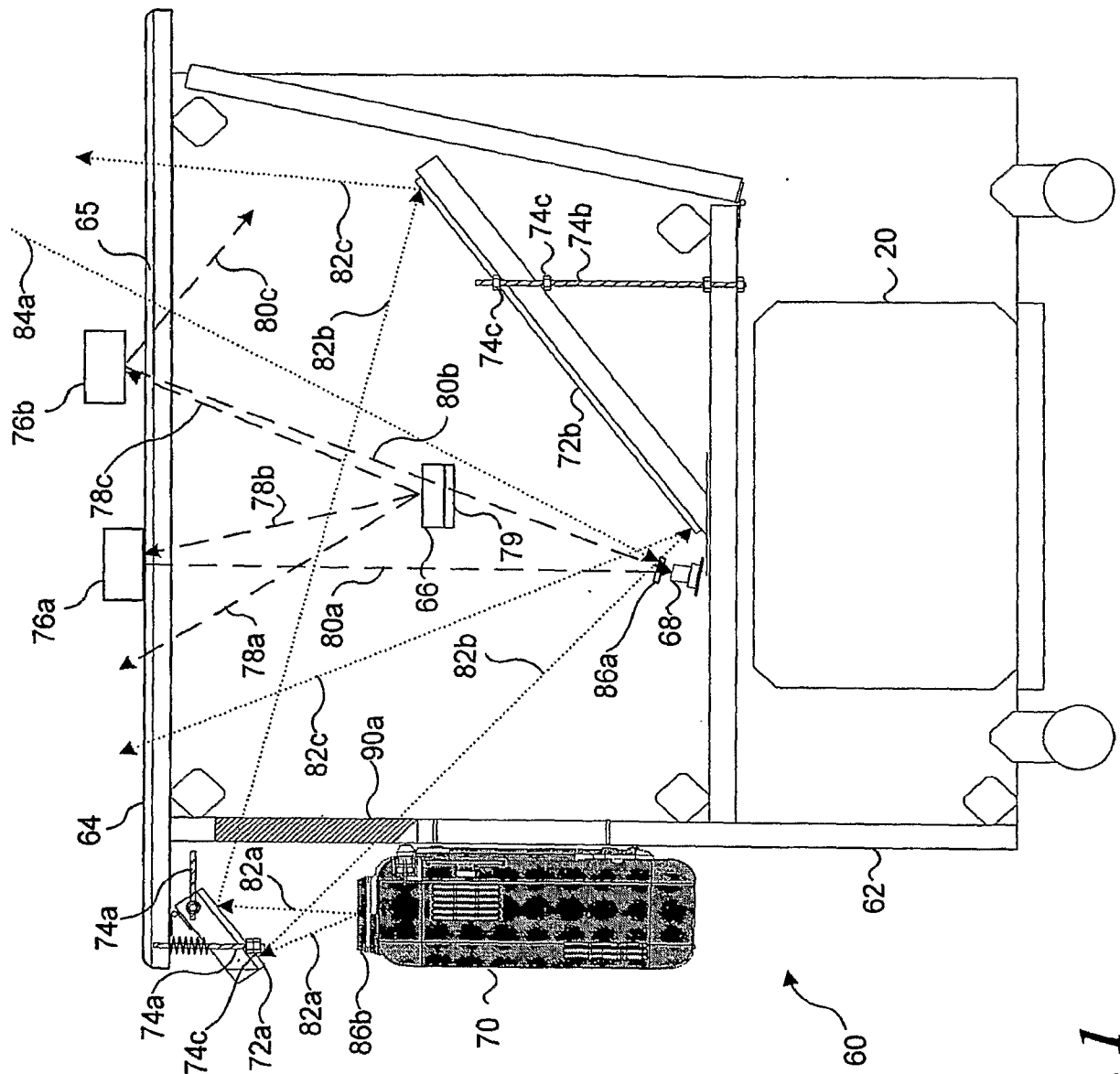


FIG. 1

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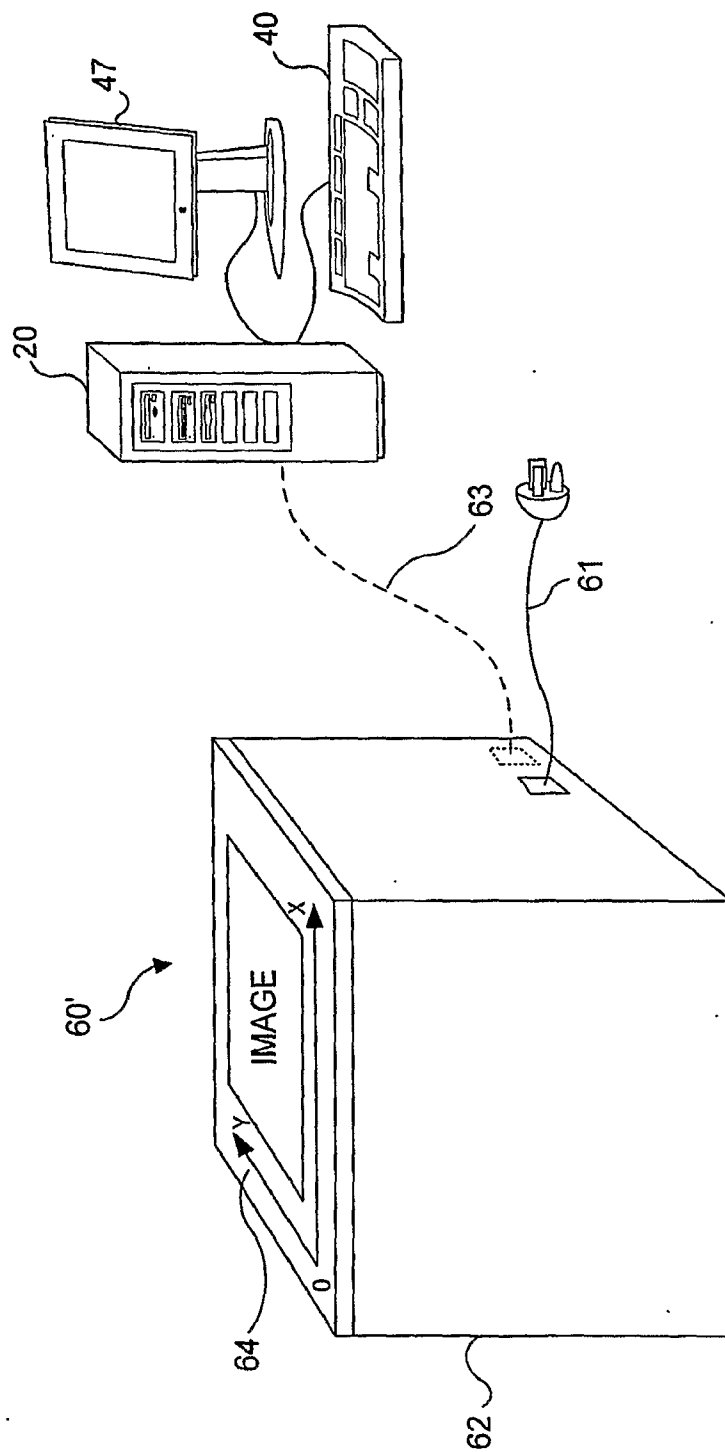
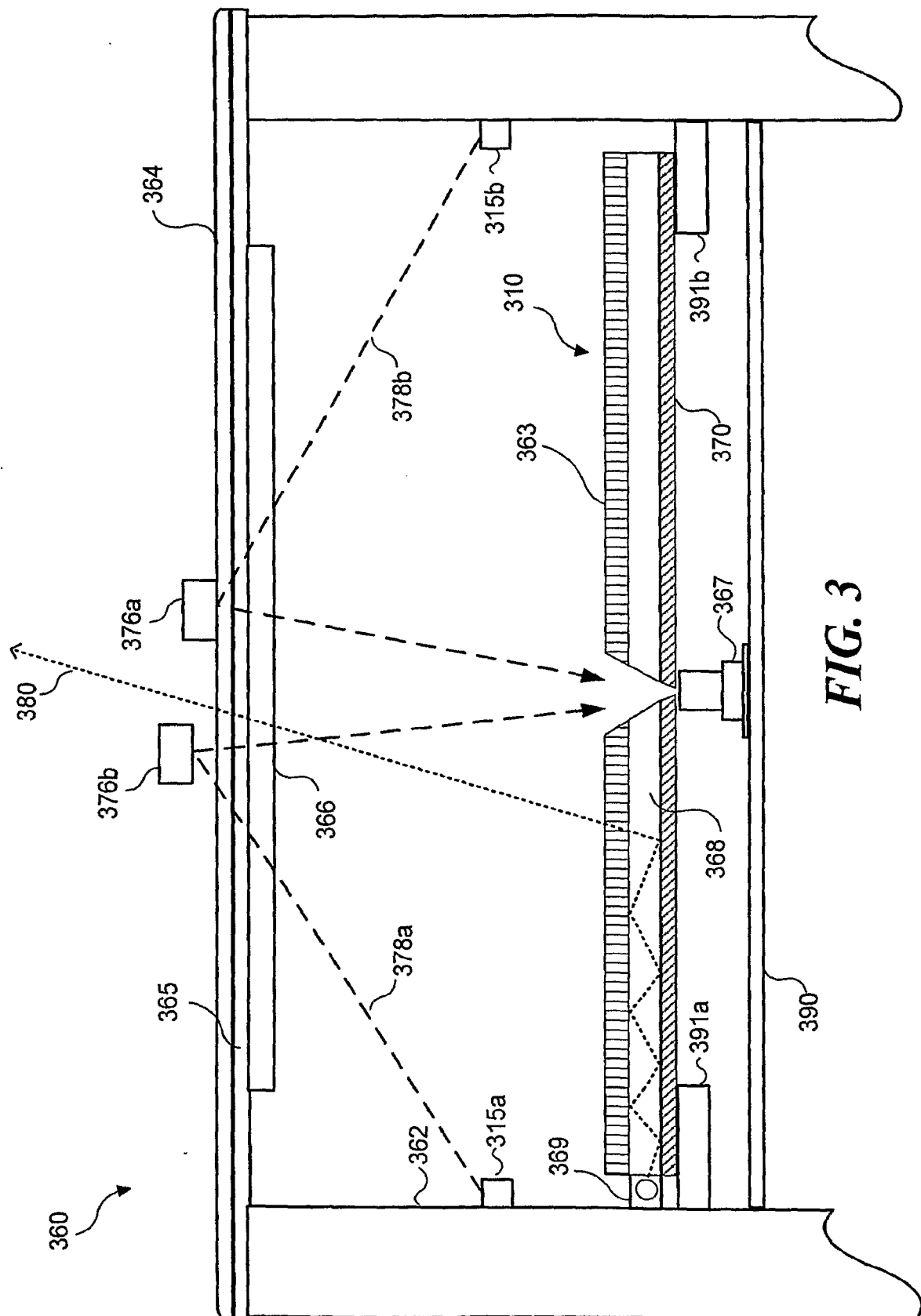
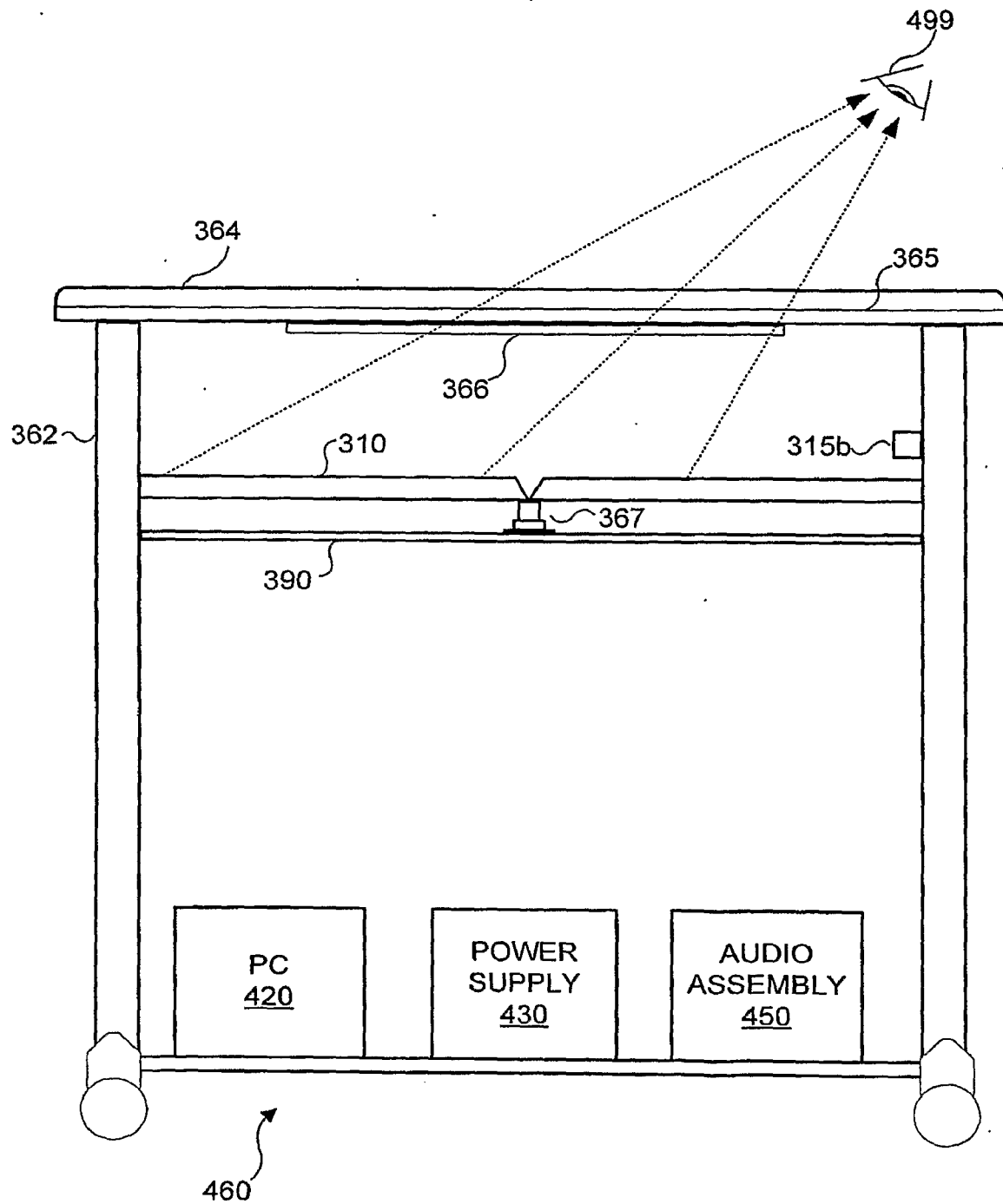


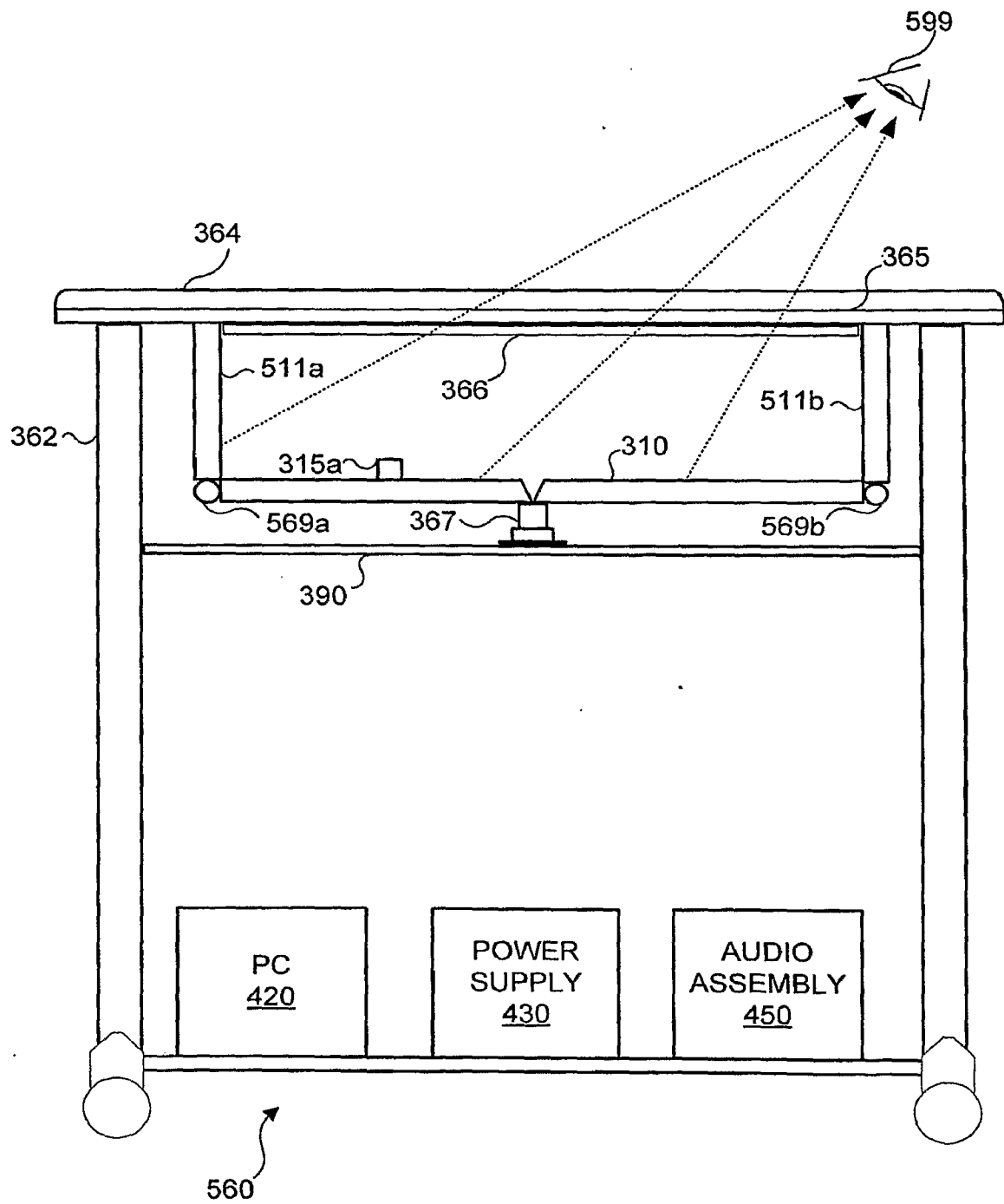
FIG. 2



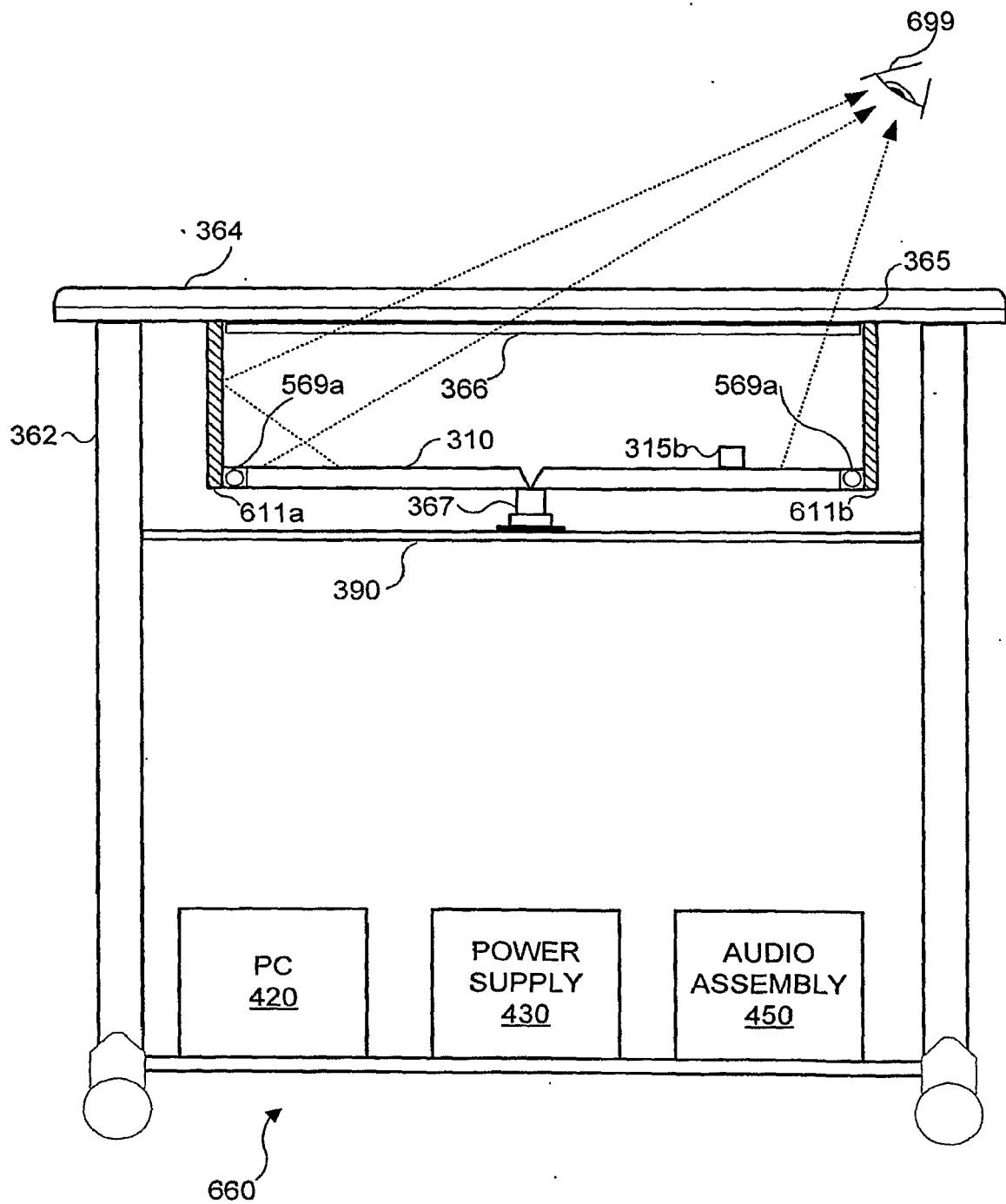
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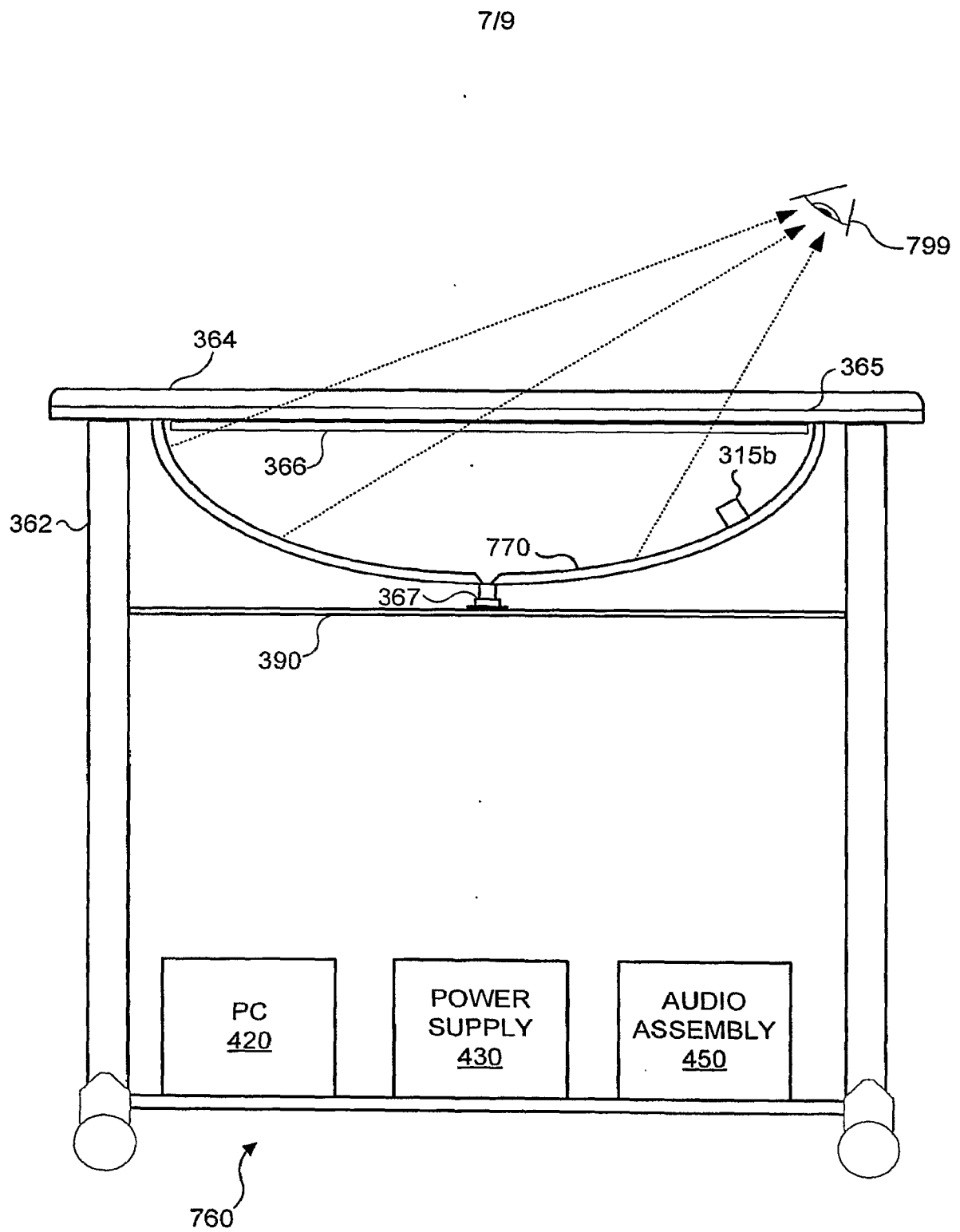
**FIG. 4**

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**FIG. 5**

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**FIG. 6**

**FIG. 7**

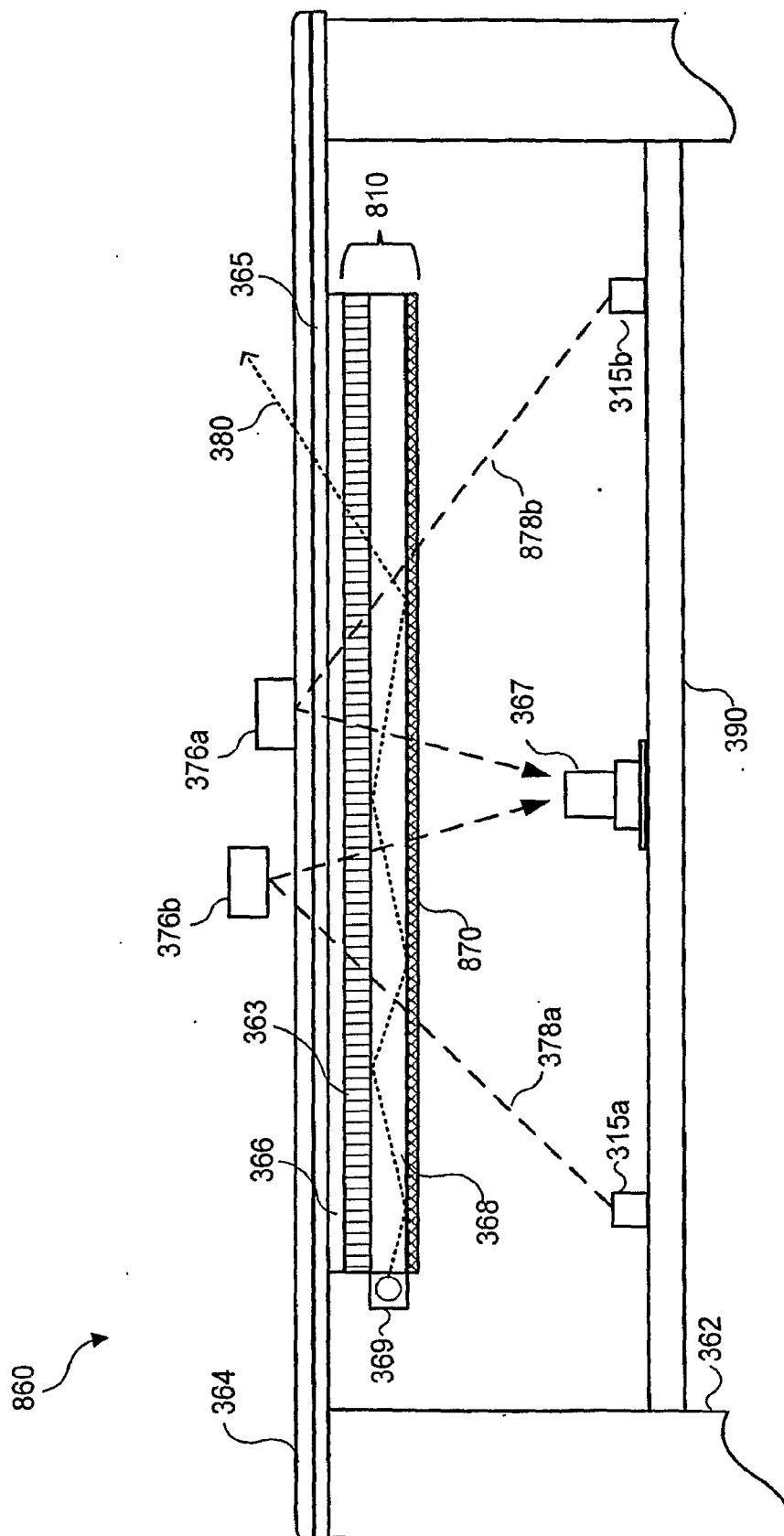


FIG. 8

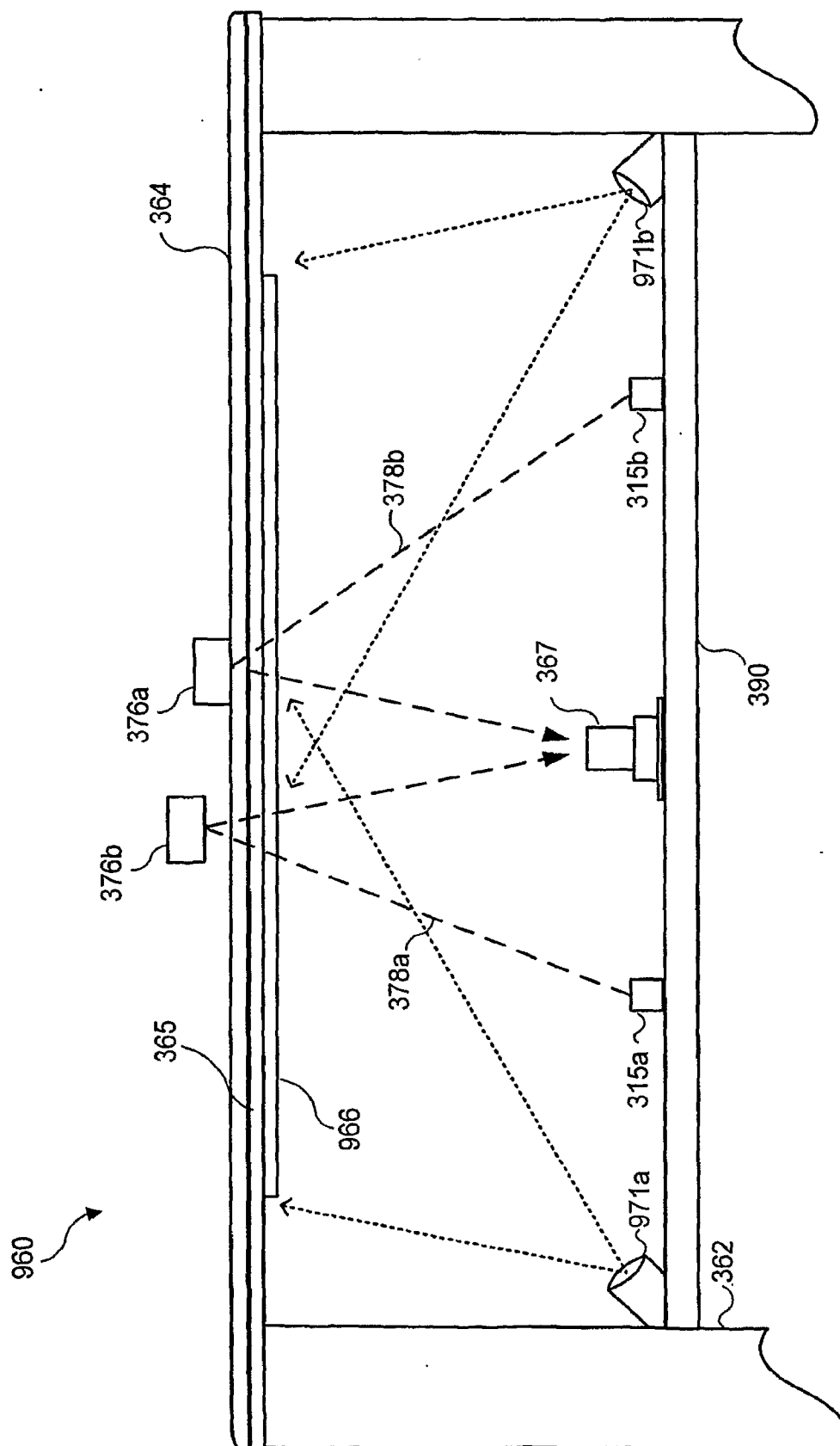


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2007/004703**A. CLASSIFICATION OF SUBJECT MATTER****G06F 3/147(2006.01)i, G06F 3/14(2006.01)i**

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)

IPC 8: G06F, G09G

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

Korean Utility models applications for Utility Models since 1975, IPC as above

Japanese Utility Models and application for Utility Models since 1975, IPC as above

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

eKIPASS, IEEEExpl, Google;interactive;video;screen;diffussing; LCD;

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US2005/0122308 A1(BELL, MATTHEW, et.al) 9 June 2005 See all documents, especially Paragraphs[0095]-[0199] and Claims 1-82.	1-20
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A	US5,528,263 A (PLATZKER D.M, et.al) 18 JUNE 1996 See Abstract, and Figures 1, 6A&6B.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

03 AUGUST 2007 (03.08.2007)

Date of mailing of the international search report

03 AUGUST 2007 (03.08.2007)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
920 Dunsan-dong, Seo-gu, Daejeon 302-701,
Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

SEONG, KYOUNG A

Telephone No. 82-42-481-8171



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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