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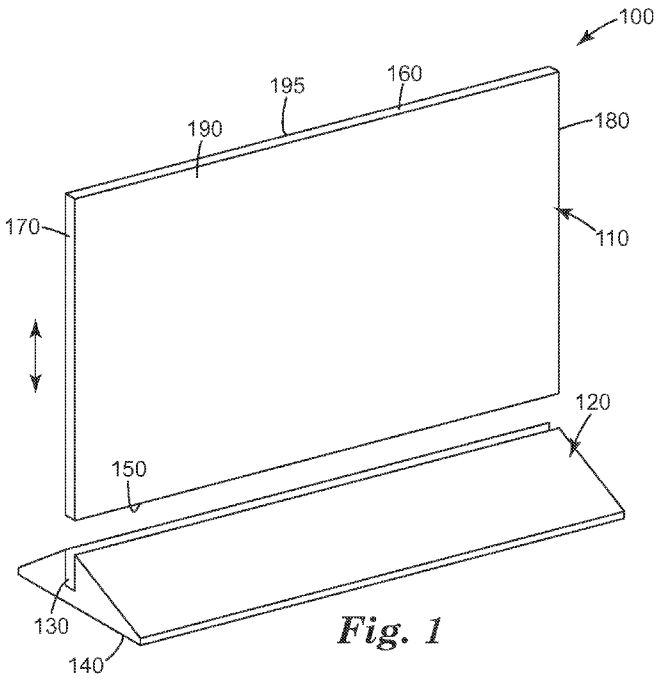

Fig. 1

(57) Abstract: Modular displays and methods of assembling modular displays are disclosed. The displays include a display element and a base element. The base element includes a light source configured to inject light into the display element, and electronics to drive the display element when the display element is attached to the base element. The display element includes a lightguide and a display panel, such as a liquid crystal display (LCD) panel. The base element further includes a receptacle configured to accept the display element and couple the light source to the lightguide, and couple the electronics to the LCD panel. The display element and the base element can be removably attached to each other. The base element and the display element can each be configured so that different display elements can be attached to the same base element, providing flexibility of modular display design.

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MODULAR DISPLAY

Background

Consumer preference continually drives the display industry toward thinner displays, and as ultra-thin organic light emitting diode (OLED) displays increase in size, the liquid crystal display (LCD) industry is under pressure to produce ever thinner displays. However, both direct-lit and edge-lit LCD displays have barriers which limit the minimum thickness. Direct-lit systems require adequate light mixing in the thickness direction to achieve uniform brightness, or RGB color mixing as in light emitting diode (LED) direct-lit systems. Further, mechanical, structural and electronic components are positioned behind the backlight in a direct-lit system, accounting for a large portion of the overall display thickness. These components include display drivers, tuners, thermal management devices, and other electronics that are positioned on the back side of the display. Edgelit backlights typically position lighting components on one or two edges of the display. Edgelit displays also typically position the electronics behind the backlight, adding to thickness. A typical edgelit monitor having a light source on two opposing edges also includes bezels which add significant area around the display.

The process for assembly of these displays can be inefficient due to lack of modularity and flexibility. Non-optical components such as power supplies, video board, LCD panel driver, heat sinks, inverters, and other electronics are positioned across the rear of the backlight. The non-optical components can add 300% or more to the thickness of the display. Further, manufacturing processes for a conventional display is non-modular, that is, components for a particular display configuration are assembled and sold as a completed unit. Customizations of displays often involve creating additional stocked complete units, rather than individual stocked parts, thereby adding to inventory costs.

Summary

In one aspect of the disclosure, a display that includes a display element and a base element is described. The display element includes a lightguide that has an output surface and an input edge, and a liquid crystal display (LCD) that faces the output surface of the lightguide. The base element includes a receptacle configured to attach the display element to the base element along the input edge of the lightguide, a light source configured to inject light into the input edge of the lightguide, and electronic components. The base element also includes an electrical connector provided between the electronic components and the LCD panel. In one embodiment, the receptacle is configured to removably attach the display element to the base element.

In a further aspect of the disclosure, a display that includes a first and a second display element, and a base element is described. Each of the first and the second display elements includes a light guide having an output surface, an input edge, and an output edge opposite the input edge, and an LCD panel facing the output surface of the lightguide. The base element includes a receptacle configured to attach each display element to the base element along the input edge of each lightguide, a light source configured to inject light into the input edge of each lightguide, and electronic components. The base element also includes an electrical connector provided between the electronic components and each LCD panel. In one embodiment, the receptacle is configured to removably attach each display element to the base element.

In a further aspect of the disclosure, a method of assembling a display is described. The method of assembling the display includes selecting a display element, selecting a base element, and attaching the display element to the base element. The display element includes a light guide having an output surface and an input edge, and an LCD panel facing the output surface. The base element includes a receptacle configured to attach the display element to the base element along the input edge of the lightguide, a light source configured to inject light into the input edge of the lightguide, and electronic components. The base element also includes an electrical connector provided between the electronic components and the LCD panel. In one embodiment, the receptacle is configured to removably attach the display element to the base element.

These and other aspects of the present application will be apparent from the detailed description below. In no event, however, should the above summaries be construed as limitations of the claimed subject matter, which subject matter is defined solely by the attached claims, as may be amended during prosecution.

Brief Description of the Drawings

Throughout the specification reference is made to the appended drawings, where like reference numerals designate like elements, and wherein:

FIG. 1 is a perspective schematic of a modular display;

FIG. 2 is a cross-section schematic of a modular display;

FIG. 3 is a cross-section schematic of a modular display; and

FIGS. 4a-4c are cross-section schematics of an attachment technique.

The figures are not necessarily to scale. Like numbers used in the figures refer to like components. However, it will be understood that the use of a number to refer to a component in a given figure is not intended to limit the component in another figure labeled with the same number.

Detailed Description

The present disclosure provides for a modular display which is thin, highly modular, enables increased process and assembly efficiencies, and which provides sleek, near zero bezel displays. Generally, the display is an LC display which includes two separate modules. The first module (the "display element") includes a lightguide such as a solid lightguide or a hollow optical cavity lightguide, and at least one display panel, such as an LCD panel. The second module (the "base element") includes a base containing at least one light source; an optical, mechanical and electronic coupling mechanism (the "receptacle"); and electronics.

The display element and base element are configured to connect together, so that the light source is coupled to inject light into the lightguide of the display element, and the electronics are coupled to drive the display panel. The display element and base element can be removably attached together, or they can be permanently attached together. The display element can further include features such as a camera, light sensors, motion sensors such as used for gaming devices, memory elements, batteries, or ultra-flat speakers such as NXT flat speakers, but generally these would be located in the base element to minimize the thickness of the display element.

The disclosed modular display has several advantages over conventional displays. The modular display enables a dramatically thinner display by locating the light sources, most of the display electronics, power supplies, and thermal management in the base element. The modular display also enables a new display selection and assembly process that is well suited to a fast and flexible display manufacturing platform. Further, the modular display design enables display features that can be readily upgraded by consumer replacement of the base element, base sub-components, or the display element. Further yet, the modular display design enables the interchange of display elements with different base elements.

Several configurations of the modular display are possible, including wall mount, table top, ceiling mount, and side mount. The architecture of the modular display generally lowers the center of gravity toward the base element, compared to a conventional display where heavier components are also mounted on the back of the backlight. In this way, for example in a table top display, the modular display increases stability and reduces the likelihood of the display tipping over.

In one aspect, the LCD panel in the display element can be chosen based on factors such as resolution, switching speed and panel transmission. Lower and higher resolution LCD panels such as 720p and 1080p can be used. Different LCD panel types can be used including in-plane switching (IPS), Vertically Aligned (VA) and Twisted Nematic (TN). Additional protective sheets can be included facing the output surface of the LCD to provide glare resistance, scratch resistance, smudge resistance, matte appearance, and the like, to the panel.

In one aspect, the lightguide in the display element can be a solid lightguide or a hollow optical cavity lightguide. The lightguide can be of any desired size or shape, and can be of uniform thickness such as a slab, tapered such as a wedge, or have a combination of slab and tapers, such as in a stepped lightguide design. In one particular embodiment, a solid lightguide or a hollow optical cavity lightguide can include a laminated polarizer element such as described in, for example, U.S. Patent Application Serial No. 61/298830 entitled "Immersed Asymmetric Reflector with Reduced Color" (Attorney Docket No. 66125US002, filed on January 27, 2010), and also as described in U.S. Patent Application Serial No. 61/254672 entitled "Light source and Display System Incorporating Same" (Attorney Docket No. 65782US002, filed on October 24, 2009).

Light extraction features can be provided on a front surface or elsewhere on or in the lightguide, to direct light out of the lightguide towards the LCD. The extraction features can be a film selected to transmit a portion of incident light, such as an Asymmetric Reflector Film (ARF) used with a hollow optical cavity lightguide, as described elsewhere. The extraction features can instead be grooves, lenslets, or other microstructured features designed to extract light from the lightguide, for example a solid lightguide. The extraction features can be imparted to the solid lightguide using several methods, including but not limited to casting, embossing, microreplicating, printing, ablating, etching and other techniques known in the art. Examples of structured extraction features can be found, for example, in U.S. Patent Nos. 6,845,212 (Gardiner et al.) and 7,223,005 (Lamb et al.); and also in U.S. Patent Application Serial Number 11/421,241.

A light management film stack can also be provided on the front surface of the lightguide, between the lightguide and the LCD. Protective films can also be provided on the front (output) surface of the LCD. The films could be a structured (or microstructured) surface film such as Brightness Enhancement Film (BEF) to provide brightness enhancement, or other films including reflective polarizers including interference type such as multilayer optical films, blend polarizers, wire grid polarizers; other structured surfaces including turning films, retroreflective cube corner films; diffusers such as surface diffusers, gain diffuser structured surfaces, or structured bulk diffusers; antireflection layers, hard coat layers, stain resistant hard coat layers, louvered films, absorptive polarizers, partial reflectors, asymmetric reflectors, wavelength selective filters, films having localized optical or physical light transmission regions including perforated mirrors; compensation films, birefringent or isotropic monolayers or blends, as well as bead coatings, Fresnel films, lenslet films and dual-sided microstructured films. Various light management films are known, and include prism films such as Vikuiti™ Brightness Enhancement Film "BEF" or Thin Brightness

Enhancement Film "TBEF", and reflective polarizer film such as Vikuiti™ Dual Brightness Enhancement Film "DBEF", available from 3M Company. Furthermore, a list of

additional coatings or layers is discussed in further detail in U.S. Patent Nos. 6,459,514 (Jonza) and 6,827,886 (Neavin et al.).

In some cases, ultra-low index ("ULI") films with good mechanical integrity and low haze can be laminated to a portion of the light management film stack. Such ULI films can be coated onto almost any optical film, so as to approximate an air gap, and then any conventional optical adhesive can be applied to join the coated film with another component in the system. Suitable ultra low index materials are described in, for example, the following PCT Published Applications: "Optical Film" WO2010/120864; "Optical Construction and Display System Incorporating Same" WO2010/120971; "Retroreflecting Optical Construction" WO2010/121019; "Optical Film for Preventing Optical Coupling" WO2010/120871; "Backlight and Display System Incorporating Same" WO2010/120845; "Process and Apparatus for Coating with Reduced Defects" WO2010/120422; "Process and Apparatus for A Nanovoided Article" WO2010/120468; and US2010/051760 entitled "Optical Construction and Method of Making the Same". Ultra-low index materials can also be made using a gel type of fumed silica. The ultra-low index material may have a refractive index over visible wavelengths in a range from 1.1-1.3, or from 1.15 to 1.25, for example. In many cases, the ULI material may be porous, and in some cases techniques can be used to seal the outer surface of a layer of ULI material so that liquid material from an adjacent layer, for example, an adhesive layer, does not completely migrate into the pores of the ULI layer. Such techniques are disclosed in one or more of the cited applications.

In one embodiment, the lightguide is a hollow optical cavity lightguide. Hollow optical cavity lightguides can be highly efficient, lightweight alternatives to solid lightguides. A hollow optical cavity lightguide can include highly reflective back- and side-walls, and a partially transmissive front (output) surface. In one embodiment, the highly reflective back-and side-walls can include a multilayer optical film such as Vikuiti ESR™ (Enhanced Specular Reflective) film available from 3M Company.

The hollow optical cavity lightguide can include any suitable partially transmissive front reflector including, for example, asymmetric reflective film (ARF); multilayer reflectors including, for example, perforated mirrors such as a perforated ESR film; metal reflectors including, for example, thin film enhanced metal films; diffusive reflectors including, for example, asymmetric DRPF (diffuse reflective polarizer film available from 3M Company); and combinations of films. Exemplary hollow optical cavity lightguides and films incorporated in lightguides are described, for example, in PCT Application No. US2008/064133 (Attorney Docket No. 63274WO004), entitled "Backlight and Display System Using Same"; PCT Application No. US2008/064096 (Attorney Docket No. 63031WO003), entitled "Thin Hollow Backlights with Beneficial Design

Characteristics"; and PCT Application No. US2008/064115 (Attorney Docket No. 63032WO003), entitled "Recycling Backlights with Semispecular Components."

The base includes the light source, drive electronics, power supply, and other components such as for thermal management. The base can have a number of features customized for a particular display configuration, such as type of light sources, types of collimating optics, video drivers, tuners, electro-optical sensors, audio components, and component connectors. In one aspect, the various components within the base element can be replaced or upgraded so that the same display element can be used with different base elements or base element configurations. For example, a low color gamut base element or component could be replaced with a high color gamut base element or component while still using the same display element. The ability to replace base elements or components is convenient, and further, the cost to the consumer for an upgrade can be lower than purchasing and installing a completely new system. Made-to-order displays could be efficiently assembled on the factory floor, or even in the consumer store, based on this new modular architecture.

The display element and base element can communicate information through the electrical connections that are made when they are connected together. In some cases, the electrical connection can include a wireless connection. The electrical connection can also include a technique for radio frequency identification (RFID) of components. Two-way communication can enable the display element to identify itself to the base element, including the type of display, number of LCD panels, resolution of LCD panels, dynamic range of brightness, and switching speed or other information such as from optical light sensors or sensor arrays. The base can then provide appropriate power, video drive signals, and appropriate color mixture for attaining the correct white point through that specific panel.

The base element can include any suitable light source including, for example, a surface emitting LED, such as a blue- or UV emitting- LED with a down-converting phosphor to emit white light hemispherically from the surface; individual colored LEDs, such as arrangements of red/green/blue (RGB) LEDs or combinations of RGB LEDs with additional color LEDs such as yellow and cyan; and others such as described in PCT Patent Application US2008/064133 entitled "Backlight and Display System Using Same." Other visible light emitters such as a photonic lattice, II-VI semiconductors, lasers, laser diodes, plasma light sources such as LUXIM sources (available from LUXIM Corporation, Sunnyvale, CA), linear cold cathode fluorescent lamps (CCFLs) or hot cathode fluorescent lamps (HCFLs) can be used instead of or in addition to discrete LED sources as light sources for the disclosed base elements. In addition, hybrid systems such as, for example, (CCFL/LED), including cool white and warm white, CCFL/HCFL, such as those that emit different spectra, may be used. The combinations of light emitters may vary

widely, and include LEDs and CCFLs, and pluralities such as, for example, multiple CCFLs, multiple CCFLs of different colors, and LEDs and CCFLs.

A more uniform lightguide can result by using a partially collimated light source in order to produce a highly directional source that promotes the lateral transport of light. Suitable light injectors for edge-injection light are described, for example, in PCT Patent Application No. US2008/064125 (Attorney Docket No. 63034WO004) entitled "Collimating Light Injectors for Edge-Lit Backlights." The light rays are preferably injected into the lightguide with a predominantly parallel direction, for example, having a relatively small deviation angle relative to a plane that is transverse to the viewing axis of the display. Some finite distribution of ray angles cannot be avoided, and this distribution can be optimized by the shape of the collimating optics in conjunction with the emission pattern of the light source to maintain the uniformity of the light across the output area of the lightguide. The collimating optics can include reflectors, refractors, solid total internal reflection (TIR) reflectors, or a combination. In hollow optical cavity lightguides, the partially reflecting front reflector and the partial diffusion of a semi-specular reflector produces a light recycling and randomizing light cavity that works in harmony with the injection optics to create a uniform, thin, and efficient hollow optical cavity lightguide.

In one aspect, the base element can further include a TV tuner and video processing electronics controlling, for example, display dimming, LCD switching speed, resolution drive schemes including both pixel and sub-pixel levels, and grey scale controls for 8 or 10 bit systems. The TV tuner and video processor can drive various resolution panels such as 720p and 1080p. In one embodiment, the base element can electronically recognize the display element, such as the panel resolution in the display element, and provide appropriate drive scheme. The technique of recognition can also include radio frequency identification (RFID), optical bar codes, and the like. Drivers for various panel types such as IPS, VA, and TN, can be included in the base element.

In one embodiment, an electronics interface for a touch screen panel or a remote control can be incorporated into the base element. Various types of connectivity can also be included in the base, such as a high definition multimedia interface (HDMI), digital video input (DVI), component input, USB, cable card for cable TV, digital camera SD card, audio connectors, and others typically associated with displays. In one embodiment, the base element can contain sensors, such as optoelectronic sensors to monitor display color and/or brightness, the level of room ambient light, or to receive remote signals such as from a remote control device. In some embodiments, a camera can be incorporated in the base element. Various types of speakers of low to high quality can be included in the base, such as NXT ultra flat speaker technology.

Appropriate power supplies and thermal management devices including heat sinks, fans, heat pipes, and the like can be included in the base element. Additionally, the base element can

contain components such as CD, DVD player, mp3, satellite radio and digital video recorder. A base element used for a multimedia monitor or a computer can include wireless connectivity, computer hard drive, CD/DVD burner, and a memory device.

The receptacle can be designed to provide high light injection efficiency from the base element to the lightguide within the display element. In one embodiment, the receptacle may have an interlock switch which prevents the base element from illuminating and sending power to the display element until the two modules are fully engaged and locked in place. In another embodiment, the two elements can be disconnected for removal or replacement. In yet another embodiment, a subcomponent can be removed from the base element, such as removing a bank of white LEDs and replacing them with a bank of RGB LEDs. In yet another embodiment, a display element attached to a first base element having an LED light source can be removed from the first base element and attached to a second base element having a CCFL light source, and vice-versa.

FIG. 1 shows a perspective schematic of a modular display 100 according to one aspect of the disclosure. Modular display 100 includes a base element 120 which houses a light source and one or more electronic components (not shown), as described elsewhere. Modular display 100 also includes a display element 110 having a display output surface 190, a back surface 195, a lightguide input edge 150, a top edge 160 opposite the lightguide input edge 150, a first side edge 170 and a second side edge 180 opposite the first side edge 170.

The base element 120 includes a receptacle 130 that is configured to attach the display element 110 to the base element 120 along the lightguide input edge 150 of the display element 110. The receptacle 130 and display element 110 both include an electrical connection (not shown) that is configured to connect the electronics within the base element 120 to the display element 110. The receptacle 130 also includes an optical connector (not shown) so that light from the light source (not shown) within the base element 120 can inject light into the lightguide input edge 150, as described elsewhere. Optional optical sensors both internal to the lightguide and external to the modular display can be positioned to monitor light from both the light source and ambient light. Electronics within the base module can be used to control the light output based on ambient viewing conditions.

The base element further includes a bottom 140 that can be disposed adjacent to, or affixed to, a floor, a table, a wall, a ceiling, or other surface (not shown), so that the modular display 100 can be used in any desired orientation. In one embodiment, the receptacle 130 can be a pivotable section of the base element 120, so that the display element 110 can be rotated.

In one aspect of the disclosure, the base element 120 can be configured to accept more than one display element, so that either multiple displays of different information or one larger display can be viewed from one modular display. In one embodiment, a first display element can

be attached to the base module alongside a second display element, so that one of the side edges of the first display element is adjacent one of the side edges of the second display element, making a wider modular display. In another embodiment, a first display element can be attached to the base module and a second display element can be attached to the top edge of the first display element, making a modular display having increased height. Any combination of base modules and display modules can be assembled, to result in a display having a desired height and width.

FIG. 2 shows a cross-section schematic of a modular display 200, according to one aspect of the disclosure. Modular display 200 includes a base element 220 and a display element 210, shown in FIG. 2 as separate elements prior to being attached to each other. Base element 220 includes a receptacle 230 into which display element 210 is attached, a bottom 240, a light source 250, and a base electrical connector 255. Base element 220 further includes electronics (not shown) in communication with base electrical connector 255, as described elsewhere.

Light source 250 can be any of the light sources described previously, and can also include collimating optics useful for injecting light into display element 210. In one particular embodiment, light source 250 can be located at a position that is remote to modular display 200, and can include light delivery elements (not shown) such as a fiber optic, a light pipe, and the like, for delivery of the light to the base element 220.

Display element 210 includes a housing 260 at least partially surrounding a lightguide 270, a display panel 280 and an output surface 284. Housing 260 includes a lightguide input edge 262, a top edge 264 opposite lightguide input edge 262, a back surface 295, side edges (not shown), and a display electrical connector 265. Lightguide 270 can include at least two different zones such as an emissive zone 269 where light can be at least partially directed through display panel 280, and a transport zone 267 where light from light source 250 can be spread to improve uniformity and reduce artifacts such as dark spots that can arise from, for example, a separation between multiple distributed light source(s) 250. In one particular embodiment, the emissive zone 269 extends from an emissive zone boundary 263 to the top edge 264, and the transport zone 267 extends from the lightguide input edge 262 to the emissive zone boundary 263. In some cases, other optical films including, for example, a specular ESR film or semispecular ESR film, can be disposed within the transport zone 267 to further improve the uniformity of light entering the emissive zone 269 of lightguide 270.

In one embodiment, top edge 264 can be configured as a second receptacle, so that a second display element can be attached, increasing the height of the modular display (not shown, described elsewhere). Display electrical connector 265 is configured so that it is in communication with display panel 280 and an optional light sensor 266. When base element 220 is

attached to display element 210 through receptacle 230, display electrical connector 265 contacts base electrical connector 255, and provides the connection needed to operate modular display 200.

Housing 260 can be fabricated from any suitable material commonly used for display manufacture, including sheet metals, thermoplastics, composites, and the like. Housing 260 provides a support and connection structure for lightguide 270, display panel 280 and additional components as described elsewhere. In one embodiment, collimating optics for light source 250 can be included in display element 210, such as the wedge shaped portion adjacent lightguide input edge 262 shown in FIG. 2, or other collimating optics as described elsewhere.

In one embodiment, lightguide 270 can be a solid lightguide as described previously. In this embodiment, there may be an airgap surrounding lightguide 270, to promote total internal reflection (TIR). A light management film stack 272 can be placed adjacent an output surface 271 of lightguide 270 to condition light entering display panel 280, as described elsewhere. A protective film stack 282 can also be place adjacent display panel 280, to further condition the image produced by modular display 200, and protect the output surface 284 from damage. Interior surfaces 268 of housing 260 can be a highly reflective surface such as ESR, for efficient utilization of light injected into lightguide 270 through light input edge 262.

In another embodiment, lightguide 270 can be a hollow optical cavity lightguide as described previously. In this embodiment, interior surface 268 of housing 260 can be a highly reflective film such as ESR, lightguide 270 is filled with air, and light management stack 272 includes a partially transmissive reflector such as ARF, described elsewhere. Light management stack 272 can be affixed directly to the display panel 280, if desired.

FIG. 3 shows a cross-section schematic of a modular display 300, according to another aspect of the disclosure. Two-sided modular display 300 includes a base element 320 and a display element 310, shown in FIG. 3 as separate elements prior to being attached to each other. Base element 320 includes a receptacle 330 into which display element 310 can be attached, a bottom 340, a light source 350, and a first and a second base electrical connector 355, 357. Base element 320 further includes electronics (not shown) in communication with each base electrical connector 355, 357, as described elsewhere. First and second base electrical connectors 355, 357 can be disposed adjacent each other (not shown), or on different locations within receptacle 330. Light source 350 can be any of the light sources described previously, and can also include collimating optics useful for injecting light into display element 310.

Display element 310 includes a housing 360 at least partially surrounding a lightguide 370, a first display panel 380 having a first output surface 384, and a second display panel 390 having a second output surface 395. Housing 360 includes a lightguide input edge 362, a top edge 364 opposite lightguide input edge 362, side edges (not shown), and a first and a second display

electrical connector 365, 367. In one embodiment, lightguide 370 further includes a reflector (not shown) that partitions lightguide 370 so that each of the first and second display panels 380, 390 are independently illuminated by a different side of the lightguide.

Lightguide 370 can include at least two different zones such as an emissive zone 369 where light can be at least partially directed through first and second display panels 380, 390, and a transport zone 375 where light from light source 350 can be spread to improve uniformity and reduce artifacts such as dark spots that can arise from, for example, a separation between multiple distributed light source(s) 350. In one particular embodiment, the emissive zone 369 extends from an emissive zone boundary 363 to the top edge 364, and the transport zone 375 extends from the lightguide input edge 362 to the emissive zone boundary 363. In some cases, other optical films including, for example, a specular ESR film or semispecular ESR film, can be disposed within the transport zone 375 to further improve the uniformity of light entering the emissive zone 369 of lightguide 370.

In one embodiment, top edge 364 can be configured as a second receptacle, so that a second display element can be attached, increasing the height of the modular display (not shown, described elsewhere). First and second display electrical connectors 365, 367 are configured so that they are in communication with first and second display panels 380, 390 and an optional light sensor 366. When base element 320 is attached to display element 310 through receptacle 330, first and second display electrical connectors 365, 367 contact first and second base electrical connector 355, 357, respectively, and provides the connection needed to operate modular display 300.

In one embodiment, each of the first and second display electrical connectors 365, 367 can provide different information to each of the first and second display panels 380, 390, so that two-sided modular display 300 can be used to view a different image from each side. In one embodiment, each of the first and second display electrical connectors 365, 367 can provide the same information to each of the first and second display panels 380, 390, so that two-sided modular display 300 can be used to view the same image from each side.

Housing 360 can be fabricated from any suitable material commonly used for display manufacture, including sheet metals, thermoplastics, composites, and the like. Housing 360 provides a support and connection structure for lightguide 370, first and second display panels 380, 390, and additional components as described elsewhere. In one embodiment, collimating optics for light source 350 can be included in display element 310, such as the wedge shaped portion adjacent lightguide input edge 362 shown in FIG. 3, or other collimating optics as described elsewhere.

In one embodiment, lightguide 370 can be a solid lightguide as described previously. In this embodiment, there may be an airgap surrounding lightguide 370, to promote TIR. A first and a second light management film stack 372, 374 can be placed adjacent a first and a second output surface 371, 373 of lightguide 370 to condition light entering first and second display panels 380, 390,respectively, as described elsewhere. A first and a second protective film stack 382, 392 can be place adjacent first and second display panels 380, 390, respectively, to further condition the images produced by two-sided modular display 300, and protect the output surfaces 384, 394 from damage. Interior surfaces 368 of housing 360 can be a highly reflective surface, such as ESR, for efficient utilization of light injected into lightguide 370 through light input edge 362.

In another embodiment, lightguide 370 can be a hollow optical cavity lightguide as described previously. In this embodiment, interior surface 368 of housing 360 can be a highly reflective film such as ESR, lightguide 370 is filled with air, and first and second light management stacks 372, 374 include a partially transmissive reflector such as ARF, described elsewhere.

FIG. 4a-4c is a schematic cross-section of a technique that can be used to couple a base element 420 to a display element 410, according to one aspect of the disclosure. The display element 410 has a tapered housing 460 in the shape of a wedge, which serves to align the display element 410 as it is inserted into a matching tapered receptacle 430 located in the base element 420. The tapered receptacle 430 can include a locking mechanism 475 actuated by a lever 486. Display element 410 can be inserted into receptacle 430, contacting locking mechanism 475 which pivots inward to housing 460 adjoining base electrical connector 455 and display electrical connector 465 as shown in FIGS. 4a-4b. Lever 485 can then be rotated as shown in FIGS. 4b-4c so that flange 461 on housing 460 is pulled downwards to secure display element 410 to base element 420.

The wedge can be a two axis wedge connector to provide alignment in both axes as the display element is inserted. The wedge can be an external heavy duty molded wedge that can be made of a high temperature moldable material such as glass filled nylon or polyethermide (for example trade name Ultem by GE plastics), polysulfone, polyethertherketone, or polyethersulfone. The outer surface of this part can have vertical ribs to facilitate unplugging, and can also include supporting members that reinforce the display element when attached to the base element.

The internal surface of the wedge can be lined with a highly reflective specular material such as ESR, which can act as a collimating optic for the injected light. The module-to-module electrical connection can be made via conventional electrical contacts, or with a ZIF (zero insertion force) connector which has a mating portion within the base element. When the panel is unlocked,

the electrical connector is also opened to prevent contact damage. The mechanical interlock and mechanical release can lift the display element out slightly on release.

The disclosed modular displays could provide significant advantages for the consumer during purchase as well as use in the home. For online purchases, delivery speed, range of choices and customization could be improved since modules and module components could be selected and easily combined for delivery. Retail purchases could be improved assuming the retailer were to carry interchangeable base/display combinations in stock. The consumer could have a wide range of choices of base elements which could be sold separately or attached to a range of display elements before final sale. Advantages over current methods of retailing displays would include the choice of features, and speed of acquiring the customized merchandise.

In one aspect, consumers could have several base elements within a home, but only one display element. For example, bases could be located in several different rooms, and the light weight and easily portable display element would be convenient to move from one base element to another. In another aspect, consumers could upgrade the base element or the display element, rather than buying an entire new TV. For example, a new high color gamut RGB LED base element could replace a white LED base element. Alternatively, a new high color gamut RGB light source could replace a white LED light source in the same element if that capability were included. The resulting cost savings might be several hundred dollars, and also provides for less waste generation of electronic components.

For larger displays it may be desirable to increase mechanical stability to prevent tipping over, or to prevent excessive stress on the connection mechanism. Several techniques can be used, including both external and internal supports that attach the base element to the top of the display element. For example, a mechanical reinforcing member could extend from the base up through the center of the airspace of the backlight. The reinforcing member could be one or more rods or beams which are part of the LCD module and attach to the base during insertion. If located in the optical cavity, the reinforcing members should have low optical absorption. A clear material such as acrylic or polycarbonate can be used. Alternatively, any structural material could be used for the reinforcing members if it is coated or lined with a reflective material (for example ESR) so as not to reduce optical efficiency of the cavity. Additionally, the shape and weight of the base can be designed to ensure a sufficiently low center of gravity and increase stability of the unit.

The embodiments described can be applied anywhere that thin display or light emitting structures are used, including displays such as TV, notebook and monitors, and used for advertising, information display, digital signage, or lighting. The present disclosure is also applicable to electronic devices including laptop computers and handheld devices such as Personal Data Assistants (PDAs), personal gaming devices, cell phones, personal media players, handheld

computers and the like, which incorporate optical displays. The modular displays of the present disclosure have application in many other areas. In some embodiments, a display panel may be excluded from the modular displays, and the resulting light emitting panel can instead be used as a luminaire, task light, light source, sign or point of purchase display

Following are a list of embodiments of the present disclosure:

Item 1 is a display, comprising: a display element, comprising: a lightguide having a first output surface and an input edge, and a liquid crystal display (LCD) panel facing the first output surface of the lightguide; and a base element, comprising: a receptacle configured to attach the display element to the base element along the input edge of the lightguide; a light source configured to inject light into the input edge of the lightguide; and electronic components, wherein an electrical connection is provided between the electronic components and the LCD panel.

Item 2 is the display of item 1, wherein the lightguide comprises a hollow optical cavity lightguide.

Item 3 is the display of item 1 or item 2, wherein the lightguide comprises a solid lightguide.

Item 4 is the display of item 1 to item 3, wherein the display element further comprises a memory device capable of storing at least one image.

Item 5 is the display of item 1 to item 4, further comprising a support extending from the base element to the display element.

Item 6 is the display of item 1 to item 5, wherein the light source comprises a fluorescent lamp.

Item 7 is the display of item 1 to item 6, wherein the light source comprises a light emitting diode, a laser diode, or combinations thereof.

Item 8 is the display of item 7, wherein the light emitting diode comprises a white, a red, a blue, a green, a cyan, a yellow, a magenta, or an ultraviolet light emitting diode, or combinations thereof.

Item 9 is the display of item 1 to item 8, wherein the light source includes at least two different colors or brightness levels of light or a combination thereof.

Item 10 is the display of item 1 to item 9, wherein the lightguide further comprises an interior light sensor in communication with the electronic components.

Item 11 is the display of item 1 to item 10, further comprising an ambient light sensor in communication with the electronic components.

Item 12 is the display of item 1 to item 11, wherein the lightguide comprises an emissive zone capable of directing light through the LCD, and an adjacent transport zone capable of spreading the injected light into the emissive zone.

Item 13 is the display of item 12, wherein the transport zone further comprises a specular reflector, a semispecular reflector, or a combination thereof.

Item 14 is the display of item 1 to item 13, wherein the display element further comprises: a second output surface opposite the first output surface; a second LCD panel facing the second output surface; and a second electrical connection provided between the electronic components and the second LCD.

Item 15 is a display, comprising: a first and second display element, each comprising: a lightguide having an output surface, an input edge, and an output edge opposite the input edge, and an LCD panel facing the output surface of the lightguide; and a base element, comprising: a receptacle configured to attach each display element to the base element along the input edge of each lightguide; a light source configured to inject light into the input edge of each lightguide; and electronic components, wherein an electrical connection is provided between the electronic components and each LCD panel.

Item 16 is the display of item 15, wherein the receptacle is configured to removably attach at least one of the first and second display elements to the base element.

Item 17 is the display of item 15 or item 16, wherein the base element electronically recognizes the first and second display elements.

Item 18 is a method of assembling a display, comprising: selecting a display element, wherein the display element comprises: a lightguide having an output surface and an input edge, and a liquid crystal display (LCD) panel facing the output surface; and selecting a base element, wherein the base element comprises: a receptacle configured to attach the display element to the base element along the input edge of the lightguide; a light source configured to inject light into the input edge of the lightguide; and electronic components, wherein an electrical connection is provided between the electronic components and the LCD panel; and attaching the display element to the base element.

Item 19 is the method of item 18, wherein selecting a display element comprises selecting the lightguide and the LCD panel.

Item 20 is the method of item 18 or item19, wherein the lightguide comprises a solid lightguide or a hollow optical cavity lightguide.

Item 21 is the method of item 18 to item 20, wherein the lightguide comprises an Asymmetric Reflector Film.

Item 22 is the method of item 18 to item 21, wherein selecting a base element comprises selecting the light source and the electronic components.

Item 23 is the method of item 18 to item 22, wherein the light source comprises a fluorescent lamp.

Item 24 is the method of item 18 to item 22, wherein the light source comprises a light emitting diode, a laser diode, or a combination thereof.

Item 25 is the method of item 18 to item 24, wherein the light source comprises a white, a red, a blue, a green, a cyan, a yellow, a magenta, or an ultraviolet light emitting diode, or combinations thereof.

Item 26 is the method of item 18 to item 25, wherein the electronic components comprise video drivers, tuners, electro-optical sensors, audio components, or component connectors, or combinations thereof.

Item 27 is a light emitting panel, comprising: a hollow optical cavity lightguide having an output surface and an input edge; and a base element, comprising: a receptacle configured to attach the hollow optical cavity lightguide to the base element along the input edge of the hollow optical cavity lightguide; a light source configured to inject light into the input edge of the lightguide; and electronic components.

Unless otherwise indicated, all numbers expressing feature sizes, amounts, and physical properties used in the specification and claims are to be understood as being modified by the term "about." Accordingly, unless indicated to the contrary, the numerical parameters set forth in the foregoing specification and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by those skilled in the art utilizing the teachings disclosed herein.

All references and publications cited herein are expressly incorporated herein by reference in their entirety into this disclosure, except to the extent they may directly contradict this disclosure. Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a variety of alternate and/or equivalent implementations can be substituted for the specific embodiments shown and described without departing from the scope of the present disclosure. This application is intended to cover any adaptations or variations of the specific embodiments discussed herein. Therefore, it is intended that this disclosure be limited only by the claims and the equivalents thereof.

What is claimed is:

1. A display, comprising:

a display element, comprising:

a lightguide having a first output surface and an input edge, and

a liquid crystal display (LCD) panel facing the first output surface of the lightguide; and

a base element, comprising:

a receptacle configured to attach the display element to the base element along the input edge of the lightguide;

a light source configured to inject light into the input edge of the lightguide; and

electronic components, wherein an electrical connection is provided between the electronic components and the LCD panel.

2. The display of claim 1, wherein the lightguide comprises a hollow optical cavity lightguide.

3. The display of claim 1, wherein the lightguide comprises a solid lightguide.

4. The display of claim 1, wherein the display element further comprises a memory device capable of storing at least one image.

5. The display of claim 1, further comprising a support extending from the base element to the display element.

6. The display of claim 1, wherein the light source comprises a fluorescent lamp.

7. The display of claim 1, wherein the light source comprises a light emitting diode, a laser diode, or combinations thereof.

8. The display of claim 7, wherein the light emitting diode comprises a white, a red, a blue, a green, a cyan, a yellow, a magenta, or an ultraviolet light emitting diode, or combinations thereof.

9. The display of claim 1, wherein the light source includes at least two different colors or at least two different brightness levels of light, or a combination thereof.

10. The display of claim 1, wherein the lightguide further comprises an interior light sensor in communication with the electronic components.

11. The display of claim 1, further comprising an ambient light sensor in communication with the electronic components.

12. The display of claim 1, wherein the lightguide comprises an emissive zone capable of directing light through the LCD panel, and an adjacent transport zone capable of spreading the injected light into the emissive zone.

13. The display of claim 12, wherein the transport zone further comprises a specular reflector, a semispecular reflector, or a combination thereof.

14. The display of claim 1, wherein the display element further comprises:

a second output surface opposite the first output surface; a second LCD panel facing the second output surface; and

a second electrical connection provided between the electronic components and the second LCD.

15. A display, comprising:

a first and a second display element, each comprising:

a lightguide having an output surface, an input edge, and an output edge opposite the input edge, and

an LCD panel facing the output surface of the lightguide; and

a base element, comprising:

a receptacle configured to attach each display element to the base element along the input edge of each lightguide;

a light source configured to inject light into the input edge of each lightguide; and

electronic components, wherein an electrical connection is provided between the electronic components and each LCD panel.

16. The display of claim 15, wherein the receptacle is configured to removably attach at least one of the first and the second display elements to the base element.

17. The display of claim 15, wherein the base element electronically recognizes the first and the second display elements.

18. A method of assembling a display, comprising:
selecting a display element, wherein the display element comprises:
a lightguide having an output surface and an input edge, and
a liquid crystal display (LCD) panel facing the output surface; and
selecting a base element, wherein the base element comprises:
a receptacle configured to attach the display element to the base element along the input edge of the lightguide;
a light source configured to inject light into the input edge of the lightguide; and
electronic components, wherein an electrical connection is provided between the electronic components and the LCD panel; and
attaching the display element to the base element.

19. The method of claim 18, wherein selecting the display element comprises selecting the lightguide and the LCD panel.

20. The method of claim 19, wherein the lightguide comprises a solid lightguide or a hollow optical cavity lightguide.

21. The method of claim 19, wherein the lightguide comprises an Asymmetric Reflector Film.

22. The method of claim 18, wherein selecting the base element comprises selecting the light source and the electronic components.

23. The method of claim 22, wherein the light source comprises a fluorescent lamp.

24. The method of claim 22, wherein the light source comprises a light emitting diode, a laser diode, or a combination thereof.

25. The method of claim 24, wherein the light source comprises a white, a red, a blue, a green, a cyan, a yellow, a magenta, or an ultraviolet light emitting diode, or combinations thereof.

26. The method of claim 22, wherein the electronic components comprise video drivers, tuners, electro-optical sensors, audio components, or component connectors, or combinations thereof.

27. A light emitting panel, comprising:

a hollow optical cavity lightguide having an output surface and an input edge; and

a base element, comprising:

a receptacle configured to attach the hollow optical cavity lightguide to the base element along the input edge of the hollow optical cavity lightguide;

a light source configured to inject light into the input edge of the lightguide; and

electronic components.

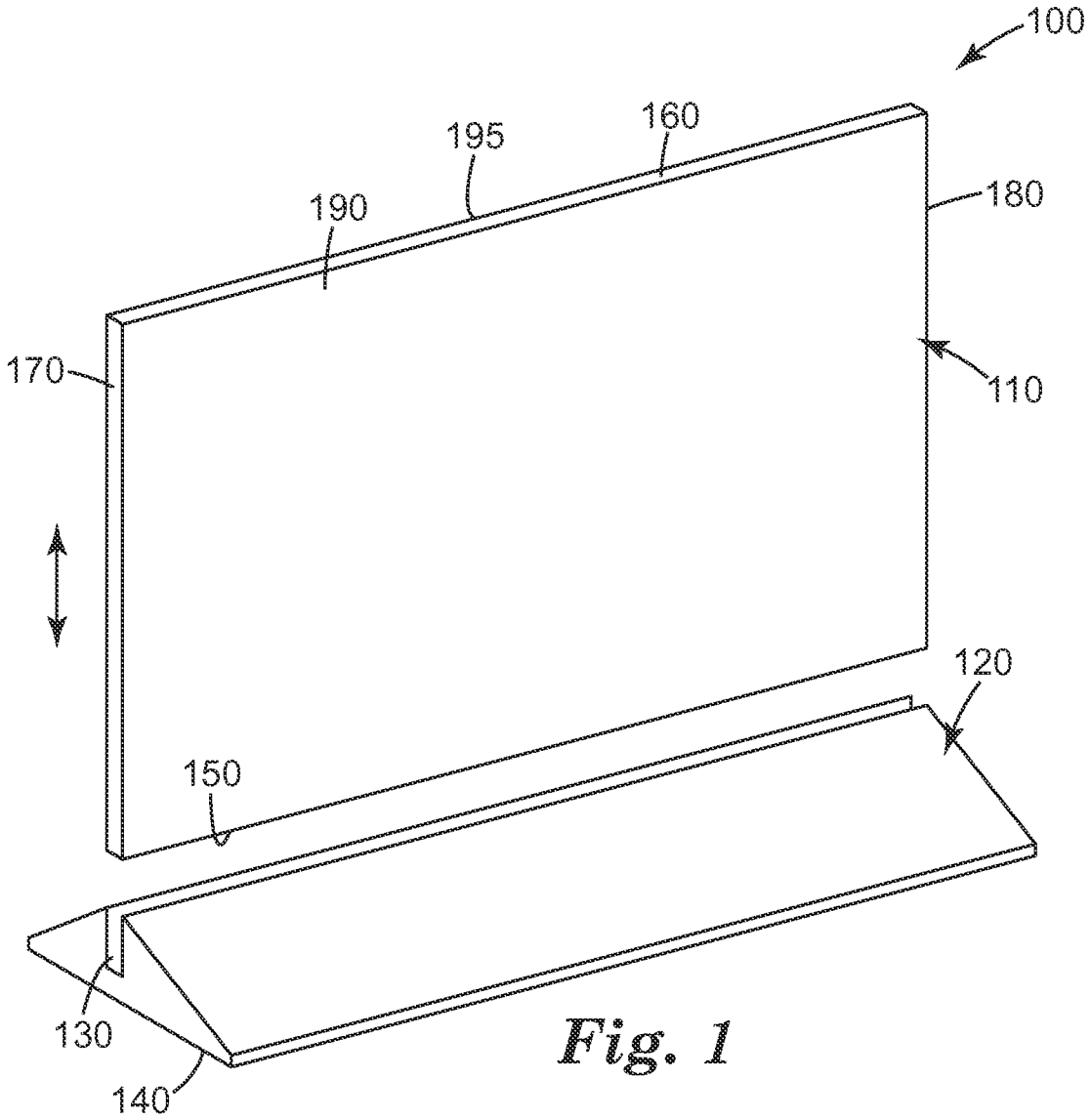

Fig. 1

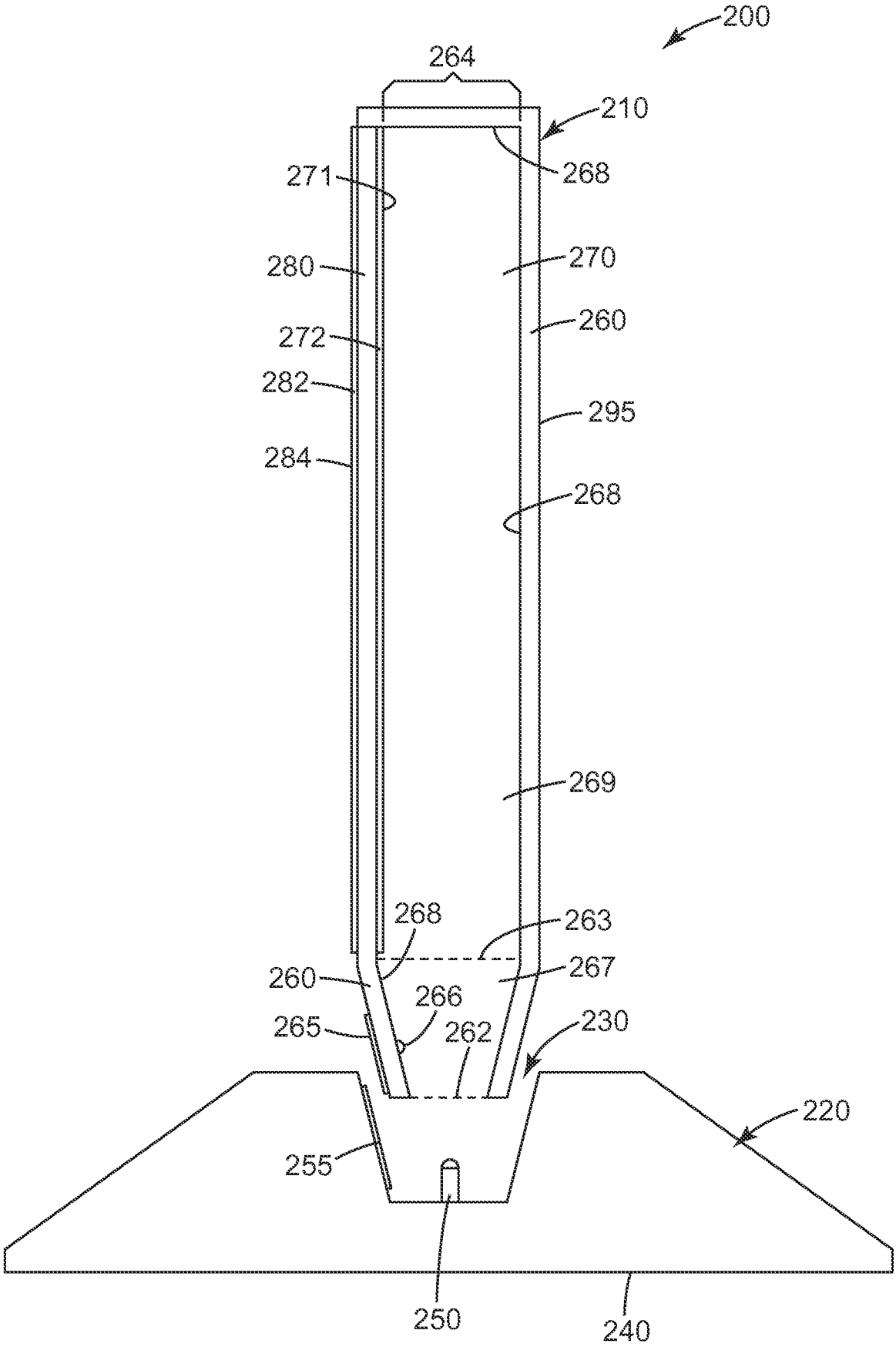
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Fig. 2

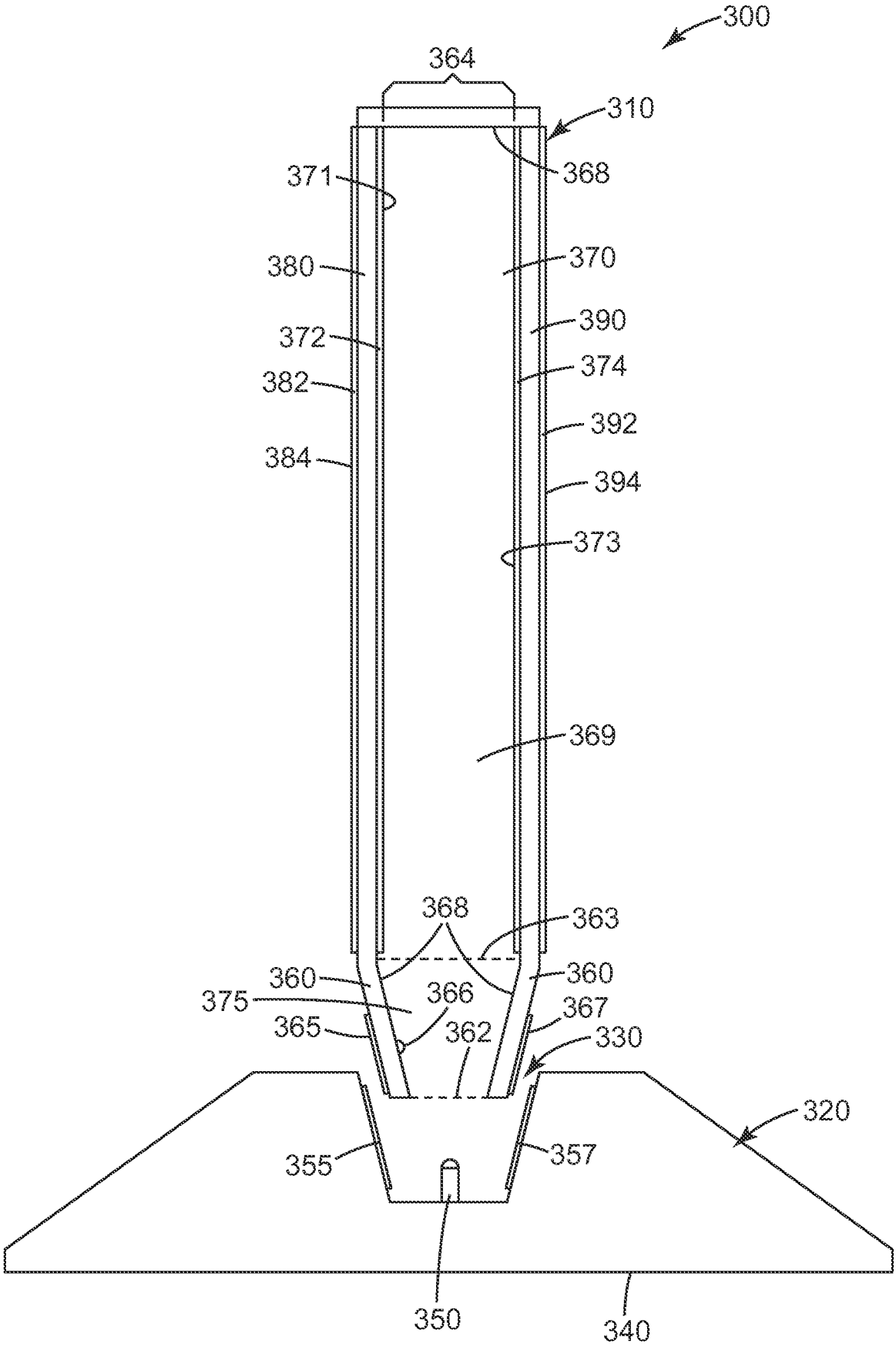
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Fig. 3

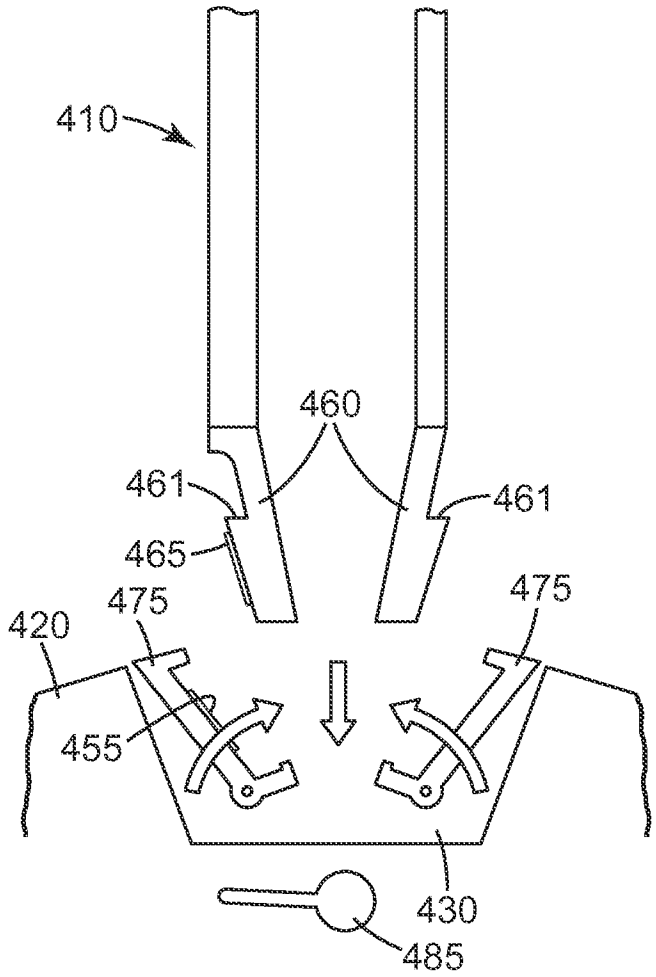
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Fig. 4a

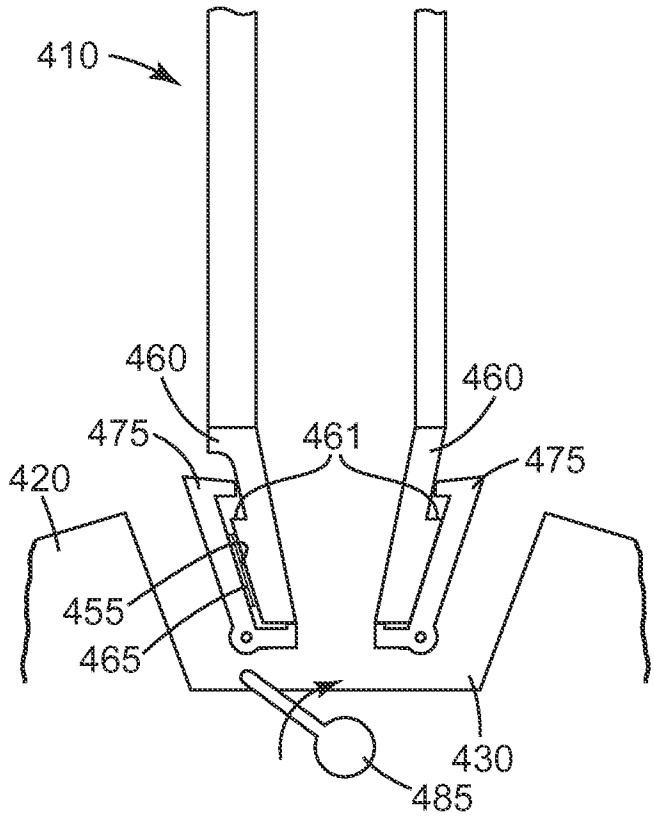
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Fig. 4b

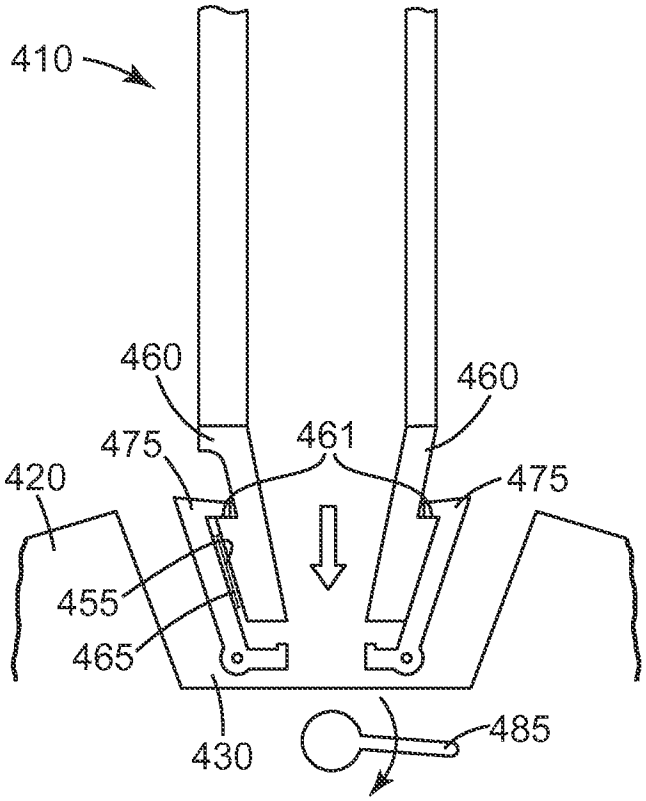

Fig. 4c