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(54) **INTEGRATED PRINTING AND DISPLAY DEVICE WITH REPLACEABLE INK CARTRIDGE**

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(73) Assignee: **Silverbrook Research Pty Ltd**

(21) Appl. No.: **13/284,942**

(22) Filed: **Oct. 30, 2011**

Related U.S. Application Data

(63) Continuation of application No. 12/500,574, filed on Jul. 9, 2009, now Pat. No. 8,059,308, which is a continuation of application No. 10/803,073, filed on Mar. 18, 2004, now Pat. No. 7,570,389.

(30) **Foreign Application Priority Data**

Mar. 20, 2003 (AU) 2003901297

Publication Classification

(51) **Int. Cl.**

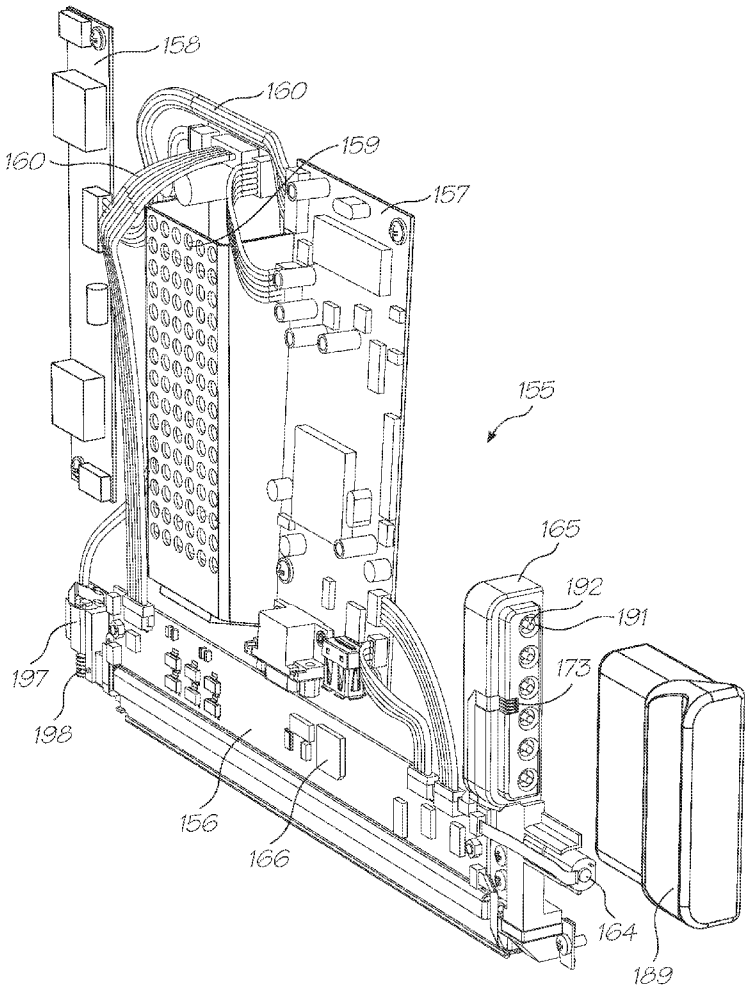
B41J 3/00 (2006.01)

H01R 13/648 (2006.01)

(52) **U.S. Cl.** **347/2**; 439/607.14

(57) **ABSTRACT**

A printing and display device includes a flat panel display for displaying images from an external computer; a printer having an inkjet printhead; a video socket adapted to engage with a video plug and video cable from the external computer to receive therefrom a video signal; a print data connection for selective connection to the external computer to receive therefrom print instructions; a rear cover molding enclosing therein the flat panel display; a paper chute ; and an ink delivery bus provided within the rear cover molding. The rear cover molding includes an aperture for receiving therein an external ink cartridge. The aperture facilitates coupling of the external ink cartridge with the ink delivery bus. The ink delivery bus includes fluid ports for engaging with the external ink cartridge, each of the one or more fluid port including a hollow needle adapted to penetrate a seal of the external ink cartridge.



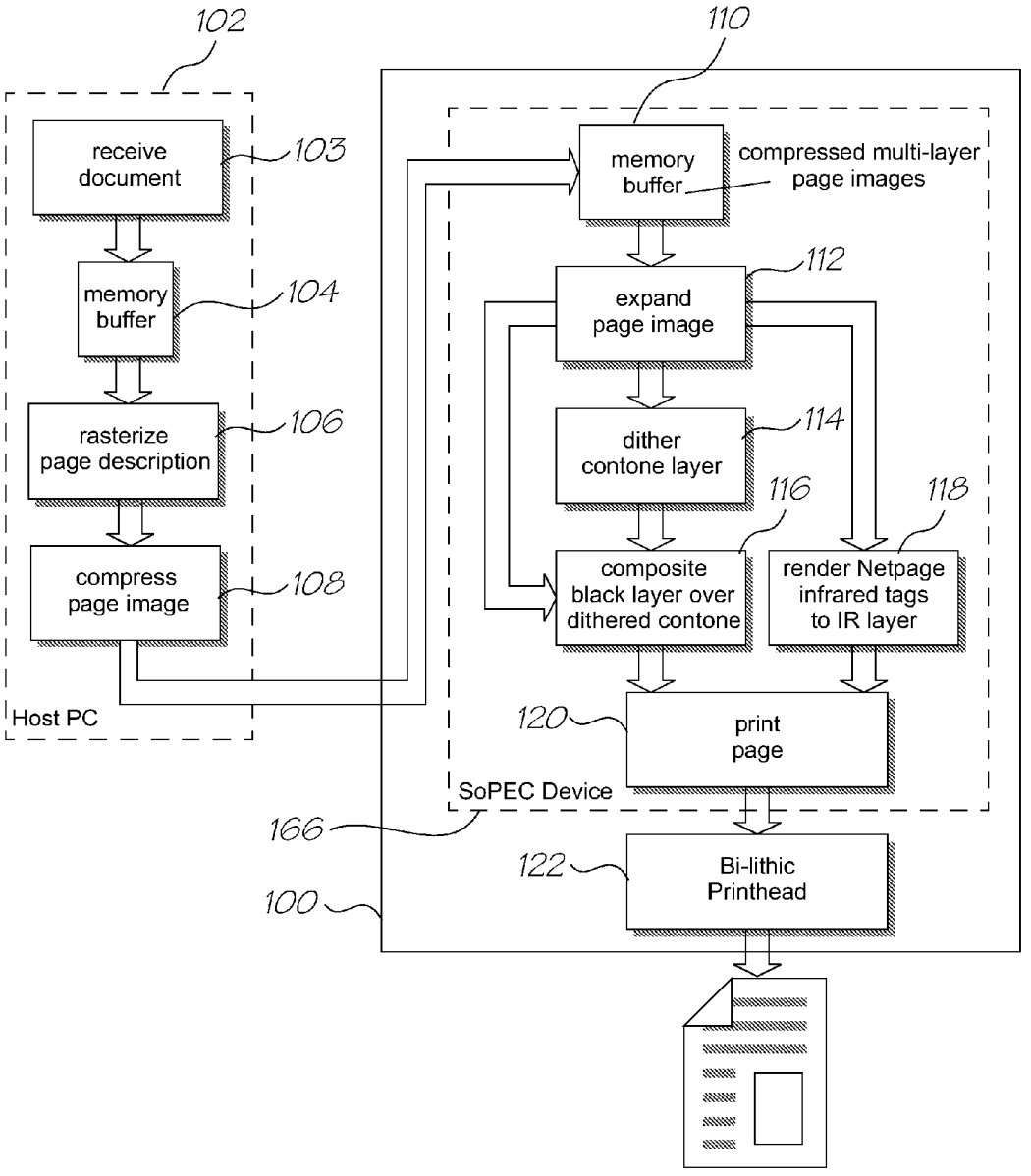

102
110
receive document
103
memory buffer
104
rasterize page description
106
compress page image
108
Host PC
memory buffer
compressed multi-layer page images
112
expand page image
dither contone layer
114
116
118
composite black layer over dithered contone
render Netpage infrared tags to IR layer
120
print page
SoPEC Device
166
122
Bi-lithic Printhead
100

FIG. 1

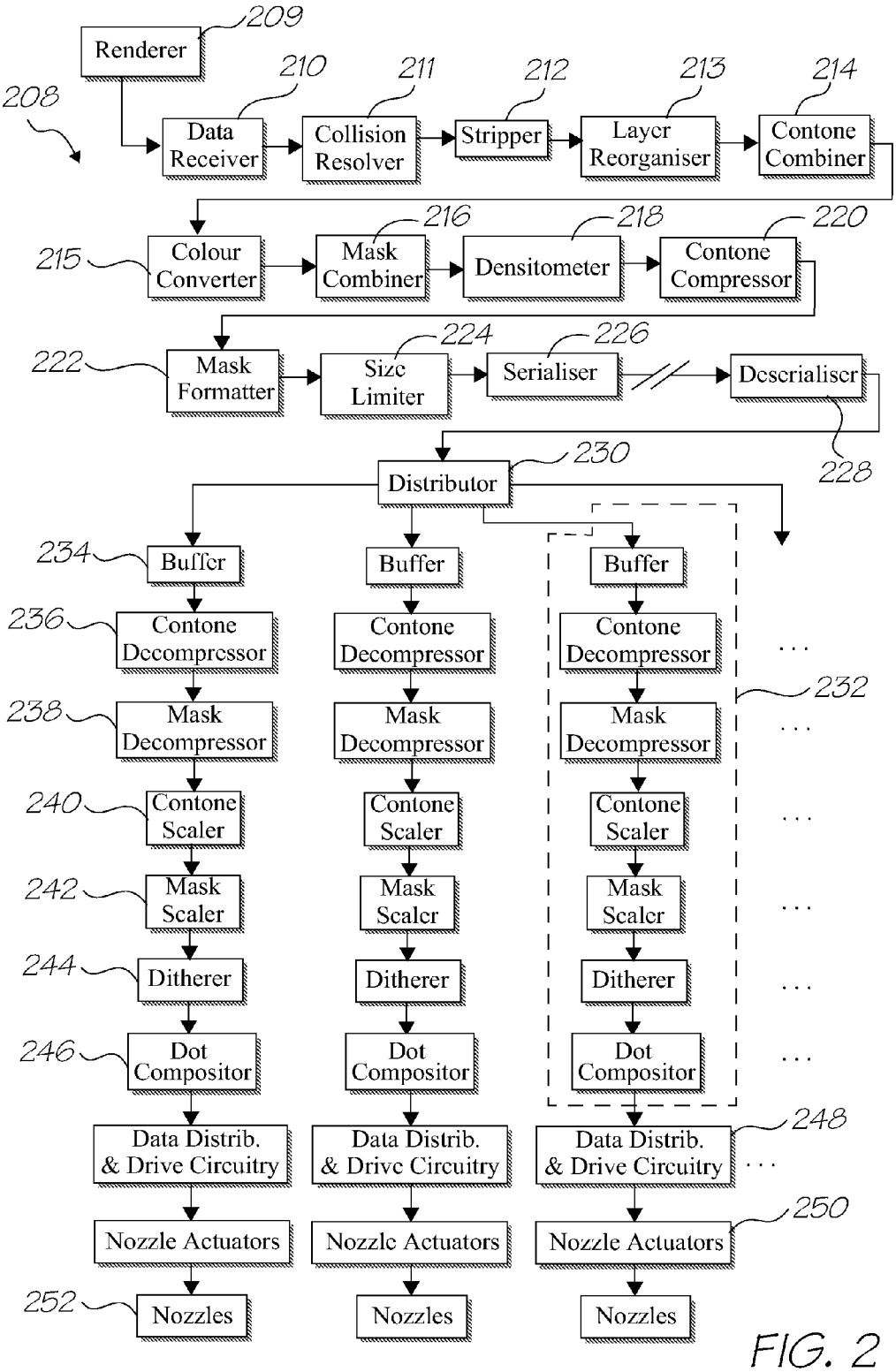

208
209
Renderer
210
Data Receiver
211
Collision Resolver
212
Stripper
213
Layer Reorganiser
214
Contone Combiner
215
Colour Converter
216
Mask Combiner
218
Densitometer
220
Contone Compressor
222
Mask Formatter
224
Size Limiter
226
Serialiser
Descrialiser
228
230
Distributor
234
Buffer
236
Contone Decompressor
238
Mask Decompressor
240
Contone Scaler
242
Mask Scaler
244
Ditherer
246
Dot Compositor
Data Distrib. & Drive Circuitry
248
Nozzle Actuators
250
252
Nozzles
232

FIG. 2

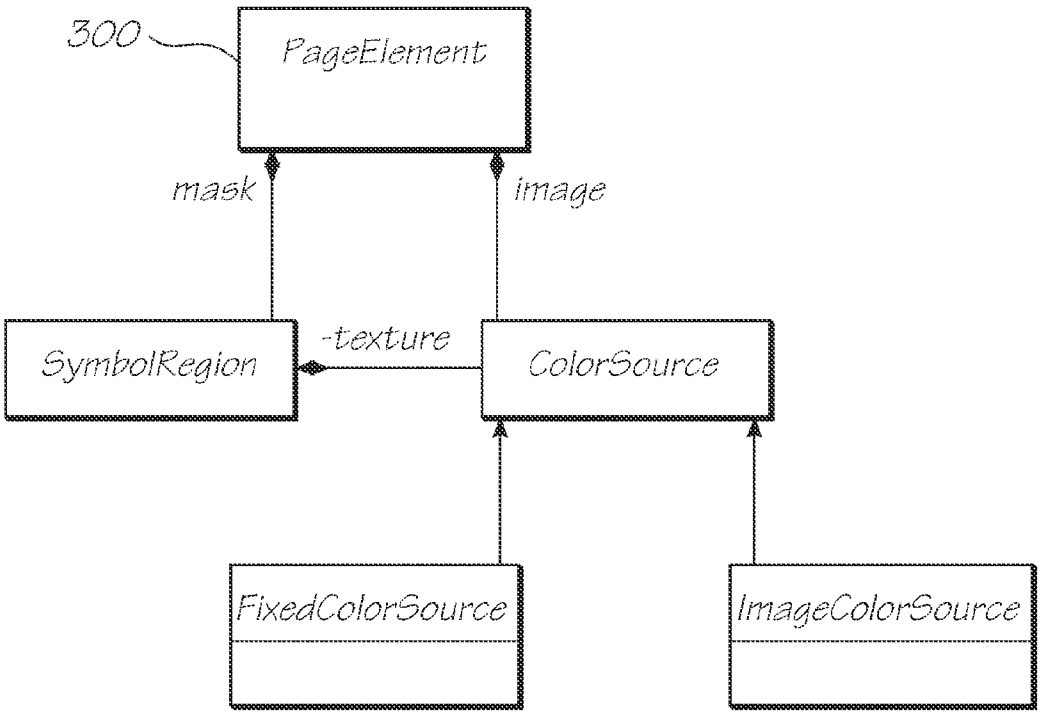

300
PageElement
mask
image
SymbolRegion
-texture
ColorSource
FixedColorSource
ImageColorSource

FIG. 3

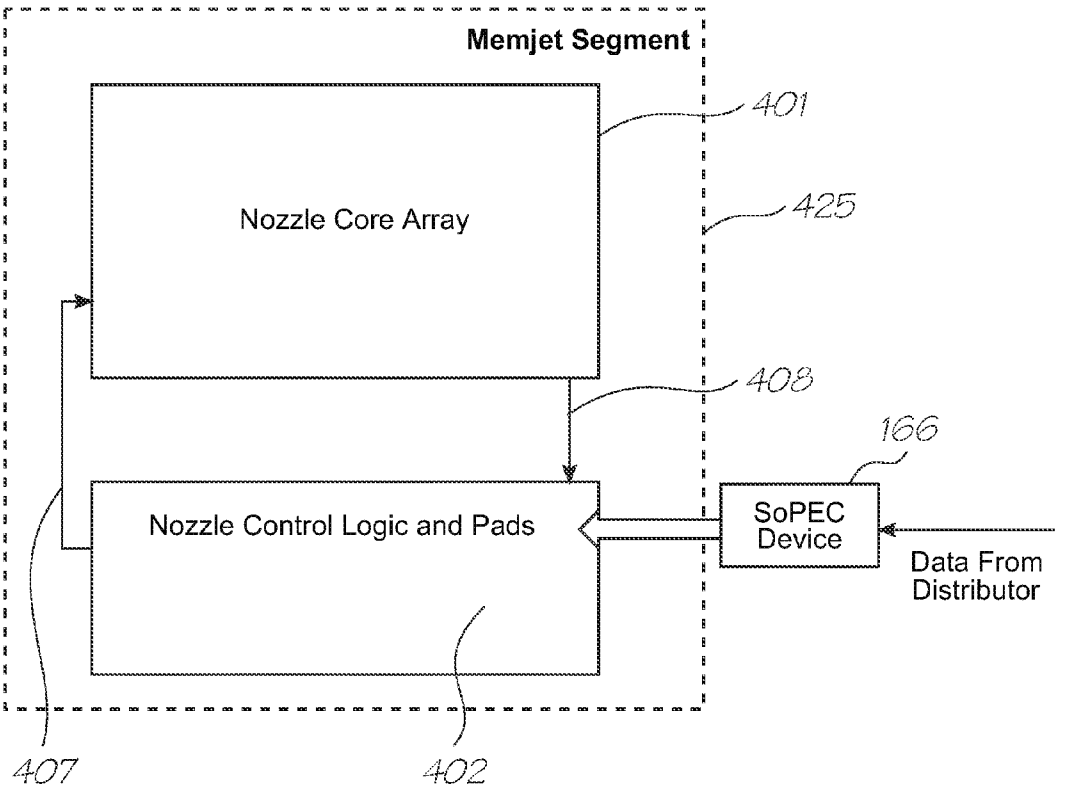

Memjet Segment
401
Nozzle Core Array
425
408
166
Nozzle Control Logic and Pads
SoPEC Device
Data From Distributor
407
402

FIG. 4

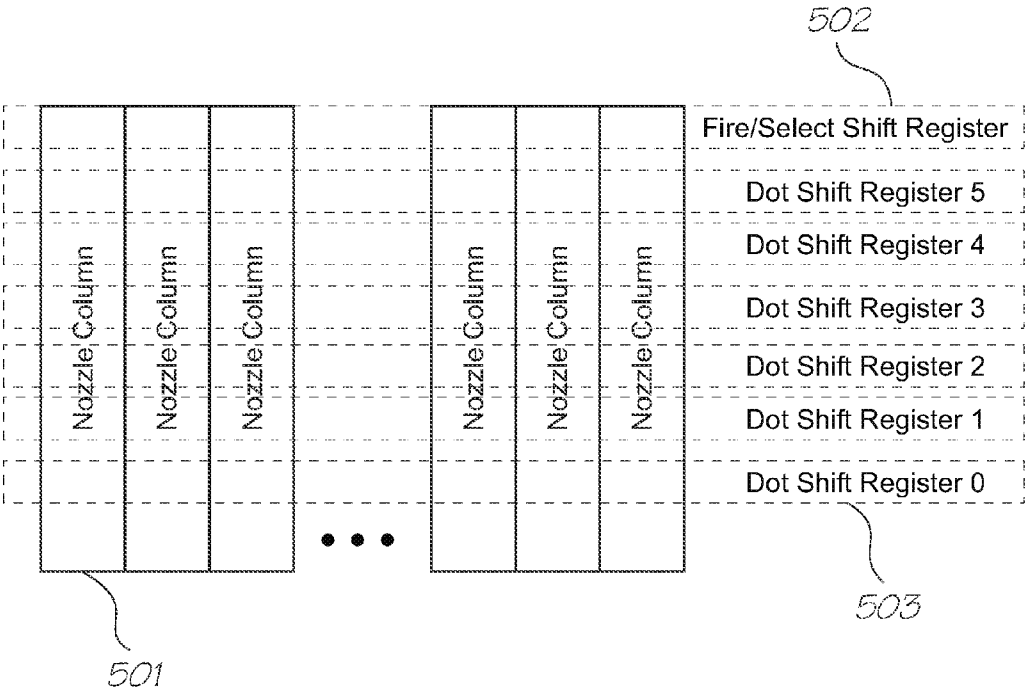

502
Fire/Select Shift Register
Dot Shift Register 5
Dot Shift Register 4
Dot Shift Register 3
Dot Shift Register 2
Dot Shift Register 1
Dot Shift Register 0
Nozzle Column
Nozzle Column
Nozzle Column
Nozzle Column
Nozzle Column
Nozzle Column
503
501

FIG. 5

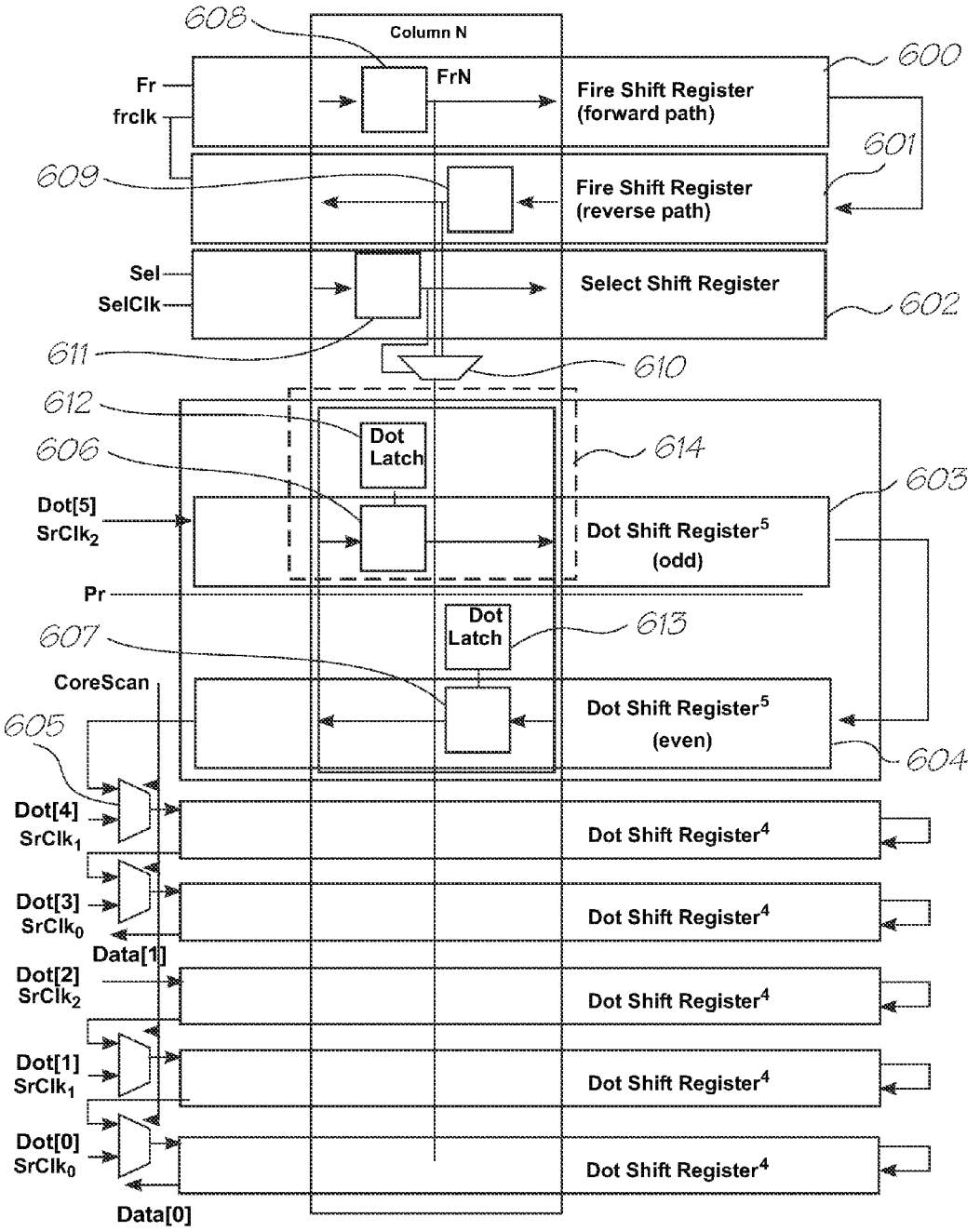

608
Column N
600
Fr
frclk
FrN
Fire Shift Register
(forward path)
601
609
Fire Shift Register
(reverse path)
Sel
SelClk
Select Shift Register
602
611
610
612
Dot
Latch
614
606
603
Dot[5]
SrClk2
Dot Shift Register5
(odd)
Pr
Dot
Latch
613
607
CoreScan
Dot Shift Register5
(even)
605
604
Dot[4]
SrClk1
Dot Shift Register4
Dot[3]
SrClk0
Dot Shift Register4
Data[1]
Dot[2]
SrClk2
Dot Shift Register4
Dot[1]
SrClk1
Dot Shift Register4
Dot[0]
SrClk0
Dot Shift Register4
Data[0]

FIG. 6

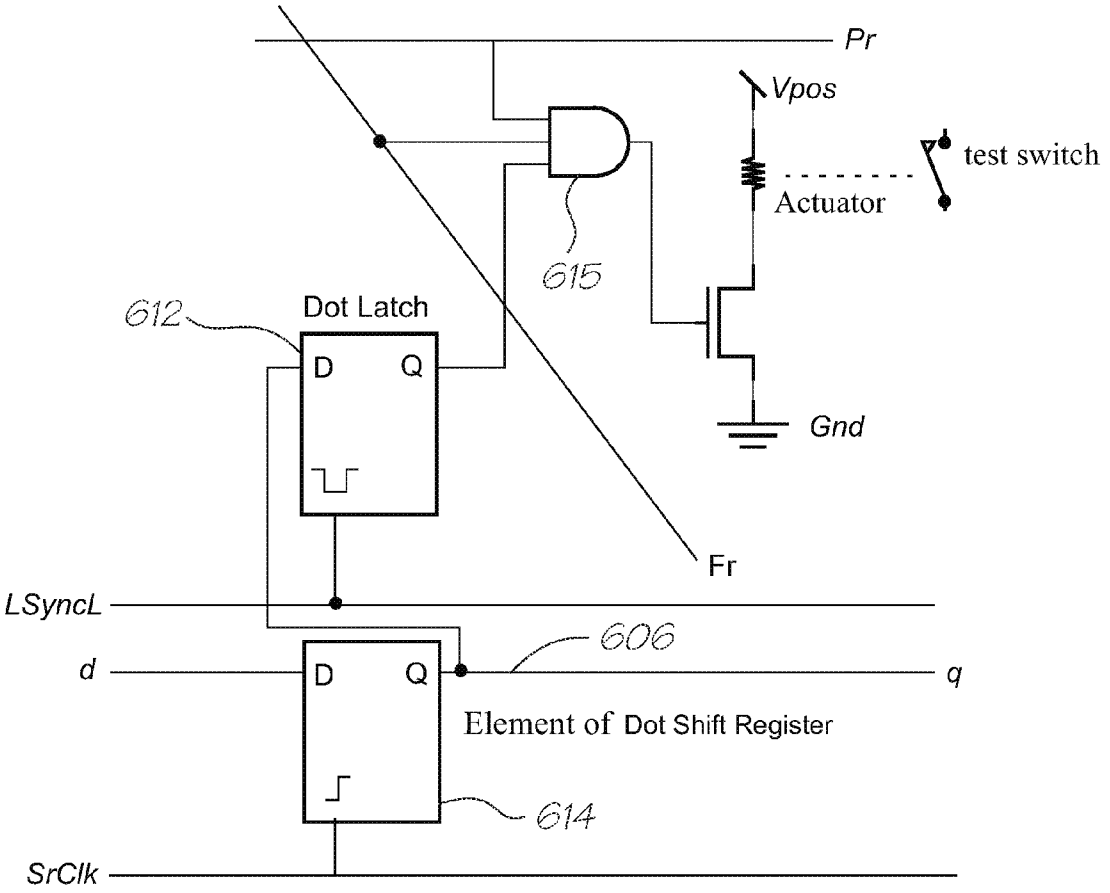

Pr
Vpos
test switch
Actuator
615
612
Dot Latch
D
Q
Gnd
Fr
LSyncL
606
d
D
Q
q
Element of Dot Shift Register
614
SrClk

FIG. 7

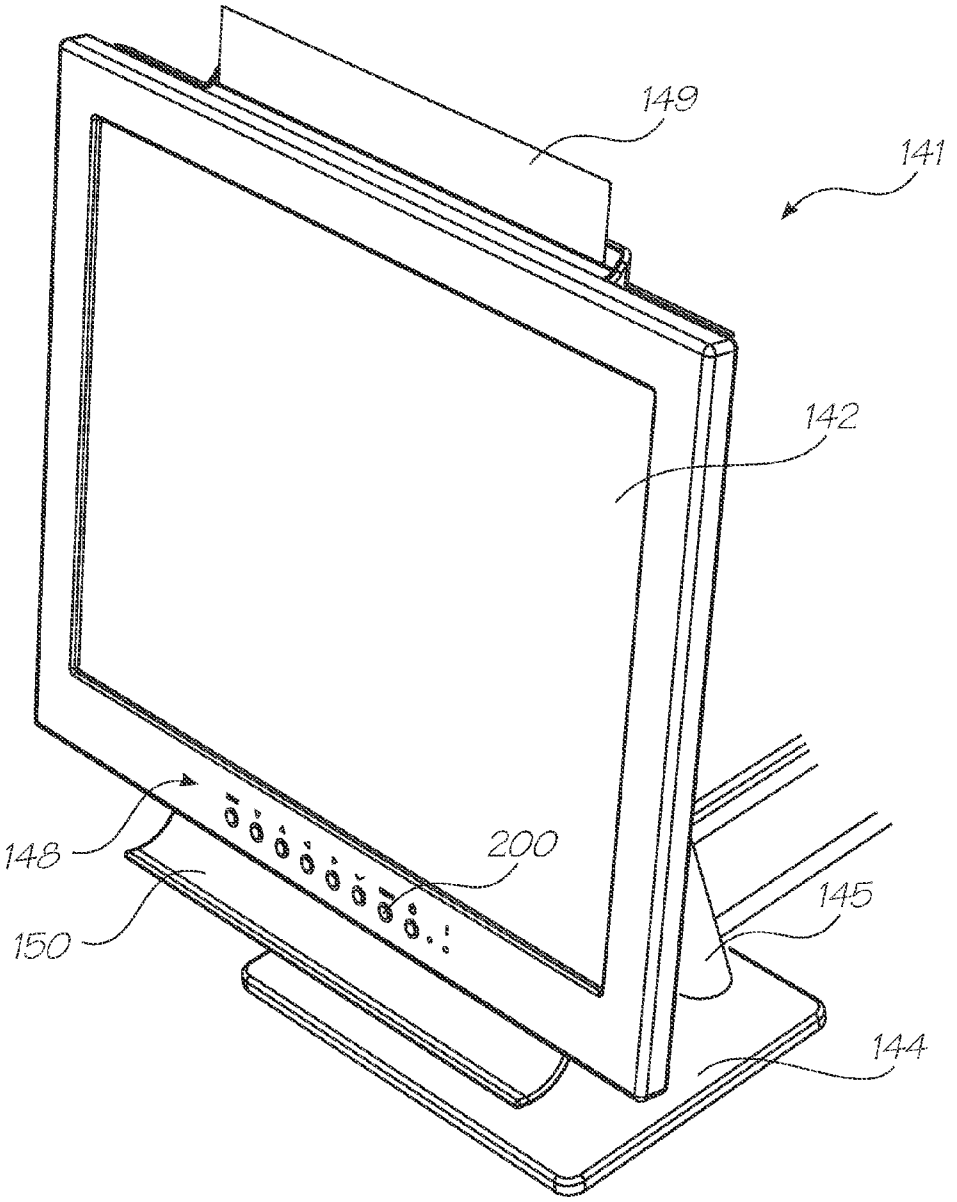


FIG. 8

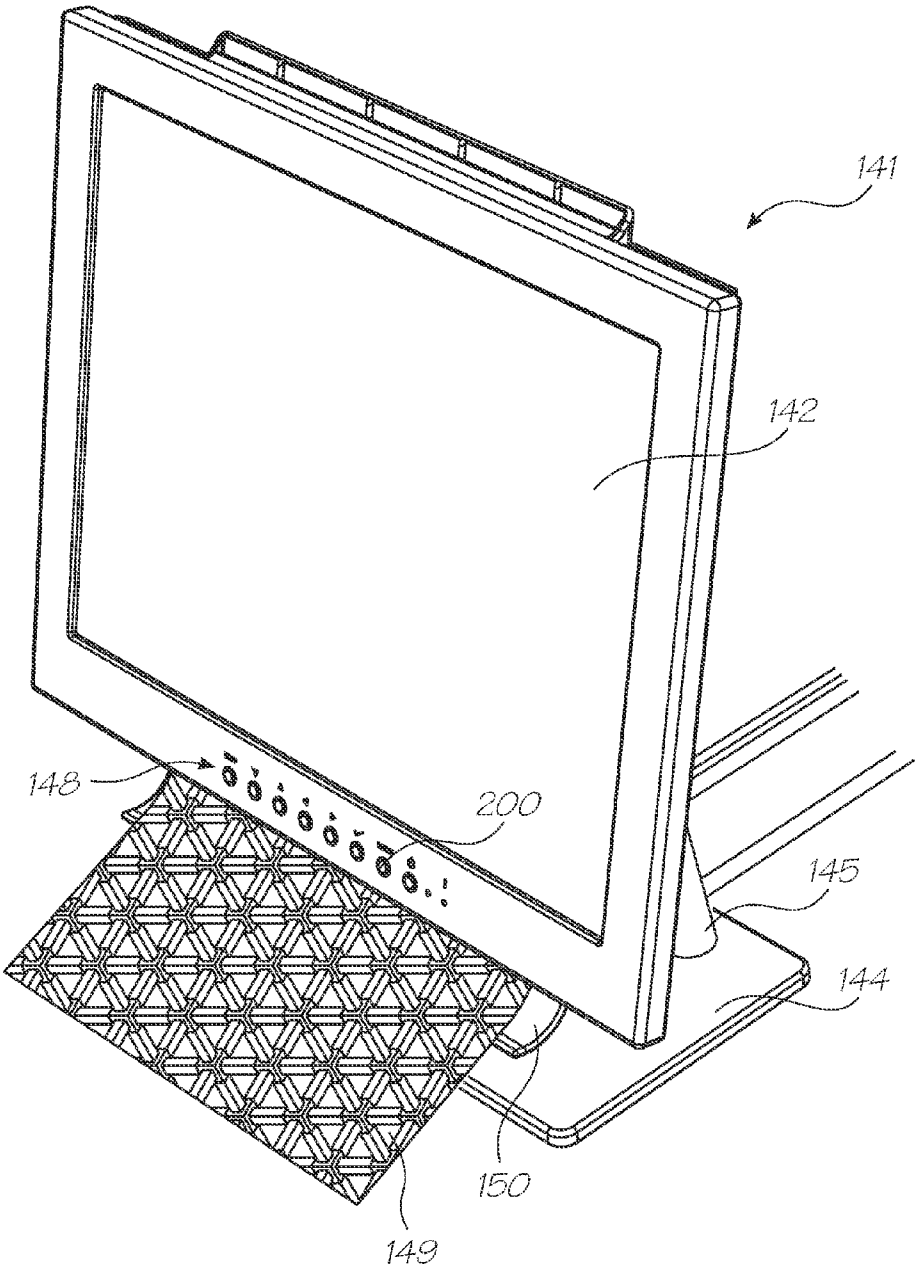


FIG. 9

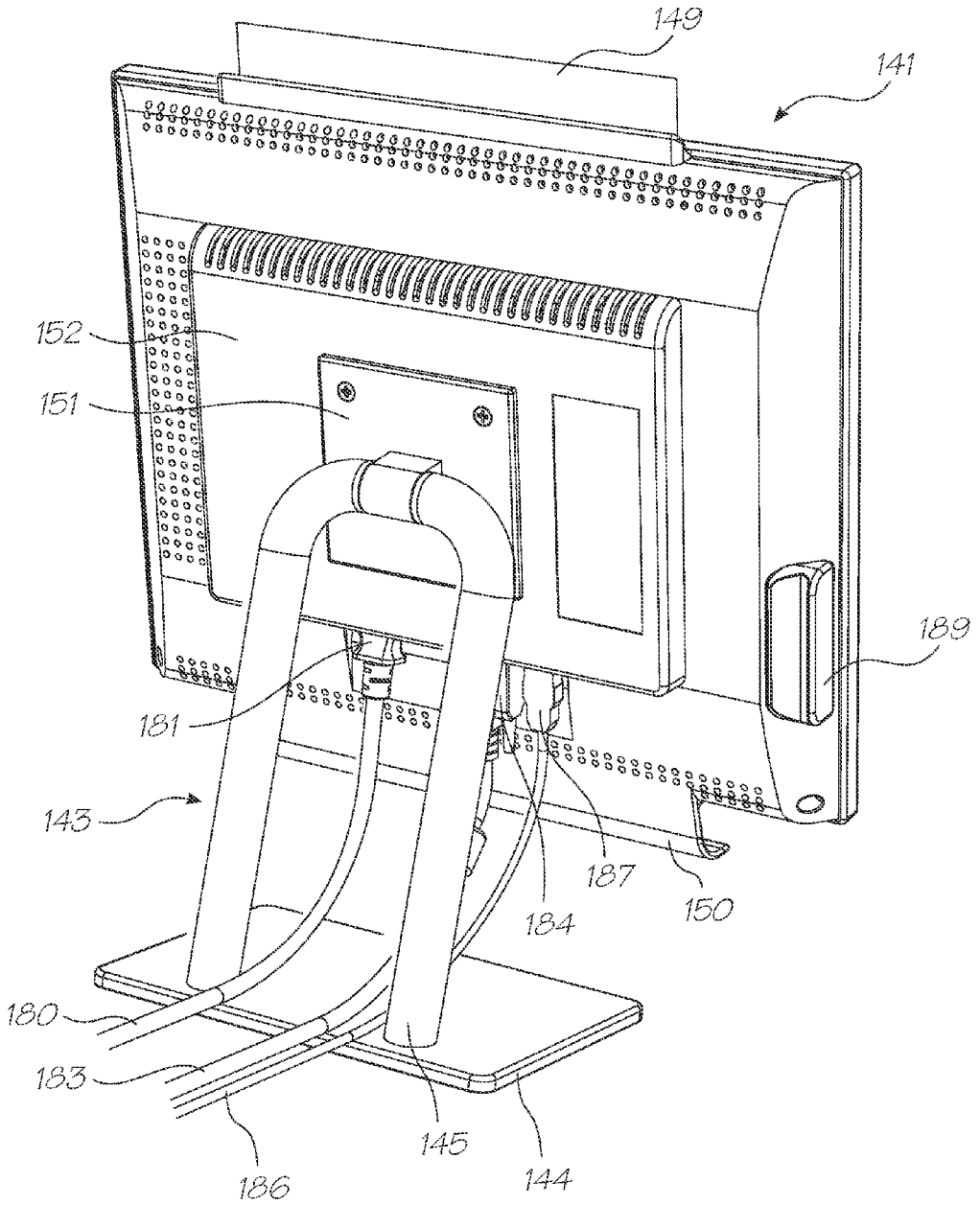


FIG. 10

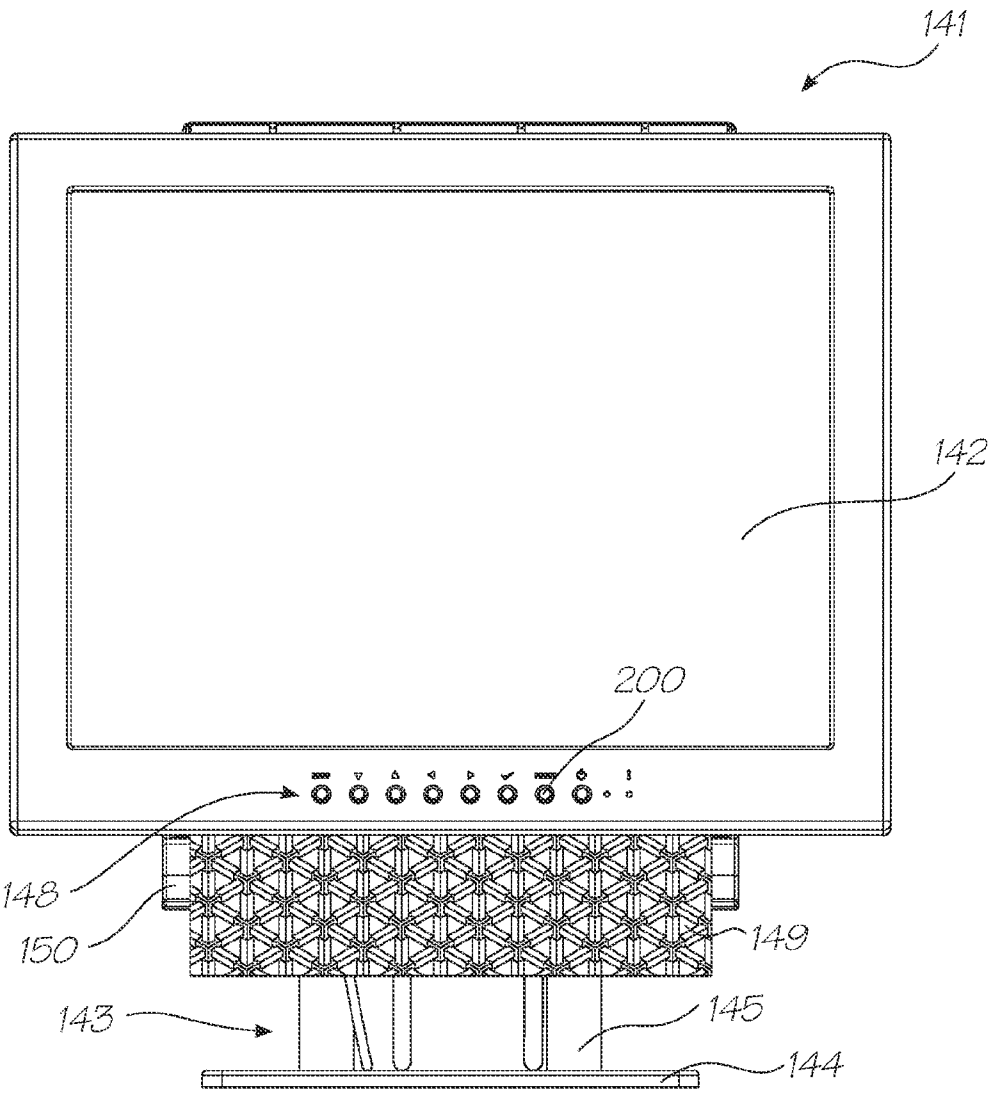


FIG. 11

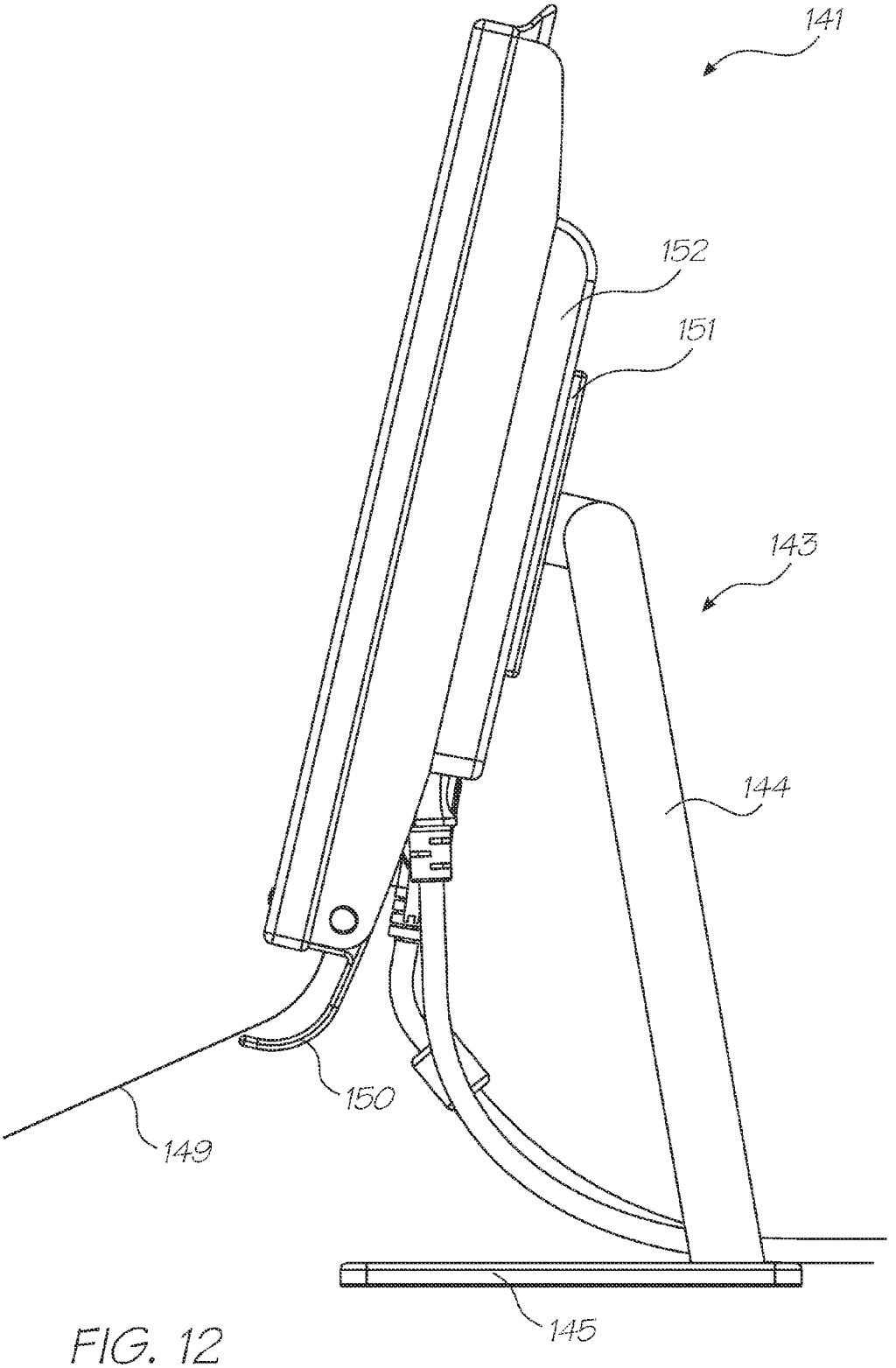


FIG. 12

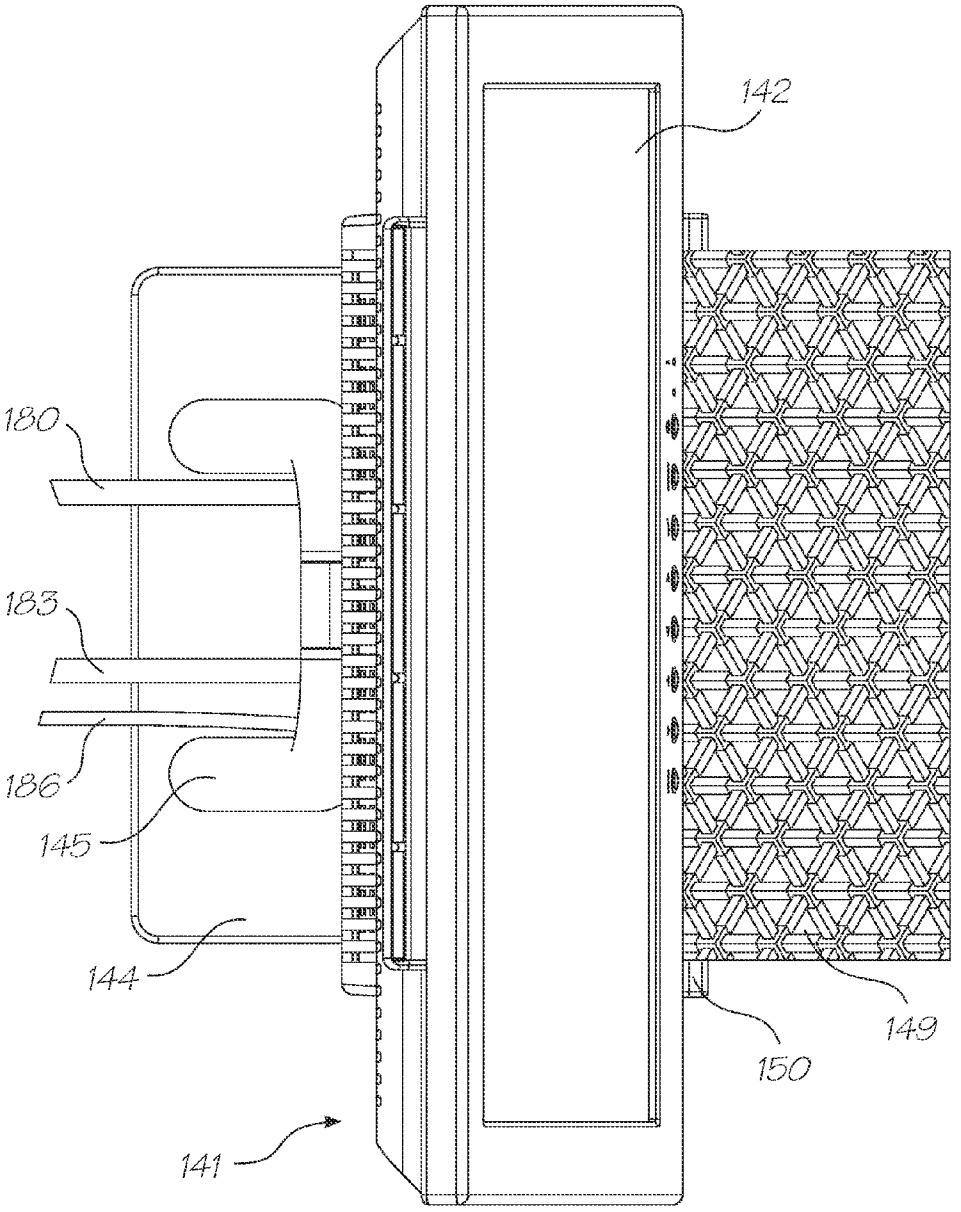


FIG. 13

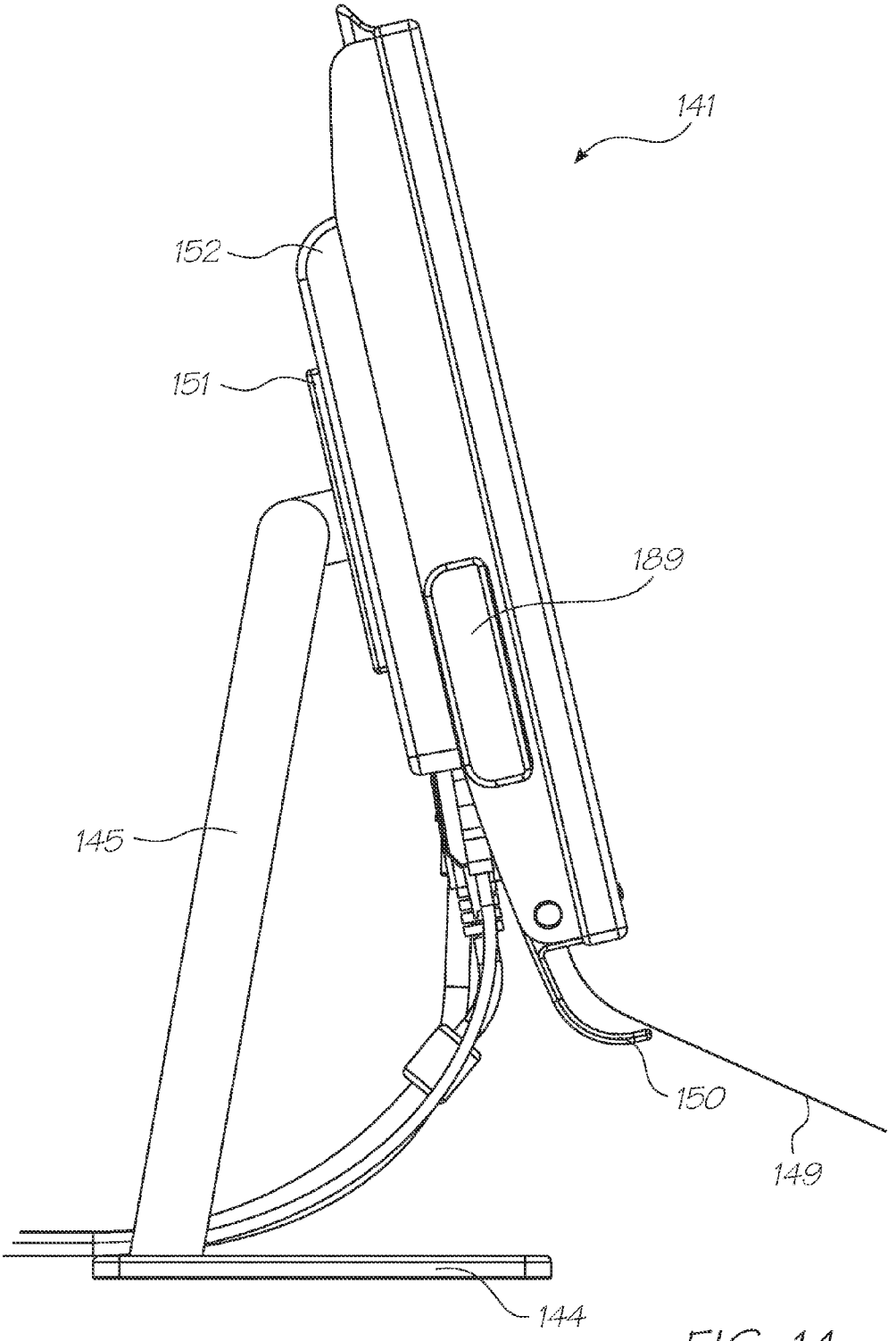


FIG. 14

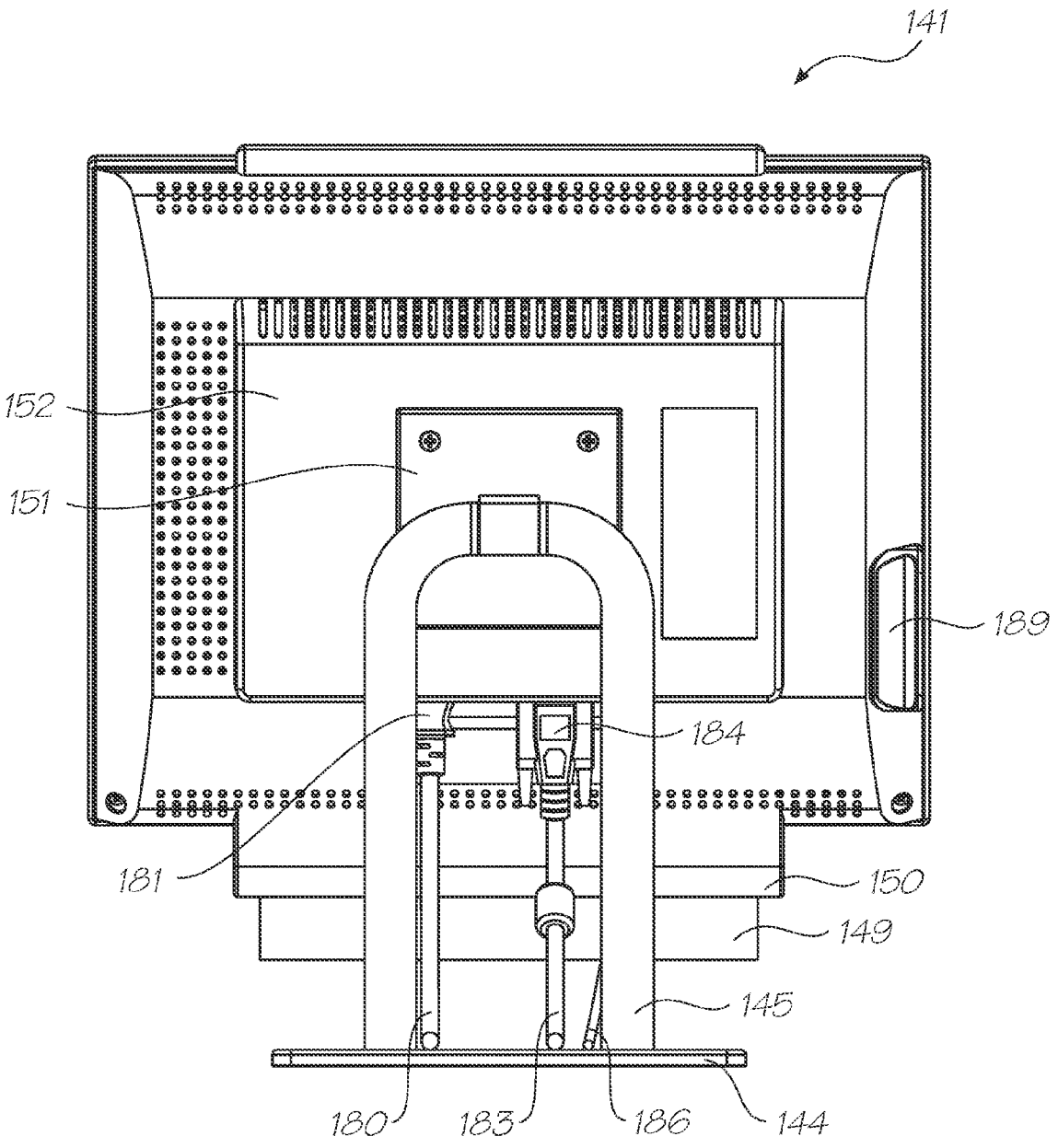


FIG. 15

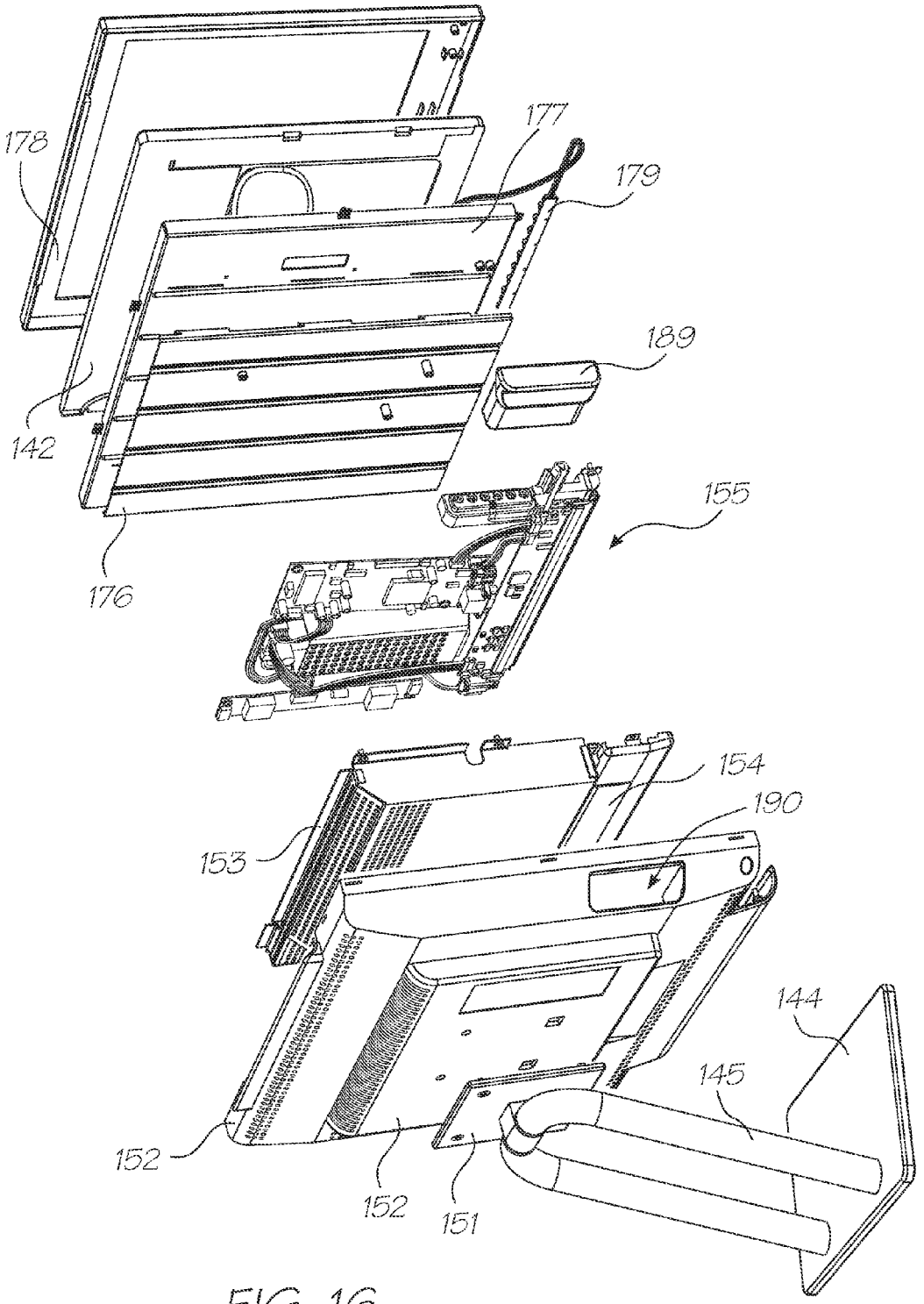


FIG. 16

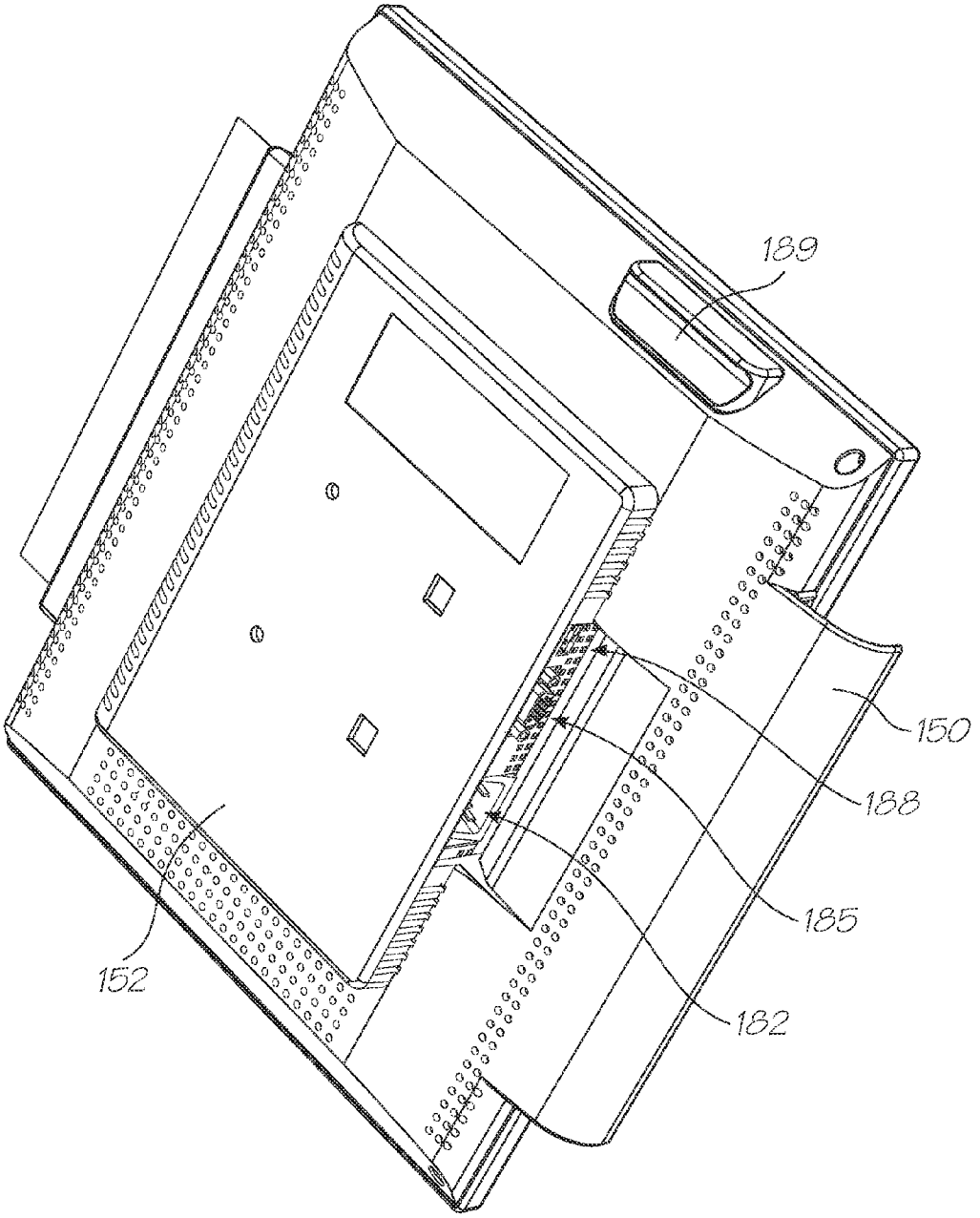


FIG. 17

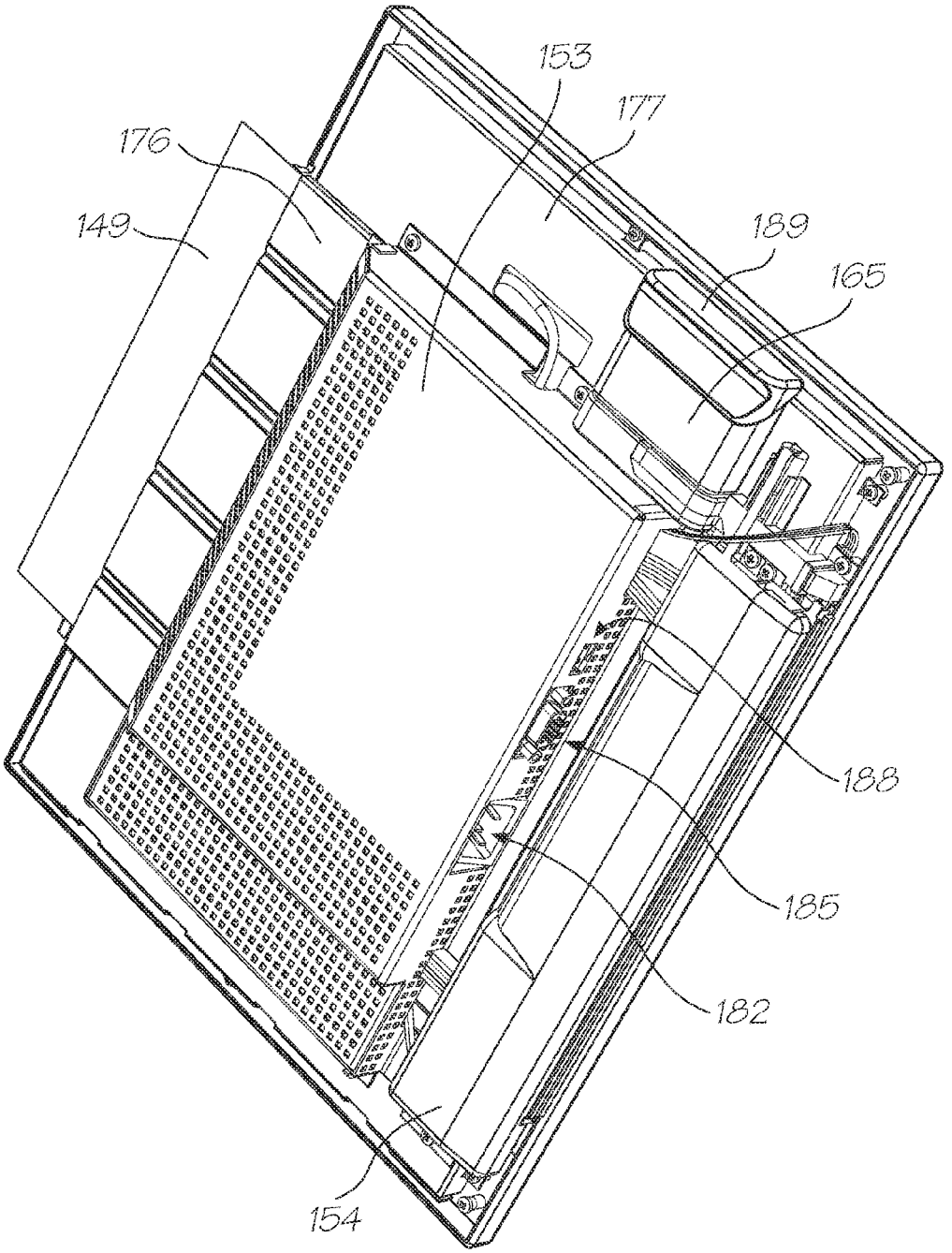


FIG. 18

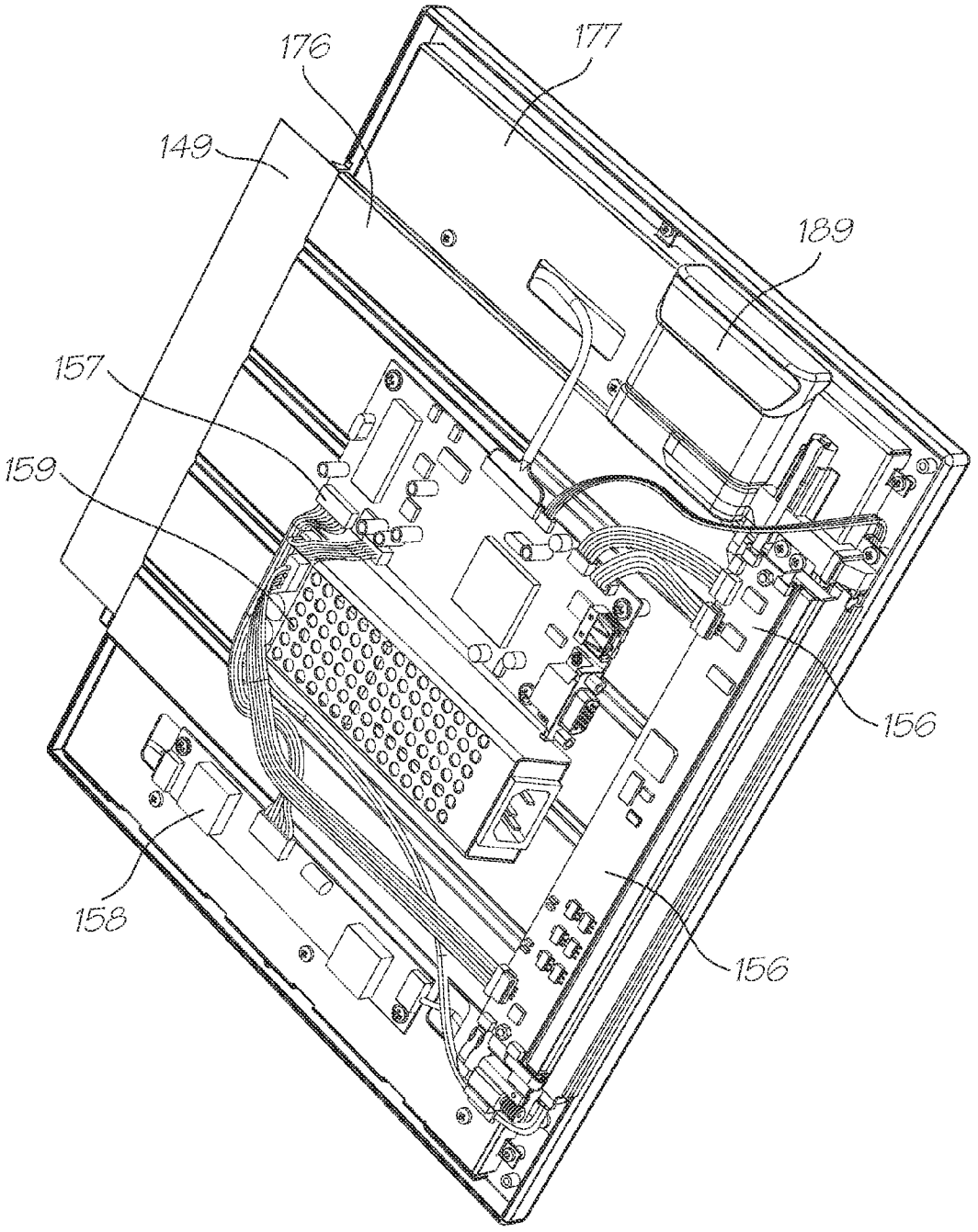


FIG. 19

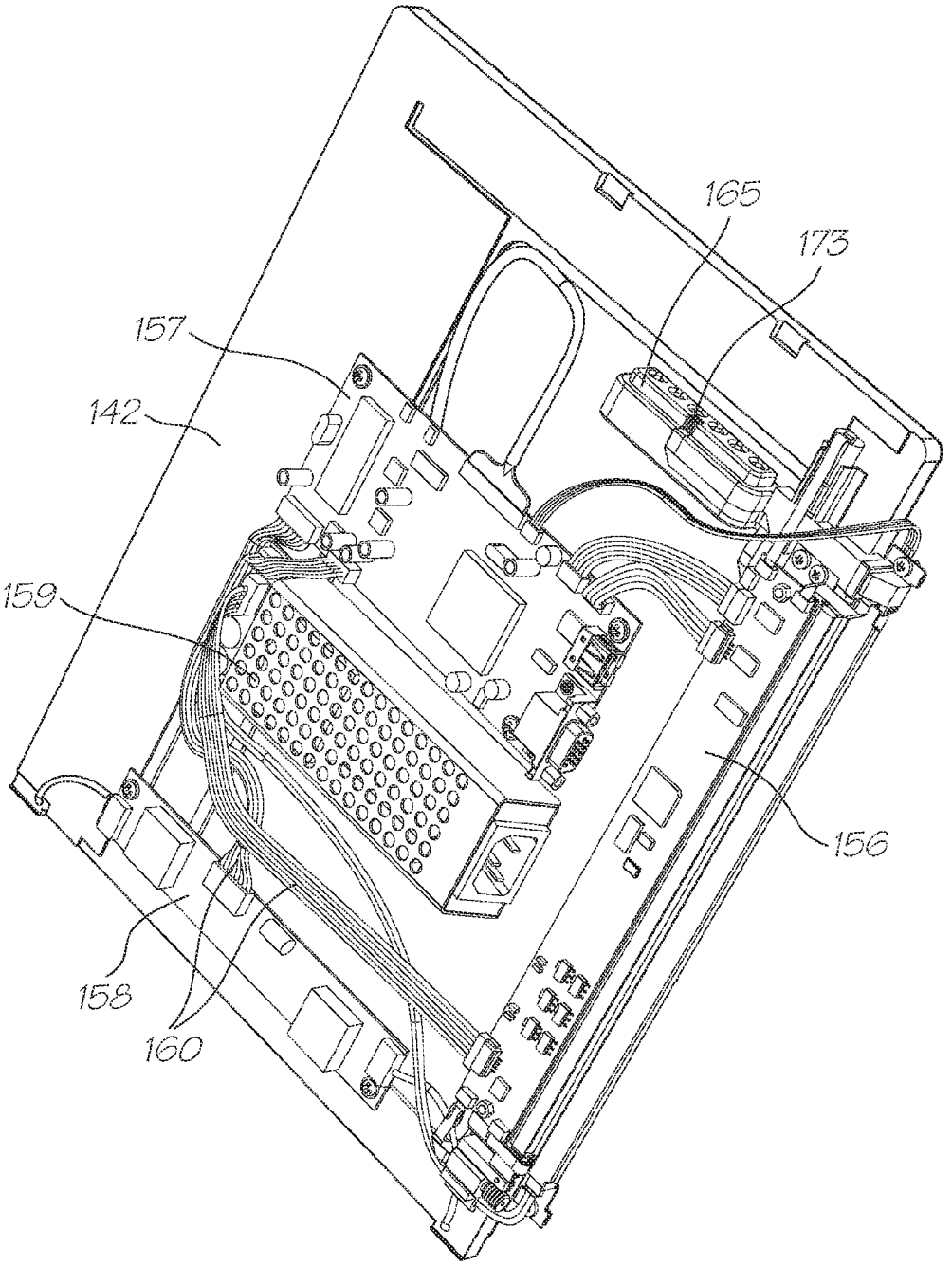


FIG. 20

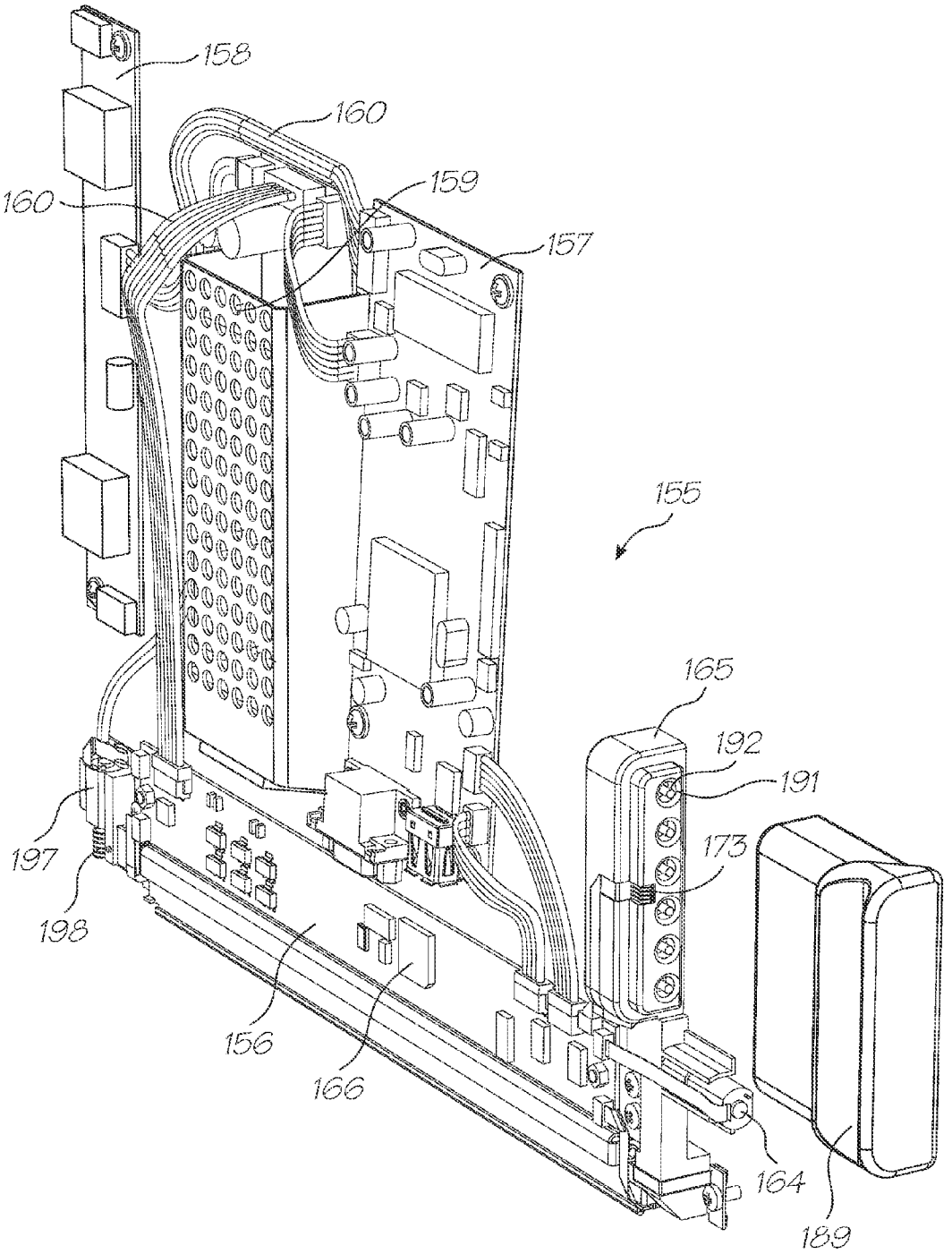


FIG. 21

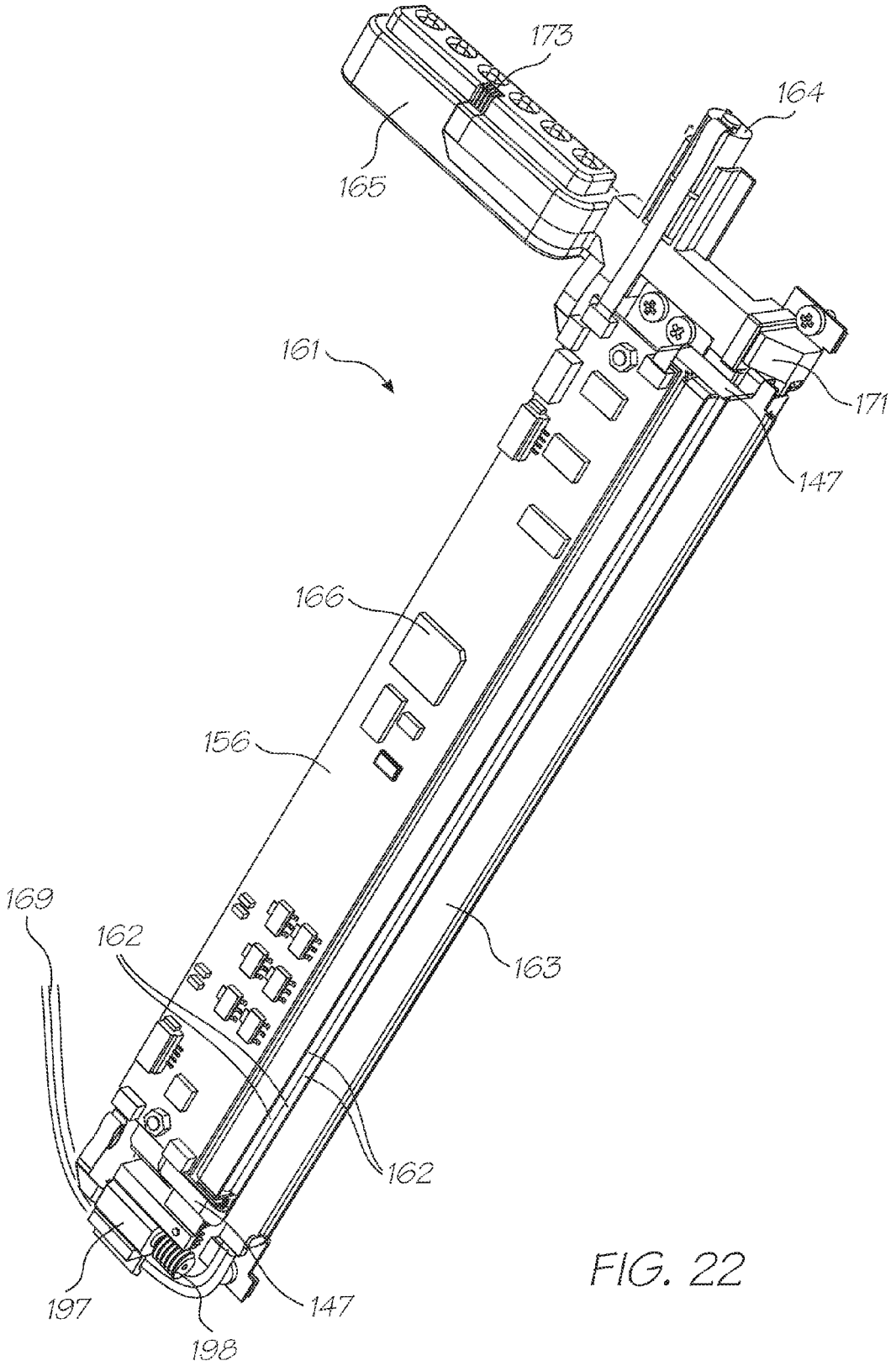


FIG. 22

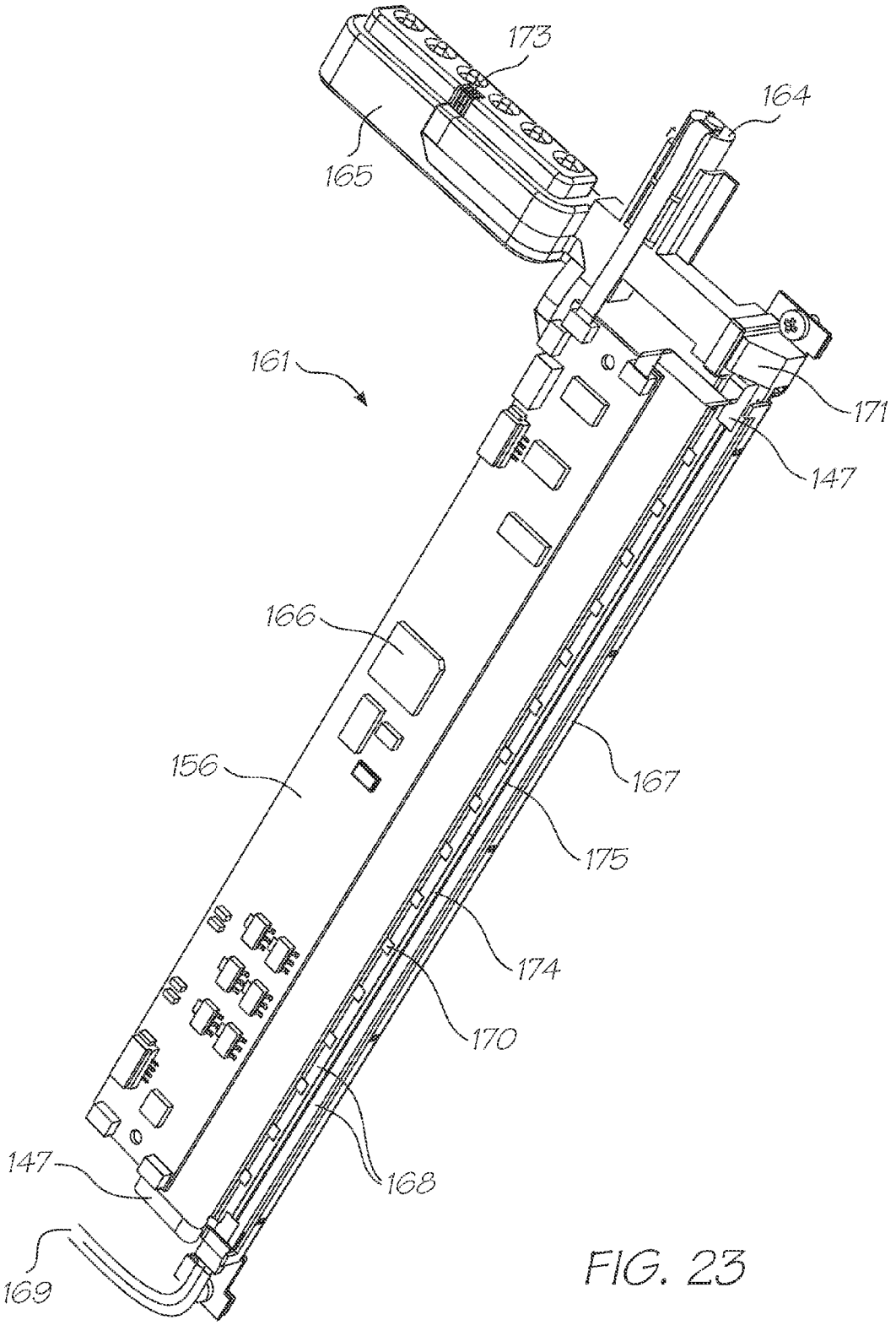


FIG. 23

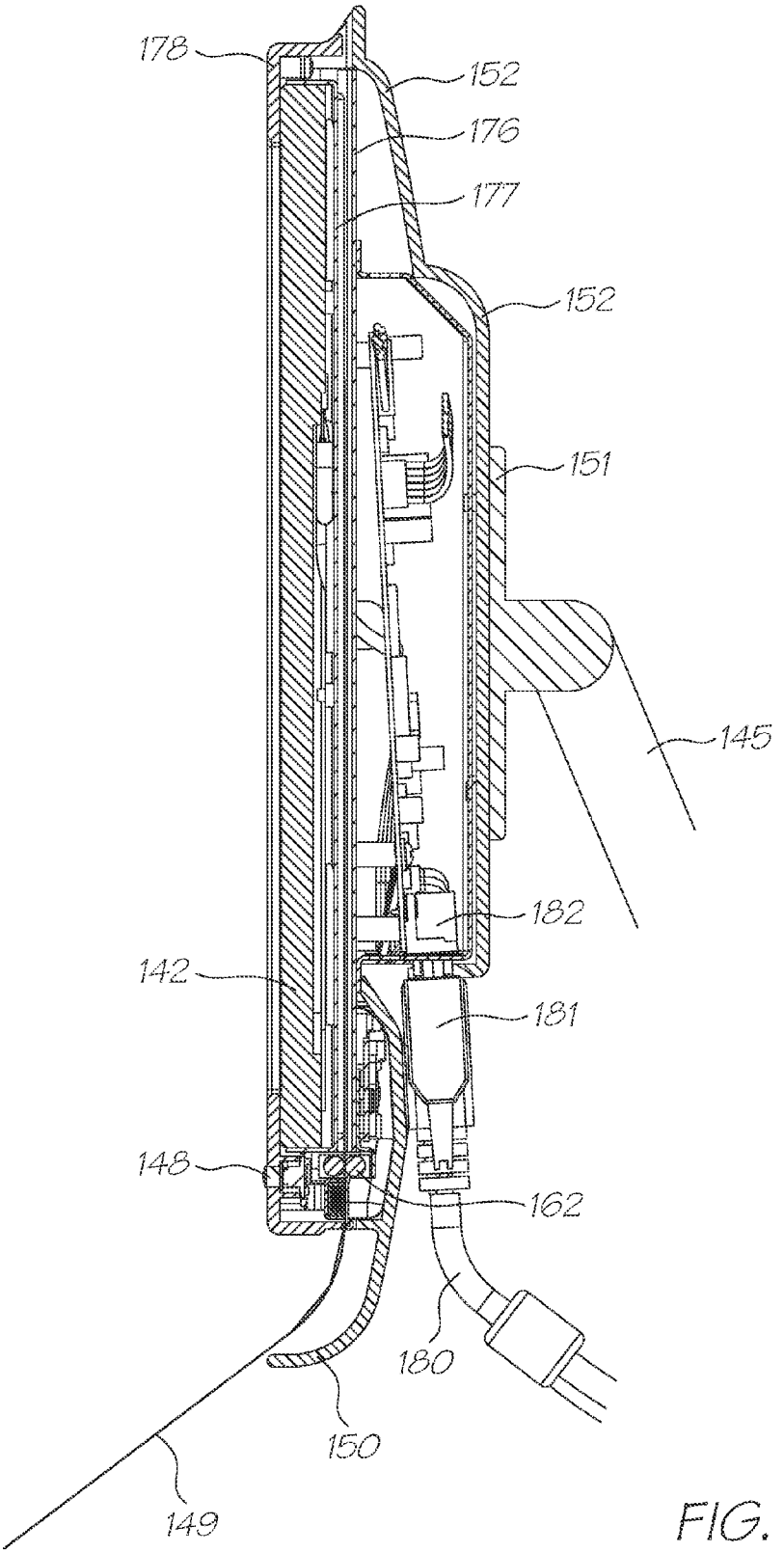


FIG. 24

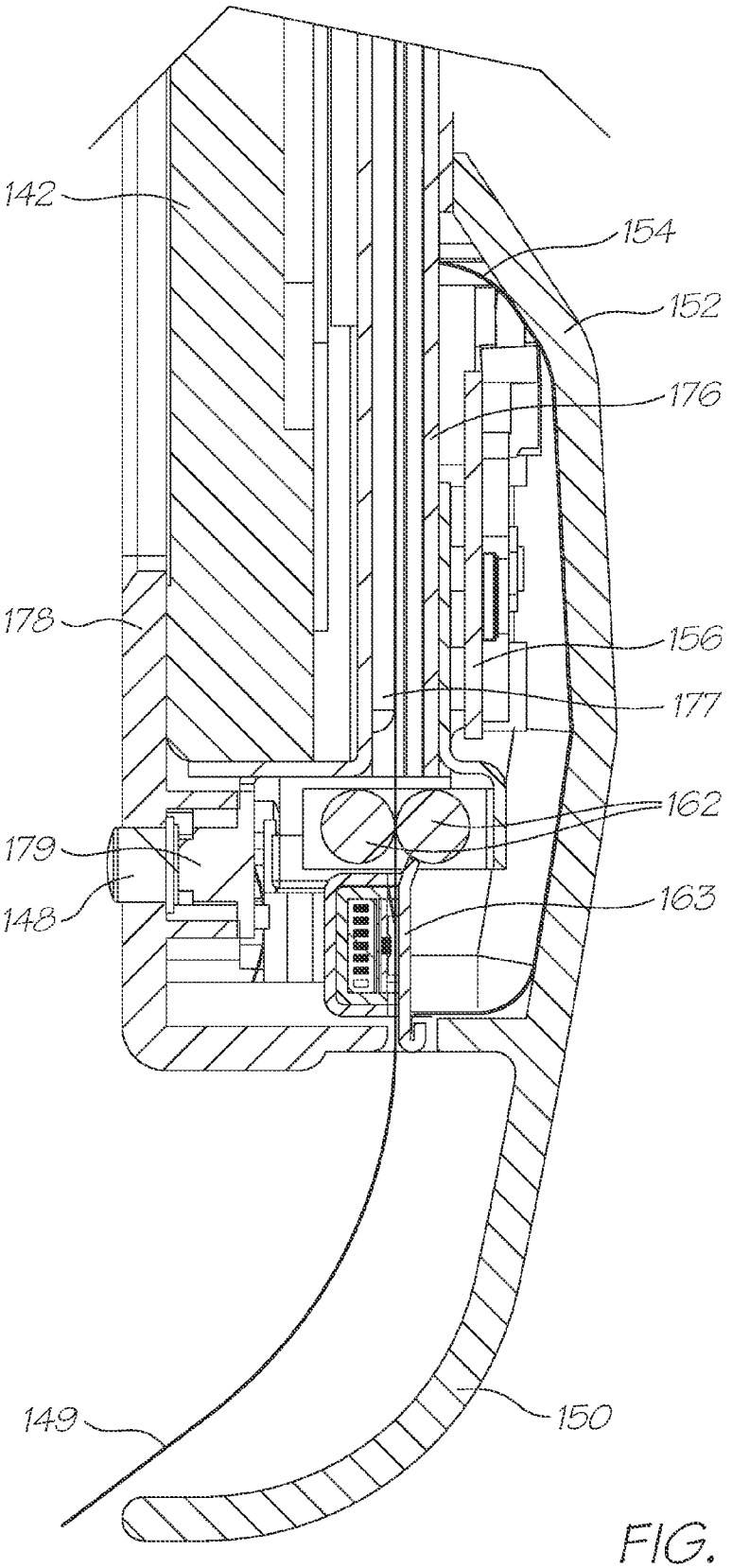


FIG. 25

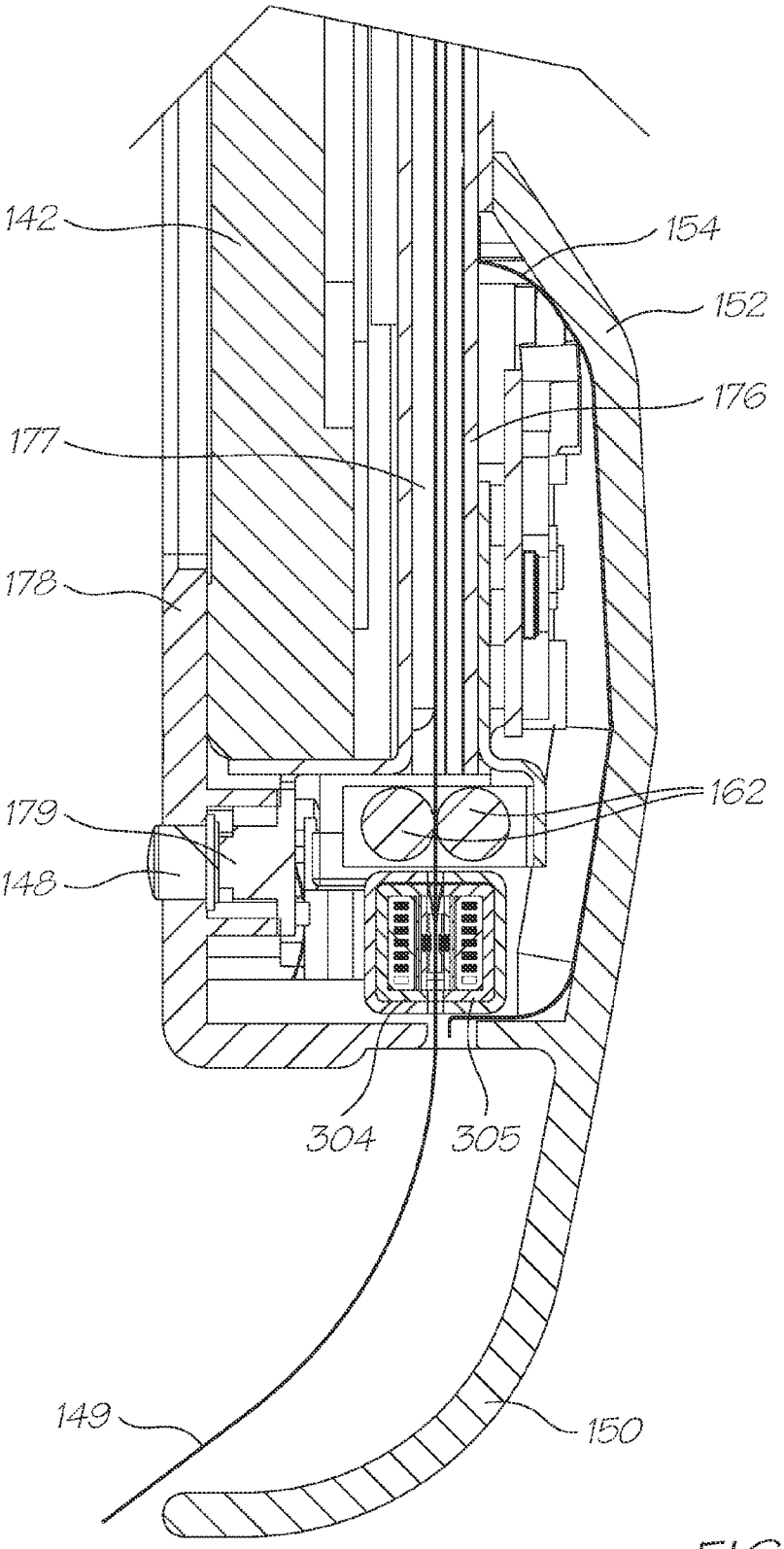


FIG. 26

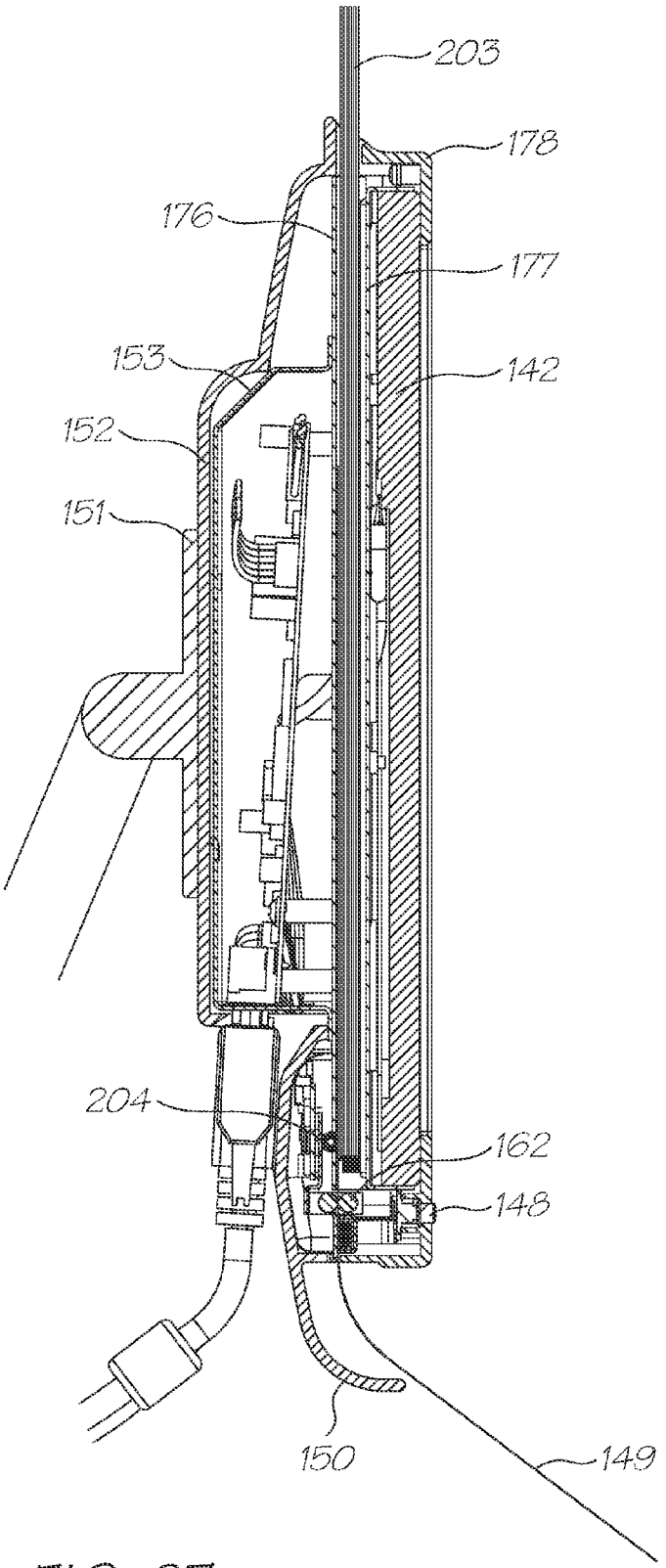


FIG. 27

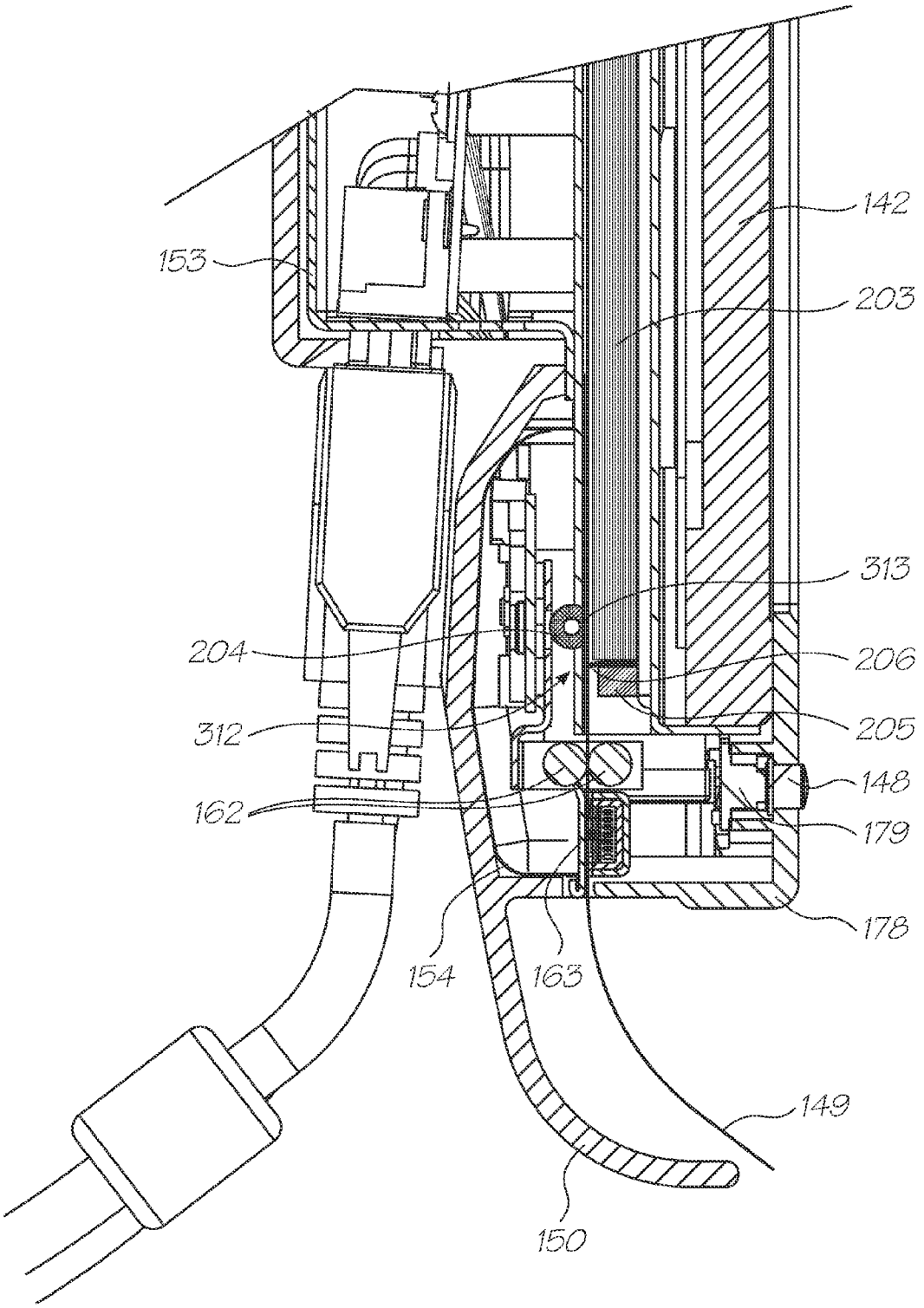


FIG. 28

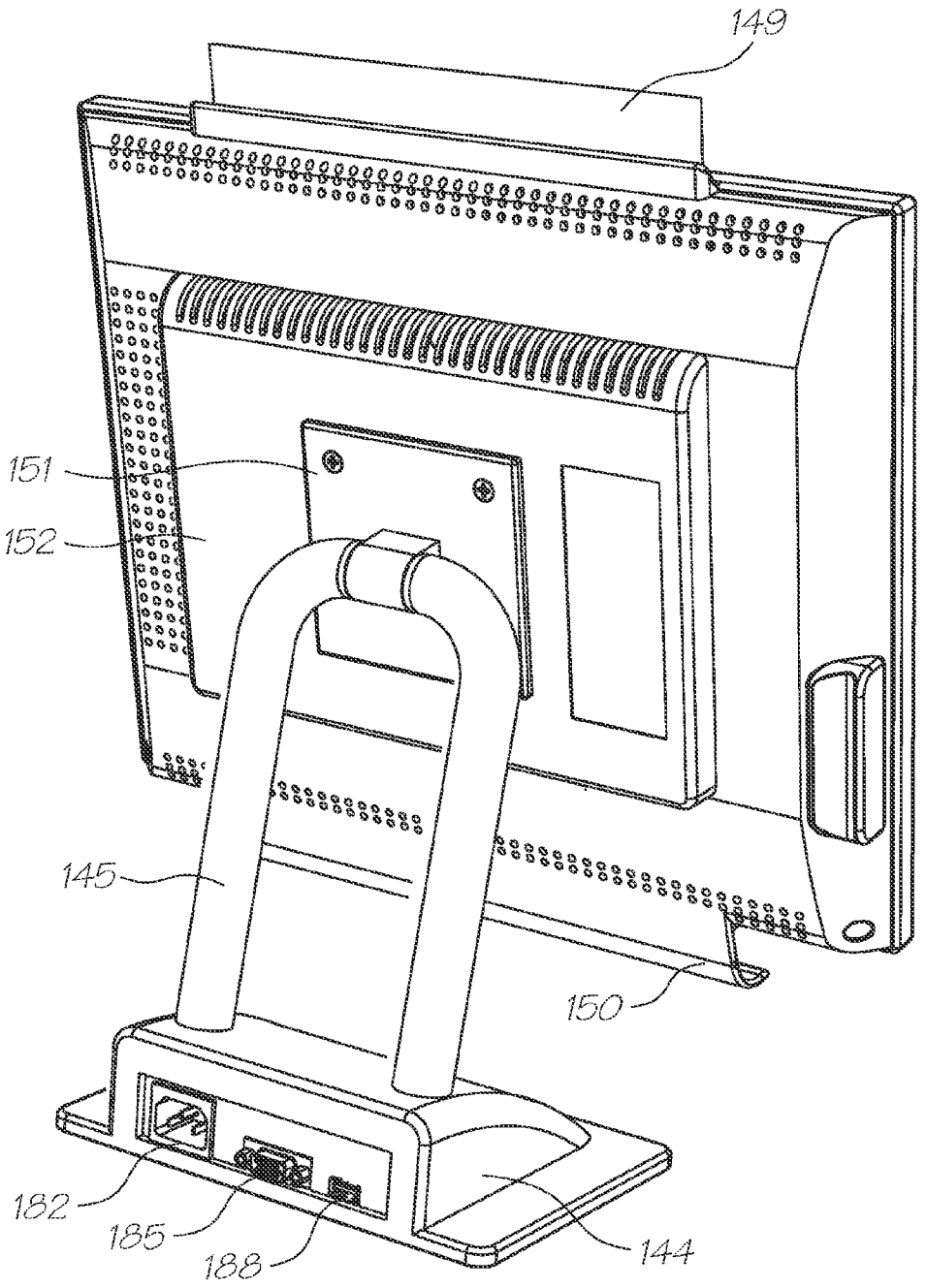


FIG. 29

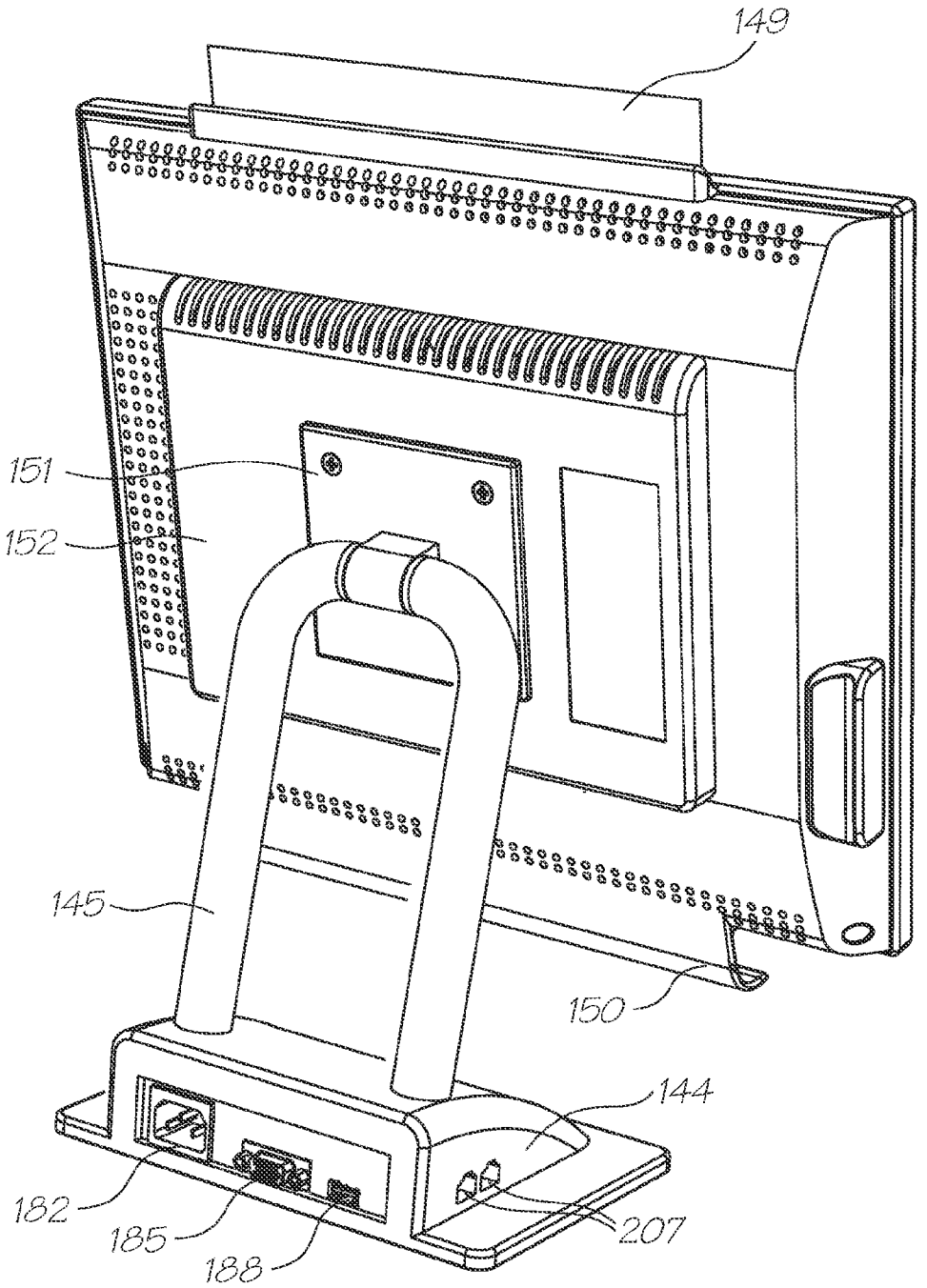


FIG. 30

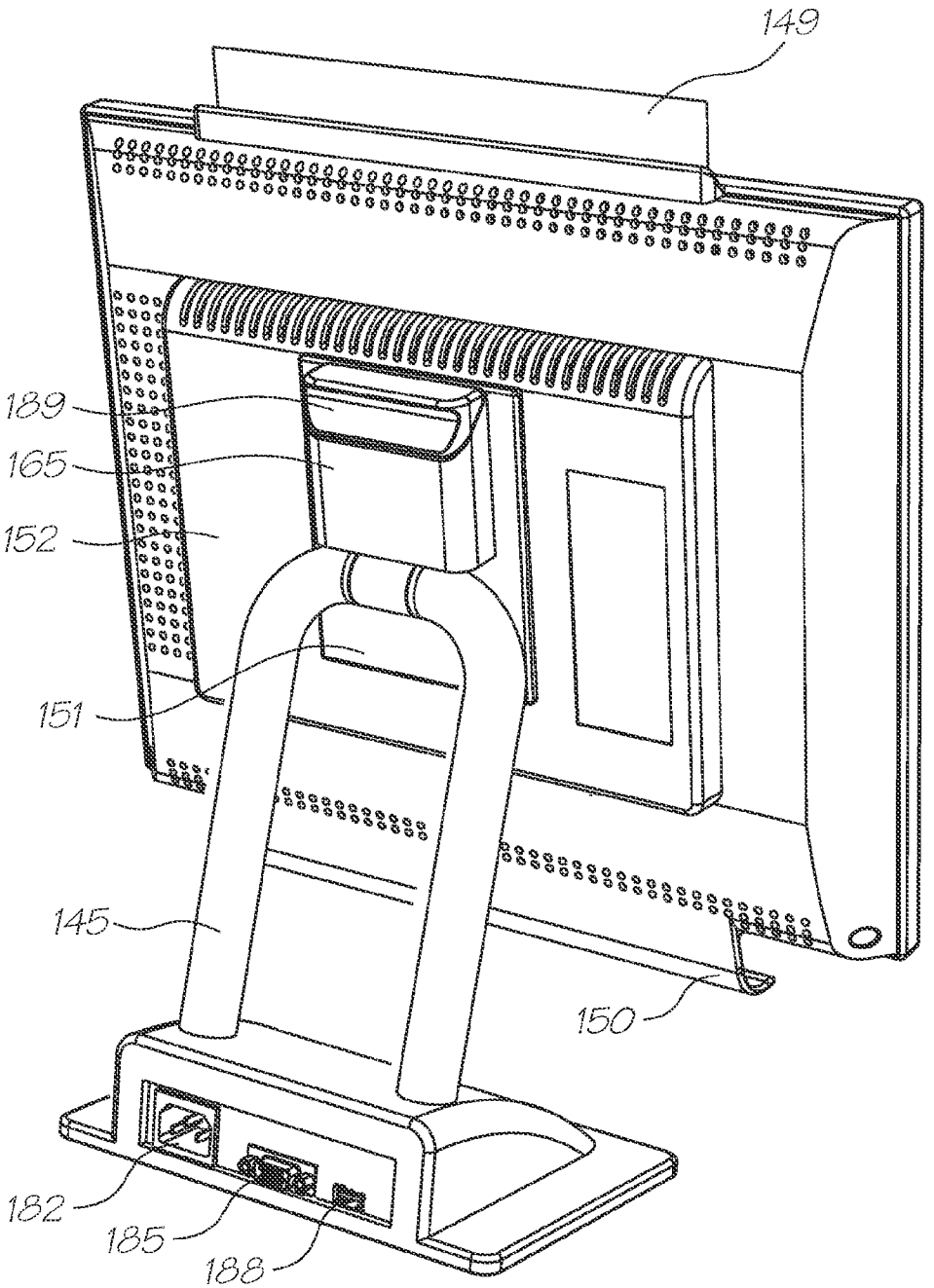


FIG. 31

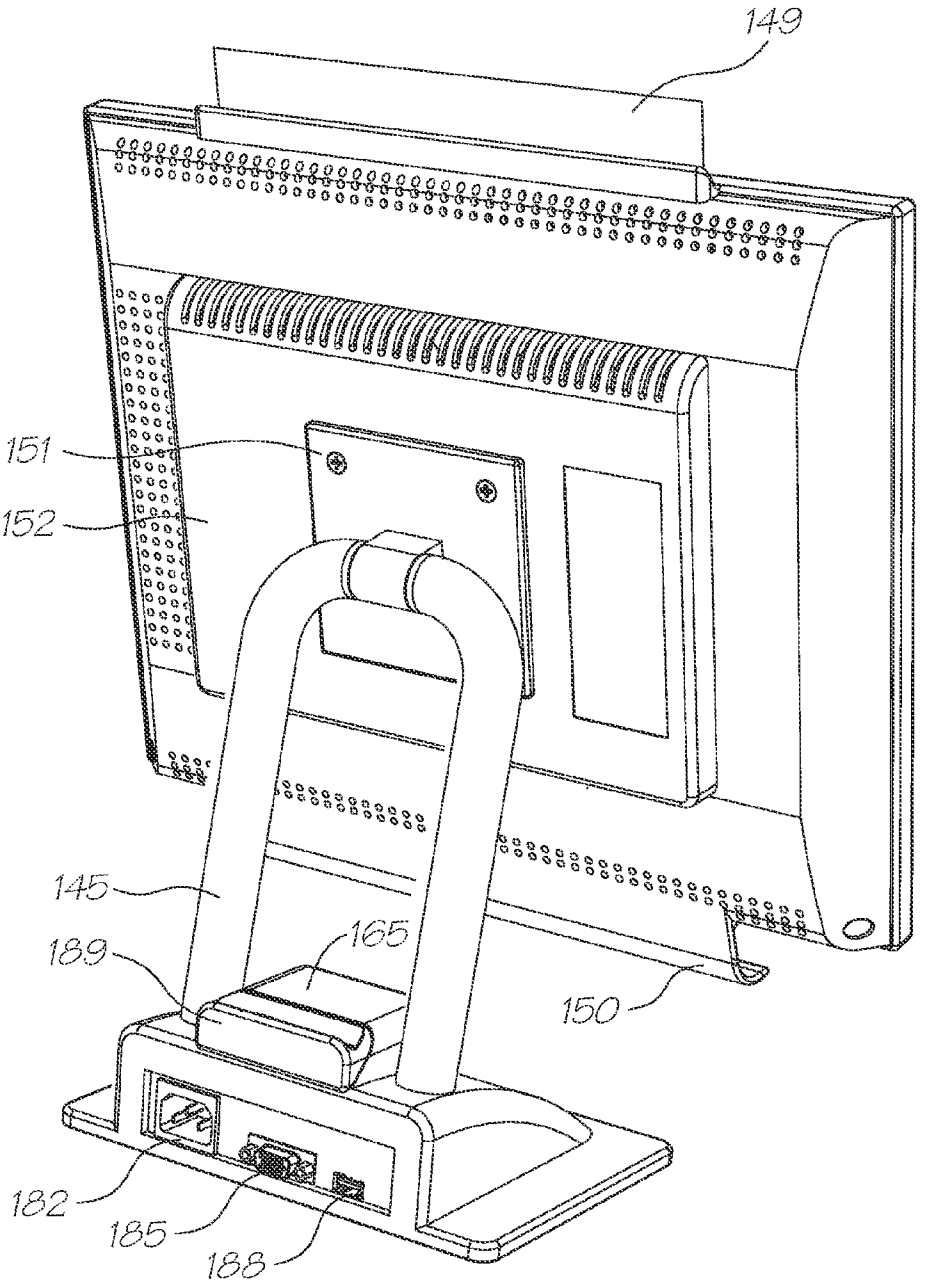


FIG. 32

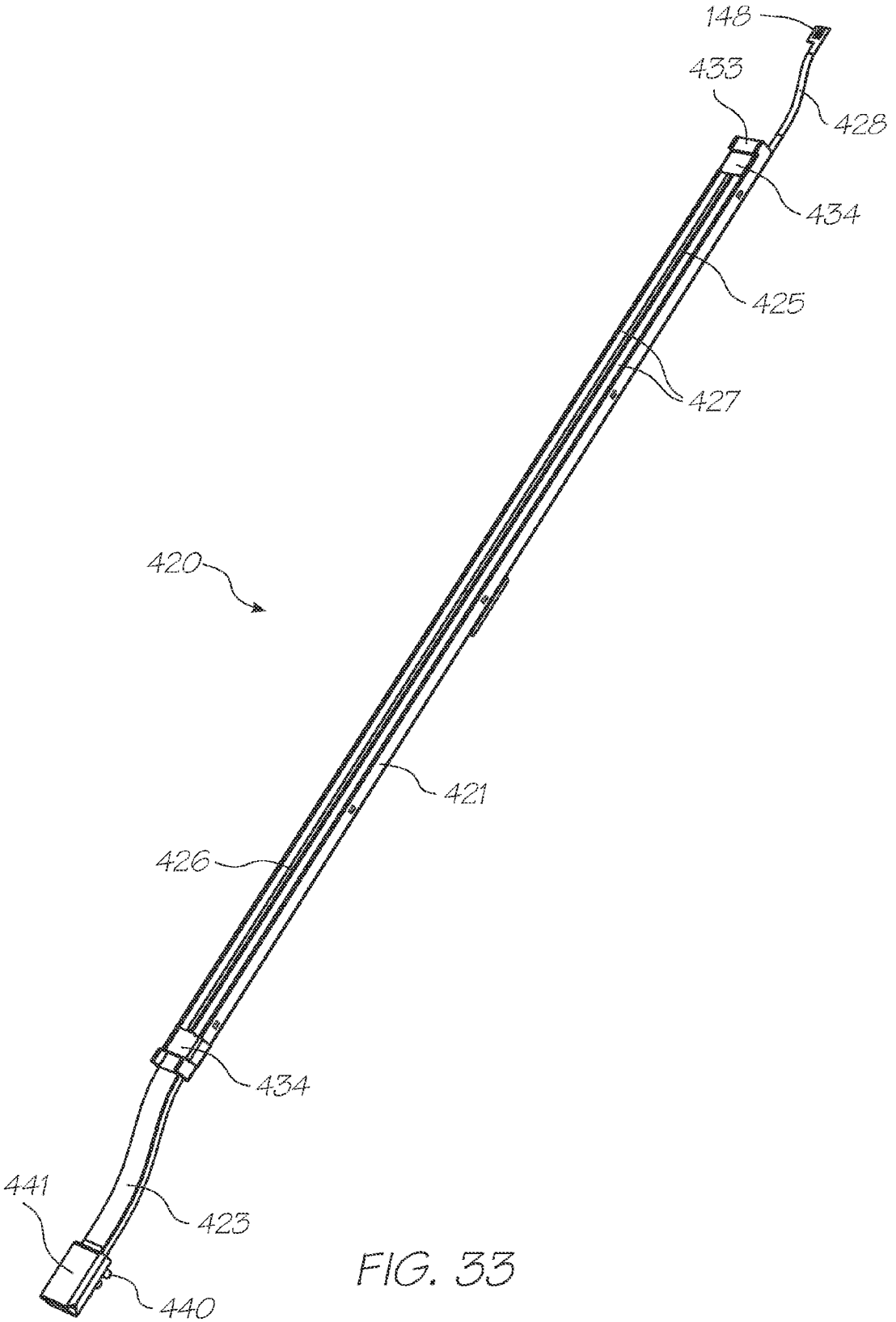


FIG. 33

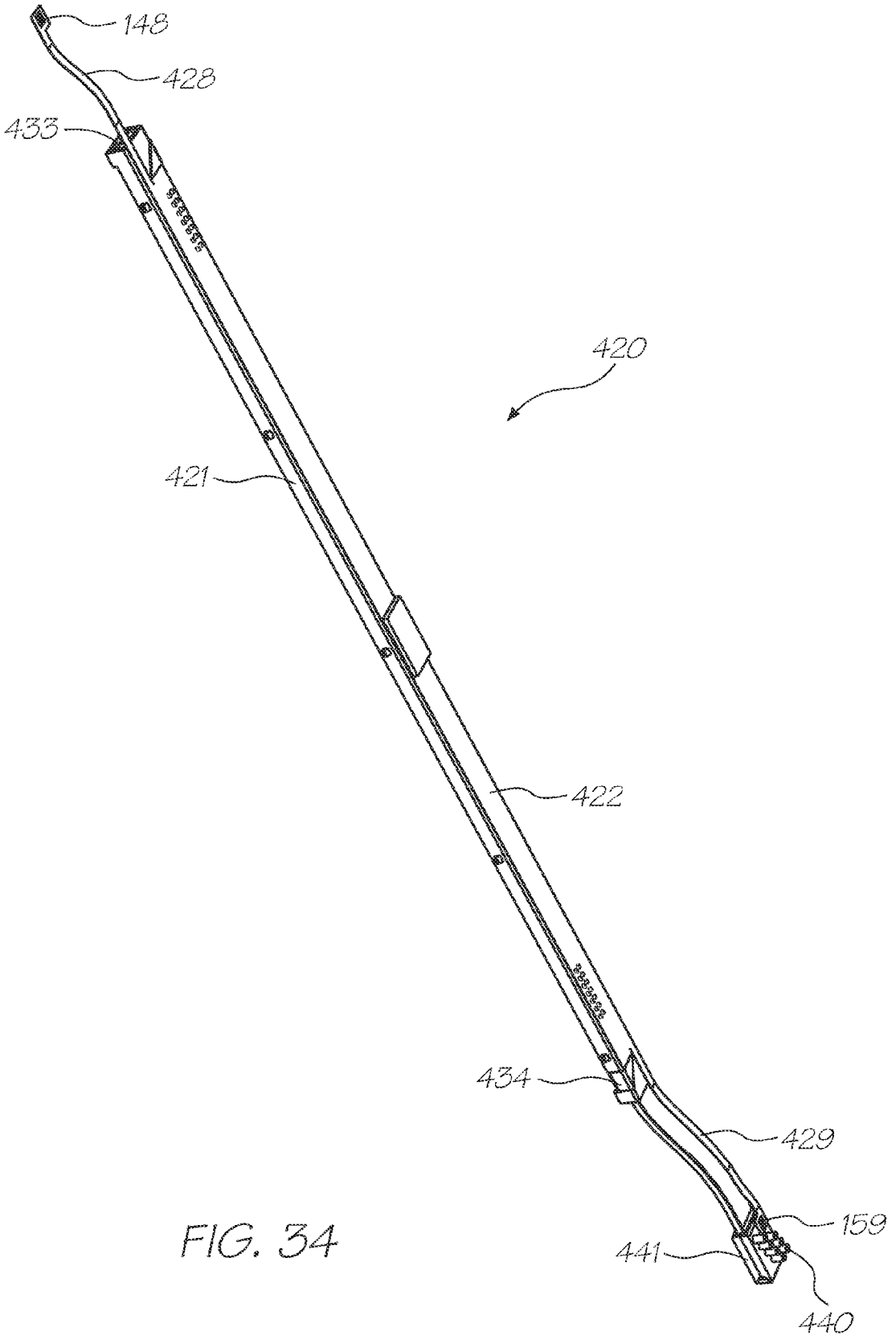


FIG. 34

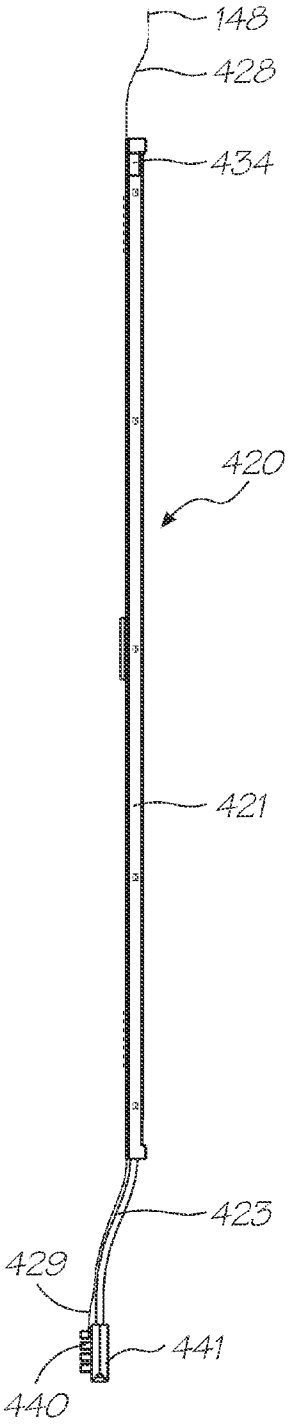


FIG. 35(A)

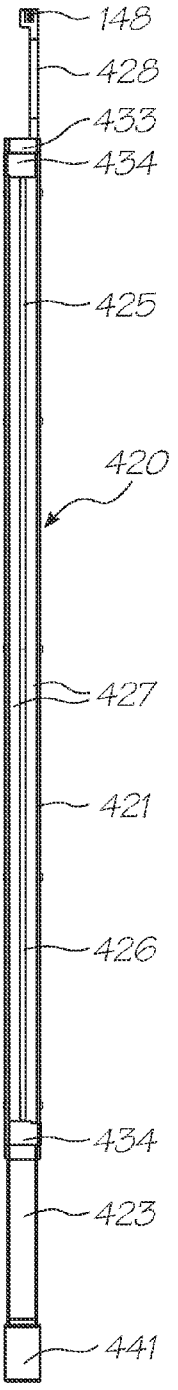


FIG. 35(B)

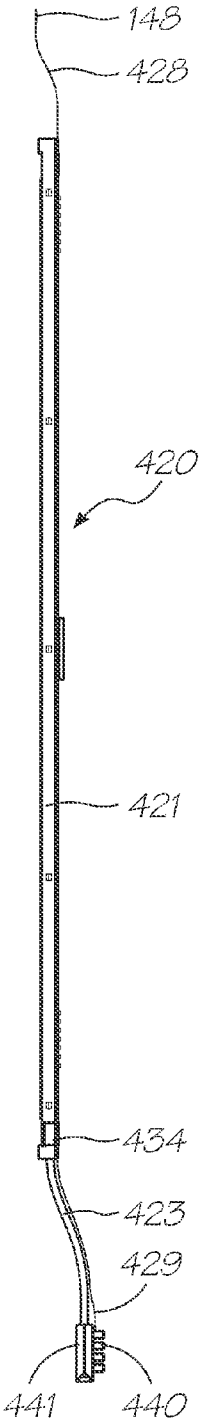


FIG. 35(C)

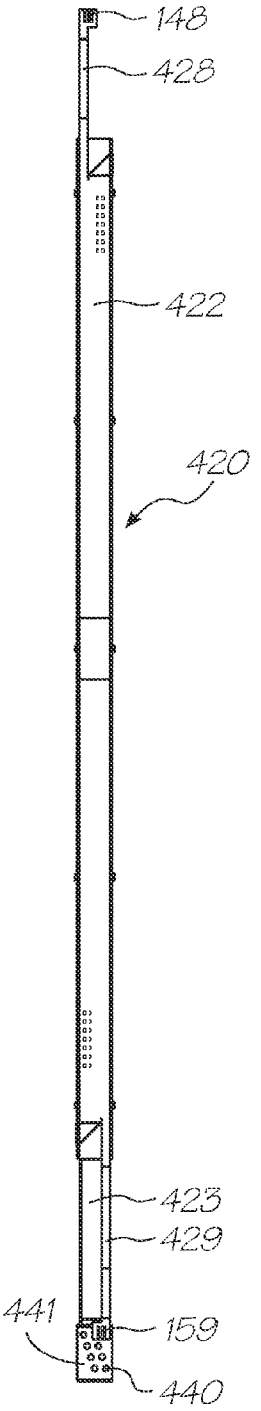


FIG. 35(D)

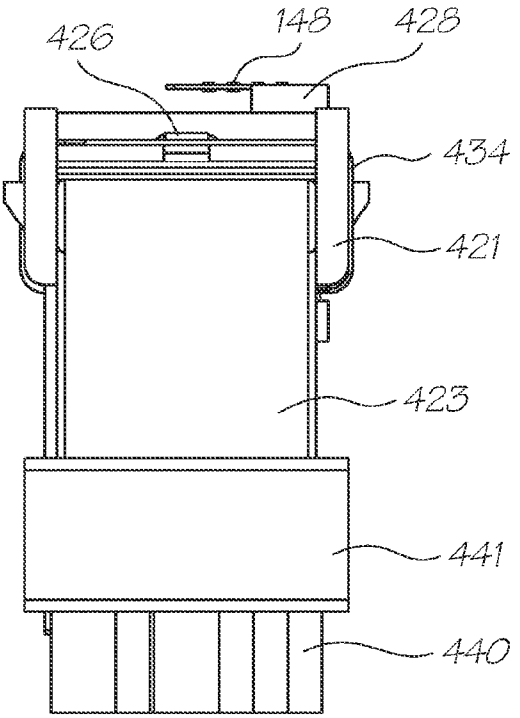

426
148
428
434
421
423
441
440

FIG. 36

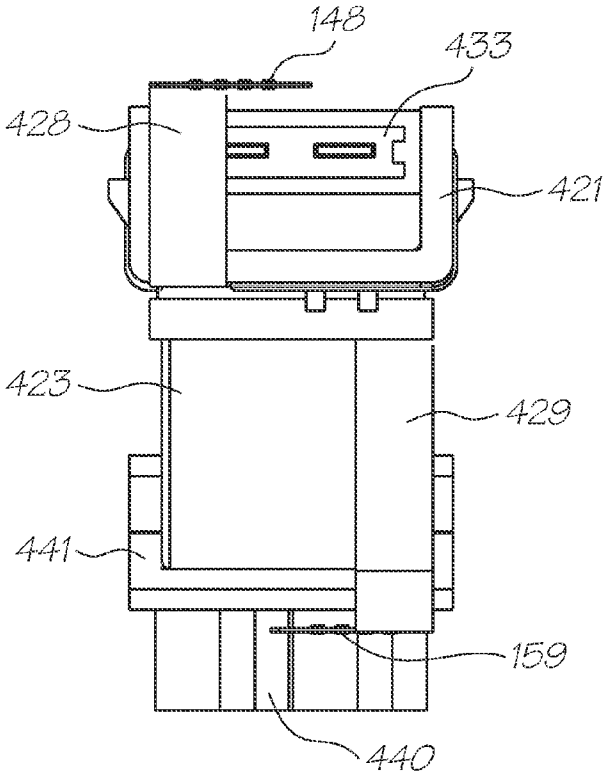

148
433
428
421
423
429
441
159
440

FIG. 37

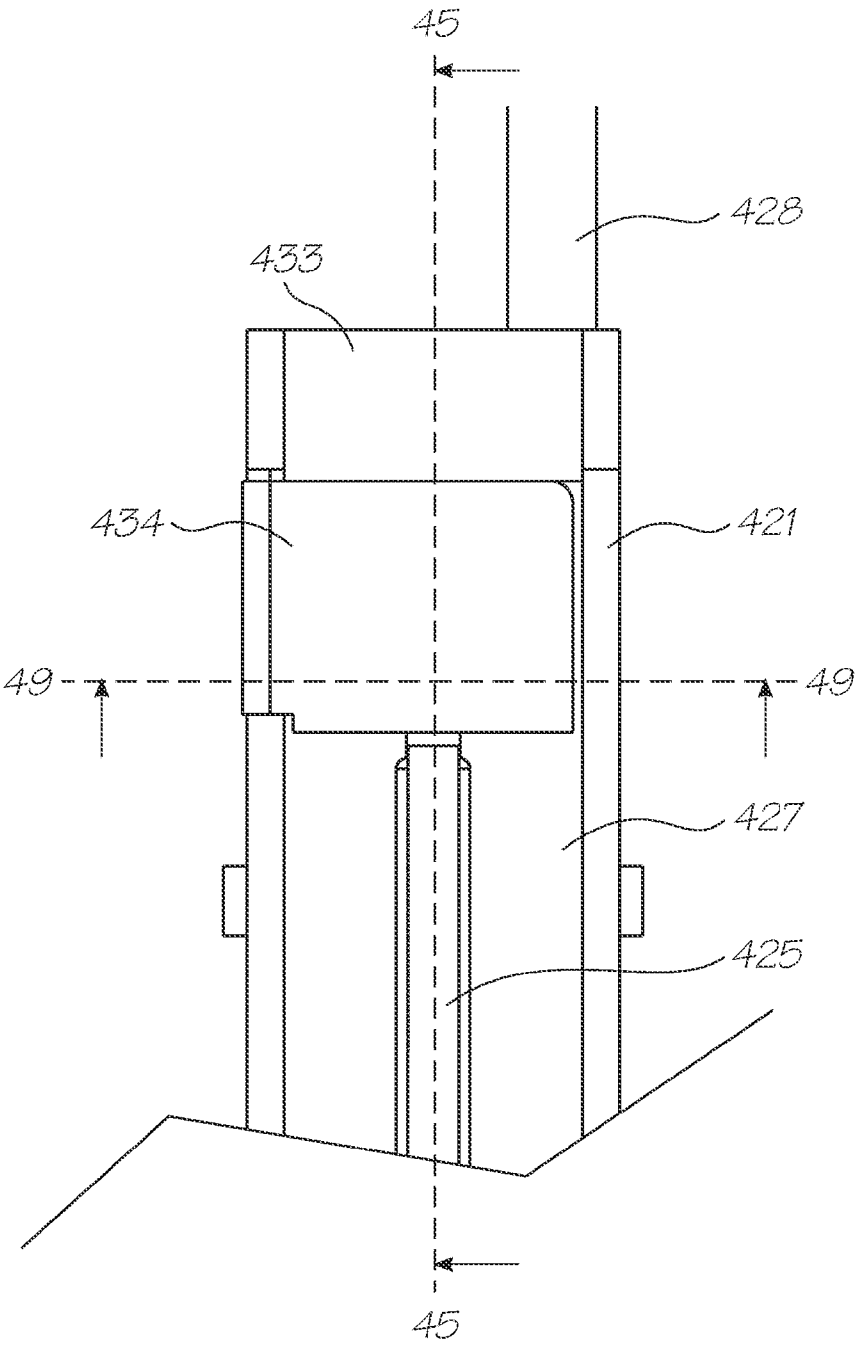


FIG. 38

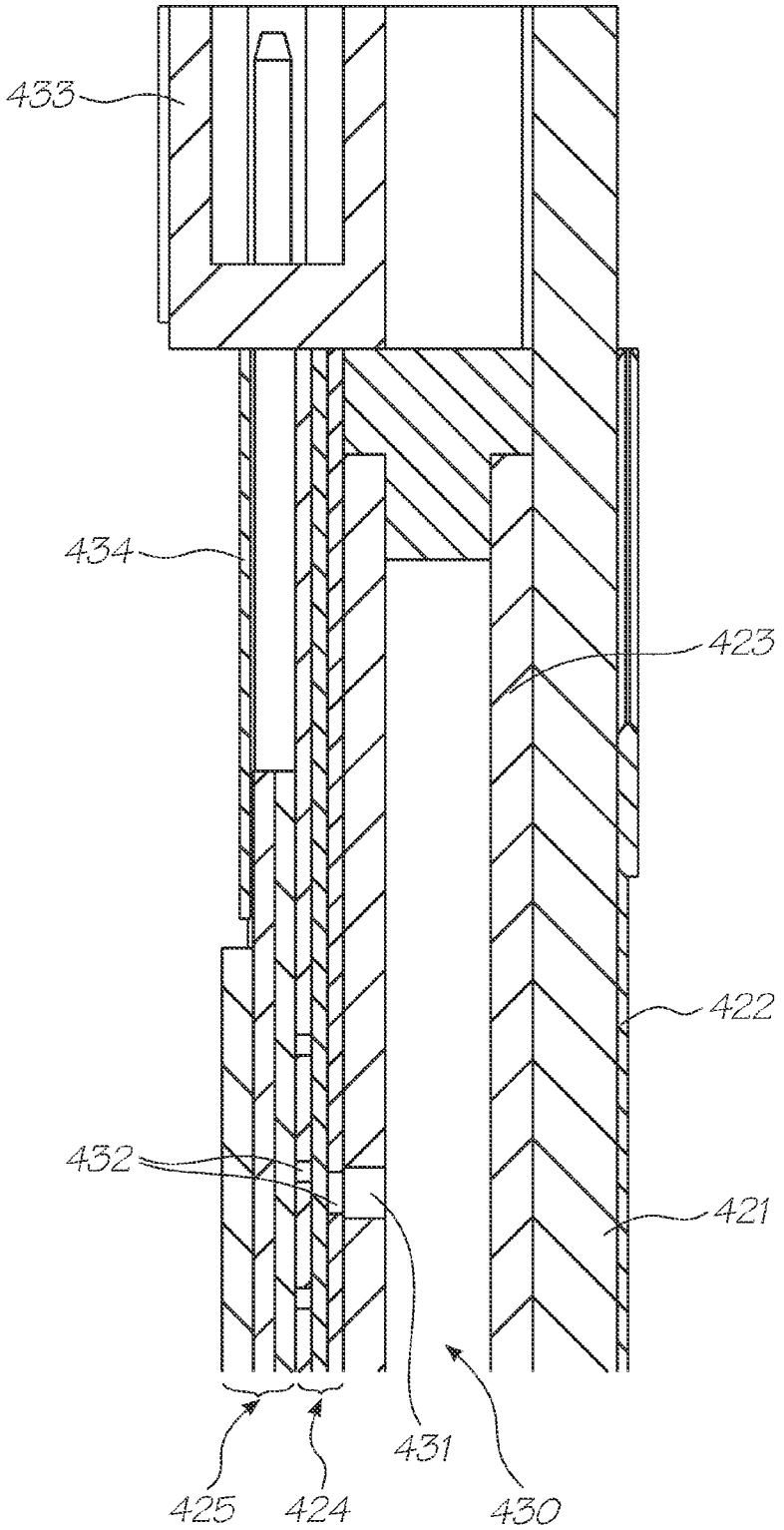


FIG. 39

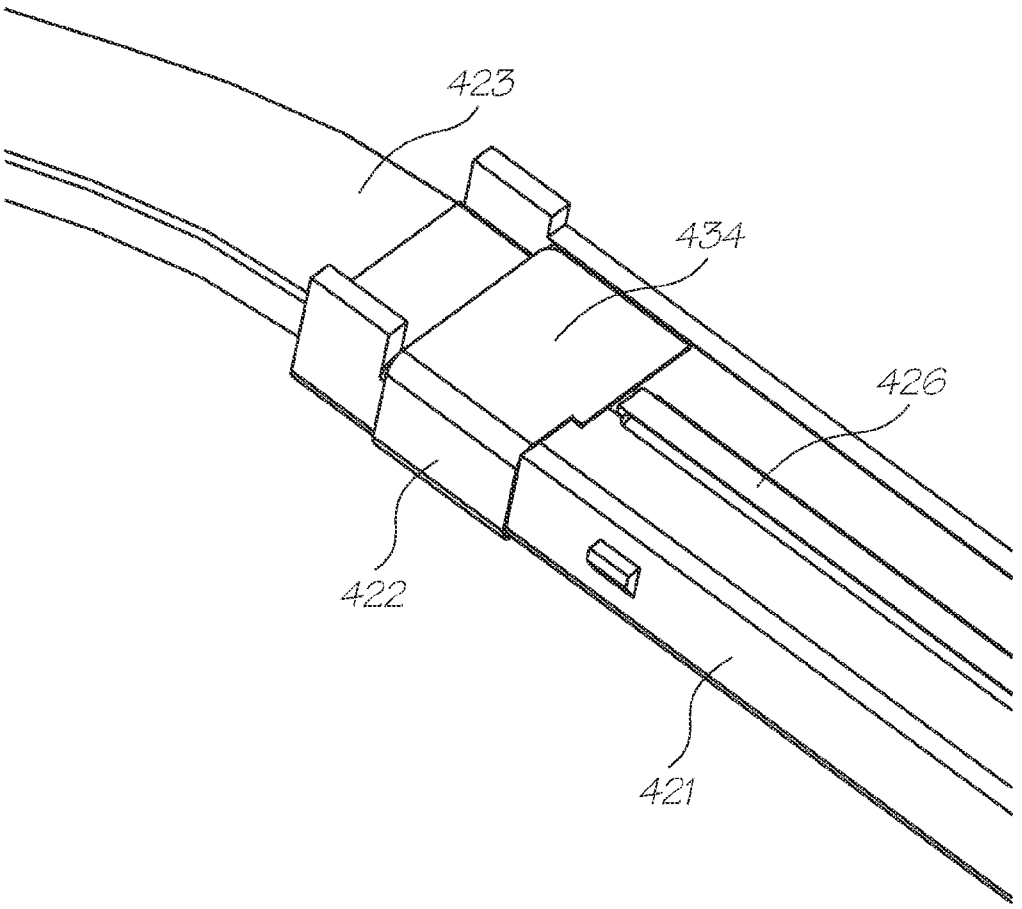


FIG. 40

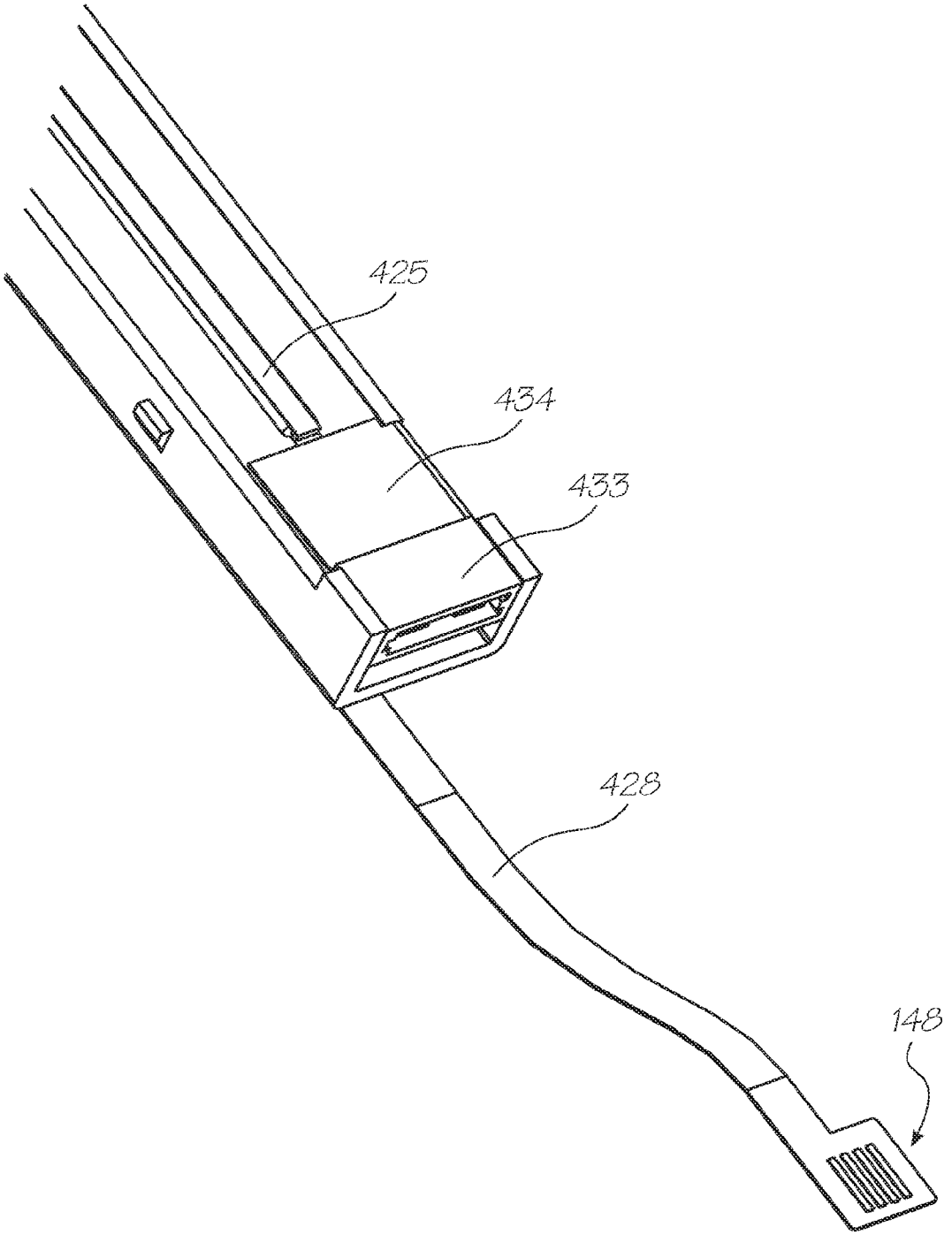


FIG. 41

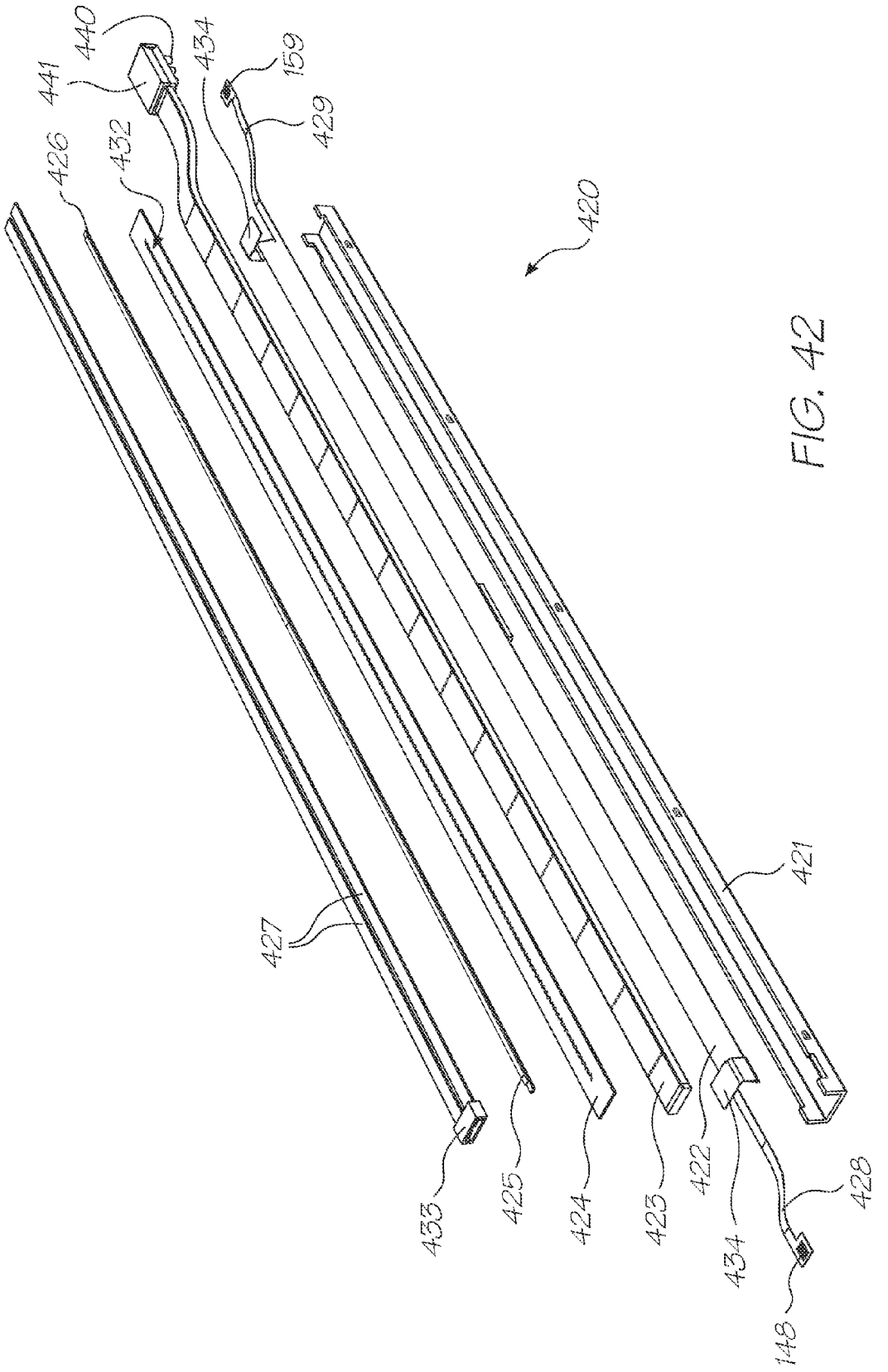

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159
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420
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421
433
425
424
423
422
434
428
148

FIG. 42

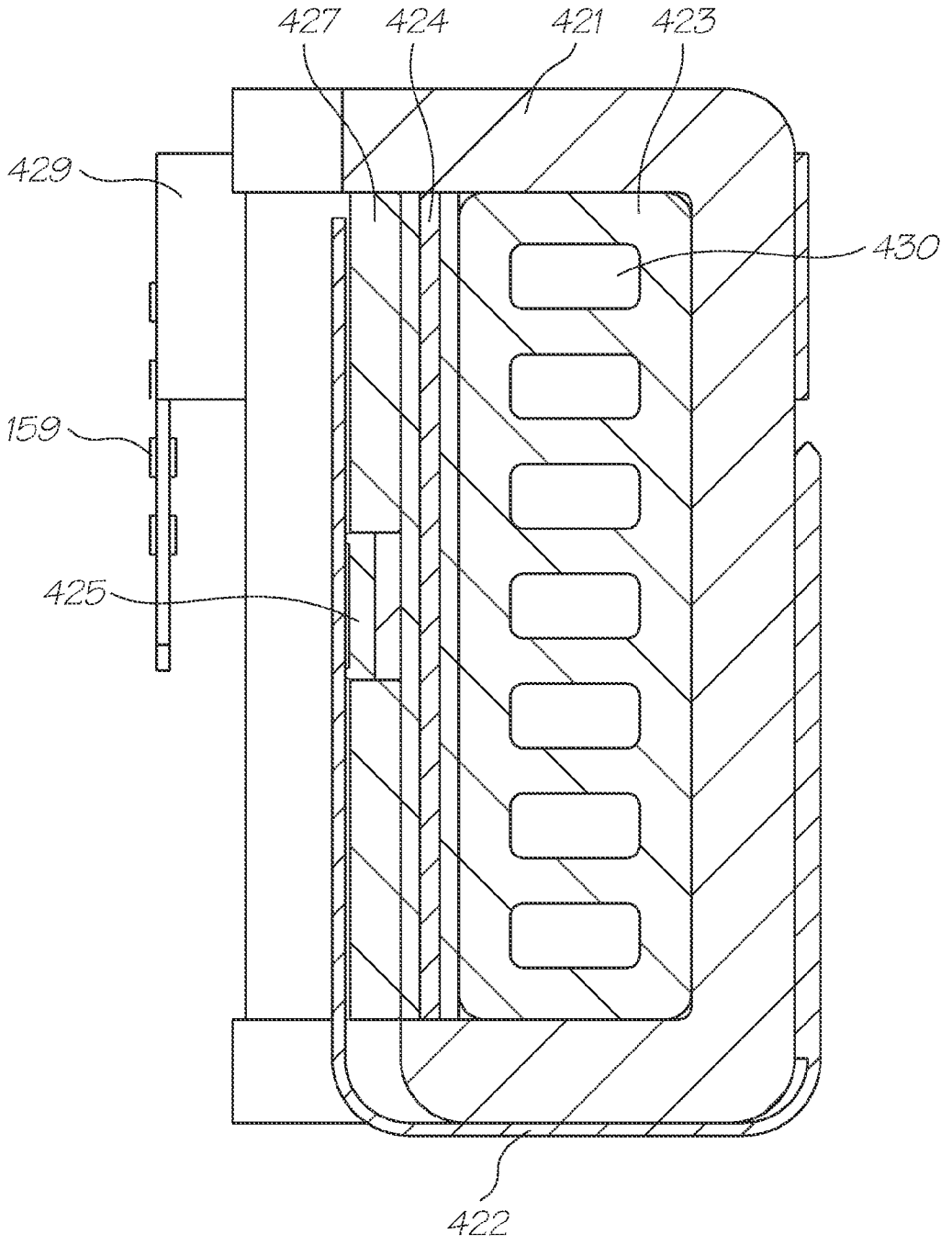


FIG. 43

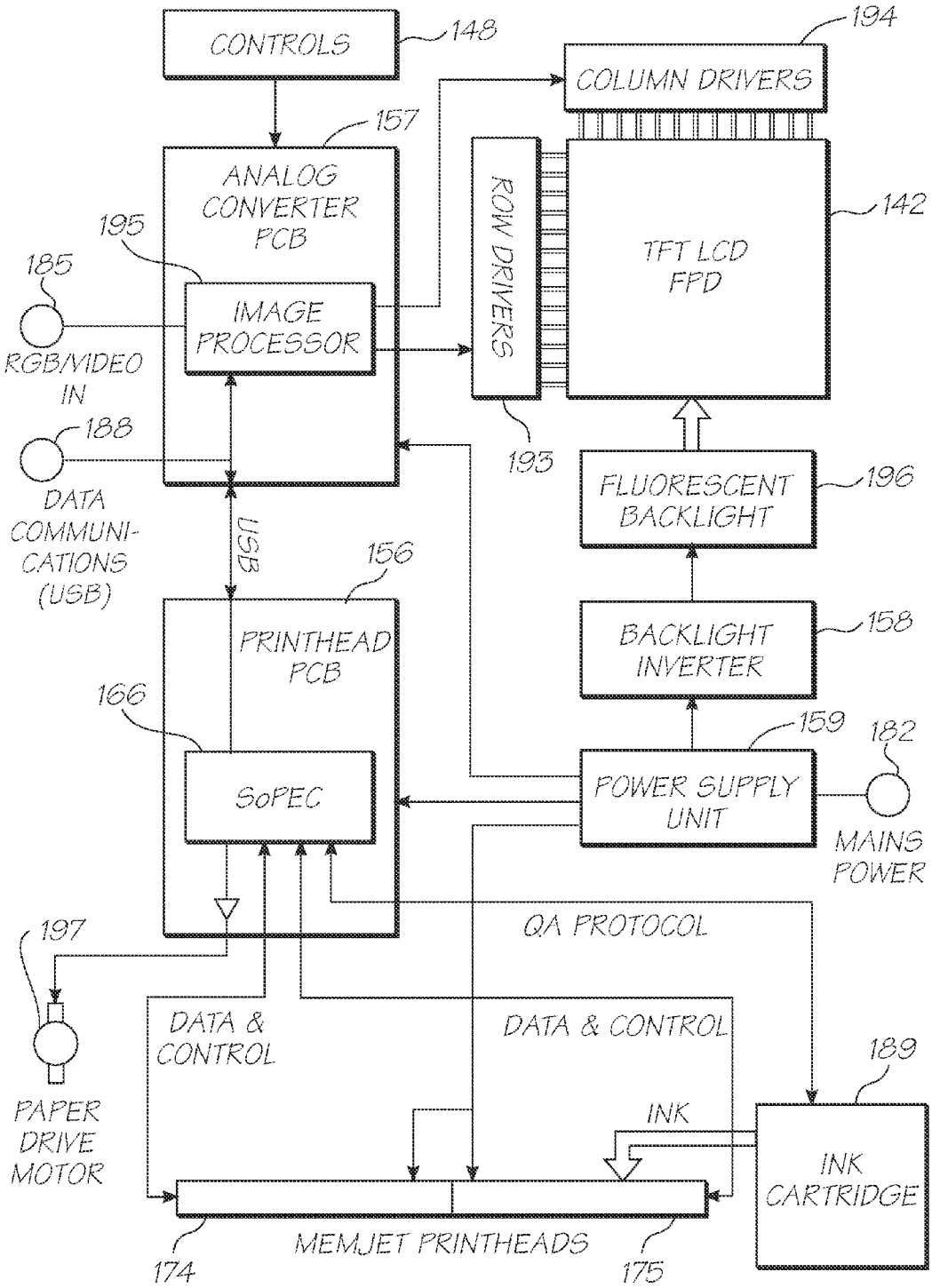

CONTROLS
148
194
COLUMN DRIVERS
157
ANALOG CONVERTER PCB
195
IMAGE PROCESSOR
185
RGB/VIDEO IN
188
DATA COMMUNI-CATIONS (USB)
USB
ROW DRIVERS
193
TFT LCD FPD
142
FLUORESCENT BACKLIGHT
196
BACKLIGHT INVERTER
158
159
182
POWER SUPPLY UNIT
MAINS POWER
156
PRINTHEAD PCB
166
SoPEC
QA PROTOCOL
197
PAPER DRIVE MOTOR
DATA & CONTROL
DATA & CONTROL
189
INK
INK CARTRIDGE
MEMJET PRINTHEADS
174
175

FIG. 44

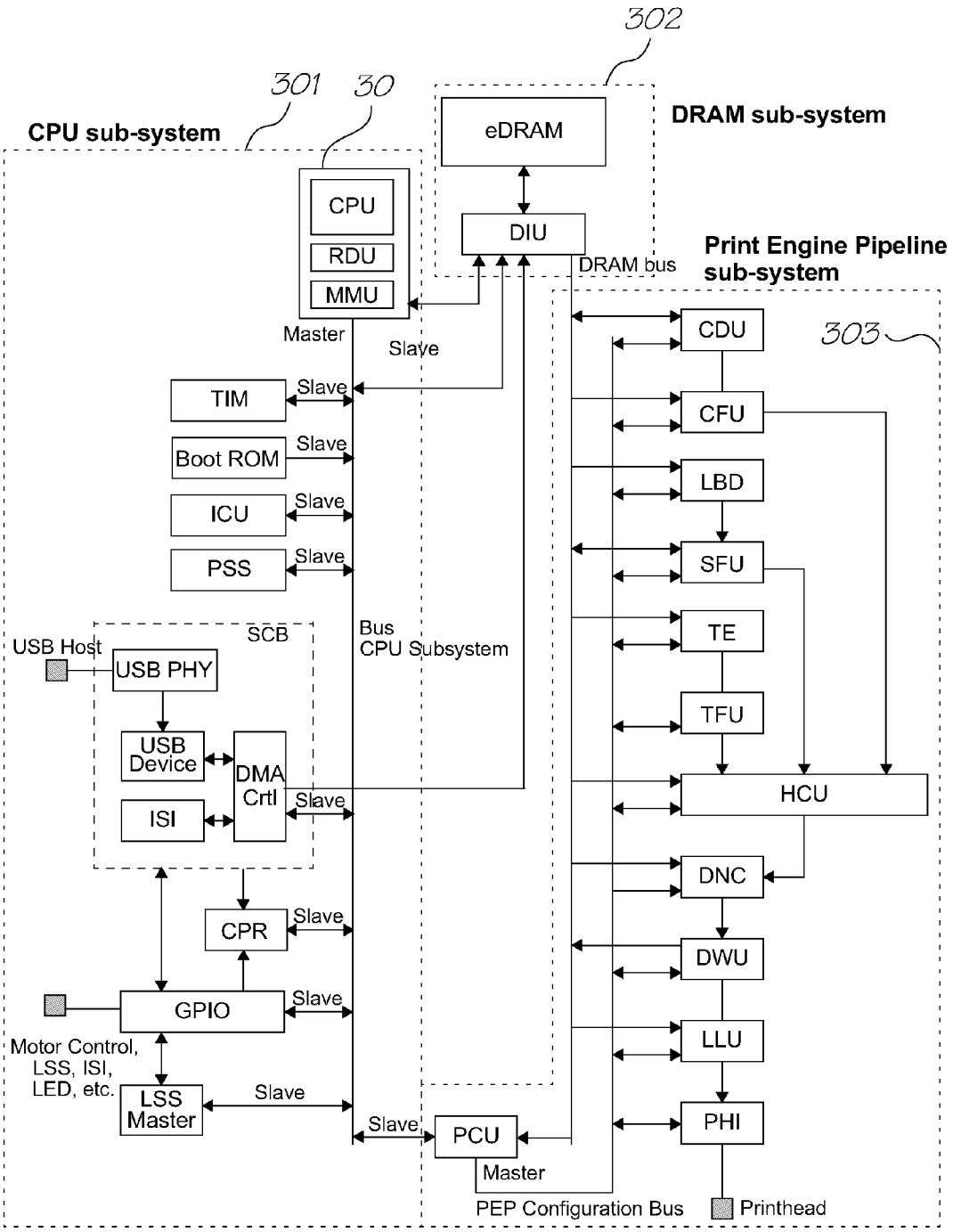

302
301
30
CPU sub-system
eDRAM
DRAM sub-system
CPU
RDU
MMU
DIU
DRAM bus
Print Engine Pipeline sub-system
Master
Slave
303
CDU
TIM
Slave
CFU
Boot ROM
Slave
LBD
ICU
Slave
SFU
PSS
Slave
TE
SCB
Bus
CPU Subsystem
USB Host
USB PHY
TFU
USB Device
DMA Crtl
HCU
ISI
Slave
DNC
CPR
Slave
DWU
GPIO
Slave
LLU
Motor Control, LSS, ISI, LED, etc.
LSS Master
Slave
Slave
PCU
PHI
Master
PEP Configuration Bus
Printhead

FIG. 45

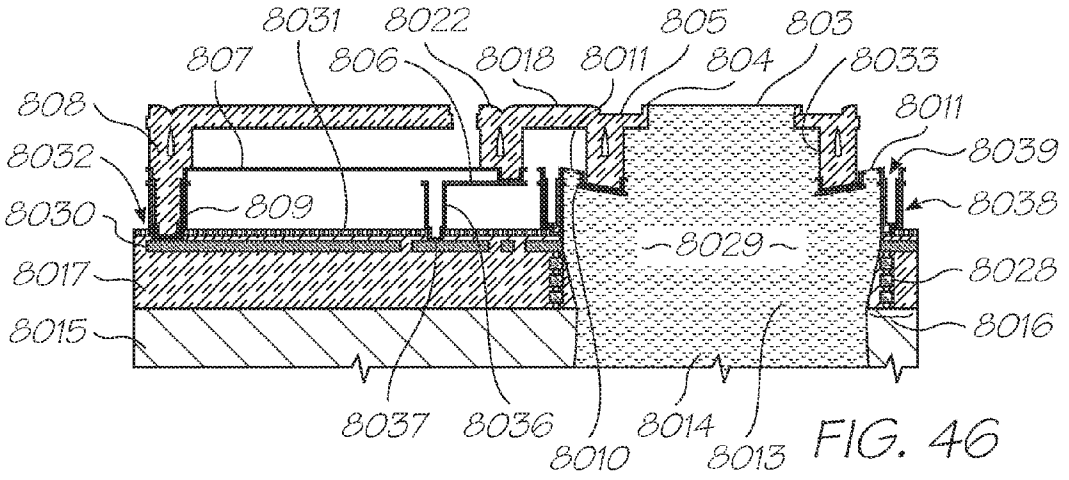


FIG. 46

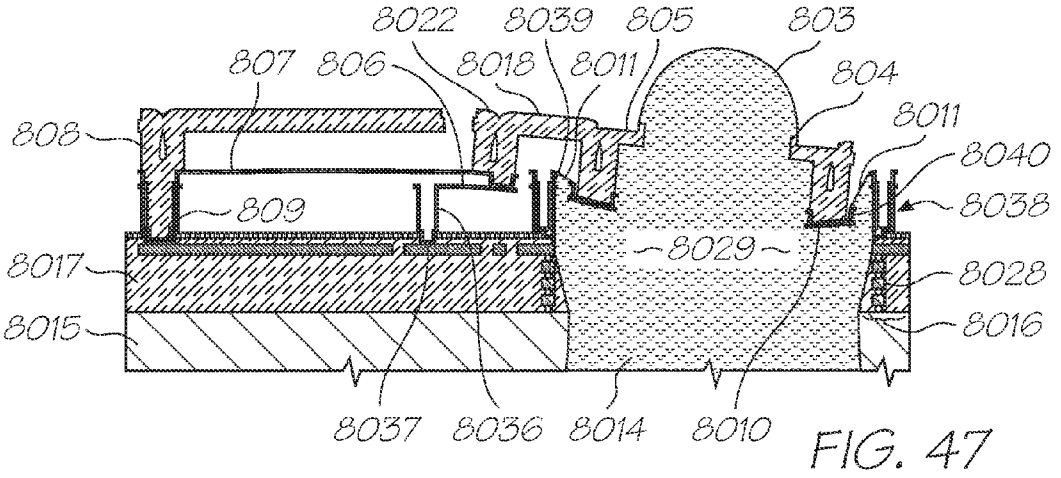


FIG. 47

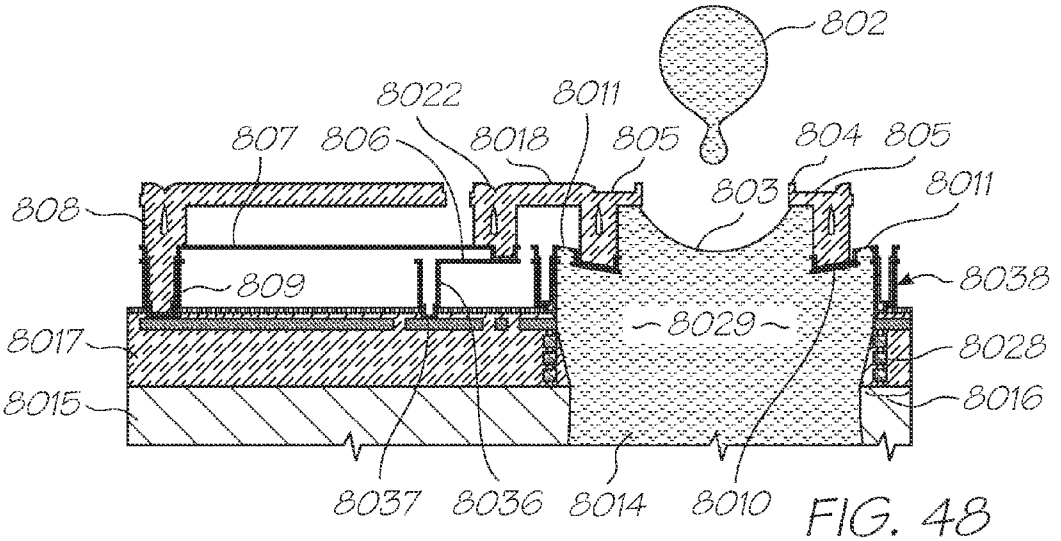


FIG. 48

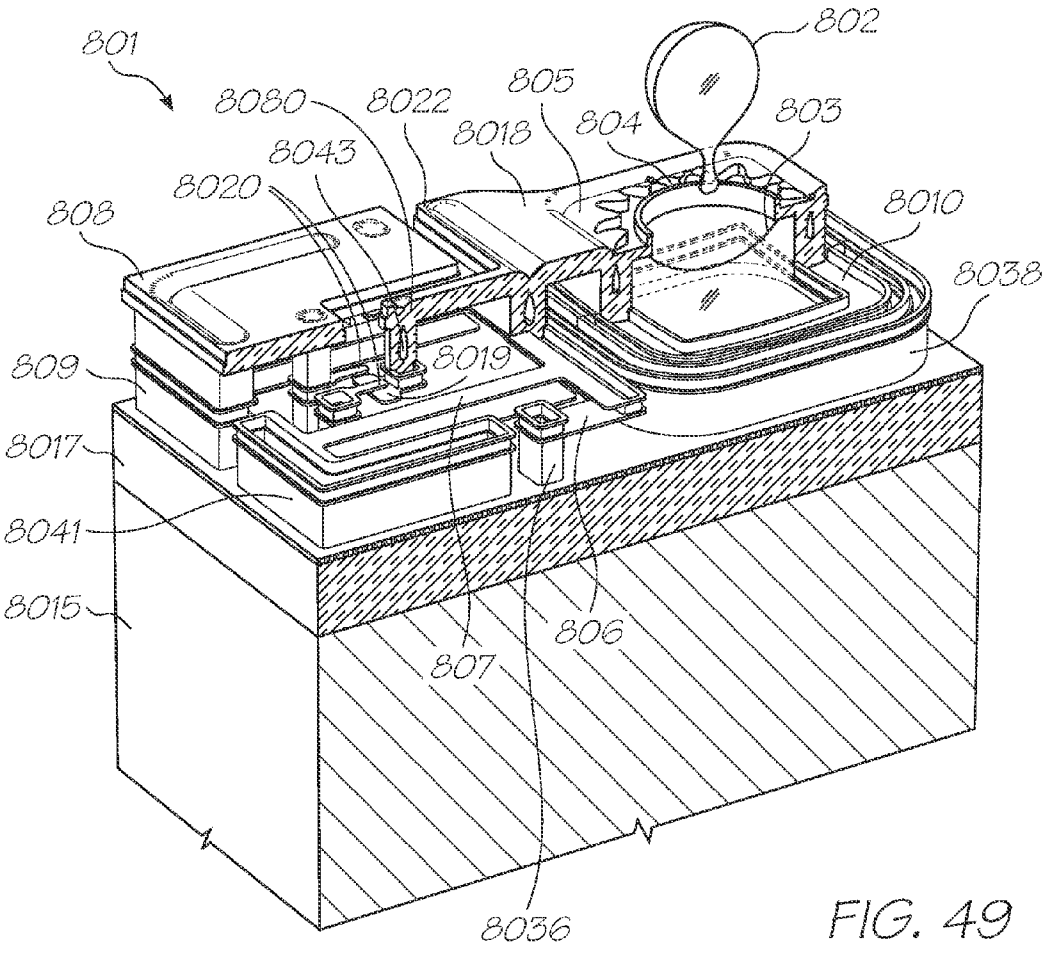

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FIG. 49

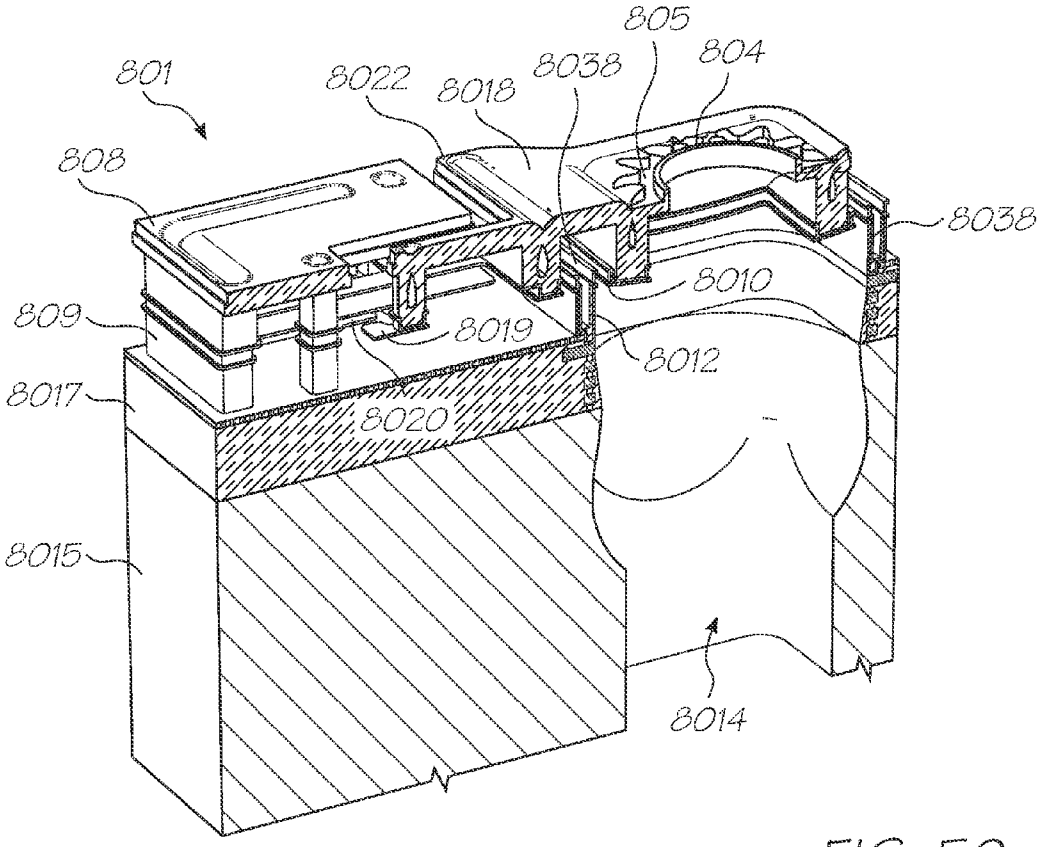

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FIG. 50

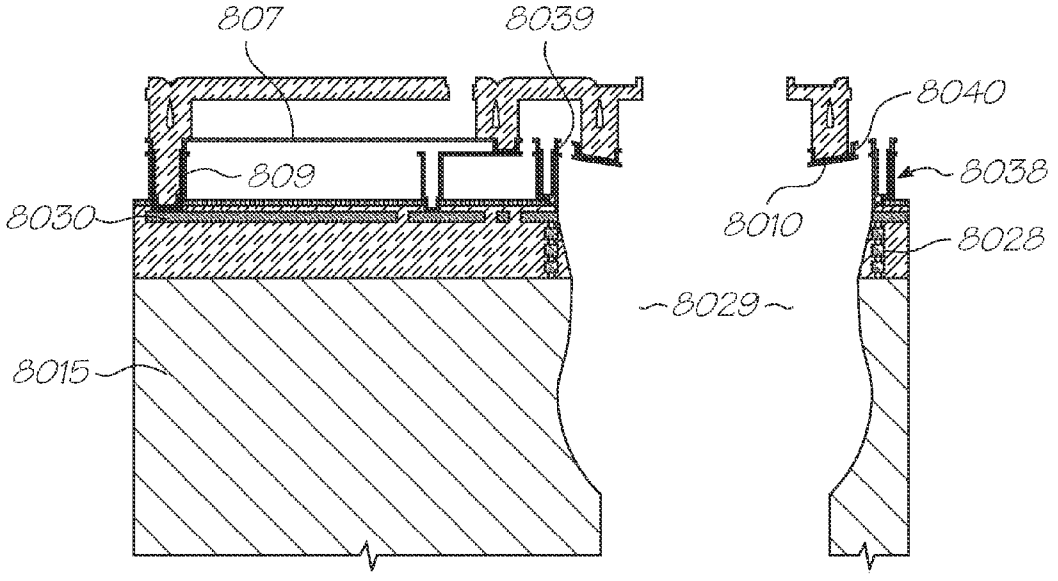

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FIG. 51

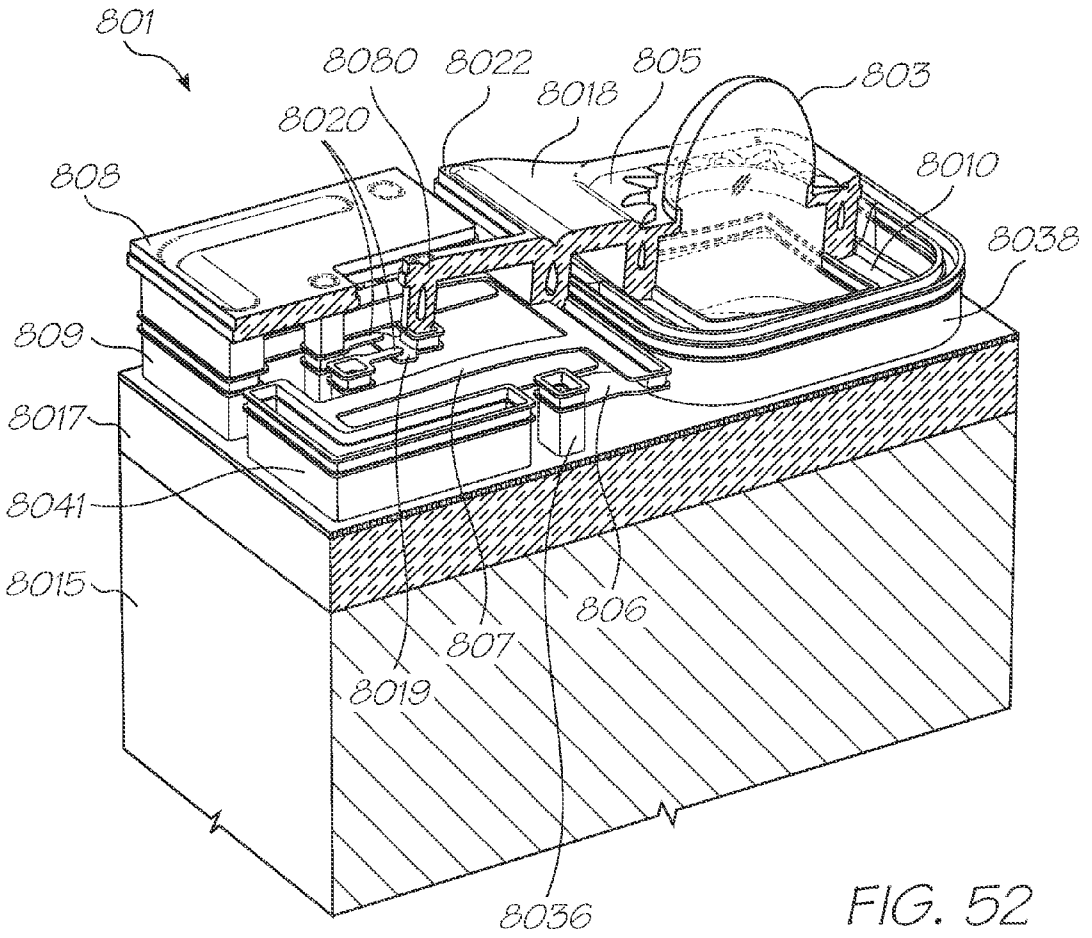

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FIG. 52

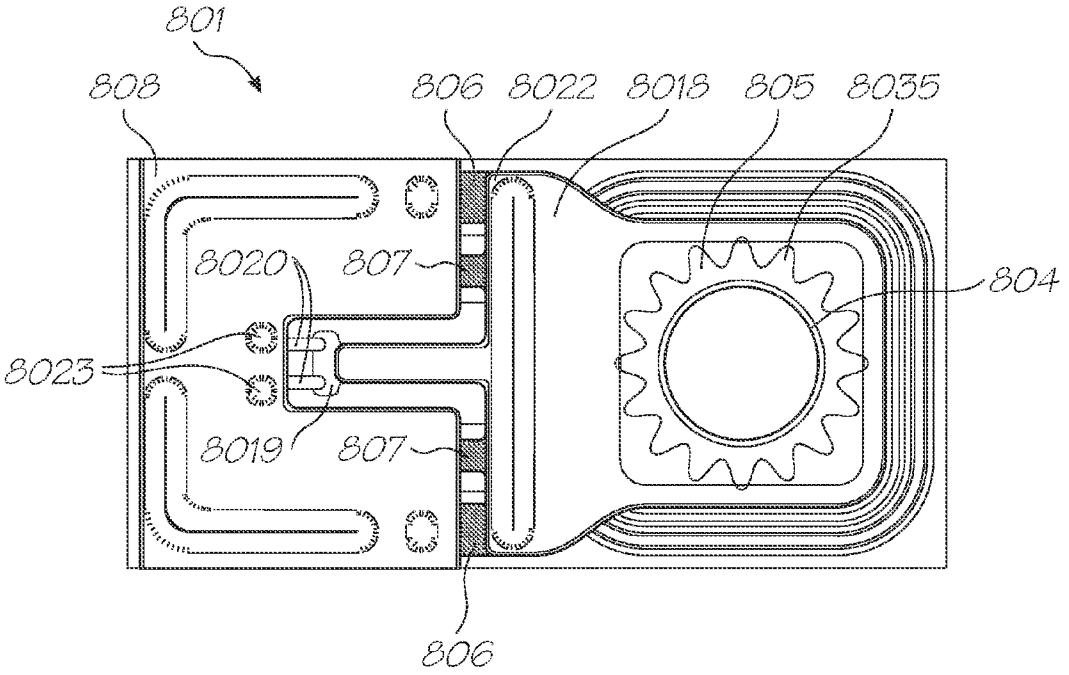

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FIG. 53

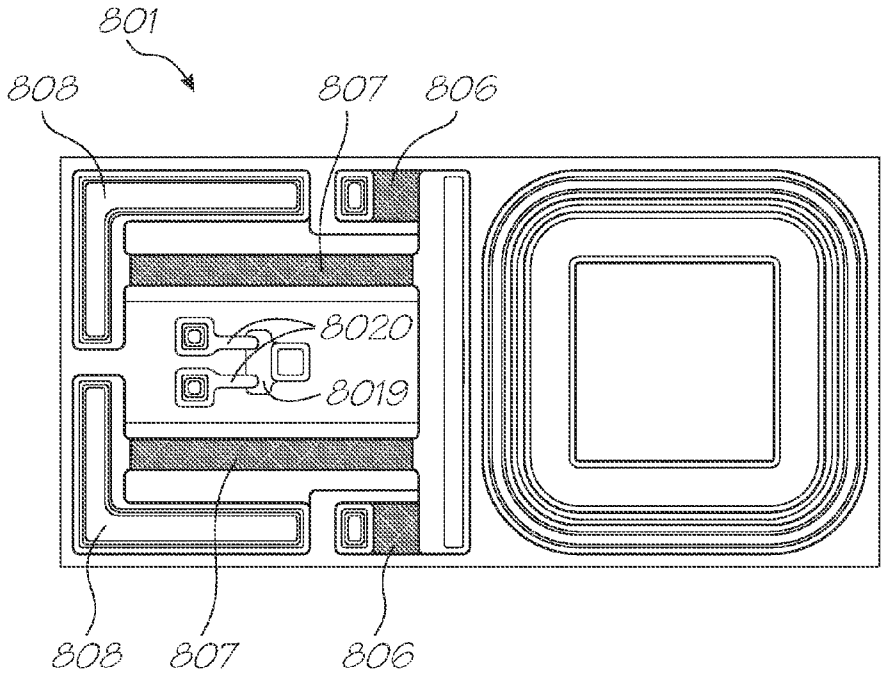

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FIG. 54

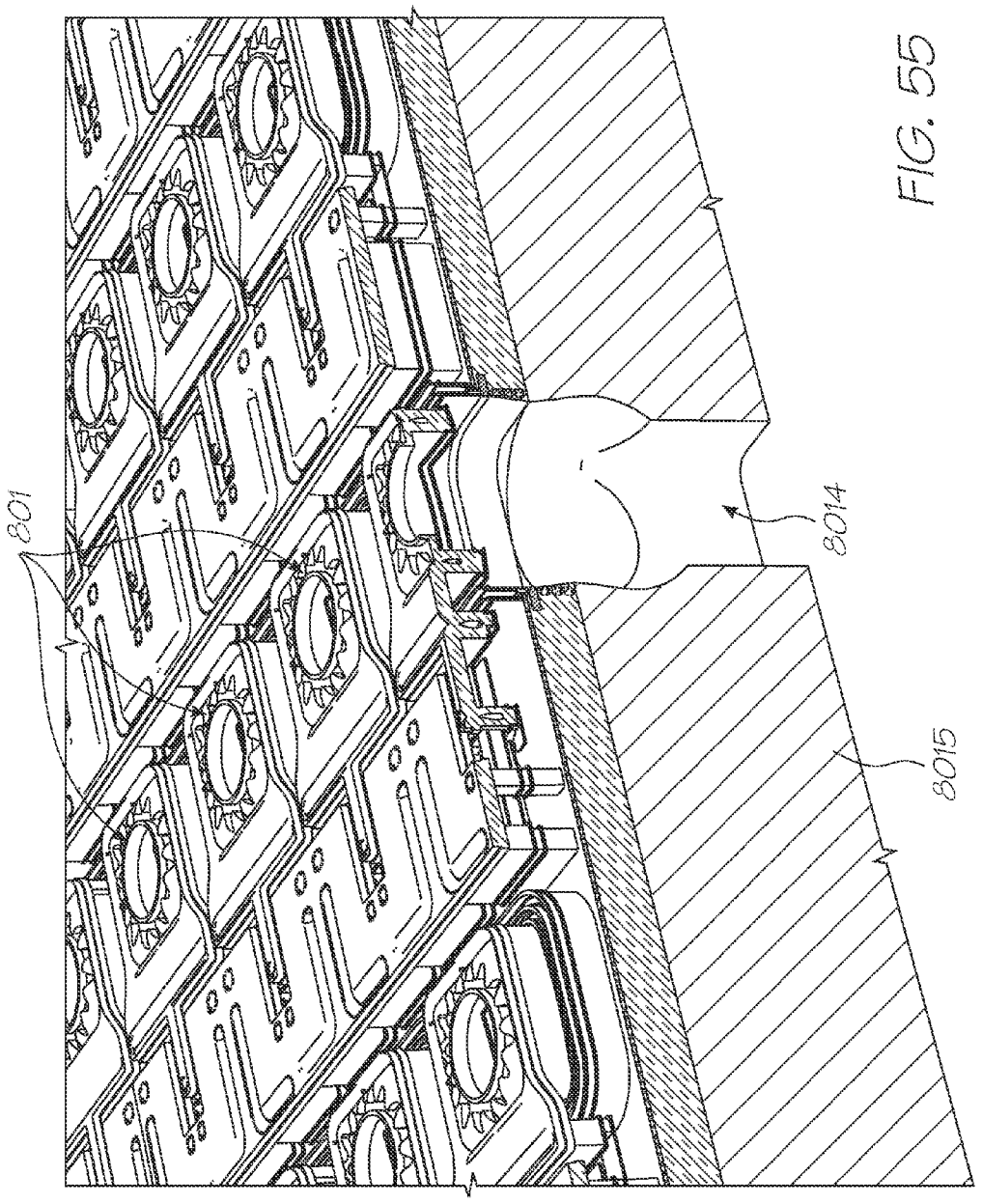


FIG. 55

INTEGRATED PRINTING AND DISPLAY DEVICE WITH REPLACEABLE INK CARTRIDGE

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of U.S. application Ser. No. 12/500,574 filed Jul. 9, 2009, which is a continuation of U.S. application Ser. No. 10/803,073 filed Mar. 18, 2004, now issued U.S. Pat. No. 7,570,389, all of which are herein incorporated by reference.

CO-PENDING APPLICATIONS

[0002] Various methods, systems and apparatus relating to the present invention are disclosed in the following co-pending applications filed by the applicant or assignee of the present invention with application Ser. No. 10/803,073:

[0003] U.S. Pat. No. 7,040,823 7,535,599 7,528,987 7,661,779

[0004] The disclosures of these co-pending applications are incorporated herein by cross-reference.

CROSS-REFERENCES

[0005] Various methods, systems and apparatus relating to the present invention are disclosed in the following co-pending applications filed by the applicant or assignee of the present invention. The disclosures of all of these co-pending applications are incorporated herein by cross-reference.

7,721,948	6,987,573	7,152,942	7,818,519	7,377,608	7,399,043
7,121,639	7,165,824	7,188,282	7,592,829	7,181,572	7,096,137
7,302,592	7,278,034	7,707,621	7,523,111	7,573,301	7,660,998
7,783,886	7,770,008	7,831,827			

TECHNICAL FIELD

[0006] The present invention relates to an integrated printing and flat panel display unit. The invention has been developed primarily as an integrated peripheral unit that is connectable to a personal computer such as Macintosh or IBM compatible PC. However, it will be appreciated by those skilled in the art that the invention is not limited to these applications.

BACKGROUND

[0007] Flat panel displays are known. A popular technology presently in use is the Thin Film Transistor (TFT) Liquid Crystal Display (LCD), which comprises an array of liquid crystal pixel elements driven by respective thin film transistors. In each element, liquid crystal is sandwiched between glass plates. A backlight is positioned behind the LCD layer relative to a position from which the display will be viewed. A polarizing screen is placed between the backlight and the LCD layer, and another polarizing screen is positioned on the other side of the LCD layer. The polarizing screens are orientated to be orthogonally polarizing with respect to each other.

[0008] Using the corresponding TFT to alter a voltage applied to the liquid crystal element causes a change in its crystalline structure that correspondingly alters the polarization of light passing through the element from the backlight. This change in polarization causes a corresponding change in the amount of light transmitted through the polarizing screens and LCD element.

[0009] Multiple colors are dealt with by providing each pixel with multiple LCD pixel elements (usually red, green and blue) that can individually be controlled for each pixel, thereby allowing various color combinations.

[0010] The design and operation of TFT LCD screens is well known to those skilled in the art and so is not described in more detail in this document.

[0011] Typically, flat panel displays, including TFT LCD displays, are more expensive than Cathode Ray Tube (CRT) display of comparable performance. However, the relative lightness and compactness of flat panel displays (particularly in terms of front to back depth) make them particularly suitable for situations where a small footprint is desirable. They are ubiquitous in laptop computers, and have come down in price sufficiently for them to be attractive to many desktop computer users. The relatively shallow front to back depth means that the display can be pushed back further from the user than would be possible with a CRT in many situations, thereby allowing better viewing comfort. Flat panel displays also enable a user to utilize considerably smaller areas than would be possible with an equivalent CRT display, which can be important in situations where a wall, partition or divider is located close to a work area in which the display is to be situated.

[0012] Often, computer users wish to print a hard copy of documents, images, web pages and the like. Usually, a printer is provided as a peripheral device that can be connected to the computer using a suitable cable. Alternatively, the computer can be connected via a Local Area Network (LAN) or other communications network. Printers can be bulky, and tend to take up additional space in a user's work area. Where space is at a premium, such printers can be intrusive or at least inconvenient. In many cases where a flat panel display is selected, space is already at a premium, so printers can exacerbate the problem.

SUMMARY

[0013] According to an aspect of the present disclosure, A printing and display device comprises a flat panel display for displaying images from an external computer; a printer having an inkjet printhead; a video socket adapted to engage with a video plug and video cable from the external computer to receive therefrom a video signal; a print data connection for selective connection to the external computer to receive therefrom print instructions; a rear cover molding enclosing therein the flat panel display; a paper chute for guiding paper between the flat panel display and the printhead; and an ink delivery bus provided within the rear cover molding. The rear cover molding includes an aperture for receiving therein an external ink cartridge. The aperture facilitates coupling of the external ink cartridge with the ink delivery bus. The ink delivery bus includes one or more fluid ports for engaging with the external ink cartridge, each of the one or more fluid port including a hollow needle adapted to penetrate a seal of the external ink cartridge.

BRIEF DESCRIPTION OF DRAWINGS

[0014] Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

[0015] FIG. **1** is a schematic of document data flow in a printing system;

[0016] FIG. **2** is a more detailed schematic showing an architecture used in the printing system of FIG. **1**;

[0017] FIG. **3** is a data representation of page element used in the printing system of FIG. **1**,

[0018] FIG. **4** is a schematic showing CMOS drive and control blocks for use with the printer of FIG. **1**;

[0019] FIG. **5** is a schematic showing the relationship between nozzle columns and dot shift registers in the CMOS blocks of FIG. **4**;

[0020] FIG. **6** is a more detailed schematic showing a unit cell and its relationship to the nozzle columns and dot shift registers of FIG. **5**;

[0021] FIG. **7** is a circuit diagram showing logic for a single printer nozzle in the printer of FIG. **1**;

[0022] FIG. **8** is a perspective view of a flat panel display incorporating a printer, in accordance with the invention;

[0023] FIG. **9** is a perspective view of the flat panel display of FIG. **8**, whilst printing a page;

[0024] FIG. **10** is a rear perspective view of the flat panel display of FIG. **8**;

[0025] FIG. **11** is a front elevation of the flat panel display of FIG. **9**;

[0026] FIG. **12** is a right-hand side elevation of the flat panel display of FIG. **9**;

[0027] FIG. **13** is a plan view of the flat panel display of FIG. **9**;

[0028] FIG. **14** is a left-hand side elevation of the flat panel display of FIG. **9**;

[0029] FIG. **15** is a rear elevation of the flat panel display of FIG. **9**;

[0030] FIG. **16** is a perspective exploded view of the flat panel display of FIG. **8**;

[0031] FIG. **17** is a rear perspective view of the flat panel display of FIG. **8** with the stand detached;

[0032] FIG. **18** is a rear perspective view of the flat panel display of FIG. **8** with the rear cover removed;

[0033] FIG. **19** is a rear perspective view of the flat panel display of FIG. **8** with the shields removed;

[0034] FIG. **20** is a rear perspective view of the flat panel display of FIG. **8** showing the core electrical and electronic components;

[0035] FIG. **21** is a perspective view of interconnected printed circuit boards used in the flat panel display of FIG. **8**;

[0036] FIG. **22** is a perspective view of the print engine used in the flat panel display of FIG. **8**;

[0037] FIG. **23** is a perspective view of the print engine of FIG. **22**, with some componentry removed to reveal the printhead;

[0038] FIG. **24** is a vertical section along the centerline of the flat panel display of FIG. **8**;

[0039] FIG. **25** is an enlarged detail view of the vertical section of FIG. **24**;

[0040] FIG. **26** is an enlarged detail view of a vertical section of a second embodiment of a flat panel display incorporating a duplex printhead, in accordance with the invention;

[0041] FIG. **27** is a vertical section along the centerline of a third embodiment of a flat panel display incorporating a multi-sheet paper feeder, in accordance with the invention;

[0042] FIG. **28** is an enlarged detail view of the vertical section of FIG. **27**

[0043] FIG. **29** is a rear perspective view of an alternative embodiment of a flat panel display including power and data connections in its base, in accordance with the invention;

[0044] FIG. **30** is a rear perspective view of an alternative embodiment of a flat panel display including a power input, data inputs and data outputs in its base, in accordance with the invention;

[0045] FIG. **31** is a rear perspective view of an alternative embodiment of a flat panel display including power and data connections in its base and an ink cartridge in its mounting plate, in accordance with the invention;

[0046] FIG. **32** is a rear perspective view of an alternative embodiment of a flat panel display including an ink cartridge, a power input and data connections in its base, in accordance with the invention;

[0047] FIG. **33** is a perspective view of a bi-lithic printhead for use in the flat panel display of FIG. **8**;

[0048] FIG. **34** is a rear perspective view of the bi-lithic printhead of FIG. **33**;

[0049] FIGS. **35**(A) to **35**(D) show a side elevation, plan view, opposite side elevation and reverse plan view, respectively, of the bi-lithic printhead of FIG. **33**;

[0050] FIGS. **36** and **37** show enlarged end views of the bi-lithic printhead of FIG. **33**;

[0051] FIG. **38** shows an enlarged detail plan view of one end of the bi-lithic printhead of FIG. **33**;

[0052] FIG. **39** is a sectional view taken along line **45-45** in FIG. **38**;

[0053] FIG. **40** is an enlarged detail perspective view of one end of the bi-lithic printhead of FIG. **33**;

[0054] FIG. **41** is an enlarged detail perspective view of an opposite end of the bi-lithic printhead of FIG. **33**;

[0055] FIG. **42** is an exploded perspective view of the bi-lithic printhead of FIG. **33**;

[0056] FIG. **43** is a sectional view taken along line **49-49** in FIG. **38**;

[0057] FIG. **44** is a schematic view showing the components of the flat panel display of FIG. **8**;

[0058] FIG. **45** is a schematic view of a print engine chip incorporated in the flat panel display of FIG. **8**;

[0059] FIG. **46** is a vertical sectional view of a single nozzle for ejecting ink, for use with the invention, in a quiescent state;

[0060] FIG. **47** is a vertical sectional view of the nozzle of FIG. **46** during an initial actuation phase;

[0061] FIG. **48** is a vertical sectional view of the nozzle of FIG. **57** later in the actuation phase;

[0062] FIG. **49** is a perspective partial vertical sectional view of the nozzle of FIG. **48**, at the actuation state shown in FIG. **48**;

[0063] FIG. **50** is a perspective vertical section of the nozzle of FIG. **46**, with ink omitted;

[0064] FIG. **51** is a vertical sectional view of the of the nozzle of FIG. **50**;

[0065] FIG. **52** is a perspective partial vertical sectional view of the nozzle of FIG. **46**, at the actuation state shown in FIG. **47**;

[0066] FIG. **53** is a plan view of the nozzle of FIG. **46**;

[0067] FIG. **54** is a plan view of the nozzle of FIG. **46** with the lever arm and movable nozzle removed for clarity;

[0068] FIG. **55** is a perspective vertical sectional view of a part of a printhead chip incorporating a plurality of the nozzle arrangements of the type shown in FIG. **46**.

DETAILED DESCRIPTION

[0069] As shown in FIG. **1**, in the preferred embodiment, the printing aspect of the invention is embodied in an A4/Letter printer **100** that prints documents supplied by a computer system **102**. The computer system **102** is programmed to perform various steps involved in printing a document, including receiving the document (step **103**), buffering it (step **104**) and rasterizing it (step **106**), and then compressing it (step **108**) for transmission to the printer **100**.

[0070] The compressed, multi-layer page image is buffered (step **110**) upon receipt in the printer **100**, then expanded (step **112**). The expanded contone layer is dithered (step **114**) and then the black layer from the expansion step is composited over the dithered contone layer (step **116**). Coded data can also be rendered (step **118**) to form an additional layer, to be printed (in the preferred form) using an infrared ink that is substantially invisible to the human eye. The black, dithered contone and infrared layers are combined (step **120**) to form a page that is supplied to a printhead for printing (step **122**). In the preferred embodiment, the printhead is a bi-lithic printhead configured to print in 6 colors in a pagewidth format, although the design can be adapted to print using any desired number of colors, and can be monolithic or require multiple substrates depending upon implementation.

[0071] The preferred embodiment divides printer data into a high-resolution bi-level mask layer for text and line art and a medium-resolution contone color image layer for images or background colors. Optionally, colored text can be supported by the addition of a medium-to-high-resolution contone texture layer for texturing text and line art with color data taken from an image or from flat colors. The preferred printing architecture, elements of which are described in more detail below, generalises these contone layers by representing them in abstract "image" and "texture" layers which can refer to either image data or flat color data. This division of data into layers based on content follows the base mode Mixed Raster Content (MRC) model specified in ITU-T.44. Like the MRC base mode, the preferred printing architecture makes compromises in some cases when data to be printed overlap. In particular, in the preferred form all overlaps are reduced to a 3-layer representation in a process (collision resolution) embodying the compromises explicitly.

[0072] As shown in FIG. **3**, the central data structure for the preferred printing architecture is a generalised representation of the three layers, called a page element. A page element can be used to represent units ranging from single rendered elements emerging from a rendering engine up to an entire band of a print job. FIG. **3** shows a simplified UML diagram of a page element **300**. Conceptually, the bi-level symbol region selects between the two color sources, as described in more detail below.

[0073] Printing Architecture

[0074] A more detailed description of the printing architecture will now be described with reference to FIGS. **2** and **3**. It will be appreciated that the components of the architecture **208** shown in FIG. **2** will typically be device dependent, in that they process the data into a form required by a software or hardware component further downstream.

[0075] In FIG. **2**, a renderer **209** exists outside of the more general printer system pipeline. Its purpose is to render files to be printed and deliver rendered elements to the data receiver **210** of the pipeline, using an API ("Application Programming Interface") exposed by the data receiver **210** for that purpose. The rendered elements are delivered in order according to the painter's algorithm, which is well known to those skilled in the art of image processing. The data passed in through the API is converted by the data receiver **210** into lists of dictionaries and page elements for processing in later stages.

[0076] A collision resolver **211** accepts the simple page elements created by the data receiver and creates a fully opaque "resolved" page element for each intersection of a new element with the background and any elements already present. Fundamentally, the collision resolver guarantees that the entire page is tiled with opaque elements.

[0077] A stripper **212** divides a band of data into horizontally overlapping pieces. This need only be performed in the case where relatively wide or fast printers use multiple parallel devices in order to achieve the required output dot-rate. In such cases, each horizontally overlapping piece is fed into a corresponding device downstream. Where such data division is not required, the stripper **212** can be omitted.

[0078] Different printing configurations will require different configurations of layers for delivery to the downstream hardware. A layer reorganiser **213** converts 3-layer page elements to the appropriate 2- or 3-layer form for the specific configuration. Again, there may be cases in which this function is not required, in which case the layer organiser can be omitted.

[0079] A contone combiner **214** combines and clips the image and texture layers of all page elements in a strip into single image and texture layers, as required by downstream hardware.

[0080] A color converter **215** transforms the contone planes of all page elements from the input color space to a device-specific color space (which is usually CMYK).

[0081] A mask combiner **216** performs the same operation on the mask layer as the contone combiner performs on the contone layers. All elements are clipped to a strip boundary and drawn into a single mask buffer.

[0082] A densitometer **218** measures the density of the current page as a percentage of total possible density. This operation is necessary only in low-end printers with power supplies that may not be able to handle a fully dense page at full speed.

[0083] A contone compressor **220** compresses the contone layers of all page elements in order to reduce downstream memory and/or transmission bandwidth requirements.

[0084] A mask formatter **222** converts the mask layer of page elements, which may be represented as regions of placed symbol references, into the form expected by a downstream mask decompressor.

[0085] A size limiter **224** ensures that all size limitations, for bands and for entire pages, are adhered to, by either dividing bands into smaller bands or by recompressing the data, repeating until the constraint is satisfied.

[0086] If data is to be transmitted to the printer between pipeline stages, a serialised form of the data structures is generated (in serialiser **226**), transmitted, then deserialised (in deserialiser **228**).

[0087] Within the printer, a distributor **230** converts data from a proprietary representation into a hardware-specific representation and ensures that the data for each strip is sent to the correct hardware device whilst observing any constraints or requirements on data transmission to these devices.

The distributor distributes the converted data to an appropriate one of a plurality of pipelines **232**. The pipelines are identical to each other, and in essence provide decompression, scaling and dot compositing functions to generate a set of printable dot outputs.

[0088] Each pipeline **232** includes a buffer **234** for receiving the data. A contone decompressor **236** decompresses the color contone planes, and a mask decompressor **238** decompresses the monotone (text) layer. Contone and mask scalers **240** and **242** scale the decompressed contone and mask planes respectively, to take into account the size of the medium onto which the page is to be printed.

[0089] The scaled contone planes are then dithered by ditherer **244**. In the preferred form, a stochastic dispersed-dot dither is used. Unlike a clustered-dot (or amplitude-modulated) dither, a dispersed-dot (or frequency-modulated) dither reproduces high spatial frequencies (i.e. image detail) almost to the limits of the dot resolution, while simultaneously reproducing lower spatial frequencies to their full color depth, when spatially integrated by the eye. A stochastic dither matrix is carefully designed to be relatively free of objectionable low-frequency patterns when tiled across the image. As such, its size typically exceeds the minimum size required to support a particular number of intensity levels (e.g. 16×16×8 bits for 257 intensity levels).

[0090] The dithered planes are then composited in a dot compositor **246** on a dot-by-dot basis to provide dot data suitable for printing. This data is forwarded to data distribution and drive circuitry **248**, which in turn distributes the data to the correct nozzle actuators **250**, which in turn cause ink to be ejected from the correct nozzles **252** at the correct time. This process is described in more detail below.

[0091] The architecture **208** includes a mainly software-based computer system portion prior to the serialiser **226**, and a mainly hardware-based printer portion that is located within a printer remote from the computer system, which includes everything from the deserialiser **228** onwards. It will be appreciated, however, that the indicated division between computer system and printer is somewhat arbitrary, and various components can be placed on different sides of the divide without substantially altering the operation of the architecture as a whole. It will also be appreciated that some of the components in the architecture **208** can be handled in hardware or software remotely from the main computer system and printer. For example, rather than relying on the general-purpose processor of a personal computer, some of the components in the architecture can be accelerated using dedicated hardware.

[0092] SoPEC Device

[0093] In the preferred form, the hardware pipelines **232** are embodied in a Small Office Home Office Printer Engine Controller (SoPEC), as shown in FIG. **2** and described in more detail below. The printer preferably also includes one or more system on a chip (SoC) components, as well as the print engine pipeline control application specific logic, configured to perform some or all of the functions described above in relation to the printing pipeline.

[0094] As shown in FIG. **45**, from the highest point of view a SoPEC device consists of 3 distinct subsystems: a Central Processing Unit (CPU) subsystem **301**, a Dynamic Random Access Memory (DRAM) subsystem **302** and a Print Engine Pipeline (PEP) subsystem **303**.

[0095] The CPU subsystem **301** includes a CPU **30** that controls and configures all aspects of the other subsystems. It provides general support for interfacing and synchronizing the external printer with the internal print engine. It also controls the low-speed communication to QA chips (which are described elsewhere in this specification). The CPU subsystem **301** also contains various peripherals to aid the CPU, such as General Purpose Input Output (GPIO, which includes motor control), an Interrupt Controller Unit (ICU), LSS Master and general timers. The Serial Communications Block (SCB) on the CPU subsystem provides a full speed USB1.1 interface to the host as well as an Inter SoPEC Interface (ISI) to other SoPEC devices (not shown).

[0096] The DRAM subsystem **302** accepts requests from the CPU, Serial Communications Block (SCB) and blocks within the PEP subsystem. The DRAM subsystem **302**, and in particular the DRAM Interface Unit (DIU), arbitrates the various requests and determines which request should win access to the DRAM. The DIU arbitrates based on configured parameters, to allow sufficient access to DRAM for all requestors. The DIU also hides the implementation specifics of the DRAM such as page size, number of banks and refresh rates.

[0097] The Print Engine Pipeline (PEP) subsystem **303** accepts compressed pages from DRAM and renders them to bi-level dots for a given print line destined for a printhead interface that communicates directly with up to 2 segments of a bi-lithic printhead. The first stage of the page expansion pipeline is the Contone Decoder Unit (CDU), Lossless Bi-level Decoder (LBD) and Tag Encoder (TE). The CDU expands the JPEG-compressed contone (typically CMYK) layers, the LBD expands the compressed bi-level layer (typically K), and the TE encodes Netpage tags for later rendering (typically in IR or K ink). The output from the first stage is a set of buffers: the Contone FIFO unit (CFU), the Spot FIFO Unit (SFU), and the Tag FIFO Unit (TFU). The CFU and SFU buffers are implemented in DRAM.

[0098] The second stage is the Halftone Compositor Unit (HCU), which dithers the contone layer and composites position tags and the bi-level spot layer over the resulting bi-level dithered layer.

[0099] A number of compositing options can be implemented, depending upon the printhead with which the SoPEC device is used. Up to 6 channels of bi-level data are produced from this stage, although not all channels may be present on the printhead. For example, the printhead may be CMY only, with K pushed into the CMY channels and IR ignored. Alternatively, the encoded tags may be printed in K if IR ink is not available (or for testing purposes).

[0100] In the third stage, a Dead Nozzle Compensator (DNC) compensates for dead nozzles in the printhead by color redundancy and error diffusing of dead nozzle data into surrounding dots.

[0101] The resultant bi-level 6 channel dot-data (typically CMYK, Infrared, Fixative) is buffered and written to a set of line buffers stored in DRAM via a Dotline Writer Unit (DWU).

[0102] Finally, the dot-data is loaded back from DRAM, and passed to the printhead interface via a dot FIFO. The dot FIFO accepts data from a Line Loader Unit (LLU) at the system clock rate (pclk), while the PrintHead Interface (PHI) removes data from the FIFO and sends it to the printhead at a rate of ⅔ times the system clock rate.

[0103] In the preferred form, the DRAM is 2.5 Mbytes in size, of which about 2 Mbytes are available for compressed page store data. A compressed page is received in two or more bands, with a number of bands stored in memory. As a band of the page is consumed by the PEP subsystem **303** for printing, a new band can be downloaded. The new band may be for the current page or the next page.

[0104] Using banding it is possible to begin printing a page before the complete compressed page is downloaded, but care must be taken to ensure that data is always available for printing or a buffer under-run may occur.

[0105] The embedded USB 1.1 device accepts compressed page data and control commands from the host PC, and facilitates the data transfer to either the DRAM (or to another SoPEC device in multi-SoPEC systems, as described below).

[0106] Multiple SoPEC devices can be used in alternative embodiments, and can perform different functions depending upon the particular implementation. For example, in some cases a SoPEC device can be used simply for its onboard DRAM, while another SoPEC device attends to the various decompression and formatting functions described above. This can reduce the chance of buffer under-run, which can happen in the event that the printer commences printing a page prior to all the data for that page being received and the rest of the data is not received in time. Adding an extra SoPEC device for its memory buffering capabilities doubles the amount of data that can be buffered, even if none of the other capabilities of the additional chip are utilized.

[0107] Each SoPEC system can have several quality assurance (QA) devices designed to cooperate with each other to ensure the quality of the printer mechanics, the quality of the ink supply so the printhead nozzles will not be damaged during prints, and the quality of the software to ensure printheads and mechanics are not damaged.

[0108] Normally, each printing SoPEC will have an associated printer QA, which stores information printer attributes such as maximum print speed. An ink cartridge for use with the system will also contain an ink QA chip, which stores cartridge information such as the amount of ink remaining The printhead also has a QA chip, configured to act as a ROM (effectively as an EEPROM) that stores printhead-specific information such as dead nozzle mapping and printhead characteristics. The CPU in the SoPEC device can optionally load and run program code from a QA Chip that effectively acts as a serial EEPROM. Finally, the CPU in the SoPEC device runs a logical QA chip (ie, a software QA chip).

[0109] Usually, all QA chips in the system are physically identical, with only the contents of flash memory differentiating one from the other.

[0110] Each SoPEC device has two LSS system buses that can communicate with QA devices for system authentication and ink usage accounting. A large number of QA devices can be used per bus and their position in the system is unrestricted with the exception that printer QA and ink QA devices should be on separate LSS busses.

[0111] In use, the logical QA communicates with the ink QA to determine remaining ink. The reply from the ink QA is authenticated with reference to the printer QA. The verification from the printer QA is itself authenticated by the logical QA, thereby indirectly adding an additional authentication level to the reply from the ink QA.

[0112] Data passed between the QA chips, other than the printhead QA, is authenticated by way of digital signatures. In the preferred embodiment, HMAC-SHA1 authentication is used for data, and RSA is used for program code, although other schemes could be used instead.

[0113] A single SoPEC device can control two bi-lithic printheads and up to six color channels. Six channels of colored ink are the expected maximum in a consumer SOHO, or office bi-lithic printing environment, and include:

[0114] CMY (cyan, magenta, yellow), for regular color printing.

[0115] K (black), for black text, line graphics and grayscale printing.

[0116] IR (infrared), for Netpage-enabled applications.

[0117] F (fixative), to enable printing at high speed.

[0118] Because the bi-lithic printer is capable of printing so fast, a fixative may be required to enable the ink to dry before the page touches the page already printed. Otherwise ink may bleed between pages. In relatively low-speed printing environments the fixative may not be required.

[0119] In the preferred form, the SoPEC device is color space agnostic. Although it can accept contone data as CMYX or RGBX, where X is an optional 4th channel, it also can accept contone data in any print color space. Additionally, SoPEC provides a mechanism for arbitrary mapping of input channels to output channels, including combining dots for ink optimization and generation of channels based on any number of other channels. However, inputs are typically CMYK for contone input, K for the bi-level input, and the optional Netpage tag dots are typically rendered to an infrared layer. A fixative channel is typically generated for fast printing applications.

[0120] In the preferred form, the SoPEC device is also resolution agnostic. It merely provides a mapping between input resolutions and output resolutions by means of scale factors. The expected output resolution for the preferred embodiment is 1600 dpi, but SoPEC actually has no knowledge of the physical resolution of the Bi-lithic printhead.

[0121] In the preferred form, the SoPEC device is page-length agnostic. Successive pages are typically split into bands and downloaded into the page store as each band of information is consumed.

[0122] The following three tables show the constituents of each of the three distinct subsystems which make up the SoPEC device. In particular, each of the columns provide the unit acronym, the unit name and a description of the functions performed by each unit.

Subsystem	Unit Acronym	Unit Name	Description
DRAM	DIU	DRAM interface unit	Provides interface for DRAM read and write access for the various SoPEC units, CPU and the SCB block. The DIU provides arbitration between competing units and controls DRAM access.
	DRAM	Embedded DRAM	20 Mbits of embedded DRAM.

-continued

Subsystem	Unit Acronym	Unit Name	Description
CPU	CPU	Central Processing Unit	CPU for system configuration and control.
	MMU	Memory Management Unit	Limits access to certain memory address areas in CPU user mode.
	RDU	Real-time Debug Unit	Facilitates the observation of the contents of most of the CPU addressable registers in SoPEC, in addition to some pseudo-registers in real time.
	TIM	General Timer	Contains watchdog and general system timers.
	LSS	Low Speed Serial Interfaces	Low level controller for interfacing with the QA chips
	GPIO	General Purpose IOs	General IO controller, with built-in Motor control unit, LED pulse units and de-glitch circuitry
	ROM	Boot ROM	16 KBytes of System Boot ROM code
	ICU	Interrupt Controller Unit	General Purpose interrupt controller with configurable priority, and masking.
	CPR	Clock, Power and Reset block	Central Unit for controlling and generating the system clocks and resets and powerdown mechanisms
	PSS	Power Save Storage	Storage retained while system is powered down
	USB	Universal Serial Bus Device	USB device controller for interfacing with the host USB.
	ISI	Inter-SoPEC Interface	ISI controller for data and control communication with other SoPECs in a multi-SoPEC system
	SCB	Serial Communication Block	Contains both the USB and ISI blocks.

Subsystem	Unit Acronym	Unit Name	Description
Print Engine Pipeline (PEP)	PCU	PEP controller	Provides external CPU with the means to read and write PEP Unit registers, and read and write DRAM in single 32-bit chunks.
	CDU	Contone Decoder Unit	Expands JPEG compressed contone layer and writes decompressed contone to DRAM
	CFU	Contone FIFO Unit	Provides line buffering between CDU and HCU
	LBD	Lossless Bi-level Decoder	Expands compressed bi-level layer.
	SFU	Spot FIFO Unit	Provides line buffering between LBD and HCU
	TE	Tag Encoder	Encodes tag data into line of tag dots.
	TFU	Tag FIFO Unit	Provides tag data storage between TE and HCU
	HCU	Halftoner Compositor Unit	Dithers contone layer and composites the bi-level spot and position tag dots.
	DNC	Dead Nozzle Compensator	Compensates for dead nozzles by color redundancy and error diffusing dead nozzle data into surrounding dots.
	DWU	Dotline Writer Unit	Writes out the 6 channels of dot data for a given printline to the line store DRAM

-continued

Subsystem	Unit Acronym	Unit Name	Description
	LLU	Line Loader Unit	Reads the expanded page image from line store, formatting the data appropriately for the bi-lithic printhead.
	PHI	PrintHead Interface	Responsible for sending dot data to the bi-lithic printheads and for providing line synchronization between multiple SoPECs. Also provides test interface to printhead such as temperature monitoring and Dead Nozzle Identification.

[0123] Printhead Mechanical

[0124] In the preferred form, a Memjet printer has two printhead integrated circuits that are mounted adjacent each other to form a pagewidth printhead. Typically, the printhead ICs can vary in size from 2 inches to 8 inches, so several combinations can be used to produce, say, an A4 pagewidth printhead. For example two printhead ICs of 7 and 3 inches, 2 and 4 inches, or 5 and 5 inches could be used to create an A4 printhead (the notation is 7:3). Similarly 6 and 4 (6:4) or 5 and 5 (5:5) combinations can be used. An A3 printhead can be constructed from 8 and 6-inch printhead integrated circuits, for example. For photographic printing, particularly in camera, smaller printheads can be used. It will also be appreciated that a single printhead integrated circuit, or more than two such circuits, can also be used to achieve the required printhead width.

[0125] A preferred printhead embodiment will now be described with reference to FIGS. **33** to **43**. As best shown in FIGS. **33** to **35** and FIG. **42**, a printhead **420** takes the form of an elongate unit. As best shown in FIG. **42**, the components of the printhead **420** include a support member **421**, a flexible PCB **422**, an ink distribution molding **423**, an ink distribution plate **424**, a MEMS printhead comprising first and second printhead integrated circuits (ICs) **425** and **426**, and busbars **427**.

[0126] The support member **421** is can be formed from any suitable material, such as metal or plastic, and can be extruded, molded or formed in any other way. The support member **421** should be strong enough to hold the other components in the appropriate alignment relative to each other whilst stiffening and strengthening the printhead as a whole.

[0127] The flexible PCB extends the length of the printhead **420** and includes first and second electrical connectors **428** and **429**. The electrical connectors **428** and **429** correspond with the flexible connectors **147** shown FIG. **22**. The electrical connectors include contact areas **148** and **159** that, in use, are positioned in contact with corresponding output connectors (not shown) from the SoPEC chip **166** (FIG. **21**). Data from the SoPEC chip **166** passes along the electrical connectors **428** and **429**, and is distributed to respective ends of the first and second printhead ICs **425** and **426**.

[0128] As shown in FIG. **43**, the ink distribution molding **423** includes a plurality of elongate conduits **430** that distribute fluids (ie, colored inks, infrared ink and fixative) and pressurized air from the air pump along the length of the printhead **420** (FIG. **42**). Sets of fluid apertures **431** (FIG. **39**) disposed along the length of the ink distribution molding **423** distribute the fluids and air from the conduits **430** to the ink distribution plate **424**. The fluids and air are supplied via nozzles **440** formed on a plug **441** (FIG. **35**), which plugs into a corresponding socket (not shown) in the printer.

[0129] The distribution plate **424** is a multi-layer construction configured to take fluids provided locally from the fluid apertures **431** and distribute them through smaller distribution apertures **432** into the printhead ICs **425** and **426** (as shown in FIG. **39**).

[0130] The printhead ICs **425** and **426** are positioned end to end, and are held in contact with the distribution plate **424** so that ink from the smaller distribution apertures **432** can be fed into corresponding apertures (not shown) in the printhead ICs **425** and **426**.

[0131] The busbars **427** are relatively high-capacity conductors positioned to provide drive current to the actuators of the printhead nozzles (described in detail below). As best shown in FIGS. **39** to **41**, the busbars **427** are retained in position at one end by a socket **433**, and at both ends by wrap-around wings **434** of the flexible PCB **422**. The busbars also help hold the printhead ICs **425** in position, as best shown in FIGS. **38**, **40** and **41**.

[0132] As shown best in FIGS. **40**, **41** and **42**, when assembled, the flexible PCB **422** is effectively wrapped around the other components, thereby holding them in contact with each other. Notwithstanding this binding effect, the support member **421** provides a major proportion of the required stiffness and strength of the printhead **420** as a whole.

[0133] Printhead CMOS

[0134] Turning now to FIGS. **4** to **7**, a preferred embodiment of the printhead **420** (comprising printhead ICs **425** and **426**) will be described. For clarity, only one printhead IC **425** is shown in FIG. **4**, but it will be appreciated that a corresponding arrangement is implemented for the printhead IC **426**.

[0135] FIG. **4** shows an overview of printhead IC **425** and its connections to the SoPEC device **166**. Printhead IC **425** includes a nozzle core array **401** containing the repeated logic to fire each nozzle, and nozzle control logic **402** to generate the timing signals to fire the nozzles. The nozzle control logic **402** receives data from the SoPEC chip **166** via a high-speed link. In the preferred form, a single SoPEC chip **166** feeds the two printhead ICs **425** and **426** with print data.

[0136] The nozzle control logic **402** is configured to send serial data to the nozzle array core for printing, via a link **407**, which for printhead **425** is the electrical connector **428**. Status

and other operational information about the nozzle array core **401** is communicated back to the nozzle control logic via another link **408**, which is also provided on the electrical connector **428**.

[0137] The nozzle array core **401** is shown in more detail in FIGS. **5** and **6**. In FIG. **5**, it will be seen that the nozzle array core comprises an array of nozzle columns **501**. The array includes a fire/select shift register **502** and up to 6 color channels, each of which is represented by a corresponding dot shift register **503**.

[0138] As shown in FIG. **6**, the fire/select shift register **502** includes forward path fire shift register **600**, a reverse path fire shift register **601** and a select shift register **602**. Each dot shift register **503** includes an odd dot shift register **603** and an even dot shift register **604**. The odd and even dot shift registers **603** and **604** are connected at one end such that data is clocked through the odd shift register **603** in one direction, then through the even shift register **604** in the reverse direction. The output of all but the final even dot shift register is fed to one input of a multiplexer **605**. This input of the multiplexer is selected by a signal (corescan) during post-production testing. In normal operation, the corescan signal selects dot data input Dot[x] supplied to the other input of the multiplexer **605**. This causes Dot[x] for each color to be supplied to the respective dot shift registers **503**.

[0139] A single column N will now be described with reference to FIG. **6**. In the embodiment shown, the column N includes 12 data values, comprising an odd data value **606** and an even data value **607** for each of the six dot shift registers. Column N also includes an odd fire value **608** from the forward fire shift register **600** and an even fire value **609** from the reverse fire shift register **601**, which are supplied as inputs to a multiplexer **610**. The output of the multiplexer **610** is controlled by the select value **611** in the select shift register **602**. When the select value is zero, the odd fire value is output, and when the select value is one, the even fire value is output.

[0140] Each of the odd and even data values **606** and **607** is provided as an input to corresponding odd and even dot latches **612** and **613** respectively.

[0141] Each dot latch and its associated data value form a unit cell, such as unit cell **614**. A unit cell is shown in more detail in FIG. **7**. The dot latch **612** is a D-type flip-flop that accepts the output of the data value **606**, which is held by a D-type flip-flop **614** forming an element of the odd dot shift register **603**. The data input to the flip-flop **614** is provided from the output of a previous element in the odd dot shift register (unless the element under consideration is the first element in the shift register, in which case its input is the Dot[x] value). Data is clocked from the output of flip-flop **614** into latch **612** upon receipt of a negative pulse provided on LsyncL.

[0142] The output of latch **612** is provided as one of the inputs to a three-input AND gate **615**. Other inputs to the AND gate **615** are the Fr signal (from the output of multiplexer **610**) and a pulse profile signal Pr. The firing time of a nozzle is controlled by the pulse profile signal Pr, and can be, for example, lengthened to take into account a low voltage condition that arises due to low battery (in a battery-powered embodiment). This is to ensure that a relatively consistent amount of ink is efficiently ejected from each nozzle as it is fired. In the embodiment described, the profile signal Pr is the same for each dot shift register, which provides a balance between complexity, cost and performance. However, in other embodiments, the Pr signal can be applied globally (ie, is the same for all nozzles), or can be individually tailored to each unit cell or even to each nozzle.

[0143] Once the data is loaded into the latch **612**, the fire enable Fr and pulse profile Pr signals are applied to the AND gate **615**, combining to the trigger the nozzle to eject a dot of ink for each latch **612** that contains a logic 1.

[0144] The signals for each nozzle channel are summarized in the following table:

Name	Direction	Description
d	Input	Input dot pattern to shift register bit
q	Output	Output dot pattern from shift register bit
SrClk	Input	Shift register clock in - d is captured on rising edge of this clock
LsyncL	Input	Fire enable - needs to be asserted for nozzle to fire
Pr	Input	Profile - needs to be asserted for nozzle to fire

[0145] As shown in FIG. **7**, the fire signals Fr are routed on a diagonal, to enable firing of one color in the current column, the next color in the following column, and so on. This averages the current demand by spreading it over 6 columns in time-delayed fashion.

[0146] The dot latches and the latches forming the various shift registers are fully static in this embodiment, and are CMOS-based. The design and construction of latches is well known to those skilled in the art of integrated circuit engineering and design, and so will not be described in detail in this document.

[0147] The combined printhead ICs define a printhead having 13824 nozzles per color. Therefore, in the case where the printhead ICs **425** and **426** are equal in length, each of them includes 6912 nozzles per color. The circuitry supporting each nozzle is the same, but the pairing of nozzles happens due to physical positioning of the MEMS nozzles; odd and even nozzles are not actually on the same horizontal line

[0148] Power and ground are provided via pads disposed along the length of the printhead ICs. The pads are connected to busbars **427** using conductive adhesive, as described above.

[0149] Printhead Nozzles and Actuators

[0150] The preferred printhead nozzle arrangement, comprising a nozzle and corresponding actuator, will now be described with reference to FIGS. **46** to **55**. FIG. **47** shows an array of the nozzle arrangements **801** formed on a silicon substrate **8015**. The nozzle arrangements are identical, but in the preferred embodiment, different nozzle arrangements are fed with different colored inks and fixative. It will be noted that rows of the nozzle arrangements **801** are staggered with respect to each other, allowing closer spacing of ink dots during printing than would be possible with a single row of nozzles. The multiple rows also allow for redundancy (if desired), thereby allowing for a predetermined failure rate per nozzle.

[0151] Each nozzle arrangement **801** is the product of an integrated circuit fabrication technique. In particular, the nozzle arrangement **801** defines a micro-electromechanical system (MEMS).

[0152] For clarity and ease of description, the construction and operation of a single nozzle arrangement **801** will be described with reference to FIGS. **46** to **54**.

[0153] Each of the ink jet printhead chips **425**, **426** includes a silicon wafer substrate **801**. 0.35 Micron 1 P4M 12 volt CMOS microprocessing circuitry is positioned on the silicon wafer substrate **8015**.

[0154] A silicon dioxide (or alternatively glass) layer **8017** is positioned on the wafer substrate **8015**. The silicon dioxide layer **8017** defines CMOS dielectric layers. CMOS top-level metal defines a pair of aligned aluminium electrode contact layers **8030** positioned on the silicon dioxide layer **8017**. Both the silicon wafer substrate **8015** and the silicon dioxide layer **8017** are etched to define an ink inlet channel **8014** having a generally circular cross section (in plan). An aluminium diffusion barrier **8028** of CMOS metal 1, CMOS metal 2/3 and CMOS top level metal is positioned in the silicon dioxide layer **8017** about the ink inlet channel **8014**. The diffusion barrier **8028** serves to inhibit the diffusion of hydroxyl ions through CMOS oxide layers of the drive circuitry layer **8017**.

[0155] A passivation layer in the form of a layer of silicon nitride **8031** is positioned over the aluminium contact layers **8030** and the silicon dioxide layer **8017**. Each portion of the passivation layer **8031** positioned over the contact layers **8030** has an opening **8032** defined therein to provide access to the contacts **8030**.

[0156] The nozzle arrangement **801** includes a nozzle chamber **8029** defined by an annular nozzle wall **8033**, which terminates in a nozzle rim **804** that is circular in plan. The ink inlet channel **8014** is in fluid communication with the nozzle chamber **8029**. At a lower end of the nozzle wall, there is disposed a moving rim **8010**, that includes a moving seal lip **8040**. An encircling wall **8038** surrounds the movable nozzle, and includes a stationary seal lip **8039** that, when the nozzle is at rest as shown in FIG. **46**, is adjacent the moving rim **8010**. A fluidic seal **8011** is formed due to the surface tension of ink trapped between the stationary seal lip **8039** and the moving seal lip **8040**. This prevents leakage of ink from the chamber whilst providing a low resistance coupling between the encircling wall **8038** and the nozzle wall **8033**.

[0157] As best shown in FIG. **47**, a plurality of radially extending recesses **8035** is defined in the roof **8034** about the nozzle rim **804**. The recesses **8035** serve to contain radial ink flow as a result of ink escaping past the nozzle rim **804**.

[0158] The nozzle wall **8033** forms part of a lever arrangement that is mounted to a carrier **8036** having a generally U-shaped profile with a base **8037** attached to the layer **8031** of silicon nitride.

[0159] The lever arrangement also includes a lever arm **8018** that extends from the nozzle walls and incorporates a lateral stiffening beam **8022**. The lever arm **8018** is attached to a pair of passive beams **806**, formed from titanium nitride (TiN) and positioned on either side of the nozzle arrangement, as best shown in FIGS. **49** and **54**. The other ends of the passive beams **806** are attached to the carrier **8036**.

[0160] The lever arm **8018** is also attached to an actuator beam **807**, which is formed from TiN. It will be noted that this attachment to the actuator beam is made at a point a small but critical distance higher than the attachments to the passive beam **806**.

[0161] As best shown in FIGS. **49** and **52**, the actuator beam **807** is substantially U-shaped in plan, defining a current path between the electrode **809** and an opposite electrode **8041**. Each of the electrodes **809** and **8041** are electrically connected to respective points in the contact layer **8030** (shown in FIGS. **46** and **51**). As well as being electrically coupled via the contacts **809**, the actuator beam is also mechanically anchored to anchor **808**. The anchor **808** is configured to constrain motion of the actuator beam **807** to the left of FIGS. **46** to **48** when the nozzle arrangement is in operation.

[0162] The TiN in the actuator beam **807** is conductive, but has a high enough electrical resistance that it undergoes self-heating when a current is passed between the electrodes **809** and **8041**. No current flows through the passive beams **806**, so they do not expand.

[0163] In use, the device at rest is filled with ink **8013** (FIG. **46**) that defines a meniscus **803** under the influence of surface tension. The ink is retained in the chamber **8029** by the meniscus, and will not generally leak out in the absence of some other physical influence.

[0164] As shown in FIG. **47**, to fire ink from the nozzle, a current is passed between the contacts **809** and **8041**, passing through the actuator beam **807**. The self-heating of the beam **807** due to its resistance causes the beam to expand. The dimensions and design of the actuator beam **807** mean that the majority of the expansion in a horizontal direction with respect to FIGS. **46** to **48**. The expansion is constrained to the left by the anchor **808**, so the end of the actuator beam **807** adjacent the lever arm **8018** is impelled to the right.

[0165] The relative horizontal inflexibility of the passive beams **806** prevents them from allowing much horizontal movement with respect to the lever arm **8018**. However, the relative displacement of the attachment points of the passive beams and actuator beam respectively to the lever arm causes a twisting movement that causes the lever arm **8018** to move generally downwards. The movement is effectively a pivoting or hinging motion. However, the absence of a true pivot point means that the rotation is about a pivot region defined by bending of the passive beams **806**.

[0166] The downward movement (and slight rotation) of the lever arm **8018** is amplified by the distance of the nozzle wall **8033** from the passive beams **806**. The downward movement of the nozzle walls and roof causes a pressure increase within the chamber **8029**, causing the meniscus to bulge as shown in FIG. **47**. It will be noted that the surface tension of the ink means the fluid seal **8011** is stretched by this motion without allowing ink to leak out.

[0167] As shown in FIG. **48**, at the appropriate time, the drive current is stopped and the actuator beam **807** quickly cools and contracts. The contraction causes the lever arm to commence its return to the quiescent position, which in turn causes a reduction in pressure in the chamber **8029**. The interplay of the momentum of the bulging ink and its inherent surface tension, and the negative pressure caused by the upward movement of the nozzle chamber **8029** causes thinning, and ultimately snapping, of the bulging meniscus to define an ink drop **802** that continues upwards until it contacts adjacent print media.

[0168] Immediately after the drop **802** detaches, the meniscus forms the concave shape shown in FIG. **48**. Surface tension causes the pressure in the chamber **8029** to remain relatively low until ink has been sucked upwards through the inlet **8014**, which returns the nozzle arrangement and the ink to the quiescent situation shown in FIG. **48**.

[0169] As best shown in FIG. **49**, the nozzle arrangement also incorporates a test mechanism that can be used both post-manufacture and periodically after the printhead is installed. The test mechanism includes a pair of contacts **8020** that are connected to test circuitry (not shown). A bridging contact **8019** is provided on a finger **8043** that extends from the lever arm **8018**. Because the bridging contact **8019** is on

the opposite side of the passive beams **806**, actuation of the nozzle causes the priding contact to move upwardly, into contact with the contacts **8020**. Test circuitry can be used to confirm that actuation causes this closing of the circuit formed by the contacts **8019** and **8020**. If the circuit closed appropriately, it can generally be assumed that the nozzle is operative.

[0170] Flat Panel Display Device with Integrated Printer

[0171] A preferred embodiment of the invention is shown in FIGS. **8** to **25**. Referring particularly to FIGS. **8** to **15**, a flat panel display unit **141** includes a flat panel display **142** that is supported on a stand **143**. The present invention primarily applies to flat panel displays where a viewable size of the flat panel display exceeds 40 cm measured along a diagonal of the flat panel display. The stand **143** includes a base portion **144**, which supports an arm **145** to which a housing **146** for the display **142** is hingedly connected. Various control buttons **148** are provided on the display unit **141**, for controlling display functions such as contrast, brightness, color temperature and the like.

[0172] The display unit **141** incorporates a page-width printer (described below) that accepts, in the preferred embodiments shown in FIGS. **8** to **32**, single sheets of standard A4 or US Letter paper **149**. A curved paper guide **150** causes paper exiting the printer to be directed away from the base **144** of the display unit **141**, as best shown in FIGS. **9** and **12**.

[0173] The sub-components that comprise the display unit **141** are shown in exploded view in FIG. **16**. A mounting plate **151** is hingedly mounted to the arm **145** and attached to a rear cover molding **152** formed from a plastics material. The cover molding is perforated to allow convective air currents to cool the electronic circuitry inside the display unit **141**.

[0174] A metallic radio frequency interference and electromagnetic interference (RFI/EMI) shield **153** fits inside the concave side of the rear cover molding **152**. The shield **153** screens the various circuitry elements from external radiation, whilst reducing any radiation generated by the circuitry being transmitted from the display unit **141**. The shield **153** takes the form of a cage with cooling holes that allow ventilation of the circuitry. An additional shield **154** covers the printhead (described below in relation to FIG. **23**).

[0175] The various electronic, mechanical and electromechanical components that comprise the printer are mounted on interconnected printed circuit boards (PCBs) **155**, as best shown in FIGS. **19** to **21**. The PCBs **155** include a printhead PCB **156**, an analog converter PCB **157**, a backlight inverter PCB **158**, and a power supply unit (PSU) **159**. The PSU **159** supplies power at appropriate voltage and current to the various other PCBs via wiring **160**.

[0176] Turning to FIG. **22**, the printhead PCB forms part of a print engine assembly **161**. The print engine assembly **161** also includes paper feed rollers **162**, a platen **163** for supporting paper as it is fed past the printhead, an air pump **164** for supplying pressurized air to the printhead, a flexible connector **147** for supplying data from the print engine chips on the print engine PCB to the printhead, an ink delivery bus **165**, and a print engine controller (SoPEC) chip **166**. The feed rollers **162** are driven by a paper drive motor **197** and drive assembly **198**.

[0177] As shown in FIG. **23** (in which the platen and feed rollers are removed for clarity), the print engine assembly **161** also includes support metalwork **167** for mounting the various components, copper busbars **168** for supplying power from the power leads **169** to the printheads, and flexible paper guide fingers **170** Ink channel moldings **171** route ink from the ink delivery bus **165**, which also includes electrical contacts **173** that enable communication between an ink cartridge (described below) and the print engine assembly. It will be noted that the present embodiment includes two printhead segments **174** and **175** of equal length that together form a pagewidth printhead. As described earlier in this document,

[0178] Referring back to FIG. **16**, a metal paper chute **176** is provided to guide paper behind the display and down to the printhead. A metal chassis **177** is provided to support the display **142**, which is surrounded and protected by a plastic front bezel molding **178**. A menu PCB **179** holds the menu buttons **148** and associated status LEDs.

[0179] As best shown in FIG. **10**, the display unit **141** is provided with power via a mains cord **180** and associated mains plug **181**. The mains plug **181** is inserted into mains socket **182**, which is shown in FIG. **17** with the mains plug **181** removed. The mains socket **182** is hard-wired into the PSU **159**.

[0180] A video input cable **183** and associated video plug **184** supply video data from a computer. The video plug **184** is inserted into a video socket **185**, which is shown in FIG. **17** with the video plug **184** removed for clarity.

[0181] A data connection in the form of a USB 2 link is provided by way of a data cable **186** and associated data plug **187**. The plug **187** is inserted into a USB 2 compliant data socket **188**, which is shown in FIG. **17** with the data plug **187** removed for clarity.

[0182] As shown in FIG. **21** an ink cartridge **189** containing the various inks required for operation of the printer releasably engages the ink delivery bus **165** via an aperture **190** (FIG. **16**) formed in the rear molding **152**. The cartridge is preferably held in position by an interference fit, although a positive retaining mechanism such as a clip can be supplied in alternative embodiments. As best shown in FIG. **21**, the ink delivery bus **165** includes a plurality of fluid ports **191** that engage with corresponding fluid outputs (not shown) formed in the cartridge. In the embodiment shown, each fluid port **191** includes a hollow needle **192** that penetrates a seal (not shown) in the corresponding fluid output. The seal can be an annular resilient seal with a frangible membrane, or simply a frangible membrane that self-seals around the needle **192** as the cartridge **189** is inserted into an operative position.

[0183] The cartridge **189** contains the inks necessary for its use with the printer. The various possible combinations of colored inks (such as CMY), black ink, infrared ink and a fixative are described elsewhere in this document. The cartridge **189** also includes a QA ("Question-Answer") chip that is configured to store information accessible by the SoPEC chip **166**, such as ink levels remaining (preferably on a per-ink basis), types of ink contained in the cartridge, security data for ensuring the cartridge is compliant with the printer's needs and any other data that might be useful for the operation of the printer based on the particular cartridge inserted. The QA chip is electrically connected to a set of contacts (not shown) that operatively engage the electrical contacts **173** on an edge of the ink delivery bus **165**. The electrical contacts allow information to be read from the QA chip in the cartridge **189** as required. This can be when the cartridge is first inserted, and possibly periodically thereafter. In the preferred embodiment, the SoPEC chip **166** can also write back to the cartridge. Typically, this will involve determining the amount of ink used and then updating the QA chip in the cartridge.

[0184] A number of other elements of the display unit **141** not shown in other Figures are shown in FIG. **44**. It will be noted that the flat panel display **142** is preferably a Thin Film Transistor (TFT) Liquid Crystal Display (LCD). However, it will be understood that the particular technology employed in the flat panel display **142** is not critical to the invention. The flat panel display **142** can therefore be of any other type, including those using Organic Light Emitting Diode (OLED), Field Emission Display (FED) and Plasma Display Panel (PDP) technologies.

[0185] As shown in FIG. **44** the display unit includes row drivers **193** and column drivers **194** that are provided with input signals by an image processor **195** located on the analog converter PCB **157**. The image processor receives display data from a personal computer (not shown) via the video socket **185**. The fluorescent backlight inverter PCB **158** drives a fluorescent backlight **196**.

[0186] The USB input **188** (FIG. **17**) provides data in accordance with the USB 2 protocol to the SoPEC chip **166**. The image processor **195** can also provide data to the SoPEC chip **166**, as described in detail below.

[0187] Operation of the display unit will now be described with reference to FIG. **44**. Display data is received from a personal computer, or other suitable video data source, via the video input socket **185**. The display data is provided to the image processor **195**, which processes and converts it into a format suitable for supply to the row drivers **193** and column drivers **194**. These drive the various TFTs required to display the image on the flat panel display **142**. The fluorescent backlight **196** provides illumination from behind the TFTs, thereby enhancing visibility of images displayed. Various display settings, such as contrast, brightness and resolution, can be altered by a user via the controls **148**.

[0188] The USB input socket **188** accepts USB formatted data from a connected personal computer, such as personal computer **102** in FIG. **1**. It will be appreciated that this data can come from any other suitable source, such as a network connection or any other data communication link.

[0189] Upon receipt, the data is forwarded via an internal USB link to the printhead PCB **156** and the SoPEC chip **166**. The data is decompressed and formatted in accordance with the steps shown in FIG. **1**, using the hardware **232** described in relation to FIG. **2**. The formatted data is forwarded from the SoPEC chip **166** to the Memjet printheads **174** and **175**. The data is then printed onto the paper **149** as it is driven past the printheads.

[0190] In the preferred embodiment, the print button **200** (FIGS. **8** and **9**) can be used to generate a printout of the presently displayed image. This enables a printout of the screen to be taken without the need to use a mouse, keyboard or other control device associated with the personal computer **102**.

[0191] The invention has a number of advantages over the prior art. The combination of a printer and flat panel display saves a considerable amount of room compared to a separate display and printer combination. The printed matter, in the preferred embodiment, is ejected right in front of the user, unlike the case with prior art printers which are, for the most part, too bulky to be placed directly in front of the user.

[0192] In the particularly preferred embodiment described, the pagewidth nature of the printer and its relatively compact dimensions compared with inkjet and laser printers respectively mean that high quality printing can be provided without substantially increasing the size of the flat panel display casing. Given that a major advantage of flat panel displays is their compactness, this can be considered a major feature of the preferred embodiment. With the use of a pagewidth printhead, there is less vibration than with a reciprocating inkjet printhead, resulting in a more stable image for a user viewing the display whilst printing.

[0193] An alternative embodiment of the invention is shown in FIG. **26**, in which like numerals indicate features corresponding to those described in relation to the embodiment of FIGS. **8** to **25**. The embodiment of FIG. **26** is a duplex printer, which includes a pair printheads **304** and **305**. The printheads are preferably of the same construction as the single printhead, each comprising two printhead segments. In the preferred embodiment, each of the printheads **304** and **305** has its own associated SoPEC device.

[0194] In operation, the embodiment of FIG. **26** prints onto both sides of the paper **149** as it is fed between the printheads **304** and **305**.

[0195] A further embodiment is shown in FIGS. **27** and **28**, in which like numerals indicate features corresponding to those described in relation to the embodiment of FIGS. **8** to **25**. The embodiment includes a multi-sheet feeder **312** that enables a single sheet at a time to be taken from a stack of paper and fed past the printhead. The feeder **312** is best shown in FIG. **28**, and includes a paper stop **205** that holds a stack of paper **203** in position. The preferred capacity of the stack **203** is about 50 sheets, although other capacities can be used. A flexible shim **206** extends across the top of the paper stop **205**, terminating in an edge adjacent and below a pickup roller **204**. The pickup roller **204** is generally circular in cross-section, but incorporates a flat portion **313**.

[0196] In use, the paper stack **203** is loaded such that it rest on the flexible shim **206**, which is in turn supported by the paper stop **205**. The pickup roller **204** is positioned rotationally such that the flat portion **313** (FIG. **28**) is aligned with the nearest piece of paper in the stack. The pickup roller **204** is then rotated clockwise (relative to FIG. **28**), until the rounded portion engages the piece of paper. As this happens, friction between the paper and the roller increases, causing a downward force on the paper. The flexible shim **206** causes the sheet of paper to be separated from the stack **203** and driven downwards towards the feed rollers **162**. As the paper engages the feed rollers, the flat spot rotates back into the position shown in FIG. **28**, which reduces the friction between the pickup roller and the paper, thereby enabling the feed rollers to push the paper past the printhead.

[0197] It will be appreciated that any other known paper feeding mechanisms can be employed for taking a single sheet from a stack and feeding it for printing. It will also be appreciated that a duplex printhead arrangement such as that shown in FIG. **26** can also be employed with a multi-sheet feed mechanism.

[0198] Another embodiment is shown in FIG. **29**, in which the sockets **182**, **185** and **188** are positioned in the base portion **144** of the display unit. This enables a neater arrangement of cables, since there is no need to route them all the way up to the rear molding **152**. Rather, internal wiring takes the power and data from the sockets to the relevant components via the interior of the arms **145**.

[0199] FIG. **30** shows another embodiment, in which the base portion **144** acts as a data hub. Circuitry (not shown) in the base portion **144** allows the USB connection enabled by socket **188** to send and receive data to and from other devices via data hub connectors **207**. This enables anything from

network to peripheral devices to be connected via the base portion **144**, rather than needing to access ports or sockets on the personal computer to which the display unit is connected. This can be advantageous given that ports and sockets on personal computers are often positioned in relatively difficult to access places. Often, the computer device itself is positioned out of the way, such as underneath a desk, which can contribute to this inconvenience of making data connections in the prior art.

[0200] Yet another embodiment, shown in FIG. **31**, the ink bus **165** is positioned such that the ink cartridge **189** is positioned on the mounting plate **151**.

[0201] FIG. **32** shows another embodiment of the invention, in which the ink cartridge **189** is positioned in the base portion **144** of the display unit. In this case, the arms **145** also include ink conduits for supplying ink from the cartridge **189** to the printer. In some cases, it may be necessary to provide some form of pump or other pressurization arrangement to push the ink upwards through the conduits in the arms **145**.

[0202] One Touch Print Button

[0203] A desktop printer attached to a personal computer (PC) may usefully incorporate an "Print" button which when pressed causes the active Windows application on the PC to print its entire active document to the printer, without an intervening print dialog. As a variation on this theme, when the printer is embedded in a flat-panel display (FPD), then the Print button may be incorporated in the display.

[0204] By active application we mean the application whose window is top-most, and with which the user it typically currently interacting. By active document we mean the document displayed in the active application's top-most window.

[0205] When the Print button is incorporated in a printer, it is important that the button initiates printing to that printer. When the Print button is incorporated in a display, it is reasonable for it to initiate printing to the default printer, which may or may not be configured to be the in-panel printer.

[0206] Windows Printing Background

[0207] There is no single standard way under Microsoft Windows to programmatically instruct the active application to print its active document to the default or to a designated printer. However, there are several mechanisms which may be exploited, covering most application types.

[0208] Although not explored here, comparable mechanisms exists under other operating systems and windowing systems, including Apple MacOS, Unix, X Windows, Linux etc. It should be appreciated by those skilled in the art that the invention is not limited to use with any particular hardware, operating system or software combination.

[0209] Printing User Interface

[0210] Most Microsoft Windows applications, as a matter of convention, provide a fairly standard printing user interface. This consists of: (a) a Print option on the File menu, usually accessible via the two keyboard sequences ALT,F,P and CTRL+P, which displays a print dialog to print the current document; and (b) a Print tool on the toolbar (shown as a printer icon) which prints the current document to the default printer without displaying the print dialog. Dialog-less direct printing has no standard keyboard shortcut.

[0211] If the active application is receptive to a keyboard sequence in this way, then a client application can instruct it to print by queuing the appropriate keyboard events (using the keybd_event or SendInput SDK functions) or by queuing the appropriate keyboard messages (using the AttachThreadInput, GetFocus, and PostMessage SDK functions). Direct printing can be simulated by appending a carriage-return to the keyboard sequence, causing the print dialog to be completed without further user input.

[0212] Automation

[0213] Some Windows applications, including Microsoft Office applications such as Word and Excel, expose an Automation interface (formerly known as OLE Automation), which allows them to be controlled by a separate application. For example, Word (like many other Microsoft applications) exposes a PrintOut method which can be invoked on the active document to print the document directly. A client application can discover an open Word document and print it in this way. The application can designate a particular printer by assigning the name of the printer to Word's ActivePrinter property prior to invoking the PrintOut method.

[0214] Automation servers such as Office applications register running instances of themselves in the Running Object Table (ROT). Multi-instance applications (such as Excel and some versions of Word) are only able to create a single application entry in the ROT. However, multi-instance applications typically also register each of their open documents separately in the ROT, allowing the client application to find the application instance corresponding to a particular document via the document's entry in the ROT.

[0215] The client application can iterate through the ROT, attach to each server application of interest in turn, and identify whether the application is associated with the foreground window. If the server application is associated with the foreground window (as identified by the GetForegroundWindow SDK function), then the client application can invoke the application's PrintOut method (or equivalent) to print the active document.

[0216] In the case of a single-instance application (such as PowerPoint), the client application attaches to the server application directly via the ROT entry. In the case of a multi-instance application (such as Excel), the client application attaches to the server application via a document entry in the ROT.

[0217] The Windows SDK provides standard functions for obtaining a pointer to the ROT and iterating through it. Application and document entries in the ROT are easily recognised since each entry is associated with a class-specific programmatic identifier. For example, a Word application has the programmatic identifier "Word.Application.x" (where x indicates the application version), and a Word document has the identifier "Word.Document.y" (where y indicates the document version). An application entry in the ROT conventionally includes the application's class identifier in its name, from which the corresponding programmatic identifier can be obtained via the Windows registry. A document entry in the ROT allows its programmatic identifier to be discovered via the class identifier associated with the document's persistence interface.

[0218] Because there are several ways to programmatically instruct the current application to print its active document to the default or to a designated printer, and because no single way is optimal for all applications, support for a "Print" button is best provided (in this embodiment) by invoking the mechanism most appropriate to the current application according to the current application's type.

[0219] In its simplest form, this consists of first trying to find the active application in the ROT, specifying the target printer by setting the active application's ActivePrinter prop-

erty, and invoking the active application's PrintOut method. If the active application is not found in the ROT, then the fallback consists of queuing the standard print-invocation keyboard sequence (i.e. Control key down, P key down, P key up, Control key up, CR key down, CR key up).

[0220] In a more sophisticated implementation, a table of applications is created which lists the mechanism most appropriate to each application type, i.e. Automation versus keyboard sequence, and exact application properties and methods to use, or exact keyboard sequence to send. Automation server applications are identified by their programmatic identifiers, while conventional applications are identified by their names. For example, Word is identified by its programmatic identifier "Word.Application.x", while Notepad is identified by its name "Notepad". It is straightforward to identify the foreground window (via the GetForegroundWindow SDK function) and extract the name of the corresponding active application from the window's title (via the GetWindowText SDK function).

[0221] The "Print" button can be a physical momentary switch or it can be simulated via another interface on the printer (or FPD) such as a touch-sensitive display. In any case, when the user presses the print button, an event is relayed to a background application on the PC which invokes the corresponding printing function as described above. The background application may already be executing, i.e. awaiting events, or it may be activated by the user's act of pressing the "Print" button. The button event can be relayed by the control software in the printer, via the printer's communications interface and its printer driver, and thence to the background application. Alternatively cacan be relayed via its own communications interface and driver, in which case the driver and the background application may be one and the same. For example, the print button can be provided in the form of a separate Universal Serial Bus (USB) device on the USB bus, but may share the physical USB connection between the printer (or FPD) and the PC.

[0222] In the preferred embodiment, the background application is capable of handling the "Print" buttons of multiple devices. To allow it to distinguish multiple buttons, each button event in this embodiment uniquely identifies its originating button. An event may include a unique identifier associated with the printer in which the button is embedded, or a unique identifier associated with the button itself, retrieved from non-volatile storage attached to the button. In cases where the target printer can be selected by setting the active server application's ActivePrinter property, the background application must know which printer name to specify. Since it may be difficult for the background application to know the name of the printer associated with a particular "Print" button it is servicing, it is useful to allow the user to associate a printer with each button, indexed by the button's unique identifier. If a button is pressed which has no associated printer, then the background application can determine how many printers are configured on the PC. If there is only one printer, then the application has no need to specify a printer since the one printer must be the default printer. If there are several printers, then the application can prompt the user to select one, and can then record the association between the selected printer and the button. It is straightforward for the background application to enumerate the available printers using the EnumPrinters SDK function.

[0223] Various exemplary, non-limiting aspects of the invention are foreshadowed in the following numbered paragraphs:

I/We claim:

1. A printing and display device comprising:
- a flat panel display for displaying images from an external computer;
- a printer having an inkjet printhead;
- a video socket adapted to engage with a video plug and video cable from the external computer to receive therefrom a video signal;
- a print data connection for selective connection to the external computer to receive therefrom print instructions;
- a rear cover molding enclosing therein the flat panel display;
- a paper chute for guiding paper between the flat panel display and the printhead; and
- an ink delivery bus provided within the rear cover molding, wherein
- the rear cover molding includes an aperture for receiving therein an external ink cartridge,
- the aperture facilitates coupling of the external ink cartridge with the ink delivery bus, and
- the ink delivery bus includes one or more fluid ports for engaging with the external ink cartridge, each of the one or more fluid port including a hollow needle adapted to penetrate a seal of the external ink cartridge.

2. A printing and display device as claimed in claim **1**, wherein the ink delivery bus further includes an electrical contact, the electrical contact for connecting with an integrated circuit provided on the external ink cartridge to facilitate communication between the printing and display device and the external ink cartridge.

3. A printing and display device as claimed in claim **1**, wherein the printer includes at least two printheads, the printheads being disposed on either side of a path through which print media is fed for printing.

4. A printing and display device as claimed in claim **1**, wherein the print data connection includes a wireless receiver for receiving the print data and/or the display data.

5. A printing and display device as claimed in claim **1**, wherein the print data connection is a Universal Synchronous Bus (USB) connection.

6. A printing and display device as claimed in claim **1**, further including a paper feed mechanism for feeding the paper to the printhead for printing.

7. A printing and display device as claimed in claim **6**, wherein the paper feed mechanism is configured to position the paper substantially parallel with respect to a plane defined by the flat panel display.

8. A printing and display device as claimed in claim **7**, wherein the paper feed mechanism includes a paper separator for feeding a single sheet of paper to the printhead from a stack of sheets of paper.

9. A printing and display device as claimed in claim **1**, wherein the printer is a process color printer.

10. A printing and display device as claimed in claim **1**, wherein the printer is an inkjet printer.

11. A printing and display device as claimed in claim **1**, wherein the printer is a page-width printer spanning the length of a lower edge of the flat panel display.

12. A printing and display device as claimed in claim **1**, wherein the flat panel display measures at least 14 inches on the diagonal.

13. A printing and display device as claimed in claim **1**, further including a curved paper guide disposed adjacent a lower edge of the flat panel display and downstream from the printhead, the curved paper guide adapted to urged media exiting from the printhead horizontally and towards a front of the flat panel display.

14. A printing and display device as claimed in claim **1**, wherein the flat panel display is of one of the following types:

a. Liquid Crystal Display (LCD);

b. Organic Light Emitting Diode (OLED)

c. Field Emission Display (FED)

d. Plasma Display Panel (PDP)

15. A printing and display device as claimed in claim **1**, wherein the printhead is configured to receive halftoned print data to be printed onto the print media.

16. A printing and display device as claimed in claim **1**, further including a halftoning unit for generating halftoned image data and supplying the halftoned image data to the printhead for printing.

17. A printing and display device as claimed in claim **1**, wherein the paper chute is substantially parallel to a plane of the flat panel display.

18. A printing and display device as claimed in claim **1**, wherein the paper chute and the printhead are substantially in the same plane, whereby a print media path along which paper from the paper chute is propagated to arrive at the printhead is substantially planar.

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