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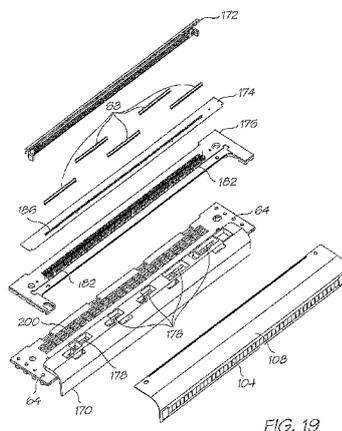


FIG. 19

(57) Abstract: A printhead for an inkjet printer that has a printhead integrated circuit (68) with nozzles for ejecting ink, and a support structure (64, 176, 108) for supporting the printhead IC. The support structure has ink conduits (182) for supplying the nozzles with ink and a fluidic damper (200) containing gas for compression by pressure pulses in the ink within the ink conduits to dissipate the pressure pulse. Damping pressure pulses using gas compression can be achieved with small volumes of gas. This preserves a compact design while avoiding any nozzle flooding from transient spikes in the ink pressure.

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Description

FLUIDICALLY DAMPED PRINTHEAD

[1] Field of the Invention

[2] The present invention relates to printers and in particular inkjet printers.

[3] Background of the Invention

[4] The Applicant has developed a wide range of printers that employ pagewidth printheads instead of traditional reciprocating printhead designs. Pagewidth designs increase print speeds as the printhead does not traverse back and forth across the page to deposit a line of an image. The pagewidth printhead simply deposits the ink on the media as it moves past at high speeds. Such printheads have made it possible to perform full colour 1600dpi printing at speeds in the vicinity of 60 pages per minute, speeds previously unattainable with conventional inkjet printers.

[5] Printing at these speeds consumes ink quickly and this gives rise to problems with supplying the printhead with enough ink. Not only are the flow rates higher but distributing the ink along the entire length of a pagewidth printhead is more complex than feeding ink to a relatively small reciprocating printhead.

[6] The high print speeds require a relatively large ink supply flow rate. This mass of ink is moving relatively quickly through the supply line. Abruptly ending a print job, or simply at the end of a printed page, means that this relatively high volume of ink that is flowing relatively quickly must also come to an immediate stop. However, suddenly arresting the ink momentum gives rise to a shock wave in the ink line. The components making up the printhead are typically stiff and provide almost no flex as the column of ink in the line is brought to rest. Without any compliance in the ink line, the shock wave can exceed the Laplace pressure (the pressure provided by the surface tension of the ink at the nozzle openings to retain ink in the nozzle chambers) and flood the front surface of the printhead nozzles. If the nozzles flood, ink may not eject and artifacts appear in the printing.

[7] Resonant pulses in the ink occur when the nozzle firing rate matches a resonant frequency of the ink line. Again, because of the stiff structure that define the ink line, a large proportion of nozzles for one color, firing simultaneously, can create a standing wave or resonant pulse in the ink line. This can result in nozzle flooding, or conversely nozzle deprime because of the sudden pressure drop after the spike, if the Laplace pressure is exceeded.

[8] Summary of the Invention

[9] Accordingly, in a first aspect the present invention provides a printhead for an inkjet printer, the printhead comprising:

[10] a printhead integrated circuit (IC) with an array of nozzles for ejecting ink;

- [11] a support structure for supporting the printhead IC, the support structure having ink conduits for supplying the array of nozzles with ink; and,
- [12] a fluidic damper containing gas for compression by pressure pulses in the ink within the ink conduits to dissipate the pressure pulse.
- [13] Damping pressure pulses using gas compression can be achieved with small volumes of gas. This preserves a compact design while avoiding any nozzle flooding from transient spikes in the ink pressure.
- [14] Optionally, the fluidic damper has an array of cavities for holding the gas such that each cavity is a separate pocket of the gas. Optionally, each of the cavities is partially defined by an ink meniscus when the ink conduits of the support structure are primed with ink.
- [15] Optionally, each of the cavities is a blind recess with an opening facing one or more of the ink conduits. Optionally, the opening of each of the blind recesses faces one of the ink conduits only. Optionally, the opening of each of the blind recesses of configured to inhibit ink filling the recess by capillary action.
- [16] Optionally, the support structure has an inlet for connecting the ink conduits to an ink supply and an outlet for connecting the ink conduits to a waste ink outlet. Optionally, the openings to each respective cavity have an upstream edge and a downstream edge, the upstream edge contacting the ink before the downstream edge during initial priming of the ink conduits from the ink supply, and the upstream edge having a transition face between the conduit and the cavity interior, the transition face being configured to inhibit from filling the cavity and purging the gas by capillary action during initial priming of the ink conduit.
- [17] Optionally, the printhead is a pagewidth printhead and the support structure is elongate with the inlet at one end and the outlet at the other end, and the ink conduits have channels extending longitudinally along the support structure between the inlet and the outlet, and each of the channels have a series ink feed passages spaced along it to provide fluid communication between the channel and the printhead IC. Optionally, the ink feed passages join to the channel along a wall of the channel that is opposite the wall including the openings to the cavities.
- [18] Optionally, the support structure is a liquid crystal polymer (LCP). Optionally the support structure is a two-part LCP molding with the channels and the feed passages formed in one part and the cavities formed in the other part.
- [19] Optionally, the support structure has a plurality of printhead ICs mounted end to end along one side face. Optionally the printhead ICs are mounted to the side face via an interposed adhesive film having holes for fluid communication between the ink feed passages and the printhead ICs.
- [20] Accordingly, in a second the present invention provides a printhead for an inkjet

printer, the printhead comprising:

- [21] a printhead integrated circuit (IC) having an array of nozzles for ejecting ink; and,
- [22] a support structure for mounting the printhead IC within the printer, the support structure having ink conduits for supplying the array of nozzles with ink, the ink conduits have a weir formation to partially obstruct ink flow; wherein,
- [23] when priming the printhead, the weir formation preferentially primes an upstream section the ink conduit.
- [24] Using a weir downstream of areas that have a propensity to prime incorrectly can force them to prime more quickly or in preference to downstream sections. As long as the downstream section is one that reliably primes, albeit delayed by the weir, there is no disadvantage to priming the upstream section in preference.
- [25] Optionally, the weir formation has a top profile configured to provide an anchor point for the meniscus of an advancing ink flow. Optionally, the upstream section has cavities in its uppermost surface that are intended to hold pockets of air after the printhead has been primed. Optionally, the cavities have openings defined in the uppermost surface of the upstream section, the upstream edge of each opening being curved and the downstream edge being relatively sharp so that ink flowing from the upstream direction does get drawn into the cavity by capillary action. Optionally the weir is positioned to momentarily anchor the meniscus of the advancing ink flow and divert it from contact the relatively sharp edge of the opening for one of the cavities. Optionally, the printhead is a cartridge configured for user removal replacement. Optionally, the cartridge is unprimed when installed and subsequently primed by a pump in the printer.
- [26] Accordingly, in a third aspect the present invention provides a printhead for an inkjet printer, the printhead comprising:
- [27] an elongate array of nozzles for ejecting ink;
- [28] a plurality of ink conduits for supplying the array of nozzles with ink, the ink conduits extending adjacent the elongate array; and,
- [29] a plurality of pulse dampers, each containing a volume of gas for compression by pressure pulses in the ink conduits, and each being individually in fluid communication with the ink conduits; wherein,
- [30] the pulse dampers are distributed along the length of the elongate array.
- [31] A pressure pulse moving through an elongate printheads, such as a pagewidth printhead, can be damped at any point in the ink flow line. However, the pulse will cause nozzle flooding as it passes the nozzles in the printhead integrated circuit, regardless of whether it is subsequently dissipated at the damper. By incorporating a number of pulse dampers into the ink supply conduits immediately next to the nozzle array, any pressure spikes are damped at the site where they would otherwise cause

detrimental flooding.

[32] Optionally, the plurality of pulse dampers are a series of cavities open at one side to the ink conduits. Optionally, each the cavities has an opening in only one of the ink conduits, each of the ink conduits connect to a corresponding ink supply and the openings are configured such that the cavities do not prime with ink when the ink conduits are primed from the corresponding ink supply.

[33] Optionally, each of the cavities is a blind recess such that the opening defines an area substantially equal to that of the blind end. Optionally, the openings each face one of the ink conduits only. Optionally, the openings are configured to inhibit ink filling the recess by capillary action.

[34] Optionally, the openings to each respective cavity have an upstream edge and a downstream edge, the upstream edge contacting the ink before the downstream edge during initial priming of the ink conduits from the ink supply, and the upstream edge having a transition face between the conduit and the cavity interior, the transition face being configured to inhibit from filling the cavity and purging the gas by capillary action during initial priming of the ink conduit.

[35] Optionally, the array of nozzles is formed in at least one printhead IC mounted to a support structure in which the ink conduits are formed. Optionally, the printhead is a pagewidth printhead and the support structure is elongate with the inlet at one end and the outlet at the other end, and the ink conduits have channels extending longitudinally along the support structure between the inlet and the outlet, and each of the channels have a series ink feed passages spaced along it to provide fluid communication between the channel and the printhead IC. Optionally, the ink feed passages join to the channel along a wall of the channel that is opposite the wall including the openings to the cavities.

[36] Optionally, the support structure is a liquid crystal polymer (LCP). Optionally the support structure is a two-part LCP molding with the channels and the feed passages formed in one part and the cavities formed in the other part.

[37] Optionally, the support structure has a plurality of printhead ICs mounted end to end along one side face. Optionally the printhead ICs are mounted to the side face via an interposed adhesive film having holes for fluid communication between the ink feed passages and the printhead ICs.

[38] Accordingly, in a fourth aspect the present invention provides a printhead for an inkjet printer, the printhead comprising:

[39] a printhead integrated circuit (IC), the printhead IC being elongate and having an array of nozzles for ejecting ink;

[40] a support structure for supporting the printhead IC and having ink outlets for supplying the array of nozzles with ink; wherein,

- [41] the ink outlets are spaced along the printhead IC such that the ink outlet spacing decreases at the ends of the printhead IC.
- [42] By increasing the number of ink outlets near the end regions, the ink supply is enhanced to compensate for the slower priming of the end nozzles. This, in turn, makes the whole nozzle array prime more consistently to avoid flooding and ink wastage from early priming nozzles (or alternatively, unprimed end nozzles).
- [43] Optionally, the support structure supports a plurality of the printhead ICs configured in an end to end relationship, the support structure having a plurality of ink feed passages for supplying ink to the ink outlets such that at least some of the ink feed passages near a junction between ends of two of the printhead ICs, supplies ink to two of the ink outlets, the two ink outlets being on different sides of the junction. Optionally, the support structure has a molded ink manifold in which the ink feed passages are formed and a polymer film in which the ink outlets are formed, such that the polymer film is mounted to the molded ink manifold and the printhead ICs are mounted to the other side of the polymer film. Optionally, the printhead ICs have ink inlet channels on one side of a wafer substrate and the array of nozzles formed on the other side of the wafer substrate such that each of the ink inlet channels connects to at least one of the ink outlets.
- [44] Optionally the support structure has a fluidic damper for damping pressure pulses in the ink being supplied to the printhead ICs. Optionally, the fluidic damper has an array of cavities for holding a volume of gas such that each cavity is a separate pocket of the gas. Optionally, each of the cavities is partially defined by an ink meniscus formed when the ink conduits of the support structure are primed with ink.
- [45] Optionally, the ink manifold has a series in main channels extending parallel to the printhead ICs, the main channels supplying ink to the ink feed passages, and each of the cavities is a blind recess with an opening facing one or more of the main channels. Optionally, the opening of each of the blind recesses faces one of the main channels only. Optionally, the opening of each of the blind recesses is configured to inhibit ink filling the recess by capillary action.
- [46] Optionally, the support structure has an inlet for connecting the ink conduits to an ink supply and an outlet for connecting the ink conduits to a waste ink outlet. Optionally, the openings to each respective cavity have an upstream edge and a downstream edge, the upstream edge contacting the ink before the downstream edge during initial priming of the main channels from the ink supply, and the upstream edge having a transition face between the conduit and the cavity interior, the transition face being configured to inhibit from filling the cavity and purging the gas by capillary action during initial priming of the ink conduit.
- [47] Optionally, the printhead is a pagewidth printhead and the support structure is

elongate with the inlet at one end and the outlet at the other end, and the main channels extend longitudinally along the support structure between the inlet and the outlet, and the ink feed passages join to one of the main channels along a wall of the main channel that is opposite the wall including the openings to the cavities.

[48] Optionally, the support structure is a liquid crystal polymer (LCP). Optionally the support structure is a two-part LCP molding with the channels and the feed passages formed in one part and the cavities formed in the other part.

[49] Accordingly, in a fifth aspect the present invention provides a detachable fluid coupling for establishing sealed fluid communication between an inkjet printhead and an ink supply; the detachable coupling comprising:

[50] a fixed valve member defining a valve seat;

[51] a sealing collar for sealing engagement with the valve seat;

[52] a resilient sleeve having one annular end fixed relative to the fixed valve member, and the other annular end engaging the sealing collar to bias it into sealing engagement with the valve seat; and,

[53] a conduit opening that is movable relative to the fixed valve member for engaging the sealing collar to unseal it from the valve seat; wherein,

[54] unsealing the sealing collar from the valve seat compresses the resilient sleeve such that an intermediate section of the sleeve displaces outwardly relative to the annular ends.

[55] With a resilient sleeve that buckles or folds outwardly, the diameter of the coupling is smaller than the conventional couplings that use an annular resilient element that biases the valve shut remaining residual tension. With a smaller outer diameter, the couplings for all the different ink colors can be positioned in a smaller more compact interface.

[56] Optionally, the intermediate section of the resilient sleeve is an annular fold to expand outwardly when the sleeve is axially compressed. Optionally, the resilient sleeve applies a restorative force to the sealing collar when the conduit opening is withdrawn such that the restorative force increases as the axial length increases such that a maximum restorative force is applied to the sealing collar when it is sealed against the valve seat. Optionally, the resilient sleeve connects to an inner diameter of the sealing collar. Optionally, both of the annular ends of the resilient sleeve are substantially the same size.

[57] Optionally, the sealing collar has resilient material where the conduit opening engages it so that a fluid tight seal forms upon such engagement. Optionally, the fluid tight seal between the conduit opening and the sealing collar forms before the sealing collar unseals from the valve seat.

[58] Optionally, the fixed valve member has a hollow section that forms part of a fluid flow path through the coupling when the coupling is open. Optionally the fixed valve

member and the resilient sleeve are on a downstream side of the coupling and the conduit opening is on an upstream side. Optionally, the downstream side is part of a cartridge with a replaceable printhead and the upstream side is part of a printer in which the cartridge can be installed.

[59] Accordingly, in a sixth aspect the present invention provides a filter for an inkjet printer, the filter comprising:

[60] a chamber divided into an upstream section and a downstream section by a filter membrane;

[61] an inlet conduit for establishing fluid communication between an ink supply and the upstream section; and,

[62] an outlet conduit for establishing fluid communication between the downstream section and a printhead; wherein during use,

[63] at least part of the inlet conduit is elevated relative to the filter membrane.

[64] By elevating the inlet conduit relative to the filter membrane, it acts as a bubble trap to retain bubbles that would otherwise obstruct the filter. This allows the filter size to be reduced for a more compact overall design.

[65] Optionally, the chamber has an internal height and width corresponding to the dimensions of the filter membrane and a thickness that is substantially less than height and width dimensions.

[66] Configuring the chamber in this way keeps the overall volume to a minimum and places the filter membrane in a generally vertical plane. The buoyancy of any bubbles in the chamber will urge them closer to the top of the chamber and possibly back into the inlet conduit. This discourages bubbles from pinning to the upstream face of the filter membrane.

[67] Optionally, the outlet conduit connects to the downstream section at its point with the lowest elevation during use. If bubbles do start to obstruct the filter, they will obstruct the lowest areas of the chamber last. Optionally the filter membrane is rectangular and the inlet connects to the upstream section at one corner and the outlet conduit connects to the diagonally opposed corner.

[68] Optionally, the downstream section has a support formation for the filter membrane to bear against such that it remains spaced from an opposing wall of the downstream section. Optionally the opposing wall is also a wall that partially defines the upstream section of a like chamber housing a like filter member, such that a number of filters are configured side-by-side.

[69] Optionally, the filter is installed in a component of the inkjet printer that is intended to be periodically replaced.

[70] Optionally, the filter is installed in a cartridge with a pagewidth printhead. Optionally the cartridge has a detachable ink coupling upstream of the filter for connection to an

ink supply.

[71] Accordingly, in a seventh aspect the present invention provides an ink coupling for establishing fluid communication between an inkjet printer and a replaceable cartridge for installation in the printer, the coupling comprising:

[72] a cartridge valve on the cartridge side of the coupling; and,

[73] a printer conduit on the printer side of the coupling, the cartridge valve and the printer conduit having complementary formations configured to form a coupling seal when brought into engagement; wherein,

[74] the cartridge valve is biased closed and configured to open when brought into engagement with the printer conduit; such that,

[75] upon disengagement, the coupling seal breaks after the cartridge valve closes, and an ink meniscus forms and recedes from the complementary formations as they separate, the cartridge valve having external surfaces configured so that the meniscus cleanly detaches from the printer conduit and only pins to the printer conduit surfaces.

[76] The invention keeps residual ink off the exterior of the cartridge valve by careful design of the external surfaces with respect to known receding contact angle of the ink meniscus. As the coupling seal breaks and the meniscus forms, the ink properties and hydrophilicity of the respective valve materials will determine where the meniscus stops moving and eventually pins itself. Knowing the ink properties and that the direction of disengagement, the valve materials and exterior design can make the meniscus pin to the printer conduits only.

[77] Optionally, at least one of the external surfaces of the cartridge valve has less hydrophilicity than at least one of the external surfaces on the printer conduit. Optionally, the cartridge engages from the printer by moving vertically downwards and disengages by moving vertically upwards. Optionally, upon engagement, the coupling seal forms before the cartridge valve and the printer valve opens. Optionally, the cartridge valve has a fixed valve member defining a valve seat and a sealing collar for sealing engagement with the valve seat, and a resilient sleeve having one annular end fixed relative to the fixed valve member, and the other annular end engaging the sealing collar to bias it into sealing engagement with the valve seat; and,

[78] the printer conduit has a conduit opening; such that,

[79] an axial end of the conduit opening and the sealing collar provide the complementary formations on the printer conduit and the cartridge valve respectively.

[80] Optionally, the conduit opening seals against the sealing collar before opening the cartridge valve. Optionally, the resilient sleeve and the sealing collar are integrally formed. Optionally, the resilient sleeve and sealing collar are silicone. Optionally, the fixed valve member is formed from poly(ethylene terephthalate) (PET). Optionally, the conduit opening is formed from poly(ethylene terephthalate) (PET).

- [81] Optionally, the cartridge has a pagewidth printhead and the printer has an ink reservoir for supplying the printhead via the coupling.
- [82] Accordingly, in an eighth aspect the present invention provides a printhead for an inkjet printer, the printhead comprising:
- [83] a printhead integrated circuit (IC) having an array of nozzles for ejecting ink; and,
- [84] a support structure for mounting the printhead IC within the printer, the support structure having ink conduits for supplying the array of nozzles with ink, the ink conduits have a weir formation to partially obstruct ink flow; wherein,
- [85] when priming the printhead, the weir formation preferentially primes an upstream section the ink conduit.
- [86] Using a weir downstream of areas that have a propensity to prime incorrectly can force them to prime more quickly or in preference to downstream sections. As long as the downstream section is one that reliably primes, albeit delayed by the weir, there is no disadvantage to priming the upstream section in preference.
- [87] Optionally, the weir formation has a top profile configured to provide an anchor point for the meniscus of an advancing ink flow. Optionally, the upstream section has cavities in its uppermost surface that are intended to hold pockets of air after the printhead has been primed. Optionally, the cavities have openings defined in the uppermost surface of the upstream section, the upstream edge of each opening being curved and the downstream edge being relatively sharp so that ink flowing from the upstream direction does get drawn into the cavity by capillary action. Optionally the weir is positioned to momentarily anchor the meniscus of the advancing ink flow and divert it from contact the relatively sharp edge of the opening for one of the cavities. Optionally, the printhead is a cartridge configured for user removal replacement. Optionally, the cartridge is unprimed when installed and subsequently primed by a pump in the printer.
- [88] Accordingly, in a ninth aspect the present invention provides a printhead for an inkjet printer, the printhead comprising:
- [89] a printhead integrated circuit (IC) having an array of nozzles for ejecting ink; and,
- [90] a support structure for mounting the printhead IC within the printer, the support structure having ink conduits for supplying the array of nozzles with ink, the ink conduits have a meniscus anchor for pinning part of an advancing meniscus of ink to divert the advancing meniscus from a path it would otherwise take.
- [91] If a printhead consistently fails to prime correctly because a meniscus pins at one or more points, then the advancing meniscus can be directed so that it does not contact these critical points. Deliberately incorporating a discontinuity into an ink conduit immediately upstream of the problem area can temporarily pin to the meniscus and skew it to one side of the conduit and away from the undesirable pinning point. Once flow

has been initiated into the side branch or downstream of the undesirable pinning point, it is not necessary for the anchor to hold the ink meniscus any longer and priming can continue.

[92] Optionally, the meniscus anchor is an abrupt protrusion into the ink conduit. Optionally, the meniscus anchor is a weir formation to partially obstruct ink flow such that, when priming the printhead, the weir formation preferentially primes an upstream section the ink conduit.

[93] Optionally, the upstream section has cavities in its uppermost surface that are intended to hold pockets of air after the printhead has been primed. Optionally, the cavities have openings defined in the uppermost surface of the upstream section, the upstream edge of each opening being curved and the downstream edge being relatively sharp so that ink flowing from the upstream direction does get drawn into the cavity by capillary action. Optionally the weir is positioned to momentarily anchor the meniscus of the advancing ink flow and divert it from contact the relatively sharp edge of the opening for one of the cavities. Optionally, the printhead is a cartridge configured for user removal replacement. Optionally, the cartridge is unprimed when installed and subsequently primed by a pump in the printer.

[94] Accordingly, in a tenth aspect the present invention provides a printhead for an inkjet printer, the inkjet printer having a print engine controller for receiving print data and sending it to the printhead, the printhead comprising:

[95] a printhead IC with an array of nozzles for ejecting ink;

[96] a support structure for mounting the printhead IC in the printer adjacent a paper path, the printhead IC being mounted on a face of the support structure that, in use, faces the paper path;

[97] a flexible printed circuit board (flex PCB) having drive circuitry for operating the array of nozzles on the printhead IC, the drive circuitry having circuit components connected by traces in the flex PCB, the flex PCB also having contacts for receiving print data from the print engine controller, the flex PCB at the contacts being mounted to the support structure on a face that does not face the paper path such that the flex PCB extends through a bent section between the printhead IC and the contacts; wherein,

[98] the printhead IC and the circuit components are adjacent each other and separated from the contacts by the bent section of the flex PCB.

[99] Optionally, the support structure has a curved surface to support the bent section of the flex PCB. The curved surface reduces the likelihood of trace cracking by holding the flex PCB at a set radius rather than allowing the flex to follow an irregular curve in the bent section, and thereby risking localized points of high stress on the traces.

[100] Optionally the flex PCB is anchored to the support structure at the circuit

components. Optionally the circuit components include capacitors that discharge during a firing sequence of the nozzles on the printhead IC. Optionally the support structure is a liquid crystal polymer (LCP) molding. LCP can be molded such that its coefficient of thermal expansion (CTE) is roughly the same as that of the silicon substrate in the printhead IC.

[101] Optionally the LCP molding has ink conduits for supplying ink to the printhead IC. Optionally the ink conduits lead to outlets in the face of the LCP molding on which the printhead IC is mounted.

[102] Optionally the printhead is a pagewidth printhead. Optionally the support structure has a cartridge bearing section located opposite the contacts, and a force transfer member extending from the contacts to cartridge bearing section such that when installed in the printer, pressure from the printer's complementary contacts is transferred directly to the cartridge bearing section via the force transfer member. Optionally the bearing section includes a locating formation for engagement with a complementary formation on the printer. Optionally, the locating formation is a ridge with a rounded distal end such that the cartridge can be rotated into position once the ridge has engaged the printer.

[103] Brief Description of the Drawings

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

[105] Figure 1 is a front and side perspective of a printer embodying the present invention;

[106] Figure 2 shows the printer of Figure 1 with the front face in the open position;

[107] Figure 3 shows the printer of Figure 2 with the printhead cartridge removed;

[108] Figure 4 shows the printer of Figure 3 with the outer housing removed;

[109] Figure 5 shows the printer of Figure 3 with the outer housing removed and printhead cartridge installed;

[110] Figure 6 is a schematic representation of the printer's fluidic system;

[111] Figure 7 is a top and front perspective of the printhead cartridge;

[112] Figure 8 is a top and front perspective of the printhead cartridge in its protective cover;

[113] Figure 9 is a top and front perspective of the printhead cartridge removed from its protective cover;

[114] Figure 10 is a bottom and front perspective of the printhead cartridge;

[115] Figure 11 is a bottom and rear perspective of the printhead cartridge;

[116] Figure 12 shows the elevations of all sides of the printhead cartridge;

[117] Figure 13 is an exploded perspective of the printhead cartridge;

[118] Figure 14 is a transverse section through the ink inlet coupling of the printhead cartridge;

- [119] Figure 15 is an exploded perspective of the ink inlet and filter assembly;
- [120] Figure 16 is a section view of the cartridge valve engaged with the printer valve;
- [121] Figure 17 is a perspective of the LCP molding and flex PCB;
- [122] Figure 18 is an enlargement of inset A shown in Figure 17;
- [123] Figure 19 is an exploded bottom perspective of the LCP/flex PCB/printhead IC assembly;
- [124] Figure 20 is an exploded top perspective of the LCP/flex PCB/printhead IC assembly;
- [125] Figure 21 is an enlarged view of the underside of the LCP/flex PCB/printhead IC assembly;
- [126] Figure 22 shows the enlargement of Figure 21 with the printhead ICs and the flex PCB removed;
- [127] Figure 23 shows the enlargement of Figure 22 with the printhead IC attach film removed;
- [128] Figure 24 shows the enlargement of Figure 23 with the LCP channel molding removed;
- [129] Figure 25 shows the printhead ICs with back channels and nozzles superimposed on the ink supply passages;
- [130] Figure 26 in an enlarged transverse perspective of the LCP/flex PCB/printhead IC assembly;
- [131] Figure 27 is a plan view of the LCP channel molding;
- [132] Figures 28A and 28B are schematic section views of the LCP channel molding priming without a weir;
- [133] Figures 29A, 29B and 29C are schematic section views of the LCP channel molding priming with a weir;
- [134] Figure 30 in an enlarged transverse perspective of the LCP molding with the position of the contact force and the reaction force;
- [135] Figure 31 shows a reel of the IC attachment film;
- [136] Figure 32 shows a section of the IC attach film between liners; and
- [137] Figure 33 is a partial section view showing the laminate structure of the attachment film.
- [138] Detailed Description of the Preferred Embodiments
- [139] Overview
- [140] Figure 1 shows a printer 2 embodying the present invention. The main body 4 of the printer supports a media feed tray 14 at the back and a pivoting face 6 at the front. Figure 1 shows the pivoting face 6 closed such that the display screen 8 is its upright viewing position. Control buttons 10 extend from the sides of the screen 8 for convenient operator input while viewing the screen. To print, a single sheet is drawn

from the media stack 12 in the feed tray 14 and fed past the printhead (concealed within the printer). The printed sheet 16 is delivered through the printed media outlet slot 18.

[141] Figure 2 shows the pivoting front face 6 open to reveal the interior of the printer 2. Opening the front face of the printer exposes the printhead cartridge 96 installed within. The printhead cartridge 96 is secured in position by the cartridge engagement cams 20 that push it down to ensure that the ink coupling (described later) is fully engaged and the printhead ICs (described later) are correctly positioned adjacent the paper feed path. The cams 20 are manually actuated by the release lever 24. The front face 6 will not close, and hence the printer will not operate, until the release lever 24 is pushed down to fully engage the cams. Closing the pivoting face 6 engages the printer contacts 22 with the cartridge contacts 104.

[142] Figure 3 shows the printer 2 with the pivoting face 6 open and the printhead cartridge 96 removed. With the pivoting face 6 tilted forward, the user pulls the cartridge release lever 24 up to disengage the cams 20. This allows the handle 26 on the cartridge 96 to be gripped and pulled upwards. The upstream and downstream ink couplings 112A and 112B disengage from the printer conduits 142. This is described in greater detail below. To install a fresh cartridge, the process is reversed. New cartridges are shipped and sold in an unprimed condition. So to ready the printer for printing, the active fluidics system (described below) uses a downstream pump to prime the cartridge and printhead with ink.

[143] In Figure 4, the outer casing of the printer 2 has been removed to reveal the internals. A large ink tank 60 has separate reservoirs for all four different inks. The ink tank 60 is itself a replaceable cartridge that couples to the printer upstream of the shut off valve 66 (see Figure 6). There is also a sump 92 for ink drawn out of the cartridge 96 by the pump 62. The printer fluidics system is described in detail with reference to Figure 6. Briefly, ink from the tank 60 flows through the upstream ink lines 84 to the shut off valves 66 and on to the printer conduits 142. As shown in Figure 5, when the cartridge 96 is installed, the pump 62 (driven by motor 196) can draw ink into the LCP molding 64 (see Figures 6 and 17 to 20) so that the printhead ICs 68 (again, see Figures 6 and 17 to 20) prime by capillary action. Excess ink drawn by the pump 62 is fed to a sump 92 housed with the ink tanks 60.

[144] The total connector force between the cartridge contacts 104 and the printer contacts 22 is relatively high because of the number of contacts used. In the embodiment shown, the total contact force is 45 Newtons. This load is enough to flex and deform the cartridge. Turning briefly to Figure 30, the internal structure of the chassis molding 100 is shown. The bearing surface 28 shown in Figure 3 is schematically shown in Figure 30. The compressive load of the printer contacts on the cartridge contacts 104 is

represented with arrows. The reaction force at the bearing surface 28 is likewise represented with arrows. To maintain the structural integrity of the cartridge 96, the chassis molding 100 has a structural member 30 that extends in the plane of the connector force. To keep the reaction force acting in the plane of the connector force, the chassis also has a contact rib 32 that bears against the bearing surface 28. This keeps the load on the structural member 30 completely compressive to maximize the stiffness of the cartridge and minimize any flex.

[145] Print Engine Pipeline

[146] The print engine pipeline is a reference to the printer's processing of print data received from an external source and outputted to the printhead for printing. The print engine pipeline is described in detail in USSNI 1/014769(RRCCOIOUS) filed December 20, 2004, the disclosure of which is incorporated herein by reference.

[147] Fluidic System

[148] Traditionally printers have relied on the structure and components within the printhead, cartridge and ink lines to avoid fluidic problems. Some common fluidic problems are deprimed or dried nozzles, outgassing bubble artifacts and color mixing from cross contamination. Optimizing the design of the printer components to avoid these problems is a passive approach to fluidic control. Typically, the only active component used to correct these were the nozzle actuators themselves. However, this is often insufficient and or wastes a lot of ink in the attempt to correct the problem. The problem is exacerbated in pagewidth printheads because of the length and complexity of the ink conduits supplying the printhead ICs.

[149] The Applicant has addressed this by developing an active fluidic system for the printer. Several such systems are described in detail in USSN 11/677049 (Our Docket SBF006US) the contents of which are incorporated herein by reference. Figure 6 shows one of the single pump implementations of the active fluidic system which would be suitable for use with the printhead described in the present specification.

[150] The fluidic architecture shown in Figure 6 is a single ink line for one color only. A color printer would have separate lines (and of course separate ink tanks 60) for each ink color. As shown in Figure 6, this architecture has a single pump 62 downstream of the LCP molding 64, and a shut off valve 66 upstream of the LCP molding. The LCP molding supports the printhead ICs 68 via the adhesive IC attach film 174 (see Figure 25). The shut off valve 66 isolates the ink in the ink tank 60 from the printhead ICs 66 whenever the printer is powered down. This prevents any color mixing at the printhead ICs 68 from reaching the ink tank 60 during periods of inactivity. These issues are discussed in more detail in the cross referenced specification USSN 11/677049 (our Docket SBF006US).

[151] The ink tank 60 has a venting bubble point pressure regulator 72 for maintaining a

relatively constant negative hydrostatic pressure in the ink at the nozzles. Bubble point pressure regulators within ink reservoirs are comprehensively described in co-pending USSNI 1/640355(Our Docket RMC007US) incorporated herein by reference.

However, for the purposes of this description the regulator 72 is shown as a bubble outlet 74 submerged in the ink of the tank 60 and vented to atmosphere via sealed conduit 76 extending to an air inlet 78. As the printhead ICs 68 consume ink, the pressure in the tank 60 drops until the pressure difference at the bubble outlet 74 sucks air into the tank. This air forms a bubble in the ink which rises to the tank's headspace. This pressure difference is the bubble point pressure and will depend on the diameter (or smallest dimension) of the bubble outlet 74 and the Laplace pressure of the ink meniscus at the outlet which is resisting the ingress of the air.

[152] The bubble point regulator uses the bubble point pressure needed to generate a bubble at the submerged bubble outlet 74 to keep the hydrostatic pressure at the outlet substantially constant (there are slight fluctuations when the bulging meniscus of air forms a bubble and rises to the headspace in the ink tank). If the hydrostatic pressure at the outlet is at the bubble point, then the hydrostatic pressure profile in the ink tank is also known regardless of how much ink has been consumed from the tank. The pressure at the surface of the ink in the tank will decrease towards the bubble point pressure as the ink level drops to the outlet. Of course, once the outlet 74 is exposed, the head space vents to atmosphere and negative pressure is lost. The ink tank should be refilled, or replaced (if it is a cartridge) before the ink level reaches the bubble outlet 74.

[153] The ink tank 60 can be a fixed reservoir that can be refilled, a replaceable cartridge or (as disclosed in RRCOOIUS incorporated by reference) a refillable cartridge. To guard against particulate fouling, the outlet 80 of the ink tank 60 has a coarse filter 82. The system also uses a fine filter at the coupling to the printhead cartridge. As filters have a finite life, replacing old filters by simply replacing the ink cartridge or the printhead cartridge is particularly convenient for the user. If the filters are separate consumable items, regular replacement relies on the user's diligence.

[154] When the bubble outlet 74 is at the bubble point pressure, and the shut off valve 66 is open, the hydrostatic pressure at the nozzles is also constant and less than atmospheric. However, if the shut off valve 66 has been closed for a period of time, outgassing bubbles may form in the LCP molding 64 or the printhead ICs 68 that change the pressure at the nozzles. Likewise, expansion and contraction of the bubbles from diurnal temperature variations can change the pressure in the ink line 84 downstream of the shut off valve 66. Similarly, the pressure in the ink tank can vary during periods of inactivity because of dissolved gases coming out of solution.

[155] The downstream ink line 86 leading from the LCP 64 to the pump 62 can include an

ink sensor 88 linked to an electronic controller 90 for the pump. The sensor 88 senses the presence or absence of ink in the downstream ink line 86. Alternatively, the system can dispense with the sensor 88, and the pump 62 can be configured so that it runs for an appropriate period of time for each of the various operations. This may adversely affect the operating costs because of increased ink wastage.

[156] The pump 62 feeds into a sump 92 (when pumping in the forward direction). The sump 92 is physically positioned in the printer so that it is less elevated than the printhead ICs 68. This allows the column of ink in the downstream ink line 86 to 'hang' from the LCP 64 during standby periods, thereby creating a negative hydrostatic pressure at the printhead ICs 68. A negative pressure at the nozzles draws the ink meniscus inwards and inhibits color mixing. Of course, the peristaltic pump 62 needs to be stopped in an open condition so that there is fluid communication between the LCP 64 and the ink outlet in the sump 92.

[157] Pressure differences between the ink lines of different colors can occur during periods of inactivity. Furthermore, paper dust or other particulates on the nozzle plate can wick ink from one nozzle to another. Driven by the slight pressure differences between each ink line, color mixing can occur while the printer is inactive. The shut off valve 66 isolates the ink tank 60 from the nozzle of the printhead ICs 68 to prevent color mixing extending up to the ink tank 60. Once the ink in the tank has been contaminated with a different color, it is irretrievable and has to be replaced.

[158] The capper 94 is a printhead maintenance station that seals the nozzles during standby periods to avoid dehydration of the printhead ICs 68 as well as shield the nozzle plate from paper dust and other particulates. The capper 94 is also configured to wipe the nozzle plate to remove dried ink and other contaminants. Dehydration of the printhead ICs 68 occurs when the ink solvent, typically water, evaporates and increases the viscosity of the ink. If the ink viscosity is too high, the ink ejection actuators fail to eject ink drops. Should the capper seal be compromised, dehydrated nozzles can be a problem when reactivating the printer after a power down or standby period.

[159] The problems outlined above are not uncommon during the operative life of a printer and can be effectively corrected with the relatively simple fluidic architecture shown in Figure 6. It also allows the user to initially prime the printer, deprime the printer prior to moving it, or restore the printer to a known print ready state using simple troubleshooting protocols. Several examples of these situations are described in detail in the above referenced USSN 11/677049 (Our Docket SBF006US).

[160] **Printhead Cartridge**

[161] The printhead cartridge 96 is shown in Figures 7 to 16A. Figure 7 shows the cartridge 96 in its assembled and complete form. The bulk of the cartridge is encased in the cartridge chassis 100 and the chassis lid 102. A window in the chassis 100

exposes the cartridge contacts 104 that receive data from the print engine controller in the printer.

[162] Figures 8 and 9 show the cartridge 96 with its snap on protective cover 98. The protective cover 98 prevents damaging contact with the electrical contacts 104 and the printhead ICs 68 (see Figure 10). The user can hold the top of the cartridge 96 and remove the protective cover 98 immediately prior to installation in the printer.

[163] Figure 10 shows the underside and 'back' (with respect to the paper feed direction) of the printhead cartridge 96. The printhead contacts 104 are conductive pads on a flexible printed circuit board 108 that wraps around a curved support surface (discussed below in the description relating to the LCP moulding) to a line of wire bonds 110 at one side of the printhead ICs 68. On the other side of the printhead ICs 68 is a paper shield 106 to prevent direct contact with the media substrate.

[164] Figure 11 shows the underside and the 'front' of the printhead cartridge 96. The front of the cartridge has two ink couplings 112A and 112B at either end. Each ink coupling has four cartridge valves 114. When the cartridge is installed in the printer, the ink couplings 112A and 112B engage complementary ink supply interfaces (described in more detail below). The ink supply interfaces have printer conduits 142 which engage and open the cartridge valves 114. One of the ink couplings 112A is the upstream ink coupling and the other is the downstream coupling 112B. The upstream coupling 112A establishes fluid communication between the printhead ICs 68 and the ink supply 60 (see Figure 6) and the downstream coupling 112B connects to the sump 92 (refer Figure 6 again).

[165] The various elevations of the printhead cartridge 96 are shown in Figure 12. The plan view of the cartridge 96 also shows the location of the section views shown in Figures 14, 15 and 16.

[166] Figure 13 is an exploded perspective of the cartridge 96. The LCP molding 64 attaches to the underside of the cartridge chassis 100. In turn the flex PCB 108 attaches to the underside of the LCP molding 64 and wraps around one side to expose the printhead contacts 104. An inlet manifold and filter 116 and outlet manifold 118 attach to the top of the chassis 100. The inlet manifold and filter 116 connects to the LCP inlets 122 via elastomeric connectors 120. Likewise the LCP outlets 124 connect to the outlet manifold 118 via another set of elastomeric connectors 120. The chassis lid 102 encases the inlet and outlet manifolds in the chassis 100 from the top and the removable protective cover 98 snaps over the bottom to protect the contacts 104 and the printhead ICs (see Figure 11).

[167] Inlet and Filter Manifold

[168] Figure 14 is an enlarged section view taken along line 14-14 of Figure 12. It shows the fluid path through one of the cartridge valves 114 of the upstream coupling 112A

to the LCP molding 64. The cartridge valve 114 has an elastomeric sleeve 126 that is biased into sealing engagement with a fixed valve member 128. The cartridge valve 114 is opened by the printer conduit 142 (see Figure 16) by compressing the elastomeric sleeve 126 such that it unseats from the fixed valve member 128 and allows ink to flow up to a roof channel 138 along the top of the inlet and filter manifold 116. The roof channel 138 leads to an upstream filter chamber 132 that has one wall defined by a filter membrane 130. Ink passes through the filter membrane 130 into the downstream filter chamber 134 and out to the LCP inlet 122. From there filtered ink flows along the LCP main channels 136 to feed into the printhead ICs (not shown).

[169] Particular features and advantages of the inlet and filter manifold 116 will now be described with reference to Figure 15. The exploded perspective of Figure 15 best illustrates the compact design of the inlet and filter manifold 116. There are several aspects of the design that contribute to its compact form. Firstly, the cartridge valves are spaced close together. This is achieved by departing from the traditional configuration of self-sealing ink valves. Previous designs also used an elastomeric member biased into sealing engagement with a fixed member. However, the elastomeric member was either a solid shape that the ink would flow around, or in the form of a diaphragm if the ink flowed through it.

[170] In a cartridge coupling, it is highly convenient for the cartridge valves to automatically open upon installation. This is most easily and cheaply provided by a coupling in which one valve has an elastomeric member which is engaged by a rigid member on the other valve. If the elastomeric member is in a diaphragm form, it usually holds itself against the central rigid member under tension. This provides an effective seal and requires relatively low tolerances. However, it also requires the elastomer element to have a wide peripheral mounting. The width of the elastomer will be a trade-off between the desired coupling force, the integrity of the seal and the material properties of the elastomer used.

[171] As best shown in Figure 16, the cartridge valves 114 of the present invention use elastomeric sleeves 126 that seal against the fixed valve member 128 under residual compression. The valve 114 opens when the cartridge is installed in the printer and the conduit end 148 of the printer valve 142 further compresses the sleeve 126. The collar 146 unseals from the fixed valve member 128 to connect the LCP 64 into the printer fluidic system (see Figure 6) via the upstream and downstream ink coupling 112A and 112B. The sidewall of the sleeve is configured to bulge outwardly as collapsing inwardly can create a flow obstruction. As shown in Figure 16, the sleeve 126 has a line of relative weakness around its mid-section that promotes and directs the buckling process. This reduces the force necessary to engage the cartridge with the printer, and

ensures that the sleeve buckles outwardly.

[172] The coupling is configured for 'no-drip' disengagement of the cartridge from the printer. As the cartridge is pulled upwards from the printer the elastomeric sleeve 126 pushes the collar 146 to seal against the fixed valve member 128. Once the sleeve 126 has sealed against the valve member 128 (thereby sealing the cartridge side of the coupling), the sealing collar 146 lifts together with the cartridge. This unseals the collar 146 from the end of the conduit 148. As the seal breaks an ink meniscus forms across the gap between the collar and the end of the conduit 148. The shape of the end of the fixed valve member 128 directs the meniscus to travel towards the middle of its bottom surface instead of pinning to a point. At the middle of the rounded bottom of the fixed valve member 128, the meniscus is driven to detach itself from the now almost horizontal bottom surface. To achieve the lowest possible energy state, the surface tension drives the detachment of the meniscus from the fixed valve member 128. The bias to minimize meniscus surface area is strong and so the detachment is complete with very little, if any, ink remaining on the cartridge valve 114. Any remaining ink is not enough a drop that can drip and stain prior to disposal of the cartridge.

[173] When a fresh cartridge is installed in the printer, the air in conduit 150 will be entrained into the ink flow 152 and ingested by the cartridge. In light of this, the inlet manifold and filter assembly have a high bubble tolerance. Referring back to Figure 15, the ink flows through the top of the fixed valve member 128 and into the roof channel 138. Being the most elevated point of the inlet manifold 116, the roof channels can trap the bubbles. However, bubbles may still flow into the filter inlets 158. In this case, the filter assembly itself is bubble tolerant.

[174] Bubbles on the upstream side of the filter member 130 can affect the flow rate - they effectively reduce the wetted surface area on the dirty side of the filter membrane 130. The filter membranes have a long rectangular shape so even if an appreciable number of bubbles are drawn into the dirty side of the filter, the wetted surface area remains large enough to filter ink at the required flow rate. This is crucial for the high speed operation offered by the present invention.

[175] While the bubbles in the upstream filter chamber 132 can not cross the filter membrane 130, bubbles from outgassing may generate bubbles in the downstream filter chamber 134. The filter outlet 156 is positioned at the bottom of the downstream filter chamber 134 and diagonally opposite the inlet 158 in the upstream chamber 132 to minimize the effects of bubbles in either chamber on the flow rate.

[176] The filters 130 for each color are vertically stacked closely side-by-side. The partition wall 162 partially defines the upstream filter chamber 132 on one side, and partially defines the downstream chamber 134 of the adjacent color on the other side.

As the filter chambers are so thin (for compact design), the filter membrane 130 can be pushed against the opposing wall of the downstream filter chamber 134. This effectively reduces the surface area of the filter membrane 130. Hence it is detrimental to maximum flowrate. To prevent this, the opposing wall of the downstream chamber 134 has a series of spacer ribs 160 to keep the membrane 130 separated from the wall.

[177] Positioning the filter inlet and outlet at diagonally opposed corners also helps to purge the system of air during the initial prime of the system.

[178] To reduce the risk of particulate contamination of the printhead, the filter membrane 130 is welded to the downstream side of a first partition wall before the next partition wall 162 is welded to the first partition wall. In this way, any small pieces of filter membrane 130 that break off during the welding process, will be on the 'dirty' side of the filter 130.

[179] LCP Molding/Flex PCB/Printhead ICs

[180] The LCP molding 64, flex PCB 108 and printhead ICs 68 assembly are shown in Figures 17 to 33. Figure 17 is a perspective of the underside of the LCP molding 64 with the flex PCB and printhead ICs 68 attached. The LCP molding 64 is secured to the cartridge chassis 100 through countersunk holes 166 and 168. Hole 168 is an obround hole to accommodate any mismatch in coefficients of thermal expansion (CTE) without bending the LCP. The printhead ICs 68 are arranged end to end in a line down the longitudinal extent of the LCP molding 64. The flex PCB 108 is wire bonded at one edge to the printhead ICs 68. The flex PCB 108 also secures to the LCP molding at the printhead IC edge as well as at the cartridge contacts 104 edge. Securing the flex PCB at both edges keeps it tightly held to the curved support surface 170 (see Figure 19). This ensures that the flex PCB does not bend to a radius that is tighter than specified minimum, thereby reducing the risk that the conductive tracks through the flex PCB will fracture.

[181] Figure 18 is an enlarged view of Inset A shown in Figure 17. It shows the line of wire bonding contacts 164 along the side of the flex PCB 108 and the line of printhead ICs 68.

[182] Figure 19 is an exploded perspective of the LCP/flex/printhead IC assembly showing the underside of each component. Figure 20 is another exploded perspective, this time showing the topside of the components. The LCP molding 64 has an LCP channel molding 176 sealed to its underside. The printhead ICs 68 are attached to the underside of the channel molding 176 by adhesive IC attach film 174. On the topside of the LCP channel molding 176 are the LCP main channels 184. These are open to the ink inlet 122 and ink outlet 124 in the LCP molding 64. At the bottom of the LCP main channels 184 are a series of ink supply passages 182 leading to the printhead ICs 68. The adhesive IC attach film 174 has a series of laser drilled supply holes 186 so that

the attachment side of each printhead IC 68 is in fluid communication with the ink supply passages 182. The features of the adhesive IC attach film are described in detail below with reference to Figure 31 to 33.

[183] The LCP molding 64 has recesses 178 to accommodate electronic components 180 in the drive circuitry on the flex PCB 108. For optimal electrical efficiency and operation, the cartridge contacts 104 on the PCB 108 should be close to the printhead ICs 68. However, to keep the paper path adjacent the printhead straight instead of curved or angled, the cartridge contacts 104 need to be on the side of the cartridge 96. The conductive paths in the flex PCB are known as traces. As the flex PCB must bend around a corner, the traces can crack and break the connection. To combat this, the trace can be bifurcated prior to the bend and then reunited after the bend. If one branch of the bifurcated section cracks, the other branch maintains the connection. Unfortunately, splitting the trace into two and then joining it together again can give rise to electro-magnetic interference problems that create noise in the circuitry.

[184] Making the traces wider is not an effective solution as wider traces are not significantly more crack resistant. Once the crack has initiated in the trace, it will propagate across the entire width relatively quickly and easily. Careful control of the bend radius is more effective at minimizing trace cracking, as is minimizing the number of traces that cross the bend in the flex PCB.

[185] Pagewidth printheads present additional complications because of the large array of nozzles that must fire in a relatively short time. Firing many nozzles at once places a large current load on the system. This can generate high levels of inductance through the circuits which can cause voltage dips that are detrimental to operation. To avoid this, the flex PCB has a series of capacitors that discharge during a nozzle firing sequence to relieve the current load on the rest of the circuitry. Because of the need to keep a straight paper path past the printhead ICs, the capacitors are traditionally attached to the flex PCB near the contacts on the side of the cartridge. Unfortunately, they create additional traces that risk cracking in the bent section of the flex PCB.

[186] This is addressed by mounting the capacitors 180 (see Figure 20) closely adjacent the printhead ICs 68 to reduce the chance of trace fracture. The paper path remains linear by recessing the capacitors and other components into the LCP molding 64. The relatively flat surface of the flex PCB 108 downstream of the printhead ICs 68 and the paper shield 172 mounted to the 'front' (with respect to the feed direction) of the cartridge 96 minimize the risk of paper jams.

[187] Isolating the contacts from the rest of the components of the flex PCB minimizes the number of traces that extend through the bent section. This affords greater reliability as the chances of cracking reduce. Placing the circuit components next to the printhead IC means that the cartridge needs to be marginally wider and this is detrimental to

compact design. However, the advantages provided by this configuration outweigh any drawbacks of a slightly wider cartridge. Firstly, the contacts can be larger as there are no traces from the components running in between and around the contacts. With larger contacts, the connection is more reliable and better able to cope with fabrication inaccuracies between the cartridge contacts and the printer-side contacts. This is particularly important in this case, as the mating contacts rely on users to accurately insert the cartridge.

[188] Secondly, the edge of the flex PCB that wire bonds to the side of the printhead IC is not under residual stress and trying to peel away from the bend radius. The flex can be fixed to the support structure at the capacitors and other components so that the wire bonding to the printhead IC is easier to form during fabrication and less prone to cracking as it is not also being used to anchor the flex.

[189] Thirdly, the capacitors are much closer to the nozzles of the printhead IC and so the electro-magnetic interference generated by the discharging capacitors is minimized.

[190] Figure 21 is an enlargement of the underside of the printhead cartridge 96 showing the flex PCB 108 and the printhead ICs 68. The wire bonding contacts 164 of the flex PCB 108 run parallel to the contact pads of the printhead ICs 68 on the underside of the adhesive IC attach film 174. Figure 22 shows Figure 21 with the printhead ICs 68 and the flex PCB removed to reveal the supply holes 186. The holes are arranged in four longitudinal rows. Each row delivers ink of one particular color and each row aligns with a single channel in the back of each printhead IC.

[191] Figure 23 shows the underside of the LCP channel molding 176 with the adhesive IC attach film 174 removed. This exposes the ink supply passages 182 that connect to the LCP main channels 184 (see Figure 20) formed in the other side of the channel molding 176. It will be appreciated that the adhesive IC attach film 174 partly defines the supply passages 182 when it is stuck in place. It will also be appreciated that the attach film must be accurately positioned, as the individual supply passages 182 must align with the supply holes 186 laser drilled through the film 174.

[192] Figure 24 shows the underside of the LCP molding with the LCP channel molding removed. This exposes the array of blind cavities 200 that contain air when the cartridge is primed with ink in order to damp any pressure pulses. This is discussed in greater detail below.

[193] Printhead IC Attach Film

[194] Turning briefly to Figures 31 to 33, the adhesive IC attachment film is described in more detail. The film 174 is laser drilled and wound into a reel 198 for convenient incorporation in the printhead cartridge 96. For the purposes of handling and storage, the film 174 is two protective liners on either side. One is the existing liner 188 that is attached to the film prior to laser drilling. The other is a replacement liner 192 added

after the drilling operation. The section of film 174 shown in Figure 32 has some of the existing liner 188 removed to expose the supply holes 186. The replacement liner 192 on the other side of the film is added after the supply holes 186 have been laser drilled.

[195] Figure 33 shows the laminate structure of the film 174. The central web 190 provides the strength for the laminate. On either side is an adhesive layer 194. The adhesive layers 194 are covered with liners. The laser drilling forms holes 186 that extend from a first side of the film 174 and terminate somewhere in the liner 188 in the second side. The foraminous liner on the first side is removed and replaced with a replacement liner 192. The strip of film is then wound into a reel 198 (see Figure 31) for storage and handling prior to attachment. When the printhead cartridge is assembled, suitable lengths are drawn from the reel 198, the liners removed and adhered to the underside of the LCP molding 64 such that the holes 186 are in registration with the correct ink supply passages 182 (see Figure 25).

[196] Enhanced Ink Supply to Printhead IC Ends

[197] Figure 25 shows the printhead ICs 68, superimposed on the ink supply holes 186 through the adhesive IC attach film 174, which are in turn superimposed on the ink supply passages 182 in the underside of the LCP channel molding 176. Adjacent printhead ICs 68 are positioned end to end on the bottom of the LCP channel molding 176 via the attach film 174. At the junction between adjacent printhead ICs 68, one of the ICs 68 has a 'drop triangle' 206 portion of nozzles in rows that are laterally displaced from the corresponding row in the rest of the nozzle array 220. This allows the edge of the printing from one printhead IC to be contiguous with the printing from the adjacent printhead IC. By displacing the drop triangle 206 of nozzles, the spacing (in a direction perpendicular to media feed) between adjacent nozzles remains unchanged regardless of whether the nozzles are on the same IC or either side of the junction on different ICs. This requires precise relative positioning of the adjacent printhead ICs 68, and the fiducial marks 204 are used to achieve this. The process can be time consuming but avoids artifacts in the printed image.

[198] Unfortunately, some of the nozzles at the ends of a printhead IC 68 can be starved of ink relative to the bulk of the nozzles in the rest of the array 220. For example, the nozzles 222 can be supplied with ink from two ink supply holes. Ink supply hole 224 is the closest. However, if there is an obstruction or particularly heavy demand from nozzles to the left of the hole 224, the supply hole 226 is also proximate to the nozzles at 222, so there is little chance of these nozzles depriming from ink starvation.

[199] In contrast, the nozzles 214 at the end of the printhead IC 68 would only be in fluid communication with the ink supply hole 216 were it not for the 'additional' ink supply hole 210 placed at the junction between the adjacent ICs 68. Having the additional ink supply hole 210 means that none of the nozzles are so remote from an ink supply hole

that they risk ink starvation.

- [200] Ink supply holes 208 and 210 are both fed from a common ink supply passage 212. The ink supply passage 212 has the capacity to supply both holes as supply hole 208 only has nozzles to its left, and supply hole 210 only has nozzles to its right. Therefore, the total flowrate through supply passage 212 is roughly equivalent to a supply passage that feeds one hole only.
- [201] Figure 25 also highlights the discrepancy between the number of channels (colors) in the ink supply- four channels - and the five channels 218 in the printhead IC 68. The third and fourth channels 218 in the back of the printhead IC 68 are fed from the same ink supply holes 186. These supply holes are somewhat enlarged to span two channels 218.
- [202] The reason for this is that the printhead IC 68 is fabricated for use in a wide range of printers and printhead configurations. These may have five color channels - CMYK and IR (infrared) - but other printers, such this design, may only be four channel printers, and others still may only be three channel (CC, MM and Y). In light of this, a single color channel may be fed to two of the printhead IC channels. The print engine controller (PEC) microprocessor can easily accommodate this into the print data sent to the printhead IC. Furthermore, supplying the same color to two nozzle rows in the IC provides a degree of nozzle redundancy that can used for dead nozzle compensation.
- [203] Pressure Pulses
- [204] Sharp spikes in the ink pressure occur when the ink flowing to the printhead is stopped suddenly. This can happen at the end of a print job or a page. The Assignee's high speed, pagewidth printheads need a high flow rate of supply ink during operation. Therefore, the mass of ink in the ink line to the nozzles is relatively large and moving at an appreciable rate.
- [205] Abruptly ending a print job, or simply at the end of a printed page, requires this relatively high volume of ink that is flowing relatively quickly to come to an immediate stop. However, suddenly arresting the ink momentum gives rise to a shock wave in the ink line. The LCP molding 64 (see Figure 19) is particularly stiff and provides almost no flex as the column of ink in the line is brought to rest. Without any compliance in the ink line, the shock wave can exceed the Laplace pressure (the pressure provided by the surface tension of the ink at the nozzles openings to retain ink in the nozzle chambers) and flood the front surface of the printhead IC 68. If the nozzles flood, ink may not eject and artifacts appear in the printing.
- [206] Resonant pulses in the ink occur when the nozzle firing rate matches a resonant frequency of the ink line. Again, because of the stiff structure that define the ink line, a large proportion of nozzles for one color, firing simultaneously, can create a standing wave or resonant pulse in the ink line. This can result in nozzle flooding, or conversely

nozzle deprime because of the sudden pressure drop after the spike, if the Laplace pressure is exceeded.

[207] To address this, the LCP molding 64 incorporates a pulse damper to remove pressure spikes from the ink line. The damper may be an enclosed volume of gas that can be compressed by the ink. Alternatively, the damper may be a compliant section of the ink line that can elastically flex and absorb pressure pulses.

[208] To minimize design complexity and retain a compact form, the invention uses compressible volumes of gas to damp pressure pulses. Damping pressure pulses using gas compression can be achieved with small volumes of gas. This preserves a compact design while avoiding any nozzle flooding from transient spikes in the ink pressure.

[209] As shown in Figures 24 and 26, the pulse damper is not a single volume of gas for compression by pulses in the ink. Rather the damper is an array of cavities 200 distributed along the length of the LCP molding 64. A pressure pulse moving through an elongate printhead, such as a pagewidth printhead, can be damped at any point in the ink flow line. However, the pulse will cause nozzle flooding as it passes the nozzles in the printhead integrated circuit, regardless of whether it is subsequently dissipated at the damper. By incorporating a number of pulse dampers into the ink supply conduits immediately next to the nozzle array, any pressure spikes are damped at the site where they would otherwise cause detrimental flooding.

[210] It can be seen in Figure 26, that the air damping cavities 200 are arranged in four rows. Each row of cavities sits directly above the LCP main channels 184 in the LCP channel molding 176. Any pressure pulses in the ink in the main channels 184 act directly on the air in the cavities 200 and quickly dissipate.

[211] Printhead Priming

[212] Priming the cartridge will now be described with particular reference to the LCP channel molding 176 shown in Figure 27. The LCP channel molding 176 is primed with ink by suction applied to the main channel outlets 232 from the pump of the fluidic system (see Figure 6). The main channels 184 are filled with ink and then the ink supply passages 182 and printhead ICs 68 self prime by capillary action.

[213] The main channels 184 are relatively long and thin. Furthermore the air cavities 200 must remain unprimed if they are to damp pressure pulses in the ink. This can be problematic for the priming process which can easily fill cavities 200 by capillary action or the main channel 184 can fail to fully prime because of trapped air. To ensure that the LCP channel molding 176 fully primes, the main channels 184 have a weir 228 at the downstream end prior to the outlet 232. To ensure that the air cavities 200 in the LCP molding 64 do not prime, they have openings with upstream edges shaped to direct the ink meniscus from traveling up the wall of the cavity.

[214] These aspects of the cartridge are best described with reference Figures 28A, 28B

and 29A to 29C. These figures schematically illustrate the priming process. Figures 28A and 28B show the problems that can occur if there is no weir in the main channels, whereas Figures 29A to 29C show the function of the weir 228.

[215] Figures 28A and 28B are schematic section views through one of the main channels 184 of the LCP channel molding 176 and the line of air cavities 200 in the roof of the channel. Ink 238 is drawn through the inlet 230 and flows along the floor of the main channel 184. It is important to note that the advancing meniscus has a steeper contact angle with the floor of the channel 184. This gives the leading portion of the ink flow 238 a slightly bulbous shape. When the ink reaches the end of the channel 184, the ink level rises and the bulbous front contacts the top of the channel before the rest of the ink flow. As shown in Figure 28B, the channel 184 has failed to fully prime, and the air is now trapped. This air pocket will remain and interfere with the operation of the printhead. The ink damping characteristics are altered and the air can be an ink obstruction.

[216] In Figure 29A to 29C, the channel 184 has a weir 228 at the downstream end. As shown in Figure 29A, the ink flow 238 pools behind the weir 228 and rises toward the top of the channel. The weir 228 has a sharp edge 240 at the top to act as a meniscus anchor point. The advancing meniscus pins to this anchor 240 so that the ink does not simply flow over the weir 228 as soon as the ink level is above the top edge.

[217] As shown in Figure 29B, the bulging meniscus makes the ink rise until it has filled the channel 184 to the top. With the ink sealing the cavities 200 into separate air pockets, the bulging ink meniscus at the weir 228 breaks from the sharp top edge 240 and fills the end of the channel 184 and the ink outlet 232 (see Figure 29C). The sharp top edge 240 is precisely positioned so that the ink meniscus will bulge until the ink fills to the top of the channel 184, but does not allow the ink to bulge so much that it contacts part of the end air cavity 242. If the meniscus touches and pins to the interior of the end air cavity 242, it may prime with ink. Accordingly, the height of the weir and its position under the cavity is closely controlled. The curved downstream surface of the weir 228 ensures that there are no further anchor points that might allow the ink meniscus to bridge the gap to the cavity 242.

[218] Another mechanism that the LCP uses to keep the cavities 200 unprimed is the shape of the upstream and downstream edges of the cavity openings. As shown in Figures 28A, 28B and 29A to 29C, all the upstream edges have a curved transition face 234 while the downstream edges 236 are sharp. An ink meniscus progressing along the roof of the channel 184 can pin to a sharp upstream edge and subsequently move upwards into the cavity by capillary action. A transition surface, and in particular a curved transition surface 234 at the upstream edge removes the strong anchor point that a sharp edge provides.

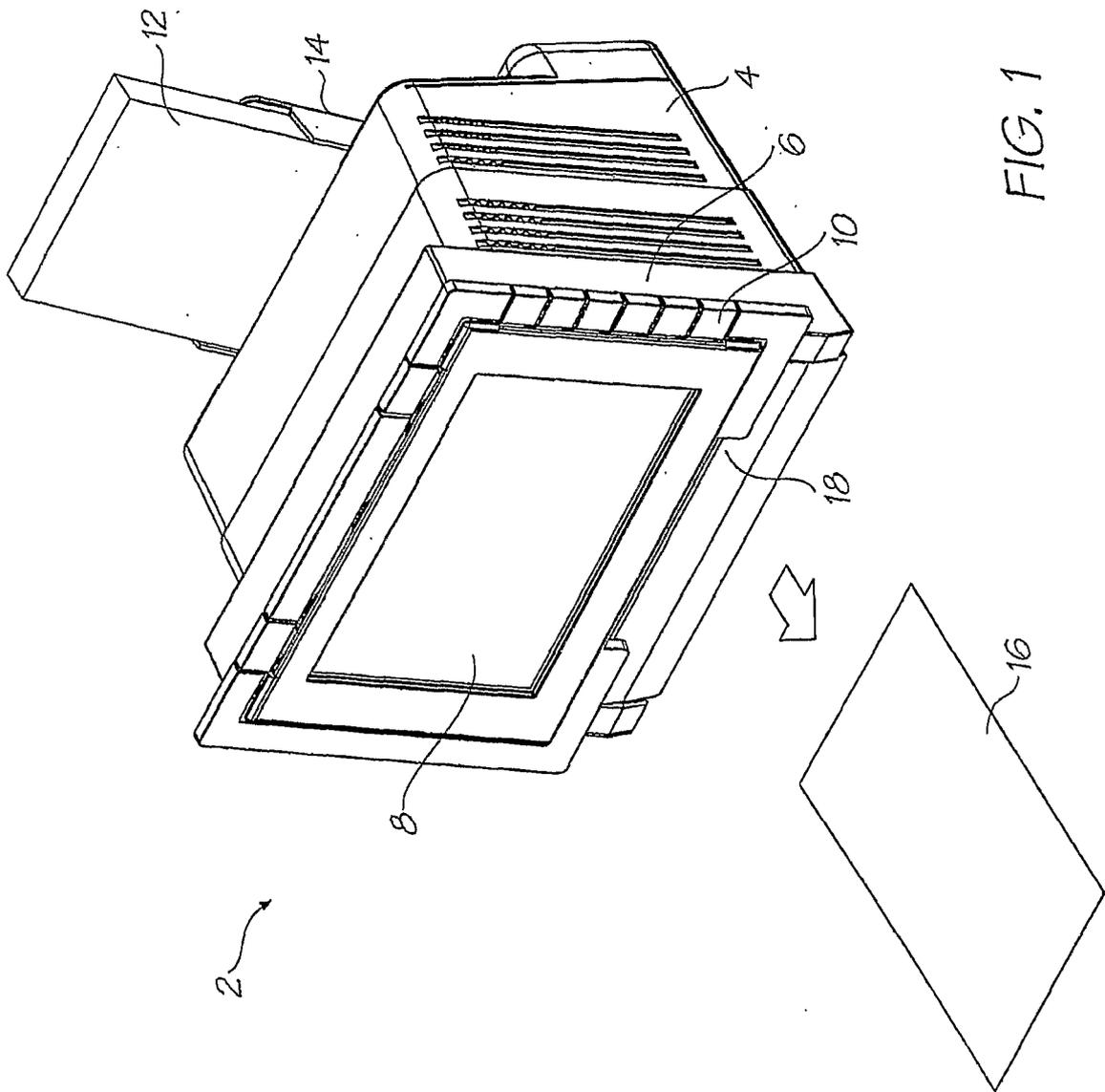
[219] Similarly, the Applicant's work has found that a sharp downstream edge 236 will promote depriming if the cavity 200 has inadvertently filled with some ink. If the printer is bumped, jarred or tilted, or if the fluidic system has had to reverse flow for any reason, the cavities 200 may fully or partially prime. When the ink flows in its normal direction again, a sharp downstream edge 236 helps to draw the meniscus back to the natural anchor point (i.e. the sharp corner). In this way, management of the ink meniscus movement through the LCP channel molding 176 is a mechanism for correctly priming the cartridge.

[220] The invention has been described here by way of example only. Skilled workers in this field will recognize many variations and modification which do not depart from the spirit and scope of the broad inventive concept. Accordingly, the embodiments described and shown in the accompanying figures are to be considered strictly illustrative and in no way restrictive on the invention.

Claims

- [1] A printhead for an inkjet printer, the printhead comprising:
a printhead integrated circuit (IC) with an array of nozzles for ejecting ink;
a support structure for supporting the printhead IC, the support structure having ink conduits for supplying the array of nozzles with ink; and,
a fluidic damper containing gas for compression by pressure pulses in the ink within the ink conduits to dissipate the pressure pulse.
- [2] A printhead according to claim 1 wherein the fluidic damper has an array of cavities for holding the gas such that each cavity is a separate pocket of the gas.
- [3] A printhead according to claim 2 wherein each of the cavities is partially defined by an ink meniscus when the ink conduits of the support structure are primed with ink.
- [4] A printhead according to claim 3 wherein each of the cavities is a blind recess with an opening facing one or more of the ink conduits.
- [5] A printhead according to claim 4 wherein the opening of each of the blind recesses faces one of the ink conduits only.
- [6] A printhead according to claim 5 wherein the opening of each of the blind recesses of configured to inhibit ink filling the recess by capillary action.
- [7] A printhead according to claim 6 wherein the support structure has an inlet for connecting the ink conduits to an ink supply and an outlet for connecting the ink conduits to a waste ink outlet.
- [8] A printhead according to claim 7 wherein the openings to each respective cavity have an upstream edge and a downstream edge, the upstream edge contacting the ink before the downstream edge during initial priming of the ink conduits from the ink supply, and the upstream edge having a transition face between the conduit and the cavity interior, the transition face being configured to inhibit ink from filling the cavity and purging the gas by capillary action during initial priming of the ink conduit.
- [9] A printhead according to claim 8 wherein the printhead is a pagewidth printhead and the support structure is elongate with the inlet at one end and the outlet at the other end, and the ink conduits have channels extending longitudinally along the support structure between the inlet and the outlet, and each of the channels have a series ink feed passages spaced along it to provide fluid communication between the channel and the printhead IC.
- [10] A printhead according to claim 9 wherein the ink feed passages join to the channel along a wall of the channel that is opposite the wall including the openings to the cavities.

- [11] A printhead according to claim 10 wherein the support structure is a liquid crystal polymer (LCP).
- [12] A printhead according to claim 11 wherein the support structure is a two-part LCP moulding with the channels and the feed passages formed in one part and the cavities formed in the other part.
- [13] A printhead according to claim 12 wherein the support structure has a plurality of printhead ICs mounted end to end along one side face.
- [14] A printhead according to claim 13 wherein the printhead ICs are mounted to the side face via an interposed adhesive film having holes for fluid communication between the ink feed passages and the printhead ICs.



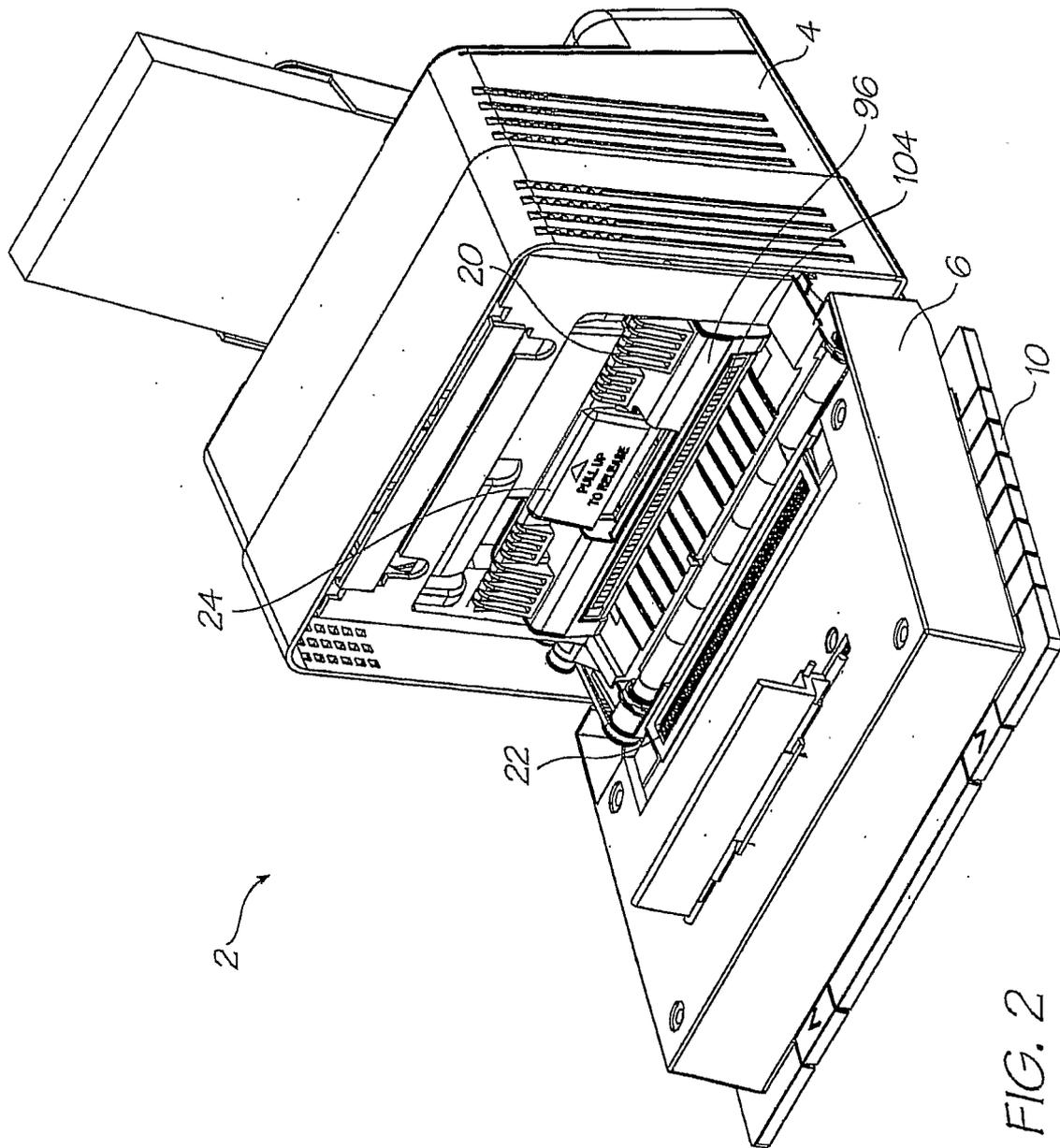


FIG. 2

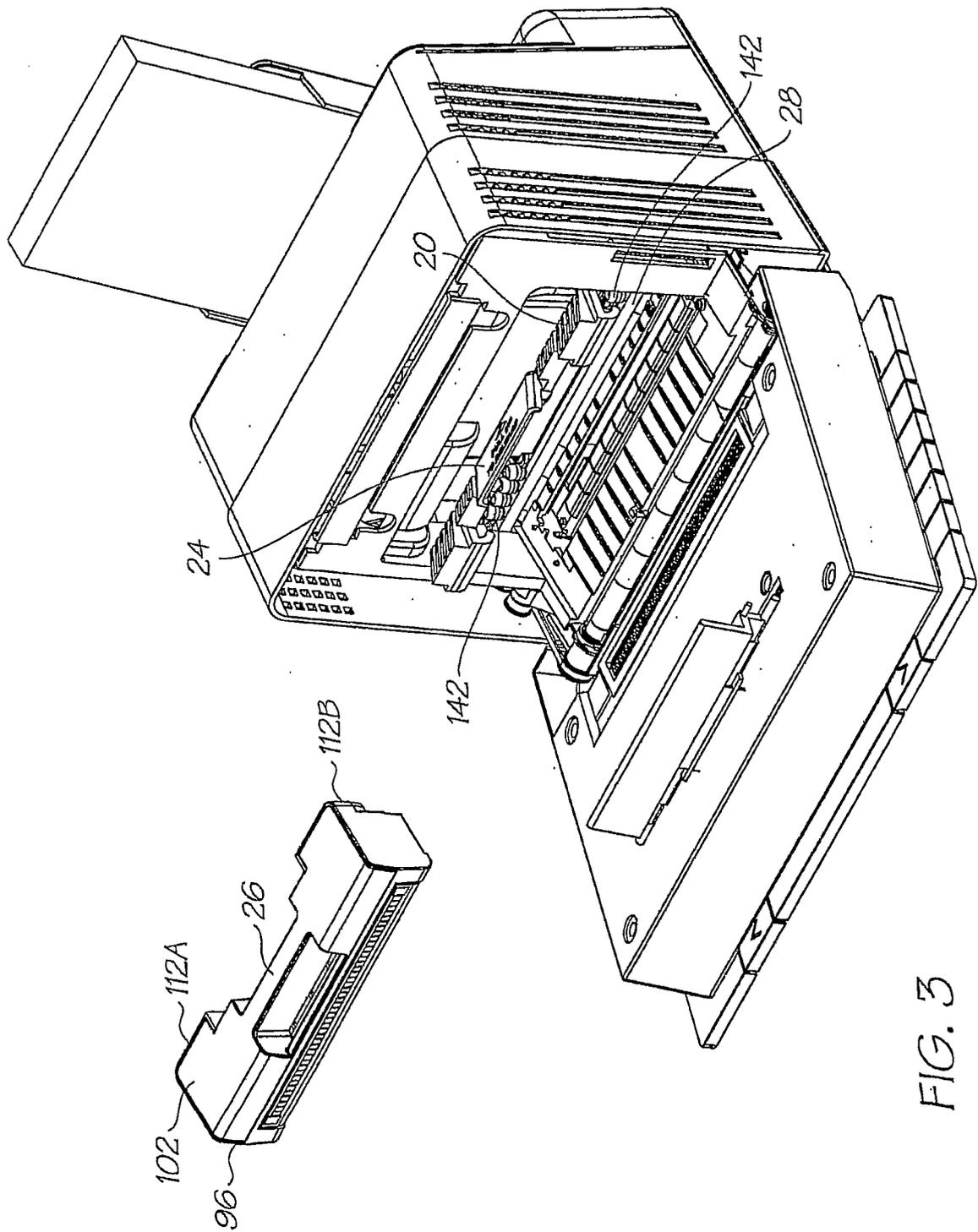


FIG. 3

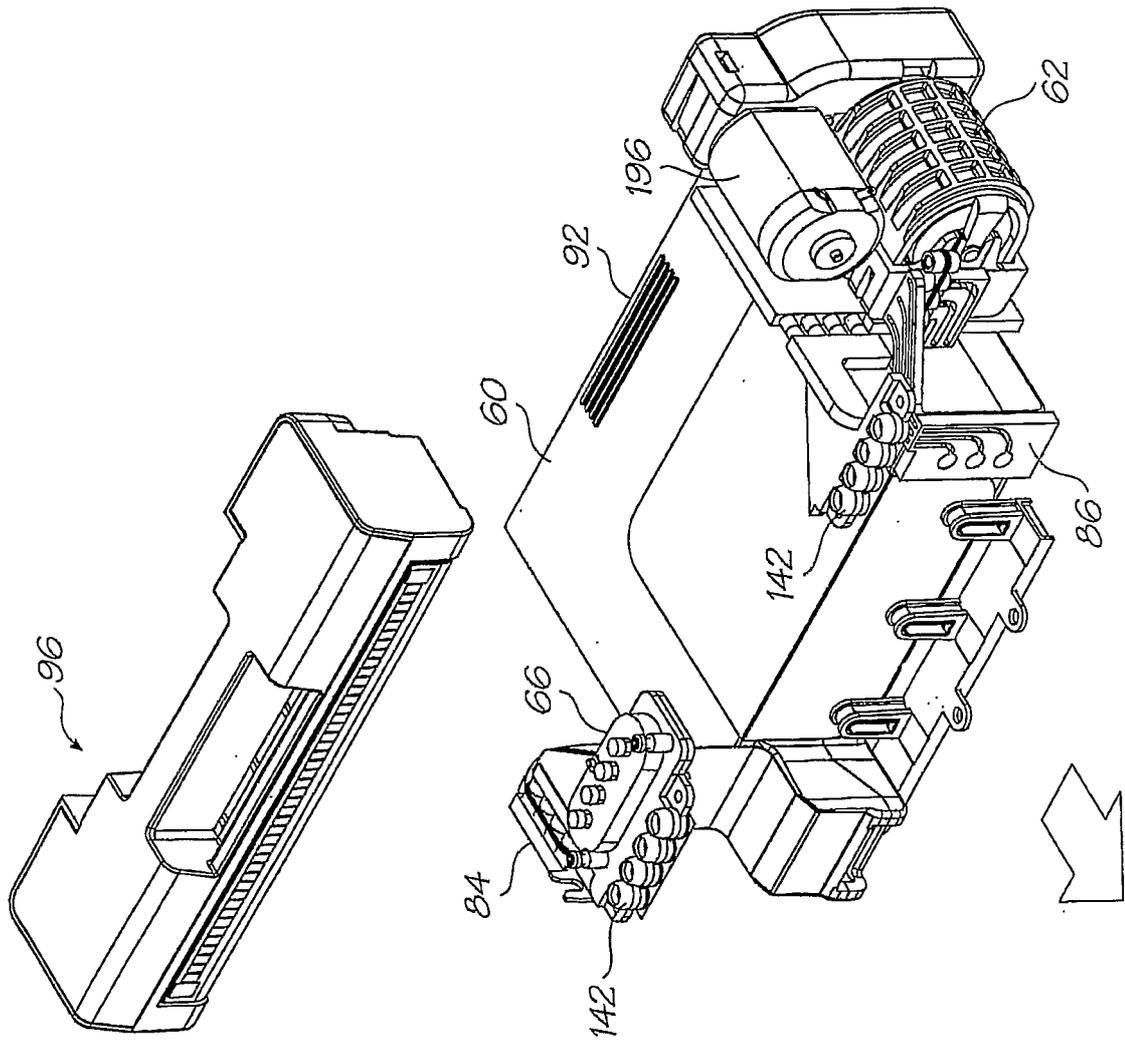


FIG. 4

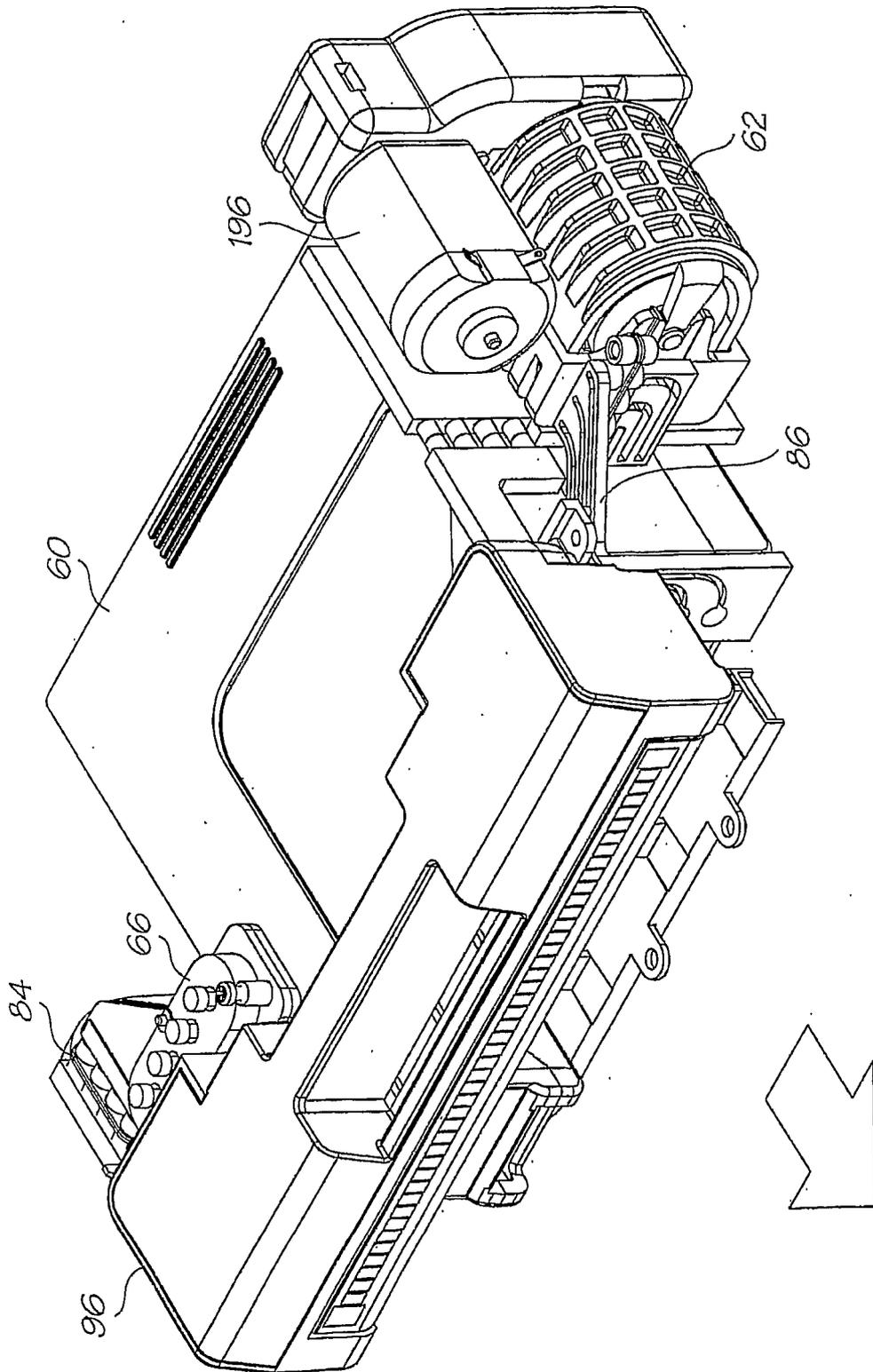


FIG. 5

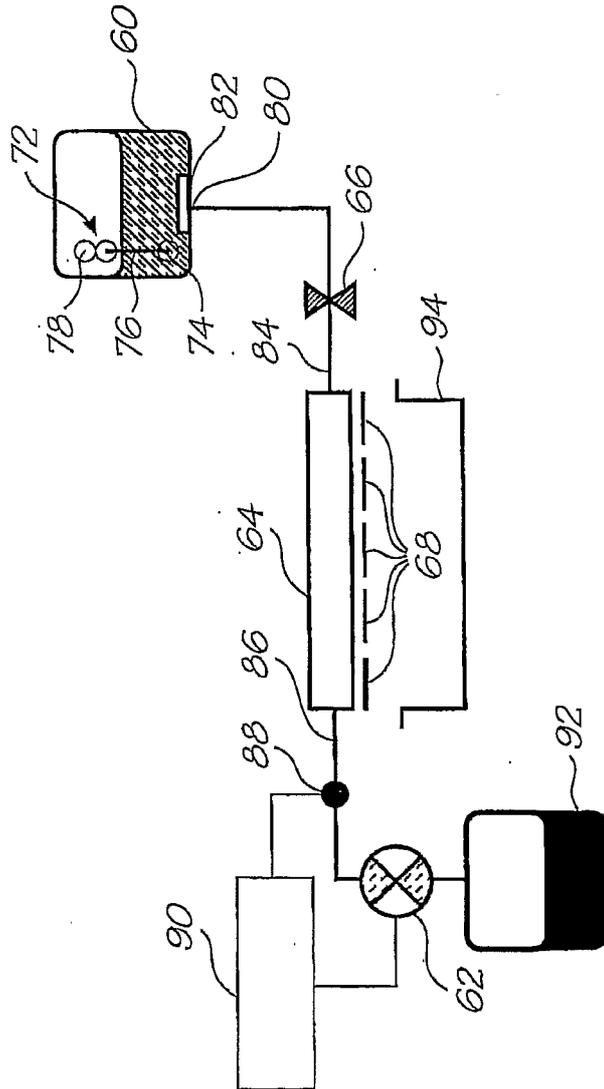


FIG. 6

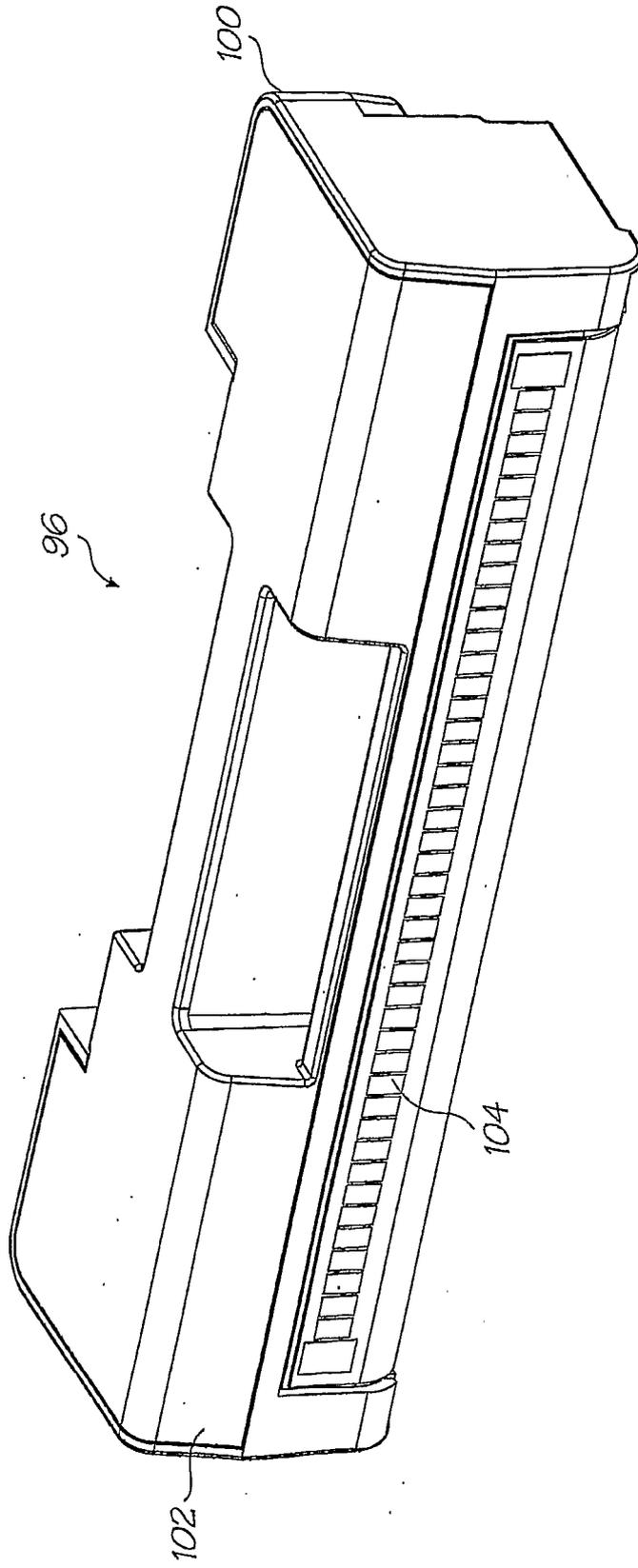


FIG. 7

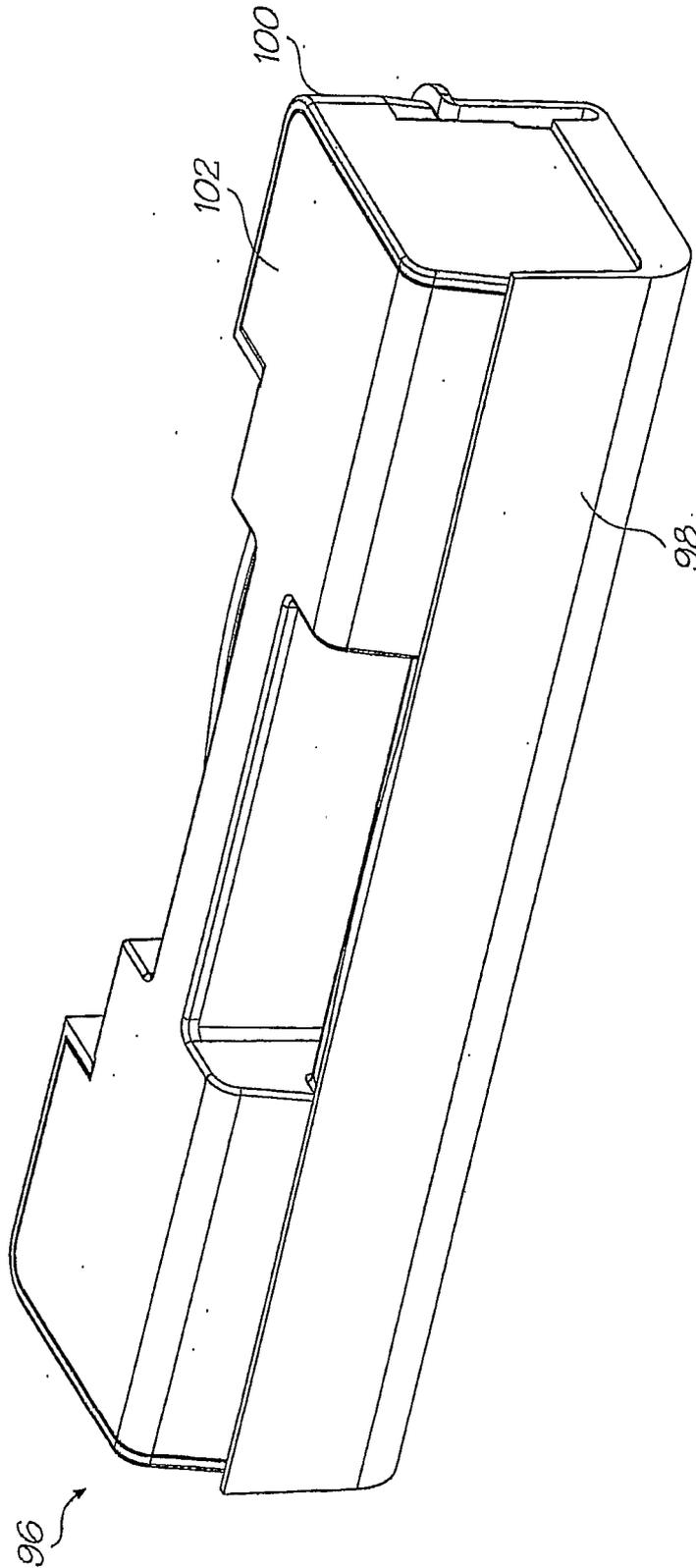


FIG. 8

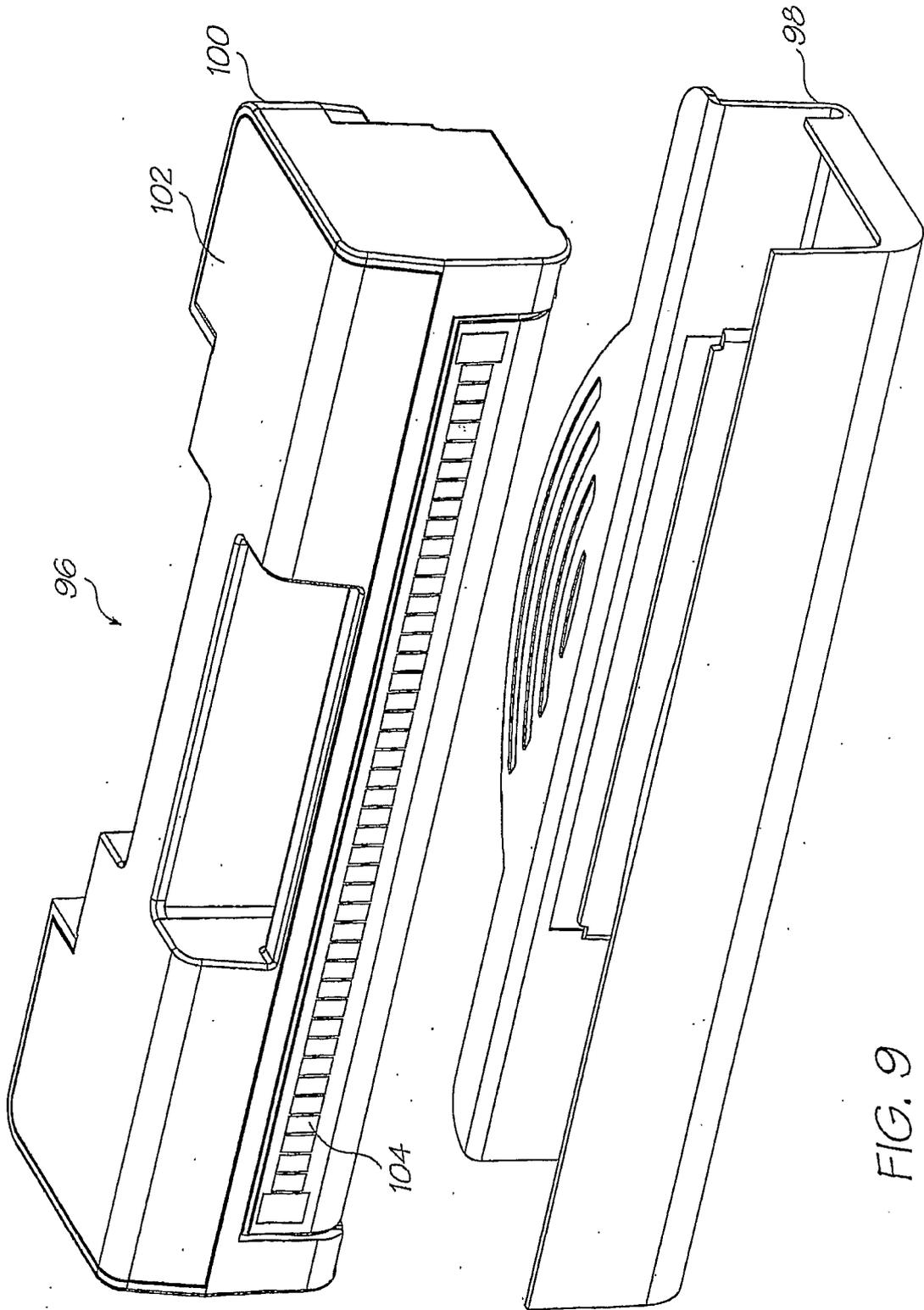


FIG. 9

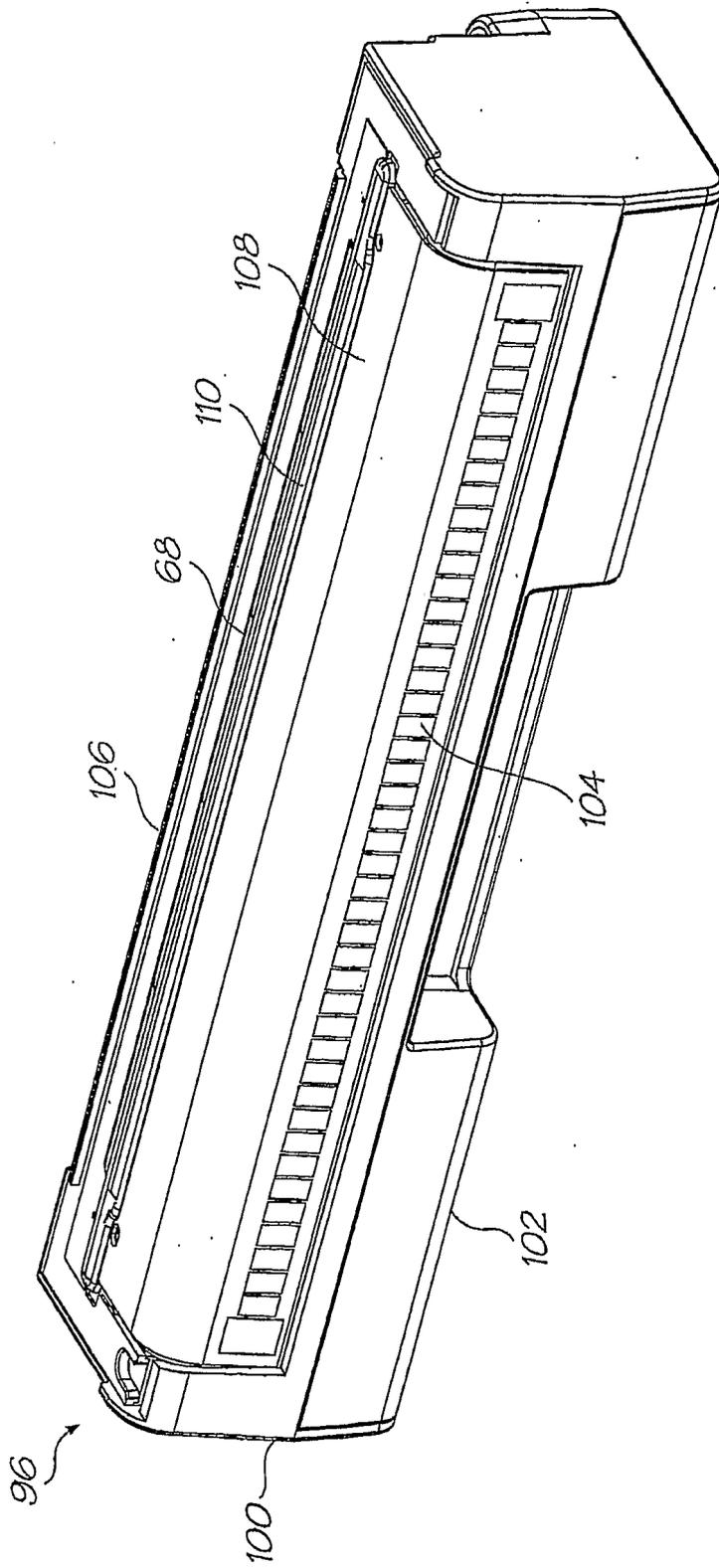


FIG. 10

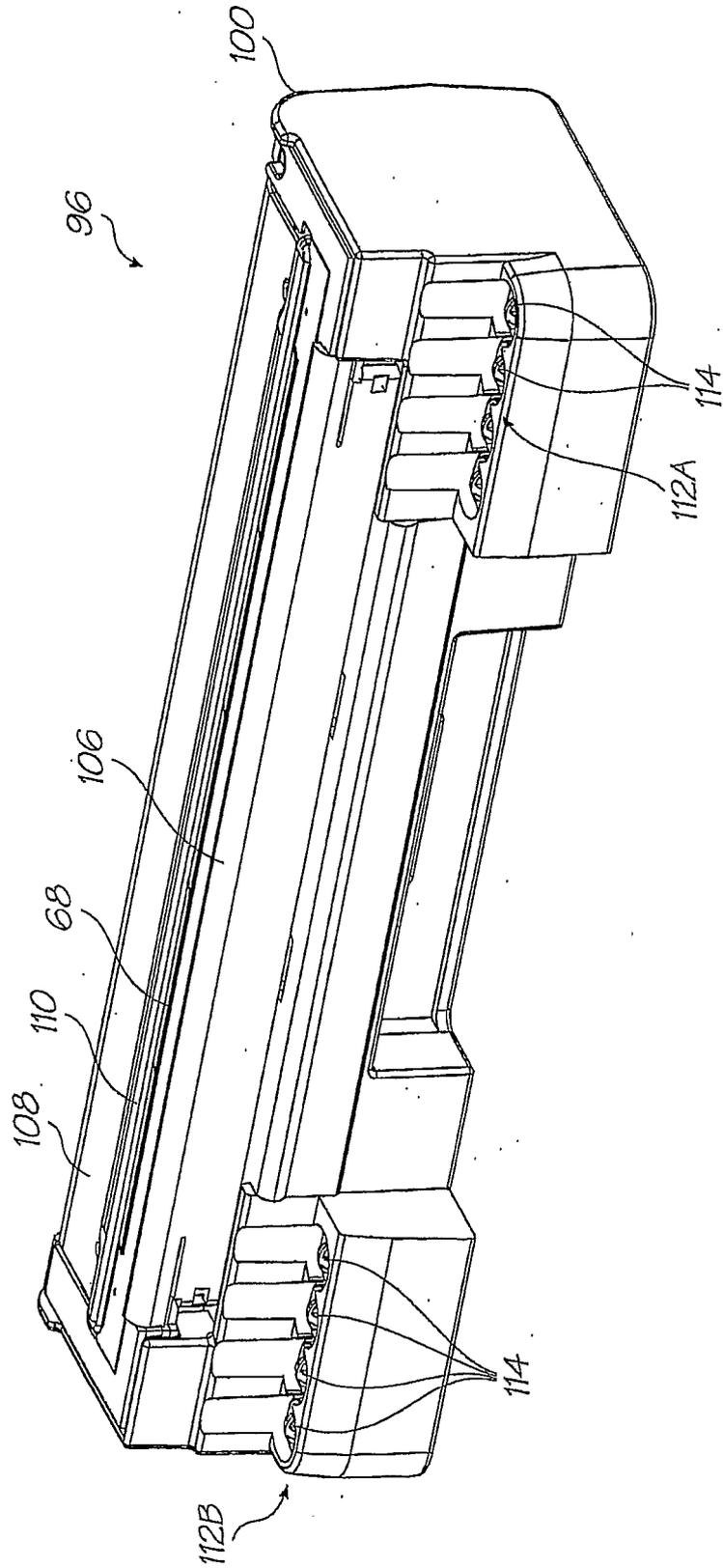


FIG. 11

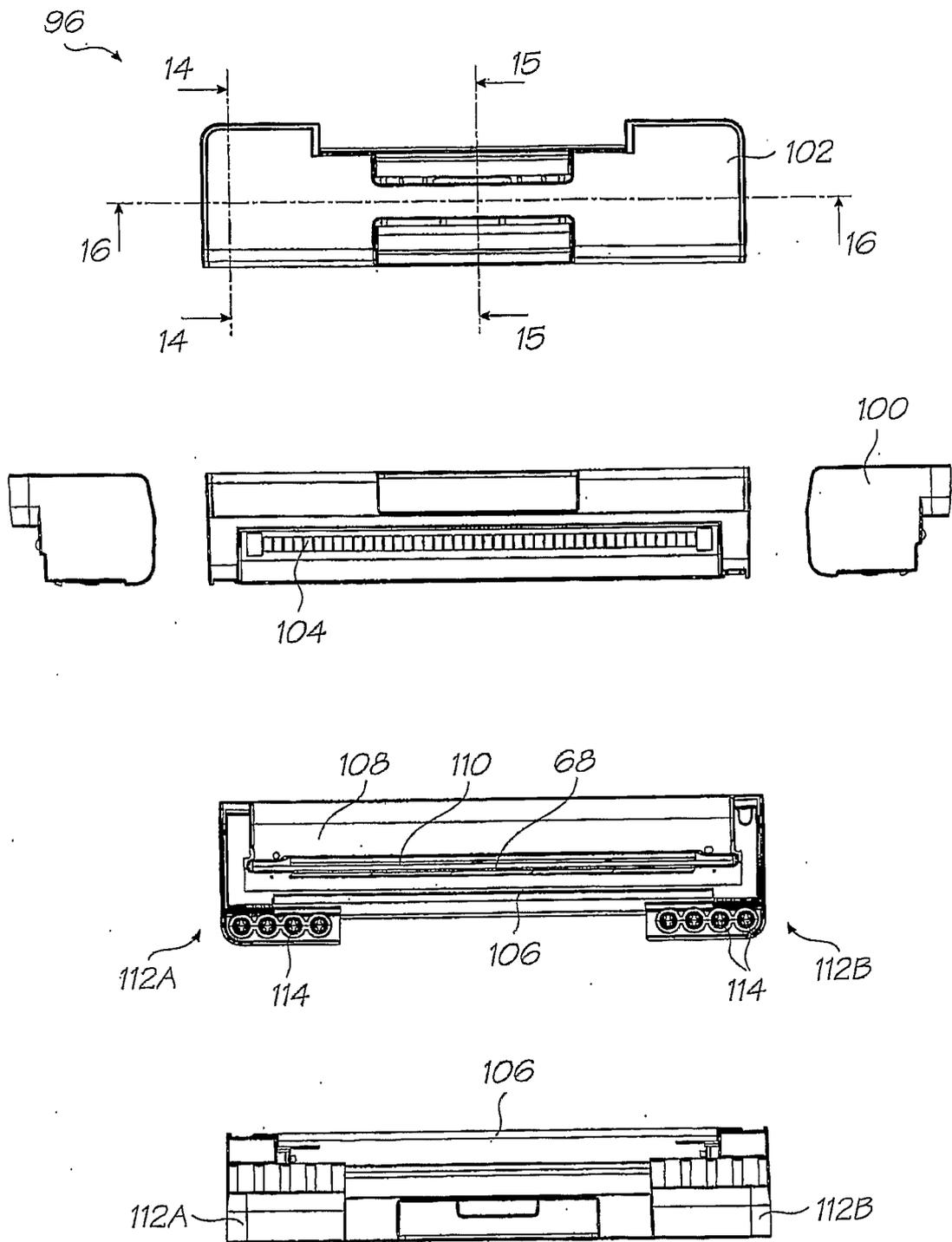


FIG. 12

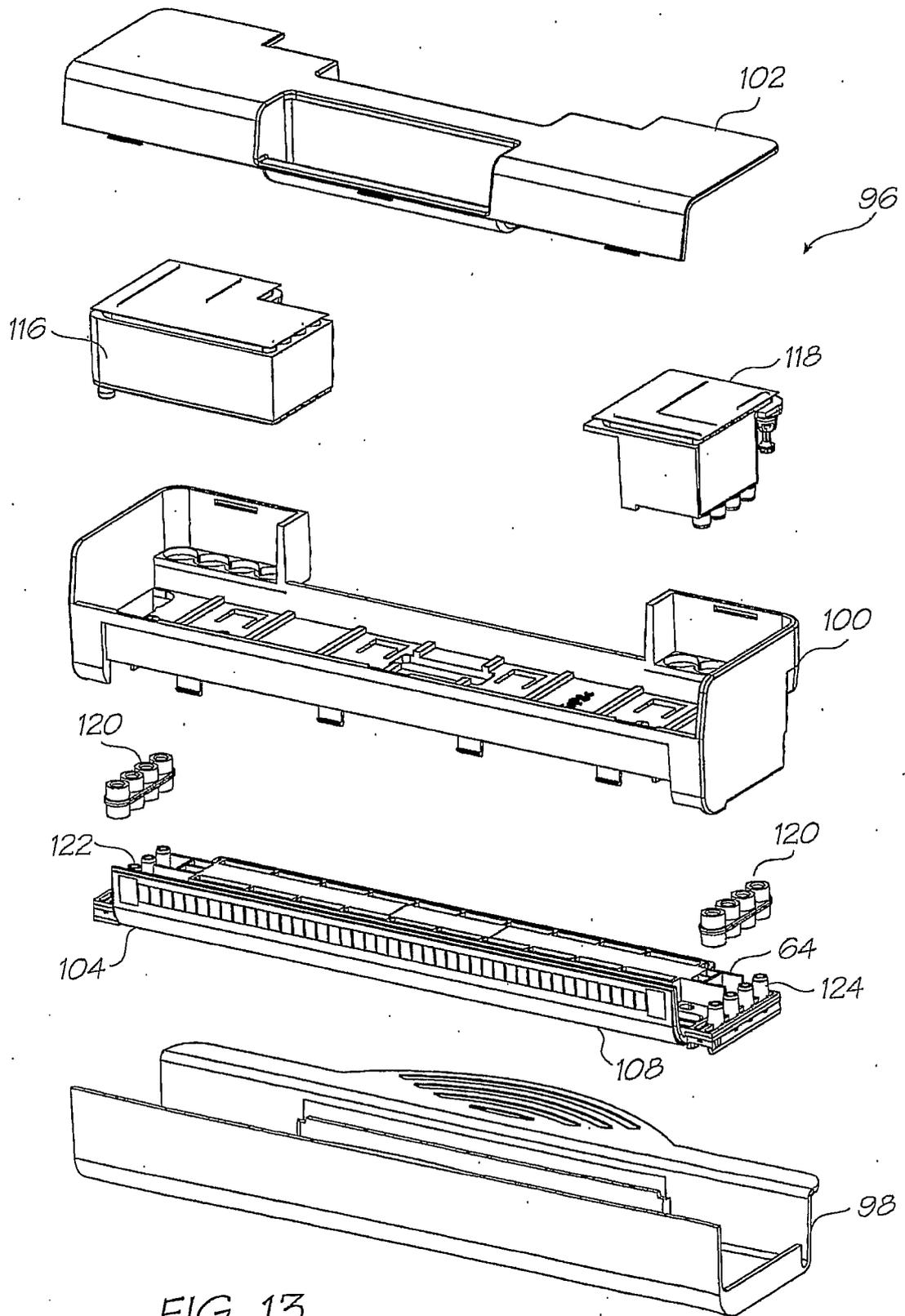


FIG. 13

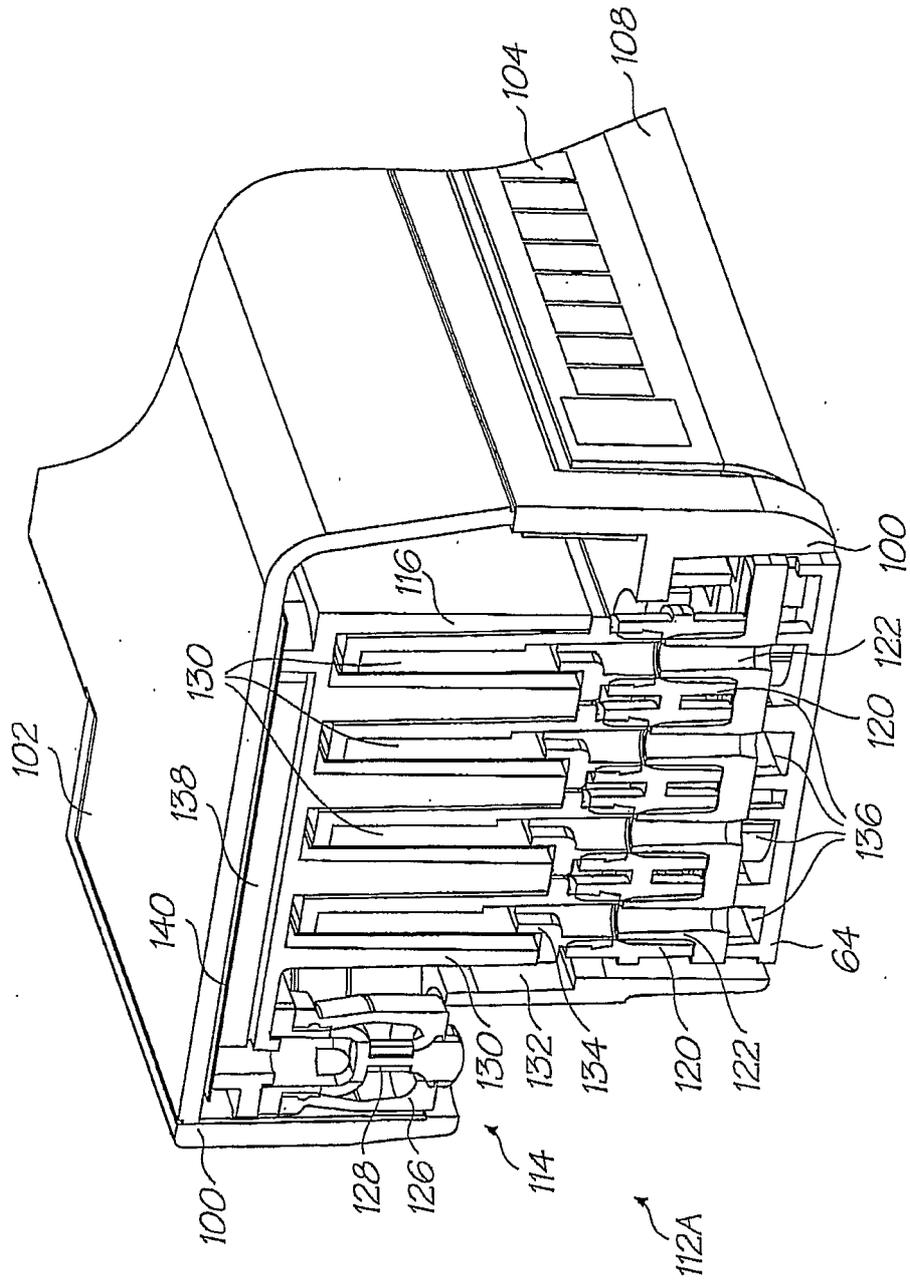


FIG. 14

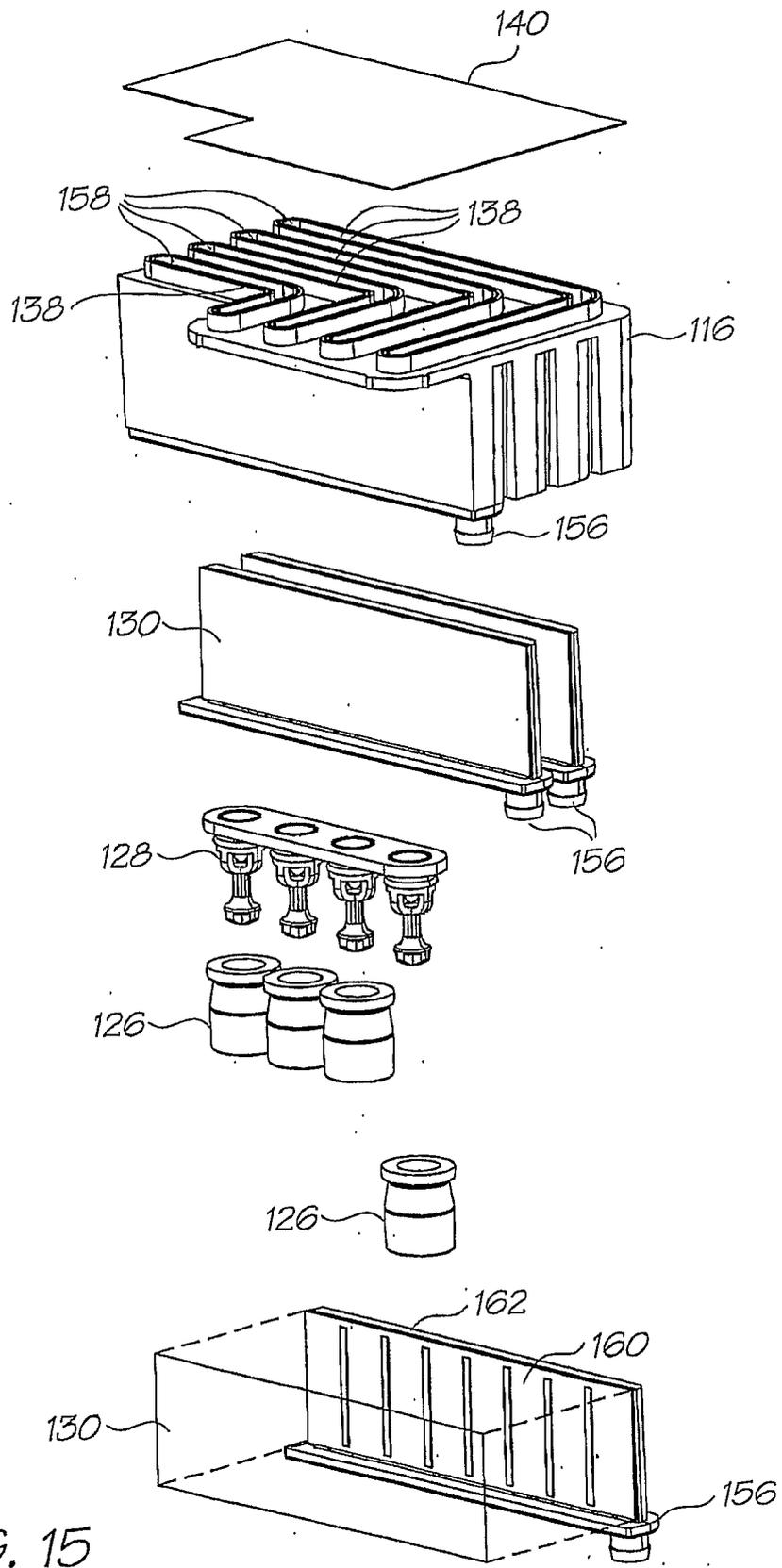


FIG. 15

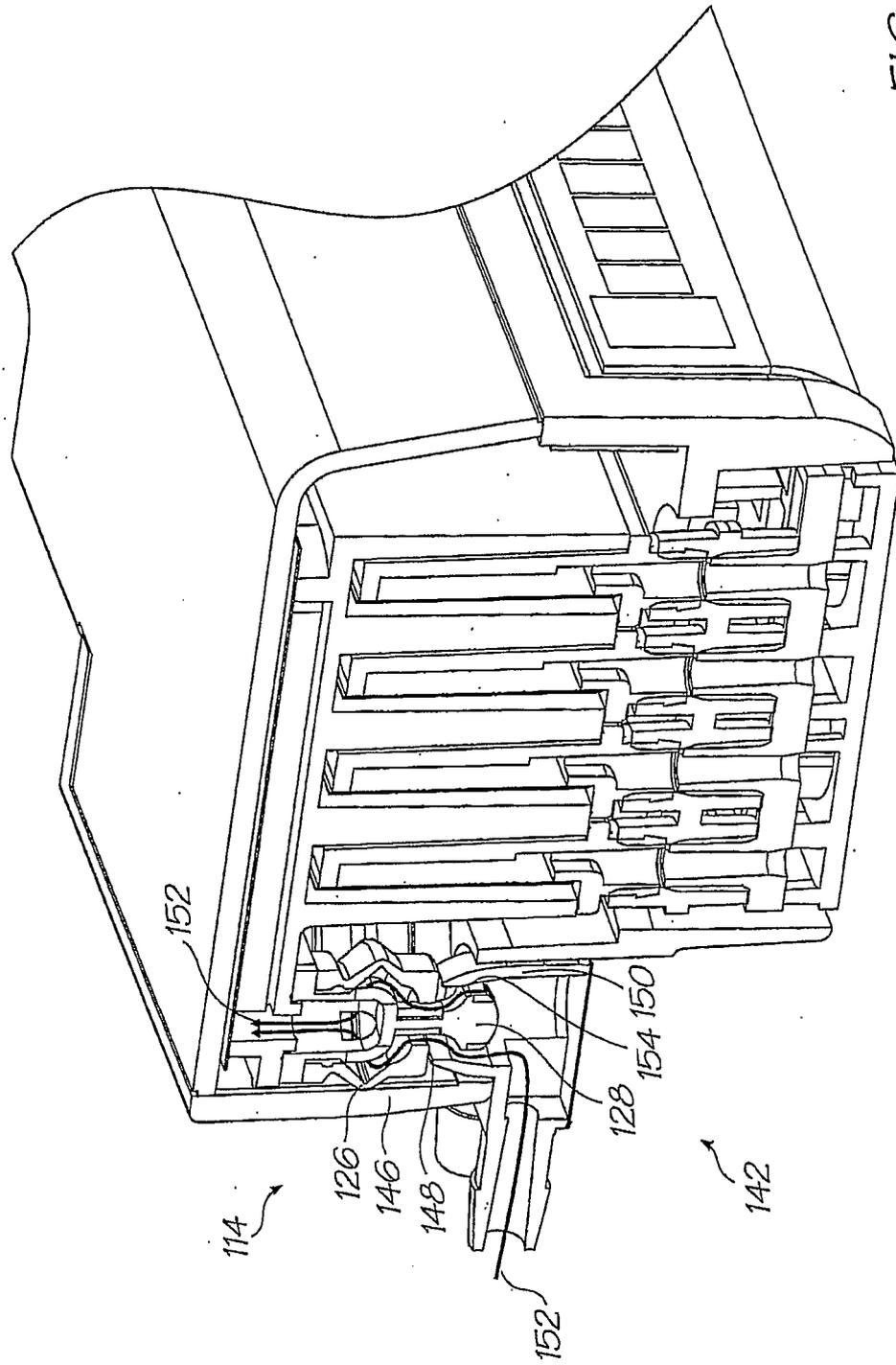


FIG. 16

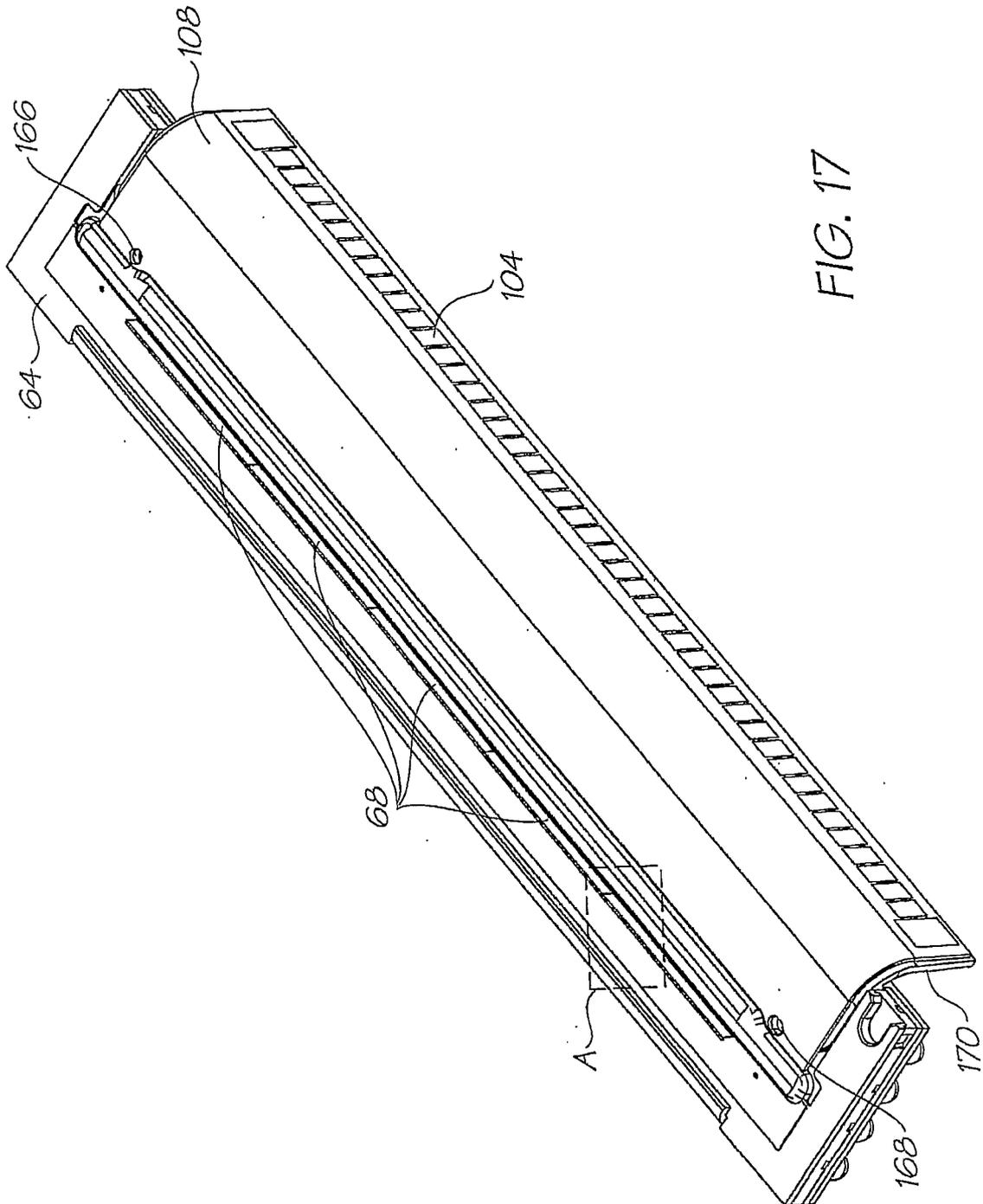


FIG. 17

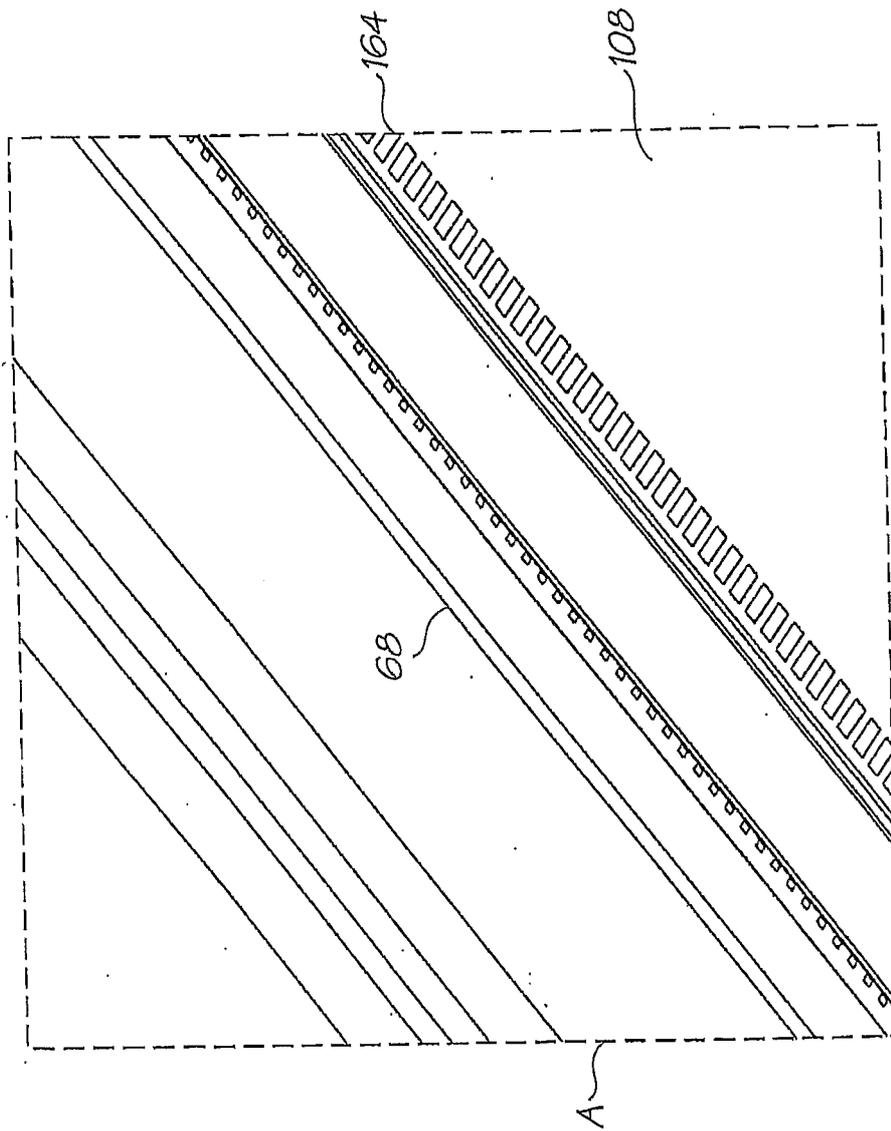


FIG. 18

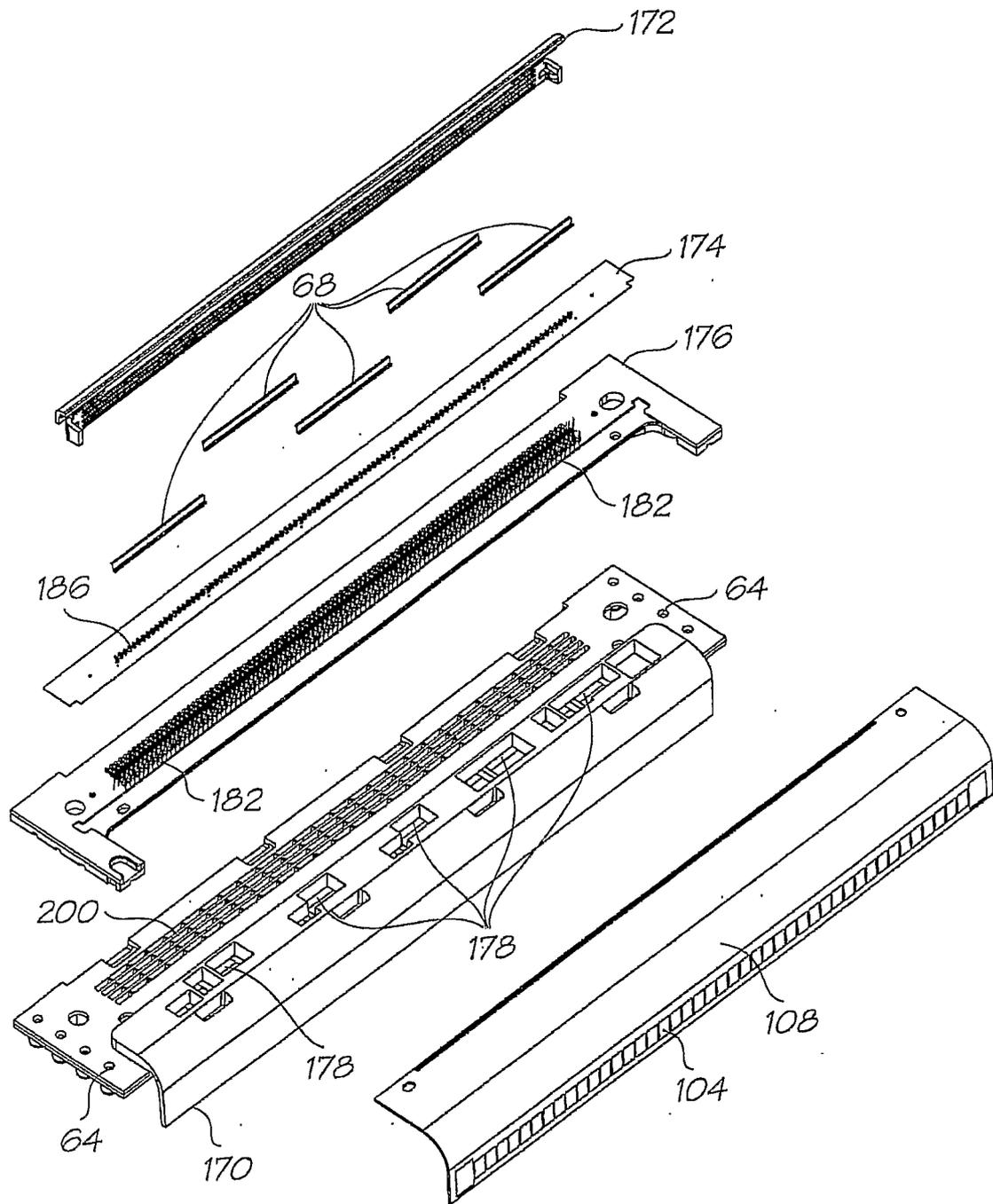


FIG. 19

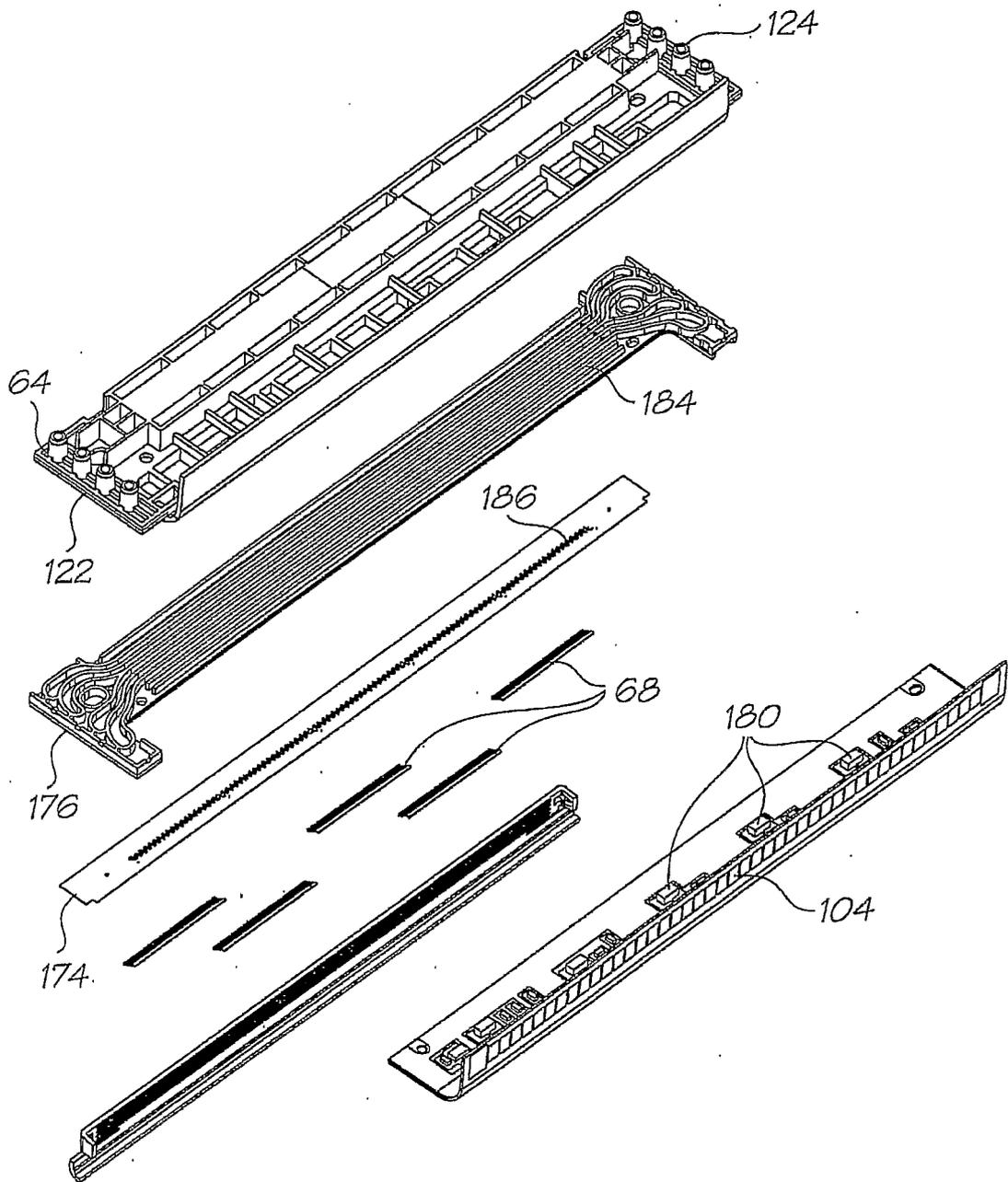


FIG. 20

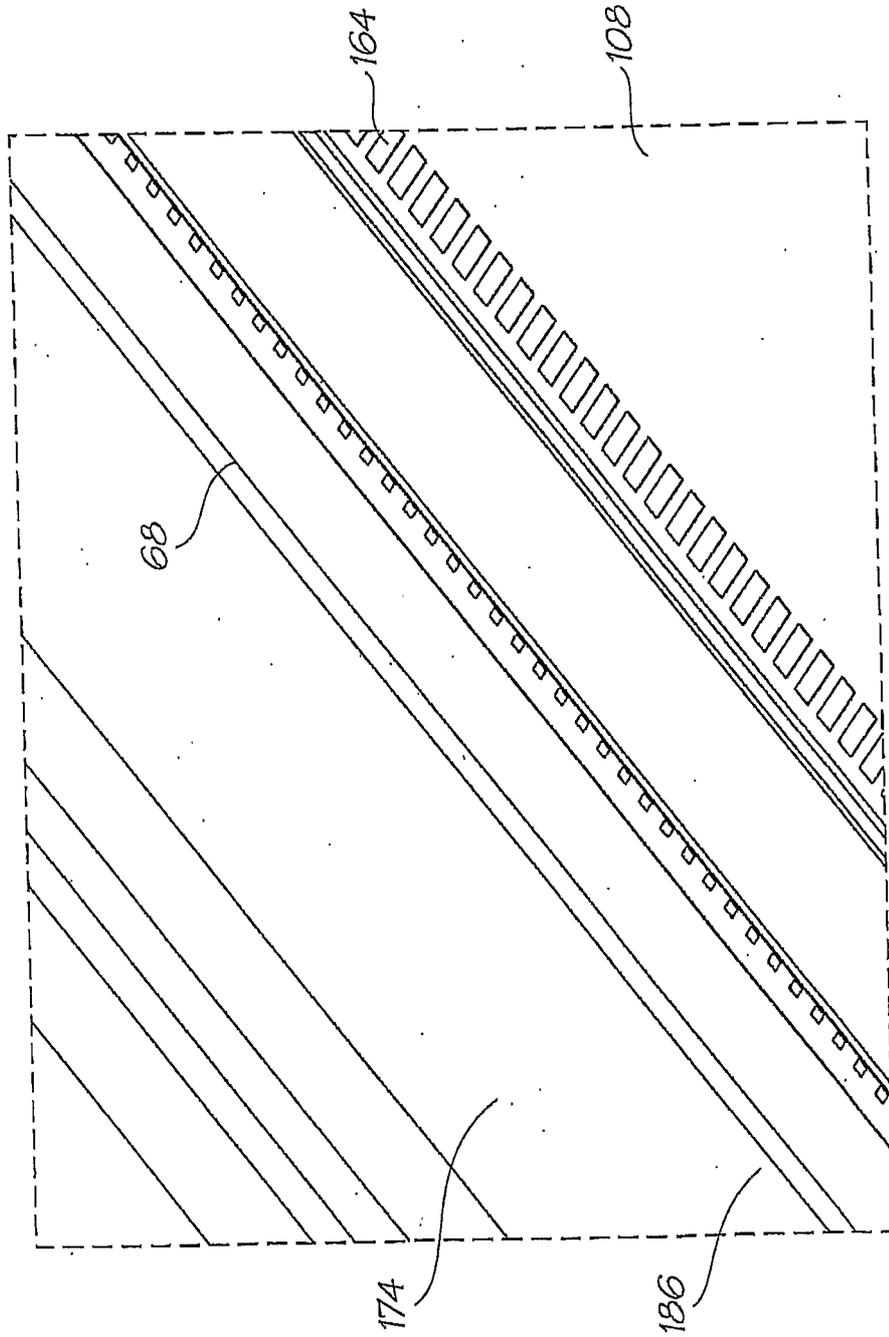


FIG. 21

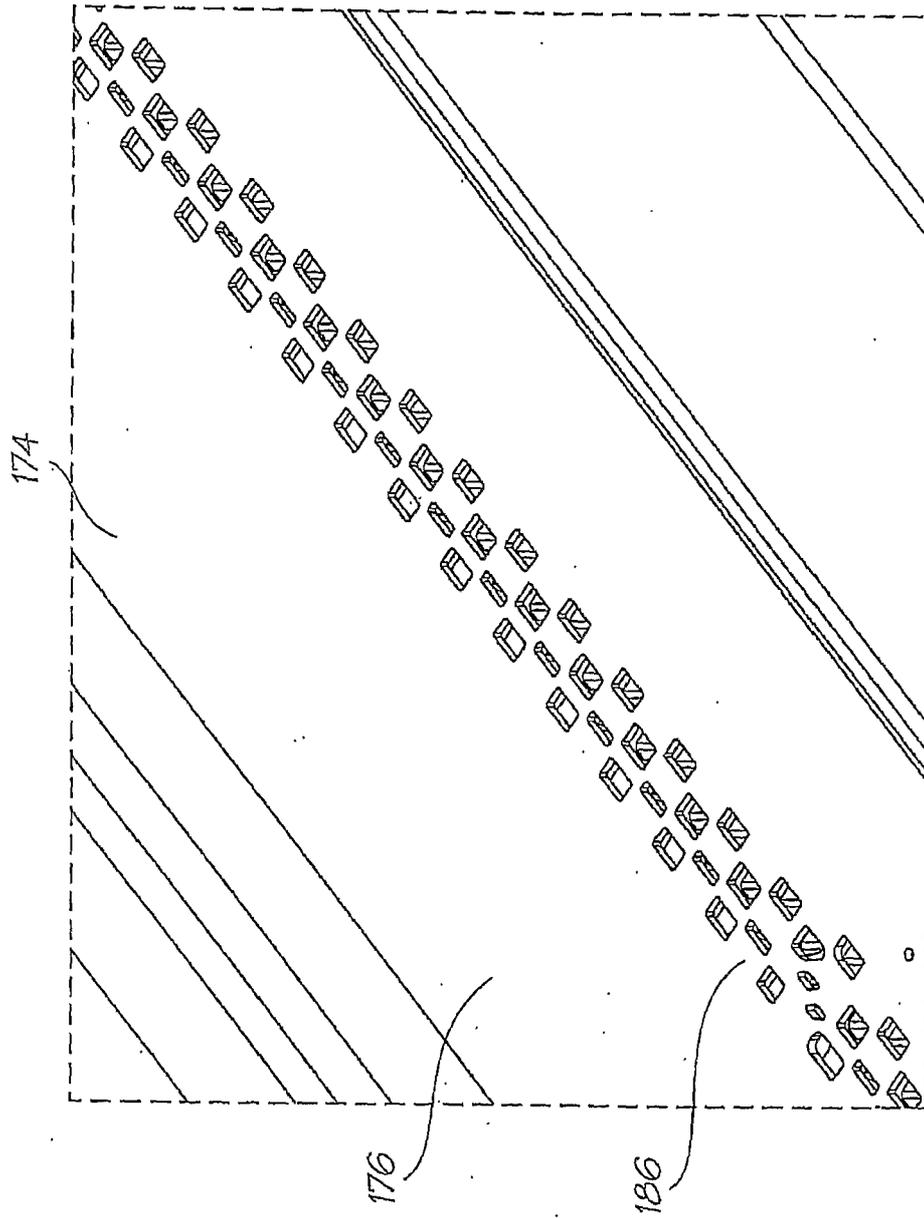


FIG. 22

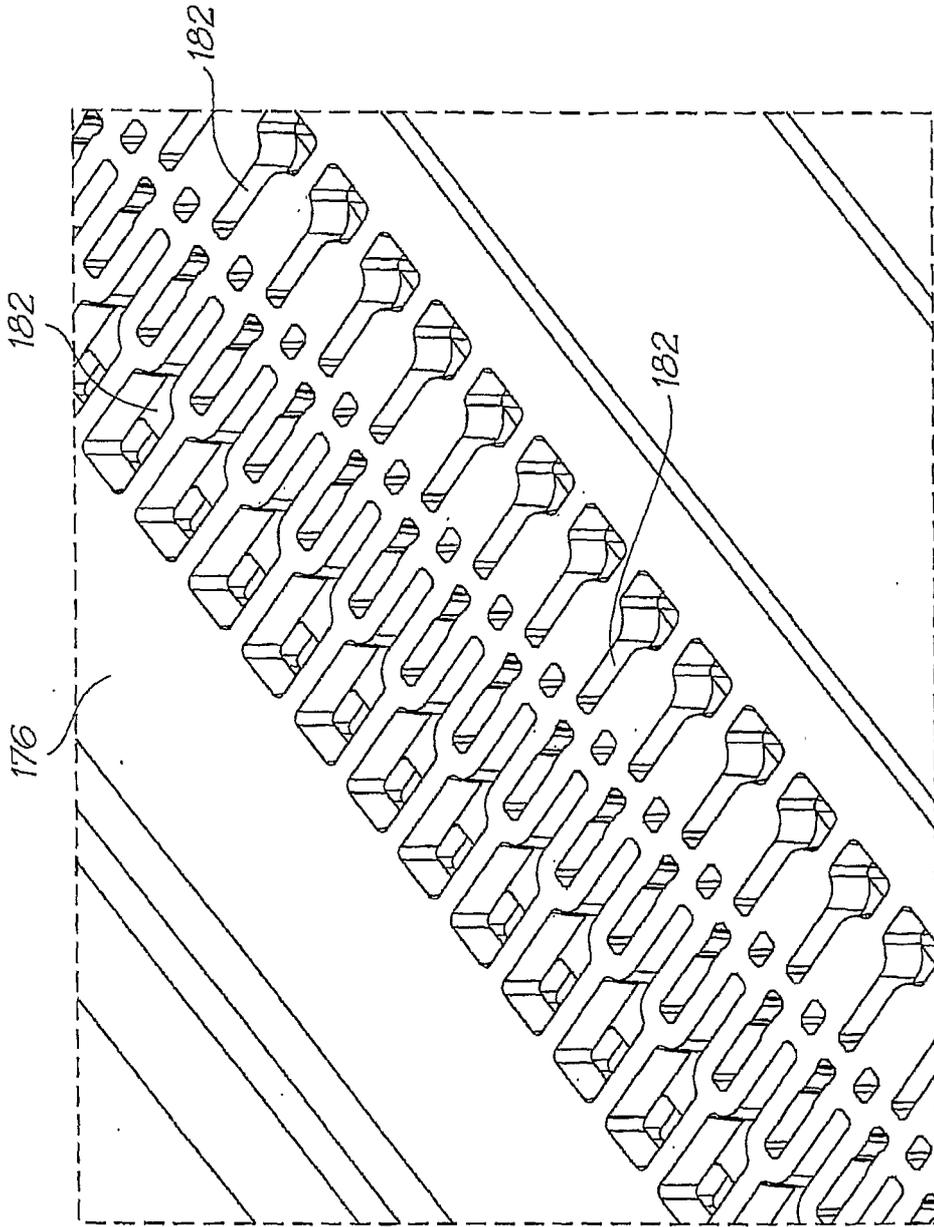


FIG. 23

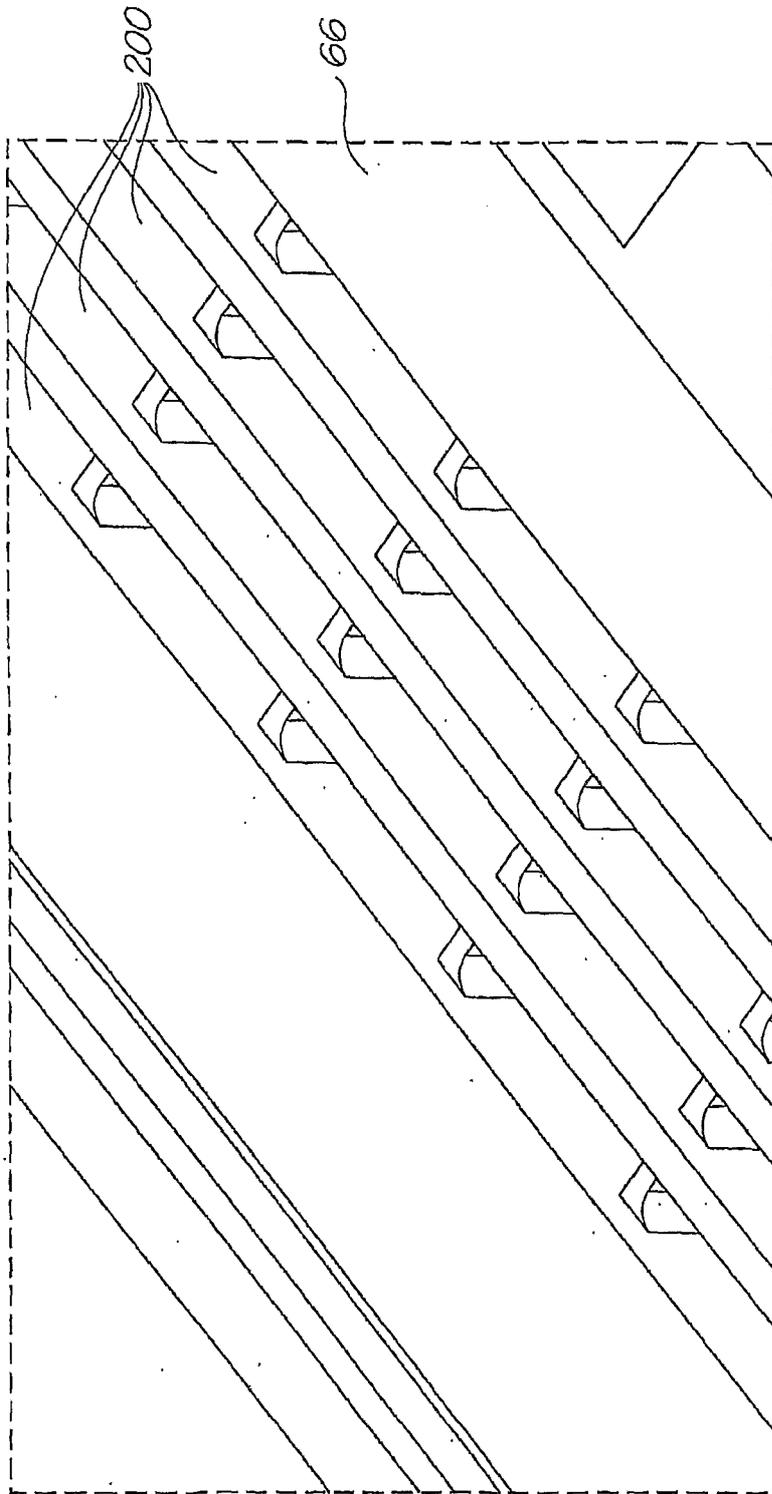


FIG. 24

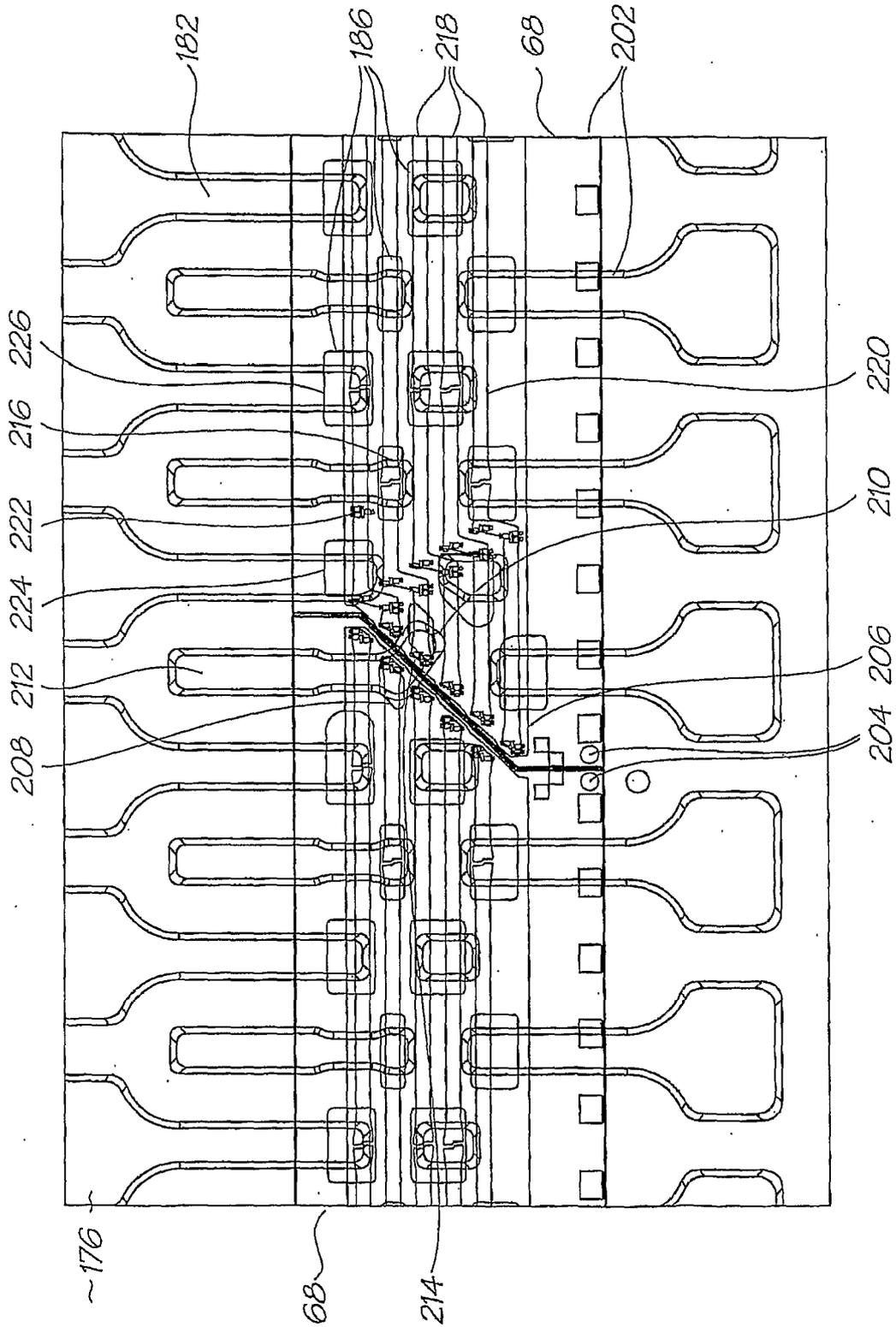


FIG. 25

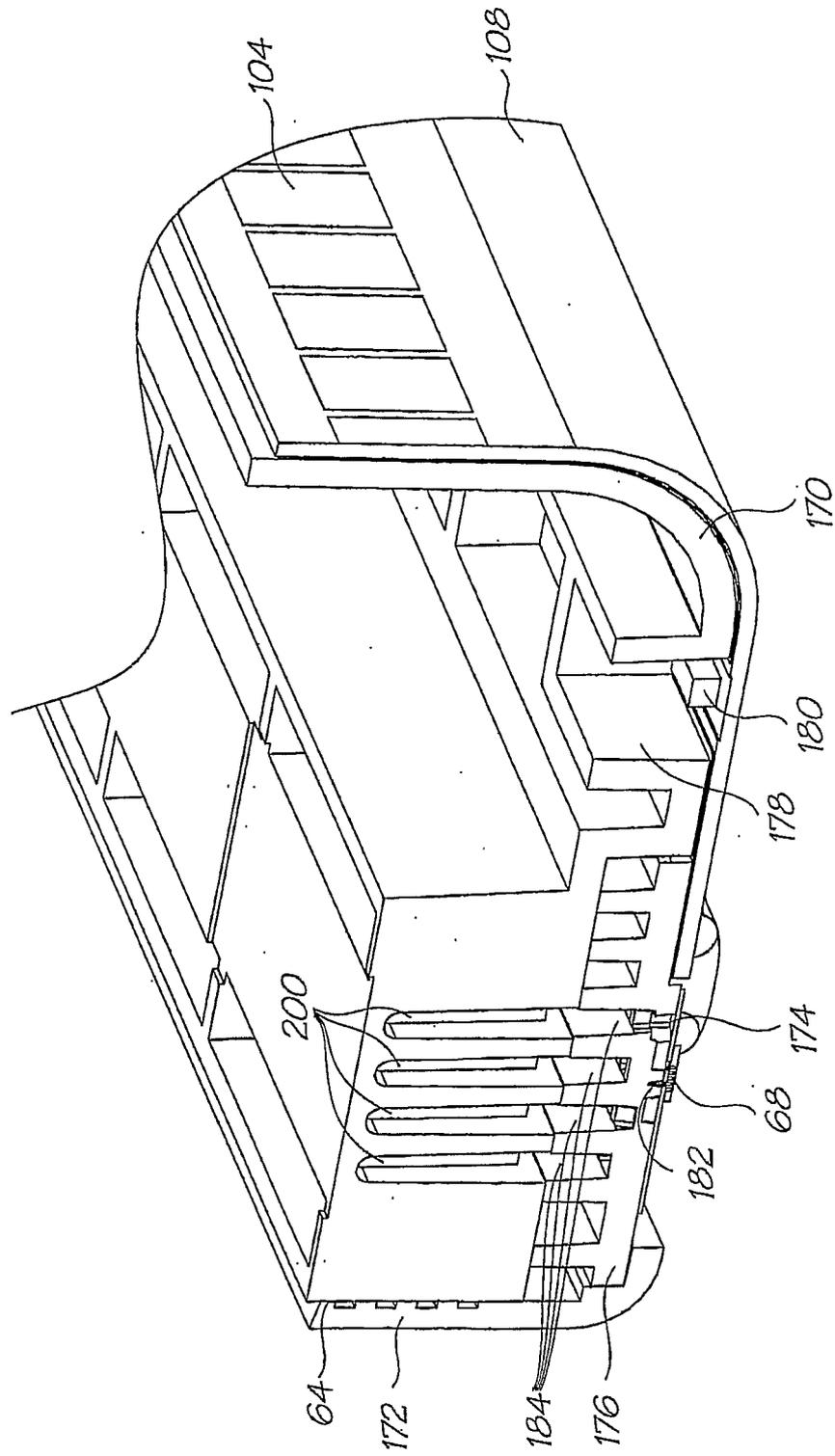


FIG. 26

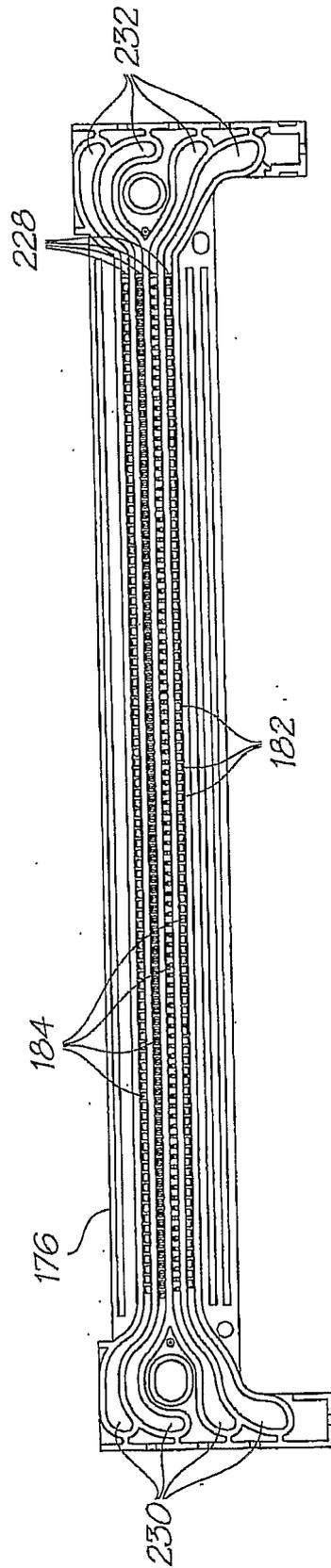


FIG. 27

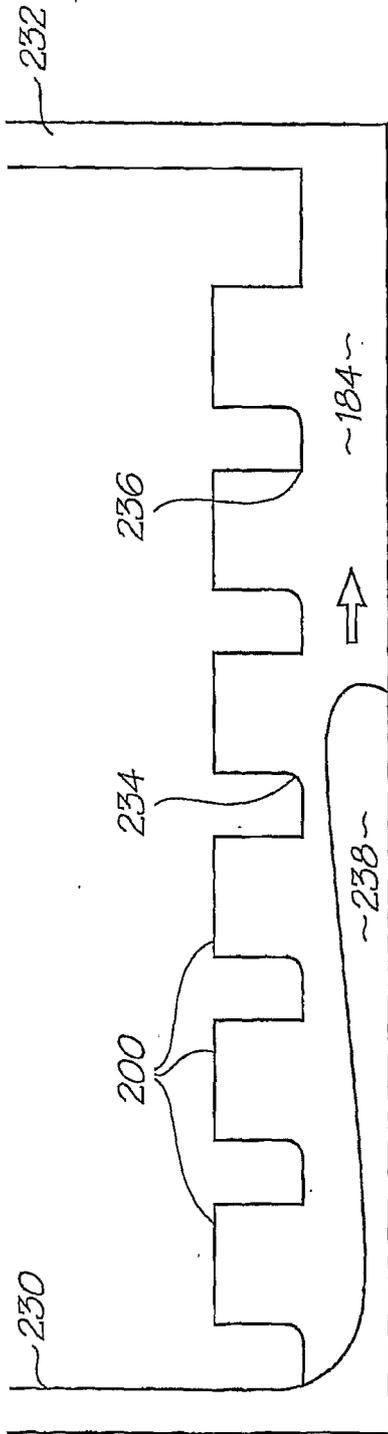


FIG. 28A

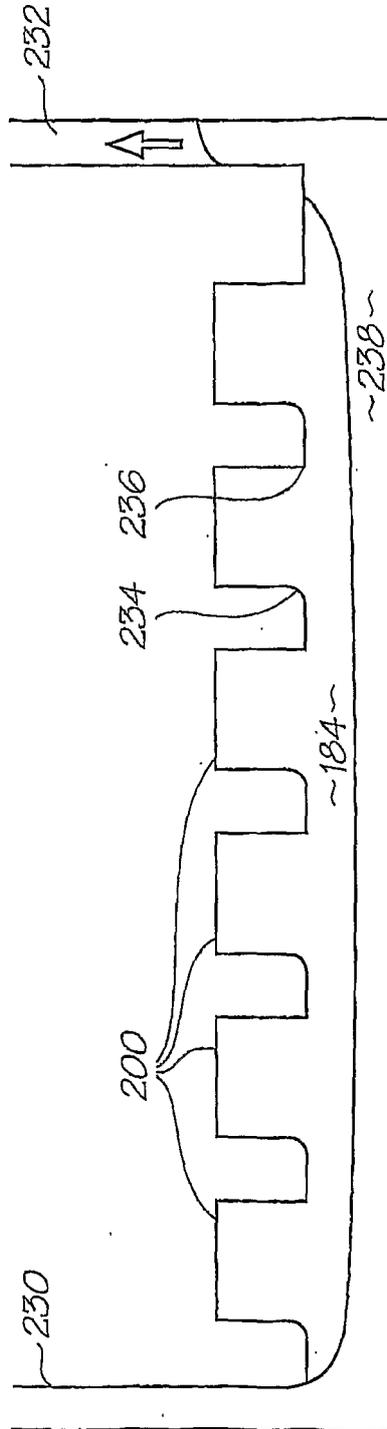


FIG. 28B

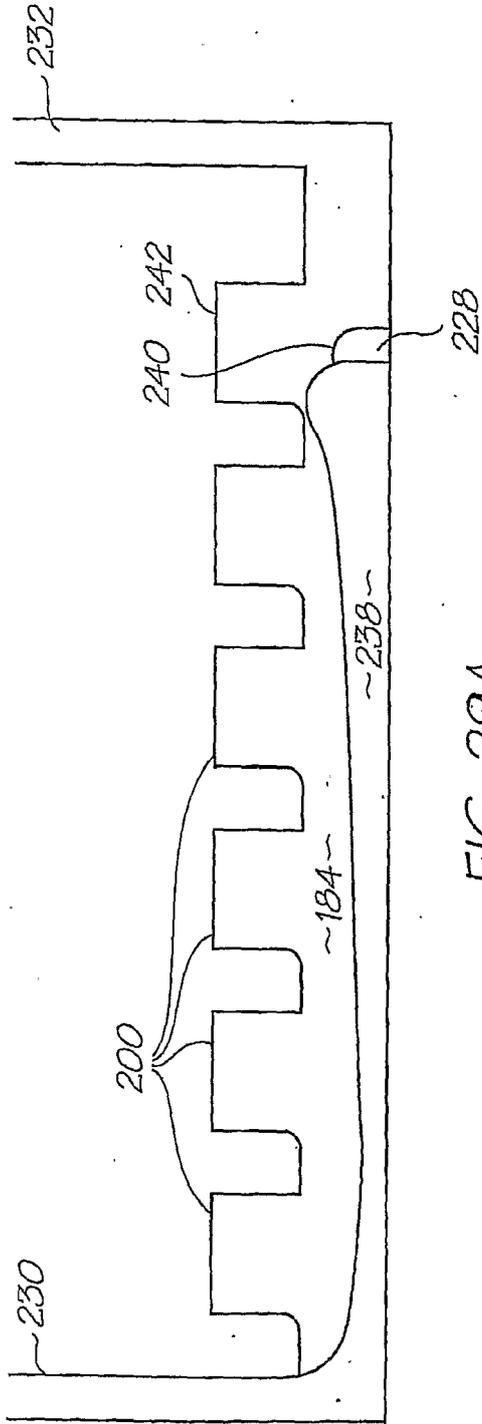


FIG. 29A

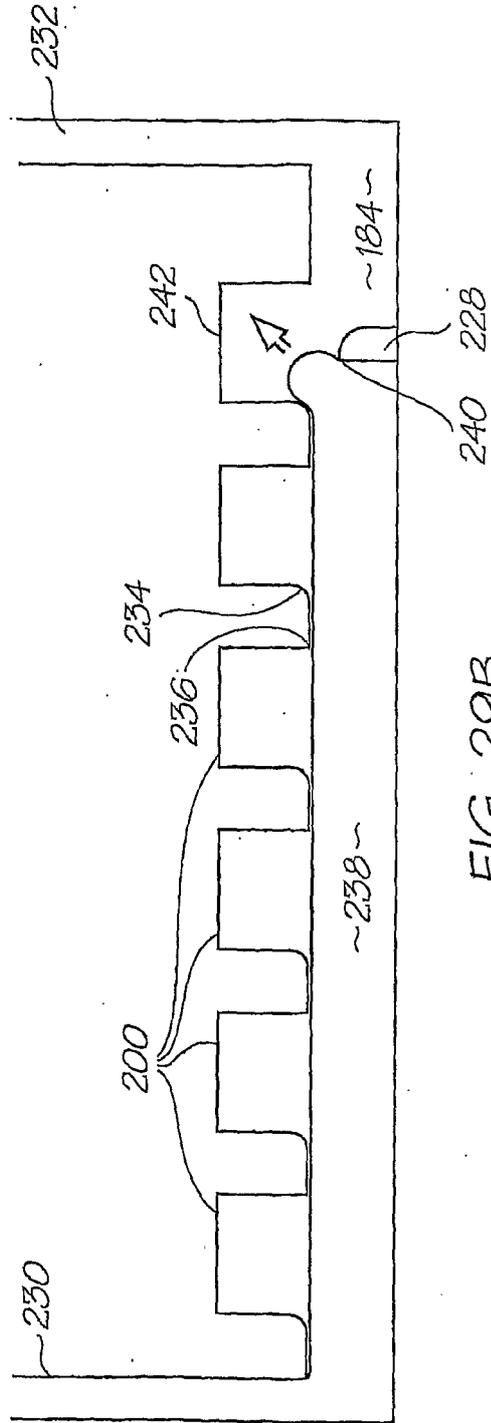


FIG. 29B

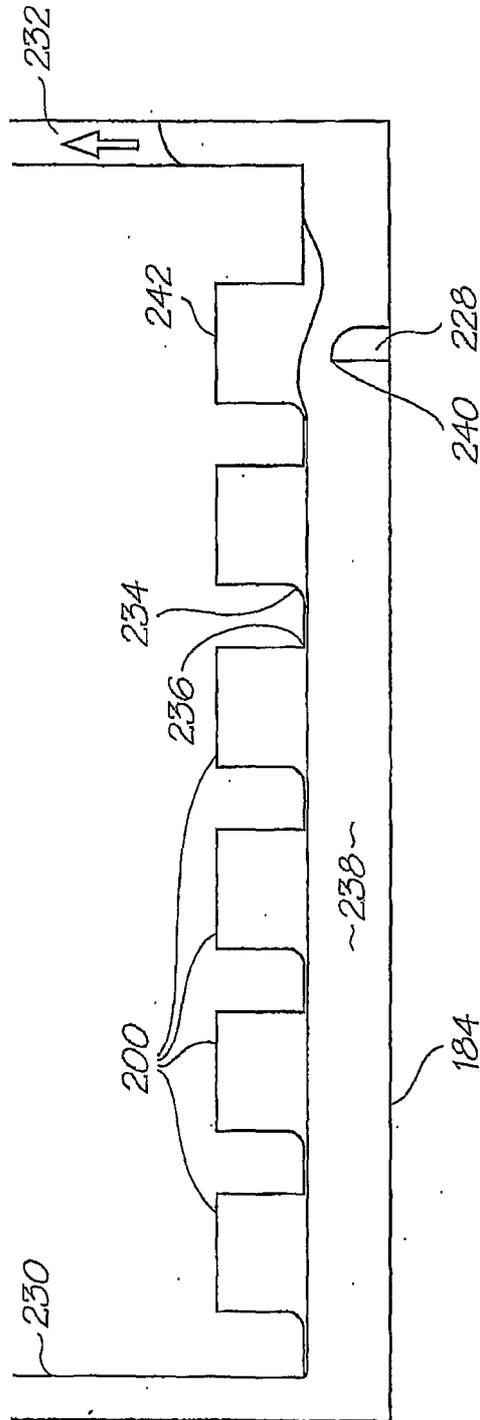


FIG. 29C

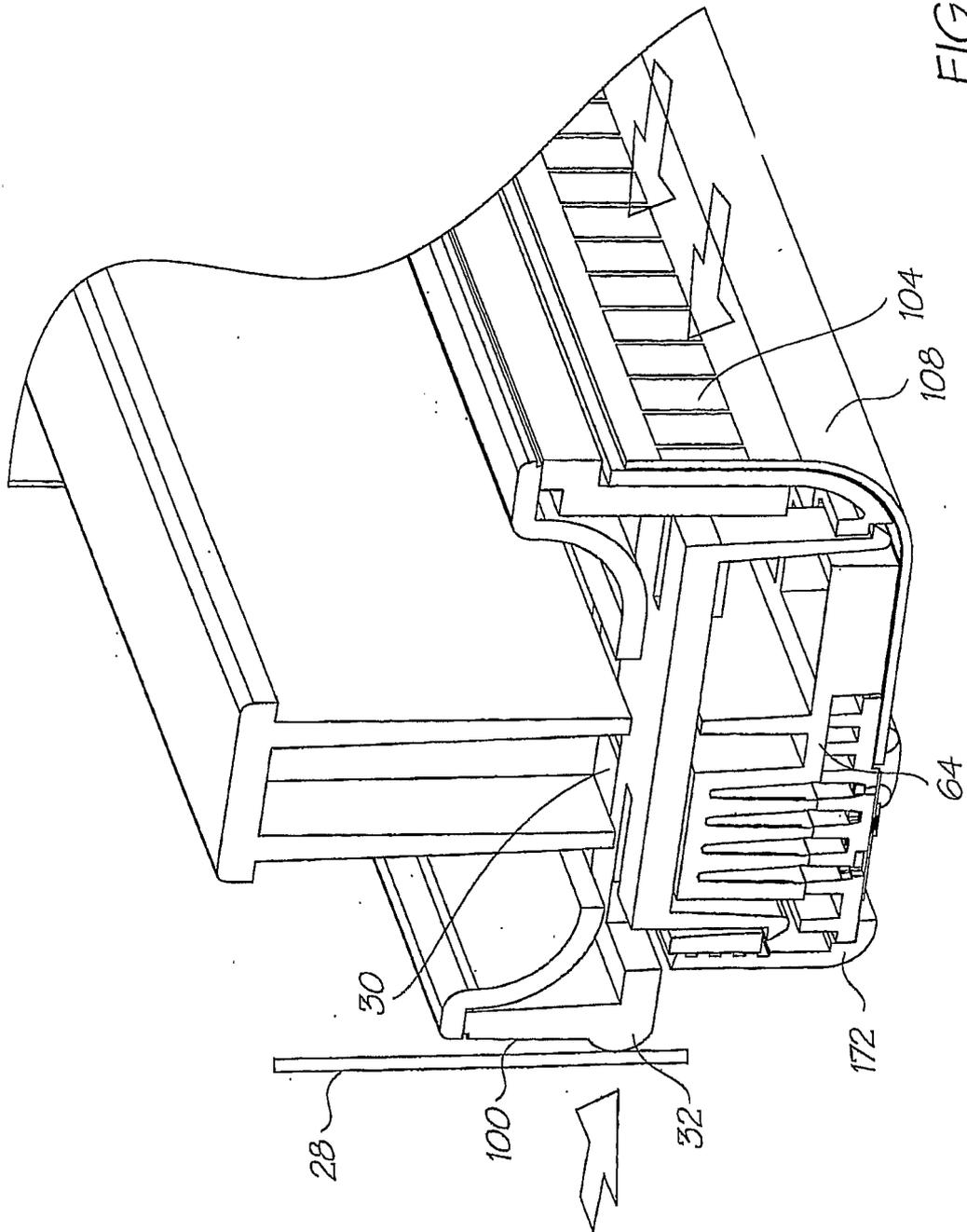


FIG. 30

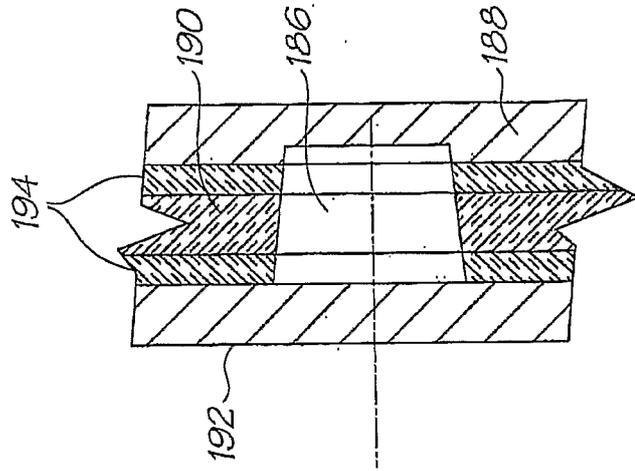


FIG. 33

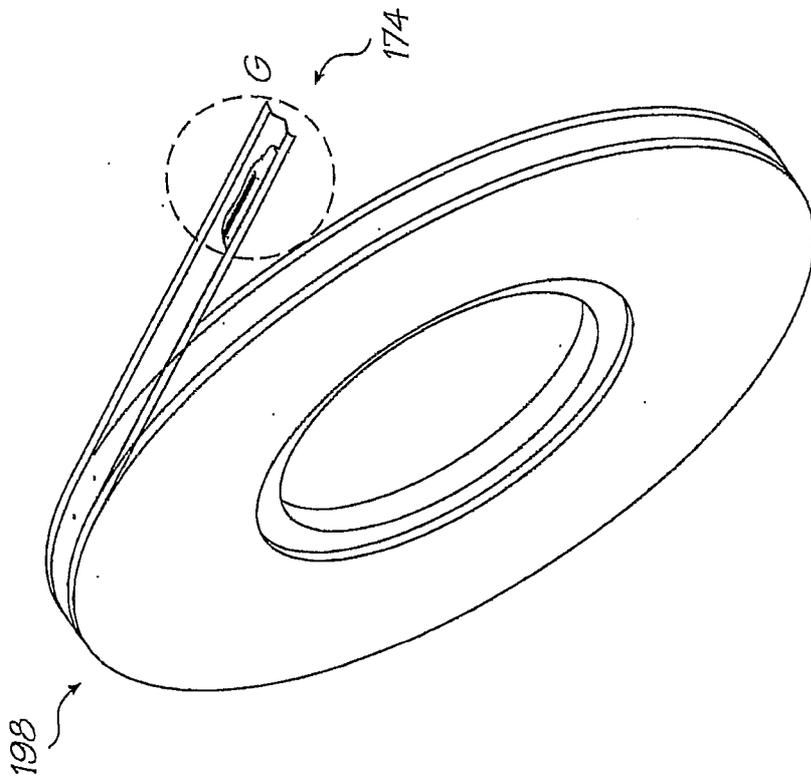


FIG. 31

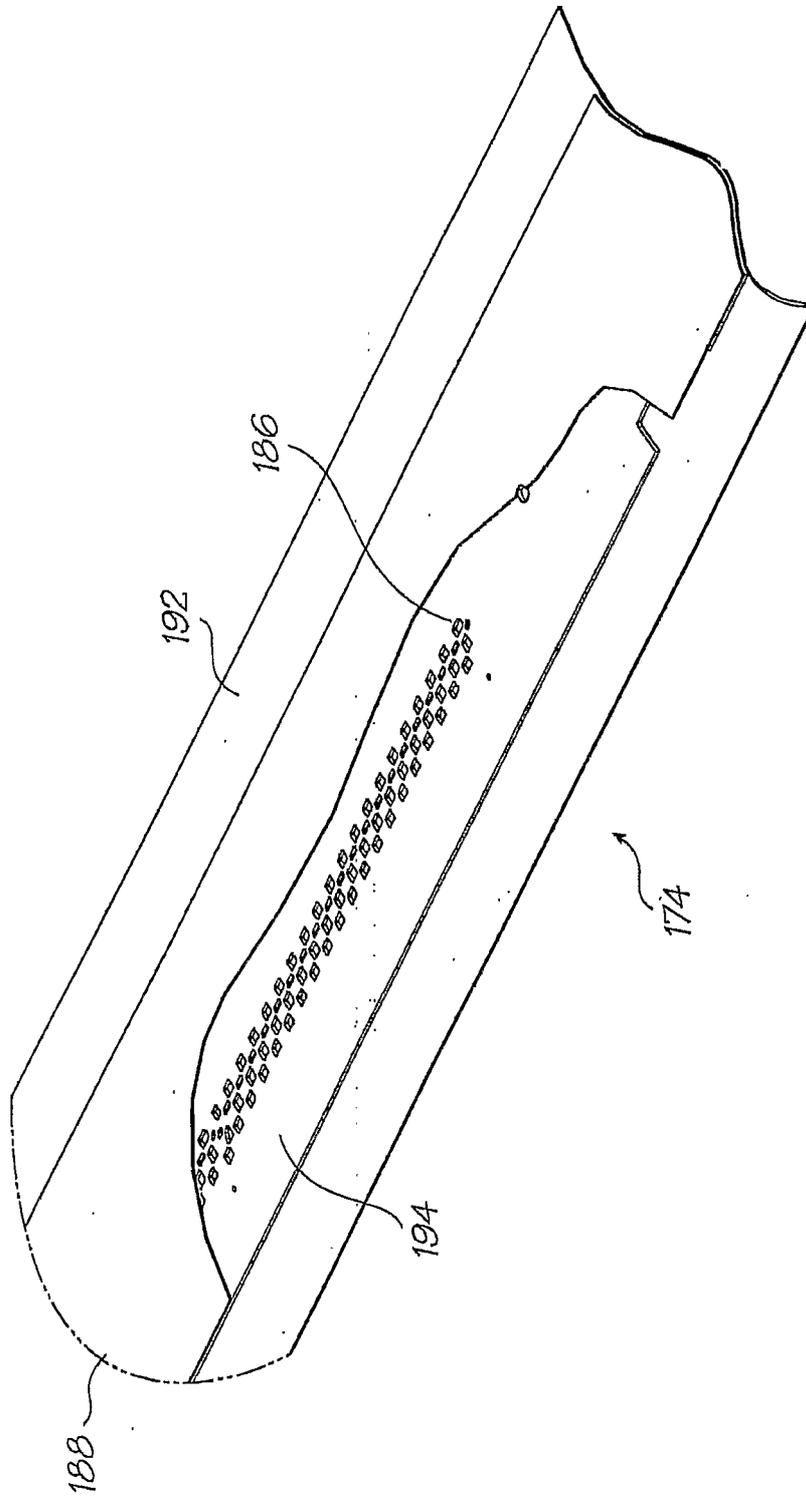


FIG. 32

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2007/000341

A. CLASSIFICATION OF SUBJECT MATTER		
Int. Cl.	<i>B41J2/1</i> 75 (2006.01)	<i>B41J2/045</i> (2006.01)
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) DWPI: B41J-002AC & Keywords (InkJet, Printhead, Fluid, Pulse, Shock, Damp, Compress, Cavity) & similar terms; Google Patent, Es@ce & Keywords (Printhead, Damper, Gas) and similar terms		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6460986 B2 (SASAKI) 8 October 2002 See whole document. Figure 2 in particular.	
A	US 2006/0170735 A1 (HONG et al.) 3 August 2006 See figures 3 to 5E.	
A	US 6905202 B2 (SHTMAMOTO et al.) 14 June 2005 See whole document.	
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C <input checked="" type="checkbox"/> See patent family annex		
<p>* Special categories of cited documents"</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>		
Date of the actual completion of the international search 23 May 2007		Date of mailing of the international search report 30 MAY 2007
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustalia.gov.au Facsimile No. (02) 6285 3929		Authorized officer ROGER SMALL AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No ; (02) 6283 7998

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2007/000341

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6955418 B2 (ITO) 18 October 2005 See abstract and figures.	
A	US 2006/0181581 A1 (JUNGetal.) 17 August 2006 See abstract and figures.	
A	US 7004576 B2 (ITO) 28 February 2006 See whole document.	
A	US 2005/0248628 A1 (ISONO) 10 November 2005 See whole document.	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT7AU2007/000341

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	6460986	CN	1318472	EP	1120257	HK	1040964
		JP	2001205818	JP	2001277537	KR	2001007803
		US	2001009434				
US	2006170735	EP	1685963	JP	2006205735	KR	2006008714
US	6905202	JP	2003237082	US	2003231230		
US	6955418	CN	1475348	EP	1375148	JP	2004025636
		US	2004001 124				
US	2006181581	EP	1693206	JP	2006224672	KR	2006009239
US	7004576	JP	2004106395	US	2004056937		
US	2005248628	JP	2005205769	JP	2006015539	US	2005162484

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX