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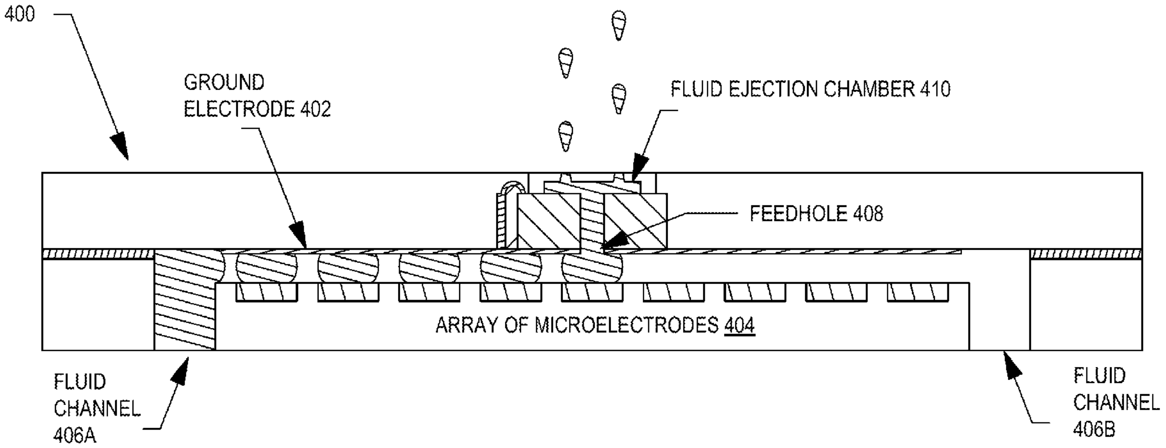

FIGURE 4

(57) **Abstract:** In an example implementation according to aspects of the present disclosure, a fluid device comprises a fluid reservoir arranged to deliver printing fluid to an ejection chamber. The fluid device further comprises a substrate including an array of microfluidic electrodes. The fluid device also comprises electrical interconnects to receive control signals to enable delivery of printing fluid from the reservoir to a fluid port.

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DIGITAL MICROFLUIDIC FLUID DELIVERY

BACKGROUND

[0001] In the context of printing devices, such as fluid-based printing devices, printing fluids may contain solids that may be used for a number of different purposes. For example, colorants in the printing fluids may be used to form text, images, and/or objects on print media, such as in the form of colors on a page of paper. In other examples, the solids may include components to provide a layer of protection on a print medium, such as polymers within a clear coat to provide a layer of protection on print media.

[0002] In yet other examples, the solids may include binder particles capable of absorbing electromagnetic radiation of desired wavelengths (e.g., ultraviolet (UV) light) and causing build material to bind together. In yet other examples, the solids may include particles that make up agents or reagents to be used in the context of a biomedical test. In these and other contexts, the printing fluids may be ejected from the printing device via fluid ejection chambers, such as including nozzles and fluid actuators, to form droplets of printing fluid to be deposited on a medium or materials.

[0003] Printing devices may use, among other things, pressurized fluid lines and capillary forces of porous media to move printing fluids from reservoirs to the ejection chambers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0001] Many aspects of the disclosure can be better understood with reference to the following drawings. While several examples are described in connection with these drawings, the disclosure is not limited to the examples disclosed herein.

[0002] Figure 1 illustrates a block diagram illustrating an example fluid device to deliver fluids to a fluid ejection chamber;

[0003] Figures 2A-2B illustrate an example linear electrode to move fluids;

[0004] Figure 3 illustrates an example array to move fluid to a fluid ejection chamber;

[0005] Figure 4 illustrates a schematic cross-sectional diagram of an example fluid device to deliver fluids to a fluid ejection chamber;

[0006] Figures 5A-5D illustrates an example fluid device for intermixing printing fluids;

[0007] Figure 6 illustrates an example digital microfluidics (DMF) device; and

[0008] Figure 7 illustrates a flow diagram of a process to deliver fluid in a fluid device, according to another example.

DETAILED DESCRIPTION

[0009] In the context of printing devices, such as fluid-based printing devices, printing fluid may be transferred to fluid ejection chambers of the printing devices using pressurized fluid lines and capillary forces in porous media. At times, air may be introduced into the fluid ejection chambers, such as via the pressurized fluid lines or the porous media. The presence of air in the fluid ejection chambers may lead to failure of the fluid actuators upon activation. Additionally, solids in the printing fluid may settle in the fluid lines, the porous media, and/or the fluid ejection chambers. As a result, the fluid lines and/or the nozzles of the ejection chambers may clog, and the resulting ejected fluid may have undesirable solid concentrations (e.g., leading to lower quality print output, false negatives or positives for biomedical tests, and the like). Additionally, fluid delivery systems including pressurized fluid lines may introduce complexity and cost into the print system, such as using pumps, valves, and the like. There may be a desire, therefore, for alternative approaches for moving printing fluid from reservoirs towards ejection chambers.

[0010] A digital microfluidic (DMF) system may be employed for moving printing fluid from reservoirs towards ejection chambers. DMF systems may enable packets of fluid to be moved from reservoirs toward the bottom of a feed hole next to the ejection chamber by activating a voltage to electrodes adjacent to a droplet and deactivating a voltage to an electrode under the droplet. The droplet may then move from the deactivated electrode it is currently on to the activated, adjacent electrode. By continuously varying the voltages of the electrodes, individual droplets may be maneuvered along a line of electrodes. Therefore, DMF systems may move printing fluid from the reservoirs towards ejection chambers without the use of pressure regulators, pumps, valves, and the like which may reduce the cost and complexity of implementing the fluid delivery system without compromising the performance of the system.

[0011] The use of a DMF system may provide increased flexibility and precision in how the fluids are delivered. As discuss above, fluid delivery systems that use pressure to move the printing fluids may result in pockets of air being pushed into the ejection chambers, creating failure of the fluid actuators upon activation. DMF systems, on the other hand, enable the fluid to be pulled toward the ejection chambers using voltage variations. The voltage variations may allow the fluid to be moved. Therefore, air and/or other composites located in a proximity to the ejection chamber would not be pulled into the ejection chamber with the fluid. Additionally, the replacement of the pressure regulators and the like to move the fluid allows the DMF system to have more precision in the amount of fluid which is moved toward each ejection chamber. Furthermore, DMF systems allow there to be precision in an amount of different fluids from different reservoirs to be moved toward the ejection chambers. Thus, precise mixtures of fluids can be created within the DMF system.

[0012] The use of DMF systems over other fluid delivery systems may enable an entire droplet of printing fluid (e.g., ink) to be moved along the line of electrodes at the time of printing. Therefore, different composites of the printing fluid are not separated in a fluid line (e.g., separation of solid and liquid) which may maintain the integrity of the fluid composition and prevent clogging due to a buildup of fluid residues. In view of the foregoing, it should be appreciated that there may be a desire to use DMF systems to deliver printing fluid to ejection chambers.

[0013] Examples described herein provide a fluid device comprising a fluid reservoir arranged to deliver printing fluid to a fluid ejection chamber. The fluid device may include a substrate including an array of microfluidic electrodes. Further in this example, electrical interconnects may be included in the fluid device to receive control signals which enable the delivery of printing fluid from the reservoir to a fluid port.

[0014] In another example described herein, a method of operating a fluid device is provided. The method may include receiving, by electrical interconnects, control signals to enable delivery of a first printing fluid from a first reservoir to a fluid port of a fluid ejection chamber. The method may also include directing, by a first microfluidic electrode from a substrate including an array of microfluidic electrodes, a first transmission of the first printing fluid from the first fluid reservoir to the fluid port of the fluid ejection chamber. The method also includes receiving, by the electrical interconnects, control signals to enable delivery of a second printing fluid from a second reservoir to the fluid port of the fluid ejection chamber and directing, by a second microfluidic electrode from the substrate including the array of microfluidic electrodes, a second transmission of the second printing fluid from the second fluid reservoir to the fluid port of the fluid ejection chamber.

[0015] In yet another example described herein, a DMF device comprises a capping fluid reservoir arranged to deliver capping fluid to a fluid ejection chamber. The fluid device may include a substrate including an array of microfluidic electrodes. Further in this example, electrical interconnects to may be included in the DMF device to receive control signals to enable delivery of the capping fluid from the reservoir to a feedhole of the fluid ejection chamber.

[0016] Throughout this specification to one implementation, an implementation, one case, an example, and/or the like means that a particular feature, structure, characteristic, and/or the like described in relation to a particular implementation, case, and/or example is included in an implementation, case, and/or example of claimed subject matter. Thus, appearances of such phrases, for example, in various places throughout this specification are not necessarily intended to refer to the same implementation, case, and/or example or to any one particular implementation, case, and/or example. Furthermore, it is to be understood that particular features, structures, characteristics, and/or the like described are capable of being combined in various ways in different implementations, cases, and/or examples and, therefore, are within intended claim scope. In general, of course, as has always been the case for the specification of a patent application, these and other issues have a potential to vary in a particular context of usage. In other words, throughout the disclosure, particular context of description and/or usage provides helpful guidance regarding reasonable inferences to be drawn; however, likewise, “in this context” in general without further qualification refers to the context of the present disclosure.

[0017] Turning to Figure 1, a block diagram of an example fluid device for moving fluids to a fluid ejection is illustrated as a block diagram. Figure 1 shows an example fluid device 100 which includes fluid reservoir 102, electrical interconnects 104, substrate 106, microelectrode array 108, and fluid ejection chamber 110.

[0018] Fluid device 100 may comprise a device capable of transferring fluids to a fluid ejection device, such as discussed above. It should be noted that fluid device 100 may include or be in communication with components of an electronic device, such as a processor, a memory, and a controller to enable functionality of fluid device 100. Examples of fluid device 100 may a include printing device, such as a two-dimensional (2D) printer and/or a three-dimensional (3D) printer. In some examples, fluid device 100 may refer to a fluid ejection device, such as an inkjet print module or printhead cartridge.

[0019] Fluid reservoir 102 may include a container capable of storing printing fluid and mechanism for transferring of printing fluid toward microelectrode array 108. The printing fluid may include any fluid capable of being dispensed by fluid ejection chamber 110 onto a media, such as paper, a layer of powder-based build material, reactive devices (such as lab-on-a-chip device), etc. In some examples, the printing fluid may include a material for printing, such as ink, toner, powders, colorants, varnishes, finishes, gloss enhancers, binders, fusing agents, inhibiting agents, and/or other such materials which may be utilized in the printing process. In other examples, printing fluids may include fluid colorants, such as pigments. In yet another example, the printing fluid comprises an ink solvent replenishment fluid.

[0020] Electrical interconnects 104 allow fluid device 100 to exchange control signaling with an electronic device, such as a controller or processor which enables fluid device 100 to deliver fluid to fluid ejection chamber 110. In particular, electrical interconnects 104 may exchange control signaling that indicates a voltage for a microelectrode in microelectrode array 108. The voltage may enable the fluid to be moved across microelectrode array 108 by attracting the fluid from one pad to another pad on microelectrode array 108. In some examples, the electronic device may be external to fluid device 100 and may communicate the control signaling using wireless signaling or wireline signaling. In other examples, the electronic device may be incorporated physically with fluid device 100.

[0021] As illustrated in Figure 1, substrate 106 may include a semiconductor material, which enables electrical interconnects 104 to transfer control signaling for fluid device 100 to deliver fluid to fluid ejection chamber 110. Substrate 106 includes various elements, such as microelectrode array 108. Although not shown for clarity, substrate 106 may include various other resources to enable fluid device 100 to perform particular functions, described herein.

[0022] Fluid ejection chamber 110 may be a device capable of receiving fluid from fluid reservoir 102 by electrical interconnects 104 and ejecting printing fluids. Specifically, fluid ejection chamber 110 may include an enclosure into which printing fluid may be propagated for storing and ejecting. The enclosure may include an actuator and an orifice. In the context of a thermal actuator, current pulses may cause the printing fluid to heat. A portion of the fluid may then be vaporized which in turn, causes droplets of the fluid to be ejected via the orifices.

[0023] It should be noted that as used herein, fluid ejection chamber 110 may refer to a thermal inkjet (TIJ) or piezo inkjet (PIJ), by way of non-limiting example. Thus, for example, a fluid device of a 3D printer may be used to eject an agent that may cause a build material to fuse together as part of an additive printing process. The agent may or may not include colorants, such as pigments. Instead, the agent may include an additive agent to be used in the formation of a 3D mold.

[0024] In operation, electrical interconnects 104 may receive control signaling from an electronic device in communication with fluid device 100. The control signaling indicates a microelectrode of microelectrode array 108 through which a current is to be pulsed across. By pulsing the current across one of the microelectrodes, an electrical potential is to be formed. The electrical potential attracts a droplet of printing fluid. Based on this attraction, the droplet of printing fluid is moved from fluid reservoir 102 to the microelectrode of microelectrode array 108.

[0025] Electrical interconnects 104 may then receive additional control signaling from the electronic device in communication with fluid device 100 indicating additional microelectrodes of microelectrode array 108 that are to receive the current pulses. The additional control signaling may also indicate that certain microelectrode(s) (e.g., microelectrode(s) already receiving the current pulses) are to cease to receive current pulses. For example, once the first droplet of fluid has moved to the first microelectrode, the control signaling may pass a second current across a second microelectrode of microelectrode array 108. This second current would form an electric potential across the surface of the second microelectrode. In this example, the first droplet of fluid would now be attracted to the second microelectrode and therefore, move from the first microelectrode to the second microelectrode in microelectrode array 108. Using the alteration of voltage currents between microelectrodes of microelectrode array 108, the droplet of printing fluid is guided toward fluid ejection chamber 110. An example further illustrating the movement of the droplet of fluid across a microelectrode array is described in Figure 2.

[0026] In one implementation, fluid device 100 may enable the provision of multiple fluids to ejection chamber 110, such as responsive to received signals. For example, fluid reservoir 102 may include a first fluid reservoir and a second fluid reservoir (or more, in some cases). Further, fluid device 100 may direct, by a microfluidic electrode of microelectrode array 108, a transfer of a first printing fluid from the first fluid reservoir to fluid ejection chamber 110. A second printing fluid of the second fluid reservoir may also be transferred to fluid ejection chamber 110. In some examples, the first fluid from the first fluid reservoir and the second fluid from the second fluid reservoir may be mixed on an electric pad prior to the transmission to in the fluid port of fluid ejection chamber 110. In yet another example, the control signals enable the transfer of a first fluid of the first fluid reservoir but block the transfer of a second fluid of the second fluid reservoir.

[0027] In yet another example, substrate 106 including microelectrode array 108 may be coated with a low contact angle hysteresis layer and/or a dielectric layer. This may enable selected microelectrodes of microelectrode array 108 to be hydrophobic, which may therefore affect the electrowetting. In some scenarios, movement of droplets of fluids across microelectrode array 108 may maintain a solid component of the printing fluid in suspension.

[0028] In some implementations, the printing fluid may include a capping fluid. As previously discussed, printing fluids may contain dissolved and/or suspended polymers (e.g., in addition to solids) that may also tend to settle. For example, as liquid evaporates concentration of the dissolved and/or suspended polymers may increase leading to increased viscosity. Thus, the quality of a printed item is decreased when fluid device 100 is uncapped for a period of time. Therefore, propagating a capping fluid may be propagated toward fluid ejection chamber 110 allows fluid ejection chamber 110 to remain in a “capped” state while not in use.

[0029] In other examples, the operation of fluid device 100 described herein may enable the printing fluid to be micro-recirculated. For example, components of fluid ejection chamber 110 (e.g., fluidic dies of a thermal inkjet device) may experience uneven heating, such as due to operation of resistive and/or thermal elements that may cause hot spots in fluid device 100. In such cases, recirculation may be of interest to dissipate thermal buildup at portions of fluid ejection chamber 110. By enabling the printing fluid to be moved using the alteration of voltage currents between microelectrodes of microelectrode array 108 (as discussed in the operation above), droplets of printing fluid may be recirculated through channels of fluid ejection chamber 110. This dissipated the thermal buildup of fluid ejection chamber 110.

[0030] In yet another example, microelectrode array 108 performs a cooling process for the printing fluid. In the cooling process, the microelectrode array 108 may micro-recirculate the printing fluid through the fluid port of the fluid ejection chamber. In other examples, the printing fluid comprises an ink solvent replenishment fluid. In this example, the control signals may enable delivery of the ink solvent replenishment fluid from the fluid reservoir to the fluid port of the fluid ejection chamber.

[0031] Figures 2A-2B illustrate an example linear electrode to move fluids, according to an example. As illustrated in Figure 2A and Figure 2B, linear electrode 200 may include feedhole region 202 and substrate 204. It should be noted that substrate 204 includes electric pads, such as electric pad 206. Further feedhole region 202 includes feedholes, such as feedhole 212. Figures 2A and 2B also include printing fluid reservoir 208. Although not illustrated in Figures 2A and 2B, linear electrode 200 includes a ground electrode and a driving electrode (illustrated in Figure 4). The surface of the ground electrode and driving electrode may be hydrophobic to prevent printing fluid from wetting the surfaces of the ground electrode and the driving electrode until activated.

[0032] In operation, the printing fluid may be stored in fluid reservoir 208, as illustrated in Figure 2A. In some examples, multiple reservoirs or fluid sources may be able to provide printing fluid to linear electrode 200. Turning to Figure 2B, a voltage may be applied to electric pad 206 on the driving electrode to generate an electric potential between the ground electrode and the driving electrode. This electric potential activates printing fluid in fluid reservoir 208 to move onto electric pad 206.

[0033] Once the printing fluid has moved to electric pad 206, the voltage applied to electric pad 206 may be deactivated on electric pad 206 and applied to a next electric pad along linear electrode 200. By varying the electric potential between the ground electrode and the driving electrode for each electric pad, the electrowetting is affected and the printing fluid is moved along linear electrode 200. The printing fluid may then be driven to the bottom of a feedhole, such as feedhole 212 next to a fluid ejection chamber, such as fluid ejection chamber 110 of Figure 1 (illustrated further in Figure 3).

[0034] It should be noted that printing fluid 210 is pulled from fluid reservoir 208 to the bottom of feedhole 212 next to the ejection chamber over linear electrode 200, instead of pushed to the ejection chamber using back pressure from a pressure regulator. The use of DMF techniques to move the printing fluid to feedhole for an ejection chamber allows more precision in the amount of fluid that is moved toward the ejection chamber. Furthermore, the substitution of the pressure regulator to move the printing fluid decreases the air moved to the fluid ejection chamber which maintains the performance of the fluid device and lowers the cost and complexity of the fluid device.

[0035] Figure 3 illustrates an example DMF array. DMF array 300 may be an example of microelectrode array 108. As illustrated in Figure 3, DMF array 300 is comprised of multiple linear electrodes, such as linear electrode 304. Linear electrode 304. DMF array 300 also includes feedhole region 302 and multiple fluid reservoirs, such as fluid reservoir 308. As illustrated in Figure 3, fluid droplets are moved from fluid reservoir 308 to linear electrode 304 using DMF techniques. In particular, a voltage is applied to a portion of linear electrode 304. For example, the voltage may be applied to an electric pad included in linear electrode 304. The applied voltage then generates an electrical potential between a driving electrode and a ground electrode. This electric potential draws a droplet of fluid, such as fluid droplet 312, onto linear electrode 304. As the electric potentials of the electric pads in linear electrode 304 continue to vary, additional droplets of fluid are pulled from fluid reservoir 308 and are moved across linear electrode 304.

[0036] Next, the droplets of fluid are move toward feedhole region 302. In particular, a voltage is applied to a portion of the linear electrode adjacent to linear electrode 304. Again, an electric potential is created which draws fluid droplet 312 from linear electrode 304 to the adjacent linear electrode. The electric potentials are then continuously varied until fluid droplet 312 moves across DMF array 300 to feedhole region 302. Once fluid droplet 312 reaches feedhole region 302, fluid droplet is moved to the bottom of a feedhole and into a fluid ejection chamber.

[0037] Figure 4 illustrates a schematic cross-sectional diagram of an example fluid device to deliver fluids to a fluid ejection chamber. Fluid device 400 includes ground electrode 402, array of microelectrodes 404, fluid channels 406A and 406B, feedhole 408, and fluid ejection chamber 410. Figure 4 may include different components of fluid device 400 in different examples. Fluid device 400 may be similar in structure and/or operation to fluid device 100 in Figure 1.

[0038] Ground electrode 402 may be used in conjunction with array of microelectrodes 404 to vary voltages of specified microelectrodes an enable the printing fluid to travel along array of microelectrodes 404 toward feedhole 408. Fluid channels 406A and 406B may carry printing fluids towards and/or away from a fluid reservoir (not shown for simplicity). Array of microelectrodes 404 may be supported by a substrate and may include an array of electric pads/electrical interconnects, as described previously. Electrical interconnects may exchange control signals to enable the delivery of the printing fluid toward fluid ejection chamber 410 via feedhole 408.

[0039] The droplet of fluid may be drawn into feedhole 408 by capillary action. For example, a surface tension created in feedhole 408 may cause the droplet of fluid to be drawn from the electric pad located below feedhole 408. Likewise, once the droplet of fluid has been drawn into feedhole 408, the fluid may continue to move toward fluid ejection chamber 410 due to the capillary action force. Once in fluid ejection chamber 410, the droplet of fluid may then be ejected and caused to deposit on an external surface, such as a print medium. Advantageously, a controlled amount of fluid or droplets of fluid may be drawn into feedhole 408 at a time. This provides more control of the amount of fluid which is drawn into feedhole 408, unlike previous techniques where a feedhole would draw all of the fluid pushed through the fluid channels toward the feedhole.

[0040] Figures 5A-5D illustrate a fluid device to continuously mix printing fluids, according to an example. More specifically, Figure 5 provides an example of how printing fluids, such as a pharmaceutical fluid, may be continuously mixed in slots of an array of microelectrodes. Referring to Figure 5A, a first pharmaceutical fluid from part A and a second pharmaceutical fluid from part B enter an array of microelectrodes. As illustrated in Figure 5B, the first pharmaceutical fluid from part A and the second pharmaceutical fluid from part B are shifted along electronic pads of the microelectronic array by varying the voltages of each of the electronic pads (e.g., the first pharmaceutical fluid is moving down onto lower electronic pads and the second pharmaceutical fluid is moving up onto higher electronic pads).

[0041] Referring to Figure 5C, after being shift along the electronic pads of the microelectronic array, the first pharmaceutical fluid from part A and the second pharmaceutical fluid from part B are merged on the array of microelectrodes. As illustrated in Figure 5D, the droplets are continuously merged to provide a steady flow of mixed pharmaceutical droplets. The continuous mixing of the pharmaceutical fluids allows the pharmaceutical fluids to be mixed in real-time at the location of the fluid dispensing. Maintaining a constant flow of a precisely mixed fluid can dramatically affect the quality of the content resulting from the dispense fluid. Of course, other types of printing fluids could be similarly mixed prior to being conveyed to an ejection chamber, consistent with the present disclosure.

[0042] Figure 6 shows an example DMF device 600. DMF device 600 may be a fluid device, such as fluid device 100. The fluid-ejection device 600 may be an inkjet-printing device. The device 600 can include other components as well, such as media trays, rollers, processing hardware, communication hardware to communicate with host computing devices or removable data storage media, and so on. For example, the printhead 104 may selectively eject ink onto media like sheets of paper to form images on the media.

[0043] DMF device 600 includes fluid reservoir 602. In one example, fluid reservoir 602 is arranged to deliver a capping fluid to a fluid ejection chamber. DMF device 600 also includes substrate 604 including an array of microfluidic electrodes. DMF device 600 also includes electrical interconnects 606 to receive control signals to enable delivery of capping fluid from the fluid reservoir to a feedhole of the ejection chamber, in the example of capping fluid delivery. Of course, other implementations of DMF device 600 are also contemplated, such as delivery of printing fluids.

[0044] Figure 7 illustrates a method for operating a fluid device, according to another example. Method 700 may be used by a fluid device, such as fluid device 100. Method 700 may include receiving, by electrical interconnects, control signals to enable delivery of a first printing fluid from a first reservoir to a fluid port of a fluid ejection device, at 701. Method 700 may also include directing, by a first microfluidic electrode from a substrate including an array of microfluidic electrodes, a first transmission of the first printing fluid from the first fluid reservoir to the fluid port of the fluid ejection device, at 702.

[0045] Still referring to Figure 7, method 700 may include receiving, by the electrical interconnects, control signals to enable delivery of a second printing fluid from a second reservoir to the fluid port of the fluid ejection device, at 703. Furthermore, method 700 may include directing, by a second microfluidic electrode from the substrate including the array of microfluidic electrodes, a second transmission of the second printing fluid from the second fluid reservoir to the fluid port of the fluid ejection device, at 704.

[0046] Although not shown in Figure 7 for clarity, in some examples, method 700 includes mixing the first fluid from the first fluid reservoir and the second fluid from the second fluid reservoir in the fluid port of the fluid ejection device in response to the first transmission of the first fluid from the first fluid reservoir and the second transmission of the second fluid from the second reservoir.

[0047] Also not shown in Figure 7 for clarity, in some examples, method 700 may include the array of microfluid electrodes performing a cooling process for the printing fluid, wherein the cooling process comprises micro-recirculating one of the first printing fluid and the second printing fluid through the fluid port of the fluid ejection device.

[0048] In the preceding description, various aspects of claimed subject matter have been described. For purposes of explanation, specifics, such as amounts, systems and/or configurations, as examples, were set forth. In other instances, well-known features were omitted and/or simplified so as not to obscure claimed subject matter. While certain features have been illustrated and/or described herein, many modifications, substitutions, changes and/or equivalents will now occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all modifications and/or changes as fall within claimed subject matter.

[0049] It is appreciated that examples described may include various components and features. It is also appreciated that numerous specific details are set forth to provide a thorough understanding of the examples. However, it is appreciated that the examples may be practiced without limitations to these specific details. In other instances, well known methods and structures may not be described in detail to avoid unnecessarily obscuring the description of the examples. Also, the examples may be used in combination with each other.

[0050] Reference in the specification to “an example” or similar language means that a particular feature, structure, or characteristic described in connection with the example is included in an example, but not necessarily in other examples. The various instances of the phrase “in one example” or similar phrases in various places in the specification are not necessarily all referring to the same example.

WHAT IS CLAIMED IS:

1. A fluid device comprising:

a fluid reservoir arranged to deliver printing fluid to a fluid ejection chamber;

a substrate including an array of microfluidic electrodes; and

electrical interconnects to receive control signals to enable delivery of printing fluid from the reservoir to a fluid port.

2. The fluid device of claim 1 wherein the fluid reservoir comprises a first fluid reservoir, and further comprising a second fluid reservoir, wherein the fluid device control signals enabling provision of multiple fluids to the ejection chamber.

3. The fluid device of claim 2 wherein the fluid device directs, by a microfluidic electrode from the substrate including the array of microfluidic electrodes, a transfer of a first amount of first printing fluid from the first fluid reservoir to the fluid port of the fluid ejection chamber and a second amount of second printing fluid to the second fluid reservoir to the fluid port of the fluid ejection chamber.

4. The fluid device of claim 3 wherein, in response to a transmission of the first printing fluid from the first fluid reservoir and the second printing fluid from the second reservoir via the array of microfluid electrodes, the first fluid from the first fluid reservoir and the second fluid from the second fluid reservoir are mixed on an electric pad prior to the transmission to in the fluid port of the fluid ejection chamber.

5. The fluid device of claim 2 wherein the control signals enable a first microfluidic electrode of the array of microfluidic electrodes associated with the first fluid reservoir to enable a transmission of a first fluid of the first fluid reservoir and disable a second microfluidic electrode of the array of microfluidic electrodes associated with the second fluid reservoir to block the transmission of a second fluid of the second fluid reservoir.

6. The fluid device of claim 1 wherein the printing fluid comprises a capping fluid and wherein the control signals enable delivery of the capping fluid from the fluid reservoir to the fluid port of the fluid ejection chamber.

7. The fluid device of claim 1 wherein the printing fluid comprises an ink solvent replenishment fluid and wherein the control signals enable delivery of the ink solvent replenishment fluid from the fluid reservoir to the fluid port of the fluid ejection chamber.

8. The fluid device of claim 1 wherein the substrate including an array of microfluidic electrodes that is coated with a low contact angle hysteresis layer.

9. The fluid device of claim 1 wherein the array of microfluid electrodes is used to maintain a solid component of the printing fluid in suspension.

10. The fluid device of claim 1 wherein the array of microfluid electrodes perform a cooling process for the printing fluid, wherein the cooling process comprises micro-recirculating the printing fluid below a die.

11. The fluid device of claim 1 wherein the array of microfluid electrodes perform a cooling process for the printing fluid, wherein the cooling process comprises micro-recirculating the printing fluid through the fluid port of the fluid ejection chamber.

12. A method of operating a fluid device comprising:

receiving, by electrical interconnect, control signals to enable delivery of a first printing fluid from a first fluid reservoir to a fluid port of a fluid ejection chamber;

directing, by a first microfluidic electrode from a substrate including an array of microfluidic electrodes, a first transmission of the first printing fluid from the first fluid reservoir to the fluid port of the fluid ejection chamber;

receiving, by the electrical interconnect, control signals to enable delivery of a second printing fluid from a second fluid reservoir to a fluid port of a fluid ejection chamber; and

directing, by a second microfluidic electrode from a substrate including the array of microfluidic electrodes, a second transmission of the second printing fluid from the second fluid reservoir to the fluid port of the fluid ejection chamber.

13. The method of claim 12 further comprising, in response to the first transmission of the first printing fluid from the first fluid reservoir and the second transmission of the second printing fluid from the second reservoir via an array of microfluidic

electrodes, mixing the first fluid from the first fluid reservoir and the second fluid from the second fluid reservoir on an electric pad prior to a third transmission to the fluid port of the fluid ejection chamber.

14. The method of claim 12 further comprising, the array of microfluid electrodes performing a cooling process for the first printing fluid, wherein the cooling process comprises micro-recirculating the first printing fluid through the fluid port of the fluid ejection chamber.

15. A Digital Microfluidics (DMF) device comprising:

a fluid reservoir arranged to deliver a capping fluid to an ejection chamber;

a substrate including an array of microfluidic electrodes; and

electrical interconnects to receive control signals to enable delivery of capping fluid from the fluid reservoir to a feedhole of the ejection chamber.

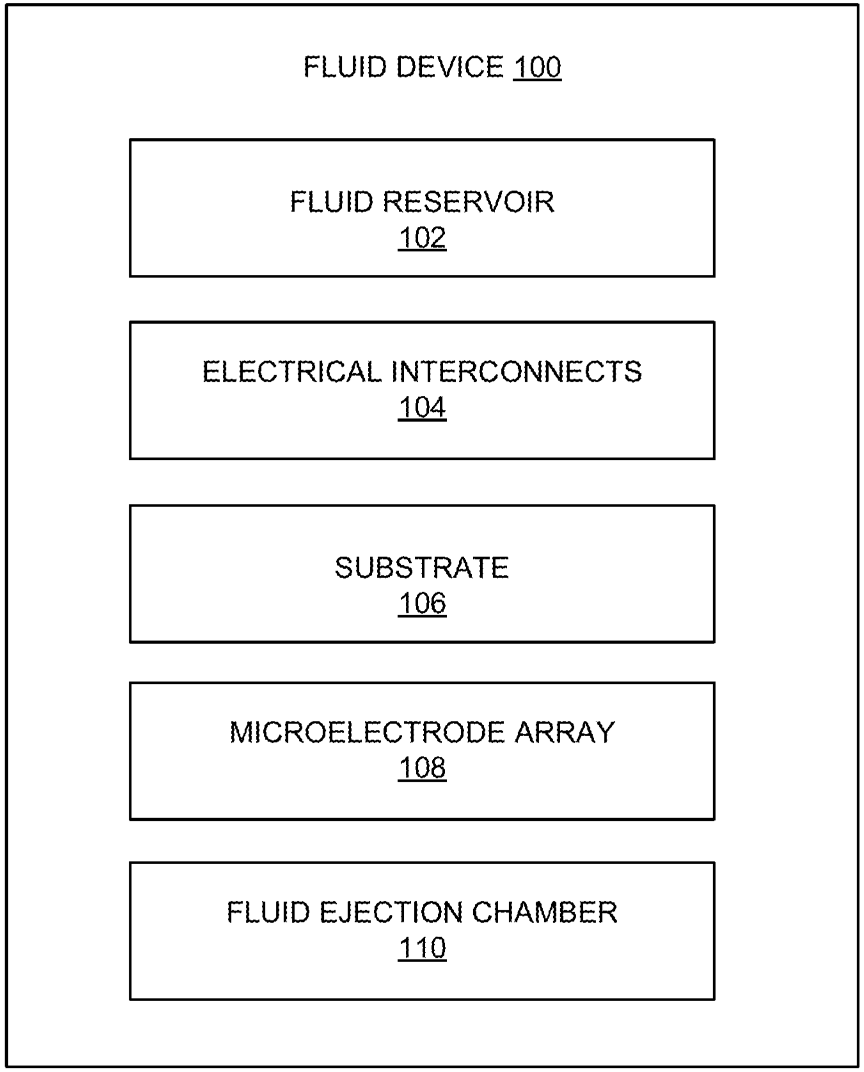
FLUID DEVICE 100
FLUID RESERVOIR 102
ELECTRICAL INTERCONNECTS 104
SUBSTRATE 106
MICROELECTRODE ARRAY 108
FLUID EJECTION CHAMBER 110

FIGURE 1

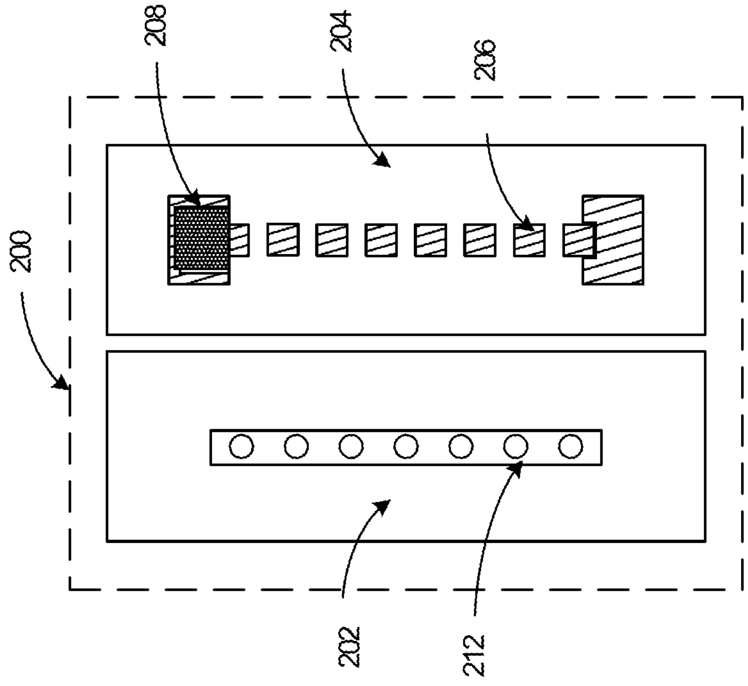

FIGURE 2A

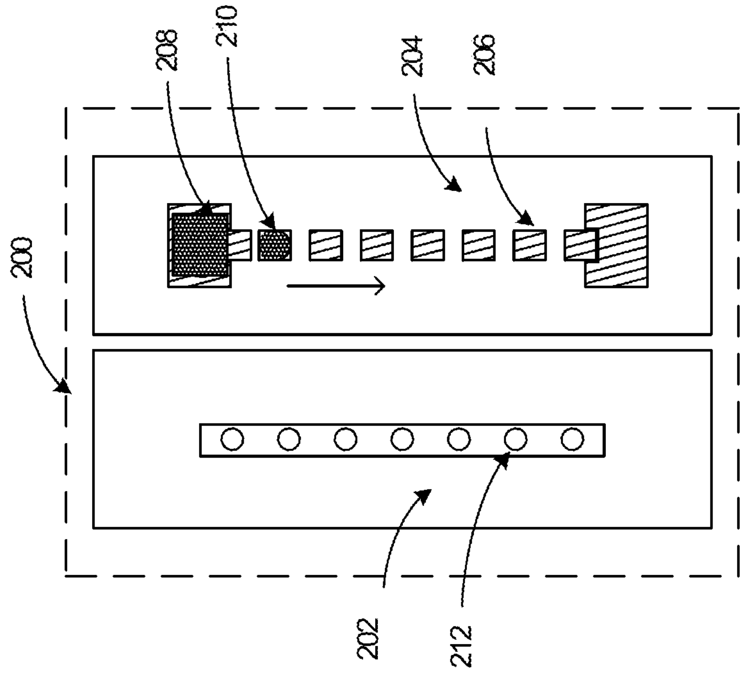

FIGURE 2B

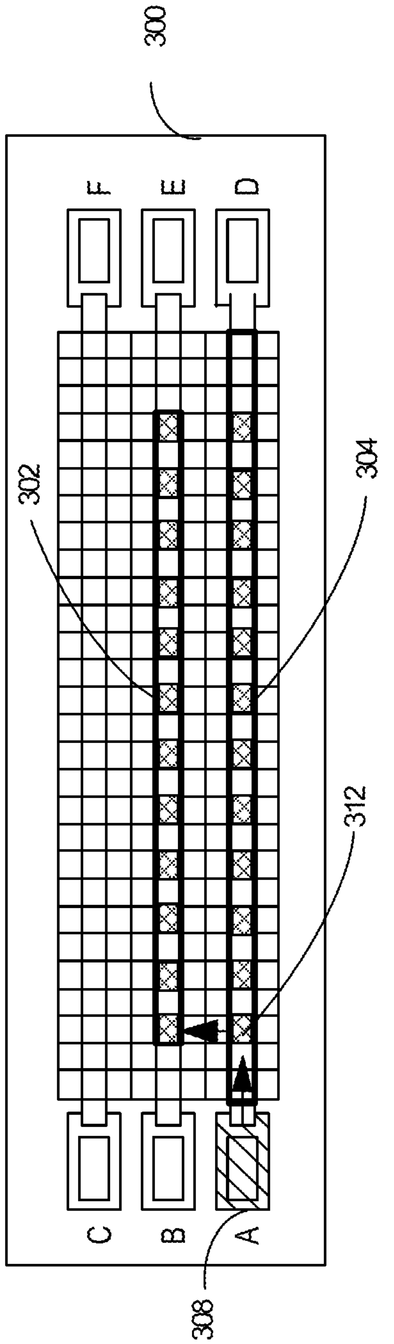

FIGURE 3

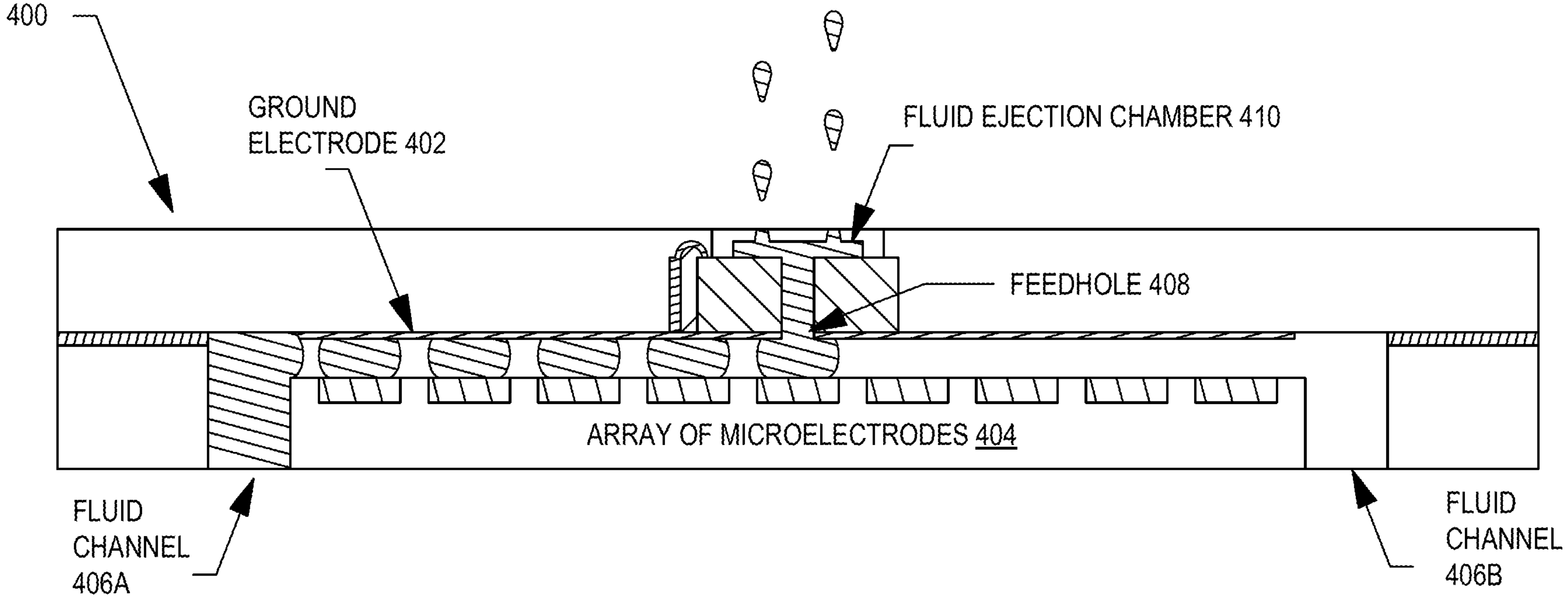
400
GROUND ELECTRODE 402
FLUID EJECTION CHAMBER 410
FEEDHOLE 408
ARRAY OF MICROELECTRODES 404
FLUID CHANNEL 406A
FLUID CHANNEL 406B

FIGURE 4

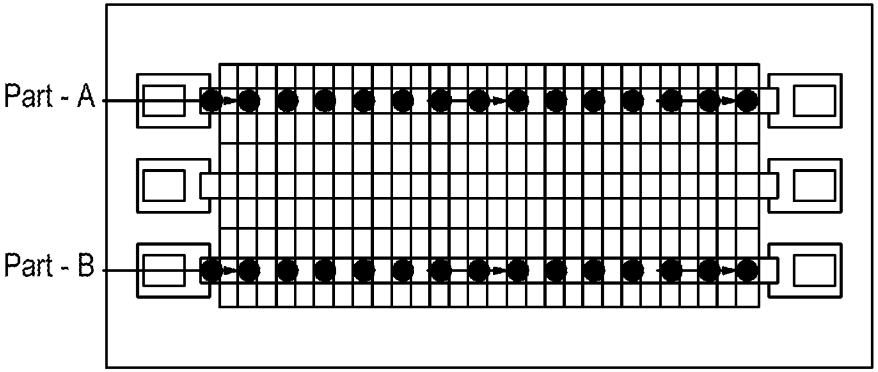

FIGURE 5A

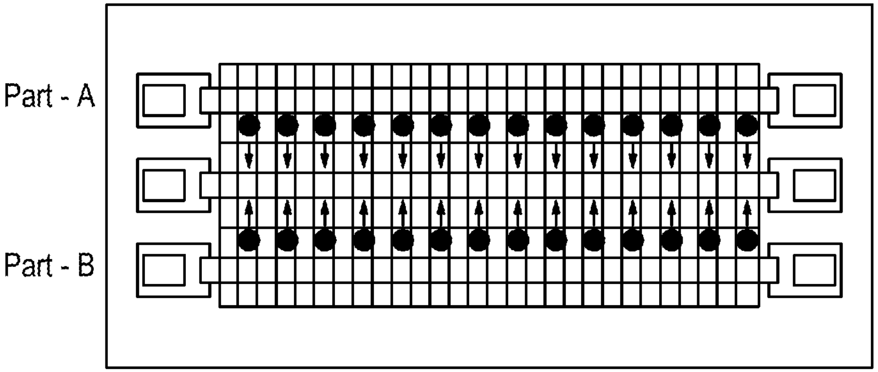

FIGURE 5B

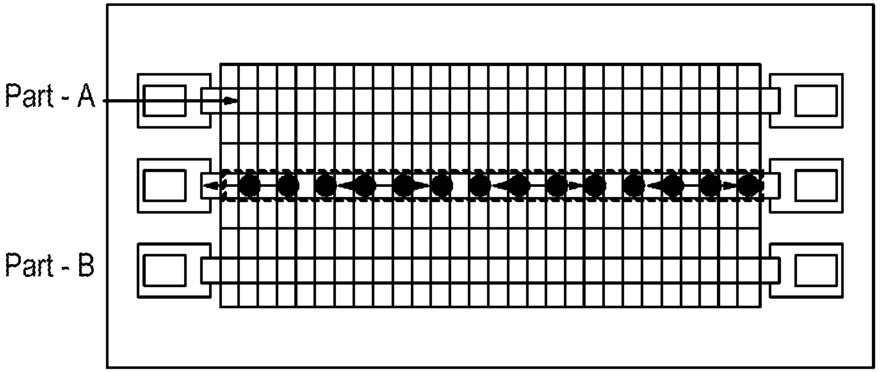

FIGURE 5C

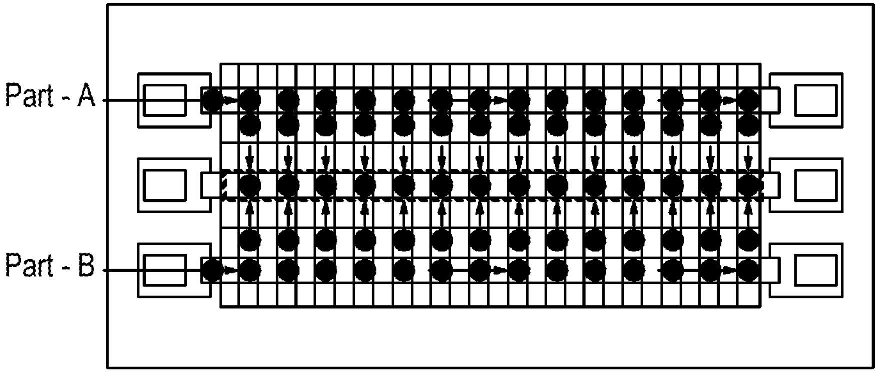

FIGURE 5D

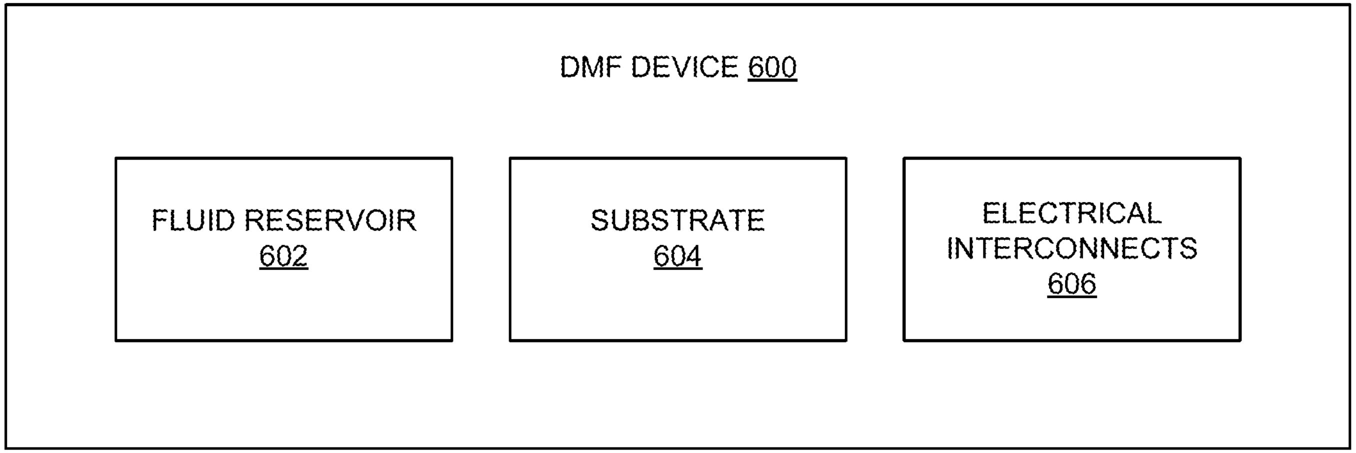
DMF DEVICE 600
FLUID RESERVOIR 602
SUBSTRATE 604
ELECTRICAL INTERCONNECTS 606

FIGURE 6

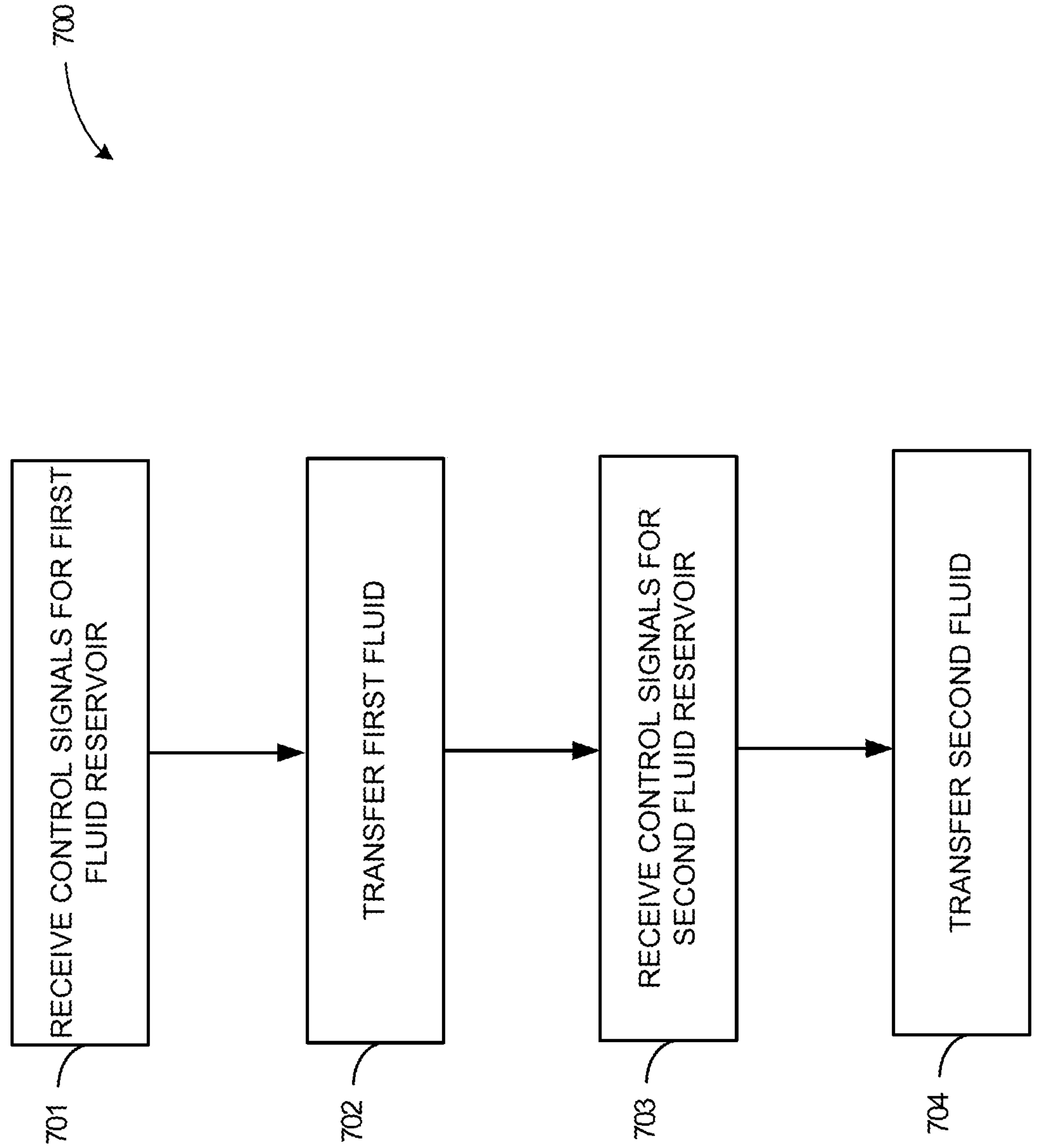
700
RECEIVE CONTROL SIGNALS FOR FIRST FLUID RESERVOIR
TRANSFER FIRST FLUID
RECEIVE CONTROL SIGNALS FOR SECOND FLUID RESERVOIR
TRANSFER SECOND FLUID
701
702
703
704

FIGURE 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2020/052564

A. CLASSIFICATION OF SUBJECT MATTER

B41J 2/175 *(2006.01)*
B41F 31/02 *(2006.01)*
B41L 27/04 *(2006.01)*
B81B 1/00 *(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)

B41J 2/00, 2/135-2/16, 2/175-2/18, B41F 23/00, 23/08, 31/00, 31/02, B41L 23/00, 23/24, 27/00, 27/04, B81B 1/00

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)

EAPATIS, ESPACENET, PatSearch (RUPTO internal), USPTO, PATENTSCOPE, Google

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2020/159518 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.) 06.08.2020, paragraphs [0013], [0022]-[0027], [0034], [0043], figure 1	1, 9
Y		2, 6-8, 10, 11, 15
A		3-5, 12-14
Y	US 2012/0027942 A1 (FELIPE MIGUEL JOOS) 02.02.2012, paragraph [0028]	6, 15
Y	WO 1997/009176 A1 (THE GENERAL ELECTRIC COMPANY, PLC) 13.03.1997, claim 1	2, 7

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:
“A”	document defining the general state of the art which is not considered to be of particular relevance
“D”	document cited by the applicant in the international application
“E”	earlier document but published on or after the international filing date
“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)
“O”	document referring to an oral disclosure, use, exhibition or other means
“P”	document published prior to the international filing date but later than the priority date claimed
“T”	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
“X”	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
“Y”	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
“&”	document member of the same patent family

Date of the actual completion of the international search 17 May 2021 (17.05.2021)	Date of mailing of the international search report 10 June 2021 (10.06.2021)
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37	Authorized officer A. Grigoryan Telephone No. +7 (495) 531-64-81

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2020/052564

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2013/162606 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P. et al.) 31.10.2013, paragraphs [0026], [0027]	8
Y	US 2020/0238699 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.) 30.07.2020, paragraph [0049]	10, 11