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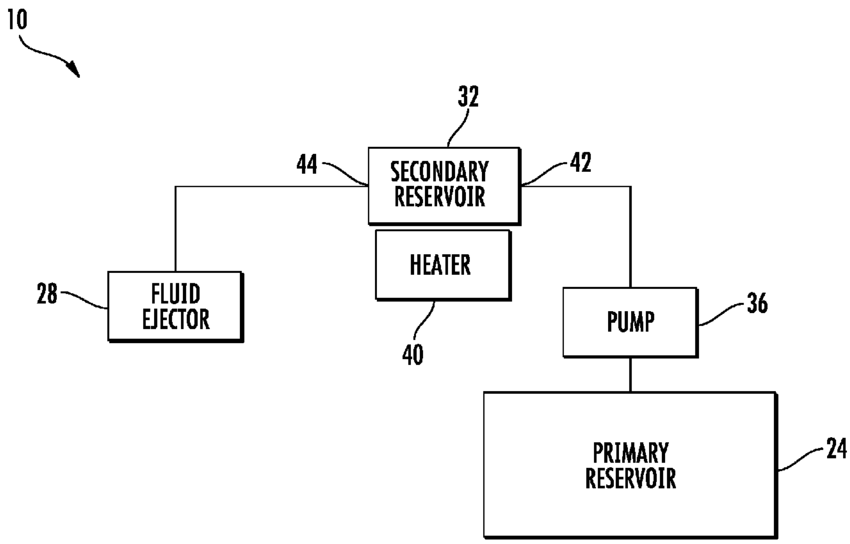

FIG. 1

(57) **Abstract:** A fluid delivery and ejection system may include a primary reservoir, a fluid ejector to eject fluid, a secondary reservoir having an outlet connected to the fluid ejector, a heater to heat fluid within the secondary reservoir and a pump to pump fluid from the primary reservoir to the secondary reservoir. The secondary reservoir has a volume of no greater than 50 cc.

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FLUID DELIVERY WITH SECONDARY RESERVOIR FLUID HEATING

BACKGROUND

[0001] Fluid ejection systems, such as printing systems, utilize a fluid ejection device to eject fluid, in the form of a liquid, to a target. With two-dimensional printing, the target is a two-dimensional sheet or web of media. With three-dimensional printing, the target may be a layer or multiple layers of a build material from which a three-dimensional object may be formed. Many fluid ejection systems may include a fluid delivery system that supplies fluid from a reservoir to the fluid ejection device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Figure 1 is a block diagram schematically illustrating portions of an example fluid delivery and ejection system.

[0003] Figure 2 is a flow diagram of an example method for delivering fluid to a fluid ejector.

[0004] Figure 3 is a block diagram schematically illustrating portions of an example fluid delivery and ejection system.

[0005] Figure 4 is a diagram schematically illustrating portions of an example fluid delivery and ejection system.

[0006] Throughout the drawings, identical reference numbers designate similar, but not necessarily identical, elements. The figures are not necessarily to scale, and the size of some parts may be exaggerated to more clearly illustrate the example shown. Moreover, the drawings provide examples and/or implementations consistent with the description; however, the description is not limited to the examples and/or implementations provided in the drawings.

DETAILED DESCRIPTION OF EXAMPLES

[0007] Disclosed are example fluid delivery systems, fluid delivery methods and fluid delivery and ejection systems that supply fluid in the form of a liquid to a fluid ejection device. The disclosed example fluid delivery systems, fluid delivery methods and fluid delivery and ejection systems control or manage air within the delivery system that may otherwise impair performance of the fluid ejection device. The disclosed fluid delivery systems, fluid delivery methods and fluid delivery and ejection systems utilize an intermediate, auxiliary or secondary reservoir that temporarily holds a small amount of fluid to allow the fluid to be quickly and efficiently heated to separate out air otherwise trapped within the fluid prior to the fluid being delivered to the fluid ejection device. Because the auxiliary or secondary reservoir holds a small amount of fluid that is heated to release entrapped air, the fluid within the system is less likely to become dehydrated.

[0008] In one implementation, the secondary reservoir has a volume of no greater than 50 cc. In one implementation, the secondary reservoir has a volume that is no greater than one half that of a primary reservoir which stores and delivers fluid to the secondary reservoir. In one implementation, fluid within the primary reservoir is not to directly heated, heat is not applied to the fluid while the fluid is within the primary reservoir. As a result, the larger volume of fluid within the primary reservoir is not directly heated and is not subjected to dehydration which may interfere with the performance of the ejection system.

[0009] In one implementation, the secondary reservoir comprises a sealed reservoir or a sealed chamber, being sealed from atmosphere to inhibit the direct introduction of atmospheric air into the secondary reservoir. In one implementation, air separated or released from the fluid within the sealed secondary reservoir, along with fluid, is permitted to flow through a fluid return line back to the primary reservoir. Because the secondary reservoir a sealed from atmosphere, the moist air resulting from the heating of the fluid in the secondary reservoir is not permitted to uncontrollably escape to atmosphere, but is redirected back to the primary reservoir to maintain hydration of the overall fluid within the system.

[00010] In addition to returning the moist air in the secondary reservoir back to the primary reservoir, the fluid return line also facilitates the “overpumping” of fluid by the pump to the secondary reservoir to maintain sufficient fluid in the secondary reservoir to satisfy the demands of fluid ejector 28. The fluid return line is located at a predetermined height to provide a maximum fill level for the secondary reservoir. As a result, the pump may supply fluid to the secondary reservoir at a rate higher than expected consumption rate of the fluid ejector.

[00011] In one implementation, the primary reservoir may comprise a vent to allow the discharge of the air returned from the secondary reservoir. In one implementation, the fluid return line may incorporate a pressure control device, such as a check valve set at a predefined pressure to control a pressure within the secondary reservoir and to provide the fluid ejector 28 with pressurized fluid.

[00012] In another implementation, the secondary reservoir may comprise an electrically controlled vent to release air and to control the pressure within the secondary reservoir. Such pressure control facilitates the supply of fluid at an appropriate pressure to the fluid ejector. In one such implementation, the secondary reservoir may additionally comprise a fluid level sensor, wherein signals from the fluid level sensor are used to control the rate at which the pump supplies fluid from the primary reservoir to the secondary reservoir.

[00013] Disclosed herein is an example fluid delivery and ejection system fluid delivery and ejection system may include a primary reservoir, a fluid ejector to eject fluid, a secondary reservoir having an outlet connected to the fluid ejector, a heater to heat fluid within the secondary reservoir and a pump to pump fluid from the primary reservoir to the secondary reservoir. The secondary reservoir has a volume of no greater than 50 cc.

[00014] Disclosed herein is an example fluid delivery method. The method may include supplying fluid from a primary reservoir to a secondary reservoir, the primary reservoir having a volume at least twice a volume of the secondary reservoir, heating fluid within the secondary reservoir to release air from within the fluid, discharging the released air from the secondary reservoir and supplying the heated fluid to a fluid ejector.

[00015] Disclosed herein is an example fluid delivery system for supplying fluid to a fluid ejector. The fluid delivery system may comprise a primary reservoir, a secondary reservoir sealed from atmosphere and having an outlet port for connection to the fluid ejector, a pump to pump fluid from the primary reservoir to the secondary reservoir, a heater to heat fluid within the secondary reservoir, a fluid return line extending from the secondary reservoir to the primary reservoir and a pressure control device along the fluid return line to control a pressure within the secondary reservoir.

[00016] Figure 1 is a block diagram schematically illustrating portions of an example fluid delivery and ejection system 20. System 10 controls or manages air within the delivery system that may otherwise impair performance of the fluid ejection device. System 10 utilizes an intermediate, auxiliary or secondary reservoir that temporarily holds a small amount of fluid to allow the fluid to be quickly and efficiently heated to separate out air otherwise trapped within the fluid prior to the fluid being delivered to the fluid ejection device. System 10 utilizes a larger primary reservoir to contain a sufficiently large volume to carry out printing or other tasks. Because primary

heating and degassing of the fluid occurs in a much smaller reservoir, dehydration of the fluid within the system 10 is reduced. Reservoir System 10 comprises primary reservoir 24, fluid ejector 28, secondary reservoir 32, pump 36 and heater 40.

[00017] Primary reservoir 24 comprises an internal volume to contain a fluid, in the form of a liquid. In one implementation, a sufficient amount of fluid to print a three-dimensional object having a maximum mass, wherein reservoir 24 has an internal volume having a fluid holding capacity no less than the amount of the fluid to print three-dimensional object having the maximum mass. As a result, primary reservoir 24 is sufficiently sized to supply all of the fluid that would be consumed when printing or forming the largest three-dimensional object producible by fluid ejection system, eliminating or reducing the task of filling or exchanging reservoir 24 in the middle of a three-dimensional printing task.

[00018] Primary reservoir 24 has a much larger volume as compared to secondary reservoir 32. In one implementation, primary reservoir 24 has a fluid containing volume at least twice that of secondary reservoir 32. In one implementation, primary reservoir 24 has a fluid containing volume of at least 10 times that of secondary reservoir 32. In some implementations, primary reservoir 24 has a volume of at least 100 times that of secondary reservoir 32.

[00019] In one implementation, primary reservoir 24 omits heaters, avoiding the heating of the relatively large volume of fluid within primary reservoir which may dehydrate the fluid as well as being time-consuming and inefficient. In some implementations, primary reservoir 24 may comprise additional components such as an air vent to release air from primary reservoir 24 as well as a fluid level sensor to detect a level fluid within primary reservoir 24. In one implementation, primary reservoir 24 contains a fluid that is in a liquid state at room temperature. In one implementation, the fluid may comprise a fluid selected from a group of fluids consisting of aqueous or solvent based marking fluid.

[00020] Fluid ejector 28 comprises a device that ejects the fluid under the control of a controller. In one implementation, fluid ejector 28 ejects fluid using a fluid actuator that displaces fluid in a chamber adjacent the fluid actuator through an orifice. Examples of such a fluid actuators include, but are not limited to, piezo-membrane based actuators, electrostatic membrane actuators, mechanical/impact driven membrane actuators, magnetostrictive drive actuators, electrochemical actuators, external laser actuators (that form a bubble through boiling with a laser beam), other such microdevices, or any combination thereof. In one implementation, fluid ejector 28 operates using pressurized fluid, fluid that is supplied at a pressure above atmospheric pressure.

[00021] Secondary reservoir 32 comprises a reservoir for temporarily containing fluid received from primary reservoir 24 as it is being heated by heater 40 and prior to the fluid being supplied to fluid ejector 28. Secondary reservoir 32 has a volume sufficiently small to facilitate fast and efficient heating of the liquid within the secondary reservoir 32 to a temperature that results in air within the fluid being released and separated from the fluid prior to the fluid being supplied to fluid ejector 28. In one implementation, secondary reservoir 32 has a minimal volume just large enough to supply fluid ejector 28 for a single pass across a two-dimensional print medium or three-dimensional printing bed or platform. In one such implementation, fluid ejector 28 has a minimum volume of at least 1 cc (1 mL) and nominally at least 2 cc (2 mL). In one implementation, reservoir 32 has a volume of no greater than 50 cc (50 milliliters). In one implementation, secondary reservoir 32 has a fluid containing volume at least 50% smaller than that of primary reservoir 24.

[00022] In one implementation, secondary reservoir 32 comprises a sealed chamber or a sealed reservoir, sealed from the outside atmosphere. In one implementation, secondary reservoir 32 has a single inlet 42 extending from pump 36 and a single outlet 44 leading to fluid ejector 28. In other implementations, secondary reservoir may be sealed from outside air or atmosphere, yet have other additional inlet or outlet ports. For example, in one up limitation, secondary reservoir 32 may comprise a single inlet 42, and a pair of outlets, outlet 44 and an additional outlet for return fluid line that extends back to primer reservoir 24. In those implementations in which secondary reservoir 32 is sealed from atmosphere and in which a return line is provided, the warm moist air resulting from the heating of fluid within secondary reservoir 32 is returned back to the primary reservoir 24 to reduce hydration of the overall fluid within system 20. The sealing of secondary reservoir 32 from atmosphere further facilitates the provision of pressurized fluid to fluid ejector 28.

[00023] In some implementations, secondary reservoir 42 may include a vent that is actuatable between different open states to control the degree of venting. For example, in some implementations, secondary reservoir 42 may comprise an electrically controlled vent, the opening the vent being adjustable based upon pressure conditions within secondary reservoir 32 or the operational state of system 20. The controllable vent may assist in controlling the pressure of the fluid being supplied to fluid ejector 28 as well as reduce hydration of the fluid within the overall system 20

[00024] Pump 36 comprises a fluid pump that moves or pumps fluid from primary reservoir 24 to secondary reservoir 32.

[00025] Heater 40 comprises a device to apply heat to fluid located within secondary reservoir 32. Heater 40 emits sufficient heat to raise the temperature of fluid within reservoir 32 and to maintain the temperature of the fluid for sufficient amount of time for air entrapped or dissolved in the fluid to be released and separated from the fluid, degassing the fluid. The temperature to which heater 40 heats the fluid may be dependent upon the holding time of the fluid within reservoir 32 prior to its discharge include ejector 28, the dissolution characteristics of the fluid itself (the ability of the fluid to retain dissolved air at different temperatures), and the rate at which the fluid is heated. In one implementation, heater 40 applies heat to the fluid located within secondary reservoir 32 to heat the fluid to a temperature of at least 20 degrees C and less than the boiling point of the fluid

[00026] In one implementation, heater 40 heats the fluid to a temperature based upon the temperature of the fluid flowing are circulating within fluid ejector 28 just prior to its ejection. For example, in one implementation, heater 40 heats the fluid to a temperature equal to the estimated temperature of the fluid currently residing within fluid ejector 28 during fluid ejection. In one implementation, heater 40 heats the fluid to a temperature that is below but within 10 degrees Celsius of the temperature of the fluid when it being circulated through fluid ejector 28 for ejection. In one implementation, the temperature the fluid circulating through fluid ejector 28 is between 45°C and 65°C, wherein the fluid within reservoir 32 is heated to a temperature of between 45°C and 65°C. In one implementation, heater 40 is controlled to heat the fluid within reservoir 32 to a temperature at a maximum temperature of the fluid being circulated within fluid ejector 28, such as 65°C in the above example. As a result, the fluid does not undergo substantial additional heating within fluid ejector 28 or does not rise to a much higher temperature which might otherwise cause additional air to be released so as to detrimentally impact the performance of fluid ejector 28. In other words, the majority the air that would otherwise be released within fluid ejector 28 due to an elevated temperature of the fluid within fluid ejector 28 is preemptively released in secondary reservoir 32 where it may be safely discharged without impairing the performance of fluid ejector 28.

[00027] In one implementation, heater 40 comprises an electrical resistor which generates heat in response to the application of electrical current through the electrical resistor. The heat is thermally conducted from the electrical resistor to the fluid within reservoir 32. In other implementations, heater 40 may generate heat in other fashions and may direct the heat to the fluid within the secondary reservoir 32 in other manners.

[00028] Figure 2 is a flow diagram of an example method 100 for delivering fluid to a fluid ejector. Method 100 controls or manages air within the delivery system that may otherwise impair performance of a fluid ejection device. Method 100 utilizes an intermediate, auxiliary or secondary reservoir that temporarily holds a small amount of fluid to allow the fluid to be quickly and efficiently heated to separate out air otherwise trapped within the fluid prior to the fluid being delivered to the fluid ejection device. Because a small amount of fluid is heated in a smaller auxiliary reservoir, rather than a large volume being heated in the larger primary reservoir or a larger other reservoir, energy is conserved and dehydration of the fluid is reduced. Although method 100 is disclosed in the context of being carried out by system 20, it should be appreciated that method 100 may likewise be carried out in any of the following described systems or with similar systems.

[00029] As indicated by block 104, fluid, such as a fluid ink, fluid binder or other liquid, is supplied from primary reservoir 24 to secondary reservoir 32. The primary reservoir 24 holds a relatively large volume of the fluid for fluid ejection while the second a reservoir 32 has a much smaller volume of liquid sufficient to satisfy the demands of fluid ejector 28 with preheated fluid from which entrapped air has been released and separated. In one implementation, the primary reservoir 24 has a volume of at twice that of the volume of secondary reservoir 32. Said another way, the secondary reservoir 32 has a volume at least 50% smaller than that of primary reservoir 24. In one implementation, secondary reservoir 32 has a volume of at least 10 cc

and no greater than 50 cc. In one implementation, secondary reservoir 32 has a volume of at least 10 cc and no greater than 30 cc.

[00030] As indicated by block 106, fluid within secondary reservoir 32 is heated to release dissolved air from within the fluid. For example, heater 40 may heat fluid within reservoir 32 to a temperature followed by maintaining the fluid at the temperature or at a temperature above a predetermined temperature threshold such that the fluid has a lower ability to dissolve air, resulting in the entrapped air being released and separated from the fluid to an empty gas containing volume above the fluid, wherein the degassed fluid may then be delivered to the fluid ejector. In one implementation, such as where the fluid comprises a 3D printing fluid, the fluid is heated to a threshold temperature of at least 45 degrees C and maintained at the threshold temperature for a period of time of 4 seconds per cc.

[00031] In one implementation, heater 40 heats the fluid to a temperature based upon the temperature of the fluid being circulated or flowing within fluid ejector 28 prior to the fluid being injected. In implementation were fluid ejector 28 uses a thermal resistive fluid actuator, the fluid is heated to a temperature that results in nucleation of the fluid to create a bubble to expel remaining fluid through nozzle. Heat produced through the repeated firing of the thermal resistive fluid actuator may be conducted throughout the rest of the fluid ejector. Operation of fluid ejector may additionally require some preheating of the fluid. As a result, even prior to its nucleation, the fluid within the fluid ejector 28 attains an elevated temperature. Without the fluid being preheated by reservoir 32, the fluid might otherwise undergo the much larger temperature changes resulting in a larger degree of degassing, producing air or air bubbles that might otherwise impair the performance of fluid ejector 28. Reservoir 32 preemptively heats the fluid to reduce the occurrence of such issues.

[00032] For example, in one implementation, heater 40 heats the fluid to a temperature equal to the estimated temperature of the fluid currently residing within fluid ejector 28 during fluid ejection. In one implementation, heater 40 heats the fluid to a temperature that is below but within 10 degrees Celsius of the temperature of the fluid when it is being circulated through fluid ejector 28 for ejection. In one implementation, the temperature the fluid circulating through fluid ejector 28 is between 45 degrees Celsius and 65°C, wherein the fluid within reservoir 32 is heated to a temperature of between 45°C and 65°C. In one implementation, heater 40 is controlled to heat the fluid within reservoir 32 to a temperature at a maximum temperature of the fluid being circulated within fluid ejector 28, such as 65°C in the above example. As a result, the fluid does not undergo substantial additional heating within fluid ejector 28 or does not rise to a much higher temperature which might otherwise cause additional air to be released so as to detrimentally impact the performance of fluid ejector 28. In other words, the majority of the air that would otherwise be released within fluid ejector 28 due to an elevated temperature of the fluid within fluid ejector 28 is preemptively released in secondary reservoir 32 where it may be safely discharged without impairing the performance of fluid ejector 28.

[00033] As indicated by block 110, the air that is released from the fluid within secondary reservoir 32 is discharged. In one implementation, the released air is discharged through a vent in secondary reservoir 32. In one implementation, the released air is discharged through an electrically controlled vent, wherein the degree of venting or the size of the vent opening is automatically adjusted based upon a pressure within reservoir 32 or an operating state of the system. In another implementation, the secondary reservoir may be sealed from atmosphere, wherein the released air is directed back to the primary reservoir 24 and its vent for the ultimate discharge from system 20.

[00034] As indicated by block 114, the heated degassed fluid is supplied to a fluid ejector, such as fluid ejector 28. In one implementation, the supply of fluid from reservoir 32 to the fluid ejector 28 is unidirectional. In other words, fluid is not recirculated from fluid ejector 28 back to secondary reservoir 32 or back to primary reservoir 24.

[00035] Figure 3 is a block diagram schematically illustrating portions of an example fluid delivery and ejection system 210. Fluid delivery and ejection system 210 comprises fluid delivery system 222 and fluid ejector 228. In one implementation, fluid ejector 228 may be interchangeable with other fluid ejectors when used with fluid delivery system 222. As with system 20, system 210 controls or manages air within the delivery system that may otherwise impair performance of the fluid ejection device. System 210 utilizes an intermediate, auxiliary or secondary reservoir that temporarily holds a small amount of fluid to allow the fluid to be quickly and efficiently heated to separate out air otherwise trapped within the fluid prior to the fluid being delivered to the fluid ejection device. Because heating and degassing of the fluid is primarily carried out in a smaller secondary reservoir as compared to in a larger primary reservoir or other larger reservoir, a smaller volume of fluid is heated at any point in time and in closer proximity (in location and/or time) to its consumption by fluid ejector 228 , resulting in less dehydration of the fluid in the system . System 210 is similar to system 10 except that system 210 and additionally comprises fluid return line 250, pressure control device 252 and controller 254. Those remaining components of system 210 which correspond to components of system 10 are numbered similarly.

[00036] Fluid return line 250 comprises a fluid passage fluidically coupling secondary reservoir 32 to primary reservoir 24. Fluid return line 250 returns air that has been released from the fluid within secondary reservoir 32 to primary reservoir 24. In implementations where secondary reservoir 32 is sealed from atmosphere, the returned air may be warm and moist do the heating of the fluid within reservoir 32. Secondary reservoir 32 returns as

warm moist air to primary reservoir 24 to reduce overall dehydration of fluid within system 210.

[00037] Fluid return line 250 further assists in controlling the level of fluid within secondary reservoir 32. The example illustrated, fluid return line 250 has an inlet 43 (an outlet of secondary reservoir 32) that is above the outlet 44. Fluid return line 250 automatically sets a maximum fill level for reservoir 32. As a result, fluid return line also facilitates the “overpumping” of fluid by the pump 36 to the secondary reservoir 32 to maintain sufficient fluid in the secondary reservoir to satisfy the demands of fluid ejector 228. The fluid return line 250 is located at a predetermined height to provide a maximum fill level for the secondary reservoir 32. As a result, the pump 36 may supply fluid to the secondary reservoir 32 at a rate higher than the expected consumption rate of the fluid ejector 228.

[00038] Pressure control device 250 comprises a pressure regulating device incorporated along fluid return line 250. Pressure control device 250 controls the pressure within the sealed secondary reservoir 32 to control the pressure which fluid is supplied to fluid ejector 228. In one implementation compression controlled by 250 comprises a check valve. In implementations where fluid ejector 228 does not utilize pressurized fluid, fluid at a pressure above atmospheric pressure, or where the fluid is pressurized in other manners with other devices, pressure control device 252 may be omitted.

[00039] Controller 254 comprises a device that controls pump 36, heater 40 and fluid ejector 228. Controller 254 comprises a processor 256 and a non-transitory computer-readable medium or memory 258. In some implementations, controller 254 may be distributed and may comprise multiple processors and memories that cooperate to form the below operations. Memory 258 contains instructions for directing the processor 256. Following such instructions, processor 256 controls the operation of heater 40 in the application of heat to the fluid within reservoir 32, controls a rate which fluid is

supplied to secondary reservoir 32 by pump 36 and controls the ejection fluid by fluid ejector 228. Based upon the rate at which fluid is injected by fluid ejector 228, controller 254 may adjust the rate at which fluid is supplied to secondary reservoir 32 and the rate and/or timing at which fluid within secondary reservoir 32 is heated. In one implementation, controller 254 may receive input indicating the fluid currently being ejected by fluid ejector 228 and within system 210, wherein controller 254 consults a lookup table or other source to determine the control parameters for heater 40 based upon determined dissolution properties of the fluid being used.

[00040] As shown by broken lines, in some implementations, system 210 may additionally comprise a fluid level sensor 262 and/or a temperature sensor 264 for further providing feedback to controller 254. Controller 254 may utilize signals from fluid level sensor 262 to further control the supply of fluid to reservoir 32 by pump 36. Controller 254 may utilize signals from sensor 264 to provide closed-loop feedback regarding the temperature the fluid within reservoir 32 so as to more precisely control the generation and application of heat by heater 40 to the fluid within reservoir 32.

[00041] As shown by broken lines, in some implementations, system 210 may additionally comprise a vent, such as an electronically controlled vent 266. Controller 254 may control the degree to which vent 266 vents reservoir 32 and releases air to control the pressure within the secondary reservoir to supply pressurized fluid to fluid ejector 228 at an appropriate pressure.

[00042] Figure 4 schematically illustrates portions of an example fluid ejection and delivery system 310. As with systems 10 and 210, system 310 controls or manages air within the delivery system that may otherwise impair performance of the fluid ejection device. System 210 utilizes an intermediate, auxiliary or secondary reservoir that temporarily holds a small amount of fluid to allow the fluid to be quickly and efficiently heated to separate out air

otherwise trapped within the fluid prior to the fluid being delivered to the fluid ejection device. Because heating and degassing of the fluid is primarily carried out in a smaller secondary reservoir as compared to in a larger primary reservoir or other larger reservoir, a smaller volume of fluid is heated at any point in time and in closer proximity (in location and/or time) to its consumption by a fluid ejector, in the form of a print bar, resulting in less dehydration of the fluid in the system .

[00043] System 310 comprises fluid supply station module 312, fluid supply station connector module 314, fluid reservoir module 316, fluid degassing and recirculation module 317, fluid ejection device 382 and controller 400. Fluid supply station module 312 comprise a single unit or enclosed unit that supplies fluid, in the form of a liquid, from a connected fluid supply 360 to fluid reservoir module 316 through fluid supply station connector module 314. In the example illustrated, fluid supply station module 312 serves as a dock for removably mounting or releasably connecting to fluid supply 360. In the example illustrated, fluid supply station module 312 comprises a fluid interface connector 361 that releasably and cooperatively mates with a corresponding fluid interface connector 363 associated with the fluid supply 360 such that an empty or exhausted fluid supply 360 may be replaced with a full fluid supply 360. In one implementation, the fluid interface connectors 361, 363 may comprise male and female parts, such as a plug and port that receives the plug. In another implementation, fluid interface connectors 361, 363 may comprise a needle and a septum. In yet other implementations, fluid interface connector 361, 363 may comprise other fluid coupling structures that form a fluid passage between the interior of supply 360 and fluid supply station module 312.

[00044] Fluid supply station module 312 further comprises a fluid interface connector 362 which is connected to a fluid supply 260. Fluid interface connector 362 is located at an exterior surface or exterior portion of the housing forming module 312. Fluid interface connector 362 releasably mates with a corresponding fluid interface connector of fluid supply station connector module 314.

[00045] Fluid supply station connector module 314 comprises a single unit or enclosed unit that interconnects fluid supply station module 312 and fluid reservoir module 316. Fluid supply station connector module 314 further assists in the withdrawing of fluid from fluid supply 360 of fluid supply station module 312. Fluid supply station connector module 314 comprises fluid interface connector 364, fluid interface connector 366, fluid supply station pump 368 and a one-way check valve 369.

[00046] Fluid interface connector 364 releasably and removably connects to fluid interface connector 362. Fluid interface connector 364 cooperate with fluid interface connector 362 to form a fluid coupler between modules 312 and 314. Fluid interface connector 364 is located at an exterior surface or exterior portion of the housing forming module 314. In one implementation, connectors 362, 364 comprise cooperating male and female parts, such as a plug and a port, which when connected, provide a fluid passageway for fluid from fluid supply 260 to pass into module 314. Fluid interface connector 364 facilitates the use of different fluid supply station modules 312 containing different fluid supplies 360 as part of system 310.

[00047] Fluid supply station pump 368 comprises a fluid pump that moves or pumps fluid received through fluid interface connector 364, through the one-way check valve 369, through fluid interface connector 366 and into fluid reservoir module 316. Fluid interface connector 366 releasably and removably connects to a corresponding fluid interface connector of fluid reservoir module 316. Fluid interface connector 366 is located at an exterior surface or exterior portion of the housing forming module 314. Fluid interface connectors 364 and 366 facilitate the provision of fluid supply station pump 368 independent of fluid supply station module 312 and independent of fluid reservoir module 316. As a result, fluid supply station module 312 may be less complex and less expensive. Likewise, fluid reservoir module 316 may be less complex and less expensive. In some implementations, fluid supply station module 312 and fluids of fluid supply connector module 314 may be provided as a single module or a single unit releasably connected to fluid reservoir module 316 using a pair of cooperating fluid interface connectors.

[00048] Fluid reservoir module 316 comprises a single housed or enclosed unit that serves as a reservoir for storing fluid to be supplied to a fluid ejection module 316 and for facilitating the controlled pumping or withdrawal of fluid from a reservoir of module 316. Fluid reservoir module 316 comprises primary fluid reservoir 328, fluid interface connector 368, reservoir pump 370, fluid interface connector 372, fluid interface connector 374 and pressure control device in the form of a one-way check valve 385.

[00049] Primary fluid reservoir 328 comprises an internal volume to contain a fluid, in the form of a liquid. In one implementation, fluid reservoir 328 is to supply fluid to print a three-dimensional object having a maximum mass, wherein reservoir 328 has an internal volume 329 having a fluid holding capacity no less than the amount of the fluid to print three-dimensional object having the maximum mass. As a result, fluid reservoir 328 is sufficiently sized to supply all of the fluid that would be consumed when printing or forming a largest three-dimensional object producible by fluid ejection system, limiting the task of filling or exchanging reservoir 328 in the middle of a three-dimensional printing task.

[00050] Primary reservoir 328 has a much larger volume as compared to the secondary reservoir (described hereafter) contained in the recirculation and degassing module 317. In one implementation, primary reservoir 24 has a fluid containing volume at least twice that of the secondary reservoir. In one implementation, primary reservoir 328 has a fluid containing volume of at least 10 times that of the secondary reservoir. In some implementations, primary reservoir 328 has a volume of at least 100 times that of the secondary reservoir.

[00051] In one implementation, primary reservoir 328 omits heaters, avoiding the heating of the relatively large volume of fluid within primary reservoir which may dehydrate the fluid as well as being time-consuming and inefficient. In one implementation, primary reservoir 24 contains a fluid that is in a liquid state at room temperature. In one implementation, the fluid may comprise a fluid selected from a group of fluids consisting of aqueous or solvent based marking fluid.

[00052] As further shown by Figure 4, primary fluid reservoir 328 additionally comprises sump 330, fluid sensor 332, fluid supply port 344, fluid outlet port 346, fluid inlet port 348 and atmospheric vent 350. Sump 330 comprises a cavity, recess or depression extending from and below a floor 336 of the interior 329 of reservoir 328. Sump 330 extends adjacent or proximate to outlet port 346. Sump 330 contains the last amounts of fluid within reservoir 328 as reservoir 328 is emptied. Sump 330 facilitates more complete exhaustion or use of fluid from reservoir 328. Sump 330 further facilitates a collection or gathering of fluid about and above outlet port 346 to reduce a likelihood of air entering through outlet port 346 or being pumped by pump 370 through outlet port 346. In one implementation, sump 330 has a depth of at least 3.5 mm. In one implementation, sump 330 contains a volume of fluid of at least 2 cubic centimeters.

[00053] Fluid sensor 332 comprise a device to sense the presence of fluid. In one implementation, fluid sensor 332 comprises a pair of electrodes that, when submersed, conduct electrical charge. In other implementations, fluid sensor 332 may comprise other sensing devices. As shown by Figure 4, fluid sensor 332 comprises at least one probe 338 having a lower terminus 339 that is positioned such that the fluid outlet is submerged while the terminus 339 is no longer in contact with the liquid. In another implementation,

terminus 339 of fluid sensor 332 projects to a top mouth of the sump 330 or into sump 330 to detect the presence of fluid within sump 330, despite fluid above floor 336 having been exhausted.

[00054] Fluid supply port 344 comprises a port through which fluid may be supplied to the interior 329 of fluid reservoir 328. For example, fluid supply port 344 may be connected to a fluid supply station and/or a fluid supply such that the fluid within reservoir 328 may be replenished. In one implementation, fluid supply port 344 is located at a top of reservoir 328, at an elevation higher than an anticipated height of the fluid within reservoir 328, reducing the likelihood of the fluid from flowing black to the supply.

[00055] Fluid outlet port 346 and fluid inlet port 348 cooperate to facilitate fluid recirculation. Fluid outlet port 346 comprises a port through which fluid is pumped or drawn from reservoir 328, wherein a first portion is supplied or delivered to fluid ejection device 382 and wherein a second portion is recirculated or returned to reservoir 328 through fluid inlet port 348. During such recirculation, air may become partially trapped within the lines providing the recirculation loop extending between ports 346 and 348. Recirculation of the fluid may result in air within the fluid line being pushed into reservoir 328 through fluid inlet port 348.

[00056] Atmospheric vent 350 comprises an air passage extending from the interior of fluid reservoir 328 to the exterior of fluid reservoir 328, the ambient air or “atmosphere”. In one implementation, atmospheric vent 350 may be a direct passage. In other implementations, atmospheric vent 350 be serpentine or in the form of a labyrinth. In one implementation, atmospheric vent 350 comprises a labyrinth screw or vent plug. Because vent 350 vents air within reservoir 328 to atmosphere, separate air gas containing chambers or receivers may be omitted. Pressure within reservoir 328 is maintained, reducing the likelihood of air become entrapped in the fluid delivered to fluid ejection device 382.

[00057] Fluid interface connector 368 releasably connects to fluid interface connector 366 of fluid supply station connector module 314. Fluid interface connector 368 is located at an exterior surface or exterior portion of the housing 317 forming module 316. Fluid interconnect 368 cooperatively mates with fluid interconnect 366 to form a fluid coupler that provides a continuous fluid passage such that fluid pumped by fluid supply station pump 368 may flow into fluid reservoir module 316. In one implementation, fluid interconnects 366 and 368 comprise male and female parts, such as a plug and a port. In another implementations, fluid interconnects 366 and 368 may have other cooperating and interlocking structures.

[00058] Fluid reservoir pump 370 comprises a fluid pumping mechanism connected fluid outlet port 346. Fluid reservoir pump 370 pumps fluid or withdraws fluid from the interior fluid reservoir 328 and supplies such fluid to fluid recirculation module 317 through fluid interface connector 372. Fluid interface connector 372 comprises a fluid connector that is to be releasably connected to a corresponding fluid connector of fluid circulation module 317. Fluid interface connector 372 facilitates the circulation of fluid from fluid reservoir 328 and out of module 316.

[00059] Fluid interface connector 374 comprises a fluid connector connected to fluid inlet port 348. Fluid interface connector 372 comprises a fluid connector that is to be releasably connected to a corresponding fluid connector of fluid recirculation module 317. Fluid interface connector 374 facilitates the circulation of fluid and separated air, resulting from degassing, back to reservoir 328.

[00060] Fluid recirculation module 317 comprises a single housed or enclosed unit that provides for the ejection of fluid received from fluid reservoir module 316. Fluid recirculation module 317 comprises fluid interface connector 376, secondary reservoir 432, heater 440, fluid interface connector 381 and fluid interface connector 384. Fluid interface connector 376 is connected to reservoir pump 370 at an exterior surface or exterior portion of the housing 385 forming module 317. Fluid interface connector 376 cooperatively mates with fluid interface connector 372 to form a continuous uninterrupted fluid passage extending between modules 316 and 317. At the same time, fluid interface connector 376 facilitates separation of modules 316 and 317. In one implementation, connectors 372 and 376 may comprise male and female parts, such as a plug and port. In other implementations, connectors 372 and 376 may connect to one another in other releasable fashions.

[00061] Secondary reservoir 432 couples the recirculation loop 352 to the fluid ejection device 382. Purging manifold 377 includes a reservoir 389 to store a fluid that may facilitate separation of gas and liquid prior to the liquid being transmitted or transferred to fluid ejection device 382. Secondary reservoir 432 comprises a reservoir for temporarily containing fluid received from primary reservoir 328 as it is being heated by heater 440 and prior to the fluid being supplied to fluid ejector 382. Secondary reservoir 432 has a volume sufficiently small to facilitate fast and efficient heating of the liquid within the secondary reservoir 432 to a temperature that results in air within the fluid being released and separated from the fluid prior to the fluid being supplied to fluid ejector 382. In one implementation, secondary reservoir 432 has a minimal volume just large enough to supply fluid ejector 382 for a single pass across a two-dimensional print medium or three-dimensional printing bed or platform. In one such implementation, fluid ejector 382 has a minimum volume of at least 1 cc (1 mL) and nominally at least 2 cc (2 mL). In one implementation, reservoir 432 has a volume of no greater than 50 cc (50 milliliters). In one implementation, secondary reservoir 432 has a fluid containing volume at least 50% smaller than that of primary reservoir 328.

[00062] In one implementation, secondary reservoir 432 comprises a sealed chamber or a sealed reservoir, sealed from the outside atmosphere but for his fluid inlets and outlets 390, 392 and 394. In those implementations in which secondary reservoir 432 is sealed from atmosphere and in which a return line 450 is provided, the warm moist air resulting from the heating of fluid within secondary reservoir 432 is returned back to the primary reservoir 328 to reduce hydration of the overall fluid within system 310. The sealing of secondary reservoir 432 from atmosphere further facilitates the provision of pressurized fluid to fluid ejector 382.

[00063] In other implementations, secondary reservoir 432 may include a vent that is actuatable between different open states to control the degree of venting. For example, in some implementations, secondary reservoir 432 may comprise an electrically controlled vent, the opening the vent being adjustable based upon pressure conditions within secondary reservoir 432 or the operational state of system 310. The controllable vent may assist in controlling the pressure of the fluid being supplied to fluid ejector 382 as well as reduce hydration of the fluid within the overall system 310.

[00064] Fluid return line 450 comprises a fluid passage fluidically coupling secondary reservoir 432 to primary reservoir 328. Fluid return line 450 returns air that has been released from the fluid within secondary reservoir 432 to primary reservoir 328. In implementations where secondary reservoir 432 is sealed from atmosphere, the returned air may be warm and moist due the heating of the fluid within reservoir 432. Secondary reservoir 432 returns as warm moist air to primary reservoir 328 to reduce overall dehydration of fluid within system 310.

[00065] Fluid return line 450 further assists in controlling the level of fluid within secondary reservoir 432. The example illustrated, fluid return line 450 has an inlet 392 (an outlet of secondary reservoir 432) that is above the outlet 390. Fluid return line 450 automatically sets a maximum fill level for reservoir 432. As a result, fluid return line also facilitates the “overpumping” of fluid by the pump 370 to the secondary reservoir 432 to maintain sufficient fluid in the secondary reservoir 432 to satisfy the demands of fluid ejector 382. The fluid

return line 450 is located at a predetermined height to provide a maximum fill level for the secondary reservoir 432. As a result, the pump 370 may supply fluid to the secondary reservoir 432 at a rate higher than expected consumption rate of the fluid ejector 382.

[00066] Heater 440 comprises a device to apply heat to fluid located within secondary reservoir 432. Heater 440 emits sufficient heat to raise the temperature of fluid within reservoir 432 and to maintain the temperature of the fluid for sufficient amount of time for air entrapped or dissolved in the fluid to be released and separated from the fluid, degassing the fluid. The temperature to which heater 440 heats the fluid may be dependent upon the holding time of the fluid within reservoir 432 prior to its discharge include ejector 382, the dissolution characteristics of the fluid itself (the ability of the fluid to retain dissolved air at different temperatures), and the rate at which the fluid is heated. In one implementation, heater 440 applies heat to the fluid located within secondary reservoir 432 to heat the fluid to a temperature of at least 20 degrees C and less than a boiling point of the fluid.

[00067] In one implementation, heater 440 heats the fluid to a temperature based upon the temperature of the fluid flowing are circulating within fluid ejector 382 just prior to its ejection. For example, in one implementation, heater 440 heats the fluid to a temperature equal to the estimated temperature of the fluid currently residing within fluid ejector 382 during fluid ejection. In one implementation, heater 440 heats the fluid to a temperature that is below but within 10 degrees Celsius of the temperature of the fluid when it being circulated through fluid ejector 382 for ejection. In one implementation, the temperature the fluid circulating through fluid ejector 382 is between 45°C and 65°C, wherein the fluid within reservoir 432 is heated to a temperature of between 45°C and 65°C. In one implementation, heater 440 is controlled to heat the fluid within reservoir 432 to a temperature at a maximum temperature of the fluid being circulated within fluid ejector created to, such as 65°C in the above example. As a result, the fluid does not undergo substantial additional heating within fluid ejector 382 or does not rise to a much higher temperature which might otherwise cause additional air to be released so as to detrimentally impact the performance of fluid ejector created to. In other words, the majority the air that would otherwise be released within fluid ejector 32 due to an elevated temperature of the fluid within fluid ejector created to is preemptively released in secondary reservoir 432 where it may be safely discharged without impairing the performance of fluid ejector 382.

[00068] In one implementation, heater 440 comprises an electrical resistor which generates heat in response to the application of electrical current through the electrical resistor. The heat is thermally conducted from the electrical resistor to the fluid within reservoir 432. In other implementations, heater 440 may generate heat in other fashions and may direct the heat to the fluid within the secondary reservoir 432 in other manners.

[00069] Fluid ejection device 382 comprises a device that ejects the fluid under the control of a controller. In one implementation, fluid ejection device 382 ejects fluid using a fluid actuator that displaces fluid in a chamber adjacent the fluid actuator through an orifice. Examples of such a fluid actuator include, but are not limited to, piezo-membrane based actuators, electrostatic membrane actuators, mechanical/impact driven membrane actuators, magnetostrictive drive actuators, electrochemical actuators, external laser actuators (that form a bubble through boiling with a laser beam), other such microdevices, or any combination thereof. In the example illustrated, fluid ejection device 382 receives fluid from purging manifold 377 through fluid interface connector 381 that releasably connects to a corresponding fluid interface connector 395 of fluid ejection device 382.

[00070] Fluid interface connector 384 comprise a connector that releasably connects to or cooperatively mates with fluid interface connector

374, forming a continuous fluid passage between modules 316 and 317 for the return of circulating fluid back to reservoir 328 through fluid inlet port 348. In one implementation, fluid interface connectors 384 and 374 comprise male and female parts, such as a plug and port, that provide the breakable interconnection, that allows modules 316 and 317 to be separated and reconnected.

[00071] Controller 400 comprises a device that controls pump 370, heater 440 and fluid ejector 382. Controller 400 comprises a non-transitory computer-readable medium or memory 402 and a processor 404. In some implementations, controller 400 may be distributed and may comprise multiple processors and memories that cooperate to form the below operations. Memory 402 contains instructions for directing the processor 404. Following such instructions, processor 404 controls the operation of heater 440 in the application of heat to the fluid within reservoir 432, controls a rate which fluid is supplied to secondary reservoir 432 by pump 370 and controls the ejection fluid by fluid ejector 382. Based upon the rate at which fluid is injected by fluid ejector 382, controller 400 may adjust the rate at which fluid is supplied to secondary reservoir 432 and the rate and/or timing at which fluid within secondary reservoir 432 is heated. In one implementation, controller 400 may receive input indicating the fluid currently being injected by fluid ejector 382 and within system 310, wherein controller 400 consults a lookup table or other source to determine the control parameters for heater 440 based upon determined dissolution properties of the fluid being used.

[00072] Although the present disclosure has been described with reference to example implementations, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the claimed subject matter. For example, although different example implementations may have been described as including features providing one or more benefits, it is contemplated that the described features may be interchanged with one another or alternatively be combined with one another in the described example implementations or in other alternative implementations. Because the technology of the present disclosure is relatively complex, not all changes in the technology are foreseeable. The present disclosure described with reference to the example implementations and set forth in the following claims is manifestly intended to be as broad as possible. For example, unless specifically otherwise noted, the claims reciting a single particular element also encompass a plurality of such particular elements. The terms “first”, “second”, “third” and so on in the claims merely distinguish different elements and, unless otherwise stated, are not to be specifically associated with a particular order or particular numbering of elements in the disclosure.

WHAT IS CLAIMED IS:

1. A fluid delivery and ejection system comprising:

a primary reservoir;

a fluid ejector to eject fluid;

a secondary reservoir having an outlet connected to the fluid ejector, the secondary reservoir having a volume of no greater than 50 cc;

a heater to heat fluid within the secondary reservoir; and

a pump to pump fluid from the primary reservoir to the secondary reservoir.

2. The fluid delivery and ejection system of claim 1, wherein the fluid ejector is to circulate the fluid at a first predetermined temperature prior to ejection and wherein the heater is to heat the fluid within the secondary reservoir to a second temperature no greater than the first predetermined temperature.

3. The fluid delivery and ejection system of claim 1 further comprising a fluid level sensor in the primary reservoir.

4. The fluid delivery and ejection system of claim 1 further comprising a fluid return line extending from the secondary reservoir to the primary reservoir to return air within the secondary reservoir to the primary reservoir.

5. The fluid delivery and ejection system of claim 4, wherein the secondary reservoir is sealed from atmosphere, the fluid delivery and ejection system further comprising a pressure control device along the fluid return line to maintain a predetermined pressure within the secondary reservoir.

6. The fluid delivery and ejection system of claim 4, wherein the secondary reservoir comprises a first outlet connected to the fluid ejector and a second outlet connected to the fluid return line, wherein the second outlet is above the first outlet.

7. The fluid delivery and ejection system of claim 4, wherein none of the fluid supplied from the secondary reservoir to the fluid ejector is recirculated back to the secondary reservoir and wherein the pump is to pump fluid to the secondary reservoir at a rate greater a rate at which fluid is supplied to the fluid ejector from the secondary reservoir.

8. The fluid delivery and ejection system of claim 1, wherein the primary reservoir omits heaters.

9. The fluid delivery and ejection system of claim 1, wherein the secondary reservoir comprises an electrically controlled vent.

10. A fluid delivery method comprising:

supplying fluid from a primary reservoir to a secondary reservoir, the primary reservoir having a volume of at least twice the volume of the secondary reservoir;

heating fluid within the secondary reservoir to release air from within the fluid;

discharging the released air from the secondary reservoir;

supplying the heated fluid to a fluid ejector.

11. The fluid delivery method of claim 10, wherein the discharging of the released air from the secondary reservoir comprises circulating the released air to the primary reservoir.

12. The fluid delivery method of claim 11, wherein the secondary reservoir is sealed from atmosphere, wherein the supplying of the fluid from the prior reservoir to the secondary reservoir is at a rate greater than a rate at which the heated fluid is supplied to the fluid ejector and wherein the pressure within the secondary reservoir is controlled with a pressure control device.

13. The fluid delivery method of claim 10, the secondary reservoir has a volume of no greater than 50 cc.

14. A fluid delivery system for supplying fluid to a fluid ejector, the fluid delivery system comprising:

a primary reservoir;

a secondary reservoir sealed from atmosphere and having an outlet port for connection to the fluid ejector;

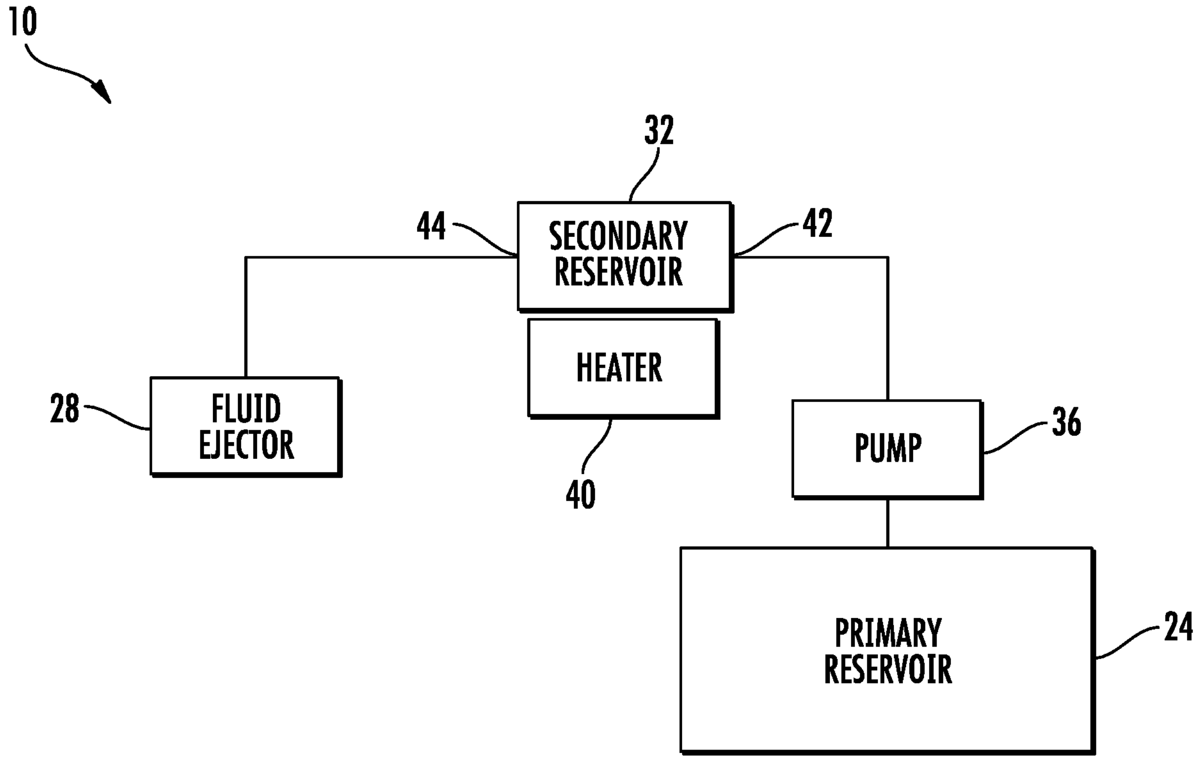
a pump to pump fluid from the primary reservoir to the secondary reservoir;

a heater to heat fluid within the secondary reservoir;

a fluid return line extending from the secondary reservoir to the primary reservoir; and

a pressure control device along the fluid return line to control a pressure within the secondary reservoir.

15. The fluid delivery system of claim 14, wherein the primary reservoir has a volume at least twice a volume of the secondary reservoir and omits any direct heating of the fluid within the primary reservoir.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32
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42
HEATER
28
FLUID EJECTOR
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PUMP
36
PRIMARY RESERVOIR
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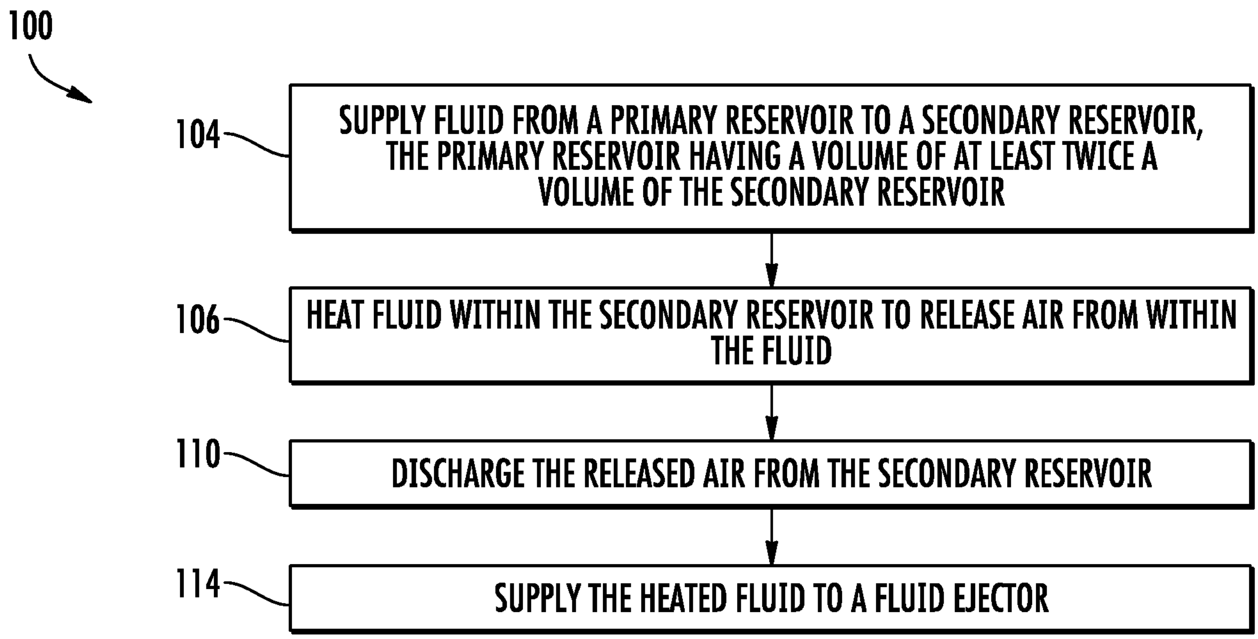
FIG. 1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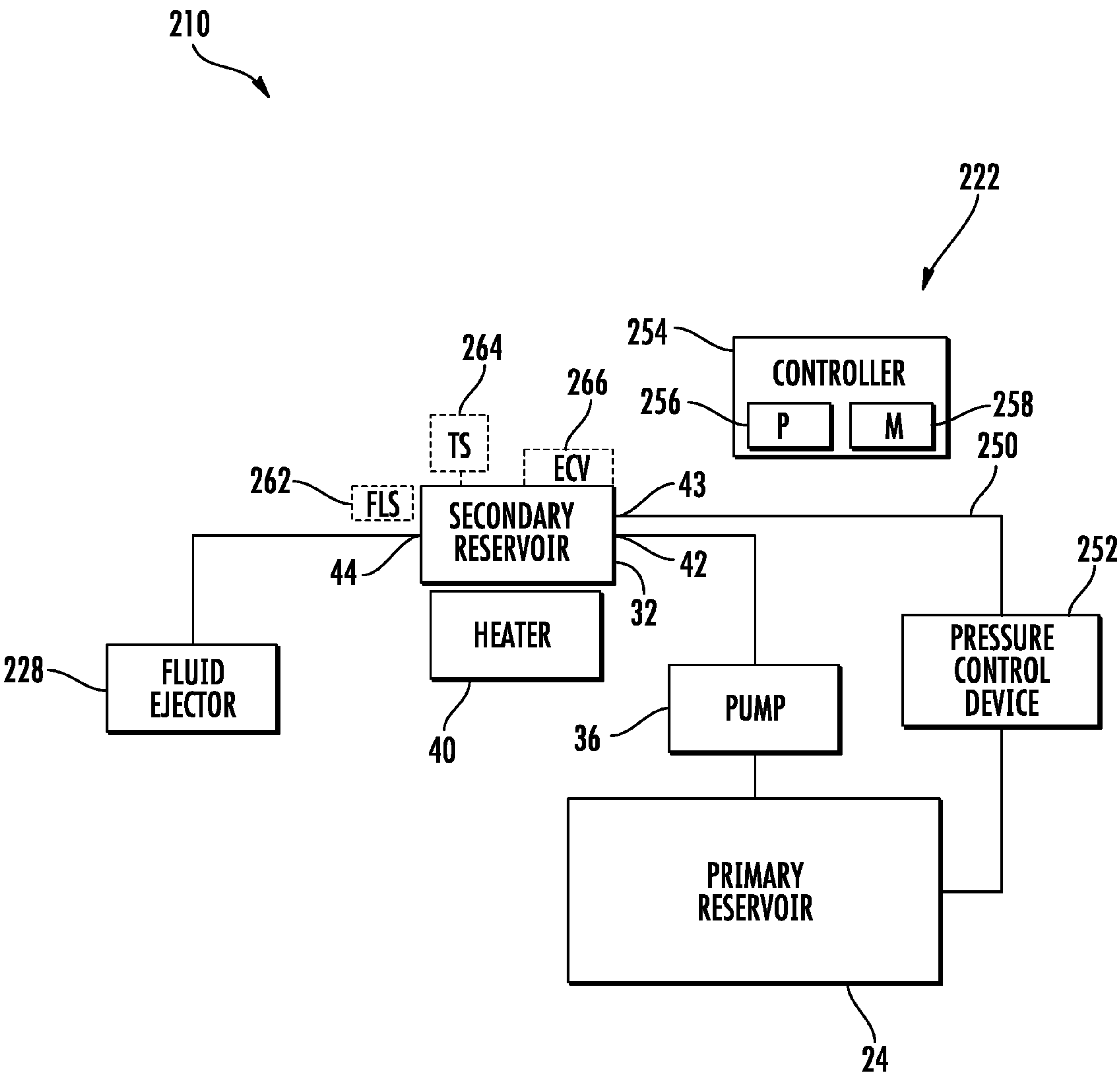
104
SUPPLY FLUID FROM A PRIMARY RESERVOIR TO A SECONDARY RESERVOIR, THE PRIMARY RESERVOIR HAVING A VOLUME OF AT LEAST TWICE A VOLUME OF THE SECONDARY RESERVOIR
106
HEAT FLUID WITHIN THE SECONDARY RESERVOIR TO RELEASE AIR FROM WITHIN THE FLUID
110
DISCHARGE THE RELEASED AIR FROM THE SECONDARY RESERVOIR
114
SUPPLY THE HEATED FLUID TO A FLUID EJECTOR

FIG. 2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ECV
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FLS
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42
44
32
HEATER
228
FLUID EJECTOR
40
PUMP
36
252
PRESSURE CONTROL DEVICE
PRIMARY RESERVOIR
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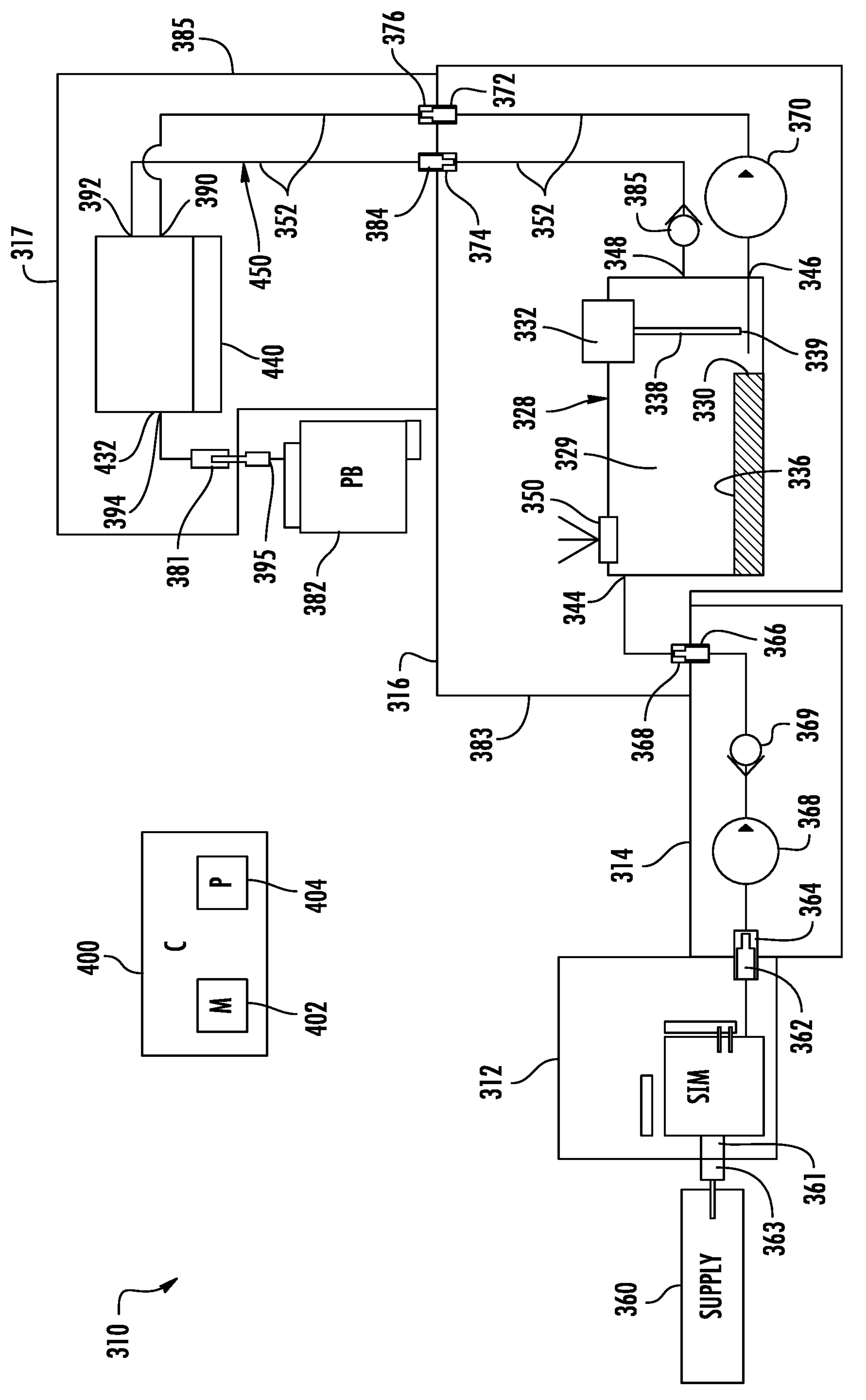
FIG. 3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C
P
404
M
402
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SIM
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361
363
360
SUPPLY
310

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2018/057831

A. CLASSIFICATION OF SUBJECT MATTER

B41J 2/175 *(2006.01)*
B29C 64/329 (2017.01)

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, 2/175, B29C 64/321, 64/329

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)

PatSearch (RUPTO Internal), USPTO, PAJ, Espacenet, Information Retrieval System of FIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2007/0035594 A1 (JAFFREY B. BROOKS et al) 15.02.2007, paragraph [0094], abstract, fig.3, ref.no 98, ref.no 220	1-2 3-15
Y	WO 2010/077386 A1 (MARKEM-IMAJE CORPORATION) 08.07.2010, paragraphs [0035], [0036], [0047], fig.1	3-15
A	US 2009/0211474 A1 (ATWATER RICHARD G) 27.08.2009	1-15
A	US 2006/0193081 A1 (SEAGATE TECHNOLOGY LLC) 31.08.2006	1-15

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

* Special categories of cited documents:

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"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	Date of mailing of the international search report
22 May 2019 (22.05.2019)	30 May 2019 (30.05.2019)

Name and mailing address of the ISA/RU:	Authorized officer
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	S. Zhuravlev Telephone No. (495) 531 64 81