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- (71) Applicant: FUNAI ELECTRIC CO., LTD. [JP/JP]; 7-7-1, Nakagaito, Daito-Shi, Osaka 574-0013 (JP).
- (72) Inventors: MUYSKENS, Robert, H.; 3364 Overbrook Drive, Lexington, KY 40502 (US). MARRA, Michael, A.; 3012 Ashley Oaks Drive, Lexington, KY 40515 (US).
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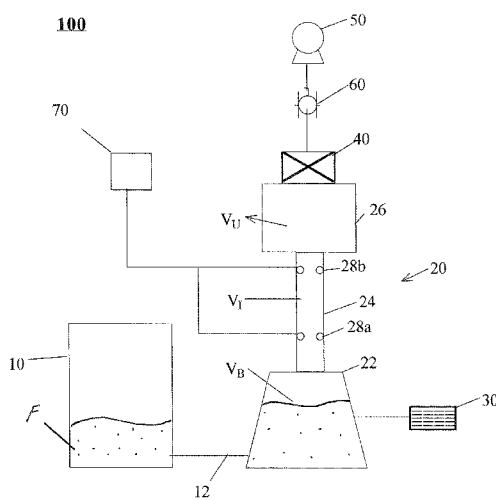


FIG. 1A

(57) Abstract: An inkjet printing system is disclosed and comprises at least one fluid reservoir containing a fluid, a fluid line that fluidly couples the at least one fluid reservoir with an imaging device, and a fluid level sensing apparatus fluidly coupled with the at least one fluid reservoir. The fluid level sensing apparatus comprises: a bottom portion having a fluid volume V_B ; an intermediate portion vertically adjacent the bottom portion and having a fluid volume V_I , the intermediate portion including a first fluid sensor spaced vertically from a second fluid sensor; and an upper portion vertically adjacent the intermediate portion and having a fluid volume V_U , wherein $V_U > V_I > V_B$. The inkjet printing system also comprises a pump fluidly coupled with the at least one fluid level sensing apparatus and configured to exert fluid pressure along the at least one fluid level sensing apparatus.

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FLUID LEVEL SENSING APPARATUS AND METHOD OF USING THE SAME FOR INKJET
PRINTING SYSTEMS

FIELD

[0001] The present invention is directed to apparatuses and methods for detecting fluid levels in inkjet printing systems.

SUMMARY

[0002] According to an exemplary embodiment of the present disclosure, an inkjet printing system is disclosed and comprises at least one fluid reservoir containing a fluid, a fluid line that fluidly couples the at least one fluid reservoir with an imaging device, and a fluid level sensing apparatus fluidly coupled with the at least one fluid reservoir. The fluid level sensing apparatus comprises: a bottom portion having a fluid volume V_B ; an intermediate portion vertically adjacent the bottom portion and having a fluid volume V_I , the intermediate portion including a first fluid sensor spaced vertically from a second fluid sensor; and an upper portion vertically adjacent the intermediate portion and having a fluid volume V_U , wherein $V_U > V_I > V_B$. The inkjet printing system also comprises a pump fluidly coupled with the at least one fluid level sensing apparatus and configured to exert fluid pressure along the at least one fluid level sensing apparatus.

[0003] According to an exemplary embodiment, the fluid level sensing apparatus has an asymmetric configuration.

[0004] According to an exemplary embodiment, the inkjet printing system further comprises a vent fluidly coupled with the fluid level sensing apparatus.

[0005] According to an exemplary embodiment, the vent includes an aperture configured to transmit the fluid away from the fluid level sensing apparatus.

[0006] According to an exemplary embodiment, the inkjet printing system further comprises at least one valve disposed upstream of the fluid level sensing apparatus.

[0007] According to an exemplary embodiment, the inkjet printing system further comprises at least one valve disposed downstream of the fluid level sensing apparatus.

[0008] According to an exemplary embodiment, the first fluid sensor or the second fluid sensor is one of a light detector, a float, or a fluid sensing pin.

[0009] According to an exemplary embodiment, the time the fluid takes to reach first fluid sensor corresponds to a volume of fluid in the fluid reservoir.

[0010] According to an exemplary embodiment, the time the fluid takes to reach the second fluid sensor is used to calibrate a reading taken by the first fluid sensor.

[0011] According to an exemplary embodiment, the inkjet printing system further comprises a processor electrically coupled with one or both of the first fluid sensor and the second fluid sensor.

[0012] According to an exemplary embodiment of the present disclosure, an inkjet printing system comprises a plurality of fluid reservoirs, each reservoir containing fluid, a fluid line that fluidly couples each fluid reservoir with an imaging device, and a fluid level sensing apparatus fluidly coupled with each fluid reservoir. The fluid level sensing apparatus comprises: a bottom portion having a fluid volume V_B ; an intermediate portion vertically adjacent the bottom portion and having a fluid volume V_I , the intermediate portion including a first fluid

sensor spaced vertically from a second fluid sensor; and an upper portion vertically adjacent the intermediate portion and having a fluid volume V_U , wherein $V_U > V_I > V_B$. The inkjet printing system further comprises a pump fluidly coupled to all of the fluid sensing apparatuses by a common fluid line and configured to exert fluid pressure along all of the fluid level sensing apparatuses.

[0013] According to an exemplary embodiment, at least one of the fluid level sensing apparatuses has an asymmetric configuration.

[0014] According to an exemplary embodiment, the inkjet printing system further comprises a vent fluidly coupled with all of the fluid level sensing apparatuses.

[0015] According to an exemplary embodiment, the inkjet printing system further comprises at least one valve disposed along the common fluid line.

[0016] According to an exemplary embodiment, the time the fluid takes to reach a respective first fluid sensor corresponds to a volume of fluid in a respective fluid reservoir.

[0017] According to an exemplary embodiment, the time the fluid takes to reach a respective second fluid sensor is used to calibrate a reading taken by the respective first fluid sensor.

[0018] According to an exemplary embodiment, each fluid level sensing apparatus is configured and dimensioned so that any nonzero amount of fluid in any fluid reservoir is pumped through a respective fluid level sensing apparatus over a sufficient amount of time so that any nonzero amount of fluid in any other fluid reservoir can be pumped through at least the respective intermediate portion of the respective fluid level sensing apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The features and advantages of the present invention will be more fully understood with reference to the following, detailed description of illustrative embodiments of the present invention when taken in conjunction with the accompanying figures, wherein:

[0020] FIG. 1A is a first sequential schematic view of an inkjet printing system incorporating a fluid level sensing apparatus according to an embodiment of the present disclosure;

[0021] FIG. 1B is a second sequential schematic view of an inkjet printing system incorporating a fluid level sensing apparatus according to an embodiment of the present disclosure;

[0022] FIG. 1C is a third sequential schematic view of an inkjet printing system incorporating a fluid level sensing apparatus according to an embodiment of the present disclosure;

[0023] FIG. 1D is a fourth sequential schematic view of an inkjet printing system incorporating a fluid level sensing apparatus according to an embodiment of the present disclosure;

[0024] FIG. 1E is a fifth sequential schematic view of an inkjet printing system incorporating a fluid level sensing apparatus according to an embodiment of the present disclosure;

[0025] FIG. 2A is a first sequential schematic view of an inkjet printing system incorporating multiple fluid level sensing apparatuses according to an embodiment of the present disclosure;

[0026] FIG. 2B is a second sequential schematic view of an inkjet printing system incorporating multiple fluid level sensing apparatuses according to an embodiment of the present disclosure;

[0027] FIG. 2C is a third sequential schematic view of an inkjet printing system incorporating multiple fluid level sensing apparatuses according to an embodiment of the present disclosure;

[0028] FIG. 2D is a fourth sequential schematic view of an inkjet printing system incorporating multiple fluid level sensing apparatuses according to an embodiment of the present disclosure;

[0029] FIG. 2E is a fifth sequential schematic view of an inkjet printing system incorporating multiple fluid level sensing apparatuses according to an embodiment of the present disclosure;

[0030] FIG. 3A is a first sequential schematic view of an inkjet printing system incorporating multiple fluid level sensing apparatuses according to an embodiment of the present disclosure.

[0031] FIG. 3B is a second sequential schematic view of an inkjet printing system incorporating multiple fluid level sensing apparatuses according to an embodiment of the present disclosure; and

[0032] FIG. 3C is a third sequential schematic view of an inkjet printing system incorporating multiple fluid level sensing apparatuses according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0033] Exemplary embodiments of the present disclosure are directed to apparatuses and methods for detecting fluid levels, such as ink levels, in inkjet printing systems. In embodiments, such apparatuses may be used to detect fluid levels along any portion of an inkjet printing system, such as a printhead, fluid line, ink cartridge, ink reservoir, and/or any location therebetween, to name a few. Such apparatuses may be used to alert one or more users to a fluid full condition, a fluid empty condition, and/or any condition therebetween.

[0034] Turning to FIG. 1A, a system diagram of an inkjet printing system 100 is shown. Inkjet printing system 100 may include at least one fluid reservoir 10. Inkjet printing system 100 may include one or more fluid delivery lines 12, a fluid level sensing apparatus 20, an imaging device 30, and a pump 50. In embodiments, fluid reservoir 10 may be configured to contain a fluid F, for example, ink. In embodiments, fluid F may be an ink of any type, for example, color or composition. Imaging device 30 may be an inkjet printer or any component thereof, such as a printhead or other fluid ejection device. Inkjet printing system may include a vent 40, one or more valves 60, and/or a processor 70, as described further herein. In embodiments, fluid reservoir 10 may be, for example, an ink cartridge, an ink reservoir, or another type of ink storing member, to name a few.

[0035] Fluid reservoir 10 may be separated coupled with imaging device 30 via one or more fluid delivery lines 12. Fluid delivery line 12 may have an elongate, hollow configuration, such as a tubular member, configured to transmit fluids between fluid reservoir 10 and other portions of inkjet printing system 100. In embodiments, fluid delivery line 12 may be formed of any suitable material, such as a polymeric material. Fluid delivery line 12 may be transparent so that fluids being transmitted therethrough may be inspected, measured, analyzed, or otherwise sensed, for example, by a photodetector. In embodiments, fluid reservoir 10 may be directly fluidly coupled with imaging device 30.

[0036] Fluid level sensing apparatus 20 may be a portion of inkjet printing system 100 that is fluidly coupled with at least fluid reservoir 10. In embodiments, fluid level sensing apparatus 20 may be configured as a fluid path extending away from fluid line 12 and disposed between fluid reservoir 10 and imaging device 30. In embodiments, fluid level sensing apparatus 20 may include a portion of fluid reservoir 10 or imaging device 30. In embodiments, fluid level sensing apparatus may 20 have a symmetric configuration, such as a tubular column, or an asymmetric configuration. Fluid level sensing apparatus 20 may be formed of a similar material to fluid line 12, such as a polymeric material. In embodiments, fluid level sensing apparatus may have a transparent configuration.

[0037] Fluid level sensing apparatus 20 may include a first, bottom portion 22, a second, intermediate portion 24, and a third, upper portion 26. Bottom portion 22, intermediate portion 24, and upper portion 26 of fluid level sensing apparatus 20 may be in fluid communication with one another. In embodiments, bottom portion 22, intermediate portion 24, and upper portion 26

may be adjacent one another and fluidly coupled, for example, by fluid lines. Fluid level sensing apparatus 20 may be configured to be oriented so that bottom portion 22 is disposed closest to the ground or other surface supporting inkjet printing system 100, with intermediate portion 22 disposed above bottom portion 24, and upper portion 26 disposed above intermediate portion 24. In embodiments, bottom portion 22, intermediate portion 24, and upper portion 26 may have a substantially linear, vertical arrangement, such as a vertically stacked arrangement.

[0038] Each of bottom portion 22, intermediate portion 24, and upper portion 26 may have a distinct configuration, such as shape and/or dimensioning. Bottom portion 22 may be dimensioned to hold a fluid volume V_B , intermediate portion 24 may be dimensioned to hold a fluid volume V_I , and upper portion 26 may be dimensioned to hold a fluid volume V_U . In embodiments, fluid level sensing apparatus 20 may be configured such that V_U is larger than V_I and/or V_B . In embodiments, fluid level sensing apparatus may be configured such that V_U is larger than V_I and V_B is larger than V_I . In such embodiments, fluid level sensing apparatus 20 may be configured such that $V_U > V_B > V_I$.

[0039] Fluid level sensing apparatus 20 may include at least one sensor disposed therealong. In embodiments, fluid level sensing apparatus 20 may include a first sensor 28a and a second sensor 28b vertically spaced from the first sensor 28a. Sensors 28a, 28b may be configured to detect the presence, quantity, and/or chemical properties of fluid disposed therein. In embodiments, sensors 28a, 28b may be configured to generate an electrical signal, such as an electrically conductive member, such as a pin, with conductive properties that change in the presence of a fluid. In embodiments, sensors 28a, 28b may be configured floating members that

can rise and fall in the presence of fluid, or light-detecting members such as photodetectors, to name a few. Sensors 28a, 28b may be disposed externally and/or internally along a portion of fluid level sensing apparatus 20. Fluid level sensing apparatus 20 may include one, two, or more than two of each sensor 28a, 28b.

[0040] Sensors 28a, 28b may be configured so that, upon contact with a fluid, sensors 28a, 28b provide an indication to a user, such as an audible and/or visual indicator. In such embodiments, an indicator may be a light such as an LED, an indicium on a visual display, and/or an audible alarm.

[0041] A vent 40 may be disposed above fluid level sensing apparatus 20. In embodiments, vent 40 may be substantially vertically adjacent upper portion 26 of fluid sensing apparatus 20 and fluidly coupled with the fluid level sensing apparatus 20. Vent 40 may comprise one or more openings for fluids to exit fluid sensing apparatus 20. Vent 40 may be configured to facilitate the release or intake of fluid pressure to achieve a desired pressure environment within inkjet printing system 100, for example, equilibrium with a surrounding environment. Vent 40 may have an open or closed condition. In embodiments, vent 40 may be in fluid communication with a storage container or recirculation system.

[0042] A pump 50 may be in fluid communication with fluid level sensing apparatus 20. Pump 50 may be any suitable fluid pressure-generating member, and may be configured to generate one or more pressure differentials along fluid level sensing apparatus 20 so that fluids disposed therein are caused to move through fluid level sensing apparatus 20. In embodiments, a pump 50 may be disposed above vent 40. In embodiments, a pump 50 may be disposed along a

portion of fluid level sensing apparatus 20. In embodiments, an inkjet printing system 100 may include multiple pumps 50 for use with fluid level sensing apparatus 20.

[0043] One or more valves 60 may be disposed along fluid level sensing apparatus 20. In embodiments, valves 60 may be disposed upstream and/or downstream of fluid sensing apparatus 20, vent 40 and/or pump 50. Valves 60 may be configured to inhibit fluid flow in at least one direction, for example, to inhibit leaks, backflow, and the like.

[0044] Still referring to FIG. 1A, inkjet printing system 100 is shown with fluid reservoir 10 being partially filled with fluid F and with vent 40 in a closed condition. A residual pressurized environment, for example, from prior printing operations, may be present within portions of inkjet printing system 100.

[0045] Turning to FIG. 1B, vent 40 may be opened such that a fluid pressure within inkjet printing system 100 is returned to an equilibrium state with respect to a surrounding environment. Accordingly, the level of fluid F present in fluid reservoir 10 is caused to sit at a resting level, for example, under atmospheric pressure, within inkjet printing system 100. In embodiments, fluid F has a resting level within fluid level sensing apparatus 20 that is determined by the initial volume of fluid F in fluid reservoir 10. As shown, fluid F may sit at a vertical height H_1 that is substantially similar to a vertical height of fluid F in the fluid reservoir 10. In embodiments, a resting level of fluid F in fluid level sensing apparatus 20 may be within bottom portion 22, intermediate portion 24, or upper portion 26 of fluid level sensing apparatus 20.

[0046] Referring to FIG. 1C, vent 40 may be closed and pump 50 may be actuated upon a signal received from imaging device 30, a user input, or another condition, so that fluid F is caused to rise within fluid level sensing apparatus 20. Upon further operation of pump 50, fluid F may rise within fluid sensing apparatus 20 to reach first sensor 28a. Fluid F may reach first sensor 28a in a period of time dependent upon the amount of fluid F present in fluid reservoir 10 so that fluid F may reach first sensor 28a in a shorter period of time if fluid reservoir 10 is substantially filled as compared to a longer period of time if fluid reservoir 10 is less than substantially filled due to the initial resting level of fluid F within fluid level sensing apparatus 20. First sensor 28a may detect the presence of fluid F and generate a corresponding signal. In such embodiments, such a signal may correspond to a recorded time that fluid F reached first sensor 28a as compared to an initial time recorded when fluid F is at a resting level within the fluid level sensing apparatus 20.

[0047] In embodiments, pump 50 may exert a negative fluid pressure on fluid F that is different from the known or expected capabilities of pump 50, and/or the resulting volume flow rate of fluid F through the fluid level sensing apparatus 20 may be different than expected, for example, due to variable pump performance, power supply, fluid consistency, or other factors, to name a few.

[0048] With reference to FIG. 1D, further operation of pump 50 may cause fluid F to rise through intermediate portion 24 of fluid sensing apparatus 20. When fluid F reaches second sensor 28b, a signal may be generated. With a known flow rate of the pump 50, and known volume V_1 of the intermediate portion 24, the time differential between the time at which fluid F

reaches first sensor 28a and the time at which fluid F reaches second sensor 28b may correspond to the actual flow rate of the fluid F through the fluid level sensing apparatus 20 as compared to the expected flow rate of the fluid F through the fluid level sensing apparatus 20. In this manner, second sensor 28b may be used to calibrate the measurement of the time fluid F takes to reach first sensor 28b by accounting for local variations of the pump 50, fluid F, etc.. In embodiments, multiple additional sensors may be used in conjunction with first sensor 28 to improve accuracy of the readings taken of fluid F traveling through fluid level sensing apparatus 20.

[0049] In embodiments, inkjet printing system 100 may include a processor 70 for calculating the time differentials between the actuation of the pump 50 and the fluid F reaching the first sensor 28a, and/or the time differential between the fluid F reaching first sensor 28a and second sensor 28b. Processor 70 may also be used, for example, to calibrate the reading taken by the first sensor 28a based on the reading taken by second sensor 28b. Processor 70 may be electrically coupled with either or both of sensors 28a, 28b. In embodiments, processor 70 may include a portion of imaging device 30, fluid sensing apparatus 20, or any other portion of inkjet printing system 100.

[0050] Referring to FIG. 1E, further operation of pump 50 may cause fluid F to rise into upper portion 26 of fluid sensing apparatus 20 and fill volume V_U . Thereafter, fluid F reaches vent 40 and begins to exit fluid sensing apparatus 20. In embodiments, fluid sensing apparatus 20 may be configured such that a sensor is associated with vent 40 so that upon reaching vent 40, pump 50 is shut down. Fluid F may thereafter fall through fluid sensing apparatus 20 to a resting vertical height, such as similar to that shown in FIG. 1A or 1B.

[0051] Turning to FIG. 2A, an embodiment of an inkjet printing system, generally designated 200, is shown. Inkjet printing system 200 may include substantially similar components to inkjet printing system 100 above, such as an imaging device 30, vent 40, pump 50, valve 60, and processor 70. However, inkjet printing system may include a plurality of ink reservoirs 10a, 10b, 10c each containing fluid F (FIG. 2B), and each with a respective fluid line 12a, 12b, 12c fluidly coupling each respective fluid reservoir 10a, 10b, 10c with imaging device 30. In embodiments, fluid reservoirs 10a, 10b, 10c may contain a similar or identical fluid, or may include different fluids, such as different colored ink. A fluid sensing apparatus 20a, 20b, 20c is fluidly coupled with each respective fluid reservoir 10a, 10b, 10c. Each fluid level sensing apparatus 20a, 20b, 20c may each include a respective bottom portion 22a, 22b, 22c, intermediate portion 24a, 24b, 24c, and upper portion 26a, 26b, 26c. Each respective bottom portion 22a, 22b, 22c may have a fluid volume V_{Ba} , V_{Bb} , V_{Bc} , each respective intermediate portion 24a, 24b, 24c may have a fluid volume V_{Ia} , V_{Ib} , V_{Ic} , and each respective upper portion 26a, 26b, 26c may have a fluid volume V_{Ua} , V_{Ub} , V_{Uc} . Ink reservoirs 10a, 10b, 10c, respective fluid lines 12a, 12b, and 12c, and fluid sensing apparatuses 20a, 20b, 20c may be similar to ink reservoir 10, fluid line 12, and fluid sensing apparatus 20 described above.

[0052] Each respective fluid sensing apparatus 20a, 20b, 20c may have a respective first sensor 28a₁, 28b₁, 28c₁ and second sensor 28a₂, 28b₂, 28c₂ which may be similar to first and second sensors 28a, 28b described above. Pump 50 and/or vent 40 may be fluidly coupled via a common fluid line 14 to all of the fluid sensing apparatuses 20a, 20b, 20c and configured to exert fluid pressure therealong.

[0053] Referring to FIG. 2B, fluid reservoir 10b may be substantially filled with fluid F, and fluid reservoirs 10a, 10c may be partially filled with fluid F. In embodiments, fluid reservoirs 10a, 10b, 10c may be filled in any combination or variation. Vent 40 may be opened in an initial configuration so that fluid pressure within inkjet printing system 200 returns to an equilibrium state and levels of fluid F may be disposed at resting vertical heights within fluid level sensing apparatuses 20a, 20b, 20c of H_a , H_b , H_c , respectively.

[0054] Turning to FIG. 2C, upon actuation of pump 50, fluid F may rise within each fluid sensing apparatuses 20a, 20b, 20c and contact respective first sensors $28a_1$, $28b_1$, $28c_1$ in the manner described above with respect to inkjet printing system 100.

[0055] Turning to FIG. 2D, further operation of pump 50 may cause fluids F to rise within intermediate portions 24a, 24b, 24c of fluid sensing apparatuses 20a, 20b, 20c. As shown, fluid F from the first fluid reservoir 10b may be pumped through fluid level sensing apparatus 20b to vent 40 before fluid F from the partially-filled fluid reservoirs 10a and 10c is completely pumped through respective fluid level sensing apparatuses 20a and 20c. Since contact of fluid F with the vent 40 may cause a shutdown of the pump 50, such a discrepancy in fluid levels among different fluid reservoirs along a common pump line may cause premature termination of a fluid level sensing operation before all fluid reservoirs are properly measured.

[0056] However, with additional reference to FIG. 2E, because the fluid volume V_{Ub} , upper portion 26b of fluid sensing apparatus 20b is greater than the volume V_{Ib} of intermediate portion 26b, any nonzero volume of fluid F initially in fluid reservoir 10b may be pumped through fluid line 12b and fluid level sensing apparatuses 20b over a sufficient period of time

before reaching vent 40 so that fluid F in fluid reservoirs 10a, 10c has sufficient time to be pumped through and fill at least intermediate portions 24a, 24c of fluid sensing apparatuses 20a, 20c before the fluid F initially in fluid reservoir 10b reaches vent 40, which may cause a shutdown of pump 50. In this manner, inkjet printing system 200 is configured so that multiple fluid reservoirs 10a, 10b, 10c may be coupled to a common fluid line 14 and simultaneously pumped through respective fluid sensing apparatuses 20a, 20b, 20c in a manner so that any nonzero volume of fluid F in each of fluid reservoirs 10a, 10b, 10c is sufficient to allow proper sensing of levels of fluid F in all fluid reservoirs 10a, 10b, 10c before fluid F from one of fluid reservoirs 10a, 10b, 10c is pumped through vent 40. In this manner, inkjet printing system 200 is configured and dimensioned so that multiple fluid reservoirs may be coupled with a common pump and/or fluid line and be measured with respect to fluid levels therein regardless of the volume of fluid initially stored therein, without any one fluid reservoir interrupting operation of the measurement of the fluid level of any other fluid reservoir.

[0057] In embodiments, fluid F may be evacuated through vent 40 without causing a shutdown of the pump 50. In such embodiments, the configuration of the fluid level sensing apparatuses 20a, 20b, 20c is such that a fluid F may be pumped therethrough over a sufficient period of time so that proper sensing may be performed of all fluid reservoirs before any one fluid reservoir and respective fluid sensing apparatus is completely evacuated of fluid F, which may cause improper operation of pump 50.

[0058] Turning to FIG. 3A, an embodiment of an inkjet printing system, generally designated 300, is shown. Inkjet printing system 300 may include some similar components to

inkjet printing system 200 described above, such as an imaging device 30, vent 40, pump 50, valve 60, and/or processor 70. However, inkjet printing system 300 may include fluid reservoir 11 which has a fluid volume V_R . Sensors 28a, 28b may be incorporated or associated with the fluid reservoir 11 as described above.

[0059] Turning to FIG. 3B, vent 40 may be opened to allow fluid pressure within inkjet printing system 300 to return to equilibrium and allow fluid F to become disposed at a resting level H_3 .

[0060] Turning to FIG. 3C, vent 40 may be closed and pump 50 may be actuated to provide fluid pressure through line 12 such that fluids F in fluid reservoir 11 rise vertically. The time fluid F takes to reach first sensor 28a may correspond to a volume of fluid F present in the fluid reservoir 11 due to the initial proximity of fluid F to first sensor 28a within fluid level sensing apparatus 20. Second sensor 28b may be provided to calibrate the reading taken by first sensor 28a in the manner described above with respect to inkjet printing systems 100, 200. It will be understood that such a configuration may be employed with respect to inkjet printing systems 100, 200 described above.

[0061] While this invention has been described in conjunction with the embodiments outlined above, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, the exemplary embodiments of the invention, as set forth above, are intended to be illustrative, not limiting. Various changes may be made without departing from the spirit and scope of the invention.

What is Claimed is:

1. An inkjet printing system, comprising:
at least one fluid reservoir containing a fluid;
a fluid line fluidly coupling the at least one fluid reservoir with an imaging device; and
a fluid level sensing apparatus fluidly coupled with the at least one fluid reservoir and
comprising:
a bottom portion having a fluid volume V_B ;
an intermediate portion vertically adjacent the bottom portion and having a fluid
volume V_I , the intermediate portion including a first fluid sensor spaced vertically from a
second fluid sensor; and
an upper portion vertically adjacent the intermediate portion and having a fluid
volume V_U , wherein $V_U > V_I > V_B$; and
a pump fluidly coupled with the at least one fluid level sensing apparatus and configured
to exert fluid pressure along the at least one fluid level sensing apparatus.
2. The inkjet printing system of claim 1, wherein the fluid level sensing apparatus
has an asymmetric configuration.
3. The inkjet printing system of claim 1, further comprising a vent fluidly coupled
with the fluid level sensing apparatus.

4. The inkjet printing system of claim 3, wherein the vent includes an aperture configured to transmit the fluid away from the fluid level sensing apparatus.

5. The inkjet printing system of claim 1, further comprising at least one valve disposed upstream of the fluid level sensing apparatus.

6. The inkjet printing system of claim 1, further comprising at least one valve disposed downstream of the fluid level sensing apparatus.

7. The inkjet printing system of claim 1, wherein the first fluid sensor or the second fluid sensor is one of a light detector, a float, or a fluid sensing pin.

8. The inkjet printing system of claim 1, wherein the time the fluid takes to reach first fluid sensor corresponds to a volume of fluid in the fluid reservoir.

9. The inkjet printing system of claim 8, wherein the time the fluid takes to reach the second fluid sensor is used to calibrate a reading taken by the first fluid sensor.

10. The inkjet printing system of claim 1, further comprising a processor electrically coupled with one or both of the first fluid sensor and the second fluid sensor.

11. An inkjet printing system, comprising:
a plurality of fluid reservoirs, each reservoir containing fluid;
a fluid line fluidly coupling each fluid reservoir with an imaging device; and
a fluid level sensing apparatus fluidly coupled with each fluid reservoir and comprising:
a bottom portion having a fluid volume V_B ;
an intermediate portion vertically adjacent the bottom portion and having a fluid volume V_I , the intermediate portion including a first fluid sensor spaced vertically from a second fluid sensor; and
an upper portion vertically adjacent the intermediate portion and having a fluid volume V_U , wherein $V_U > V_I > V_B$; and
a pump fluidly coupled to all of the fluid sensing apparatuses by a common fluid line and configured to exert fluid pressure along all of the fluid level sensing apparatuses.
12. The inkjet printing system of claim 11, wherein at least one of the fluid level sensing apparatuses has an asymmetric configuration.
13. The inkjet printing system of claim 11, further comprising a vent fluidly coupled with all of the fluid level sensing apparatuses.
14. The inkjet printing system of claim 11, further comprising at least one valve disposed along the common fluid line.

15. The inkjet printing system of claim 11, wherein the time the fluid takes to reach a respective first fluid sensor corresponds to a volume of fluid in a respective fluid reservoir.

16. The inkjet printing system of claim 15, wherein the time the fluid takes to reach a respective second fluid sensor is used to calibrate a reading taken by the respective first fluid sensor.

17. The inkjet printing system of claim 11, wherein each fluid level sensing apparatus is configured and dimensioned so that any nonzero amount of fluid in any fluid reservoir is pumped through a respective fluid level sensing apparatus over a sufficient amount of time so that any nonzero amount of fluid in any other fluid reservoir can be pumped through at least the respective intermediate portion of the respective fluid level sensing apparatus.

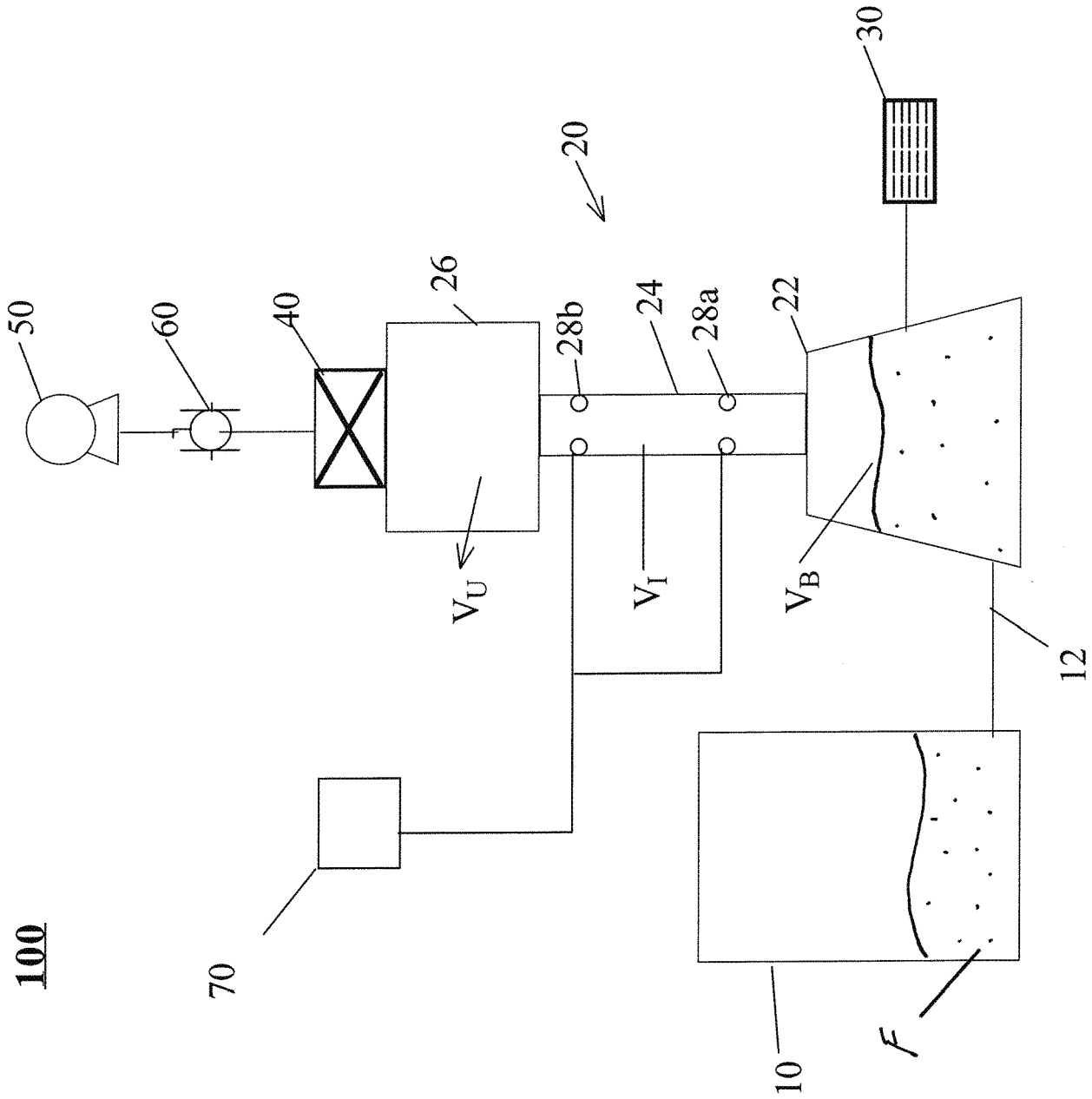


FIG. 1A

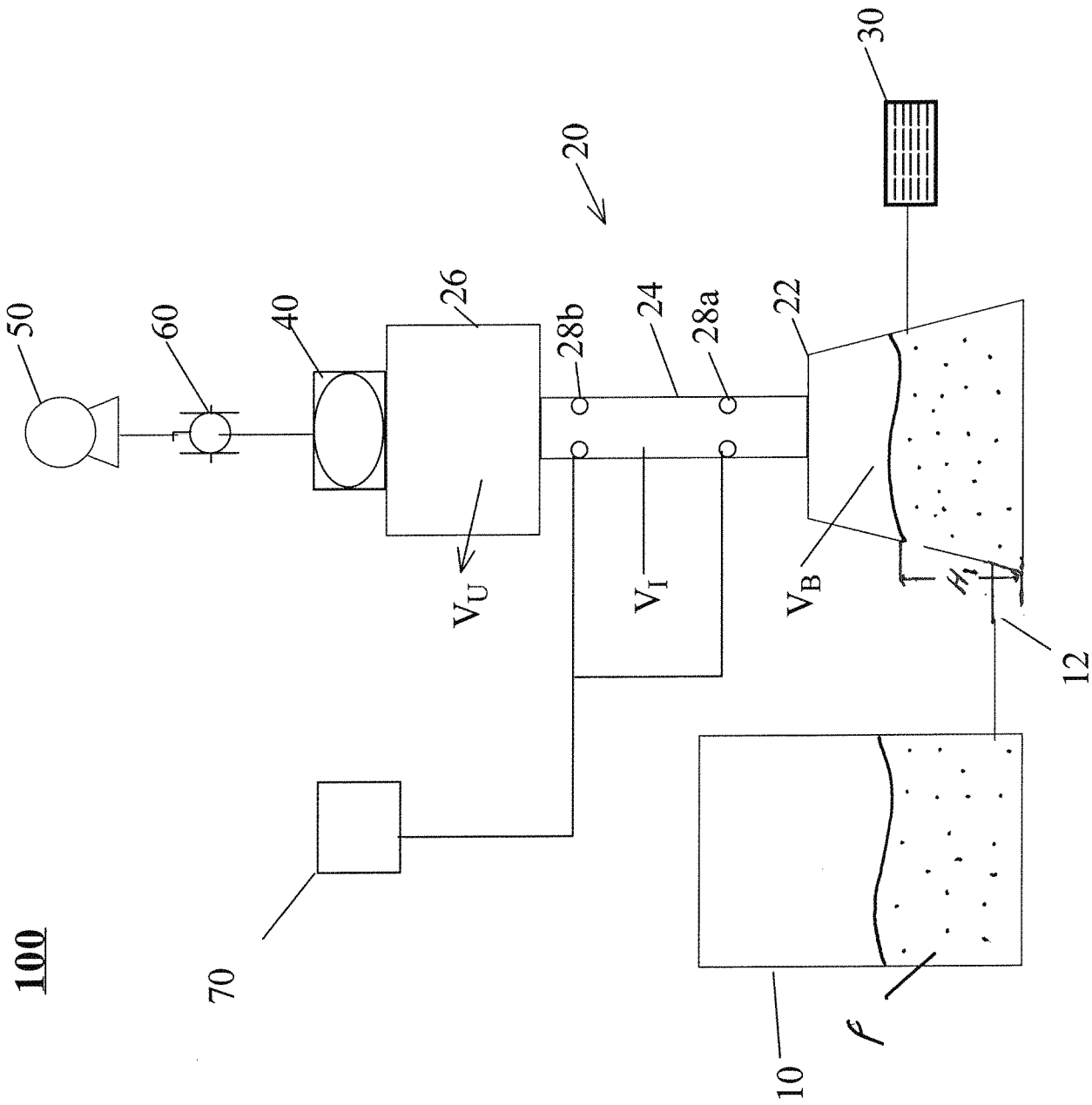


FIG. 1B

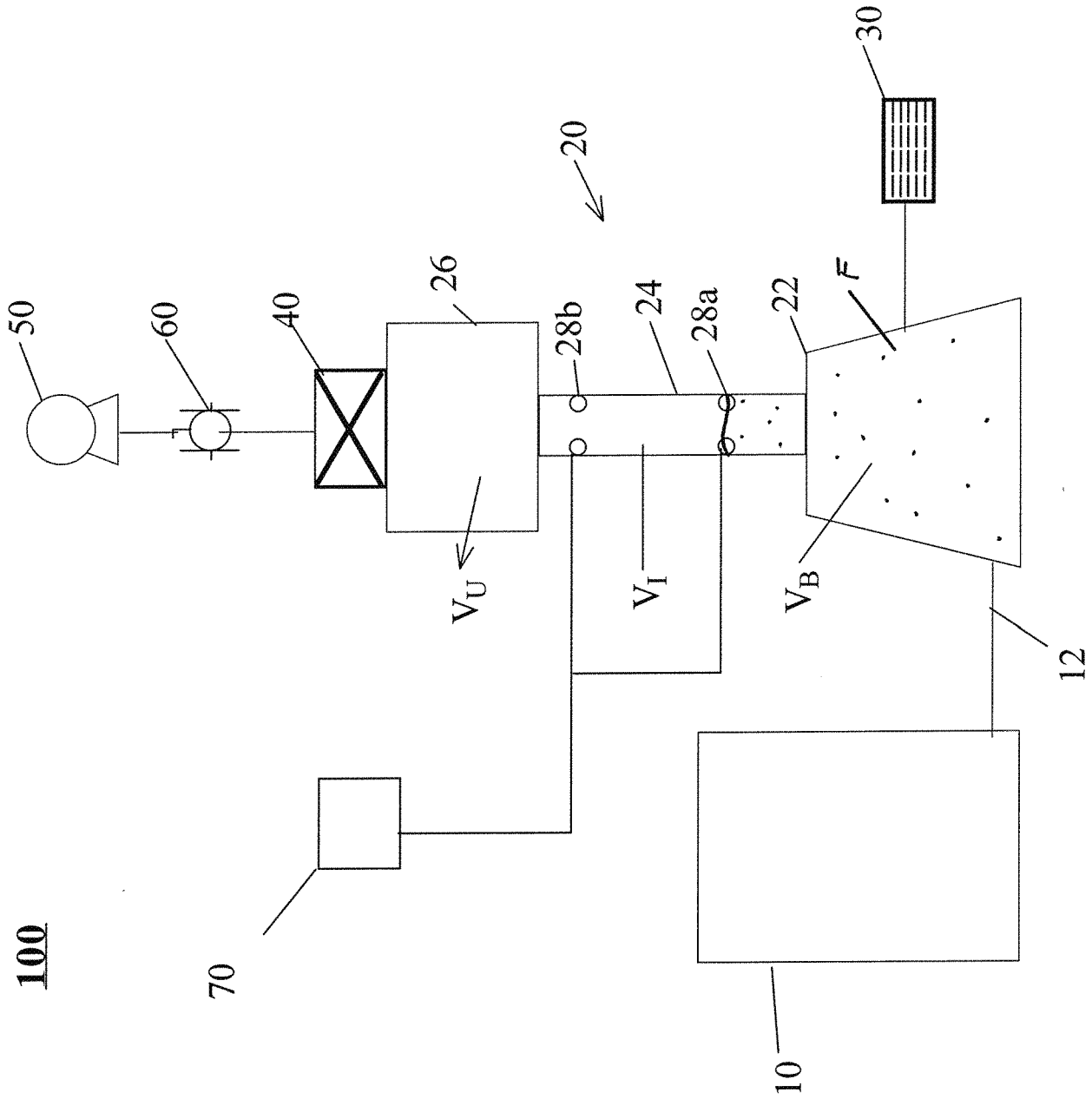


FIG. 1C

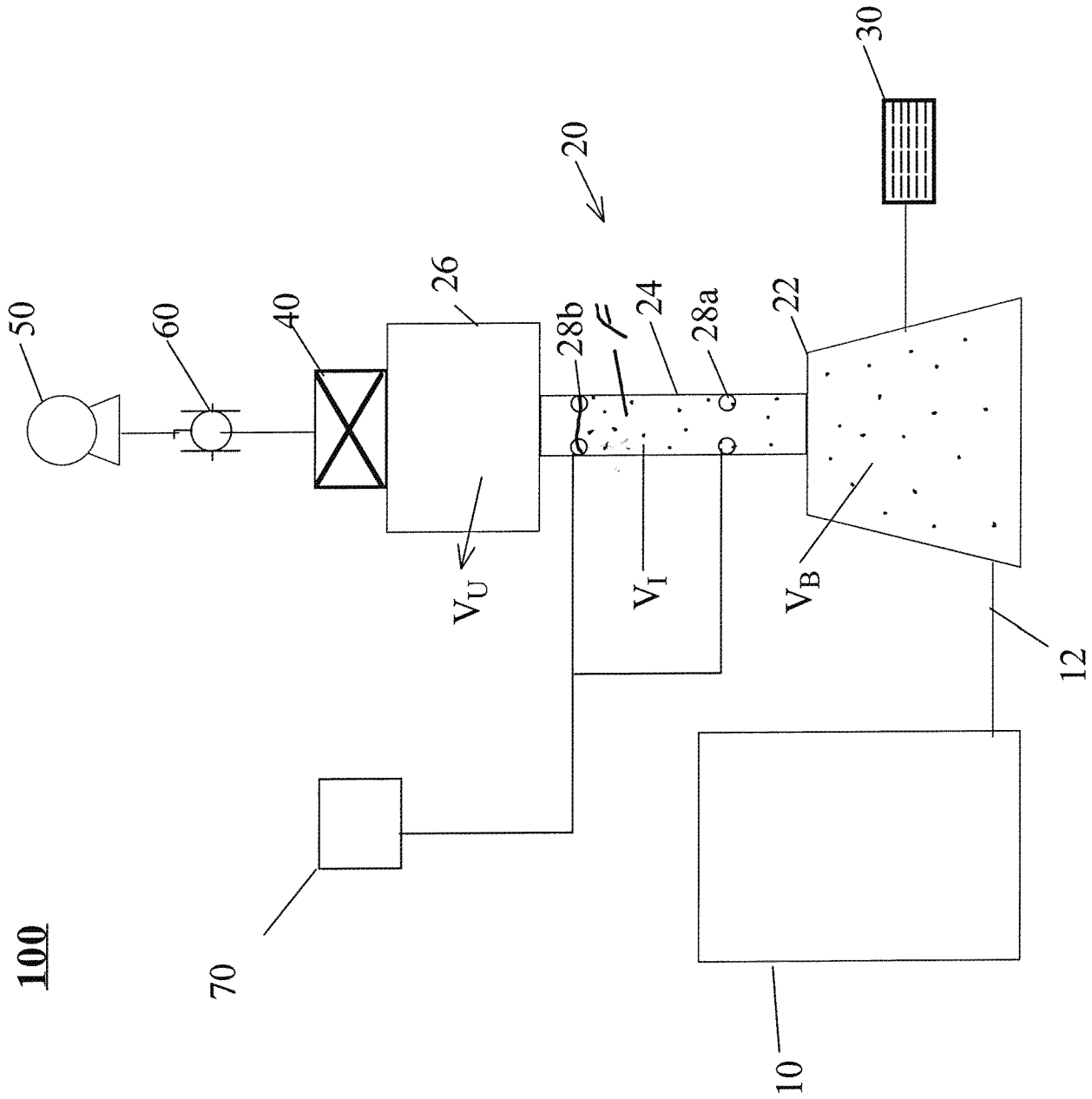


FIG. 1D

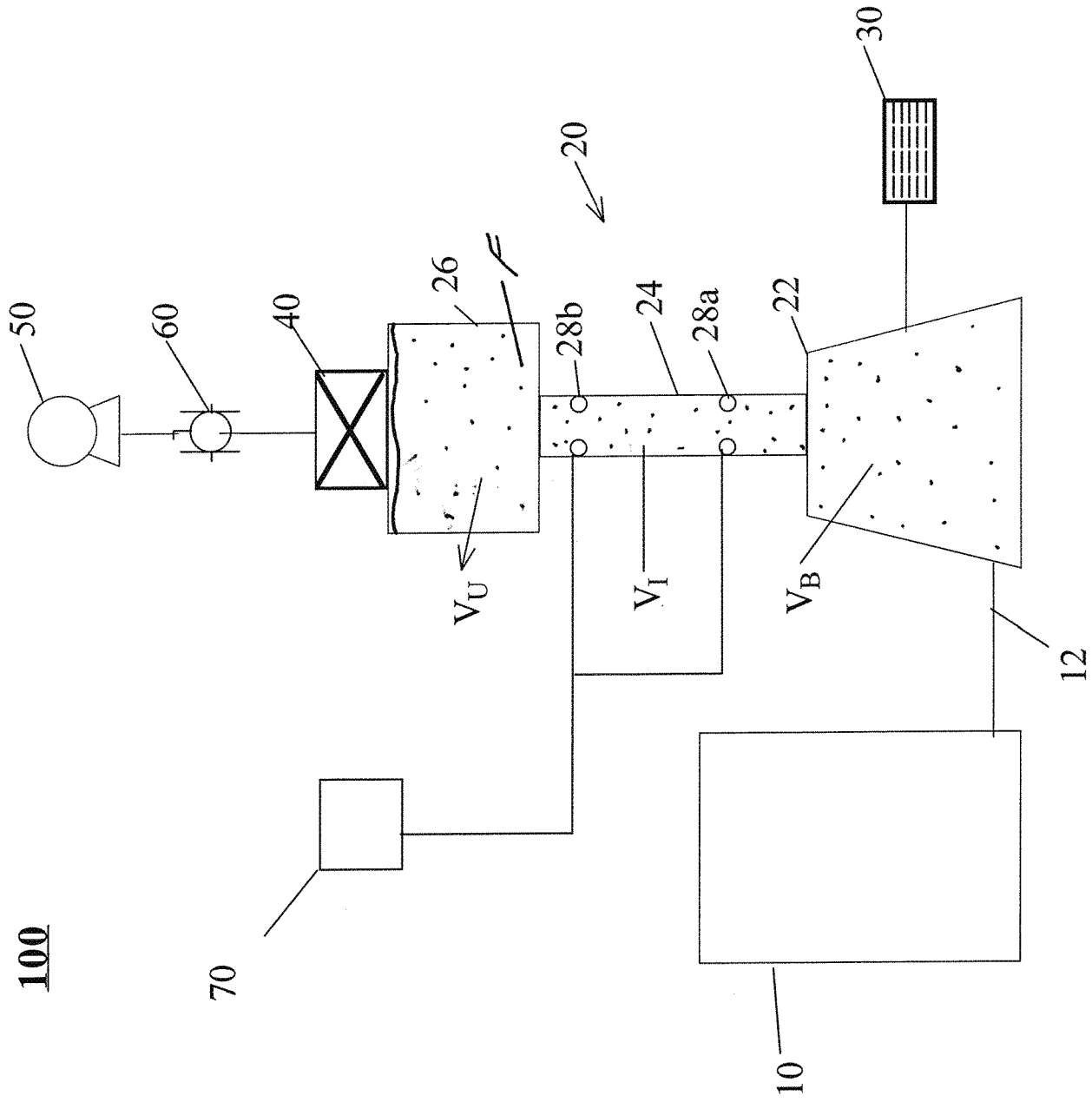
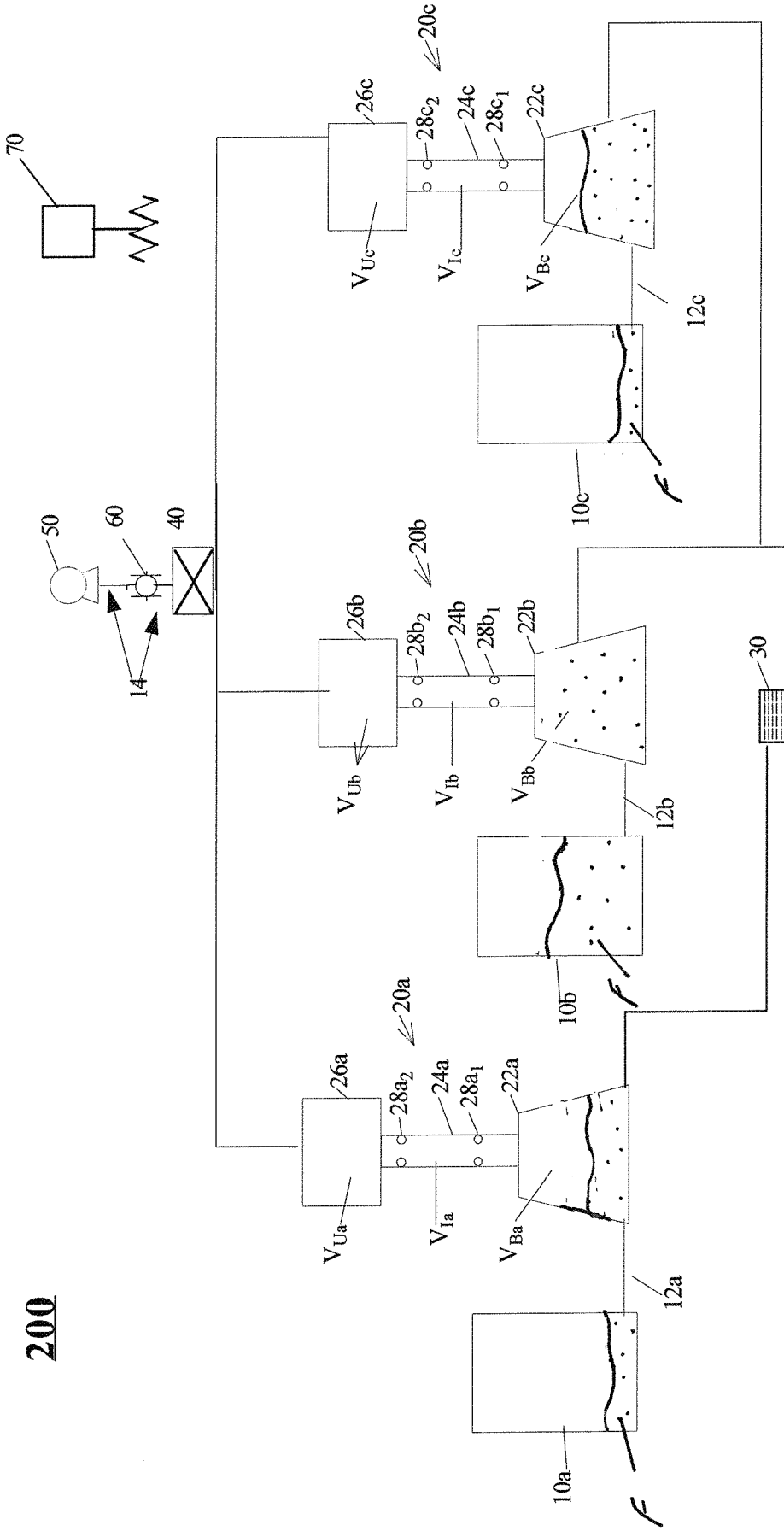


FIG. 1E



200

FIG. 2C

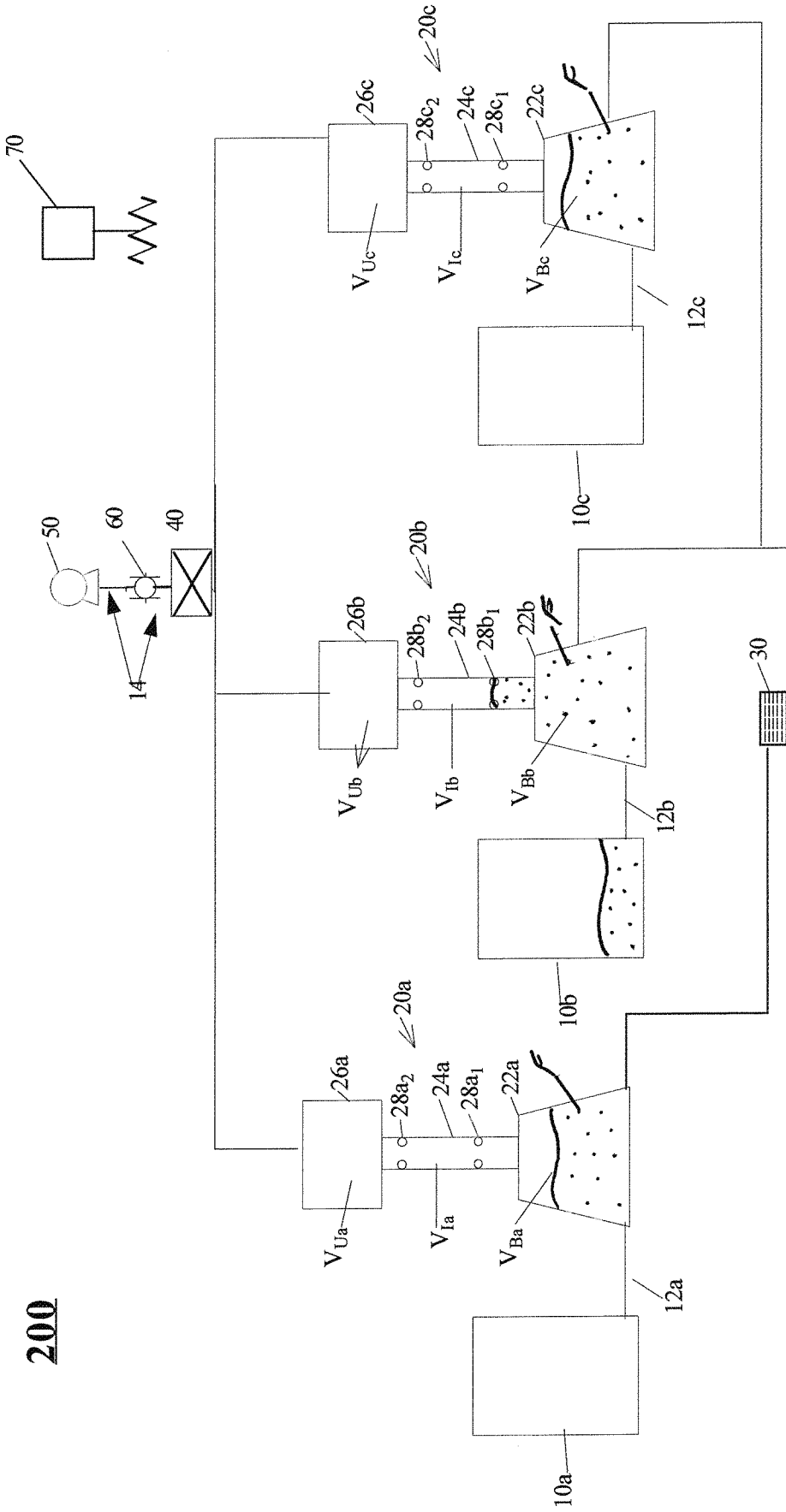
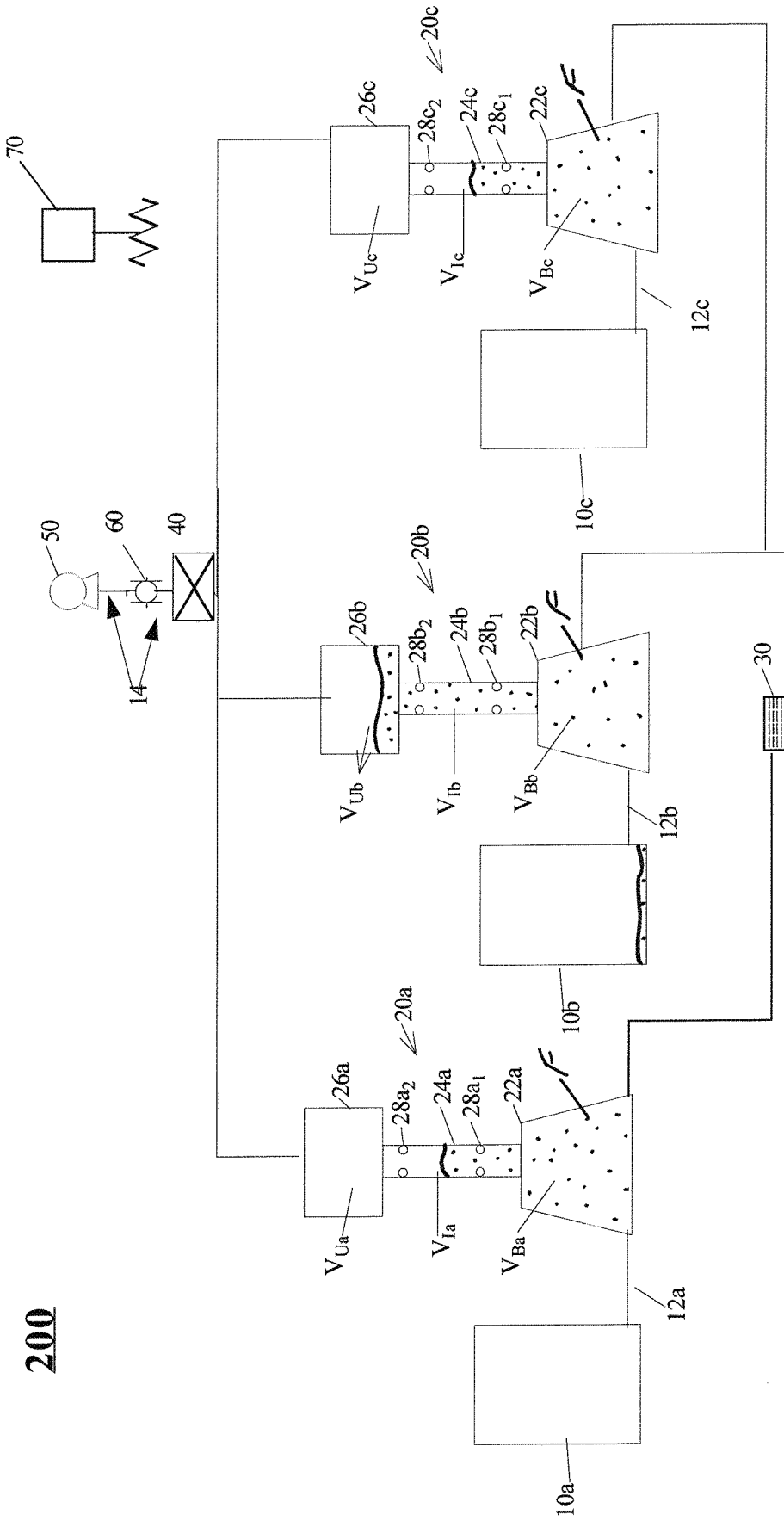


FIG. 2D



200

FIG. 2E

300

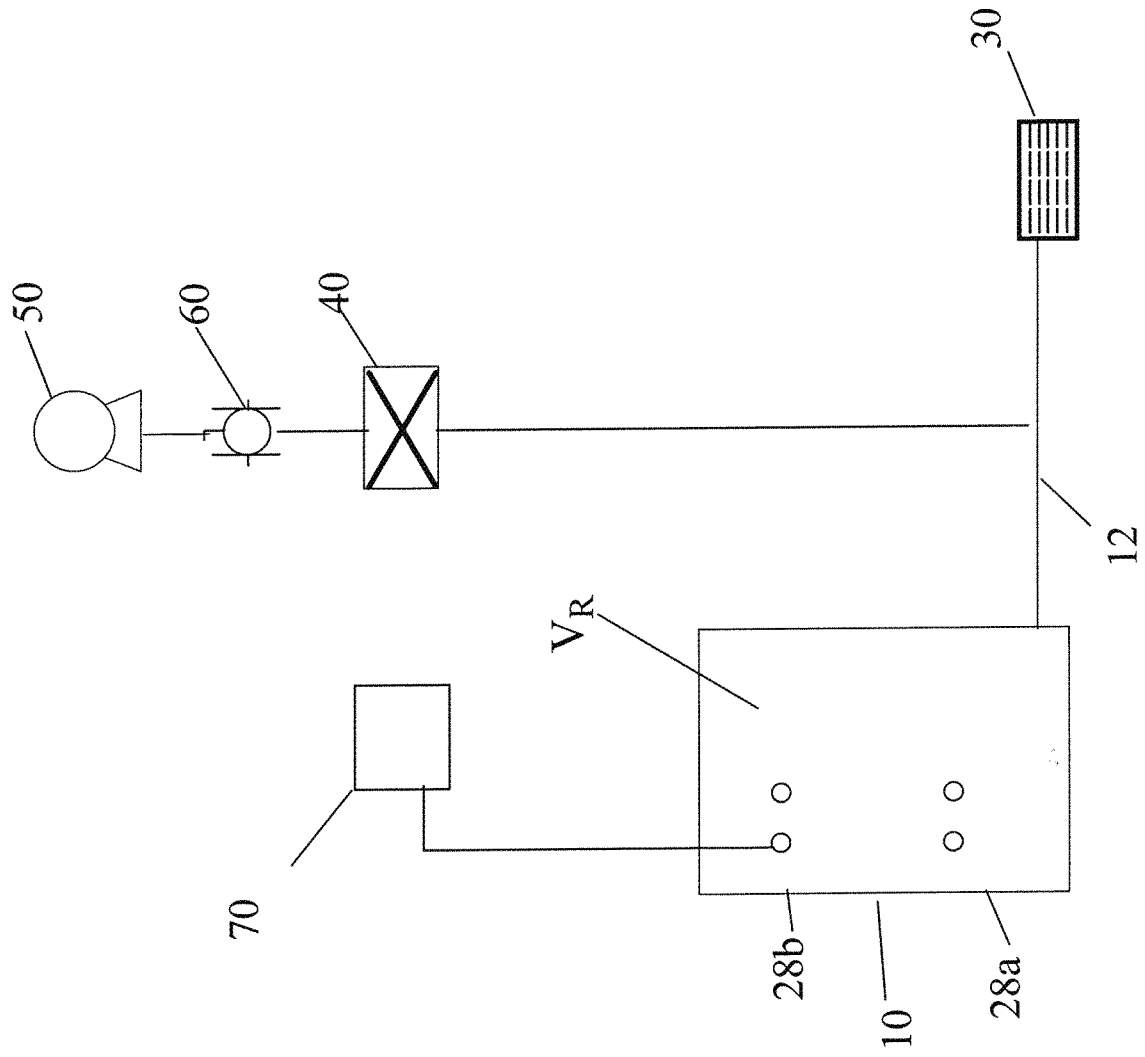


FIG. 3A

300

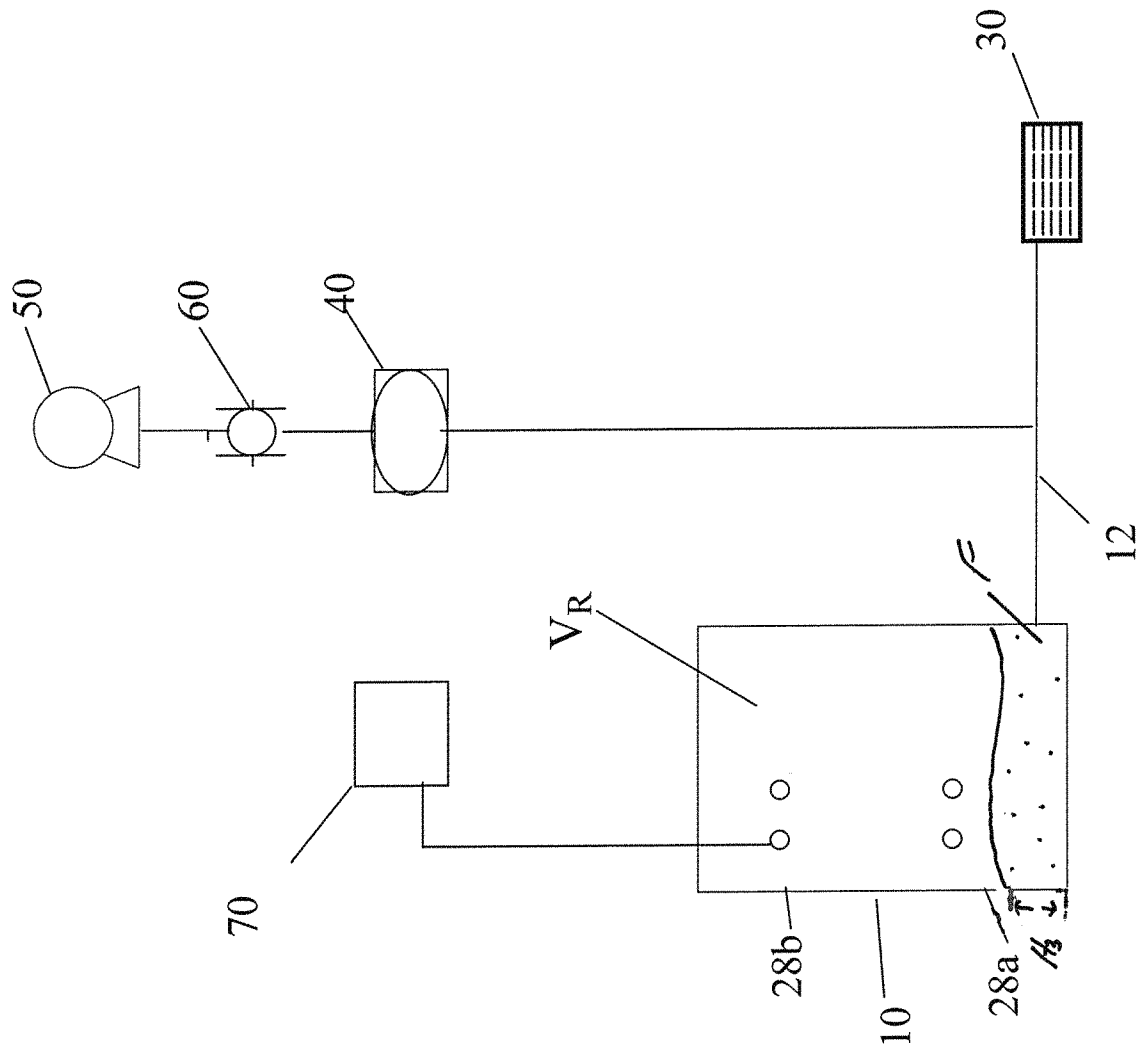


FIG. 3B

300

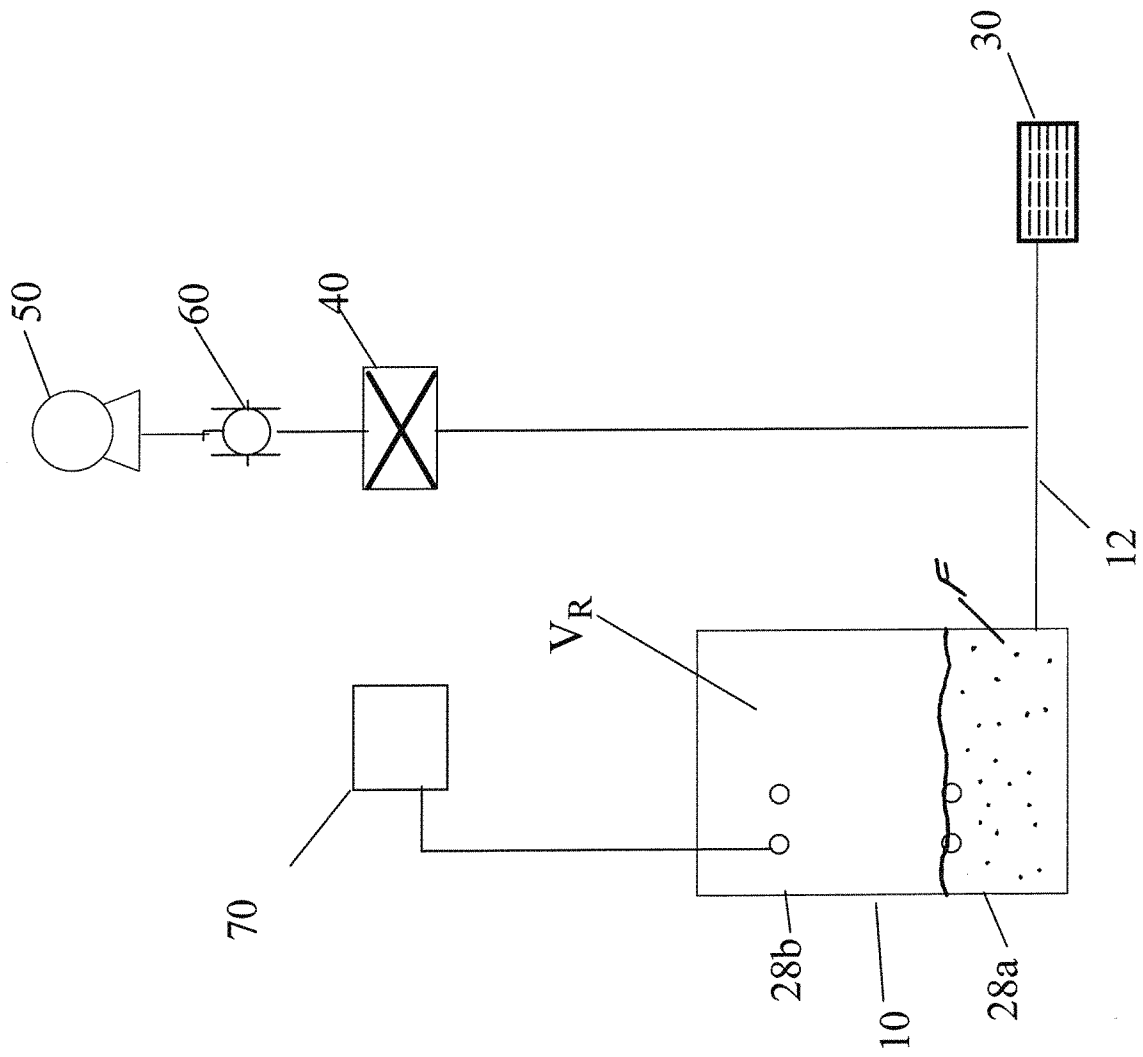


FIG. 3C