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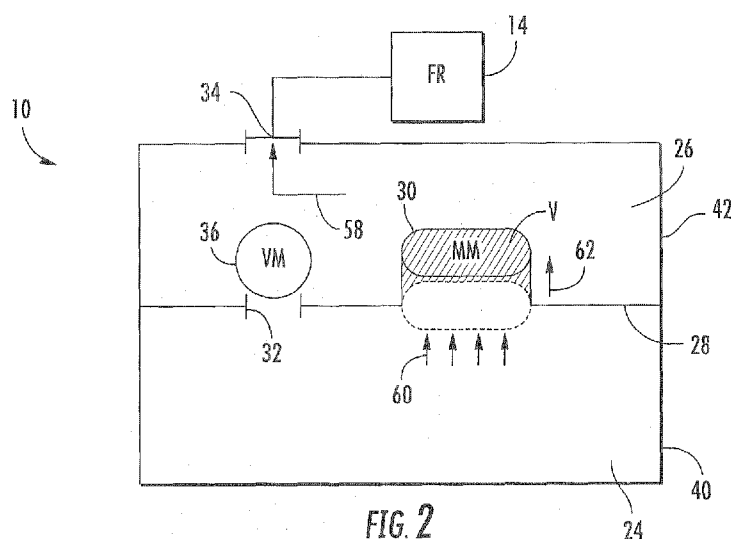
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(57) Abstract: A liquid dispensing system (10, 110, 210) includes a movable member (30, 230) that moves in response to a pressure differential between a first volume (24, 224) and a second volume (26, 226) to dispense liquid pressurized by a propellant.

LIQUID HANDLING SYSTEM

BACKGROUND

[0001] Aerosol liquids are sometimes dispensed using a propellant and a valve. Non-aerosol liquids are often dispensed using manual or electric pumps. Such pumps are often complex and space consuming. Moreover, accurately metering and monitoring the dispensed liquid is difficult.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Figure 1 is a schematic illustration of a liquid dispensing system in a non-dispensing state according to an example embodiment.

[0003] Figure 2 is a schematic illustration of the liquid dispensing system of Figure 1 in a dispensing state according to an example embodiment.

[0004] Figure 3 is a schematic illustration of a liquid marking system according to an example embodiment.

[0005] Figure 4 is a sectional view of another embodiment of the liquid dispensing system of Figure 1 in a non-dispensing state according to an example embodiment.

[0006] Figure 5 is a sectional view of the liquid dispensing system of Figure 4 in a dispensing state according to an example embodiment.

DETAILED DESCRIPTION OF THE EXAMPLE EMBODIMENTS

[0007] Figure 1 is a schematic illustration of a liquid handling system (shown as a liquid dispensing system 10) according to an example embodiment. Liquid dispensing system 10 is configured to meter and dispense non-aerosol liquids or liquids which do not atomize at atmospheric pressure. In the example illustrated, liquid dispensing system 10 dispenses or meters doses of liquids to a liquid receiver 14. Liquid dispensing system 10 includes chamber or volume 24, chamber or volume 26, partition 28, movable member 30, passage 32, passage 34 and valve mechanism 36.

[0008] Volume 24 comprises an internal enclosure formed by one or more structures or walls 40 and configured to be pressurized with a liquid and a propellant. In one embodiment, volume 24 comprises an entire container containing all of the liquid to be dispensed by system 20. In another embodiment, volume 24 comprises a volume configured to be connected to a larger volume, such as a separate container, containing liquid to be dispensed. For example, in one embodiment, container 24 may be part of a cap or module configured to be mounted upon an existing self pressurized container containing a propellant and a non-aerosol liquid.

[0009] Volume 26 comprises an internal enclosure formed by one or more structures or walls 42 and separated or isolated from volume 24 when passage 32 is closed. Partition 28 comprises one or more walls or structures extending between volumes 24 and 26 to isolate volume 24 from volume 26 when passage 32 is closed.

[0010] Movable member 30 comprises one or more members extending between volumes 24 and 26 and in contact with the liquids and/or propellants in the interiors of volumes 24 and 26. Movable member 30 is configured to move in response to pressure differentials between a pressure of volume 24 and a pressure of volume 26. For example, movable member 30 may be configured to move or reposition itself to change or adjust a size of at least volume 26.

[0011] In one embodiment, movable member 30 comprises a flexible diaphragm. The diaphragm is flexible so as to resiliently flex or stretch in response to pressure differentials across the flexible diaphragm of movable member 30. In another embodiment, movable member 30 may comprise a wall, flexible or inflexible, movably supported by a flexible sleeve, skirt or bellows. In still another embodiment, movable member 30 may comprise a piston sealed within and against a tube or bore and movable within the tube or bore in response to pressure differentials on opposite sides of the piston. In still other embodiments, movable member 30 may pivot in response to pressure differentials between volumes 24 and 26, wherein such movement adjusts a size of volume 26. In one embodiment, movable member 30 comprises a single member, such as the diaphragm, extending across an opening in partition 28. In yet another

embodiment, movable member 30 comprises multiple elements disposed between volumes 24 and 26. For example, in one embodiment, movable member 30 may comprise a first diaphragm adjacent volume 24, a second diaphragm adjacent volume 26 and an intermediate spacer member between the pair of diaphragms.

[0012] Passage 32 comprises an opening, port, conduit and the like providing liquid flow or liquid communication between volumes 24 and 26. Passage 32 is configured to be selectively opened and closed by valve mechanism 36. Although passage 32 is illustrated as comprising an opening through partition 28, in other embodiments, passage 32 may comprise a conduit extending around passage 28 such as a passage exterior to walls 40 and 42. Although passage 32 is illustrated as being completely unobstructed, in other embodiments, one or more filtering devices may be positioned across passage 32 to filter liquid as it flows through passage 32.

[0013] Passage 34 comprises an opening, port, conduit or the like providing liquid flow from volume 26 to the exterior of volume 26. Passage 34 is configured to be selectively opened and closed by valve mechanism 36. In some embodiments, passage 34 is completely unobstructed. In other embodiments, passage 34 may include one or more filters to filter liquid as it flows through passage 34. In the example illustrated, passage 34 comprises a conduit or passage extending to liquid receiver 50. In one embodiment, passage 34 is opened by valve mechanism 36 in response to a demand for liquid by liquid receiver 14.

[0014] In one embodiment, the liquid receiver 14 may comprise a marking device or an image forming device which utilizes liquid received through passage 34 to print or mark upon a substrate or print media. In another embodiment, liquid receiver 14 may comprise other devices which utilize liquid. In still other embodiments, passage 34 may be connected to another dispensing device or liquid receiver such as a manually actuatable or powered nozzle, liquid gun or the like. Liquid receiver 14 exposes or connects passage 34 to volume or space at a pressure less than a pressure of the liquid or liquid in volume 26. In one embodiment, the liquid within volume 26 is at least partially

pressurized by a propellant. When passage 34 is opened, liquid within volume 26 flows under pressure into passage 34.

[0015] Valve mechanism 36 comprises one or more valve members configured to selectively open and close passages 32 and 34. In the embodiment illustrated, valve mechanism 36 comprises one or more valve members configured to concurrently open passage 32 while closing passage 34 or close passage 32 while opening passage 34. In one embodiment, valve mechanism 36 comprises a single valve member which moves between a first position in which the member closes passage 32 and opens passage 34 and a second position in which the same member closes passage 32 and opens passage 34. In one embodiment, mechanism 36 includes a valve seat which is movable between different positions to selectively open and close passages 32 and 34. In one embodiment, the valve seat is driven between the different positions by an actuator such as an electric motor or solenoid.

[0016] Figures 1 and 2 illustrate operation of liquid dispensing system 10. Figure 1 illustrates system 10 in a default, at rest state when dispensing system 10 is not dispensing or releasing liquid. In the at rest state, the one or more valve members of valve mechanism 36 open passage 32 and close passage 36. In the example illustrated, valve mechanism 36 is resiliently biased to the non-dispensing position shown in Figure 1 in which valve mechanism 36 closes passage 34. In one embodiment, such biasing is achieved by a spring. In other embodiments, valve mechanism 36 may be held by an actuator in the non-dispensing position in which valve mechanism 36 closes passage 32.

[0017] As indicated by arrows 54, liquid, under pressure, freely flows in both directions through open passage 32. However, such liquid is not permitted to flow into passage 34. As indicated by arrows 56, the ability of liquid or liquid to substantially freely flow through passage 32 creates a pressure equilibrium across movable member 30. In other words, the pressure of the liquid in volume 24 exerted upon movable member 30 is substantially same as the pressure of the liquid in the volume 26 exerted upon movable member 30. As a result, movable member 30 does not move and is maintained in a

predetermined default state or position. At the same time, liquid from volume 24 substantially fills the available space of volume 26 through passage 32.

[0018] Figure 2 illustrates liquid dispensing system 10 in a liquid dispensing state. In response to a demand or request for liquid from liquid receiver 14, valve mechanism 36 actuates or moves from the non-dispensing position of Figure 1 to the dispensing position shown in Figure 2. In one embodiment, an actuator such as electric motor or solenoid moves one or more valve seats of valve mechanism 36 to the dispensing position or positions. In the dispensing position, valve mechanism 36 closes passage 32 and opens passage 34. Because passage 34 and liquid receiver 14 are at a pressure less than the pressure of the liquid within volume 26, the liquid within volume 26 flows under pressure into the now open passage 34 as indicated by arrow 58. As a result, the initial discharge of liquid from volume 26 into passage 34 reduces pressure within volume 26. This creates a pressure differential across movable member 30. In particular, the pressure within volume 24 is greater than the pressure within volume 26 and the open passage 34 and liquid receiver 50. This pressure differential is schematically represented by arrows 60 on the side of movable member 30 adjacent volume 24.

[0019] The pressure differential across movable member 30 exerts a force upon movable member 30 so as to move or displace movable member 30 in a manner so as to increase the space or volume of volume 24 while decreasing the space or volume of volume 26. In the example illustrated, movable member 30 moves in the direction indicated by arrow 62 further into volume 26, increasing the volume of volume 24 and decreasing the volume of volume 26 by volume V (identified with hatching). Volume V is substantially proportionate to or corresponds to the volume of liquid discharged from volume 26 through passage 34 to liquid receiver 50. Volume V is the size of the dosage of liquid discharged by dispensing system 10 during a single dispensing event when valve mechanism 36 moves from the non-dispensing state showing Figure 1 to the dispensing state shown in Figure 2. Multiple actuations of valve mechanism 36 between the non-dispensing state and the dispensing state results in multiple doses of volume V. As a result, the metering or dosing of liquid occurs in a "digital" fashion wherein a

metered dose volume V is discharged or released substantially independent of the speed at which valve mechanism 36 is actuated between the different positions or states. Thus, system 10 meters liquid with enhanced consistency and predictability. This enhanced metering of liquid enables system 10 to provide greater control over the amount of liquid delivered to liquid receiver 14 and to also better track or monitor remaining amounts of unused liquid or liquid that has not been dispensed.

[0020] In addition, as shown by Figure 1, when dispensing system 10 is in the at rest state, non-dispensing state, passage 34 is closed. During this time, liquid receiver 14 is not exposed to or subjected to the potentially relatively high pressures associated with the liquid within volumes 24 and 26. Because the time during which valve mechanism 36 is in the dispensing position or state is relatively short in duration, liquid receiver 14 is also subjected to such relatively high pressures for a short time. As a result, liquid receiver 14 is largely protected from wear or other damage which might otherwise result from prolonged exposure of liquid receiver 14 to such relatively high pressures.

[0021] Figure 3 schematically illustrates another liquid handling system (shown as liquid marking system 100) according to an example embodiment. Liquid marking system 100 is configured to print or mark a substrate, surface or print media using liquid. Liquid marking system 100 includes liquid supplies 102C, 102M, 102Y and 102B (collectively referred to as liquid supplies 102), liquid dispensing systems 110C, 110M, 110Y and 110B (collectively referred to as liquid dispensing systems 110), actuators 112C, 112M, 112Y and 112B (collectively referred to as actuators 112), liquid receivers 114C, 114M, 114Y and 114B (collectively referred to as liquid receivers 114), sensors 116C, 116M, 116Y and 116B (collectively referred to as sensors 116) and controller 118.

[0022] Liquid supplies 102 comprise self pressurized containers of liquid to be used by liquid receivers 114. In the example illustrated, liquid supplies 102 comprise containers having internal volumes at least partially filled with the liquid and pressurized using one or more propellants such as those employed in aerosol can industry. In one embodiment, liquid supplies 102 contain non-aerosol liquids or liquids which have a composition such that the liquids do not atomize or flash at atmospheric pressure.

[0023] According to one embodiment, liquid supplies 102 contain and supply liquid inks for use by liquid receivers 114. In the example illustrated, system 100 includes four liquid supplies containing different colors or shades of ink. In particular, system 100 includes liquid supply 102C containing cyan colored ink, liquid supply 102M containing magenta colored ink, liquid supply 102Y containing yellow colored ink and liquid supply 102B containing black ink. Because system 100 includes at least liquid supplies 102C, 102Y and 102M, three primary printing colors, system 100 is able to print a wide variety of colors and shades using half-toning and other color printing techniques.

[0024] In other embodiments, system 100 may include greater or fewer of such supplies 102 supplying the same or different liquids. For example, in other embodiments, system 100 may additionally include a fixer liquid. In other embodiments, system 100 may include additional supplies 102 supplying a light cyan and a light magenta liquid ink or additionally supplying another black ink, such as when one of the black inks is a pigment-based ink. and the other black ink is a dye-based ink. In another embodiment, system 100 may include a set of other primary ink colors such as red ink, blue ink and green ink. In another embodiment, supplies 102 may supply other liquids which are not necessarily inks.

[0025] Liquid dispensing systems 110 are substantially identical to liquid dispensing system 10 shown in Figures 1 and 2. Each of liquid dispensing systems 110 includes volumes 24, 26, partition 28, movable member 30, passage 32, passage 34 and valve mechanism 36 shown in Figures 1 and 2. Volume 26 of each of liquid dispensing systems 110 is connected to one of liquid receivers 114 via passage 34. Volume 24 of each liquid dispensing system 110 is connected to the interior of an associated one of liquid supplies 102. As a result, volume 24 of each liquid dispensing system 110 is pressurized with liquid and propellant contained in the associated liquid supply 102.

[0026] In the example illustrated, each liquid dispensing system 110 is coupled to an associated one of liquid supplies 102 such that each liquid dispensing system 110 and its associated liquid supply 102 forms an independent module or independent unit. As an independent unit, each liquid dispensing system 110 and its associated liquid supply 102

remain connected to one another when dispensing system 110 is disconnected from the associated liquid receiver 114. The independent unit may be transported, sold, distributed, held and inventoried as a single independent unit. Each liquid dispensing system 110 serves as a top or a cap for the container of the associated liquid supply 102. In such an embodiment, passage 34 may include an additional cap or septum which closes off passage 34 until the independent unit is connected to an associated liquid receiver 114.

[0027] In other embodiments, each liquid dispensing system 110 may be provided as part of a liquid receiver station, wherein each liquid dispensing system 110 remains connected to any part of the liquid receiving station even when liquid supplies 102 are separated and disconnected from liquid receivers 114. In such an embodiment, volume 24 may include a valve or septum which closes off volume 24 until volume 24 is connected to a liquid supply 102. In another embodiment, the supply 102 may include a discharge port or opening having a valve, septum or cap which closes off the interior of the liquid supply 102 until the liquid supply 102 is connected to volume 24.

[0028] Like liquid dispensing system 10, each of liquid dispensing systems 110 meters liquid with enhanced consistency and predictability without the complexity and cost associated with other liquid pumping systems. In particular, liquid dispensing systems 110 utilize the force or pressure in their associated supplies 102 to push the non-aerosol liquid to their associated liquid receivers 114. As a result, additional manual or electric powered pumps may be omitted.

[0029] Actuators 112 comprise mechanisms configured to move valve mechanism 36 between the non-dispensing position shown Figure 1 and the dispensing position shown in Figure 2. Actuators 112 are configured to operate independent of one another so as to independently actuate dispensing system 110 between dispensing and non-dispensing states. As a result, actuators 112 may control dispensing systems 110 so as to differently deliver liquid to liquid supplies 114 based upon the liquid demands of liquid supplies 114. In one embodiment, actuators 112 each comprise an electric motor such as a DC electric motor and associated cam or worm screw. In other embodiments, actuators 112

may comprise electric solenoids or other powered actuators which are configured to actuate valve mechanism 36 in response to control signals from controller 118.

[0030] Liquid receivers 114 utilize the liquid from liquid supplies 102 and dispensed or metered by dispensing systems 110. In the example illustrated, liquid receivers 114 eject the liquid onto a surface, substrate or print medium so as to mark the print medium with the liquid. In one embodiment, each of liquid receivers 114 is a drop-on-demand inkjet printing device. In one embodiment, each of liquid receivers 114 is a thermal resistive inkjet printing device. In another embodiment, each of liquid receivers 114 is a piezo resistive inkjet printing device. In the example illustrated, system 100 includes four liquid receivers 114. In other embodiments, system 100 may alternatively include a greater or fewer of such liquid receivers 114.

[0031] In the example illustrated, each of receivers 114 comprises a delivery tube 180, distribution tubes 182 and marking devices 184. In particular, receiver 114C includes delivery tube 180C, distribution tubes 182C1, 182C2, and marking devices 184C1, 184C2. Receiver 114M includes delivery tube 180M, distribution tubes 182M1, 182M2, and marking devices 184M1, 184M2. Receiver 114Y includes delivery tube 180Y, distribution tubes 182Y1, 182Y2, and marking devices 184Y1, 184Y2. Receiver 114B includes delivery tube 180B, distribution tubes 182B1, 182B2, and marking devices 184B1, 184B2.

[0032] Each of delivery tubes 180C, 180M, 180Y and 180B (collectively referred to as delivery tubes 180) extends from the passage 34 of the associated liquid delivery system 110 and is connected to the two associated distribution tubes 182. For example, delivery tube 180C is connected to each of distribution tubes 182C1 and 182C2. Distribution tubes 182 branch off of their associated delivery tube 180 to deliver liquid to each of the associated marking devices 184 of the liquid delivery device 114. For example, distribution tubes 182C1 and 182C2 branch off of delivery tube 180 and deliver liquid to marking devices 184C1 and 184C2, respectively.

[0033] Each of the other liquid receivers 114 has the same arrangement. In particular, distribution tubes 182M1 and 182M2 branch off of delivery tube 180M and deliver liquid

to marking devices 184M1 and 184M2, respectively. Distribution tubes 182Y1 and 182Y2 branch off of delivery tube 180Y and deliver liquid to marking devices 184Y1 and 184Y2, respectively. Distribution tubes 182B1 and 182B2 branch off of delivery tube 180B and deliver liquid to marking devices 184B1 and 184B2, respectively. Although each liquid receiver 114 is illustrated as including two distribution tubes 182 branching off of the delivery tube 180 to deliver liquid to two marking devices 184, in other embodiments, each liquid receiver 114 may include additional distribution tubes and additional marking devices. In other embodiments, where each delivery system 114 includes a single marking device, distribution tubes 182 may be omitted, wherein delivery tube 180 is directly connected to the individual marking device 184.

[0034] As noted above, system 100 utilizes the pressure supplied by liquid supplies 102 to force or push liquid from supplies 102 through dispensing systems 110 and to liquid receivers 114. System 100 further utilizes the pressure supplied by liquid supplies 102 to force or push liquid through delivery tubes 180 and distribution tubes 182. As a result, reliance upon additional pumps for moving such liquid to marking devices 184 may be reduced or even eliminated. In the example illustrated, liquid supplies 102 have a relatively high level of pressure. In one embodiment, liquid supplies 102 include a propellant which pressurizes the liquid as it flows from the supplies 102 to marking devices 184. In one embodiment, the liquid in supply 102 is pressurized by the pressure of at least 30 psi (pounds per square inch) and nominally about 70 PSI.

[0035] Because system 100 utilizes relatively high pressure provided by liquid supplies 102, flow losses are reduced. As a result, delivery tubes 180 may be provided with a much smaller diameter. Because delivery tubes 180 may be provided with a smaller diameter, delivery tubes 180 may be bent to make sharper angle turns and are more flexible. This allows system 100 to have a more compact architecture or arrangement. In embodiments where marking devices 184 are carried by a carriage and scanned or moved back and forth across a surface being printed upon, the reduced diameter and greater flexibility of delivery tubes 180 further facilitates movement of the carriage with less

resistance, reducing energy consumption and/or permitting use of smaller or less expensive motors or other carriage drive systems.

[0036] According to one embodiment, a diameter of delivery tube 180 which would otherwise be utilized for delivering liquid at a pressure of about 5 psi is reduced by 75%. According to one embodiment, delivery tubes 180 each have a diameter of less than or equal to 4 mm and nominally less than or equal to 1 mm. In other embodiments, the diameter of delivery tubes 180 may have other values depending upon the length of delivery tubes 180 and the amount or rate which liquid is supplied to marking devices 184.

[0037] Distribution tubes 182 branch off from delivery tubes 180 and have a larger diameter as compared to delivery tubes 180. As a result, the pressure and rate at which liquid is supplied to marking devices 184 is more uniform. In other words, there is less variance between the amount or rate at which liquid is supplied to the two or more marking devices 184 supplied with liquid through the same individual delivery tube 180. In other embodiments, tubes 182 may each have a diameters similar to those of delivery tubes 180.

[0038] Marking devices 184 eject the liquid onto a surface, substrate or print medium so as to mark the print medium with the liquid. In one embodiment, each of marking devices 184 is a drop-on-demand inkjet print head. In one embodiment, each of marking devices 184 is a thermal resistive inkjet print head. In another embodiment, each of marking devices 184 is a piezo resistive inkjet print head. In the example illustrated, each marking device 184 includes a single print head. In other embodiments, each marking device 184 may alternatively include a greater number of print heads.

[0039] Sensors 116 comprise devices configured to sense or detect when liquid for marking devices 184 should be replenished. In the example illustrated, each sensor 116 is located so as to sense the pressure of liquid already dispensed to liquid receivers 114 by dispensing system 116. In particular, each sensor 116 is located between the inlet of passage 34 of the associated dispensing system 110 and the one or more print heads of the associated marking device 184. As liquid is consumed by marking devices 184, the

pressure within delivery tubes 180 and any volume between the inlet of passage 34 and the one or more print heads of marking device 184 will fall. Each sensor 116 is located and configured to sense this fall in pressure. The falling pressures are communicated to controller 118. Although each of sensors 116 is illustrated as being along passage 34 of each associated dispensing system 110, in other embodiments, each of sensors 116 may be provided at other locations such as along delivery tubes 180, along distribution tubes 182 or proximate to the internal chamber adjacent to the one or more print heads of marking devices 184. In yet other embodiments, sensors 116 may be omitted or other devices may be utilized to determine when dispensing system 110 should be actuated to a dispensing state to dispense liquid to liquid receivers 114 or how many liquid actuations or shots (individual actuations between the dispensing and non-dispensing state) should be made.

[0040] Controller 118 comprises one or more processing units configured to generate control signals which direct actuators 112 to actuate dispensing systems 110 between the non-dispensing state and the dispensing state. In some embodiments, controller 118 may be configured to generate control same as directing other operations as well, such as the operation of marking devices 184. For purposes of this application, the term “processing unit” shall mean a presently developed or future developed processing unit that executes sequences of instructions contained in a memory. Execution of the sequences of instructions causes the processing unit to perform steps such as generating control signals. The instructions may be loaded in a random access memory (RAM) for execution by the processing unit from a read only memory (ROM), a mass storage device, or some other persistent storage or computer readable medium. In other embodiments, hard wired circuitry may be used in place of or in combination with software instructions to implement the functions described. For example, controller 118 may be embodied as part of one or more application-specific integrated circuits (ASICs). Unless otherwise specifically noted, the controller is not limited to any specific combination of hardware circuitry and software, nor to any particular source for the instructions executed by the processing unit.

[0041] In operation, during marking or printing, sensors 116 continuously or periodically senses the pressure of liquid available to marking devices 184. The sensed pressures are communicated to controller 118. When the sensed pressure falls below a predetermined threshold, controller 118 generates control signals directing actuator 112 to actuate valve mechanism 36 from the non-dispensing position shown in Figure 1 to the dispensing position shown in Figure 2. As a result, a predefined amount or dosage of liquid is ejected under pressure through passage 34 to the particular liquid receiver 114. After pre-determined amount of time has elapsed, controller 118 generates control signals directing one more actuators 112 to return the valve mechanism 36 back to its original non-dispensing position shown in Figure 1. In one embodiment, the return may be initiated by the cessation of power to actuator 112, wherein a bias member, such as a spring, resiliently returns valve mechanism 36 to the default non-dispensing position shown in Figure 1. As a result, dispensing system 110 provides its associated receiver 114 with a predefined precise amount of liquid. If the sensed pressure at the end of an actuation from a non-dispensing state to a dispensing state (a liquid dose or shot) is still not above the predetermined threshold, additional shots or doses are completed.

[0042] In one embodiment, controller 118 may additionally count the number of actuations or doses to monitor the amount of liquid consumed by the particular liquid receiver 114 or the remaining amount of liquid in the associated liquid supply 102. When the pressure of liquid sensed by sensor 116 remains below the predetermined threshold despite the delivery of one or more dosages of liquid, controller 118 may determine that the particular liquid supply 102 is out of ink or liquid and needs replacement or refilling. In one embodiment, to blow prime nozzles of marking device 184, controller 118 may additionally generate control signals directing one or more of the dispensing systems 110 to deliver more dosages or liquid shots just to push the liquid out of the nozzles. In such an embodiment, back pressure within the receiver 184 may be reset by spitting of liquid through such nozzles.

[0043] Figures 4 and 5 illustrate dispensing system 210, a particular embodiment of dispensing systems 10 and 110. In one embodiment, dispensing system 210 is utilized in

place of the illustrated dispensing system 110 in Figure 3. Like dispensing systems 10 and 110, dispensing system 210 delivers a relatively precise and controlled volume or amount of liquid to a liquid receiver utilizing pressure provided by a liquid supply. Dispensing system 210 includes chamber or volume 224, chamber or volume 226, movable member 230, passage 232, passage 234 and valve mechanism 236.

[0044] Volume 224 comprises an internal enclosure formed by one of more structures 240 and is configured to be pressurized with a liquid and a propellant. In one embodiment, volume 224 comprises an entire container containing all of the liquid to be dispensed by system 210. In another embodiment, volume 224 comprises a volume configured to be connected to a larger volume, such as a separate container, containing liquid to be dispensed. For example, in one embodiment, volume 224 may be part of a cap or module configured to be mounted upon an existing self pressurized container containing a propellant and a non-aerosol liquid.

[0045] Volume 226 comprises an internal enclosure formed by one or more structures 242 and separated or isolated from volume 224 when passage 232 is closed. In the example illustrated, structures 240 and 242 comprise substantially solid structures having recesses, depressions or bores forming volumes 224 and 226 as well as passage 232. The structures 240 and 242 abut one another to sandwich and capture movable member 230 between structures 240 and 242 and between volumes 224 and 226 to isolate volume 224 from volume 226 when passage 232 is closed. Because structures 240 and 242 sandwich or capture movable member 230, movable member 230 is securely retained in place and fabrication of system 210 is less complex and costly. In other embodiments, the formation of volumes 224 and 226 and the retention of movable member 230 may be achieved in other manners.

[0046] Movable member 230 comprises one or more members extending between volumes 224 and 226 and in contact with the liquids and/or propellants in the interiors of volumes 224 and 226. Movable member 230 is configured to move in response to pressure differentials between a pressure of volume 224 and a pressure of volume 226. In

particular, movable member 230 is configured to move or reposition itself to change or adjust a size of at least volume 226.

[0047] In the embodiment illustrated, movable member 230 comprises a flexible diaphragm. The diaphragm is flexible so as to resiliently flex or stretch in response to pressure differentials across the flexible diaphragm of movable member 230. In another embodiment, movable member 230 may comprise a wall, flexible or inflexible, movably supported by a flexible sleeve, skirt or bellows. In still another embodiment, movable member 230 may comprise a piston sealed within and against a tube or bore and movable within the tube or bore in response to pressure differentials on opposite sides of the piston. In still other embodiments, movable member 230 may pivot in response to pressure differentials between volumes 224 and 226, wherein such movement adjusts a size of volume 226. In the embodiment illustrated, movable member 230 comprises a single diaphragm extending between and directly adjacent to both volumes 224 and 226. In yet another embodiment, movable member 230 comprises multiple elements disposed between volumes 224 and 226. For example, in one embodiment, movable member 230 may comprise a first diaphragm adjacent volume 224, a second diaphragm adjacent volume 226 and an intermediate spacer member between the pair of diaphragms.

[0048] Passage 232 comprises an opening, port, conduit and the like providing liquid flow or liquid communication between volumes 224 and 226. Passage 232 is configured to be selectively opened and closed by valve mechanism 36. Although passage 232 is illustrated as comprising aligned bores in structures 240 and 242, in other embodiments, passage 232 may comprise a conduit extending around the structures 240 and 242.

Although passage 232 is illustrated as being completely unobstructed, in other embodiments, one or more filtering devices may be positioned across passage 232 to filter liquid as it flows through passage 232.

[0049] Passage 234 comprises an opening, port, conduit or the like providing liquid flow from volume 226 or to the exterior of volume 226 to a location or volume at a lower pressure as compared to the pressure within volume 224. Passage 234 is configured to be selectively opened and closed by valve mechanism 236. Passage 234 includes an inlet

245 configured to connect passage 234 to volume 226 and an outlet 247 configured to connect passage 234 to a liquid receiver such as liquid receiver 14 or liquid receiver 114. In some embodiments, passage 234 is completely unobstructed. In other embodiments, passage 34 may include one more filters to filter liquid as it flows through passage 34. In one embodiment, passage 234 is opened by valve mechanism 236 in response to a demand for liquid by liquid receiver 214. In one embodiment, the liquid within volume 226 is pressurized at least partially provided by a propellant. When passage 234 is opened, liquid within volume 226 flows under pressure into passage 234.

[0050] Valve mechanism 236 comprises one or more valve members configured to selectively open and close passages 232 and 234. In the embodiment illustrated, valve mechanism 236 comprises one or more valve members configured to concurrently open passage 232 while closing passage 234 or close passage 232 while opening passage 234. In one embodiment, valve mechanism 236 comprises a single valve member which moves between a first position in which the member closes passage 232 and opens passage 234 and a second position in which the same member closes passage 232 and opens passage 234.

[0051] In the example illustrated, valve mechanism 236 includes seal 270, shuttle pin 272, bias 274 and lever 276. Seal 270 comprises a mechanism along volume 226 configured to seal off or close inlet 245 of passage 234 from volume 226 when inlet 245 of passage 234 is positioned across from or on opposite side of seal 270 as volume 226. In one embodiment, seal 270 comprises one or more elastomeric or compressible o-rings. In other embodiments, seal 270 may comprise a gasket or other sealing members.

[0052] Shuttle pin 272 comprises a shaft having an axial inner bore forming passage 234 and a radial bore or opening extending from passage 234 so as to form inlet 245. Shuttle pin 272 further includes a seat 280 configured to be positioned within or against passage 232 so as to close passage 232 between volumes 224 and 226. As shown by Figures 4 and 5, shuttle pin 272 is movably supported by structures 240 and 242 so as to move between (1) a non-dispensing position shown in Figure 4 in which inlet 245 is closed by seal 270 and which valve seat 280 is withdrawn from passage 232 and (2) a

dispensing position shown a Figure 5 in which inlet 245 is lowered below seal 270 so as to be connected to volume 226 and in which valve seat 280 is positioned within passage 232 so as to close passage 232.

[0053] Bias 274 resiliently biases or urges shuttle pin 272 towards the non-dispensing position shown in Figure 4. As a result, shuttle pin 272 automatically returns to and is maintained at the non-dispensing position shown in Figure 4 when external forces are not being applied to lever 276 by an actuator. In embodiments where dispensing system 210 is provided as part of a liquid supply, such as one of liquid supplies 102, separation or removal of the liquid supply 102 from a liquid receiver, such as a printer, will result in valve mechanism 236 automatically returning to a non-dispensing position.

[0054] In the example illustrated, bias 274 comprises a compression spring captured between structure 240 and a circumferential shoulder of shuttle pin 272. In other embodiments, bias 274 may comprise other types of springs and may be operably coupled to shuttle pin 272 in other locations and manners. In other embodiments, bias 274 may be omitted where an actuator, such as actuator 112 shown in Figure 3, moves shuttle pin 272 to both the non-dispensing position and the dispensing position.

[0055] Lever 276 comprises a member connected to structure 240 for pivotal movement about axis 284. Lever 276 is configured to transmit force to shuttle pin 272 against bias 274 so as to move shuttle pin 272 from the non-dispensing position shown in Figure 4 to the dispensing position shown in Figure 5. Lever 276 provides a lever arm such that a lower level of force may be used to move shuttle pin 272 against the force of bias 274. In operation, lever 276 is pivoted about axis 284 to the position shown in Figure 5 by an actuator, such as actuator 112 shown and described with respect to Figure 3.

[0056] Figures 4 and 5 illustrate operation of liquid dispensing system 210. Figure 4 illustrates system 210 in a default, at rest state when dispensing system 210 is not dispensing or releasing liquid. In the at rest state, biased 274 moves shuttle pin 272 so as to withdraw seat 280 from passage 232 and so as to close inlet 245 of passage 234. As a

result, as indicated by arrows 290, liquid in volume 224 flows through passage 232 into volume 226 to create pressure equilibrium on opposite sides of movable member 230.

[0057] Figure 5 illustrates liquid dispensing system 210 in a liquid dispensing state. In response to a demand or request for liquid from a liquid receiver, an actuator, such as actuator 112 shown in Figure 3, depresses lever 276 to move shuttle pin 272 to the dispensing position. In one embodiment, an actuator such as electric motor or solenoid moves one or more valve seats of valve mechanism 36 to the dispensing position or positions. In the dispensing position, seat 280 closes off passage 232 while inlet 245 is positioned in connection with volume 226 such that liquid may flow from volume 226 into and through passage 234. Because passage 234 and the liquid receiver connected to passage 234 are at a pressure less than the pressure of the liquid within volume 226, the liquid within volume 226 flows under pressure into the now open passage 234 as indicated by arrow 292. As a result, the initial discharge of liquid from volume 226 into passage 234 reduces pressure within volume 226. This creates a pressure differential across movable member 230. In particular, the pressure within volume 224 is greater than the pressure within volume 226 and the open passage 234. This pressure differential is schematically represented by arrows 294 on the side of movable member 230 adjacent volume 224.

[0058] The pressure differential across movable member 230 exerts a force upon movable member 230 so as to move or displace movable member 230 in a manner so as to increase the space or volume of volume 224 while decreasing the space or volume of volume 226. In the example illustrated, movable member 230 moves in the direction indicated by arrow 296 further into an expansion chamber 298 of volume 226, increasing the volume of volume 224 and decreasing the volume of volume 226. The extent to which movable member 230 moves is limited by the size of expansion chamber 298 which extends opposite to movable member 230. As a result, expansion member 230 provides an uppermost limit to the size of the dosage. Multiple actuations of valve mechanism 36 between the non-dispensing state and the dispensing state results in multiple doses of the size of expansion chamber 298. As a result, the metering or dosing

of liquid occurs in a "digital" fashion wherein a metered dose volume is discharged or released substantially independent of the speed at which valve mechanism 236 is actuated between the different positions or states. Thus, system 210 meters liquid with enhanced consistency and predictability. This enhanced metering of liquid enables system 210 to provide greater control over the amount of liquid delivered to a liquid receiver and to also better track remaining amounts of unused liquid or liquid that has not been dispensed.

[0059] Although the present disclosure has been described with reference to example embodiments, 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 embodiments may have been described as including one or more 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 embodiments or in other alternative embodiments. 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 embodiments 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.

WHAT IS CLAIMED IS:

- 1 1. A liquid handling system comprising:
2 a first volume (24, 224) adapted to be pressurized with a liquid and a
3 propellant;
4 a second volume (26, 226);
5 a movable member (30, 230) between the first volume (24, 224) and the
6 second volume (26, 226) and configured to move in response to a pressure differential
7 between the first volume (24, 224) and the second volume (26, 226);
8 a first passage (32, 232) between and connecting the first volume (24, 224)
9 and the second volume (26, 226);
10 a second passage (34, 234) between and connecting the second volume
11 (26, 226) to the liquid receiver (14, 114); and
12 a valve mechanism (36, 236) actuatable between a first state in which the
13 first passage (32, 232) is closed and the second passage (34, 234) is open and a second
14 state in which the first passage (32, 232) is open and the second passage (34, 234) is
15 closed.
- 1 2. The liquid handling system of claim 1, wherein the movable member (30,
2 230) comprises a flexible diaphragm.
- 1 3. The liquid handling system of any of claims 1 and 2, wherein the valve
2 mechanism (236) comprises:
3 a shaft (272) comprising:
4 a seat (280) configured to selectively open and close the first passage (32,
5 232); and
6 the second passage (34, 234) having an inlet port (245); and
7 a seal (270), wherein the shaft (272) is movable between the first position
8 in which the seat closes the first passage (32, 232) and in which the inlet port (245) is
9 connected to the second volume (26, 226) and a second position in which the seat (280) is

10 withdrawn from the first passage (32, 232), opening the first passage (32, 232), and in
11 which the inlet port (245) is isolated from the second volume (26, 226) by the seal (270),
12 closing the second passage (34, 234).

1 4. The liquid handling system of claim 3, wherein the shaft (272) is
2 resiliently biased towards the first position.

1 5. The liquid handling system of any of claims 1-4 further comprising a
2 container (102) having an interior filled with liquid and propellant, wherein the interior is
3 fluidly connected to the first volume (24, 224).

1 6. The liquid handling system of claim 5, wherein the liquid has a
2 composition such that the liquid does not atomize at atmospheric pressure.

1 7. The liquid handling system of any of claims 5 and 6, wherein the liquid
2 comprises a marking liquid.

1 8. The liquid handling system of claim 7, wherein the liquid has a color
2 selected from a group of colors consisting of: red, green, blue, cyan, magenta, yellow,
3 black and shades thereof.

1 9. The liquid handling system of any of claims 1-8 further comprising the
2 liquid receiver (14, 114), wherein the liquid receiver (14, 114) comprises:
3 a first marking device (184) configured to mark using liquid; and
4 a first liquid tube (182) connected to the second passage (34, 234) and the
5 first marking device (184).

1 10. The liquid handling system of claim 9, wherein the liquid receiver (14,
2 114) further comprises:
3 a second marking device (184) configured to mark using the liquid;
4 a second liquid tube (182) connected to the second passage (34, 234) and
5 the second marking device (184); and

6 a third tube (180) connected between the second passage (34, 234) and
7 each of the first tube (182) and the second tube (182), wherein the first tube (182) and the
8 second tube(182) have a first diameter and a second diameter, respectively and wherein
9 the third tube (180) has a third diameter smaller than each of the first diameter and the
10 second diameter.

1 11. The liquid handling system of any of claim 1-2, wherein the movable
2 member (30, 230) comprises a flexible diaphragm and wherein the valve mechanism
3 comprises:

4 a shaft (272) comprising:

5 a seat (280) configured to selectively open and close the first passage (32,
6 232); and

7 the second passage (34, 234) having an inlet port (245); and

8 a seal (270), wherein the shaft (272) is movable between the first position
9 in which the seat (280) closes the first passage (32, 232) and in which the inlet port (245)
10 is connected to the second volume (26, 226) and a second position in which the seat (280)
11 is withdrawn from the first passage (32, 232), opening the first passage (32, 232), and in
12 which the inlet port (245) is isolated from the second volume (26, 226) by the seal (270),
13 closing the second passage (34, 234).

1 12. The liquid handling system of claim 11 further comprising a container
2 (102) having an interior filled with liquid and propellant, wherein the interior is fluidly
3 connected to the first volume (24, 224).

1 13. The liquid handling system of claim 12 wherein the liquid has a color
2 selected from a group of colors consisting of: red, green, blue, cyan, magenta, yellow,
3 black and shades thereof.

1 14. The liquid handling system of any of claims 1-4 further comprising:
2 a container (102) having an interior filled with liquid and propellant,
3 wherein the interior is fluidly connected to the first volume (24, 224); and

4 the liquid receiver (14, 114), wherein the liquid receiver (14, 114)
5 comprises:
6 a first marking device (184) configured to mark using liquid; and
7 a first liquid tube connected to the second passage (34, 234) and the first
8 marking device (184).

1 15. A method comprising:
2 supplying liquid and propellant at a first pressure from a first volume (24,
3 224) on a first side of a movable member (30, 230) to a second volume (26, 226) on a
4 second side of the movable member (30, 230); and
5 disconnecting the first volume (24, 224) from the second volume (26, 226)
6 while connecting the second volume (26, 226) to a liquid receiver (14, 114) at a second
7 pressure lower than the first pressure to create a pressure differential across the movable
8 member (30, 230) to move the movable member (30, 230) such that the movable member
9 (30, 230) forces liquid to the liquid receiver (14, 114).

1/3

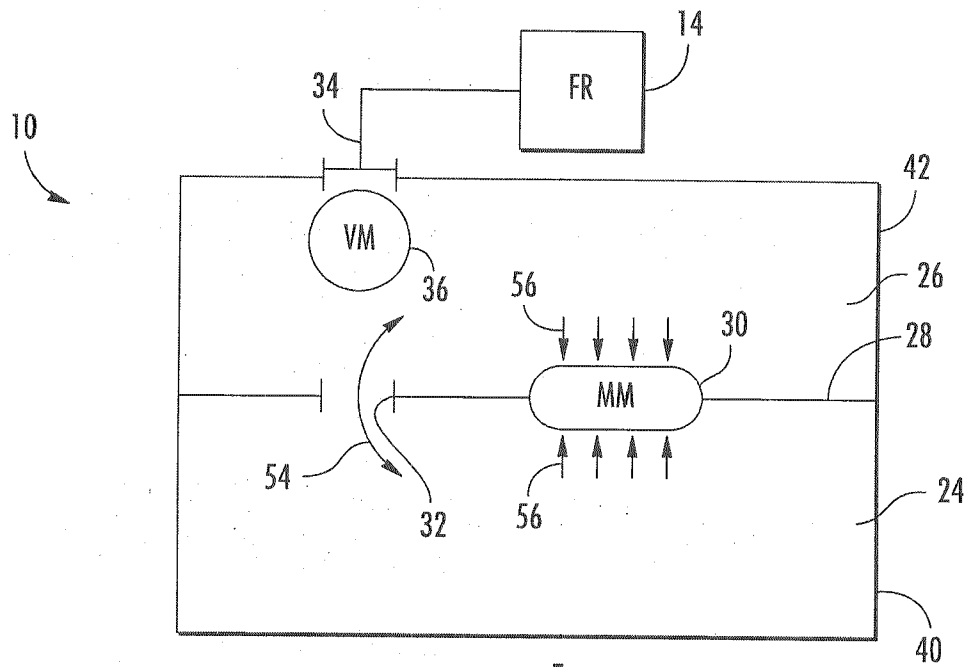


FIG. 1

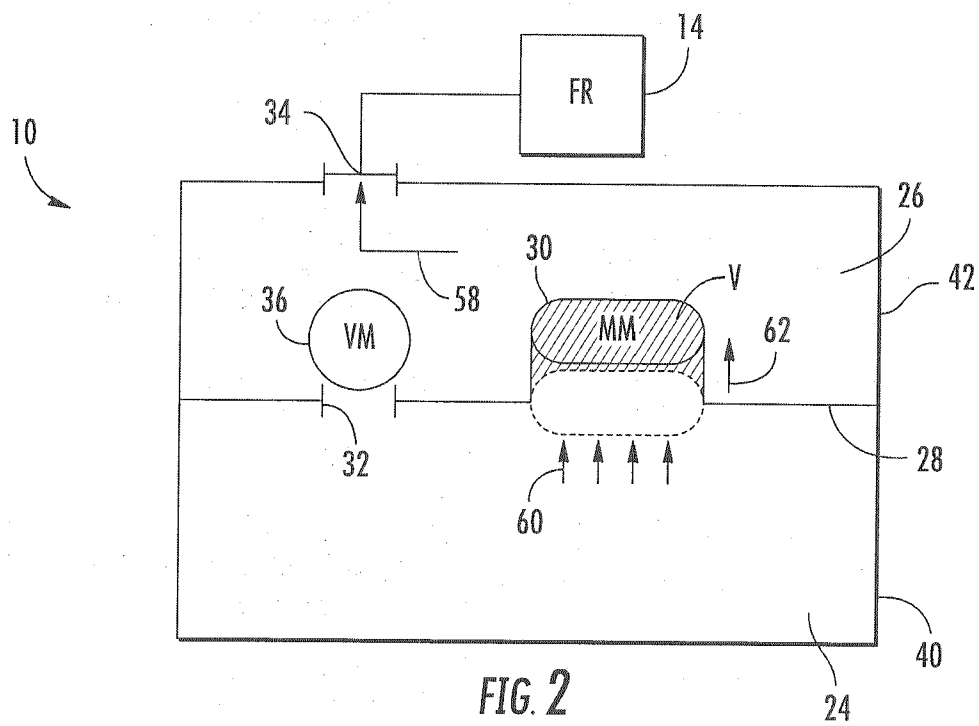
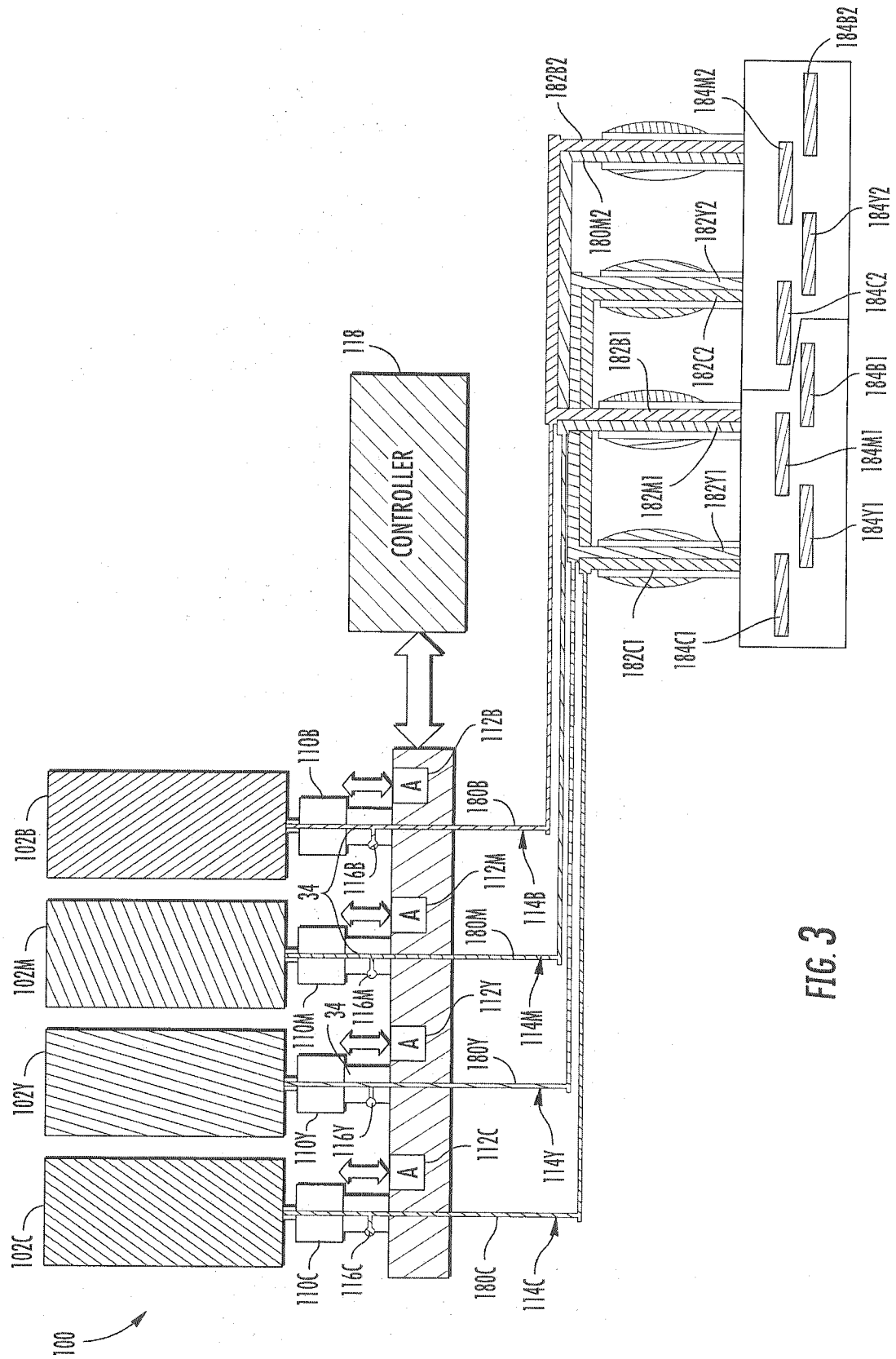


FIG. 2



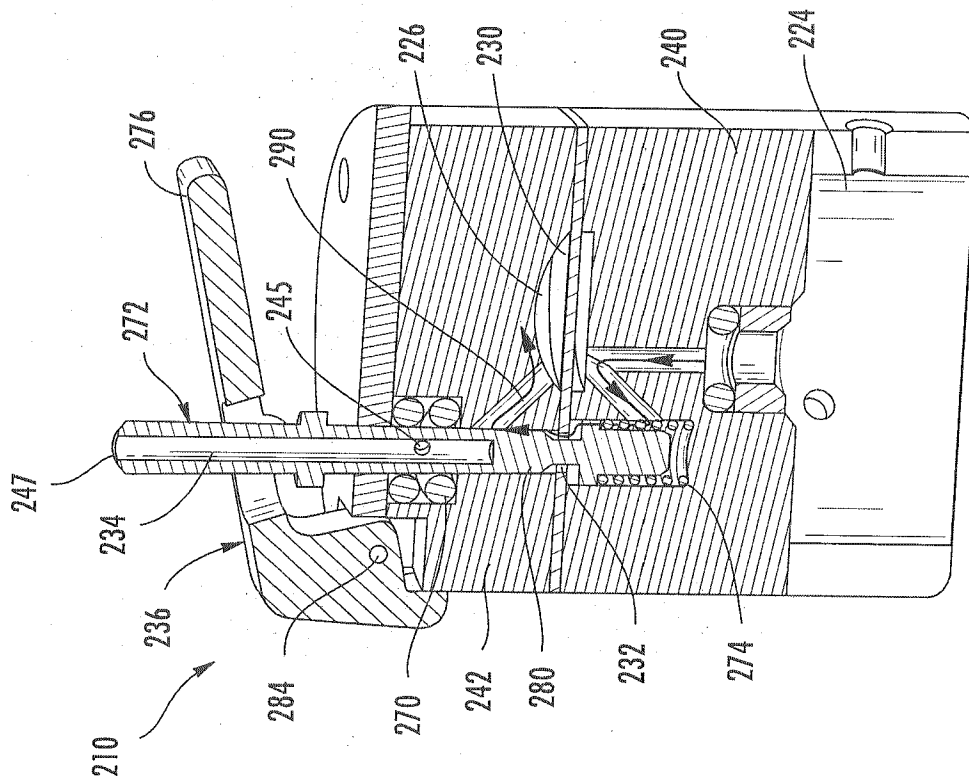


FIG. 4

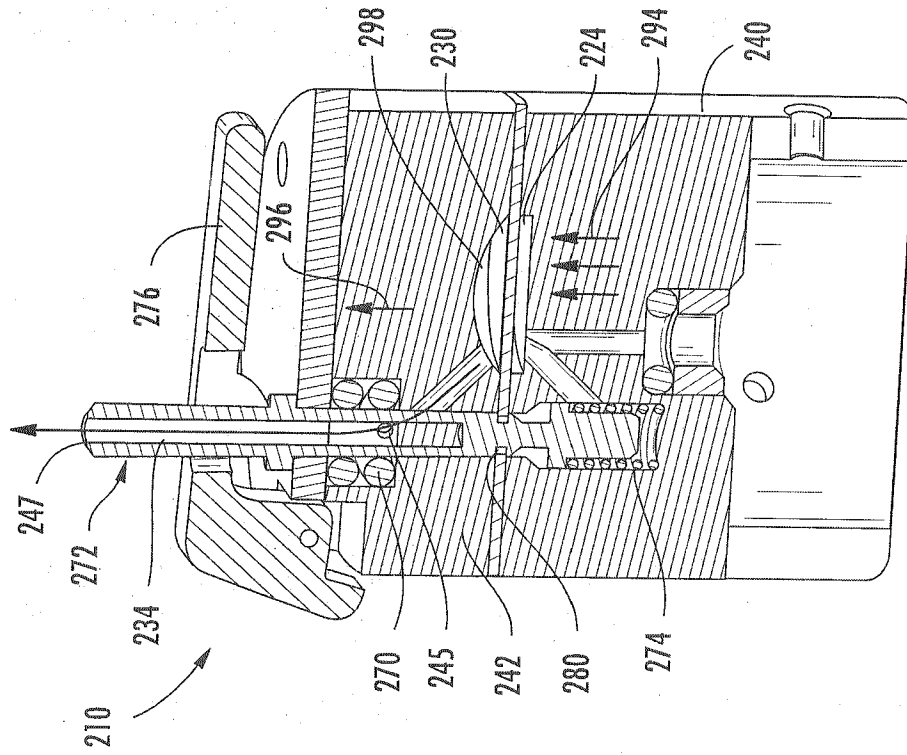


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2009/037875**A. CLASSIFICATION OF SUBJECT MATTER****B41J 2/175(2006.01)i**

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)

IPC

B41J 2/175, B65D 83/14, B01F 15/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Utility models and applications for Utility models since 1975

Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

D/B : eKOMPASS(KIPO internal)

KEY WORD : liquid, membrane, pressure

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 04433797 A1 (GALIA) 28 February 1984 See figures 1 and 2, and column 3, line 46 - column 4, line 45.	1, 2, 15
A	US 05213129 A (SOMEAH et al.) 25 May 1993 See abstract, figure 1 and column 3, line 9 - column 4, line 20.	1-4, 11-13, 15
A	US 04950134 A (BAILEY et al.) 21 August 1990 See figure 1 and column 2, line 11 - column 3, line 35.	1-4, 11-13, 15
A	US 06021925 A (GASHGAEE et al.) 8 February 2000 See abstract, figure 1 and column 3, lines 21-59.	1-4, 11-13, 15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent 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 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

29 SEPTEMBER 2009 (29.09.2009)

Date of mailing of the international search report

30 SEPTEMBER 2009 (30.09.2009)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2009/037875**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 5-10, 14
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2009/037875

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