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(54) **METHOD AND APPARATUS FOR CONTROLLING FLUID FLOW**

VERFAHREN UND VORRICHTUNG ZUR STEUERUNG EINES FLÜSSIGKEITSFLUSSES

MÉTHODE ET APPAREIL DE CONTRÔLE DE L'ÉCOULEMENT DE FLUIDE

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(73) Proprietor: **Drummond Scientific Company**
Broomall, PA 19008 (US)

(72) Inventor: **KENNEY, James, W.**
Broomall, PA 19008 (US)

(74) Representative: **Dunleavy, Kevin James et al**
Mendelsohn Dunleavy, P.C.
p/o De Vries & Metman
Overschiestraat 180
1062 XK Amsterdam (NL)

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Description

Field of the Invention

[0001] The present invention relates to an apparatus and method for controlling fluid flow.

Background of the Invention

[0002] Devices that control both negative (vacuum) and positive (pressure) fluid flow are known in the prior art. Such devices typically include a bi-directional pump, such as a diaphragm pump, having both a pressure port and a vacuum port. The pump includes a plurality of internal, mechanical valves (usually flap type) that cyclically open and close to create sustained negative fluid flow at the vacuum port and sustained positive fluid flow at the pressure port.

[0003] To control bi-directional fluid flow through a common utility port, it is known to connect the pressure and vacuum ports of the pump to a second mechanical valve, which selectively connects in fluid communication the common utility port with one of either the pressure or vacuum ports of the pump. The valve is controlled by an operator to selectively create either vacuum or pressure at a downstream utility port. An operator may control the valve by, for example, depressing one of either a positive or negative pressure trigger. An example of a bi-directional, fluid-flow device is a laboratory pipetting device that admits and emits fluid to a disposable pipette. EP 1 531 004 A2 discloses a fluid dispensing system that indirectly measures fluid flow by using a non-linear system model to correlate vacuum existing at the top of a column of suspended fluid. The fluid dispensing system comprises an electronic controller within a gun-shaped, cordless self-contained pipetter housing capable of dynamically calculating valve opening time based on a non-linear equation. U.S. Patent No. 4,475,666 discloses a servo controlled actuator for an automated liquid dispenser including at least one reciprocable syringe, valving and a syringe actuator driven by a hybrid servo control. The actuator has a bi-directional variable speed motor and an encoder. A microprocessor controls the operation of the dispenser. U.S. Patent No. 3,835,874 discloses a method of introducing accurately measured doses of liquid into a product by the use of apparatus which includes a measuring cylinder, a fluid-tight piston movable therein to selected heights to measure out a dose of selected variable size and means to force the liquid into a discharge line leading to the product by applying force to the piston in the direction of the opening into the discharge line. US 2005/079079 discloses a dilutor that has a control interface to receive control signals and a block having an orifice. The dilutor has a single piston at least partially within the block, a motor and drive configured to automatically move the single piston, and a first valve coupled to the orifice. US 2004/050861 discusses a pipette system comprising a pipette capillary tube and an actuator, with the actuator serving to set the position of a phase boundary between a system medium and a second medium in the pipette capillary and with a sensor element being provided for measuring the position of the phase boundary in such a way that the actuator is controlled by a regulating element in response to an output signal from the sensor element. WO 2005/035126 discloses a pipette device comprising a plurality of multichannels which are arranged in one or several rows and columns and which are connected to the tip of a pipette on the end side thereof. At least one separate micromembrane pump is associated with each pipette channel for dosed suction or discharge of fluids, said pump consisting of several disk-type microstructures which are placed on top of each other and between which a pump chamber is formed and wherein one of which is provided with a membrane which can be deformed by an actuating element.

Summary of the Invention

[0004] The present invention provides an apparatus for controlling fluid flow. The apparatus for controlling bi-directional fluid flow comprises a utility port; a bi-directional pump (20, 120, 220) having a common fluid flow port (46, 246), which operates in a continuous pump cycle between a positive pressure phase and a negative pressure phase to produce either a positive or a negative pressure at said common fluid flow port (46, 246) in a cyclically alternating direction; means for connecting said common fluid flow port and said utility port in fluid communication; valve means for regulating air flow between said common fluid flow port, said utility port and the atmosphere, said valve means operating between a first position isolating said common fluid flow port and said utility port and connecting the common fluid flow port to the atmosphere, and a second position connecting said common fluid flow port and said utility port in fluid communication and isolating the common fluid flow port from the atmosphere; means for continuously detecting whether said pump is operating in the pressure phase or vacuum phase of the pump cycle by tracking movement of a cyclically moving element of the pump; and control means connected to said detecting means and said valve means, said control means continuously actuating the valve means between the first position and second position in synchronization with the positive pressure phase and the negative pressure phase to generate either continuous positive fluid flow through the utility port or continuous negative fluid flow through said utility port.

[0005] In a preferred embodiment, the invention controls bi-directional fluid flow through a utility port by synchronizing movement of a single, electrically-actuated control valve with the alternating phases of a pump. An embodiment of the invention comprises a pipetting device for admitting and emitting fluid from a disposable pipette. In one embodiment, the bi-directional, fluid-flow control device generally comprises a utility port, a bi-directional pump, an electrically-controlled valve, a detector, and a controller. The controller is connected to the detector and the valve. The user activates the device using a user interface connected to the controller.

[0006] The pump produces bi-directional fluid flow at a common fluid flow port and operates in a continuous pump cycle having a pressure phase and a vacuum phase. A conduit connects the common pump port to the utility port. In one embodiment, the pump includes a reciprocating volume-displacement element that creates positive air pressure during one half of the pump cycle and creates negative air pressure during the other half of the pump cycle.

[0007] The electrically-controlled valve regulates air flow through the conduit. The valve operates between a first position isolating the pump and the utility port, and a second position connecting the pump and the utility port in fluid communication. In a preferred embodiment, the valve comprises a three-way solenoid valve having a common port connected to the pump, a normally-open (NO) port vented to the atmosphere, and a normally-closed (NC) port connected to the utility port. The valve connects the NC port and the common port in fluid communication in the second position and connects the NO port and the common port in fluid communication in the first position. In an alternative embodiment, the valve comprises a first, electrically-actuated, two-way valve controlling fluid flow through the conduit, and a second, electrically-actuated, two-way valve controlling fluid flow from the pump to the atmosphere.

[0008] The detector continuously detects and communicates a signal identifying whether the pump is operating in the pressure or vacuum phase of the pump cycle. For example, the detector may comprise a photosensor that detects movement of the volume-displacement element or other cyclically-moving element of the pump. Alternatively, the detector may comprise an ultrasonic sensor that detects movement of the volume-displacement element.

[0009] The controller uses the detector signal to synchronize actuation of the valve with the pump cycle to generate either continuous positive or continuous negative pressure at the utility port. Negative pressure is generated at the utility port by cyclically actuating the valve to the second position during the negative pressure phase and then actuating the valve back to the first position during the pressure phase. Positive pressure is generated at the utility port by cyclically actuating the valve to the second position during the pressure phase and then actuating the valve back to the first position during the vacuum phase of the pump cycle.

[0010] In a further embodiment of the invention, the device includes means for controlling the flow rate through the utility port. In this embodiment, the controller changes the length of time the valve is actuated to the second position during either phase of the pump cycle.

[0011] In yet another embodiment of the invention, the device includes means for controlling the flow of a measured volume (V) of fluid through the utility port. In this embodiment, the volume displacement per stroke (DPS) of the pump is either calculated or experimentally determined and programmed into the controller. The controller calculates and operates the pump for a calculated number (N) of pump cycles based on the DPS of the pump. In this embodiment, the device may include a sensor that measures the head pressure at the utility port and communicates the head pressure to the controller. The controller uses the head pressure to calculate more accurately the number (N) of pump cycles needed to meet the predetermined required volume.

[0012] The invention also provides a method of controlling positive and negative fluid flow through a utility port. In accordance with the method, a bi-directional pump having a common fluid flow port is provided that which operates in a continuous pump cycle between a positive pressure phase and a negative pressure phase to produce either a positive or a negative pressure at said common fluid flow port in a cyclically alternating direction. The source is continuously detected to determine whether the bi-directional pump is operating in the pressure phase or vacuum phase by tracking movement of a cyclically-moving element of the bi-directional pump. To produce continuous positive fluid flow through the utility port, the common fluid flow port is connected in fluid communication with the utility port during the pressure phase and isolated from the utility port during the vacuum phase in synchronization with the positive pressure phase and the negative pressure phase at the common fluid flow port. To produce continuous negative fluid flow through the utility port, the common fluid flow port is connected in fluid communication with the utility port during the vacuum phase and isolated from the utility port and the atmosphere during the pressure phase in synchronization with the positive pressure phase and the negative pressure phase of the common fluid flow port.

[0013] In a further embodiment of the method of the invention, the flow rate through the utility port is controlled by changing the length of time the fluid flow source is connected in fluid communication with the utility port during either the pressure or vacuum phase of each cycle.

[0014] In an additional embodiment of the method of the invention, a predetermined, measured volume (V) of fluid is delivered through the utility port by calculating and operating the pump for a calculated number (N) of pump cycles based on the volume displacement per stroke (DPS) of the pump. In this embodiment, the head pressure at the utility port may be measured to more precisely calculate the number (N) of pump cycles, especially for controlling fluid flow of compressible fluids.

[0015] In an additional embodiment, the apparatus controls uni-directional fluid flow through the utility port by controlling actuation of an electrically-actuated control valve. The invention also includes a pipetting (410) device for admitting and emitting fluid from a disposable device (406) comprising the device (10, 110, 201, 310) for controlling bi-directional fluid flow described above.

The pipetting device (410) also includes a housing (411) having a hand grip portion (414), a pipette connector (416) proximate said utility port (29, 129, 229), and a user interface (426, 428).

Brief Description of the Drawings

[0016]

Fig. 1 is a schematic illustration of an apparatus for controlling fluid flow in accordance with an embodiment of the invention;

Fig. 2 is a schematic illustration of the diaphragm pump and detector shown in Fig. 1;

Figs. 3a- 3d are fragmentary schematic illustrations of a pump motor shaft and detector in accordance with alternative embodiments of the invention;

Fig. 4 is a schematic illustration of a diaphragm pump and detector in accordance with a further embodiment of the invention;

Fig. 5 is a schematic illustration of an embodiment of an electrically-actuated valve shown in Fig. 1;

Fig. 6 is a graph illustrating the cyclical phases of the pump shown in Fig. 1;

Fig. 7 is a schematic illustration of an apparatus for controlling fluid flow having a head pressure detector in accordance with an additional embodiment of the invention;

Fig. 8 is a schematic illustration of an apparatus for controlling fluid flow having a pair of electrically-actuated, two-way valves in accordance with a further embodiment of the invention;

Fig. 9 is a schematic illustration of an apparatus for controlling unidirectional fluid flow in accordance with yet another embodiment of the invention; and,

Fig. 10 is a pipetting device in accordance with another embodiment of the invention.

Description of Preferred Embodiments

[0017] For the purpose of illustration, there is shown in the accompanying drawings several embodiments of the invention.

[0018] As used herein, the term "bi-directional pump" means a pump that alternately creates positive (pressure) and then negative (vacuum) displacement during a repeating pump cycle. The term "uni-directional pump" means a pump that creates only either positive or negative displacement.

[0019] A fluid flow device in accordance with a first embodiment of the present invention is shown in Fig. 1 and is designated generally by reference numeral 10. The fluid flow device 10 generally comprises a detector 18, a bi-directional pump 20, an electrically-controlled valve 22, and a controller 24, which are contained within a housing 28 having a single utility port 29. Depending on the direction of fluid flow, the utility port 29 acts as either an input or exit port. A fluid flow conduit 19 connects the pump 20 to the utility port 29. Preferably, the valve 22 is located intermediate the conduit 19. A user interface 25 is located outside the housing 28. The fluid flow device 10 selectively provides either continuous positive or continuous negative fluid flow at the utility port 29.

[0020] In a preferred embodiment, the pump 20 comprises a diaphragm pump having a housing 30, a single, common fluid flow port 46, and a flexible diaphragm 34 bifurcating the piston chamber 32 as seen in Fig. 2. The diaphragm 34 is attached by a yoke 36 to one end of a drive rod 38. The other end of the drive rod 38 is eccentrically connected to a flywheel 40, which is centrically connected to the shaft 42 of a motor (not shown). Rotation of the shaft 42 and flywheel 40 causes the drive rod 38 and diaphragm 34 to move upwardly and downwardly, thereby creating positive pressure at the common fluid flow port 46 on the upstroke and negative or vacuum pressure at the common fluid flow port 46 on the downstroke. The pump has no valving between the diaphragm 34 and the common fluid flow port 46. The pump 20 alternately produces positive pressure and then negative pressure throughout the pump cycle, the duration of which is a single rotation of the motor shaft 42.

[0021] The detector 44 continuously monitors whether the pump 20 is operating in the positive pressure or negative pressure phase of the pump cycle. In a preferred embodiment, the detector 44 monitors the phase of the pump cycle by tracking movement of a cyclically-moving (either linear or rotational movement) element of the pump 20. In the embodiment shown in Fig. 2, the detector 44 comprises a photosensor, which is located within the pump housing 30, and which reflects light off the surface of the flywheel 40. To differentiate the phases of the pump cycle, one half 40a of the flywheel 40 has a dark, non-reflective surface (shown in cross hatch) and the other half 40b of the flywheel 40 has a light, reflective surface. In this embodiment, the detector 44 and flywheel 40 are synchronized so that the detector 44 reads the boundary between the reflective and non-reflective surfaces at the same time the pump 20 transitions from one phase of the pump cycle to the other.

[0022] Additional embodiments of detector/flywheel arrangements are shown in Figs. 3a - 3d. In the embodiment shown in Fig. 3, the detector 144 emits and detects light reflected off the surface of the motor shaft 142. In this embodiment, the shaft has a dark, non-reflective band 142a (shown in cross hatch) extending 180 degrees around the radial surface of the shaft 142. The other 180 degree portion 142b of the shaft has a light, reflective surface. The detector 144 is axially aligned with the non-reflective band 142a of the shaft 142. In this embodiment, the detector 144 and shaft 142 are synchronized so that the detector 144 reads the boundary between the reflective and non-reflective surfaces at the same time the pump 20 transitions from one phase of the pump cycle to the other.

[0023] In the embodiment shown in Fig. 3b, the detector 244 comprises a Hall effect transducer that interacts with a magnetic encoder on the flywheel. To differentiate the phases of the pump cycle, the encoder on one half 240a of the flywheel 240 has an opposite polarity than the encoder on the other half 240b of the flywheel. The detector 244 and flywheel 240 are synchronized so that the detector 44 detects a change in polarity at the same time the pump 20 transitions from one phase of the pump cycle to the other.

[0024] In the embodiment shown in Fig. 3c, the detector 344 comprises a microswitch and cam-shaped flywheel 340. The microswitch includes a cam follower 347 that tracks the outer, irregularly-shaped periphery of the flywheel 340. The detector 344 and flywheel 340 are synchronized so that the microswitch is either opened or closed at the same time the pump 20 transitions from one phase of the pump cycle to the other.

[0025] In the embodiment shown in Fig. 3d, the detector 444 detects light directly emitted from a source 445. The flywheel 440 has an irregular shape that cyclically interrupts the line of sight between the light source 445 and the detector. The detector 444 and flywheel 440 are synchronized so that the detector 444 detects an interruption and then resumption of the light source at the same time the pump 20 transitions from one phase of the pump cycle to the other.

[0026] In yet another embodiment shown in Fig. 4, the detector 544 comprises an ultrasonic sensor 544 mounted inside piston chamber 532. The ultrasonic sensor 544 emits sound waves towards the diaphragm 534 to continuously measure the distance between the detector 544 and the diaphragm 534. In this embodiment, a maximum or minimum distance reading between the detector 544 and the diaphragm 534 indicates a transition from one phase of the pump cycle to the other. Other types of detectors may be used so long as the detector is capable of continuously determining the phase in which the pump is operating and electronically transmitting a signal to the controller that identifies the phase.

[0027] The electrically-actuated valve 22 is located intermediate the conduit 19 connecting the pump 20 to the outlet port 29. In a preferred embodiment, the valve 22 comprises a three-way solenoid valve such as shown in Fig. 5. The solenoid valve 22 has a housing 52 with a normally-closed (NC) port 54, a common port 56, and a normally-open (NO) port 58. The NC port 54 is connected to the utility port 29 by a section 19b of the conduit 19. The common port 56 of the valve is connected to the common port 29 of the pump by a section 19a of the conduit 19. The NO port 58 vents to the atmosphere.

[0028] The solenoid valve has a ferrous reciprocating element 60, which has a valve head 61 at one end and a cylindrical base 63 at the other end. An induction coil 64 surrounds the base 63 while a compression spring 68 surrounds the head 61. First and second seals 70, 72 are seated on opposed ends of the head 61. The compression spring 68 normally biases the valve head 61 to a first position wherein the common port 56 is arranged in fluid connection with the NO port 58 and the NC 54 port is closed. In the first position, the internal conduit 19 between the pump 20 and the utility port 29 is closed. When the induction coil 64 is energized, a magnetic field urges the valve head 61 to a second position wherein the common port 56 is arranged in fluid connection with the NC 54 port 58 and the NO port 58 is closed. In the second position, the internal conduit 19 between the pump 20 and the utility port 29 is open.

[0029] In the embodiment shown Fig. 1, the user interface 26 comprises a first trigger 26, which activates the device in the positive pressure mode, and a second trigger 27, which activates the device in the negative pressure mode. In a preferred embodiment, the device 10 is inactive until one of the triggers is a depressed. Alternatively, other forms of input device such as pressure sensitive transducers, capacitance transducers, multi-directional joy stick, key pad, computer, or other electronic input devices may be connected to the controller 24.

[0030] The valve 22, detector 44, and user interface 26 communicate with the controller 24. The detector 44 continuously transmits to the controller 24 a signal identifying the phase of the pump cycle in which the pump is operating. The controller 24 synchronizes actuation of the valve 22 with the cycle of the pump 20 to create a sustained flow of either positive or negative air flow to the utility port 29. If positive pressure is desired at the utility port 29, the solenoid is energized only during the positive pressure phase of the pump cycle, i.e., $t=0$ to $t=T/2$. Then, from $t=T/2$ to $t=T$, the solenoid valve is de-energized. When the valve 22 is energized, it moves from the first position to the second position, described above. Conversely, if vacuum pressure is desired at the utility port 29, the solenoid valve 22 is energized only during the negative pressure phase of the pump cycle, i.e., $t=T/2$ to $t=T$. Because the detector 44 and solenoid valve 22 have very fast response times, the aforementioned cycle (either positive or negative pressure) can be repeated at a very high frequency to create a continuous, sustained flow of fluid either into or out of the utility port 29.

[0031] If a digital detector is provided, such as the detector 44 of the embodiment shown in Fig. 2, the signal has the square wave illustrated in Fig. 6a, which illustrates voltage (v) as a function of the pump cycle. If an analog detector is provided, such as the detector 544 of the embodiment of Fig. 4, the signal has the sinusoidal shape shown in Fig. 6b, which illustrates distance (d) of the diaphragm from a neutral position as a function of the pump cycle.

[0032] In another embodiment of the invention, the device not only selectively creates negative or positive pressure at the utility port 29, but also controls additional fluid flow properties. For example, the flow rate through the utility port 29 can be varied by controlling the amount of time the valve 22 is energized during either phase of the pump cycle. Referring to Figs. 6a and 6b, the flow rate exiting the utility port 29, represented by cross hatch, is reduced by 50% if the valve is energized only during the time period t=0 to t=T/4, and then closed during the remainder of the positive pressure phase of the pump cycle, *i.e.,* t=T/4 to t=T/2, and the entirety of the negative pressure phase of the pump cycle, *i.e.,* t=T/2 to t=T.

[0033] To communicate the desired flow rate to the controller, the triggers 26, 27 may be connected to potentiometers. The user controls the volumetric flow rate by controlling the distance each trigger 26, 27 is depressed. Other known user interface devices such as described above could be substituted for the triggers 26, 27.

[0034] In another embodiment of the invention shown in Fig. 7, the device 110 delivers a measured volume (V) of fluid through the utility port 129. In this embodiment, the volume displacement per unit stroke (DPS) of the pump 120 is programmed into the controller 124. The DPS may be calculated based on the dimensions of the pump 120 or experimentally calculated using a calibration scale. The controller 124 calculates and allows the pump 120 to operate for the requisite number (N) of strokes to deliver the desired volume (V) of fluid. Data from the detector 118 allows the controller 124 to count each stroke of the pump.

[0035] In this embodiment, the user interface 125 may comprise a keypad or a computer. The keypad 125 may include a plurality of input keys 127 and an LCD 128, which displays a wide variety of additional control options that have been programmed into the controller.

[0036] In this embodiment, the device 110 includes a sensor 178 that measures the external pressure or head at the utility port 129. The pressure sensor 178 communicates the head pressure to the controller 124, which factors this value into the ideal gas equation of state (pV=nRT) and Boyle's law to more accurately calibrate the number (N) of strokes of the pump 20 required to deliver the specified volume (V) of fluid. The pressure sensor 78 is preferably provided if the device 110 is controlling the flow of a compressible fluid at constant temperature such as air, whose properties are governed by the equation $P_1V_1=P_2V_2$.

[0037] The aforementioned embodiments have been described with reference to a motor-driven diaphragm pump. However, other types of bi-directional pumps may be used for the invention. For example, a solenoid-activated diaphragm pump, such as manufactured by MEDO U.S.A., Inc., may be used. Other types of bi-directional pump may be used so long as the detector can continuously determine the phase of the pump cycle in which the pump is operating.

[0038] Similarly, the aforementioned embodiments have been described with reference to a detector that continuously determines the phase in which the pump is operating by tracking movement of a cyclically-moving element of the pump. However, depending on the type of pump, other types of detectors may be used so long as it is capable of continuously determining the phase in which the pump is operating and electronically transmitting a signal to the controller that identifies the phase. For example, if a solenoid-activated pump is used, the detector may identify the transition from one phase to another by detecting a change in polarity created by the solenoid.

[0039] The aforementioned embodiments have been described with reference to an electrically-actuated, three-way solenoid valve. However, it should be appreciated that the three-way valve could be replaced by other arrangements of electrically-actuated valves such as shown in Fig. 8. In this embodiment, the device 210 includes a detector 218, bi-directional pump 220, controller 224, and user interface 225 that are similar in construction and arrangement as described above. However, in this embodiment, the three-way solenoid valve of the embodiment in Fig. 1 is replaced with a pair of electrically-actuated, two-way valves, 280, 281, each of which regulates fluid flow through one branch of a manifold 283 connected to the common fluid flow port 246 of the pump 220. One valve 280 regulates fluid flow from the pump 220 to the utility port 229 via a fluid flow conduit 219. The other valve 281 regulates fluid flow from the pump 220 to an atmospheric vent 282.

[0040] Using the input signal from the detector 218, the controller 224 selectively opens and closes the valves 280, 281 in synchronization with the phases of the pump cycle to create either positive or negative pressure at the utility port 229. In the embodiment shown in Fig. 8, the valves 280, 281 comprise Piezo ceramic element valves, which are known to have the fast response time required to synchronize with the changing phases of the pump 220.

[0041] The aforementioned embodiments have been described with reference to a bi-directional pump. However, in a further embodiment of the invention, the device controls uni-directional fluid flow. In this embodiment, the device 310 includes a uni-directional pump 385, controller 324, user interface 325, and electrically-actuated, three-way valve 322. The device 310 may also include a detector 318. In this embodiment, the valve 322 comprises a solenoid valve such as described above. Similar to the embodiments described above, the controller 324 selectively actuates the valve 322 to deliver fluid at preset intervals, controlled quantities, measured volumes (V), defined flow rates, and other properties or steps.

[0042] It should be appreciated by those of ordinary skill in the art that the above-described embodiments of the invention may be used to control the flow of both compressible and incompressible fluids in a wide variety of environments. By way of example only, one specific embodiment is described below.

[0043] A pipetting device in accordance with a further embodiment of the present invention is shown in Fig. 10 and is designated generally by reference numeral 410. The pipetting device 410 is constructed to admit and emit fluid from a disposable pipette 406, which may vary in size and shape.

[0044] In the embodiment shown in Fig. 10, the pipetting device 410 has the shape of a known "gun-type" pipettor, which is easily gripped by the user 408 (shown in phantom). However, the device 410 could be made in a variety of shapes and sizes.

[0045] The housing 411 of the pipetting device 412 has a handle portion 414 and a barrel portion 415 oriented transversely to the handle portion 414. A nosepiece or pipette connector 416 is fixed to and oriented downwardly transverse to the barrel portion 415. The pipette connector 416 is constructed and arranged to removably attach pipettes 406 of various lengths and diameters. The pipette connector 16 may include a hydrophobic filter 417, which may be removed and replaced. The filter 417 prevents contamination of the pipetting device 410 in the event the pipette 18 is overadmitted with fluid.

[0046] The device 412 has a bi-directional pump 420, control valve 422, and controller 424. An internal conduit 419 connects the pump 420 to the pipette connector 416. The control valve comprises a three-way, electrically-actuated solenoid valve 422 and is located intermediate the internal conduit 419. A detector (not shown) is built into the pump 420. A positive air flow trigger 426 and negative air flow trigger 428 extend from the handle portion 414 and are connected to the controller 424.

[0047] In the manner described above, the controller 424 actuates the valve 422 in response to signals generated by depression of either the positive air flow trigger 426 or negative air flow trigger 428. Additionally, the pipetting device may be provided with a more sophisticated user interface, which would allow the user to control the wide variety of fluid flow properties described above.

Claims

1. A device (10, 110, 210, 310) for controlling bi-directional fluid flow, comprising:

   a) a utility port (29, 129, 229);
   b) a bi-directional pump (20, 120, 220) having a common fluid flow port (46, 246), which operates in a continuous pump cycle between a positive pressure phase and a negative pressure phase to produce either a positive or a negative pressure at said common fluid flow port (46, 246) in a cyclically alternating direction;
   c) means (19a) for connecting said common fluid flow port (46, 246) and said utility port (29, 129, 229) in fluid communication;

   characterized in that said device further includes:

   d) valve means (22) for regulating air flow between said common fluid flow port (46, 246) said utility port (29, 129, 229) and the atmosphere, said valve means (22) operating between a first position isolating said common fluid flow port (46, 246) and said utility port (29, 129, 229) and connecting said common fluid flow port (46, 246) to the atmosphere, and a second position connecting said common fluid flow port (46, 246) and said utility port (29, 129, 229) in fluid communication and isolating said common fluid flow port (46, 246) from the atmosphere;
   e) means (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) for continuously detecting whether said pump (20, 120, 220) is operating in the pressure phase or vacuum phase of the pump cycle by tracking movement of a cyclically moving element of the pump; and,
   f) control means (24, 124, 224, 324) connected to said detecting means (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) and said valve means (22), said control means (24, 124, 224, 324) continuously actuating the valve means (22) between the first position and second position in synchronization with the positive pressure phase and the negative pressure phase to generate either continuous positive fluid flow through the utility port (29, 129, 229) or continuous negative fluid flow through said utility port (29, 129, 229).

2. The device (10, 110, 210, 310) recited in claim 1, wherein said valve means (22) comprises an electrically-controlled valve (22); said continuous detecting means (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) comprises a detector (18, 44, 118, 144, 218, 244, 318, 344, 444, 544); and said control means (24, 124, 224, 324) comprises a controller (24, 124, 224, 324).

3. The device (10, 110, 210, 310) recited in claim 2, wherein negative fluid flow is generated at said utility port (29, 129, 229) by cyclically actuating said valve (22) to the second position during the vacuum phase of the pump cycle and then actuating the valve (22) back to the first position during the pressure phase of the pump cycle, and positive fluid flow is generated at said utility port (29, 129, 229) by cyclically actuating said valve (22) to the second position during the pressure phase of the pump cycle and then actuating the valve (22) back to the first position during the vacuum phase of the pump cycle.

4. The device (10, 110, 210, 310) recited in claim 3, including means for controlling a flow rate (22, 26, 27) through said utility port (29, 129, 229).

5. The device (10, 110, 210, 310) recited in claim 4,

wherein said means for controlling the flow rate (22, 26, 27) through the utility port changes the length of time said valve (22) is actuated to the second position during either phase of the pump cycle.

6. The device (10, 110, 210, 310) recited in claim 2, said pump (2) including a reciprocating volume-displacement element (34, 60, 534) that creates positive air pressure during one half of the pump cycle and creates negative air pressure during another half of the pump cycle.

7. The device (10, 110, 210, 310) recited in claim 6, wherein said detector (18, 44, 144, 244, 344, 444, 544) comprises a photosensor that detects movement of said volume-displacement element (34, 60, 534).

8. The device (10, 110, 210, 310) recited in claim 6, wherein said detector (18, 44, 144, 244, 344, 444, 544) comprises an ultrasonic sensor (544) that detects movement of said volume-displacement element (34, 60, 534).

9. The device (10, 110, 210, 310) recited in claim 2, including means for controlling the flow of a measured volume (V) of fluid through said utility port (29, 129, 229).

10. The device (10, 110, 210, 310) recited in claim 2, wherein said volumetric control means (24, 124, 224, 324) calculates and operates said pump (20, 120, 220) for a calculated number (N) of pump cycles based on the volume displacement per stroke (DPS) of the pump (20, 120, 220).

11. The device (10, 110, 210, 310) recited in claim 2, wherein said valve (22) comprises a three-way solenoid valve (22) having a common port (56) connected to said pump (20, 120, 220), a normally-open (NO) port (58) vented to the atmosphere, and a normally-closed (NC) port (54) connected to said utility port (29, 129, 229).

12. The device (10, 110, 210, 310) recited in claim 11, wherein said valve (22) connects said normally-closed (NC) port (54) and said common port (56) in fluid communication in the second position and connects said normally-open (NO) port (58) and said common port (56) in fluid communication in the first position.

13. The device (10, 110, 210, 310) recited in claim 2, wherein said valve (22) comprises a first, electrically-actuated, two-way valve (280) controlling fluid flow through a conduit, and a second, electrically-actuated, two-way valve (281) controlling fluid flow from said pump (20, 120, 220) to the atmosphere.

14. The device (10, 110, 210, 310) recited in claim 2, including a user interface (25, 125, 225, 325) connected to said controller (24, 124, 224, 324).

15. The device (10, 110, 210, 310) recited in claim 10, including a sensor (78, 178) that measures the head pressure at said utility port (29, 129, 229) and communicates the head pressure to said controller (24, 124, 224, 324).

16. The device (10, 110, 210, 310) recited in claim 15, wherein said volumetric control means (24, 124, 224, 324) uses the head pressure to calculate the number (N) of pump cycles needed for the predetermined volumetric delivery.

17. The device (10, 110, 210, 310) recited in claim 2, wherein said detecting means (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) detects movement of a cyclically-moving element (40, 142, 240, 340, 440, 534) of said pump (20, 120, 220).

18. A method of controlling positive and negative fluid flow through a utility port (29, 129, 229), comprising the steps of:

a) providing a bi-directional pump (20, 120, 220) having a common fluid flow port (46, 246) which operates in a continuous pump cycle between a positive pressure phase and a negative pressure phase to produce either a positive or a negative pressure at said common fluid flow port (46, 246) in a cyclically alternating direction;
b) continuously detecting whether said bi-directional pump (20, 120, 220) is operating in the pressure phase or vacuum phase by tracking movement of a cyclically-moving element of the bi-directional pump (20, 120, 220);
c) producing continuous positive fluid flow through the utility port (29, 129, 229) by connecting said common fluid flow port (46, 246) in fluid communication with said utility port (29, 129, 229) during the pressure phase and isolating said common fluid flow port (46, 246) from said utility port (29, 129, 229) during the vacuum phase in synchronization with the positive pressure phase and the negative pressure phase at said common fluid flow port (46, 246);
d) producing continuous negative fluid flow through the utility port (29, 129, 229) by connecting said common fluid flow port (46, 246) in fluid communication with said utility port (29, 129, 229) during the vacuum phase and isolating said common fluid flow port (46, 246) from said utility port and the atmosphere (29, 129, 229) during the pressure phase in synchronization with the positive pressure phase and the negative pressure phase of the common fluid flow port (46,

246).

19. The method recited in claim 18, including the step of controlling a flow rate through the utility port (29, 129, 229).

20. The method recited in claim 19, including the step of delivering measured volumes of fluid through the utility port (29, 129, 229).

21. A pipetting device (410) for admitting and emitting fluid from a disposable device (406) comprising a device (10, 110, 201, 310) for controlling bi-directional fluid flow according to claim 1, said pipetting device (410) comprising a housing (411) having a hand grip portion (414), a pipette connector (416) proximate said utility port (29, 129, 229), and a user interface (426, 428).

22. The pipetting device (410) recited in claim 21, including a sensor that measures the head pressure at said pipette connector (416).

23. The pipetting device (410) recited in claim 22, said pump comprising a diaphragm pump (420) having a motor with a shaft (38), and a reciprocating volume-displacement element (34, 534) connected to said shaft (38), said element (34, 534) creating positive pressure during one half of the pump cycle and creating negative pressure during another half of the pump cycle, wherein reciprocation of said element (34, 534) through one complete pump cycle is synchronized with a single rotation of said shaft (38).

24. The device (10, 110, 210, 310) recited in claim 1, wherein said valve means (22) is a single three-way valve comprising a single reciprocal valve head (61) moveable between said first and second positions.

Patentansprüche

1. Vorrichtung (10, 110, 210, 310) zum Steuern des bidirektionalen Fluidstroms, umfassend:

a) eine Versorgungsöffnung (29, 129, 229),
b) eine bidirektionale Pumpe (20, 120, 220) mit einer gemeinsamen Fluidströmungsöffnung (46, 246), die in einem kontinuierlichen Pumpzyklus zwischen einer Überdruckphase und einer Unterdruckphase arbeitet, um entweder einen Überdruck oder einen Unterdruck an der gemeinsamen Fluidströmungsöffnung (46, 246) in einer zyklisch wechselnden Richtung zu erzeugen,
c) Vorrichtung (19a) zum Verbinden der gemeinsamen Fluidströmungsöffnung (46, 246) und der Versorgungsöffnung (29, 129, 229) in Fluidverbindung,

dadurch gekennzeichnet, dass die Vorrichtung ferner umfasst:

d) eine Ventileinrichtung (22) zum Regeln des Luftstroms zwischen der gemeinsamen Fluidströmungsöffnung (46, 246), der Versorgungsöffnung (29, 129, 229) und der Atmosphäre, wobei die Ventileinrichtung (22) zwischen einer ersten, die gemeinsame Fluidströmungsöffnung (46, 246) und die Versorgungsöffnung (29, 129 229) trennenden Position arbeitet und die gemeinsame Fluidströmungsöffnung (46, 246) mit der Atmosphäre verbindet, und einer zweiten Position, die die gemeinsame Fluidströmungsöffnung (46, 246) und die Versorgungsöffnung (29, 129, 229) in Fluidverbindung verbindet und die gemeinsame Fluidströmungsöffnung (46, 246) von der Atmosphäre trennt,
e) eine Einrichtung (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) zum kontinuierlichen Erfassen, ob die Pumpe (20, 120, 220) in der Druckphase oder in der Vakuumphase des Pumpenzyklus arbeitet, durch Nachverfolgen der Bewegung eines sich zyklisch bewegenden Elements der Pumpe, und
f) eine Steuereinrichtung (24, 124, 224, 324), die mit der Erfassungseinrichtung (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) und der Ventileinrichtung (22) verbunden ist, wobei die Steuereinrichtung (24, 124, 224, 324) die Ventileinrichtung (22) zwischen der ersten Position und der zweiten Position in Synchronisation mit der Überdruckphase und der Unterdruckphase kontinuierlich betätigt, um entweder einen kontinuierlichen positiven Fluidstrom durch die Versorgungsöffnung (29, 129, 229) oder einen kontinuierlichen negativen Fluidstrom durch die Versorgungsöffnung (29, 129, 229) zu erzeugen.

2. Vorrichtung (10, 110, 210, 310) nach Anspruch 1, wobei die Ventileinrichtung (22) ein elektrisch gesteuertes Ventil (22) umfasst, die kontinuierliche Erfassungseinrichtung (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) einen Detektor (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) umfasst und die Steuereinrichtung (24, 124, 224, 324) eine Steuerung (24, 124, 224, 324) umfasst.

3. Vorrichtung (10, 110, 210, 310) nach Anspruch 2, wobei ein negativer Fluidstrom an der Versorgungsöffnung (29, 129, 229) erzeugt wird, indem das Ventil (22) während der Vakuumphase des Pumpenzyklus zyklisch in die zweite Position betätigt wird und dann das Ventil (22) während der Druckphase des Pumpenzyklus zurück in die erste Position betätigt wird und ein positiver Fluidstrom an der Versorgungsöffnung (29, 129, 229) erzeugt wird, indem das Ventil (22) während der Druckphase des Pumpenzyklus zyklisch in die zweite Position und dann das Ventil (22) während der Vakuumphase des Pumpenzyklus zurück in die erste Position betätigt wird.

4. Vorrichtung (10, 110, 210, 310) nach Anspruch 3, umfassend eine Einrichtung zum Steuern einer Fließgeschwindigkeit (22, 26, 27) durch die Versorgungsöffnung (29, 129, 229).

5. Vorrichtung (10, 110, 210, 310) nach Anspruch 4, wobei die Einrichtung zum Steuern der Fließgeschwindigkeit (22, 26, 27) durch die Versorgungsöffnung die Zeitspanne ändert, in der das Ventil (22) während einer beliebigen der beiden Phasen des Pumpenzyklus in die zweite Position betätigt wird.

6. Vorrichtung (10, 110, 210, 310) nach Anspruch 2, wobei die Pumpe (2) ein hin- und hergehendes Volumenverdrängungselement (34, 60, 534) enthält, das während der einen Hälfte des Pumpenzyklus einen Luftüberdruck und während der anderen Hälfte des Pumpenzyklus einen Luftunterdruck erzeugt.

7. Vorrichtung (10, 110, 210, 310) nach Anspruch 6, wobei der Detektor (18, 44, 144, 244, 344, 444, 544) einen Fotosensor umfasst, der eine Bewegung des Volumenverdrängungselements (34, 60, 534) erfasst.

8. Vorrichtung (10, 110, 210, 310) nach Anspruch 6, wobei der Detektor (18, 44, 144, 244, 344, 444, 544) einen Ultraschallsensor (544) umfasst, der eine Bewegung des Volumenverdrängungselements (34, 60, 534) erfasst.

9. Vorrichtung (10, 110, 210, 310) nach Anspruch 2, welche eine Einrichtung zum Steuern des Durchflusses eines gemessenen Flüssigkeitsvolumens (V) durch die Versorgungsöffnung (29, 129, 229) einschließt.

10. Vorrichtung (10, 110, 210, 310) nach Anspruch 2, wobei die volumetrische Steuereinrichtung (24, 124, 224, 324) die Pumpe (20, 120, 220) für eine berechnete Anzahl (N) von Pumpenzyklen auf der Grundlage der Volumenverdrängung pro Hub (displacement per stroke, DPS) der Pumpe (20, 120, 220) berechnet und betreibt.

11. Vorrichtung (10, 110, 210, 310) nach Anspruch 2, wobei das Ventil (22) ein Dreiwege-Magnetventil (22) mit einem gemeinsamen Anschluss (56), der mit der Pumpe (20, 120, 220) verbunden ist, einen normalerweise offenen (NO-) Anschluss (58), der zur Atmosphäre entlüftet wird, und einen normalerweise geschlossenen (NC-) Anschluss (54), der mit der Versorgungsöffnung (29, 129, 229) verbunden ist, umfasst.

12. Vorrichtung (10, 110, 210, 310) nach Anspruch 11, wobei das Ventil (22) den normalerweise geschlossenen (NC-) Anschluss (54) und den gemeinsamen Anschluss (56) in Fluidverbindung in der zweiten Position verbindet und den normalerweise offenen (NO-) Anschluss (58) und den gemeinsamen Anschluss (56) in Fluidverbindung in der ersten Position verbindet.

13. Vorrichtung (10, 110, 210, 310) nach Anspruch 2, wobei das Ventil (22) ein erstes, elektrisch betätigtes Zweiwegeventil (280), das den Fluidstrom durch eine Leitung steuert, und ein zweites, elektrisch betätigtes Zweiwegeventil (281) umfasst, das den Fluidstrom von der Pumpe (20, 120, 220) zur Atmosphäre steuert.

14. Vorrichtung (10, 110, 210, 310) nach Anspruch 2, die eine mit der Steuerung (24, 124, 224, 324) verbundene Benutzerschnittstelle (25, 125, 225, 325) einschließt.

15. Vorrichtung (10, 110, 210, 310) nach Anspruch 10, einschließlich eines Sensors (78, 178), der den Kopfdruck an der Versorgungsöffnung (29, 129, 229) misst und den Kopfdruck an die Steuerung (24, 124, 224, 324) übermittelt.

16. Vorrichtung (10, 110, 210, 310) nach Anspruch 15, wobei die volumetrische Steuereinrichtung (24, 124, 224, 324) den Kopfdruck verwendet, um die Anzahl (N) der für die vorbestimmte volumetrische Förderung erforderlichen Pumpenzyklen zu berechnen.

17. Vorrichtung (10, 110, 210, 310) nach Anspruch 2, wobei die Erfassungseinrichtung (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) die Bewegung eines sich zyklisch bewegenden Elements (40, 142, 240, 340, 440, 534) der Pumpe (20, 120, 220) erfasst.

18. Verfahren zum Steuern eines positiven und negativen Fluidstroms durch eine Versorgungsöffnung (29, 129, 229), umfassend die Schritte:

a) Bereitstellen einer bidirektionalen Pumpe (20, 120, 220) mit einer gemeinsamen Fluidströmungsöffnung (46, 246), die in einem kontinuierlichen Pumpzyklus zwischen einer Überdruckphase und einer Unterdruckphase arbeitet, um an der gemeinsamen Fluidströmungsöffnung (46, 246) entweder einen Überdruck oder einen Unterdruck in einer zyklisch wechselnden Richtung zu erzeugen,
b) kontinuierliches Erfassen, ob die bidirektionale Pumpe (20, 120, 220) in der Druck- oder

Vakuumphase arbeitet, durch Nachverfolgen einer Bewegung eines sich zyklisch bewegenden Elements der bidirektionalen Pumpe (20, 120, 220),

c) Erzeugen eines kontinuierlichen positiven Fluidstroms durch die Versorgungsöffnung (29, 129, 229) durch Verbinden des gemeinsamen Fluidströmungsöffnung (46, 246) in Fluidverbindung mit der Versorgungsöffnung (29, 129, 229) während der Druckphase und Trennen des gemeinsamen Fluidstroms (46, 246) von der Versorgungsöffnung (29, 129, 229) während der Vakuumphase in Synchronisation mit der Überdruckphase und der Unterdruckphase an der gemeinsamen Fluidströmungsöffnung (46, 246),

d) Erzeugen eines kontinuierlichen negativen Fluidstroms durch die Versorgungsöffnung (29, 129, 229) durch Verbinden der gemeinsamen Fluidströmungsöffnung (46, 246) in Fluidverbindung mit der Versorgungsöffnung (29, 129, 229) während der Vakuumphase, und Trennen der gemeinsamen Fluidströmungsöffnung (46, 246) von der Versorgungsöffnung und der Atmosphäre (29, 129, 229) während der Druckphase synchron mit der Überdruckphase und der Unterdruckphase der gemeinsamen Fluidströmungsöffnung (46, 246).

19. Verfahren nach Anspruch 18, das den Schritt des Steuerns einer Fließgeschwindigkeit durch die Versorgungsöffnung (29, 129, 229) einschließt.

20. Verfahren nach Anspruch 19, das den Schritt des Abgebens gemessener Fluidmengen durch die Versorgungsöffnung (29, 129, 229) einschließt.

21. Pipettiervorrichtung (410) zum Aufnehmen und Abgeben von Fluid aus einer Wegwerfvorrichtung (406) mit einer Vorrichtung (10, 110, 201, 310) zum Steuern eines bidirektionalen Fluidstroms gemäß Anspruch 1, wobei die Pipettiervorrichtung (410) ein Gehäuse (411) mit einem Handgriffabschnitt (414), einen Pipettenverbinder (416) in der Nähe der Versorgungsöffnung (29, 129, 229) und eine Benutzerschnittstelle (426, 428) aufweist.

22. Pipettiervorrichtung (410) nach Anspruch 21 mit einem Sensor, der den Kopfdruck an dem Pipettenanschluss (416) misst.

23. Pipettiervorrichtung (410) nach Anspruch 22, wobei die Pumpe eine Membranpumpe (420) mit einem Motor mit einer Welle (38) und einem mit der Welle (38) verbundenen hin- und hergehenden Volumenverdrängungselement (34, 534) umfasst, wobei das Element (34, 534) während einer Hälfte des Pumpzyklus einen Überdruck erzeugt und während einer anderen Hälfte des Pumpzyklus einen Unterdruck erzeugt, wobei die Hin- und Herbewegung des Elements (34, 534) durch einen vollständigen Pumpzyklus mit einer einzelnen Drehung der Welle (38) synchronisiert ist.

24. Vorrichtung (10, 110, 210, 310) nach Anspruch 1, wobei die Ventileinrichtung (22) ein einzelnes Dreiwegeventil ist, das einen einzigen reziproken Ventilkopf (61) aufweist, der zwischen der ersten und der zweiten Position bewegbar ist.

Revendications

1. Dispositif (10, 110, 210, 310) pour commander un écoulement de fluide bidirectionnel, comprenant :

a) un port utilitaire (29, 129, 229) ;

b) une pompe bidirectionnelle (20, 120, 220) ayant un port d'écoulement fluidique commun (46, 246), qui fonctionne suivant un cycle de pompe continu entre une phase de pression positive et une phase de pression négative pour produire une pression soit positive, soit négative au niveau dudit port d'écoulement fluidique commun (46, 246) suivant une direction qui alterne cycliquement ;

c) un moyen (19a) chargé de connecter ledit port d'écoulement fluidique commun (46, 246) et ledit port utilitaire (29, 129, 229) en communication fluidique ;

caractérisé en ce que le dispositif inclut également

d) un moyen de vanne (22) chargé de réguler l'écoulement d'air entre ledit port d'écoulement fluidique commun (46, 246) ledit port utilitaire (29, 129, 229) et l'atmosphère, ledit moyen de vanne (22) fonctionnant entre une première position isolant ledit port d'écoulement fluidique commun (46, 246) et ledit port utilitaire (29, 129, 229) et connectant ledit port d'écoulement fluidique commun (46, 246) à l'atmosphère, et une seconde position connectant ledit port d'écoulement fluidique commun (46, 246) et ledit port utilitaire (29, 129, 229) en communication fluidique et isolant ledit port d'écoulement fluidique commun (46, 246) de l'atmosphère ;

e) un moyen (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) chargé de détecter en continu si ladite pompe (20, 120, 220) fonctionne dans la phase de pression ou la phase de vide du cycle de pompe en surveillant le mouvement d'un élément de la pompe se déplaçant cycliquement ; et

f) un moyen de commande (24, 124, 224, 324) connecté audit moyen de détection (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) et audit moyen de vanne (22), ledit moyen de commande (24, 124, 224, 324) actionnant en continu le moyen de vanne (22) entre la première position et la seconde position en synchronisme avec la phase de pression positive et la phase de pression négative pour générer soit un écoulement fluidique positif continu à travers le port utilitaire (29, 129, 229), soit un écoulement fluidique négatif continu à travers ledit port utilitaire (29, 129, 229).

2. Dispositif (10, 110, 210, 310) selon la revendication 1, dans lequel ledit moyen de vanne (22) comprend une vanne à commande électrique (22) ; ledit moyen de détection en continu (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) comprend un détecteur (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) ; et ledit moyen de commande (24, 124, 224, 324) comprend un module de commande (24, 124, 224, 324).

3. Dispositif (10, 110, 210, 310) selon la revendication 2, dans lequel un écoulement fluidique négatif est généré au niveau dudit port utilitaire (29, 129, 229) en actionnant cycliquement ladite vanne (22) sur la seconde position pendant la phase de vide du cycle de pompe puis en actionnant la vanne (22) de nouveau sur la première position pendant la phase de pression du cycle de pompe, et un écoulement fluidique positif est généré au niveau dudit port utilitaire (29, 129, 229) en actionnant cycliquement ladite vanne (22) sur la seconde position pendant la phase de pression du cycle de pompe puis en actionnant la vanne (22) de nouveau sur la première position pendant la phase de vide du cycle de pompe.

4. Dispositif (10, 110, 210, 310) selon la revendication 3, incluant un moyen pour commander un débit (22, 26, 27) à travers ledit port utilitaire (29, 129, 229).

5. Dispositif (10, 110, 210, 310) selon la revendication 4, dans lequel ledit moyen pour commander le débit (22, 26, 27) à travers ledit port utilitaire change la durée pendant laquelle ladite vanne (22) est actionnée sur la seconde position pendant l'une ou l'autre phase du cycle de pompe.

6. Dispositif (10, 110, 210, 310) selon la revendication 2, ladite pompe (2) incluant un élément de déplacement de volume à va-et-vient (34, 60, 534) qui crée une pression d'air positive pendant une moitié du cycle de pompe et crée une pression d'air négative pendant une autre moitié du cycle de pompe.

7. Dispositif (10, 110, 210, 310) selon la revendication 6, dans lequel ledit détecteur (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) comprend un capteur photoélectrique qui détecte le mouvement dudit élément de déplacement de volume (34, 60, 534).

8. Dispositif (10, 110, 210, 310) selon la revendication 6, dans lequel ledit détecteur (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) comprend un capteur ultrasonore (544) qui détecte le mouvement dudit élément de déplacement de volume (34, 60, 534).

9. Dispositif (10, 110, 210, 310) selon la revendication 2, incluant un moyen pour commander l'écoulement d'un volume mesuré (V) de fluide à travers ledit port utilitaire (29, 129, 229).

10. Dispositif (10, 110, 210, 310) selon la revendication 2, dans lequel ledit moyen de commande volumétrique (24, 124, 224, 324) calcule et actionne ladite pompe (20, 120, 220) pendant un nombre calculé (N) de cycles de pompe sur la base du volume déplacé en une course (DPS, pour « volume displacement per stroke ») de la pompe (20, 120, 220).

11. Dispositif (10, 110, 210, 310) selon la revendication 2, dans lequel ladite vanne (22) comprend une électrovanne trois voies (22) ayant un port commun (56) connecté à ladite pompe (20, 120, 220), un port (58) normalement ouvert (NO) relié à l'atmosphère, et un port (54) normalement fermé (NC) connecté audit port utilitaire (29, 129, 229).

12. Dispositif (10, 110, 210, 310) selon la revendication 11, dans lequel ladite vanne (22) connecte ledit port (54) normalement fermé (NC) et ledit port commun (56) en communication fluidique dans la seconde position et connecte ledit port (58) normalement ouvert (NO) et ledit port commun (56) en communication fluidique dans la première position.

13. Dispositif (10, 110, 210, 310) selon la revendication 2, dans lequel ladite vanne (22) comprend une première vanne deux voies à actionnement électrique (280) commandant un écoulement de fluide à travers un conduit, et une seconde vanne deux voies à actionnement électrique (281) commandant un écoulement de fluide de ladite pompe (20, 120, 220) vers l'atmosphère.

14. Dispositif (10, 110, 210, 310) selon la revendication 2, incluant une interface utilisateur (25, 125, 225, 325) connectée audit module de commande (24, 124, 224, 324).

15. Dispositif (10, 110, 210, 310) selon la revendication 10, incluant un capteur (78, 178) qui mesure la pression de refoulement au niveau dudit port utilitaire (29, 129, 229) et communique la pression de refoulement audit module de commande (24, 124, 224, 324).

16. Dispositif (10, 110, 210, 310) selon la revendication

15, dans lequel ledit moyen de commande volumétrique (24, 124, 224, 324) utilise la pression de refoulement pour calculer le nombre (N) de cycles de pompe requis pour la délivrance volumétrique prédéfinie.

17. Dispositif (10, 110, 210, 310) selon la revendication 2, dans lequel ledit moyen de détection (18, 44, 118, 144, 218, 244, 318, 344, 444, 544) détecte le mouvement d'un élément se déplaçant cycliquement (40, 142, 240, 340, 440, 534) de ladite pompe (20, 120, 220).

18. Procédé de commande d'écoulement de fluide positif et négatif à travers un port utilitaire (29, 129, 229), comprenant les étapes consistant à :

a) fournir une pompe bidirectionnelle (20, 120, 220) ayant un port d'écoulement fluidique commun (46, 246), qui fonctionne suivant un cycle de pompe continu entre une phase de pression positive et une phase de pression négative pour produire une pression soit positive, soit négative au niveau dudit port d'écoulement fluidique commun (42, 246) suivant une direction qui alterne cycliquement ;
b) détecter en continu si ladite pompe bidirectionnelle (20, 120, 220) fonctionne dans la phase de pression ou la phase de vide en surveillant le mouvement d'un élément de la pompe bidirectionnelle (20, 120, 220) se déplaçant cycliquement ;
c) générer un écoulement de fluide positif continu à travers le port utilitaire (29, 129, 229) en connectant ledit port d'écoulement de fluide commun (46, 246) en communication fluidique avec ledit port utilitaire (29, 129, 229) pendant la phase de pression et en isolant ledit port d'écoulement de fluide commun (46, 246) dudit port d'écoulement de fluide (29, 129, 229) pendant la phase de vide en synchronisme avec la phase de pression positive et la phase de pression négative au niveau dudit port d'écoulement de fluide commun (46, 246) ;
d) générer un écoulement de fluide négatif continu à travers le port utilitaire (29, 129, 229) en connectant ledit port d'écoulement de fluide commun (46, 246) en communication fluidique avec ledit port utilitaire (29, 129, 229) pendant la phase de vide et en isolant ledit port d'écoulement de fluide commun (46, 246) dudit port utilitaire et de l'atmosphère (29, 129, 229) pendant la phase de pression en synchronisme avec la phase de pression positive et la phase de pression négative dudit port d'écoulement de fluide commun (46, 246).

19. Procédé selon la revendication 18, incluant l'étape consistant à commander un débit à travers le port utilitaire (29, 129, 229).

20. Procédé selon la revendication 19, incluant l'étape consistant à délivrer des volumes mesurés de fluide à travers le port utilitaire (29, 129, 229).

21. Dispositif de pipetage (410) pour aspirer et refouler un fluide d'un dispositif jetable (406) comprenant un dispositif (10, 110, 201, 310) pour commander un écoulement de fluide bidirectionnel selon la revendication 1, ledit dispositif de pipetage (410) comprenant un logement (411) ayant une partie de saisie manuelle (414), un connecteur de pipette (416) à proximité dudit port utilitaire (29, 129, 229) et une interface utilisateur (426, 428).

22. Dispositif de pipetage (410) selon la revendication 21, incluant un capteur qui mesure la pression de refoulement au niveau dudit connecteur de pipette (416).

23. Dispositif de pipetage (410) selon la revendication 22, ladite pompe comprenant une pompe à diaphragme (420) ayant un moteur avec un axe (38), et un élément de déplacement de volume à va-et-vient (34, 534) connecté audit axe (38), ledit élément (34, 534) créant une pression positive pendant une moitié du cycle de pompe et créant une pression négative pendant une autre moitié du cycle de pompe, le va-et-vient dudit élément (34, 534) lors d'un cycle de pompe complet étant synchronisé avec une seule rotation dudit arbre (38).

24. Dispositif (10, 110, 210, 310) selon la revendication 1, dans lequel ledit moyen de vanne (22) est une vanne trois voies unique comprenant une seule tête de vanne alternative (61) mobile entre lesdites première et seconde positions.

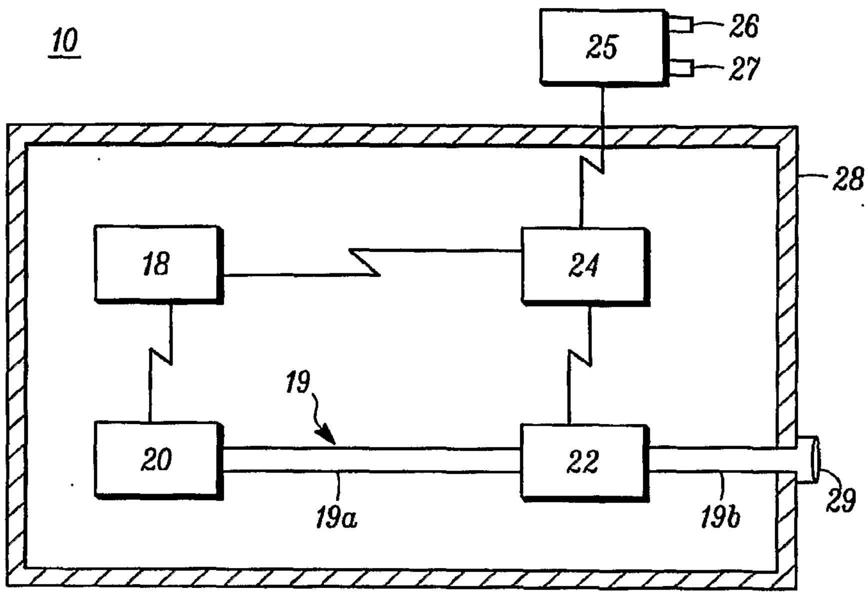

10
25
26
27
28
18
24
19
20
22
29
19a
19b

FIG. 1

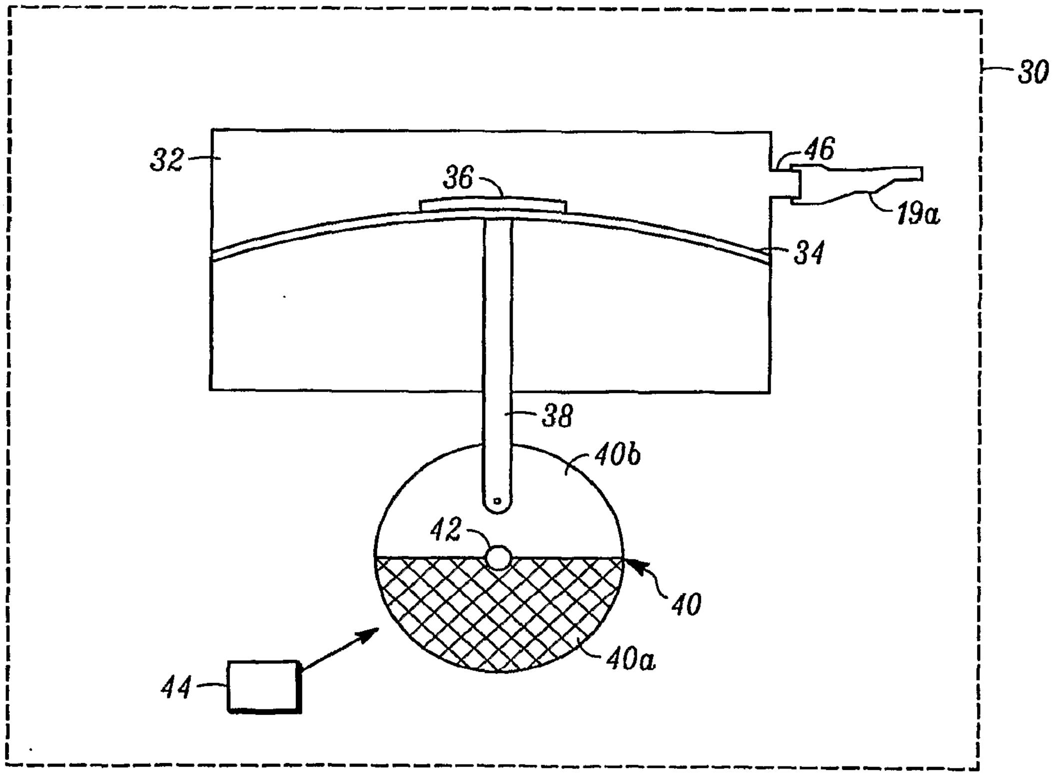

30
32
46
36
19a
34
38
40b
42
40
40a
44

FIG. 2

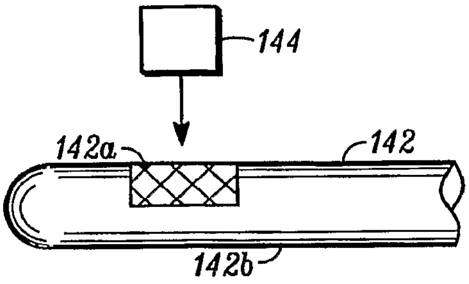
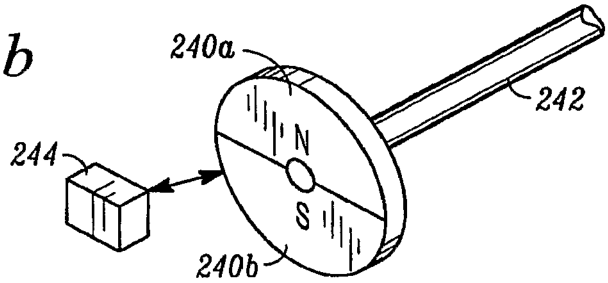


FIG. 3a

FIG. 3b



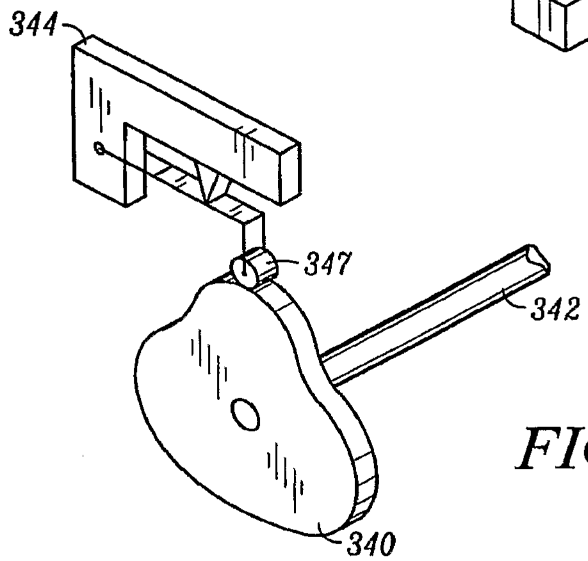


FIG. 3c

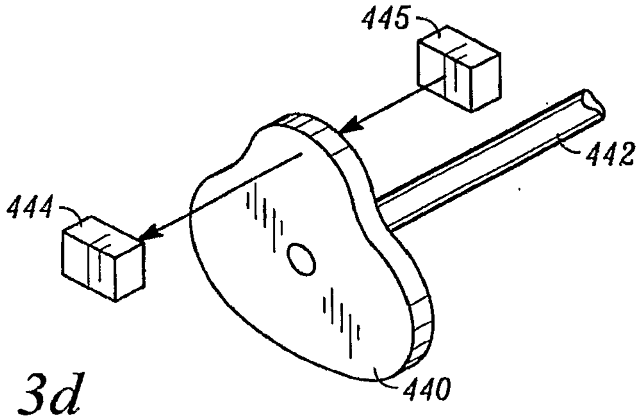


FIG. 3d

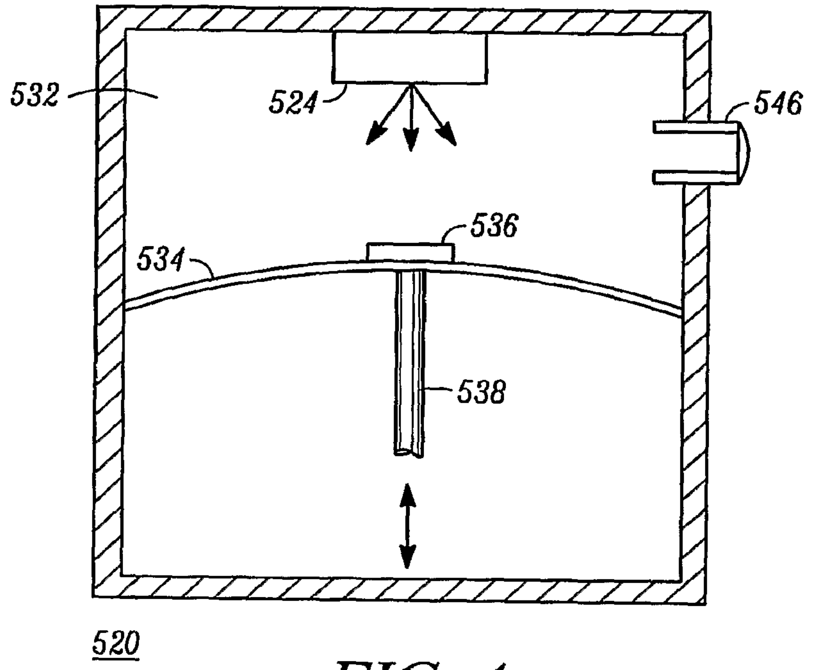
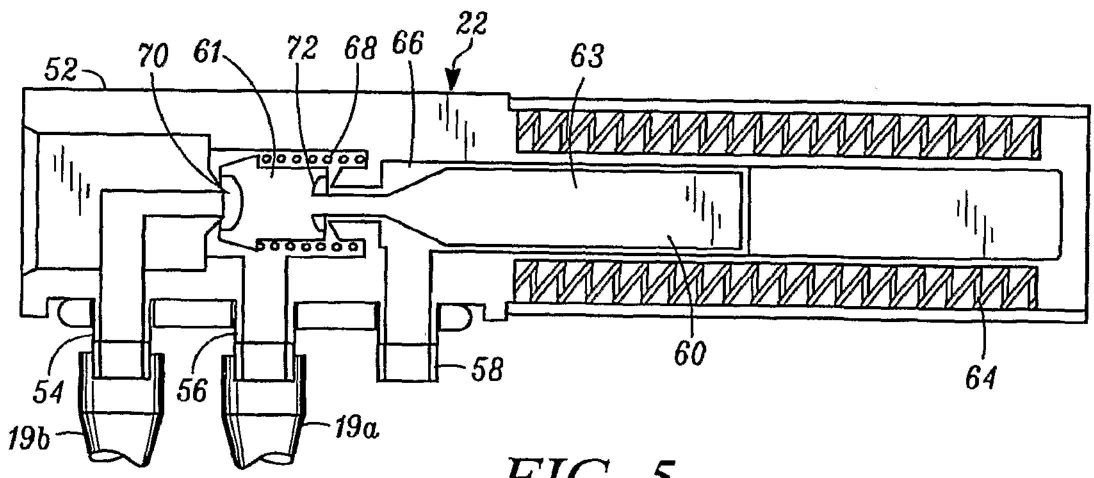

532
524
546
536
534
538
520

FIG. 4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68
66
22
63
54
56
58
60
64
19b
19a

FIG. 5

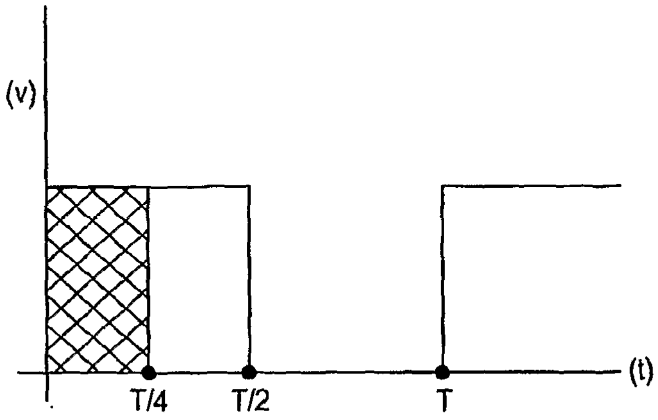

FIG. 6a

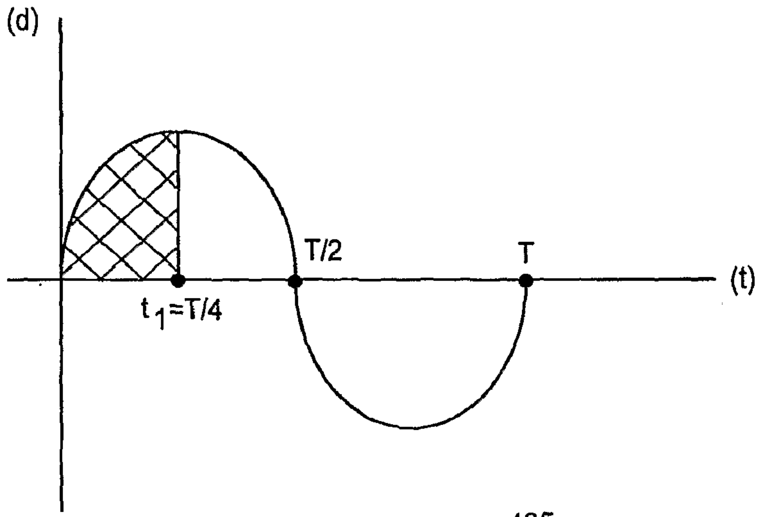

FIG. 6b

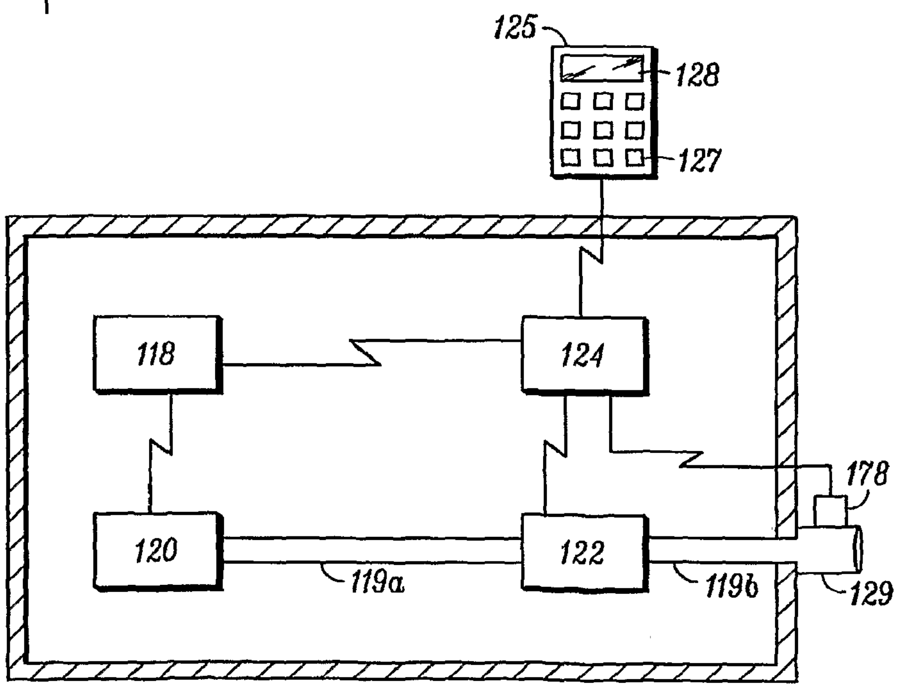

FIG. 7

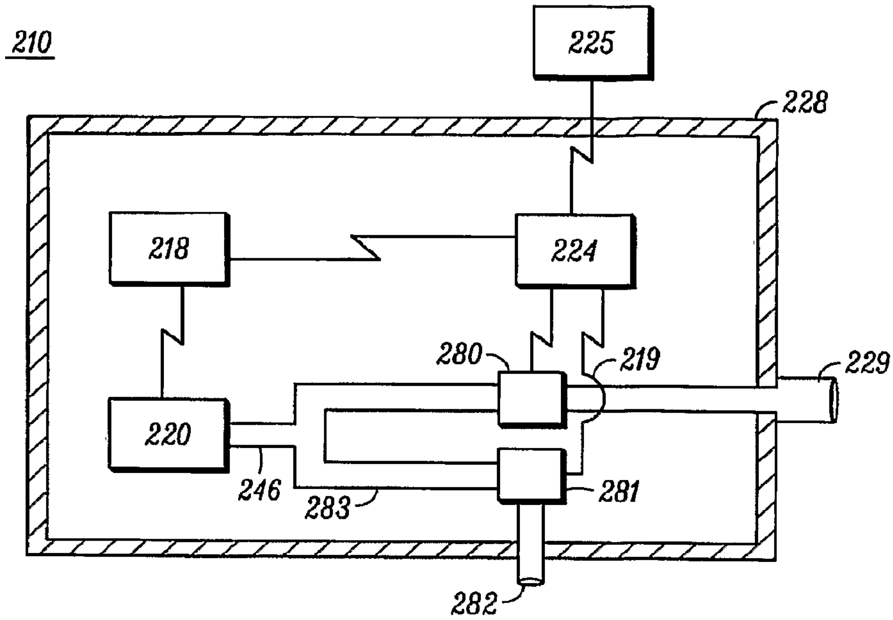
210
225
228
218
224
280
219
229
220
246
283
281
282

FIG. 8

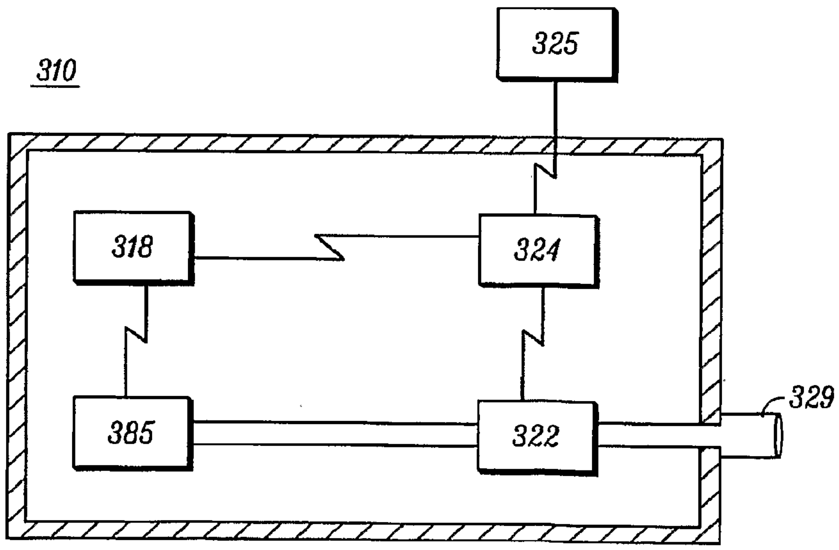
310
325
318
324
329
385
322

FIG. 9

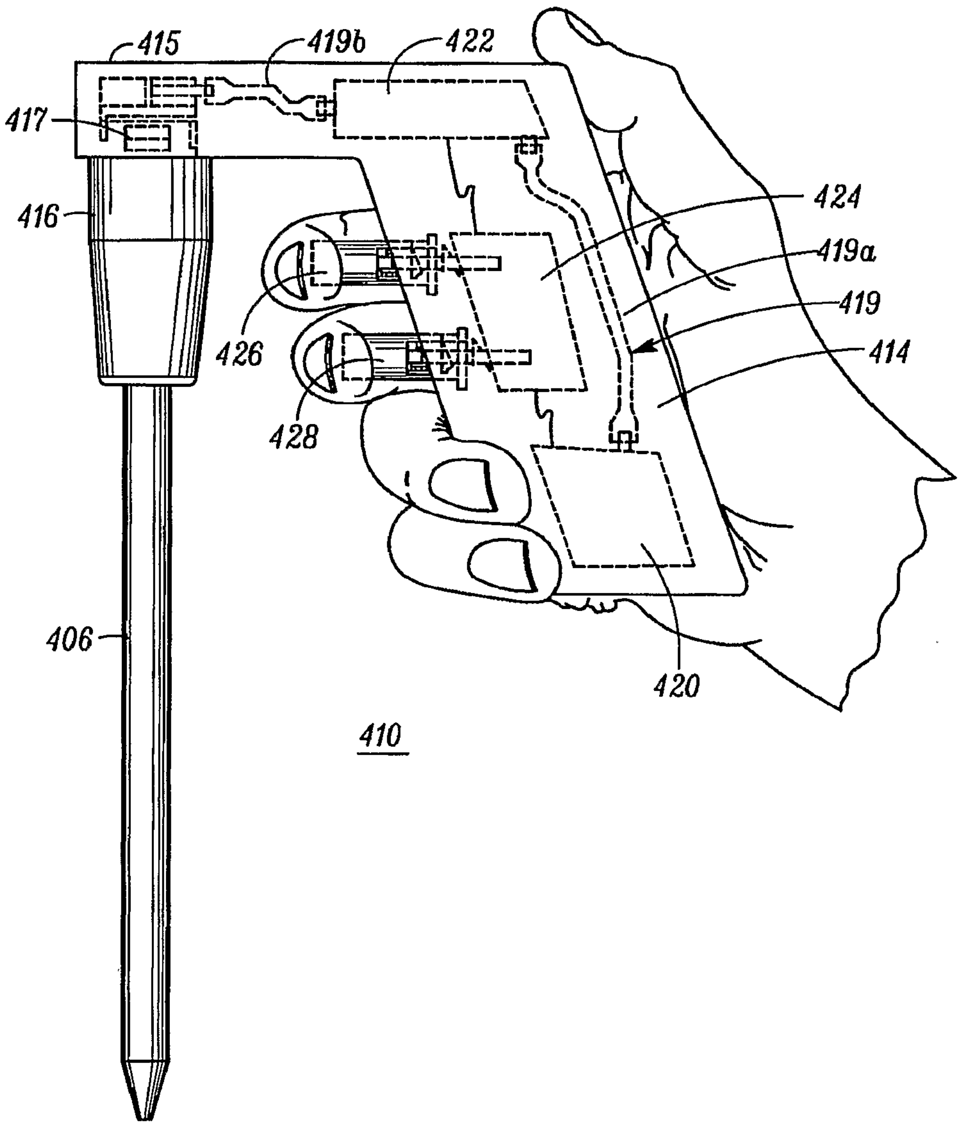

FIG. 10

REFERENCES CITED IN THE DESCRIPTION

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