DEVICE TO DETERMINE VOLUME OF FLUID DISPENSED

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 16/407,839, filed on May 9, 2019 and entitled Device to Determine Volume of Fluid Dispensed, now U.S. Publication No. US 2019-0262554-A1, published Aug. 29, 2019 (Attorney Docket No. Y96) which is a continuation of U.S. patent application Ser. No. 14/872,676, filed on Oct. 1, 2015 and entitled Device to Determine Volume of Fluid Dispensed, now U.S. Pat. No. 10,369,299, published Jan. 28, 2016 (Attorney Docket No. Q76), which is a continuation of U.S. patent application Ser. No. 14/082,579, filed on Nov. 18, 2013 and entitled Pumping Fluid Deliver Systems and Methods Using Force Application Assembly, now U.S. Publication No. US 2014-0074029-A1, published Mar. 13, 2014 (Attorney Docket No. L41), which is a continuation of U.S. patent application Ser. No. 11/704,896, filed on Feb. 9, 2007, and entitled Pumping Fluid Deliver Systems and Methods Using Force Application Assembly, now U.S. Pat. No. 8,585,377, Issued on Nov. 19, 2013 (Attorney Docket No. E71) which claims the benefit of the following:

[0002] U.S. Provisional Application No. 60/772,313, filed Feb. 9, 2006, entitled Portable Injection System (Attorney Docket No. E42),

[0003] U.S. Provisional Application No. 60/789,243, filed Apr. 5, 2006, and entitled Method of Volume Measurement for Flow Control (Attorney Docket No. E53), and

[0004] U.S. Provisional Application No. 60/793,188, filed Apr. 19, 2006, and entitled Portable Injection and Adhesive System (Attorney Docket No. E46), each of which is herein incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0005] This application relates generally to pumping fluid delivery systems and methods using force application assembly.

BACKGROUND

[0006] Many potentially valuable medicines or compounds, including biologicals, are not orally active due to poor absorption, hepatic metabolism or other pharmacokinetic factors. Additionally, some therapeutic compounds, although they can be orally absorbed, are sometimes required to be administered so often it is difficult for a patient to maintain the desired schedule. In these cases, parenteral delivery is often employed or could be employed.

[0007] Effective parenteral routes of drug delivery, as well as other fluids and compounds, such as subcutaneous injection, intramuscular injection, and intravenous (IV) administration include puncture of the skin with a needle or stylet. Insulin is an example of a therapeutic fluid that is self-injected by millions of diabetic patients. Users of parenterally delivered drugs would benefit from a wearable device that would automatically deliver needed drugs/compounds over a period of time.

[0008] To this end, there have been efforts to design portable devices for the controlled release of therapeutics. Such devices are known to have a reservoir such as a cartridge, syringe, or bag, and to be electronically controlled. These devices suffer from a number of drawbacks including the malfunction rate. Reducing the size, weight and cost of these devices is also an ongoing challenge.

SUMMARY OF THE INVENTION

[0009] In one embodiment, the present invention provides a method of dispensing a therapeutic fluid from a line. The method includes providing an inlet line connectable to an upstream fluid source. The inlet line is in downstream fluid communication with a pumping chamber. The pumping chamber has a pump outlet. The method also includes actuating a force application assembly so as to restrict retrograde flow of fluid through the inlet while pressurizing the pumping chamber to urge flow through the pump outlet.

[0010] In a related embodiment, actuating the force application assembly includes using travel of the force application assembly during a work stroke to restrict retrograde flow and to pressurize the pumping chamber in a single mechanical action. In a further related embodiment, a given degree of travel of the force actuation assembly restricts retrograde flow, and a greater degree of travel pressurizes the pumping chamber.

[0011] In a further related embodiment, actuating the force application assembly includes restricting retrograde flow toward the fluid source by occluding the inlet line. Alternatively or in addition, the method also includes preventing reverse flow of fluid from a dispensing chamber into the pumping chamber by using a passive valve placed therebetween.

[0012] Optionally actuating the force application assembly includes using a shape-memory actuator. Also optionally, using the shape-memory actuator includes inducing a phase change in a shape memory wire to transmit a force around a pulley to the force application assembly.

[0013] In a further embodiment, the method further includes measuring a parameter related to flow through the line; and adjusting operation of the pump based on the measured parameter. Optionally measuring the parameter related to flow through the line includes determining a change in volume of a resilient chamber disposed downstream of the pumping chamber. Optionally, measuring the parameter includes using acoustic volume measurement.

[0014] In a further embodiment, a tortuous flow-impedance located downstream of the resilient chamber supplies a fluid impedance sufficient to cause the resilient chamber to expand in response to pumping.

[0015] Alternatively or in addition, the method further includes causing fluid to flow downstream from the pump outlet through a tortuous flow-impeding conduit. The conduit may have various forms. It may have at least two turns. It may be coiled. It may have a serpentine shape. Optionally, the conduit has a length and an internal diameter selected to provide a predetermined impedance based on at least one of a viscosity and a density of the fluid. Optionally the internal diameter of the conduit is sufficiently large so as to prevent occlusion due to flow of the fluid through the conduit.

[0016] In a further embodiment, the inlet line, the pumping chamber, the pump outlet and the force application assembly are enclosed inside a patch-sized housing, and actuating the force application assembly includes using a processor inside the housing to cause actuation of the force application assembly.