What is claimed is:

1. A peristaltic pump, comprising:

a cam shaft;

first and second pinch-valve cams coupled to the cam shaft;

first and second pinch-valve cam followers configured to engage the first and second pinch-valve cams;

a plunger cam coupled to the cam shaft;

a plunger-cam follower configured to engage the plunger cam;

a tube receiver configured to receive a tube;

a spring-biased plunger coupled to the plunger-cam follower, wherein expansion of the plunger cam along a radial angle intersecting the plunger-cam follower as the cam shaft rotates pushes the plunger cam to disengage the spring-biased plunger from the tube, and wherein a spring coupled to the spring-biased plunger biases the spring-biased plunger to apply the crushing force to the tube;

a position sensor operatively coupled to the spring-biased plunger configured to determine a position of the spring-biased plunger; and

a processor coupled to the position sensor, wherein the processor is configured to estimate fluid flow of fluid within the tube utilizing the position using the position sensor.

2. The peristaltic pump according to claim 1, further comprising an angle sensor operatively coupled to the cam shaft configured to determine an angle of rotation of the cam shaft.

3. The peristaltic pump according to claim 1, wherein the processor compares a first static region of the position sensor to a second static region of the position sensor to estimate the fluid flow.

4. The peristaltic pump according to claim 3, wherein the processor determines the first static region by identifying the first static region within a predetermined range of angles as indicated by the angle sensor.

13. A peristaltic pump, comprising:

a housing;

a motor;

a cam shaft operatively coupled to the motor such that rotation of the motor rotates the cam shaft;

a plunger cam coupled to the cam shaft for rotation therewith;

a pivot shaft operatively coupled to the housing;

a plunger pivotally coupled to the pivot shaft, the plunger having a cam follower configured to engage the plunger cam of the cam shaft, wherein the plunger is configured to pivot to a first position to compress a tube and to a second position away from the tube;

a bias member configured to bias the plunger to the first position to compress the tube;

a position sensor coupled to the plunger to measure a position of the plunger; and

a processor coupled to the position sensor to estimate a volume of fluid discharged from the tube when the bias member causes the plunger to move towards the first position.

14. The pump according to claim 13, wherein:

the plunger and plunger cam are configured to compress the tube using only a force of the bias member,

the plunger cam is configured to only retract the plunger to the second position, and

the plunger is configured to engage the plunger cam such that the plunger cam does not force the plunger against the tube.

15. The peristaltic pump according to claim 13, wherein the plunger is L-shaped.

16. The peristaltic pump according to claim 13, wherein the plunger is U-shaped.

17. The peristaltic pump according to claim 13, further comprising:

a inlet valve; and

an outlet valve.

18. The peristaltic pump according to claim 17, where the inlet valve, the outlet valve, the plunger and the plunger cam are configured to compress the tube while the inlet and

5. The peristaltic pump according to claim 4, wherein the processor determines the second static region by identifying the second static region within a second predetermined range of angles as indicated by the angle sensor.

6. The peristaltic pump according to claim 4, wherein the processor determines the first and second static regions by measuring position sensor at predetermined angles as indicated by the angle sensor.

7. The peristaltic pump according to claim 1, wherein the processor compares a first static region measured by the position sensor to a second static region measured by the position sensor to estimate the fluid flow.

8. The peristaltic pump according to claim 6, wherein the processor determines the first static region by identifying a peak movement of the plunger as measured by the position sensor and identifies the second static region to be after the identified peak.

9. The peristaltic pump according to claim 6, wherein the processor determines the second static region by identifying an end of the first static region.

10. The peristaltic pump according to claim 1, further comprising:

a balancer cam;

a balancer-cam follower; and

a balancer spring configured to apply a force against the balancer-cam follower and thereby apply a force from the balancer-cam follower to the balancer cam;

wherein the balancer cam is shaped to reduce a peak torque of the cam shaft as the cam shaft rotates around its axis of rotation.

11. The peristaltic pump according to claim 1, further comprising an electric motor operatively coupled to the cam shaft to apply a rotational torque to the cam shaft.

12. The peristaltic pump according to claim 10, wherein the electric motor is one of a stepper motor, a DC motor, a brushless DC motor, a brushed DC motor, an AC motor, a polyphase induction motor, an electric motor with at least one permanent magnet coupled to a stator or a rotor, and an induction motor.

outlet valves are closed such that the processor can measure the first position of the plunger using the position sensor.

19. The peristaltic pump according to claim 18, where the inlet valve, the outlet valve, the plunger and the plunger cam are configured to open the outlet valve after the first position of the plunger is measured to discharge fluid out of the tube through the outlet valve, wherein the processor is configured to measure the second position of the plunger using the position sensor after the outlet valve is opened.

20. The peristaltic pump according to claim 19, wherein the processor compares the first measured position to the second measured position to determine an amount of fluid discharged through the outlet valve.

21. The peristaltic pump according to claim 17, wherein the inlet valve and the outlet value are spring biased against the tube.

22. The peristaltic pump according to claim 21, wherein the inlet valve includes an inlet-valve cam follower configured to interface an inlet- valve cam coupled to the cam shaft.

23. The peristaltic pump according to claim 22, wherein the outlet valve includes an outlet-valve cam follower configured to interface an outlet- valve cam coupled to the cam shaft.

the counter surface. In this case, a shared cam with multiple knobs placed in the center of the arc is used to activate the fingers.

[0005A] WO 2006/086723, US 5,482,446 and GB 2020735 disclose prior art pumps. At least one advantage of the present invention is to provide a measurement of actual fluid delivered by the infusion pump.

SUMMARY

[0006] A peristaltic pump, and related system method are provided. The peristaltic pump includes a cam shaft, first and second pinch-valve cams, first and second pinch-valve cam followers, a plunger cam, a plunger-cam follower, a tube receiver, and a spring-biased plunger. The first and second pinch-valve cams are coupled to the cam shaft. The first and second pinch-valve cam followers each engage the first and second pinch-valve cams, respectively. The plunger cam is coupled to the cam shaft. The plunger-cam follower engages the plunger cam. The tube receiver is configured to receive a tube. The spring-biased plunger is coupled to the plunger-cam follower such that the expansion of the plunger cam along a radial angle intersecting the plunger-cam follower as the cam shaft rotates pushes the plunger cam follower towards the plunger and thereby disengages the spring-biased plunger from the tube. A spring coupled to the spring-biased plunger biases the spring-biased plunger to apply the crushing force to the tube.

[0007] In some embodiments, a slide occluder includes an RFID tag and the infusion pump includes an RFID interrogator. A processor associated with (or in) the infusion pump interrogates the RFID tag to determine if the slide ocicuder is authorized for use. For example, the RFID tag may have an encryption key and/or authorized identification value.

[0008] In some embodiments, a cam profile for an infusion pump may be shaped such that rotation in any direction causes forward flow.

[0009] In some embodiments, an infusion pump may include a downstream occluder to create a smooth fluid flow to the patient.

[0010] In some embodiments, the infusion pump may automatically prime, e.g., the tube may have an RFID tag and/or a barcode that may be read by the pump, which the pump uses to estimate a priming volume of the downstream tube automatically (for fluid flow estimation, etc.)

[0011] In some embodiments, an infusion pump includes a resistive element that is compressed against a tube. The infusion pump estimates the fluid pressure in accordance with the resistance.

CLAIMS

1. A peristaltic pump, comprising:

a cam shaft (3080);

first (3082) and second (3084) pinch-valve cams coupled to the cam shaft;

first (3101) and second (3111) pinch-valve cam followers configured to engage the first and second pinch-valve cams;

a plunger cam (3083) coupled to the cam shaft;

a plunger-cam follower (3090) configured to engage the plunger cam;

a tube receiver (3022) configured to receive a tube;

a spring-biased plunger (3091) coupled to the plunger-cam follower, wherein expansion of the plunger cam along a radial angle intersecting the plunger-cam follower as the cam shaft rotates pushes the plunger cam to disengage the spring-biased plunger from the tube, and wherein a spring (3094) coupled to the spring-biased plunger biases the spring-biased plunger to apply the crushing force to the tube;

a position sensor (3096, 3002A) operatively coupled to the spring-biased plunger configured to determine a position of the spring-biased plunger; and

a processor (3500) coupled to the position sensor, wherein the processor is configured to estimate fluid flow of fluid within the tube utilizing the position as indicated by the position sensor.

2. The peristaltic pump according to claim 1, further comprising an angle sensor operatively coupled to the cam shaft configured to determine an angle of rotation of the cam shaft.

3. The peristaltic pump according to claim 1, wherein the processor compares a first static region of the position sensor to a second static region of the position sensor to estimate the fluid flow.

4. The peristaltic pump according to claim 3, wherein the processor determines the first static region by identifying the first static region within a predetermined range of angles as indicated by the angle sensor.

5. The peristaltic pump according to claim 4, wherein the processor determines the second static region by identifying the second static region within a second predetermined range of angles as indicated by the angle sensor.

6. The peristaltic pump according to claim 4, wherein the processor determines the first and second static regions by measuring position sensor at predetermined angles as indicated by the angle sensor.

7. The peristaltic pump according to claim 1, wherein the processor compares a first static region measured by the position sensor to a second static region measured by the position sensor to estimate the fluid flow.

8. The peristaltic pump according to claim 6, wherein the processor determines the first static region by identifying a peak movement of the plunger as measured by the position sensor and identifies the second static region to be after the identified peak.

9. The peristaltic pump according to claim 6, wherein the processor determines the second static region by identifying an end of the first static region.

10. The peristaltic pump according to claim 1, further comprising:

a balancer cam;

a balancer-cam follower; and

a balancer spring configured to apply a force against the balancer-cam follower and thereby apply a force from the balancer-cam follower to the balancer cam;

wherein the balancer cam is shaped to reduce a peak torque of the cam shaft as the cam shaft rotates around its axis of rotation.

11. The peristaltic pump according to claim 1, further comprising an electric motor operatively coupled to the cam shaft to apply a rotational torque to the cam shaft.

12. The peristaltic pump according to claim 11, wherein the electric motor is one of a stepper motor, a DC motor, a brushless DC motor, a brushed DC motor, an AC motor, a polyphase induction motor, an electric motor with at least one permanent magnet coupled to a stator or a rotor, and an induction motor.

13. A peristaltic pump, comprising:

a housing (3005, 3010);

a motor (3072);

a cam shaft (3080) operatively coupled to the motor such that rotation of the motor rotates the cam shaft;

a plunger cam (3083) coupled to the cam shaft for rotation therewith;

a pivot shaft (3120) operatively coupled to the housing;

a plunger (3091) pivotally coupled to the pivot shaft, the plunger having a cam follower configured to engage the plunger cam of the cam shaft, wherein the plunger is configured to pivot to a first position to compress a tube and to a second position away from the tube;

a bias member (3094) configured to bias the plunger to the first position to compress the tube;

a position sensor (3096, 3002A) coupled to the plunger to measure a position of the plunger; and

a processor (3500) coupled to the position sensor to estimate a volume of fluid discharged from the tube when the bias member causes the plunger to move towards the first position.

14. The pump according to claim 13, wherein:

the plunger and plunger cam are configured to compress the tube using only a force of the bias member,

the plunger cam is configured to only retract the plunger to the second position, and

the plunger is configured to engage the plunger cam such that the plunger cam does not force the plunger against the tube.

15. The peristaltic pump according to claim 13, wherein the plunger is L-shaped.

16. The peristaltic pump according to claim 13, wherein the plunger is U-shaped.

17. The peristaltic pump according to claim 13, further comprising:

a inlet valve; and

an outlet valve.

18. The peristaltic pump according to claim 17, where the inlet valve, the outlet valve, the plunger and the plunger cam are configured to compress the tube while the inlet and outlet valves are closed such that the processor can measure the first position of the plunger using the position sensor.

19. The peristaltic pump according to claim 18, where the inlet valve, the outlet valve, the plunger and the plunger cam are configured to open the outlet valve after the first position of the plunger is measured to discharge fluid out of the tube through the outlet valve, wherein the processor is configured to measure the second position of the plunger using the position sensor after the outlet valve is opened.

20. The peristaltic pump according to claim 19, wherein the processor compares the first measured position to the second measured position to determine an amount of fluid discharged through the outlet valve.

21. The peristaltic pump according to claim 17, wherein the inlet valve and the outlet value are spring biased against the tube.

22. The peristaltic pump according to claim 21, wherein the inlet valve includes an inlet-valve cam follower configured to interface an inlet-valve cam coupled to the cam shaft.

23. The peristaltic pump according to claim 22, wherein the outlet valve includes an outlet-valve cam follower configured to interface an outlet-valve cam coupled to the cam shaft.