pumping speed, allowable volume of air, temperature and pressure, the pump is actuated wherein fluid is drawn from the fluid source and expelled from the pump in a constant and metered amount.

[0007] Should the tube be misloaded into the tubeway or the tube-loading orifice, appropriate sensors would determine the existence of such a state and effect an alarm directed thereto. At the end of the infusion, actuation by an operator would serve to automatically close the slide clamp and release the tube from the pump.

[0008] The pump comprehends a variety of sensors directed to improve the safety of the infusion of medicament and which provide information on the state of the fluid passing through the pump. For example, the sensors provide information regarding the state of various mechanical subassemblies within the pump itself such as a positional location of the shuttle or v-shaped slot aforementioned, valve operation, slide clamp location, and misload detection.

[0009] The sensors relating to the state of the fluid being passed through the pump have themselves been improved with regard to accuracy. This has been accomplished by the development of a method of making contact between the sensor and the tube such that the contact is normal to the tube and the tube is placed in contact with the various sensors in such a way that there is neither a volumetric nor a stress gradient across the tube.

[0010] Aspects of the subject matter described herein may be useful alone or in combination with one or more other aspects described herein. In an ~~exemplary~~ aspect of the present disclosure, an infusion pump ~~includes~~ comprises: a housing with a door pivotally mounted to the housing; a tube channel positioned at least partially behind the door on the housing, the tube channel configured to hold a tube in the infusion pump; a pumping mechanism including a shuttle positioned behind the door; a slide clamp channel for receiving a slide clamp, the slide clamp having a slot for receiving the tube; a slide clamp ejection device including a solenoid configured to automatically eject the slide clamp from the slide clamp channel to move the tube to a non-occluding portion of the slide clamp based on one or more inputs from one or more sensors arranged on the infusion pump; wherein the slide clamp is automatically ejected from the slide clamp channel when the one or more inputs from the

one or more sensors establish that the tube is installed and loaded and the door is closed and latched.

[0011] In accordance with an~~other exemplary aspect of the present disclosure~~ example, which may be used in combination with any one or more of the preceding aspects, the infusion pump includes a tube channel on the housing configured to hold a tube in the infusion pump. The tube channel may be positioned at least partially behind the door.

[0012] In accordance with another ~~exemplary aspect of the present disclosure~~example, which may be used in combination with any one or more of the preceding aspects, the infusion pump includes a pumping mechanism including a shuttle. The pumping mechanism may be positioned behind the door.

[0013] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the infusion pump includes a slide clamp ejection device configured to eject a slide clamp from a channel.

[0014] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the slide clamp ejection device includes a solenoid configured to automatically eject the slide clamp based on one or more inputs from one or more sensors arranged on the infusion pump.

[0015] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the one or more sensors include a first Hall effect sensor configured to detect when the door is positioned in the closed state.

[0016] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the one or more sensors include an IR sensor configured to detect when the door is latched while positioned in the closed state.

[0017] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the one or more sensors include a pressure sensor configured to detect the presence of the tube at a load point along the tube channel.

[0018] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the one or more sensors include a second Hall effect sensor configured to detect that a valve is closed to place the tube in an occluded state.

[0019] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the infusion pump is configured to initiate an infusion after receiving a confirmation that at least one of the slide clamp is in an ejected state and the door is in a closed state.

[0020] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the tube is in an occluded state after the slide clamp is inserted within the channel.

[0021] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the infusion pump includes a sensor that detects the presence of the slide clamp within the channel.

[0022] In accordance with another ~~exemplary~~ example~~aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the infusion pump further includes a tube loading guidance system, wherein the tube loading guidance system includes one or more visual cues configured to provide guidance to a user during tube loading.

[0023] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the visual cues include a first light-emitting diode, a second light emitting diode, and a display. The first and second light emitting diodes are configured to indicate whether a tube is properly or improperly loaded at respective load points on the infusion pump.

[0024] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the infusion pump further includes an occlusion sensor. The occlusion sensor is configured to determine if an infusion line connected to the infusion pump is blocked.

[0025] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the occlusion sensor determines if an infusion line is blocked by calculating a slope of a force curve, a slope of a pressure curve, a comparison to a baseline force measurement, a comparison to a baseline pressure measurement, or an area under the force curve.

[0026] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the infusion pump further includes an accelerometer. The accelerometer is configured to detect an occlusion and/or whether the infusion pump experienced an external impact.

[0027] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the infusion pump is positioned in a rack with at least one other infusion pump or syringe pump.

[0028] Aspects of the subject matter described herein may be useful alone or in combination with one or more other aspects described herein. In another example~~exemplary aspect of the present disclosure~~, a tube loading guidance system for positioning a tube within an infusion pump housing includes a first visual cue, a second visual cue, and a third visual cue. The first visual cue is configured to indicate both proper and improper loading of a slide clamp in the infusion pump. The second visual cue is configured to indicate both proper and improper loading of the tube at a first load point in the infusion pump. Additionally, the third visual cue is configured to indicate both proper and improper loading of the tube at a second load point in the infusion pump.

[0029] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the second visual cue and the third visual cue include light emitting diodes.

[0030] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the light emitting diodes indicate proper loading by illuminating in a first color. Additionally, the light emitting diodes indicate improper loading by illuminating in a second color.

[0031] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the second visual cue is illuminated based on an output from a pressure sensor associated with the first load point.

[0032] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the third visual cue is illuminated based on an output from a different pressure sensor associated with the second load point.

[0033] Aspects of the subject matter described herein may be useful alone or in combination with one or more other aspects described herein. In another example~~exemplary aspect of the present disclosure~~, a method of detecting an occlusion includes monitoring a pressure measurement, comparing the pressure measurement to a threshold, and determining an occlusion exists within a tube of an infusion pump when the pressure measurement is greater than the threshold. The pressure measurement may be based on a

current ADC, a baseline ADC, and a slope of an ADC-pressure plot. Additionally, the threshold may be based on a selected occlusion detection mode.

[0034] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the selected occlusion detection mode includes one of a rapid occlusion detection mode and a non-rapid occlusion detection mode.

[0035] In accordance with another example~~exemplary aspect of the present disclosure~~, which may be used in combination with any one or more of the preceding aspects, the threshold is lower for the rapid occlusion detection mode than the non-rapid occlusion detection mode.

[0036] To the extent that any of these aspects are mutually exclusive, it should be understood that such mutual exclusivity shall not limit in any way the combination of such aspects with any other aspect whether or not such aspect is explicitly recited. Any of these aspects may be claimed, without limitation, as a system, method, apparatus, device, medium, etc.

[0037] Therefore, it is a primary object of the ~~invention~~ present disclosure to provide for an infusion pump capable of delivering an accurate volume of medicament using a standard infusion set.

[0038] It is another object of the present disclosure ~~invention~~ to provide an infusion pump capable of detecting proper IV tube loading.

[0039] It is another object of the present disclosure ~~invention~~ to provide an infusion pump capable of providing IV tube loading guidance to a user.

[0040] It is a further object of the present disclosure ~~invention~~ to provide automatically actuated slide clamp ejection based on various pump sensor input.

[0041] It is another object of the present disclosure ~~invention~~ to provide occlusion detection for an infusion pump.

[0042] It is an additional object of the present disclosure ~~invention~~ to provide drop detection for an infusion pump.

[0043] It is a further object of the present disclosure ~~invention~~ to provide power management for an infusion pump loaded in a rack configuration.

CLAIMS

1. An infusion pump comprising:

a housing with a door pivotally mounted to the housing;

a tube channel positioned at least partially behind the door on the housing, the tube channel configured to hold a tube in the infusion pump;

a pumping mechanism including a shuttle positioned behind the door; ~~and~~

a slide clamp channel for receiving a slide clamp, the slide clamp having a slot for receiving the tube;

a slide clamp ejection device including a solenoid configured to automatically eject the slide clamp from ~~a~~ the slide clamp channel to move the tube to a non-occluding portion of the slide clamp based on one or more inputs from one or more sensors arranged on the infusion pump;

wherein the slide clamp is automatically ejected from the slide clamp channel when the one or more inputs from the one or more sensors establish that the tube is installed and loaded and the door is closed and latched.

2. The infusion pump of claim 1, wherein the tube is in an occluded state after the slide clamp is inserted within the slide clamp channel.

3. The infusion pump of claim 2, wherein the one or more sensors include at least one of a first Hall effect sensor configured to detect when the door is positioned in a closed state, an optical IR sensor configured to detect when the door is latched while positioned in the closed state, a pressure sensor configured to detect the presence of the tube at a load point along the tube channel, and a second Hall effect sensor configured to detect that a valve is closed to place the tube in an occluded state.

4. The infusion pump of claim 3, wherein the infusion pump is configured to initiate an infusion after receiving a confirmation that the slide clamp is in an ejected state and the door is in a closed state.

5. The infusion pump of ~~any of~~ claim~~s~~ 1~~ to 4~~, wherein the door is configured to unlock and transition between a closed state and an open state after the slide clamp is inserted within the channel.

6. The infusion pump of ~~any of~~ claim~~s~~ 1~~ to 5~~, further including a sensor, wherein the sensor~~ detects~~ is configured to detect the presence of the slide clamp within the slide clamp channel.

7. The infusion pump of claim 6, wherein the sensor is a Hall effect sensor.

8. The infusion pump of ~~any of~~ claim~~s~~ 1~~ to 7~~, further comprising a tube loading guidance system, wherein the tube loading guidance system includes one or more visual cues configured to provide guidance to a user during tube loading.

9. The infusion pump of claim 8, wherein the visual cues include a first light-emitting diode, a second light emitting diode, and a display, wherein the first and second light emitting diodes are configured to indicate whether a tube is properly or improperly loaded at respective load points on the infusion pump.

10. The infusion pump of ~~any of~~ claim~~s~~ 1~~ to 9~~, further comprising an occlusion sensor, wherein the occlusion sensor is configured to determine if an infusion line connected to the infusion pump is blocked.

11. The infusion pump of claim 10, wherein the occlusion sensor determines if an infusion line is blocked by calculating one of a slope of a force curve, a slope of a pressure curve, a comparison to a baseline force measurement, a comparison to a baseline pressure measurement, or an area under the force curve.

12. The infusion pump of ~~any of~~ claim~~s~~ 1~~ to 11~~, further comprising an accelerometer, wherein the accelerometer is configured to detect at least one of an occlusion or whether the infusion pump experienced an external impact.

13. The infusion pump of ~~any of~~ claim~~s~~ 1~~ to 12~~, wherein the infusion pump is positioned in a rack with at least one other infusion pump or syringe pump.

~~14. A tube loading guidance system for positioning a tube within an infusion pump housing, the positioning system comprising:~~

~~a first visual cue configured to indicate both proper and improper loading of a slide clamp in the infusion pump;~~

~~a second visual cue configured to indicate both proper and improper loading of the tube at a first load point in the infusion pump; and~~

~~a third visual cue configured to indicate both proper and improper loading of the tube at a second load point in the infusion pump.~~

~~15. The tube loading guidance system of claim 14, wherein the second visual cue and the third visual cue include light emitting diodes.~~

~~16. The tube loading guidance system of claim 15, wherein the light emitting diodes indicate proper loading by illuminating in a first color, and wherein the light emitting diodes indicate improper loading by illuminating in a second color.~~

~~17. The tube loading guidance system of any of claims 14 to 16, wherein the second visual cue is illuminated based on an output from a pressure sensor associated with the first load point.~~

~~18. The tube loading guidance system of claim 17, wherein the third visual cue is illuminated based on another output from a different pressure sensor associated with the second load point.~~

~~19. A method of detecting an occlusion, the method comprising:~~

~~monitoring a pressure measurement, wherein the pressure measurement is based on a current ADC, a baseline ADC, and a slope of an ADC-pressure plot;~~

~~comparing the pressure measurement to a threshold based on a selected occlusion detection mode; and~~

~~determining an occlusion exists within a tube of an infusion pump when the pressure measurement is greater than the threshold.~~

~~20. The method of claim 19, wherein the selected occlusion detection mode includes one of a rapid occlusion detection mode and a non-rapid occlusion detection mode, and wherein the threshold is lower for the rapid occlusion detection mode than the non-rapid occlusion detection mode.~~