Claims

1. A syringe pump, comprising:

a lead screw having threads;

a motor operatively coupled to the lead screw to rotate the lead screw; and

a sliding block assembly comprising:

a half-nut housing having a lead screw void configured to receive the lead screw;

a half nut disposed within the half-nut housing, the half nut having half-nut threads at an end adjacent to the lead screw void, the half nut is slideable between an engagement position whereby the half-nut threads engage with the threads of the lead screw and a disengagement position whereby the half-nut threads are disengaged from the threads of the lead screw, wherein the half nut includes a half-nut cam-follower surface and a half nut slot; and

a barrel cam disposed within the half-nut housing and configured to engage with the half-nut cam-follower surface, the barrel cam includes a pin configured to fit within the half nut slot, wherein the barrel cam is configured to rotate between a first position and a second position to actuate the half nut between the engagement position and the disengagement position, respectively.

2. The syringe pump according to claim 1, wherein the half-nut cam-follower surface is positioned adjacent to the barrel cam.

3. The syringe pump according to claim 1, wherein the half-nut cam-follower surface is disposed near an opposite end of the half nut relative to the half-nut threads.

4. The syringe pump according to claim 1, wherein the half nut further includes a half-nut slot plate defining the half nut slot.

5. The syringe pump according to claim 4, wherein the half-nut slot plate extends away from the lead screw.

6. The syringe pump according to claim 4, wherein the half-nut slot plate is disposed near an edge of the half-nut cam-follower surface such that the half-nut slot plate engages the half-nut cam-follower surface at a right angle.

7. The syringe pump according to claim 6, wherein:
the barrel cam is disposed adjacent to the half-nut cam-follower surface,
the pin of the barrel cam is disposed on an end of the barrel cam; and
the pin of the barrel cam engages with the half nut slot of the half-nut slot plate as the barrel cam engages with the half-nut cam-follower surface.

8. The syringe pump according to claim 7, wherein rotation of the barrel cam to the second position engages with the half nut slot to pull the half nut toward the barrel cam and away from the lead screw.

9. The syringe pump according to claim 8, wherein the barrel cam includes a barrel cam shoulder cylindrically shaped and having a first radius.

10. The syringe pump according to claim 9, wherein the barrel cam has a second radius that is substantially coextensive with the first radius, wherein the barrel cam includes a barrel cam flat wherein the second radius is less than the first radius, wherein the barrel cam flat is positioned to allow the half nut to extend closer to a center axis of the barrel cam than a distance of the first radius when the half nut is pulled toward the barrel cam and the barrel cam rotates to the second position.

11. The syringe pump according to claim 10, wherein the barrel cam flat is configured to be flush against the half-nut cam-follower surface when the barrel cam is in the second position.

12. The syringe pump according to claim 11, wherein the half-nut housing includes a barrel cam void configured to be adjacent a barrel cam surface of the barrel cam so that the barrel cam freely rotates within the barrel cam void.

13. The syringe pump according to claim 1, wherein the half nut includes a rod bushing void positioned between the half-nut threads and the half-nut cam-follower surface.

14. The syringe pump according to claim 1, wherein the syringe pump communicates a speed of a plunger to a monitoring client.

15. The syringe pump according to claim 1, wherein the half-nut housing defines a half-nut housing groove configured to cooperate with a syringe pump assembly guide rail.

16. The syringe pump according to claim 1, further comprising a half-nut slot plate disposed near an edge of the half-nut cam-follower surface such that the half-nut slot plate engages the half-nut cam-follower surface at a right angle.

17. The syringe pump according to claim 1, wherein:
the barrel cam is disposed adjacent to the half-nut cam-follower surface,
the pin of the barrel cam is disposed on an end of the barrel cam, and
the pin of the barrel cam engages with the half nut slot as the barrel cam engages with the half-nut cam-follower surface.

18. The syringe pump according to claim 1, wherein rotation of the barrel cam to the second position engages with the half nut slot to pull the half nut toward the barrel cam and away from the lead screw.

19. The syringe pump according to claim 1, wherein the barrel cam includes a cylindrically shaped barrel cam shoulder.

20. The syringe pump according to claim 1, wherein the barrel cam has a second radius that is substantially coextensive with a first radius, wherein the barrel cam includes a barrel cam flat wherein the second radius is less than the first radius, wherein the barrel cam flat is positioned to allow the half nut to extend closer to a center axis of the barrel

cam than a distance of the first radius when the half nut is pulled toward the barrel cam as the barrel cam rotates to the second position.

21. The syringe pump according to claim 1, wherein the barrel cam includes he barrel cam flat configured to be flush against the half-nut cam-follower surface when the barrel cam is in the second position.

22. The syringe pump according to claim 1, wherein the half-nut housing includes a barrel cam void configured to be adjacent a barrel cam surface of the barrel cam so that the barrel cam freely rotates within the barrel cam void.

23. The syringe pump according to claim 1, further comprising a retaining finger pivotally coupled to a housing of the syringe pump, wherein the retaining finger is configured to rotate toward a syringe disposed within a syringe seat to retain the syringe.

24. The syringe pump according to claim 23, wherein the syringe pump is configured to communicate with a monitoring client.

25. The syringe pump according to claim 1, further comprising

a housing;

a syringe seat coupled to the housing, the syringe seat configured to retain a syringe having a barrel and a plunger disposed within the barrel;

a plunger head assembly coupled to the sliding block assembly and configured to drive the plunger of the syringe into the barrel of the syringe, the plunger head assembly having a force sensor operatively coupled to the plunger of the syringe to measure a force of the plunger head assembly on the plunger of the syringe; and

a processor operatively coupled to the motor and configured to control rotation of the motor to thereby control actuation of the plunger head assembly, the processor is also operatively coupled to the force sensor to receive a measured force therefrom, wherein the processor is configured to:

receive a target flow rate of the syringe loaded on the syringe pump;

determine a therapy actuation speed corresponding to the target flow rate;

command the motor to actuate the plunger of the syringe out of the barrel at a first predetermined speed until the force sensor coupled to the plunger measures a force that is less than a first predetermined force threshold or the plunger travels out of the barrel by a first predetermined distance;

command the motor to actuate the plunger of the syringe into the barrel at a second predetermined speed greater than the therapy actuation speed until the force sensor coupled to the plunger measures a force that exceeds a second predetermined threshold or the plunger travels into the barrel by a second predetermined distance; and

command the motor to actuate the plunger of the syringe into the barrel at the therapy actuation speed.

26. The syringe pump according to claim 25, wherein the therapy actuation speed corresponds to the target flow rate when there is no slack in the syringe pump or the syringe.

27. The syringe pump according to claim 25, wherein the processor is further configured issue an alarm if the plunger traveled into the barrel by the second predetermined distance without the force sensor measuring a force that exceeds the second predetermined threshold.

28. The syringe pump according to claim 25, further comprising a transceiver, wherein the processor is configured to communicate via the transceiver with a monitoring client.

29. A method of engaging a lead screw of a syringe pump, comprising:
actuating a barrel cam between a disengaged position to an engaged position
engaging the barrel cam with a half-nut cam-follower surface of a half-nut;
engaging a pin of the barrel cam with a half nut slot of a half nut; and
engaging half-nut threads with threads of the lead screw.

30. The method according to claim 29, wherein the half nut further includes a half-nut slot plate defining the half nut slot.

31. A method for removing effects of slack in a syringe pump having a syringe loaded on the syringe pump, the syringe having a barrel and a plunger disposed within the barrel, the method comprising:

coupling a sliding block assembly with lead screw, the sliding block assembly comprising:

a half-nut housing having a lead screw void configured to receive the lead screw therewithin;

a half nut disposed within the half-nut housing and having half nut threads at an end adjacent to the lead screw void, the half nut is slideable between an engagement position whereby the half nut threads engage with threads of the lead screw thereby creating the slack and a disengagement position whereby the half nut threads are disengaged from the threads of the lead screw, wherein the half nut includes a cam follower surface and a half nut slot; and

a barrel cam disposed within the half-nut housing and configured to engage with the cam follower surface, the barrel cam includes a pin configured to fit within the half nut slot, wherein the barrel cam is configured to rotate between a first position and a second position to actuate the half nut between the engagement position and the disengagement position, respectively;

receiving a target flow rate of the syringe loaded on the syringe pump;

determining a therapy actuation speed corresponding to the target flow rate;

actuating the plunger of the syringe out of the barrel by rotating the lead screw at a first predetermined speed until a force sensor coupled to the plunger measures a force that is less than a first predetermined force threshold;

actuating the plunger of the syringe into the barrel by rotating the lead screw at a second predetermined speed greater than the therapy actuation speed until the force sensor coupled to the plunger measures a force that exceeds a second predetermined threshold; and

actuating the plunger of the syringe into the barrel by rotating the lead screw at the therapy actuation speed.

32. The method according to claim 31, wherein the therapy actuation speed corresponds to the target flow rate when there is no slack in the syringe pump or the syringe.

33. The method according to claim 31, further comprising estimating a volume discharged starting from the position of the plunger when the second predetermined threshold was exceeded.

34. The method according to claim 33, further comprising stopping the syringe pump when the estimated volume discharged is equal to or exceeds a target delivery volume.

35. The method according to claim 31, further comprising communicating an actual speed of the plunger to a monitoring client.

36. A method for removing effects of slack in a syringe pump having a syringe loaded on the syringe pump, the syringe having a barrel and a plunger disposed within the barrel, the method comprising:

coupling a sliding block assembly with lead screw, the sliding block assembly comprising:

a half-nut housing having a lead screw void configured to receive the lead screw therewithin;

a half nut disposed within the half-nut housing and having half nut threads at an end adjacent to the lead screw void, the half nut is slideable between an engagement position whereby the half nut threads engage with threads of the lead screw thereby creating the slack and a disengagement position whereby the half nut threads are disengaged from the threads of the lead screw, wherein the half nut includes a cam follower surface and a half nut slot; and

a barrel cam disposed within the half-nut housing and configured to engage with the cam follower surface, the barrel cam includes a pin configured to fit within the half nut slot, wherein the barrel cam is configured to rotate between a first position and a second position to actuate the half nut between the engagement position and the disengagement position, respectively;

receiving a target flow rate of the syringe loaded on the syringe pump;

determining a therapy actuation speed corresponding to the target flow rate;

actuating the plunger of the syringe out of the barrel at a first predetermined speed by rotating the lead screw until a force sensor coupled to the plunger measures a force that is less than a first predetermined force threshold or the plunger travels out of the barrel by a first predetermined distance;

actuating the plunger of the syringe into the barrel at a second predetermined speed greater than the therapy actuation speed by rotating the lead screw until the force sensor coupled to the plunger measures a force that exceeds a second predetermined threshold or the plunger travels into the barrel by a second predetermined distance; and

actuating the plunger of the syringe into the barrel at the therapy actuation speed by rotating the lead screw.

37. The method according to claim 36, wherein the therapy actuation speed corresponds to the target flow rate when there is no slack in the syringe pump or the syringe.

38. The method according to claim 36, further comprising estimating a volume discharged starting from the position of the plunger when the second predetermined threshold was exceeded.

39. The method according to claim 36, further comprising stopping the syringe pump when the estimated volume discharged is equal to or exceeds a target delivery volume.

40. The method according to claim 36, further comprising using an alarm if the plunger traveled into the barrel by the second predetermined distance without the force sensor measuring a force that exceeds the second predetermined threshold.

41. The method according to claim 36, further comprising communicating an actual speed of the plunger to a monitoring client.

42. A syringe pump for administering an agent to a patient, the syringe pump comprising:

a plunger head assembly configured to actuate a syringe;

at least one latch configured to releasably secure the syringe to the plunger head assembly;

a shaft disposed within the syringe pump;

a sliding block assembly configured for engaging with a lead screw to move along the lead screw in accordance with rotation of the lead screw, wherein the sliding block assembly comprises:

a half-nut housing having a lead screw void configured to receive the lead screw therewithin;

a half nut disposed within the half-nut housing and having half nut threads at an end adjacent to the lead screw void, the half nut is slideable between an engagement position whereby the half nut threads engage with threads of the lead screw thereby creating slack and a disengagement position whereby the half nut threads are disengaged from the threads of the lead screw, wherein the half nut includes a cam follower surface and a half nut slot; and

a barrel cam disposed within the half-nut housing and configured to engage with the cam follower surface, the barrel cam includes a pin configured to fit within the half nut slot, wherein the barrel cam is configured to rotate between a first position and a second position to actuate the half nut between the engagement position and the disengagement position, respectively.

43. The syringe pump according to claim 42, wherein the at least one latch includes first and second flange-clamp jaws.

44. The syringe pump according to claim 43, wherein the first and second flange-clamp jaws are disposed on the plunger head assembly and are configured to grasp onto a plunger flange of a plunger of the syringe, wherein the first and second flange-clamp jaws are configured to actuate between an open position and a closed position.

45. The syringe pump according to claim 42, further comprising a user-controlled actuator disposed on the plunger head assembly and configured for actuation by a user.

46. The syringe pump according to claim 45, wherein:
the shaft is operatively coupled to the user-controlled actuator,
the shaft is elongated along a length thereby defining an axis along the length, and
actuation of the user-controlled actuator rotates the shaft around the axis.

47. The syringe pump of claim 42, wherein the plunger head assembly further comprises a pressure sensor configured to monitor a pressure of the agent being dispensed from the syringe.

48. The syringe pump of claim 47, wherein a plunger flange of the syringe is held against the pressure sensor by the at least one latch.

49. The syringe pump of claim 42, wherein the syringe pump further comprises a barrel flange clip, the barrel flange clip configured to retain a barrel flange of the syringe.

50. The syringe pump of claim 49, further comprising an optical sensor and a light source configured to detect a presence of the syringe.

51. The syringe pump according to claim 42, wherein the syringe pump is configured to communicate with a monitoring client.

52. The syringe pump according to claim 42, further comprising a potentiometer configured to monitor an actuation of the at least one latch, wherein the potentiometer is keyed to a parallel shaft operatively coupled in parallel to the shaft.

53. The syringe pump according to claim 42, further comprising at least one set of redundant sensors, the at least one set of redundant sensors configured such that if part of a set of the at least one set of redundant sensors is compromised, the syringe pump is

configured to function in a fail operative mode for at least a duration of a therapy, the set of the at least one set of redundant sensors is configured to monitor a volume being infused.

54. The syringe pump according to claim 45, wherein the user-controlled actuator is a knob operatively coupled to the shaft.

55. The syringe pump according to claim 42, wherein actuation of the shaft actuates the at least one latch.

56. The syringe pump according to claim 43, wherein the first and second flange-clamp jaws have first and second engagement surfaces, respectively, configured to engage with a plunger flange of a plunger of the syringe, wherein the first and second flange-clamp jaws are configured to actuate toward and away from each other such that the first and second engagement surfaces remain parallel to each other.

57. A syringe pump for administering an agent to a patient, the syringe pump comprising:

a plunger head assembly;

first and second flange-clamp jaws disposed on the plunger head assembly and configured to grasp onto a plunger flange of a plunger of a syringe, wherein the first and second flange-clamp jaws are configured to actuate between an open position and a closed position;

a user-controlled actuator disposed on the plunger head assembly and configured for actuation by a user;

a shaft disposed within the plunger head assembly and operatively coupled to the user-controlled actuator, the shaft being elongated along a length thereby defining an axis along the length, wherein actuation of the user-controlled actuator rotates the shaft around the axis; and

a sliding block assembly configured for engaging with a lead screw to move along the lead screw in accordance with rotation of the lead screw, wherein the sliding block assembly comprises:

a half-nut housing having a lead screw void configured to receive the lead screw therewithin;

a half nut disposed within the half-nut housing and having half nut threads at an end adjacent to the lead screw void, the half nut is slideable between an engagement position whereby the half nut threads engage with threads of the lead screw thereby creating slack and a disengagement position whereby the half nut threads are disengaged from the threads of the lead screw, wherein the half nut includes a cam follower surface and a half nut slot; and

a barrel cam disposed within the half-nut housing and configured to engage with the cam follower surface, the barrel cam includes a pin configured to fit within the half nut slot, wherein the barrel cam is configured to rotate between a first position and a second position to actuate the half nut between the engagement position and the disengagement position, respectively.

58. A syringe pump for administering an agent to a patient, the syringe pump comprising:

a plunger head assembly;

first and second flange-clamp jaws disposed on the plunger head assembly and configured to grasp onto a plunger flange of a plunger of a syringe, wherein the first and second flange-clamp jaws are configured to actuate between an open position and a closed position;

a shaft disposed within the plunger head assembly the shaft being elongated along a length thereby defining an axis along the length, wherein actuation of a user-controlled actuator rotates the shaft around the axis; and

a sliding block assembly configured for engaging with a lead screw to move along the lead screw in accordance with rotation of the lead screw, wherein the sliding block assembly comprises:

a half-nut housing having a lead screw void configured to receive the lead screw therewithin;

a half nut disposed within the half-nut housing and having half nut threads at an end adjacent to the lead screw void, the half nut is slideable between an engagement position whereby the half nut threads engage with threads of the lead screw thereby

creating slack and a disengagement position whereby the half nut threads are disengaged from the threads of the lead screw, wherein the half nut includes a cam follower surface and a half nut slot; and

a barrel cam disposed within the half-nut housing and configured to engage with the cam follower surface, the barrel cam includes a pin configured to fit within the half nut slot, wherein the barrel cam is configured to rotate between a first position and a second position to actuate the half nut between the engagement position and the disengagement position, respectively.

59. The syringe pump according to claim 58, wherein the shaft is operatively coupled to the user-controlled actuator.

60. A syringe pump for administering an agent to a patient, the syringe pump comprising:

a plunger head assembly;

first and second flange-clamp jaws disposed on the plunger head assembly and configured to grasp onto a plunger flange of a plunger of a syringe, wherein the first and second flange-clamp jaws are configured to actuate between an open position and a closed position;

a shaft being elongated along a length thereby defining an axis along the length; and

a sliding block assembly configured for engaging with a lead screw to move along the lead screw in accordance with rotation of the lead screw, wherein the sliding block assembly comprises:

a half-nut housing having a lead screw void configured to receive the lead screw therewithin;

a half nut disposed within the half-nut housing and having half nut threads at an end adjacent to the lead screw void, the half nut is slideable between an engagement position whereby the half nut threads engage with threads of the lead screw thereby creating slack and a disengagement position whereby the half nut threads are disengaged from the threads of the lead screw, wherein the half nut includes a cam follower surface and a half nut slot; and

a barrel cam disposed within the half-nut housing and configured to engage with the cam follower surface, the barrel cam includes a pin configured to fit within the half nut slot, wherein the barrel cam is configured to rotate between a first position and a second position to actuate the half nut between the engagement position and the disengagement position, respectively.