

Syringe Pump

[Technical Field]

[0001] The present invention relates to a syringe pump that feeds a liquid inside of a syringe at a set flow rate and to a control method for the syringe pump.

[Background Technology]

[0002] Conventionally, a syringe pump that can administer a liquid medicine to a patient at a high precision is used at medical sites. The syringe pump is configured to be able to hold various types of syringes of differing sizes, and by driving a piston presser that presses a piston of a syringe, a liquid medicine inside of the syringe can be fed accurately as the piston is pushed (for example, see Patent Document 1).

[0003] Specifically, a drive mechanism of the syringe pump is provided with a feed screw rotationally driven by a motor, a half nut that mates together with the feed screw, and a release lever for putting the half nut into a state separated from the feed screw, and the piston presser is linked to the half nut. Additionally, as the feed screw is rotated by the motor while in a state with the piston of the mounted syringe held by the piston presser, the half nut moves in a straight line along an axial direction of the syringe, and the piston can be pressed thereby. When another syringe is mounted after administration of the liquid medicine is completed, the piston presser must be moved to match a position of the piston of the syringe thereof; however, the release lever is made to operate by moving freely along the axial direction away from the half nut at such a time, and a position of the piston presser can be adjusted thereby.

[0004] Moreover, as is also disclosed in Patent Document 1, from a perspective of preventing a decrease of accuracy due to wear, as a screw portion of the feed screw and the half nut, a trapezoidal screw having flat

peaks on the threads is generally used.

[0005] Moreover, a high level of safety is demanded when the syringe pump is used, so various alarm functions and safety functions are incorporated therewith. For example, a photo sensor or micro switch may be used to detect the mated state of the feed screw and half nut, and if there is a mating problem, an alarm may be issued, or an injection prevention function may prevent injection even if a button for starting injection of the liquid medicine is pressed.

[Related Art Documents]

[Patent Document]

[0006] Patent Document 1: Japanese Unexamined Patent Application Publication No. 2006-105198

[Summary of the Invention]

[Problem to be Solved by the Invention]

[0007] When the syringe is mounted in the syringe pump, the release lever is operated as described above to temporarily release the half nut from the feed lever and the position of the piston presser is adjusted, after which the half nut is mated with the feed screw. However, because the screw portion between the feed screw and the half nut is a trapezoidal screw, due to the positional relationship between the feed screw and the half nut along the axial direction, a state can occur where the flat surfaces at the peaks of the threads of the feed screw and the half nut contact together, and one set of threads does not fit into the grooves of the other set of threads, that is, a mating problem can occur. In order to reduce the frequency of the occurrence of these mating problems, it is possible to consider processing the screw threads in the shape disclosed in Patent Document 1, however, as long as the screw is trapezoidal, the flat parts of the peaks of the threads will contact each other at a constant rate.

[0008] The syringe pump is made such that when a mating problem occurs, the user is notified by an alarm, or an injection prevention function prevents injection from being performed. Among causes of mating problems, minor causes such as flat parts at the peaks of the threads contacting each other account for a large share, and there are few serious instances due to damage to the screw or the like.

[0009] However, no matter what the cause, the user will have to deal with these mating problems, and the syringe pump will be regarded as being complicated and as having poor maneuverability.

[0010] Moreover, if the user performs the administration start operation without noticing that a mating problem has occurred, a state may occur where the user may think administration of the drug has started when in reality the drug is not being administered, and in this case, insufficient dosing may occur.

[0011] The present invention was conceived with the aforementioned points in mind, and an object thereof is, among causes of mating problems between the feed screw and the half nut, to reduce the frequency of occurrence of mating problems by automatically eliminating the cause of minor problems, and thereby, to make maneuverability for the user favorable, and to make it so that insufficient dosing does not occur.

[Means for Solving the Problem]

[0012] In order to achieve the aforementioned object, the present invention eliminates contact between flat surface parts at screw thread peaks by rotating a feed screw when a syringe is mounted such that screw threads can mate with grooves on a mating side.

[0013] A first invention is a syringe pump configured to include: a piston presser that presses a piston of a syringe filled with a liquid,
a drive mechanism that drives the piston presser, and
a control apparatus that controls the drive mechanism, wherein:

the drive mechanism includes a feed screw, a motor that rotates the feed screw thereof, a half nut that mates with the feed screw, and a switching member that switches the half nut thereof between a state of being mated with the feed screw and a state of being separated from the feed screw, and

the control apparatus includes syringe mounting state detection means that detect whether a syringe is mounted or not, and when the syringe mounting state detection means detect that a syringe is mounted, motor drive control is performed to drive the motor.

[0014] According to this configuration, by putting the half nut in a state separated from the feed screw by switching the drive mechanism with the switching member, the piston presser can be moved freely without using the feed screw. For example, there may be cases where flat surfaces of the screw thread peaks of the half nut and the feed screw contact each other and the half nut does not mate with the feed screw when a user attempts to put the half nut in a state mated with the feed screw using the switching member, after adjusting a position of the piston presser to meet up with a syringe that is being mounted.

[0015] In the present invention, when a syringe is mounted, the control apparatus drives the motor to rotate the feed screw. Through this rotation of the feed screw, a contact portion between the screw threads of the feed screw and the screw threads of the half nut moves relatively along an axial direction. Through this relative movement of the contact portion, the screw threads of the half nut fit in the thread grooves of the feed screw, and the half nut and feed screw are mated together. Accordingly, among causes of mating problems between the feed screw and the half nut, because the cause of the minor problem of the threads themselves abutting is automatically eliminated, the frequency of occurrence of mating problems can be reduced.

[0016] A second invention is the first invention,

wherein the control apparatus is configured to include mating state detection means for detecting whether the half nut is mated with the feed screw or not, and when it is detected by the mating state detection means that the half nut is not mated with the feed screw, motor drive control is performed.

[0017] According to this configuration, cases where the half nut is not mated with the feed screw are detected, and the motor is driven when the feed screw and the half nut are not mated. In this manner, the occurrence frequency of mating problems is reduced.

[0018] A third invention is the second invention, configured such that:

the syringe mounting state detection means are configured to determine whether the syringe mounting state is normal or not, and

the control apparatus is configured such that, after the syringe mounting state detection means detect that a syringe is mounted, if it is detected that the syringe mounting state is normal, detection is performed by the mating state detection means.

[0019] Specifically, as a cause of mating problems between the feed screw and the half nut, for example, the syringe mounting state may not be normal and the piston presser position may be bad. In such a case, there is a high possibility that the feed screw and the half nut cannot mate together even if motor drive control is performed. The present invention is configured such that the syringe mounting state is detected, and when the mounting state is detected as being normal, motor drive control is performed, and thereby unnecessary control can be eliminated as much as possible, and proper control can be performed.

[0020] The fourth invention is the second or third invention, configured such that the control apparatus includes alert means that alert if the half nut is not mated

with the feed screw, and after motor drive control is performed, detection is performed again by the mating state detection means, and if it is detected by the mating state detection means that the half nut is not mated with the feed screw, an alert is issued of a mating problem between the half nut and the feed screw through the alert means.

[0021] That is, after motor drive control is performed, if the half nut is not mated with the feed screw, there is a possibility of an abnormality with the drive mechanism or an abnormality with mounting of the syringe, and in this case, the user can be alerted of these abnormalities quickly by the alerting of the mating problem through the alert means, and can take corrective measures.

[0022] A fifth invention is any one of the first through fourth inventions, wherein the control apparatus is configured such that, in the motor drive control, if the mating state detection means detect that the half nut is mated with the feed screw while the motor is rotating, rotation of the motor is stopped.

[0023] According to such a configuration, by stopping the rotation of the motor when the half nut is mated with the feed screw, movement of the piston during motor drive control can be suppressed.

[0024] A sixth invention is any one of the first through fifth inventions, wherein the motor drive control is control that causes the feed screw to rotate toward a piston pressing side.

[0025] According to this configuration, when drive force is transmitted to the piston during motor drive control, the piston moves to the side where the liquid is administered, and therefore there is no drawing in of the patient's blood.

[0026] A seventh invention is a control method for a syringe pump that includes a piston presser that presses a piston of a syringe filled with a liquid, and

a drive mechanism that drives the piston presser,
wherein the drive mechanism includes a feed screw, a motor that rotates the feed screw thereof, a half nut that mates with the feed screw, and a switching member that switches this half nut between a state of being mated with the feed screw and a state of being separated from the feed screw, wherein in the control method:

after detecting whether a syringe is mounted or not,
if a syringe is mounted, the feed screw is caused to rotate by driving the motor.

[0027] According to this configuration, similar to the first invention, if the half nut and the feed screw are not mated due to a minor cause, because that minor cause is automatically eliminated, the frequency of occurrence of mating problems can be reduced.

[Effect of the Invention]

[0028] According to the first invention, when a syringe is mounted, because motor drive control is performed, minor causes of problems such as screw threads contacting together can be eliminated automatically. In this manner, because the frequency of occurrence of mating problems can be reduced, the maneuverability for the user can be made favorable, and it is possible to make it so that insufficient dosing does not occur.

[0029] According to the second invention, motor control is made to be performed when the half nut is not mated to the feed screw, and thereby the frequency of occurrence of mating problems can be reliably reduced.

[0030] According to the third invention, when the mounting state of the syringe is detected to be normal, the mating state is then detected, and therefore proper control can be performed in accordance with the mounting state of the syringe.

- [0031] According to the fourth invention, after motor drive control is performed, because an alert is issued for a mating problem if the half nut is not mated to the feed screw, alerts are issued quickly for abnormalities with the drive mechanism and for mounting abnormalities of the syringe, and safety can be improved.
- [0032] According to the fifth invention, during motor drive control, by stopping the rotation of the motor when the half nut is mated with the feed screw, movement of the piston during motor drive control can be suppressed, and dosing can be performed even more safely.
- [0033] According to the sixth invention, because the feed screw is made to rotate toward the pressing side of the piston during motor drive control, drawing in of the blood of the patient can be prevented.
- [0034] In the seventh invention, just as in the first invention, because the frequency of occurrence of mating problems can be reduced, the maneuverability for the user can be made favorable, and it is possible to make it so that insufficient dosing does not occur.

[Brief Description of the Drawings]

- [0035] FIG. 1 is a perspective view of a syringe pump according to an embodiment of the present invention.
- FIG. 2 is a drawing showing a drive mechanism of the syringe pump, a piston presser, and the like as viewed from the back surface side.
- FIG. 3 is a cross sectional view along line III-III of FIG. 2.
- FIG. 4 is a perspective view showing a portion of the drive mechanism of the syringe pump.
- FIG. 5 is a cross sectional view along line V-V of FIG. 3(a) for a case where a half nut is not mated with a feed screw.
- FIG. 6 is a drawing corresponding to FIG. 4 after motor drive control.

FIG. 7 is a block view of the syringe pump.

FIG. 8 is a flow chart showing a control procedure according to a control apparatus.

FIG. 9 is a flow chart showing another control procedure according to the control apparatus.

[Description of the Preferred Embodiments]

[0036] In the following, embodiments of the present invention will be explained in detail, with reference to the drawings. Note that the following explanation of preferred embodiments is essentially nothing more than an example, and the present invention is not intended to be limited in any way to these applications or to these uses.

[0037] FIG. 1 is a perspective view of a syringe pump according to an embodiment of the present invention. A syringe pump 1 is a pump for use at a medical site for administering a liquid such as a liquid medicine or the like to a patient. A syringe filled with a liquid medicine (not illustrated) is mounted, and the liquid medicine inside the syringe can be administered by pressing a piston of the syringe at a predetermined speed. Note that the syringe pump 1 is made to be supplied with electricity from an external source, and a battery (not illustrated) is also built such that the syringe pump is able to operate using this battery.

[0038] The syringe pump 1 is provided with a casing 10, a piston presser 20 for pressing the piston of the syringe outside of the casing 10, a drive mechanism 30 (shown in FIG. 2) for driving the piston presser 20, and a control apparatus A (shown in FIG. 7) that controls the drive mechanism 30. As shown in FIG. 2, a frame 15 to which the drive mechanism 3 is attached is provided inside of the casing 10. Within the frame 15, a cylindrical guide bar 16 for guiding a half nut 33 (described later), which belongs to the drive

mechanism 30, in a left and right direction of the syringe pump 1 is fixed in an attitude extending in the left and right direction of the syringe pump 1.

[0039] As shown in FIG. 1, a loading stand 10a for loading a main body portion of a syringe (tubular portion filled with liquid medicine) is formed in a back side of an upper surface of the casing 10. On a front side of the upper surface of the casing 10, a liquid crystal display panel 12, various buttons (including a start button 11 shown in FIG. 7), and the like are provided for operating the syringe pump 1.

[0040] Note that in the explanation of the embodiments, the side that is in front from the perspective of the user when operating the syringe pump 1 is called the front side, the back side from the user perspective is called the back side, the left side from the user perspective is called the left side, and the right side from the user perspective is called the right side. The piston is pressed from the right side toward the left side of FIG 1.

[0041] The syringe loaded on the loading stand 10a is positioned such that a liquid discharge side is positioned to the left side, and a piston flange side is positioned to the right. On a back side of the upper surface of the casing 10, a syringe clamp 13 is provided for pressing from the top and holding a main body portion of the syringe loaded on the loading stand 10a.

[0042] The piston presser 20 is provided on the right side at the back of the casing 10, and is made to move toward the left side from the position shown in FIG. 1. On a left side surface of the piston presser 20, a pair of claws 21 for flange holding are provided to sandwich and hold the piston flange. Moreover, at an upper part of the piston presser 20, an operation lever 23 is provided for operating the claws 21 and the half nut 33 described later.

[0043] As shown in FIG.2, the drive mechanism 30 includes a feed screw 31, a motor 32 that rotates the feed screw 31, a half nut 33 that mates with the feed screw 31, and a switching rod 34 (switching member) for switching

the half nut 33 between a state of being mated with the feed screw 31 and a state of being separated from the feed screw 31.

- [0044] The feed screw 31 is a metallic rod material that extends in a left to right direction of the syringe pump 1 and has a trapezoidal screw formed across from left and right ends at an outer periphery thereof. In the partial cross sectional views of the feed screw 31 shown in FIGS. 5 and 6, screw threads of the trapezoidal screw are indicated by the reference numeral 31a, and screw grooves are indicated by the reference numeral 31 b. A shape of the trapezoidal screw is a well-known shape.
- [0045] Both ends of the feed screw 31 are supported rotatably at the left and right ends of the frame 15 shown in FIG. 2. The motor 32 is connected to a control apparatus A, and the control apparatus A controls the stopping, rotation, change in rotational direction, the amount of rotation, the rotation speed, and the like of the motor 32. The motor 32 is fixed to the left end of the frame 15. An output of the motor 32 is made to be input to a left end of the feed screw 31 via a deceleration gear (not illustrated).
- [0046] As shown in FIGS. 2 through 4, a carriage 36 is provided at a tip of the switching rod 34. The carriage 36 is attached to the switching rod 34 so as to be immovable along the axial direction. In this state, the switching rod 34 is able to rotate axially relative to the carriage 36.
- [0047] The feed screw 31 is inserted through the carriage 36. Moreover, as shown in FIG. 4, at a lower part of the carriage 36, a through hole 36a through which a guide bar 16 passes is formed. The guide bar 16 is slideable along an inner peripheral surface of the through hole 36a of the carriage 36, whereby the guide bar 16 can guide the carriage 36 in the left and right direction.
- [0048] The half nut 33 is formed integrally with the carriage 36. An upper part of the half nut 33 is secured so as not to move in the axial direction relative to the switching rod 34, and also so as to not rock axially. Accordingly, when

the switching rod 34 is rotated axially (direction of arrow X) to switch from the state of FIG. 3(a) to the state of FIG. 3(b), the half nut 33 rotates therewith; however at this time, because the carriage 36 is rotatable relative to the switching rod 34, the carriage 36 remains in a static state and is not rotated by the rotation of the switching rod 34.

[0049] The half nut 33 is provided with a split nut portion 33A of a shape that splits a nut that threads onto the feed screw 31 roughly in half in a diameter direction, and a split nut holding member 33B that secures the split nut portion 33A. As shown in FIGS. 5 and 6, an inner peripheral surface of the split nut portion 33A is formed with screw grooves 33b and screw threads 33a that mate respectively with screw threads 31a and screw grooves 31b of the feed screw 31. In this embodiment, the feed screw 31 and the half nut 33 are trapezoidal screws, so decreasing precision from wear can be prevented.

[0050] The split nut holding member 33B attaches to the switching rod 34. The split nut holding member 33B is formed with a notch 33c for separating from an outer perimeter surface of the feed screw 31. A notch 33c is provided to keep the split nut holding member 33B from contacting the outer perimeter surface of the feed screw 31 when the half nut 33 is rotated from the state of FIG. 3(a) to the state of FIG. 3(b) by the switching rod 34. Note that the half nut 33 is constantly biased in a direction to mate with the feed screw 31 by a biasing member (not illustrated); therefore, the state shown in FIG. 3(b) can be achieved by applying a force that resists this biasing force to the switching rod 34.

[0051] As shown in FIG. 2, the switching rod 34 extends from the carriage 36 in the right direction, and the piston presser 20 is attached at the right end of the switching rod 34. That is, the piston presser 20 is in a state of being linked to the carriage 36 and the half nut 33 via the switching rod 34, and when the half nut 33 moves in the right and left direction, the

piston presser 20 moves the same amount.

[0052] Meanwhile, the operational lever 23 is coupled at the right end of the switching rod 34. By moving this operation lever 23 to the back or front as shown in FIG. 1, the switching rod 34 is made to be rotatable axially in opposition to the biasing force of the biasing member. By rotating the switching rod 34 in the direction shown by arrow X in FIG. 3, the screw threads 33a and screw grooves 33b of the half nut 33 move to the right side of the drawing shown by FIG. 3(b). In this manner, the screw threads 33a and the screw grooves 33b of the half nut 33 separate respectively from the screw grooves 31b and screw threads 31a of the feed screw 31. Meanwhile, if the operational force described above is not applied to the operation lever 23, the half nut 33 will rotate in a reverse direction from the arrow X due to the biasing force of the biasing member, and the screw threads 33a and screw grooves 33b of the half nut 33 will be mated with the screw threads 31a and screw grooves 31b of the feed screw 31.

[0053] Moreover, as shown in FIG. 7, the control apparatus A is provided with a photo sensor (mating state detection means) 40 for detecting whether the half nut 33 is mated with the feed screw 31 or not. The photo sensor 40 is configured to detect whether the half nut 33 is mated with the feed screw 31 or not by detecting the position of half nut 33. Specifically, the half nut 33 is considered as mated with the feed screw 31 when the half nut 33 is in the position shown in FIG. 3(a), and is not considered as mated with the feed screw 31 when the half nut 33 is in the position shown in FIG. 3(b) or in the position shown in FIG. 5.

[0054] Note that instead of the photo sensor 40, a micro switch may be used to directly detect the position of the half nut 33, or any other sensor may be used, as long as the mating state detection means can detect whether the half nut 33 is mated with the feed screw 31 or not.

- [0055] Moreover, as shown in FIG. 7, the control apparatus A is also provided with a syringe size detection sensor 41 for detecting a size of the syringe. The syringe size detection sensor 41 is a sensor for detecting the size of the syringe mounted in syringe pump 1, and it is possible to detect whether a syringe is mounted or not through this syringe size detection sensor.
- [0056] Moreover, the control apparatus A is also provided with a flange detection sensor 42 for detecting whether the flange of the syringe is held in the flange holding claws 21 of the piston presser 20 or not. The flange detection sensor 42 can be used to detect whether a syringe is mounted or not.
- [0057] Furthermore, the control apparatus A is also provided with a piston detection sensor 43 for detecting a presence of the piston of the syringe. The piston detection sensor 43 can be used to detect whether a syringe is mounted or not.
- [0058] The syringe size detection sensor 41, flange detection sensor 42, and piston detection sensor 43 are the same as those provided in a conventional syringe pump, so a detailed explanation will be omitted.
- [0059] Furthermore, this syringe pump 1 is also provided with an alarm (alert means) 50. The alarm 50 can be configured of a lamp, speaker, or the like, for example, and is controlled by the control apparatus A. The alarm 50 is an alarm for alerting a user or other people in the surrounding area when the alarm 50 detects through the photo sensor 40 that the half nut 33 is not mated with the feed screw 31, when it detects through the syringe size detection sensor 41 that a syringe that is outside of the standard is mounted, when it detects through the flange detection sensor 42 that the flange is not held in the flange holding claws 21, or when it detects through the piston detection sensor 43 that the piston is not in a prescribed position.
- [0060] Subsequently, the control contents of the control apparatus A will be described while referring to the flow chart of FIG. 8. The control apparatus

A can be configured to process signals from sensors such as button operation sensors including the start button 11, the photo sensor 40, the syringe size detection sensor 41, the flange detection sensor 42, and the piston detection sensor 43 and to control the motor 32 and the alarm 50. The control apparatus A may use any well-known microcomputer.

[0061] The control apparatus A determines whether a syringe is mounted or not in the flowchart step SA1, which follows Start. Note that the start timing of this flow chart is after the user turns on the power switch for the syringe pump 1.

[0062] In step SA1, determination is based on a signal from the flange detection sensor 42. In this step SA1, when it is detected by the flange detection sensor 42 that a syringe is not mounted in the syringe pump 1, a judgment of NO is output, so the same operation repeats again.

[0063] In this step SA1, when it is detected by the flange detection sensor 42 that a syringe is mounted in syringe pump 1, a judgement of YES is output, so the flow proceeds to step SA2. Step SA2 is motor drive control.

[0064] That is, when a syringe is mounted in the syringe pump 1, and the piston presser 20 is moved in the right and left directions to align with the piston of the syringe, the half nut 33 is rotated around the guide bar 16 by operation of the operation lever 23, and the half nut 33 separates from the feed screw 31 in the state shown in FIG. 3(b). In this manner, because the half nut 33 moves freely, the piston presser 20 is moved to the desired position, and then the user's finger is released from the operation lever 23 once the desired position is reached. When this happens, the half nut 33 attempts to return to the position shown in FIG. 3(a) due to the biasing force of the biasing member. At this time, depending on the position of the half nut 33 in the axial direction, as shown in FIG. 5, there may be cases where the flat surfaces of the screw threads 33a of half nut 33 and the flat surfaces of the screw threads 31a of the feed screw 31 contact and it is not possible to

return to the position shown in FIG 3 (a).

[0065] When the positional relationship is as shown in FIG. 5, rather than immediately issuing an alert, the motor 32 is driven to rotate just a certain amount in step SA4. As the motor 32 rotates, the feed screw 31 also rotates, and through this rotation of the feed screw 31, the contact portion between the screw threads 31a of the feed screw 31 and the screw threads 33a of the half nut 33 moves relatively along an axial direction. Through this relative movement, the screw threads 33a of the half nut 33 mate with the screw grooves 31b of the feed screw 31, and the half nut 33 mates together with the feed screw 31 as shown in FIG. 6. Accordingly, among causes of mating problems between the feed screw 31 and the half nut 33, because the cause of the minor problem where flat surfaces of the screw threads 31a and 33a contact each other is automatically eliminated, the frequency of occurrence of mating problems can be reduced.

[0066] Thereafter, the flow proceeds to step SA3. The step SA3 detects whether the start button 11 has been turned ON or not. If the start button 11 has not been turned ON, the process waits until it is turned ON, and the flow moves to step SA4 when the button is turned ON. Step SA4 determines whether the half nut 33 and the feed screw 31 are mated together or not. In step SA4, based on the signal from the photo sensor 40, if the half nut 33 and the feed screw 31 are mated together, the flow proceeds to step SA6 and administration begins.

[0067] In step SA6, the control apparatus A rotates the motor 32 so that the piston presser 20 moves in a direction pressing on the piston of the syringe. Rotational force from the motor 32 is transmitted to the feed screw 31 and the feed screw 31 rotates. Because the half nut 33 is mated with the feed screw 31, the half nut 33 moves in the axial direction (the left side in this embodiment) while being guided by guide bar 16. Because the piston

presser 20 is coupled to the half nut 33, when the piston presser 20 moves to the left side, the piston of the syringe is pressed at a prescribed speed, and the liquid of the syringe is administered to the patient.

[0068] When the half nut 33 and the feed screw 31 are not mated together, the flow proceeds to step SA5 and the alarm 50 is controlled to issue an alert. That is, even though the motor was rotated to eliminate a mating problem in step SA2, if the half nut 33 is still not mated together with the feed screw 31, it can be considered that there is an abnormality with the feed screw 31 and the half nut 33 or the like, and therefore an alert is issued to notify surrounding people.

[0069] Another example of the control method is explained based on the flowchart shown in FIG. 9. After start, the control apparatus A determines whether a syringe is mounted correctly in step SB1 of the flowchart. This also includes a determination of whether a syringe is mounted or not. Note that the start timing of this flow chart is after the user turns on the power switch for the syringe pump 1.

[0070] In step SB1, if at least one of any of the following is detected, that is, it is detected through the syringe size detection sensor 41 that a syringe has been mounted that is outside of standard, it is detected through the flange detection sensor 42 that the flange is not held in the flange holding claws 21, it is detected through the piston detection sensor 43 that the piston is not in a prescribed position, or it is detected through one of these sensors 41 through 43 that a syringe is not mounted, a NO is determined, or in other words, it is determined that a syringe is not mounted correctly. In such case, the flow proceeds to step SB2, and the alarm 50 is controlled to alert surrounding people.

[0071] If it is determined that a syringe is mounted correctly as a result of a signal from the syringe size detection sensor 41, the flange detection

sensor 42, or the piston detection sensor 43 being continuously viewed for about two seconds, a YES is determined and the flow moves to step SB3. Step SB3 determines whether the half nut 33 and the feed screw 31 are mated together or not. In step SB3, based on the signal from the photo sensor 40, if the half nut 33 and the feed screw 31 are mated together, because there is no problem on either the syringe side or the syringe pump 1 side, the flow proceeds to step SB9 and waits for the start button 11 to be turned ON. Once the start button 11 is turned ON, the flow moves to step SB8 and administration begins.

[0072] In step SB3, if it is determined that the half nut 33 and the feed screw 31 are not mated together, the flow moves to step SB4, motor drive control is performed, and the mating of the half nut 33 and the feed screw 31 is corrected.

[0073] Thereafter, the flow moves to step SB5 and waits for the start button 11 to be turned ON. Once the start button 11 is turned ON, the flow moves to step SB6 and the same determination is made as in step SB3. Specifically, even though the motor 32 was rotated to eliminate a mating problem in step SB4 because it was determined that the half nut 33 and the feed screw 31 were not mated together in step SB3, if the half nut 33 is still not mated together with the feed screw 31, it can be considered that there is an abnormality with the feed screw 31 and the half nut 33 or the like, and therefore the flow proceeds to step SB7, and an alert is issued in the same manner as step SB2.

[0074] In step SB6, if the half nut 33 and the feed screw 31 are determined as being mated together, the flow proceeds to step SB8 and administration begins.

[0075] As explained above, according to the syringe pump 1 related to this embodiment, for example, after the position of the piston presser 20 is

adjusted to match a mounted syringe, if the flat surfaces of the screw threads 31a and 33a of the feed screw 31 and the half nut 33 contact each other and the half nut 33 does not mate with the feed screw 31, the control apparatus A rotates the motor 32. In this manner, the feed screw 31 rotates, and through this rotation of the feed screw 31, the contact portion between the screw threads 31a of the feed screw 31 and the screw threads 33a of the half nut 33 moves relatively along an axial direction. Through this relative movement of the contact portion, the half nut 33 and feed screw 32 mate together. Accordingly, among causes of mating problems between the feed screw 31 and the half nut 33, because the cause of the minor problem where the screw threads 31a and 33a contact each other is automatically eliminated, the frequency of occurrence of mating problems can be reduced. In this manner, the maneuverability for the user can be made favorable, and it is possible to make it so that insufficient dosing does not occur.

[0076] Moreover, if the syringe is mounted in step SA1, the motor 32 is rotated in step SA2, and therefore the frequency of occurrence of mating problems can be greatly reduced.

[0077] Moreover, when it is detected in step SB1 that the mounting state of the syringe is normal, the mating state is detected in step SB3, and then motor control is performed, whereby proper control can be performed in accordance with the mounting state of the syringe.

[0078] Moreover, after motor drive control is performed in step SB4, because an alert is issued for a mating problem in step SB7 if the half nut 33 and the feed screw 31 are not detected to be mated together in step SB6, alerts are issued quickly for abnormalities with the drive mechanism 30 and for mounting abnormalities of the syringe, and safety can be improved.

[0079] Moreover, because the feed screw 31 is rotated toward the pressing side of the piston during the motor drive control of step SA2 or step SB4,

drawing in of the blood of the patient can be prevented.

- [0080] Moreover, for the amount of rotation of the motor 32 during motor drive control, an amount of rotation that turns the feed screw 31 at least half a rotation is preferable. In this manner, mating corrections can be performed in almost every case. Moreover, the motor 32 may also be made to rotate for a prescribed amount of time during motor drive control.
- [0081] Moreover, the control apparatus A may be configured to stop the rotation of the motor 32 before a certain amount of rotation that has been set in advance for the motor 32 is reached if it is detected at the time of motor drive control that while the motor 32 is rotating, the half nut 33 is mated together with the feed screw 31. In this manner, movement of the piston of the syringe during motor drive control can be suppressed, and dosing can be performed even more safely.
- [0082] Moreover, during motor drive control, the motor 32 may be rotated toward the opposite side from piston pressing side. In this case, it is preferable to keep the rotation amount of the motor 32 as low as possible.
- [0083] Moreover, in the flow charts, because motor drive control is performed only one time, it is possible to reduce the possibility of excessively pressing the piston compared to performing motor drive control two times or more, and therefore more than a prescribed amount of liquid medicine is prevented from being administered. Note that the motor drive control may be performed two times or more, however in this case, it is preferable to keep the rotation amount of the motor 32 as low as possible.
- [0084] Moreover, during motor drive control, after the motor 32 is made to rotate toward the piston pressing side, control may also be performed to reverse the rotation.
- [0085] The embodiments described above are nothing more than single examples in every point, so they must not be interpreted restrictively.

Furthermore, modifications and changes made within a fair scope of the patent claims all fall within the scope of the present disclosure.

[Field of Industrial Use]

[0086] As explained above, the syringe pump and control method for a syringe pump related to the present invention can be applied when administering a liquid medicine at a medical site.

[Reference Numerals]

- [0087] 1: syringe pump
10: Casing
20: Piston presser
30: Drive mechanism
31: Feed screw
32: Motor
33: Half nut
34: Switching rod (switching member)
40: Photo sensor (mating state detection means)
41: Cylinder size detection sensor (syringe mounting state detection means)
42: Flange detection sensor (syringe mounting state detection means)
43: Piston detection sensor (syringe mounting state detection means)
A: Control apparatus

Claims

- [Claim 1] A syringe pump comprising: a piston presser that presses a piston of a syringe filled with a liquid,
 a drive mechanism that drives the piston presser, and
 a control apparatus that controls the drive mechanism, wherein:
 the drive mechanism includes a feed screw, a motor that rotates the feed screw thereof, a half nut that mates with the feed screw, and a switching member that switches the half nut thereof between a state of being mated with the feed screw and a state of being separated from the feed screw,
 the control apparatus includes syringe mounting state detection means that detect whether a syringe is mounted or not, and when it is detected by the syringe mounting state detection means that a syringe is mounted, motor drive control is performed to drive the motor, and
 the control apparatus further includes mating state detection means for detecting whether the half nut is mated with the feed screw or not, and when it is detected by the mating state detection means that the half nut is not mated with the feed screw, the control apparatus performs motor drive control.
- [Claim 2] The syringe pump according to claim 1, wherein:
 the syringe mounting state detection means are configured to determine whether the syringe mounting state is normal or not, and
 the control apparatus is configured such that, after the syringe mounting state detection means detect that a syringe is mounted, if it is detected that the syringe mounting state is normal, detection is performed by the mating state detection means.

- [Claim 3] The syringe pump according to claim 1 or 2,
 wherein the control apparatus includes alert means that alert if the half nut and the feed screw are not mated, and after motor drive control is performed, detection is performed again by the mating state detection means, and if it is detected by the mating state detection means that the half nut is not mated with the feed screw, an alert is issued of a mating problem between the half nut and the feed screw through the alert means.
- [Claim 4] The syringe pump according to any one of claims 1 through 3,
 wherein the control apparatus is configured such that, in the motor drive control, if the mating state detection means detect that the half nut is mated with the feed screw while the motor is rotating, rotation of the motor is stopped.
- [Claim 5] The syringe pump according to any one of claims 1 through 4,
 wherein the motor drive control is control that causes the feed screw to rotate toward a piston pressing side.