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PREFILLED SYRINGE

FIELD OF THE INVENTION

The present invention relates generally to a prefilled syringe, and more particularly to a prefilled syringe capable of separate storage of at least two different substances before use, wherein one of the substances is for example a medicinal component and the other is for example a vehicle such as a dissolving agent or a dispersing agent, as the case may be. In this specification the term "prefilled" or "filled" relates to a syringe in which a medicament is stored until use. This is in contrast to storing the medicament separately from the syringe in a vial and then drawing it from the vial with the syringe immediately prior to use.

BACKGROUND OF THE INVENTION

In order to explain the background of the invention, a prefilled syringe of a known type will be described by reference to Figures 15 to 19:

The exemplary prefilled syringe includes a tubular body 31 and a plunger 32 with a rod. The tubular body 31 has a front compartment 34 and a rear compartment 35 separated by a partition 33 which is movable axially with the tubular body 31. The front compartment 34 includes a bypass 36 produced in the form of a recess. So long as

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the partition 33 stays in the rear compartment 35, it separates the two compartments 34 and 35 from each other in a sealing manner as shown in Figure 15 but when it is moved into the front compartment 34, an opening is formed between the partition 33 and the bypass 36 in the front compartment 34. The movement of the partition 33 is performed by pushing the plunger 32. When the partition 33 is moved into the front compartment 34, the liquid contained in the rear compartment 35 is introduced into the front compartment 34 through the bypass 36 and dissolves or disperses the medicinal component in the front compartment 34 or becomes mixed therewith, as the case may be. In this way an injection liquid is obtained in the front compartment 34, and is ready to be ejected from the tubular body 31. This exemplary prefilled syringe is disclosed in Japanese Patent Publication (allowed) No. 49-14465.

Figure 19 shows a modified version in which the partition 33 is provided with ring-shaped ribs 33a so as to enable the partition 33 to smoothly slide on and along the inside wall of the tubular body 31 with minimum contact therewith. The exemplary prefilled syringes have the following problems:

The front compartment 34 is filled with a powdery medicinal component. When the medicinal component is liquid, it is first filled in the front compartment 34 and then freeze-dried into a powdery state as shown in Figure 17. A vehicle L for dissolving or dispersing the medicinal component P is placed in the rear compartment 35. In this way a finished syringe is obtained. If the vehicle L is to be

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sterilized by steam, the syringe is closed by a cap 37 as shown in Figure 17. However, this steam sterilization is likely to denature the medicinal component P in the front compartment 34. As a solution to this problem, an alternative method is that after the vehicle L is sterilized by steam, the medicinal powder P is placed in the front compartment 34. However, this method is disadvantageous in that droplets of water or moisture from the steam are likely to stay on or impregnate or penetrate and later escape from the partition 33 (commonly made of rubber), thereby detrimentally wetting the desiccated powdery medicinal component P.

Since a powdery medicinal component tends to become unstable in the presence of water, it is essential to dry out at least the side of the partition 33 facing the front compartment 34 which contains a desiccated powdery injection. It is common practise to dry the syringe at a temperature of 100℃ or more for hours but this high temperature unfavorably affects the vehicle L in the rear compartment 35. As a result, this high temperature heat-drying method cannot be adopted.

It is common practice to provide the partition 33 with annular or ring-shaped ribs 33a along the periphery so as to reduce friction between the parition 33 and the inside wall of the body 33. In this case, they unavoidably form one or more ring-shaped grooves (G) therebetween. These grooves (G) trap the injection liquid when the injection liquid is ejected from the rear compartment 35 to the front compartment 34 so that the injection liquid remains unused in the

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grooves (G). Specifically, the injection liquid is pushed axially through the bypass 36, but the ribs 33a catch some of the liquid through the bypass 36 and divert it circumferentially into the grooves (G) where it is trapped and remains unused. This results in a waste of the injection liquid.

In using a prefilled syringe, it is important to mix the medicinal component and the vehicle into a homogeneous injection liquid. Normally, immediately prior to use, the syringe is swung by hand to mix these substances. However, a difficulty arises in pushing the plunger to the appropriate position; if the plunger is pushed excessively into the tubular body, it is likely that the medicinal component and vehicle are injected through the syringe without being sufficiently mixed. If the plunger stays in the midst of the bypass 36, backflow of the liquid is likely to occur from the front compartment to the rear compartment. If the insertion of the plunger is short of the appropriate distance, the vehicle L in the rear compartment fails to enter the front compartment through the bypass.

In order to solve this problem, applicants have considered indicia or markings at an appropriate position on the plunger where the plunger is to be stopped. This marking method encounters the difficulty of how to retain the plunger temporarily from axial movement relative to the tubular body while the mixing is effected by swinging the syringe. Besides, attention must be constantly paid to the marking while the rod is pushed. The conventional prefilled

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syringe has no device which has solved this problem.

SUMMARY OF THE INVENTION

A prefilled syringe according to the present invention includes a tubular body having a front end closable by a plug and adapted to accept an injection needle and a rear end closable by a plunger with a rod, a movable partition dividing the interior space of the tubular body into a front compartment and a rear compartment in a sealing manner, the partition including a front part and a second part which are independent of each other, the front compartment storing a first substance and the rear compartment storing a second substance, and a bypass produced in the front compartment with the partition being axially shorter than the bypass so as to introduce the second substance into the front compartment therethrough when the partition is moved into the front compartment under pressure provided by the plunger, thereby effecting a predetermined action such as dispersing or dissolving between the first and second substances in the front compartment.

According to another aspect of the present invention, the prefilled syringe includes a tubular body having a front end closable by a plug and adapted to accept an injection needle and a rear end closable by a plunger with a rod which is movable in the tubular body, a movable partition dividing the interior space of the tubular body into a front compartment and a rear compartment in a sealing

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manner, the front compartment storing a first substance and the rear compartment storing a second substance, the partition including circumferentially extending ring-shaped first ribs along the periphery thereof with a ring-shaped groove interposed therebetween and second transverse ribs for bridging and subdividing the groove into small recesses, the second ribs having the same height as that of the ring-shaped first ribs; and a bypass produced in the front compartment so as to introduce the second substance into the front compartment therethrough when the partition is moved into the front compartment under pressure provided by the plunger, thereby effecting a predetermined action such as dispersing or dissolving between the first and second substances in the front compartment.

The syringe and rod may be respectively provided with an engaging means for enabling the plunger to stop at an appropriate position so that the predetermined action such as dispersing or dissolving is carried out with the two substances being fully confined in the front compartment.

Thus, the invention described herein has the advantages of (1) providing a prefilled syringe which protects the first substance in the front compartment against a pre-treatment such as steam sterilization applied to the second substance stored in the rear compartment, (2) which prevents the injection liquid from staying behind and remaining unused in the syringe, and (3) which provides optimum conditions for swinging the syringe for stirring the substances in the front compartment.

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These and other advantages of the present invention will become apparent to those skilled in the art upon reading and understanding the following detailed description with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention may be better understood and its numerous objects and advantages will become apparent to those skilled in the art by reference to the accompanying drawings as follows:

Figure 1 is a schematic cross-section view through an embodiment of the present invention;

Figures 2(A) and 2(B) show a process of assembling the syringe, wherein Figure 2(A) shows a first step at which a vehicle is put in one compartment and Figure 2(B) shows a second step at which a medicinal component is put in the other compartment;

Figure 3 is a cross-section through the syringe of Figure 1 which is provided with a cap into which the plug slides and an injection needle fixed to the cap;

Figure 4 is a cross-section through the syringe of Figure 3 which is in use;

Figure 5 is a cross-section through the syringe which is provided with a stationary plug and a double-pointed injection needle in the forward open end;

Figures 6 to 9 show various types of plugs and the front part

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of the partition used in combination with its respective plug;

Figure 10 is a cross-section through a second example of the embodiment;

Figure 11 is a perspective view showing the partition of Figure 10 on an enlarged scale;

Figure 12 is a cross-section through a modified version of the example of Figure 10 in which the partition and the plunger have ring-shaped ribs and bridging ribs;

Figures 13(A) and 13(B) are cross-sections through a third example of the embodiment;

Figures 14(A) to 14(E) are views showing a modified version of the third example of Figure 13;

Figures 15-18 are cross-sections through a prefilled syringe of a known type, particularly showing the manner of using the syringe; and

Figure 19 is a perspective view showing a partition used in the known prefilled syringe shown in Figures 15-18.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Example 1

Referring to Figure 1, the exemplary prefilled syringe has a generally tubular body 1 which is open at the front and rear ends, and a plunger 2 having a push rod slidably inserted into the body 1 through the rear end. The push rod may be detachable. The body 1

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includes a front compartment 4 and a rear compartment 5 separated by a partition or sealing means 3 in a liquid-tight manner, the partition 3 being slidable axially in the body 1 under pressure provided by the plunger 2. The front compartment stores a medicinal component P in the state of powder, microcapsule, granule, tablet, liquid or any other, and the rear compartment 5 stores a vehicle L in a liquid or any other form for dissolving or dispersing the medicinal component P, or for becoming mixed therewith. The body 1 is provided with a bypass 6 on the inside wall. The bypass or bypass means 6 is produced in the form of a recess for introducing the vehicle L in the rear compartment 5 into the front compartment 4, which will be described in detail.

The partition 3 includes a front part or portion or bypass stopper or stopper plug 3a and a rear part or portion or bypass stopper or stopper plug 3b which are independent of each other and separately movable. Each of the partition parts or stoppers 3a, 3b extends radially to the inner walls of the body 1 to seal the rear compartment 5 from the front compartment 4 independently of the other partition part with which it is paired. The combined axial length of the partition parts 3a, 3b is less than the axial length of the bypass 6 to permit the injection liquid to be conveyed from the rear compartment 5 to the front compartment 4. When the partition 3 is between the bypass 6 and the rear end of the syringe, the partition parts preferably engage each other but, if slightly spaced because of air being compressed therebetween when the front part 3a is slid into

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the body during assembly, the axial distance of such a space is less than the axial width of one of the partition parts 3a, 3b. In use, as the plunger 2 is initially pushed, the air between the partition parts 3a, 3b is compressed by the movement of the rear part 3b. This compression urges the front part 3a forward until the rear face of the front partition part 3a reaches the bypass 6, whereupon any air between the partition parts 3a, 3b escapes therefrom to the bypass 6 to permit the partition parts 3a, 3b to engage each other if not already engaged. It is in this engaged state in which the partition 3 travels the remainder of the syringe.

The front end portion 1a of the body 1 is closed by a movable plug 7. As described below in detail, the front end 1a of the syringe is capped with a cap carrying an injection needle. Herein, the front end portion of the syringe covers the front end of the syringe and a further portion extending slightly toward the bypass 6 from the front end of the syringe. Hereinafter, the front end portion of the syringe may be referred to as the "front end of the syringe". It should be noted that the plug 7, before actuation of the plunger, may be spaced from the extreme front end of the syringe to minimize the chances that the plug 7 will prematurely slide out of the front end. The distant that the plug 7 is spaced from the extreme front end may depend upon the volume of the substances to be mixed. Such a volume may define the space between the bypass 6 and the plug 7, and hence the distance between the plug 7 and the extreme front end.

As stated above, the bypass 6 has a length longer than the

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total thickness of the front part 3a and the rear part 3b as shown in Figure 4. Furthermore, the combined axial length of the partition parts 3a, 3b, and the plunger 2 (exclusive of the push rod) is greater than the axial length of the bypass 6 to prevent backflow of air or liquid from the front compartment 4 to the rear compartment 5.

The plunger 2 is pushed to the left (Figure 1) whereby the front part 3a and rear part 3b of the partition 3 are moved together in a spaced apart fashion under pressure provided by the plunger 2. When the parts 3a, 3b reach the bypass 6 as shown in Figure 4, the vehicle L in the rear compartment 5 is introduced into the front compartment 4 through the bypass 6, thereby effecting a desired action such as dispersing, dissolving or mixing between the medicinal component P and the vehicle L. In this way an injecting medicine (or simply an injection) is obtained in the front compartment 4. By further pushing the plunger 2, the injection is ejected through an injection needle 82.

The prefilled syringe is assembled as shown in Figures 2A and 2B:

Referring to Figure 2A, the rear part 3b of the partition 3 is inserted in the body 1 and the vehicle L is put in the rear compartment 5. Then the plunger 2 is inserted. The vehicle L is heat sterilized by dry steam, and then the inside surface of the front compartment 5 is air dried typically with some heat (for example, up to 50-60 ℃) as long as such heat does not damage the substance in the rear compartment 5. During the step of

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sterilization, the outer ends of the rear stopper 3b and plunger 2 are exposed to the dry steam and may absorb or take in moisture, which may diffuse into the rear stopper 3b or plunger 2. This moisture, over a period of time, may escape by diffusion or some other means out of the end of the rear stopper 3b or plunger 2 into which it entered. This emanating moisture may then adversely affect the hygroscopic powder which is contained in the front compartment 4.

After the front compartment 4 has been dried and as shown in Figure 2B, the front part 3a of the partition 3, which is kept away from any moisture, is inserted into the body 1 through the front end 1a until it comes relatively near to or into contact with the rear part 3b so as to be adjacent thereto. A dose of powdery medicinal component P is placed in the front compartment 4, and then the front end 1a is closed by the plug 7. In this way a finished syringe is obtained.

When the vehicle L is sterilized by steam, the rear part 3b of the partition 3 becomes wet with deposition of dew or saturated with moisture. While much of this moisture is removed when the front compartment 4 is dried, some of this moisture remains in the rear stopper 3b only to diffuse out over a period of time. The front part 3a is kept dry and away from the sterilization process. The front part 3a thus seals the front compartment 4 against any moisture which may escape from the rear partition part 3b.

The injection needle 82 can be fixed to the syringe 1 in various manners as shown from Figures 3 and 5-9. A first example is

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shown in Figure 3:

The example shown in Figure 3 has the front end 1a capped with a cap 8 which includes a skirt 81 carrying the injection needle 82. The skirt 81 includes a groove 81a on the inside surface. The groove 81a communicates with the needle 82. The reference numeral 81b denotes a space adapted to receive the plug 7 as shown in Figure 4.

When the plunger 2 is pushed to the left (Figure 4), the plug 7 is moved into the space 81b, and the vehicle L in the rear compartment 5 is introduced into the front compartment 4 through the bypass 6. By further pushing the plunger 2 and after the syringe is shaken or swung to mix the liquid and drug, the injection is introduced into the needle 82 through the groove 81a. The needle 82 can be previously fixed to the cap 8, or it can be fixed after the cap 8 is capped to the syringe 1.

Alternatively, the plug 7 may be arranged at assembly to be placed at a distant from the front end of the syringe such that in use when it is pushed by the plunger 2, it will remain in the front end. This arrangement and the later mentioned safety engagement means are cooperatively effective to fully confine the front compartment 4 in a sealing manner.

The examples shown in Figures 5 to 9 use a double-pointed needle 10:

The example shown in Figure 5 uses a stationary plug 7 and a cap 9 holding a double-pointed needle 10 which is projected into the front compartment 4 through the plug 7. This embodiment is

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advantageous in that it saves the labor of fixing the injection needle 10, and the needle 10 can be readily connected to the front compartment 4 by fixing the cap 9 to the front end 1a. The plug 7 is provided with a recess 7a on the inner side which allows the injection to gather therein and to be funneled to or collected in the vicinity of the inlet of the needle 10, thereby preventing the injection liquid from staying behind and remaining unused. This avoids a waste of the injection liquid.

Figure 6 shows another example of a plug for a double-pointed needle wherein the plug 7 has an additional recess 7b on the outer side, the recesses 7a and 7b being aligned with each other, thereby facilitating the passage of the needle 10 because of the reduced thickness of the plug 7. In this example, the respective plug 3A has a flat front face.

Figure 7 shows another example, characterized in that the face of the front part 3a of the partition 3 is provided with a recess 30a which is aligned with the recess 7b on the outer side of the plug 7 so as to accommodate the needle end projecting through the plug 7. Because of the flat rear face of the plug 7 it is easy to ascertain that the injection needle end is projected into the front compartment 4 through the plug 7.

Figure 8 shows a further modified plug 7 having a concave surface on the inner side and the front part 3a having a convex surface at its forward end or front face which is complementary with the concave surface of the plug 7 when the partition 3 is pushed by

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the plunger 2 and brought into contact with the plug 7.

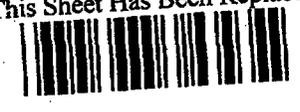
This structure of Figure 8 is advantageous in that bubbles tend to gather in the center of the concave surface of the plug 7 when the syringe 1 is raised upright prior to injection, thereby facilitating the removal of the bubbles through the injection needle 10.

Figure 9 shows a modification to the example of Figure 8, characterized in that the plug 7 is provided with a recess 7a in the concave surface, the recesses 7a and 7b being aligned with each other, with the front part 3a of the partition 3 having no recess. The recess 7a in this modification functions like the recess 7a as described with respect to example 5.

The examples shown in Figures 6 to 9 may have a ring-shaped flange 7c which secures sealing contact between the plug 7 and the inside wall of the syringe 1. The flange 7c is not necessarily required if the diameter of the plug 7 is precisely calculated such that the plug 7 adequately fits in a sealing manner in the syringe 1. The bypass parts or stoppers 3a, 3b, plug 7, and plunger 2 are preferably formed of an elastomer such as synthetic rubber.

In the exemplary or preferred embodiment the partition 3 is composed of the front part 3a and the rear part 3b, the latter of which participates in the steam sterilization of the vehicle in the rear compartment 5, and the former of which minimizes or prevents moisture of the rear part 3b from reaching the powdered medicament. However, if desired, the sealing means may include other means for

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minimizing the emanation of moisture to the hygroscopic powder. Such means may include a thin moisture-impenetrable seal placed directly on the front face of the rear stopper 3b or comprise a rear stopper 3b formed of a material which is impenetrable to moisture.

Example 2

Referring to Figures 10 and 11, the partition 3 is provided with a plurality of ring-shaped ribs 300 having grooves (G) therebetween. The adjacent grooves (G) are bridged by other ribs 301 which will be referred to as transverse or bridging ribs. The bridging ribs 301 have the same height as that of the first-mentioned ribs 300. The bridging ribs 301 subdivide the grooves (G) into separate small recesses. The illustrated example has two grooves (G) and four bridging ribs 301 displaced at 90 ° ; thereby obtaining equally divided eight recesses in all. The annular ribs 300 extend at generally a right angle to the axis of the tubular body 1 and the bridging ribs 301.

The subdividing of the grooves (G) by the bridging ribs 301 minimizes the amount of injection liquid remaining in the groove (G), thereby minimizing the amount of injection liquid which remains unused. The greater the number of bridging ribs which are used, the less the amount of injection liquid which remains unused, but as the number of the bridging ribs increases, the friction created between the partition 3 and the inside wall of the tubular body 1 increases, thereby preventing smooth movement of the partition 3 in the tubular

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body 1. The transverse or bridging ribs act as barriers which prevent the injection liquid from flowing circumferentially about the partition 3. Hence a lesser quantity of injection liquid is trapped in the circumferential grooves (G). As shown in Figure 12, the partition parts 3a, 3b may also include such transverse or bridging ribs 301. Further, it should be noted that, instead of being flat as shown in Figure 11, the annular and bridging ribs may typically have a curve or crown to reduce friction created against the inner surface of the tubular body.

Example 3

Referring to Figures 13(A)-(B) and 14(A)-(E), a further modified version will be described:

This example is designed to assist a stirring action of the medicinal component P and vehicle L after such are initially mixed in the front compartment so as to obtain a homogeneous injection liquid through a predetermined chemical state such as dispersing or dissolving as the case may be. The stirring is facilitated by a swinging of the syringe. In this case, it is difficult to retain the plunger 2 at an appropriate place when the injection liquid is in the front compartment; if the plunger 2 is moved excessively into the tubular body 1, the medicinal component P and vehicle L are likely to be injected through the syringe without reaching a homogeneous state. To solve this difficulty, the tubular body 1 is provided with a disc-shaped fingergrip 100 at the end of the tubular body 1 into which the

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plunger 2 is inserted. The fingergrip 100 has an inner peripheral rim or syringe portion 101 projecting slightly into the passage for the plunger 2. The plunger 2 has a rod 20 which is provided with projections or nubs 201 on the periphery thereof; in the exemplary embodiment, four projections 201 are displaced at 90° around the axis of the plunger 2. Each of the nubs 201 extends in a radial and axial direction. The nubs 201 are axially spaced from the rim 101 such that the plunger 2 freely slides through the rear compartment 5. The nubs 201 are also axially spaced from the rear end of the push rod so that the plunger 2 slides freely through the front compartment 4. Each projection 201 is located at such a position that it comes into engagement with the inner peripheral rim 101 when the forward end or face of the front part 3a of the partition 3 reaches the outlet or front side (left-hand side) of the bypass 6 as shown in Figure 13(B) such that the bypass is almost or in fact shut off relative to the front compartment 4 to minimize or prevent backflow to the bypass 6. At this position, the rear compartment 5 is completely sealed by the plunger 2 to prevent backflow into the push rod region during a shaking of the syringe. It should be noted that the syringe is conservatively constructed so that, even if the push rod 2 is pushed slightly past the nubs 201, the plunger still seals the bypass inlet.

In other words, the length of the plunger 2 is sufficiently long relative to the position of the nubs 201 on the push rod so as to minimize leakage to the rear compartment. The fingergrip 100 is preferably made of resilient synthetic resin to permit the fingergrip

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100 to bend or give slightly such that the nubs 201 are disengagable from the fingergrip 100. Alternatively, either the nubs 201, or both the fingergrip 100 and nubs 201, may be resilient.

In operation, as the first step, the plunger 2 is pushed as shown in Figure 13(B) to the extent that the projections 201 are brought into engagement with the inner peripheral resilient rim 101 and stopped from entering the tubular body 1. During this first step, the vehicle L in the rear compartment 5 is introduced into the front compartment 4 via the bypass 6. While the projections 201 are retained against the inner peripheral resilient rim 101, the syringe is swung to stir the medicinal component P and the vehicle L to obtain a homogeneous mixture. The projections 201 thereby prevent the plunger 2 from being slid further forwardly such as by centrifugal force created by swinging the syringe. As the second step, after an injection liquid is obtained through a desired action such as dispersing or dissolving of the medicinal component P with the vehicle L, the plunger 2 is pushed by a force which is strong enough to disengage the projections 201 from the inner peripheral resilient rim 101. Then the injection liquid is ejected in a homogeneously mixed state.

An alternative example is shown in Figures 14(A) to 14(E). This example is characterized by the provision of slots 102 in the inner peripheral rim or syringe portion 101. The illustrated example has four slots 102 displaced at 90 ° . The rod 20 of the plunger 2 is provided with a number of blades 202 corresponding to that of the

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slots 102 so that the blades 202 can fit into the slots 102. The blades 202 have a size to permit passage through the respective slots 102 after the push rod 20 has been rotated or turned to match the blades 202 to their respective slots 102. The length from the central axis of the rod 20 up to the top edge of each blade 202 is slightly larger than the inside diameter of the peripheral resilient rim 101 so as to enable each blade 202 to fit in the respective slots 102. The forward end or engagement portion of each blade 202 is axially spaced from the inner peripheral resilient rim 101 before the plunger 2 is actuated. The forward end of each blade 202 is positioned so that each blade 202 can come into engagement with the rear end face of the fingergrip 100 when the forward end of the front part 3a of the partition 3 reaches the left-hand side of the bypass 6 as shown in Figure 14(D) such that the front compartment 4 is almost or in fact sealed relative to the bypass 6 to prevent backflow into the bypass 6. At this position, the plunger 2 also seals the rear compartment 5 against backflow from the bypass 6.

In using the syringe, the rod 20 is pushed until the front ends of the blades 202 come into engagement with the rear end face of the finger grip 100 as shown in Figure 14(c) which shows the relationship between the blades 202 and the slots 102. The rod 20 is thus prevented from further entering the tubular body 1 such as when swinging the syringe creates a centrifugal force on the plunger 2 and rod 20. At this position, as shown in Figure 14(D) the front part 3a of the partition 3 has reached the left-hand side of the bypass 6 to

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almost or in fact shut off the bypass 6 and the vehicle L in the rear compartment 5 has completely entered the front compartment 4 as the plunger 2 has engaged the rear stopper. Then the syringe is swung so as to enable the medicinal component P and vehicle L to mix into a homogeneous injection liquid through a predetermined action such as dispersing or dissolving as the case may be. Finally the plunger 2 is turned or rotated and again pushed so as to enable the blades 202 to pass through the slots 102 as shown in Figure 14(E). In this way the injection liquid is ejected through the syringe in a homogeneously mixed state.

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What is claimed is:

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1. A prefilled syringe for storing at least two substances apart from each other in the syringe and for subsequently mixing the substances in the syringe prior to injection, comprising:

a tubular body having front and rear end portions and front and rear compartments, each of the compartments having one of the substances, the front end portion being sealed and engagable to a needle for injection of the substances which are mixed, the rear end portion being sealed by a plunger having a push rod for sliding the plunger axially in the tubular body;

sealing means including a first bypass stopper being axially slidable in the tubular body and disposed between the front and rear compartments for separating and sealing the compartments from each other, sliding of the sealing means being actuated by a sliding of the plunger;

a bypass disposed between the sealing means and the front end portion of the tubular body and generally between the front and rear compartments for permitting one of the substances in one of the compartments to bypass the sealing means to be introduced into the other compartment, the bypass having an axial length; and

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the sealing means including a second bypass stopper being axially slidable in the tubular body and disposed between the front and rear compartments for separating and sealing the compartments from each other independently of the first stopper, the stoppers being generally adjacent to each other, each of the stoppers having an axial thickness, the combined axial thickness of the stoppers being less than the axial length of the bypass, the stoppers being slidable at generally the same time by a sliding of the plunger to be slid to be adjacent to the bypass whereby one of the substances in one of the compartments is introduced into the other compartment.

2. The prefilled syringe of claim 1, wherein the distance between the stoppers is less than the axial thickness of one of the stoppers.

3. The prefilled syringe of claim 1, wherein the stoppers engage each other.

4. The prefilled syringe of claim 2, wherein the stoppers are spaced from each other when disposed between the bypass and the rear end portion of the tubular body, the stoppers subsequently engaging each other adjacent to the bypass after being slid thereto.

5. The prefilled syringe of claim 4, wherein each of the stoppers includes a confronting end, the confronting ends of the

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respective stoppers confronting each other to define a space therebetween when the stoppers are disposed between the bypass and the rear end portion of the tubular body, the space being empty.

6. The prefilled syringe of claim 1, and further comprising a method of loading the syringe, the method comprising:

a) inserting the first stopper into the tubular body to a position between the bypass and the rear end portion of the body; then

b) at least partially loading the portion of the body which is between the first stopper and the rear end portion of the body with at least one liquid substance; then

c) inserting the plunger into the body to seal the liquid substance between the plunger and the first stopper; then

d) heat sterilizing the liquid substance while it is sealed between the first stopper and the plunger; then

e) drying at least the inside of the tubular body between the first stopper and the front end portion of the body; then

f) inserting the second stopper into the tubular body to a

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position between the first stopper and the bypass to seal the front compartment against moisture which may escape from the first stopper and which may collect on and emanate from the end of the first stopper which is opposite of the liquid substance; then

g) at least partially loading the portion of the body which is between the second stopper and the front end portion of the body with another substance; and then

h) sealing the front end portion of the tubular body to seal in the substance which is between the second stopper and the front end portion of the tubular body.

A prefilled syringe for storing at least two substances apart from each other in the syringe and for subsequently mixing the substances in the syringe prior to injection, comprising:

a tubular body having front and rear end portions and front and rear compartments, each of the compartments having one of the substances, the front end portion being sealed and engagable to a needle for injection of the substances which are mixed, the rear end portion being sealed by a plunger having a push rod for sliding the plunger axially in the tubular body;

a bypass stopper being axially slidable in the tubular

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body and disposed between the front and rear compartments for separating and sealing the compartments from each other, sliding of the stopper being actuated by a sliding of the plunger, the stopper having an axial thickness;

a bypass disposed between the stopper and the front end portion of the tubular body and generally between the front and rear compartments for permitting one of the substances in one of the compartments to bypass the stopper to be introduced into the other compartment, the bypass having an axial length greater than the axial thickness of the stopper, the stopper being slidable to the bypass by a sliding of the plunger; and

the stopper comprising annular and bridging ribs, each of the ribs sealingly engaging the tubular body, the bridging ribs bridging between the annular ribs whereby spacing between the annular ribs is subdivided.

8. The prefilled syringe of claim 7, wherein the annular ribs extend about the stopper at generally a right angle to the axis of the tubular body.

9. The prefilled syringe of claim 7, wherein the annular and bridging ribs extend at generally right angles to each other.

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10. The prefilled syringe of claim 7, wherein the annular ribs include at least three annular ribs extending parallel to each other to define at least two spacing grooves.

11. The prefilled syringe of claim 10, wherein the bridging ribs include at least four bridging ribs spaced equidistance from each other in each of the spacing grooves.

12. A prefilled syringe for storing at least two substances apart from each other in the syringe and for subsequently mixing the substances in the syringe prior to injection, comprising:

a tubular body having front and rear end portions and front and rear compartments, each of the compartments having one of the substances, the front end portion being sealed and engagable to a needle for injection of the substances which are mixed, the rear end portion being sealed by a plunger having a push rod for sliding the plunger axially in the tubular body, the rear end portion of the tubular body engaging a syringe portion for engaging the push rod;

a bypass stopper being axially slidable in the tubular body and disposed between the front and rear compartments for separating and sealing the compartments from each other, sliding of the stopper being actuated by a sliding of the plunger, the stopper having an axial thickness and a front section;

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a bypass disposed between the stopper and the front end portion of the tubular body and generally between the front and rear compartments for permitting one of the substances in one of the compartments to bypass the stopper to be introduced into the other compartment, the bypass having an axial length greater than the axial thickness of the stopper, the stopper being slidable to the bypass by a sliding of the plunger, the bypass having an inlet and an outlet; and

the push rod connected to and extending rearwardly from the plunger for sliding the plunger in a forward direction from the rear end portion to the front end portion of the tubular body, the push rod having an engagement portion for engaging the syringe portion, the engagement portion being axially spaced from the syringe portion before the plunger is actuated, the engagement and syringe portions engaging each other after the plunger has engaged the stopper and after at least the plunger has been slid to a position adjacent to the inlet of the bypass to seal the bypass relative to the rear compartment to prevent backflow into the rear compartment, the engagement and syringe portions being disengagable from each other such that the push rod is further slidable in the forward direction for injection of the substances from the front compartment.

13. The prefilled syringe of claim 12, wherein the engagement and syringe portions engage each other after at least the front

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section of the stopper has been slid to a position adjacent to the outlet of the bypass.

14. The prefilled syringe of claim 12, wherein the push rod is freely slidable relative to the tubular body in the forward direction between the front end of the push rod and the engagement portion and between the engagement portion and the rear end of the push rod such that the plunger is freely slidable between the rear end portion of the tubular body and the bypass and between the bypass and the front end portion of the tubular body.

15. The prefilled syringe of claim 12, wherein the syringe portion comprises a fingergrip having an inner rim extending from the tubular body toward the push rod, and wherein the engagement portion comprises a nub for engaging the inner rim, the nub being disengagable from the rim by a further sliding of the push rod in the forward direction.

16. The prefilled syringe of claim 12, wherein the syringe portion comprises a fingergrip having an inner rim extending from the tubular body toward the push rod, the inner rim comprising at least one slot extending radially relative to the push rod, the push rod having at least one axially and radially extending blade, the engagement portion comprising a forward end of the blade to engage the rim, the blade being disengagable from the inner rim by rotating

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the push rod until the blade engages the slot for passage therethrough in the axial direction.

17. A prefilled syringe for storing at least two substances apart from each other in the syringe and for subsequently mixing the substances in the syringe prior to injection, comprising:

a tubular body having front and rear end portions and front and rear compartments, each of the compartments having one of the substances, the rear end portion being sealed by a plunger having a push rod for sliding the plunger axially in the tubular body;

a bypass stopper plug being axially slidable in the tubular body and disposed between the front and rear compartments for separating and sealing the compartments from each other, sliding of the stopper plug being actuated by a sliding of the plunger, the stopper plug having an axial thickness and a front section;

a bypass disposed between the stopper plug and the front end portion of the tubular body and generally between the front and rear compartments for permitting one of the substances in one of the compartments to bypass the stopper plug to be introduced into the other compartment, the bypass having an axial length greater than the axial thickness of the stopper plug, the stopper plug being slidable to the bypass by a sliding of the plunger;

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a double-pointed needle having a front end for injection and a rear piecing end, the needle being engagable to a front end of the syringe; and

a front plug for sealing the front end portion of the tubular body, the front plug having a front central recess for guiding the rear piercing end of the needle into the front plug, one of the plugs having another central recess axially aligned with the front central recess for housing the rear piercing end of the needle after the needle has pierced the front plug, the plugs engaging each other after the substances have been injected.

18. The prefilled syringe of claim 17, wherein the other central recess is disposed in the rear end of the front plug.

19. The prefilled syringe of claim 17, wherein the other central recess is disposed in the front end of the stopper plug.

20. The prefilled syringe of claim 17, wherein the front end of the stopper plug is convex and the rear end of the front plug is concave.

21. The prefilled syringe of claim 20, wherein the other central recess is disposed in the front end of the stopper plug.

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22. The prefilled syringe of claim 20, wherein the other central recess is disposed in the rear end of the front plug.

23. A prefilled syringe for storing at least two substances apart from each other in the syringe and for subsequently mixing the substances in the syringe prior to injection, comprising:

a tubular body having front and rear end portions and front and rear compartments, each of the compartments having one of the substances, the front end portion being sealed and engagable to a needle for injection of the substances which are mixed, the rear end portion being sealed by a plunger having a push rod for sliding the plunger axially in the tubular body;

sealing means including a bypass stopper being axially slidable in the tubular body and disposed between the front and rear compartments for separating and sealing the compartments from each other, sliding of the sealing means being actuated by a sliding of the plunger, the sealing means having an axial distance and two ends;

a bypass disposed between the sealing means and the front end portion of the tubular body and generally between the front and rear compartments for permitting one of the substances in one of the compartments to bypass the sealing means to be introduced into the

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other compartment, the bypass having an axial length greater than the axial distance of the sealing means;

one of the substances being a liquid, the other substance being a hygroscopic powder, the substances being separated from each other before actuation of the plunger by the sealing means;

one of the ends of the sealing means exposed to the liquid, the other of the ends being exposed to air inside of the compartment having the hygroscopic powder; and

the sealing means further comprising minimizing means adjacent to at least one of the ends of the sealing means or therebetween for minimizing any moisture in the bypass stopper from emanating to the hygroscopic powder.

24. The prefilled syringe of claim 23, wherein the minimizing means comprises another stopper between the bypass stopper and the hygroscopic powder.

25. The prefilled syringe of claim 23, wherein the liquid is heat sterilized after being sealed between the plunger and the bypass stopper and wherein the bypass stopper includes a body portion susceptible to taking in moisture, the bypass stopper taking in moisture when the liquid is heat sterilized and such moisture

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subsequently escaping from the bypass stopper.

26. A prefilled syringe for storing at least two substances apart from each other in the syringe and for subsequently mixing the substances in the syringe prior to injection, comprising:

a tubular body having front and rear end portions and front and rear compartments, each of the compartments having one of the substances, the front end portion being sealed by a plug, the rear end portion being sealed by a plunger having a push rod for sliding the plunger axially in the tubular body, the rear end portion further having a fingergrip;

a needle collar engagable to the front end portion of the tubular body for engaging a needle for injection of the substances which are mixed, the needle collar including a receptacle for receiving the plug upon sufficient actuation of the plunger, the needle collar having a passage about the receptacle through which the mixed substances are conveyed around the plug from the front compartment to the needle for injection;

sealing means including a first stopper being axially slidable in the tubular body and disposed between the front and rear compartments for separating and sealing the compartments from each other, sliding of the sealing means being actuated by a sliding of

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the plunger;

a bypass disposed between the sealing means and the front end portion of the tubular body and generally between the front and rear compartments for permitting one of the substances in one of the compartments to bypass the sealing means to be introduced into the other compartment, the bypass having an axial length;

the sealing means including a second bypass stopper being axially slidable in the tubular body and disposed generally between the front and rear compartments for separating and sealing the compartments from each other independently of the first stopper, the stoppers being generally adjacent to each other, each of the stoppers having an axial thickness, the combined axial thickness of the stoppers being less than the axial length of the bypass, the stoppers being slidable at generally the same time by a sliding of the plunger to be slid to be adjacent to the bypass whereby one of the substances in one of the compartments is introduced into the other compartment; and

each of the stoppers comprising annular and bridging ribs, each of the ribs sealingly engaging the tubular body, the bridging ribs bridging between the annular ribs whereby spacing between the annular ribs is subdivided.

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