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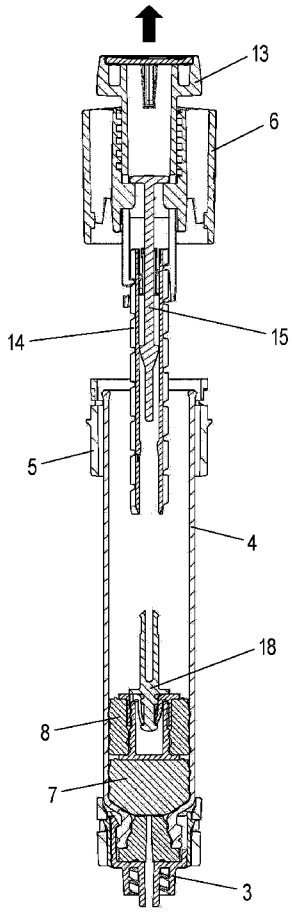

Fig. 4

(57) Abstract: A release mechanism for a piston (8) /piston rod (14) coupling in a drug delivery device is provided, said release mechanism comprises a release element which undergoes relative displacement with respect to the piston rod from a first position to a second position in response to the piston reaching a predefined position relative to the reservoir wall, thereby enabling relative motion between the piston and the piston rod.

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PISTON ROD RELEASE MECHANISM

FIELD OF THE INVENTION

The present invention relates generally to drug delivery devices and more specifically to drug delivery devices of the multi-compartment type which are capable of storing individual substances separately and mixing them to produce an administrable product.

BACKGROUND OF THE INVENTION

Many different types of devices for administration of drug on liquid form exist. Some such devices are intended to both store and deliver liquid drugs, while others are capable of storing the drug on powder form and mixing it with a suitable solvent before administration. Often, these various devices are for single use and therefore adapted to be discarded after emptying.

US 4,226,236 (Abbott Laboratories) discloses a so-called dual chamber injector which is adapted to store a powdered drug in a front chamber and a liquid in a rear chamber, and which has means in the form of a bypass section for allowing the liquid to enter the front chamber and reconstitute the powdered drug during an initial operation of the device. A piston rod is interlocked with a rear piston in order to enable both forward and backward movement of the rear piston in the drug container.

Particularly when used for administration of IV drugs a device as described in US 4,226,236 needs to be operated in a manner so as to ensure that the hypodermic needle is correctly positioned in a vein. This is done following needle insertion by applying a pulling force to the rear piston, whereby the front piston will be retracted, due to a vacuum connection between the two pistons, and a negative pressure will be established in the front chamber. The established negative pressure will then cause body fluid in the immediate vicinity of the hypodermic needle end to become aspirated into the front chamber, and by watching the colour of the entering fluid it can be determined whether the needle is located in a vein. This procedure is known as a vein indication test.

In connection with the disposal of an emptied device care must be taken to avoid contamination from parts which have been in contact with the user's blood. Therefore, the whole device is normally discarded in a dedicated safe container. However, since some components which are not prone to contact with blood during operation of the device, e.g. the piston rod,

may be recyclable, it is for environmental reasons desirable to be able to discard these components in separate waste bins for recyclable materials. The device of US 4,226,236 cannot be easily separated because the piston rod and the rear piston are interlocked and a stop surface prevents the piston rod from being axially pulled out of the container.

EP 0 144 551 (Becton Dickinson and Company) discloses a like dual chamber device where a piston rod is threadedly attached to a rear piston. During a vein indication test body fluid is sucked into the container, where it mixes with the drug and enters a space between the two pistons. Thereby, the rear piston becomes potentially contaminated, so in order to effect safe waste separation the piston rod must be unscrewed from the rear piston after emptying of the container. Such unscrewing can be difficult, however, because the piston surface is typically siliconised to reduce the friction between the rubber and the container wall during axial piston motion. An attempt to rotate the piston rod relative to the rear piston is therefore likely to give rise to a rotation of both the piston rod and the piston relative to the container wall instead. In view of the above it is desirable to provide a drug delivery device which offers the possibility of easy, e.g. axial, detachment of the drug container with pistons from non-contaminated components.

US 2007/0270743 (Ackerman) discloses a single use, auto-disabling safety syringe with an internal coupling sub-assembly interconnecting a stopper and a plunger via a coupler and a coupler ring. The coupling sub-assembly aspirates proximally and distally inside the syringe barrel as one interconnected assembly. Ribs on the inner syringe barrel wall cause the coupler ring to be released from the coupler, and in turn the coupler to disengage from the plunger, when the stopper is advanced to a distal position corresponding to a complete administration of the syringe contents.

SUMMARY OF THE INVENTION

While the set-up described in US 2007/0270743 may potentially be used to separate non-contaminated components of a drug delivery device from possibly contaminated parts for subsequent disposal in separate waste bins, the ribs on the inner container wall necessitate either a structural modification of a conventional drug container or a completely new container production. Both alternatives entail an undesirable additional cost compared to using ready-made and readily available drug containers, such as conventional single or dual chamber cartridges or syringes, not to mention a much more complicated manufacturing process.

Having regard to the above mentioned problems and deficiencies, it is an object of the invention to provide a drug delivery device which offers both selective retraction of a constituent piston and easy detachment of non-contaminated components from device parts which have potentially been in contact with blood. With such a device an easy aspiration of body fluid can be performed during use while the amount of wastage which must be handled, stored and disposed of as biohazardous after use can be reduced. Furthermore, recyclable materials, such as e.g. polymers used in the device engine, can thereby be detached from the drug container after completed administration and discarded in a separate waste bin.

It is another object of the invention to provide a drug delivery device of such kind which is capable of employing an unmodified conventional drug container.

It is a further object of the invention to provide a drug delivery device of the above mentioned kind which is easy to handle during manufacturing.

In the disclosure of the present invention, aspects and embodiments will be described which will address one or more of the above objects or which will address objects apparent from the below disclosure as well as from the description of exemplary embodiments.

Thus, in accordance with a first aspect of the invention a drug delivery device is provided comprising a variable volume reservoir comprising an outlet, a reservoir wall and a piston, piston drive means for causing movement of the piston in a first direction relative to the reservoir wall, and a coupling mechanism structured to initially interlock the piston and the piston drive means to enable joint motion of the piston and the piston drive means in a second direction relative to the reservoir wall and to release at least a portion of the piston drive means from the piston, to thereby allow movement of the at least a portion of the piston drive means relative to the piston, in response to the piston reaching a predefined position relative to the reservoir wall.

The first direction may be a first axial direction, e.g. a direction along a longitudinal axis of the reservoir, and the second direction may be a second axial direction, e.g. the opposite direction along the longitudinal axis of the reservoir. Further, the predefined position of the piston relative to the reservoir wall in which the at least a portion of the piston drive means is released from the piston may be a predefined axial position. This predefined axial position may be reached during advancement (forward/distal movement) of the piston in the reservoir.

The coupling mechanism may comprise a release element for enabling detachment of the at least a portion of the piston drive means from the piston, the release element being capable of undergoing relative displacement with respect to the piston drive means from a first position, in which relative motion between the piston and the piston drive means is at least substantially prevented, to a second position in which relative motion between the piston and the at least a portion of the piston drive means is enabled. In that case, an interface means may be provided to cause the release element to assume the second position relative to the piston drive means in response to the piston reaching a predefined position, e.g. a predefined axial position, relative to the reservoir wall. The interface means may be adapted to interact, e.g. abut or engage, with the release element when the release element reaches a certain position, e.g. a certain axial position, in the reservoir. Particularly, the interface means may comprise a stop surface or other structure suitable for interaction with the release element.

In such a drug delivery device the first position of the release element relative to the piston drive means may define an attached state in which the piston and the piston drive means are bound to translate jointly, while the second position of the release element relative to the piston drive means may define a released state in which the at least a portion of the piston drive means is removable from the piston. Any intermediate positions of the release element relative to the piston drive means between the first position and the second position may define an attached state.

The release element may specifically be capable of undergoing relative axial displacement with respect to the piston drive means from the first position to the second position. In particular embodiments the release element is structured to prevent relative axial motion (e.g. defined by a longitudinal axis of the reservoir) between the piston drive means and the piston when the release element assumes the first position. This enables a well-controlled retraction of the piston in the reservoir by the piston drive means as the piston and the piston drive means are bound to translate as a single unit (i.e. a one to one relationship exists between the axial displacements of the piston drive means and the piston), making a vein indication test easy to perform.

The interface means may be arranged proximally of the proximal most use position of the piston. By such an arrangement it is possible to provide a release mechanism for the piston/piston drive means coupling which is non-associated with the inner reservoir wall in the sense that the functionality of the release mechanism is independent of the inner structure of

the reservoir. Thereby, it is possible to use an unmodified, conventional type reservoir, e.g. an off-the-shelf cartridge or syringe, for the drug delivery device.

The interface means may be arranged stationarily with respect to the reservoir wall. This will provide a well-defined automatic transition from the attached state to the released state during advancement of the piston in the reservoir, as well as a simple device construction. Particularly, in connection with the former, it may thereby be ensured that relative motion between the release element and the piston drive means can occur only during advancement (i.e. distal motion relative to the reservoir wall) of the piston drive means.

By arranging the interface means both stationarily with respect to the reservoir wall and proximally of the proximal most use position of the piston it is possible to design a mechanism for well-defined release of the at least a portion of the piston drive means from the piston that is dependent solely on the geometry of the piston drive means and the release element. Thereby, a very simple, yet reliable, construction may be provided.

In the present context, "the proximal most use position of the piston" means the proximal most position which the piston assumes in the reservoir under normal use conditions, i.e. the position of the piston relative to the reservoir wall which corresponds to the largest intended capacity of the drug delivery device. This position may e.g. be the initial position of the piston when the drug delivery device is supplied prefilled by the manufacturer.

Also, in the context of drug delivery devices the term "proximal" is used to refer to a portion or position opposite or away from the drug outlet, whereas "distal", conversely, is used to refer to a portion or position close to the drug outlet.

The release element may be adapted for joint motion with the piston drive means during a first displacement, e.g. advancement, of the piston and for relative motion with respect to the piston drive means during a second displacement, e.g. advancement, of the piston. The position of the interface means relative to the reservoir may contribute to defining the transition between the joint motion and the relative motion. During the second displacement of the piston the release element may eventually be forced to assume the second position relative to the piston drive means, whereby an automatic release of the piston/piston drive means coupling is realised. This automatic release may even be unnoticeable to the user because it is executed while the drug is being administered and the user has his attention elsewhere. In any case the release does not require a separate dedicated user operation of the release element.

In particular embodiments the release element is adapted for joint motion with the piston drive means during a) a first advancement of the piston, b) a retraction of the piston, and c) a second advancement of the piston, and for relative motion with respect to the piston drive means during d) a third advancement of the piston.

The interface means may be arranged such that the release element is urged to assume the second position relative to the piston drive means when the piston has been advanced in the reservoir a distance which is 50% or more, preferably 75% or more, and more preferably 90% or more, of the distance between its proximal most use position and an end position in which the reservoir has been emptied (to the degree practically possible). Particularly for IV administration, it is convenient to be able to retract the piston to perform an aspiration almost throughout the entire administration procedure. This is to be able to check the current position of the delivery needle in the body at any time during the administration. Sudden movements of the delivery needle relative to the penetrated body part may have caused an initially well placed needle to withdraw from or perhaps even transpierce the vein in which case, if undiscovered, the drug will be delivered to another compartment than the intended. If the release is not executed until the piston has travelled at least 90% of the distance needed for emptying the drug reservoir or perhaps until the piston is at an end position in which the reservoir is emptied the drug delivery device offers the option of a vein indication test at most or all relevant positions of the piston, i.e. no or only a small volume of drug can accidentally be delivered to the wrong compartment without the user having the possibility of discovering it.

The interface means may be arranged exteriorly of the reservoir, or may comprise a dedicated surface for interaction with the release element which surface is arranged exteriorly of the reservoir. In case the drug delivery device further comprises a housing member, e.g. of a suitable plastic material, accommodating at least a portion of the reservoir the interface means may be arranged in the housing member. Thereby, the interface means may be made of a recyclable material, which after release of the at least a portion of the piston drive means from the piston can be detached from the reservoir along with the housing member and discarded in a separate bin. If the housing member is coupled to the reservoir in e.g. a friction fit or a snap fit engagement such a separation of the housing member and the reservoir can be accomplished by simply pulling the two apart, i.e. by an action which involves only translatory movements and which therefore is easily carried out, also by people with reduced dexterity.

The piston drive means may comprise a piston rod adapted to be coupled with the piston, which piston rod may be intended for manual manipulation by the subject user or operation by an automatic piston rod drive. The piston drive means may further comprise a piston coupling member, such as a piston rod foot, serving as an intermediate coupling element between the piston and the piston rod. The piston coupling member and the piston rod may comprise respective engagement means for engaging one another. These engagement means may be structured to allow radial displacement of one or more portions of either the piston rod or the piston coupling member relative to the other in response to an axial force being applied to the piston rod, thereby providing for separation of the piston rod from the piston coupling member. Such structure may involve bevelled surfaces on one or both members' engagement means.

One of the piston rod and the release element may be structured to at least partially encircle at least a portion of the other. This will enable a slender device design because the components involved can be arranged to operate e.g. concentrically, thereby saving space. At least 50%, preferably at least 75%, of the longitudinal dimension of the piston rod or the release element may be hollow and arranged to accommodate at least a portion of the other of the piston rod and the release element. This will allow the manufacturer to produce release elements of different longitudinal dimensions, where each chosen dimension corresponds to a desired predefined position of the piston in the reservoir in which the transition between the attached state and the released state is completed.

The piston rod, or the piston coupling member if such is present, may be attachable to the piston after arrangement of the piston in the reservoir. This will enable an easy handling of the drug delivery device during manufacturing because the piston can be arranged independently of the piston rod in e.g. an existing production line for a prefilled reservoir.

The piston rod, or the piston coupling member if such is present, may in the pre-use state of the drug delivery device be arranged axially spaced apart from the piston to thereby provide some play in the construction. This will allow fluid in the reservoir to expand during storage, e.g. as a consequence of temperature fluctuations in the storage environment, without damaging any parts of the piston rod drive mechanism. The very first operational step(s) of the device may then cause the piston rod, or the piston coupling member, to move into engagement with the piston, or with an insert in the piston.

In some embodiments the piston drive means comprise a hollow cylindrical piston rod adapted for translatory motion relative to a housing member along a general axis defined by the reservoir. The piston rod accommodates a portion of the release element and carries it during a first axial travel through the housing member. The piston rod further accommodates a portion of a piston coupling member which engages, respectively, with the release element and the inner piston rod wall, whereby an axial lock between the piston rod and the piston coupling member is provided. The coupling member has one or more deflectable arms which extend into the bore of the hollow piston rod. At least one of the deflectable arms is provided with a catch member adapted for engagement with a corresponding catch member on the inner piston rod wall. In a first position relative to the piston rod the release element urges the at least one deflectable arm into engagement with the inner piston rod wall, e.g. in a wedging action. An interface means is provided in the housing member and is structured to interact with the release element in response to the release element taking up a certain axial position relative to the housing member. During a second travel of the piston rod through the housing member the release element is obstructed by the interface means from further axial motion relative to the housing member, and the release element therefore now undergoes relative axial motion with respect to the piston rod and the piston coupling member. At some point, correlated with the piston having been advanced to a certain position in the reservoir, the release element is forced out of engagement with the one or more deflectable arms, whereby the axial lock between the piston rod and the piston coupling member is disabled. Subsequently, the housing member and the piston rod can be detached from the reservoir, leaving the piston and the piston coupling member in the reservoir.

By having such a release mechanism completely incorporated in parts of the device which are non-accessible to the user the automatic release function is concealed and the release is executed without possible user intervention and without risk of any components malfunctioning due to impurities accidentally imparted during handling of the device.

In other embodiments the piston drive means comprise a hollow tubular piston rod which is radially compressible relative to an unloaded state. The piston rod has engagement means, e.g. in the form of a couple of recesses, for engagement with corresponding engagement means on a piston coupling member, e.g. a circumferential ridge on an inner wall thereof. The release member is an elongated stick member with a distal head having a radial dimension that matches a radial clearance between two pushing jaws on the piston rod. In a first position of the release element relative to the piston rod the head is arranged between the jaws to prevent a radial compression of the piston rod. In response to the release element

being forced to assume a second position relative to the piston rod the head is pulled out of contact with the jaws, thereby allowing a radially inward movement of the jaws upon subjection to forces with inwardly directed components.

In yet other embodiments the piston drive means comprise a variable diameter piston rod and a piston coupling member with proximally oriented deflectable arms adapted to receive a distal portion of the piston rod. A tubular release element having an inner diameter corresponding to the distance between the arms is in a first position relative to the piston rod slidably arranged as an encircling sleeve, thereby preventing radial outward deflection of the arms. The arms are provided with engagement means, such as e.g. one or more protrusions, for engagement with a narrowed portion of the piston rod. The tubular release element has a radially enlarged proximal portion which is adapted to move into abutment with the interface means during advancement of the piston, whereby the release element switches from undergoing joint motion to undergoing relative motion with respect to the piston rod. At some point, correlated with the piston having been advanced to a certain position in the reservoir, the tubular release element is slid out of contact with the piston coupling member, whereby the deflectable arms are freed for radial outward deflection. By subsequent retraction of the piston rod in the reservoir the interfacing surfaces of the engagement means and the narrowed piston rod portion will exert radially outwardly directed forces on the deflectable arms urging them to deflect away from the piston rod, whereupon the piston rod will detach from the piston coupling member.

In even further embodiments the piston rod is a two-part structure and one of the two parts constitutes the release element, while the other part constitutes the actual piston driver. In this case the piston coupling member is structured to engage with the piston driver, and the release element provides a lock for this engagement while being in a first position relative to the piston driver. In that respect the piston coupling member may comprise a radially deflectable latch means which is axially and radially trapped between the piston driver and the release element. During piston advancement a portion of the release element abuts a stop surface of the interface means, whereby the two piston rod parts are urged to undergo relative axial motion. At some point, correlated with the piston having been advanced to a certain position in the reservoir, the piston rod part constituting the release element is slid out of contact with the piston coupling member, thereby releasing the lock for the engagement between the piston coupling member and the piston driver.

In accordance with a second aspect of the invention a drug delivery device is provided, comprising a dual chamber container comprising a first end portion, e.g. an outlet portion, a second end portion, e.g. an activation end portion, and a wall extending therebetween, a stopper slidably arranged in the container between the first end portion and the second end portion, and a piston arrangeable in the container between the stopper and the second end portion. A passage arrangement is adapted to allow fluid flow between a proximal side and a distal side of the stopper, e.g. when the stopper takes up a certain position in the container or when the stopper is in an open state. Further provided are piston drive means structured for coupling with the piston, a release member displaceable relative to the piston drive means from a first position in which relative motion between the piston and the piston drive means is at least substantially prevented to a second position in which relative motion between the piston and at least a portion of the piston drive means is allowed, and interface means for causing displacement of the release member to the second position relative to the piston drive means in response to the piston reaching a predefined position relative to the container wall.

The interface means may be arranged proximally of the piston, whereby the provision of a piston/piston drive means release mechanism which is independent of the particular inner structure of the reservoir is enabled.

In particular embodiments a front chamber distally of the stopper is adapted to hold a powdered drug and a rear chamber proximally of the stopper is adapted to hold a solvent. Alternatively, the front chamber is adapted to hold a first liquid and the rear chamber is adapted to hold a second liquid. A bypass channel in the wall enables transfer of the substance provided in the rear chamber to the front chamber when the stopper is in a certain position in the container.

The drug delivery device may be prefilled in the sense that it is supplied by the manufacturer in a condition where the front chamber holds a first substance, on powder or liquid form, and where the second chamber holds a second substance miscible with the first substance to produce an administrable drug product.

In certain cases it may be desired to release the at least a portion of the piston drive means from the piston already shortly after an initial aspiration. For a dual chamber device, where the piston undergoes a displacement prior to the actual drug administration (in connection with the transfer of fluid from the rear chamber to the front chamber), this may correspond to

the piston having been displaced e.g. 50 % or more, or perhaps 75% or more, of the distance needed for emptying of the reservoir, depending on the particular dual chamber reservoir employed. It is noted, however, that any specific position of the piston in the given dual chamber reservoir may be chosen by the manufacturer as the point of release, in line with the directions provided elsewhere in the present text.

In the present specification, reference to a certain aspect or a certain embodiment (e.g. "an aspect", "a first aspect", "one embodiment", "an exemplary embodiment", or the like) signifies that a particular feature, structure, or characteristic described in connection with the respective aspect or embodiment is included in, or inherent of, at least that one aspect or embodiment of the invention, but not necessarily in/of all aspects or embodiments of the invention. It is emphasized, however, that any combination of the various features, structures and/or characteristics described in relation to the invention is encompassed by the invention unless expressly stated herein or clearly contradicted by context.

The use of any and all examples, or exemplary language (e.g., such as, etc.), in the text is intended to merely illuminate the invention and does not pose a limitation on the scope of the same, unless otherwise claimed. Further, no language or wording in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be further described with references to the drawings, wherein

Fig. 1a is a cross-sectional view of a dual chamber drug mixing and delivery device according to an embodiment of the invention in a pre-use state,

Fig. 1b shows an enlargement of a section of the device shown in Fig. 1a,

Fig. 2 is a cross-sectional view of the device of Fig. 1 in a state just before automatic release of the piston/piston rod coupling,

Fig. 3 is a cross-sectional view of the device of Fig. 1 in a state after release of the piston/piston rod coupling,

Fig. 4 is a cross-sectional view showing the device of Fig. 1 after separation of the dosing engine and the drug reservoir,

Figs. 5a – 5d show in cross-sectional views a piston/piston rod decoupling mechanism in a drug delivery device according to another embodiment of the invention,

Figs. 6a – 6d show in cross-sectional views a piston/piston rod decoupling mechanism in a drug delivery device according to yet another embodiment of the invention, and

Figs. 7a – 7d show in cross-sectional views a piston/piston rod decoupling mechanism in a drug mixing and delivery device according to yet another embodiment of the invention.

In the figures like structures are mainly identified by like reference numerals.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

When in the following relative expressions, such as "forward" and "backward", are used, these refer to the appended figures and not necessarily to an actual situation of use. The shown figures are schematic representations for which reason the configuration of the different structures as well as their relative dimensions are intended to serve illustrative purposes only.

In an exemplary drug delivery device embodying the principles of the present invention the piston and the piston rod are inseparably coupled for joint forward and backward motion during one or more operational sequences, whereupon they are automatically prepared for relative motion during a subsequent operational stage of the device.

Fig. 1a shows a cross-sectional view of a dual chamber drug delivery device 1 according to an exemplary embodiment of the invention. The drug delivery device 1 is shown in a pre-use state, e.g. as delivered by the manufacturer, with its outlet end portion 2 pointing upwards. The drug delivery device 1 comprises a reservoir assembly and a dosing assembly. The reservoir assembly includes a cartridge 4 to which a Luer connector 3 is coupled at the outlet end portion 2. The Luer connector 3 is adapted for coupling with a suitable delivery element (not shown), such as e.g. an infusion set or a hypodermic needle. A stopper 7 is provided in the cartridge 4 between the outlet end portion 2 and a piston 8, just proximally of a bypass channel (not visible), e.g. as in conventional dual chamber solutions. A front chamber 9 in the cartridge 4 between the outlet end portion 2 and the stopper 7 is adapted to hold

a drug substance (not shown), e.g. in powder or liquid form, while a rear chamber 10 is adapted to hold another substance (not shown) such as e.g. a solvent or diluent. The cartridge 4 is fixed in a cartridge holder 5 which is attached at its proximal end to a housing 6. In this embodiment, the cartridge holder 5 and the housing 6 are attached via a friction fit coupling, but other means for attachment may be envisioned, such as e.g. snap fit coupling.

The housing 6 accommodates a portion of the dosing assembly, which includes a central hub 11 in the housing 6, a hollow piston rod 14 and a tube shaped actuator 12. The actuator 12 is rotationally occupied in the central hub 11 and is provided with a knob 13 at its proximal end for easy user operation. A pin 15 extends longitudinally in the hollow piston rod 14 and has a pin head 16 for abutment with the proximal end of the piston rod 14.

The reservoir assembly and the dosing assembly are also coupled via a piston rod foot 18 which at its distal end portion has a coupling head 31 adapted for engagement with a pair of radially deflectable pawls 38 on an insert in the piston 8 and at its proximal end portion has a couple of deflectable arms 19, 20 which extend into the hollow piston rod 14.

In other embodiments than the one shown in Fig. 1a the piston rod foot may in the pre-use state of the drug delivery device be arranged axially spaced apart from the piston insert, whereby no initial engagement between the coupling head and the pawls exists. This will provide for a potential proximal movement of the rear piston in the reservoir, e.g. due to temperature variations during storage causing the substance in the rear chamber to expand, which will not be damaging to any parts of the dosing assembly. In such cases the very first device operation performed by the user may cause the piston rod to advance a short distance until the coupling head engages with the pawls.

Fig. 1b is an enlargement of the portion of the drug delivery device 100 which is delimited by the area Q in Fig. 1a. The enlargement shows the functional relationship between the various parts of the dosing assembly and an interaction between the piston rod 14, the pin 15 and the piston rod foot 18. The outer peripheral surface of the tube shaped actuator 12 is provided with a male thread section (not visible) which engages with an inner female thread 26 provided in the central hub 11. The actuator 12 is further provided with an inner male thread section 25 which engages with an outer female thread 35 on the piston rod 14. The pitch of the outer female thread 35 is greater than the pitch of the inner female thread 26. Thereby, the piston 8 is advanced a first distance by a telescopic piston rod mechanism, where for each revolution of the actuator 12 the axial displacement of the piston rod 14 rela-

tive to the actuator 12 is greater than the axial displacement of the actuator 12 relative to the central hub 11.

From Fig. 1b it is further seen that the inner wall of the piston rod 14 has a circumferential collar 23 which engages with respective catches 21, 22 on the arms 19, 20. In the pre-user state and in initial use states of the drug delivery device 1 a distal portion 17 of the pin 15 is wedged between the arms 19, 20 forcing the arms 19, 20 outwards toward the cylindrical inner wall of the piston rod 14, thereby providing a lock against proximal motion of the piston rod 14 relative to the piston rod foot 18.

Fig. 2 shows the drug delivery device 1 in a state where the drug substance and the other substance have mixed and most of the mixture has been ejected out of the cartridge 4 by advancement of the stopper 7 to a position just proximally of a shoulder 27. In the shown state the wedge portion 17 has been pulled out of the space between the arms 19, 20 due to an interaction between the pin head 16 and a flange 28 in the central hub 11, as will be described further below. This relative position of the pin 15 and the piston rod foot 18 allows for proximal motion of the piston rod 14 relative to the piston 8 because a pull force applied to the piston rod 14 will cause the collar 23 to exert a force on the catches 21, 22, which force due to an inclined interface between the catches 21, 22 and the collar 23 will have a radial component urging an inward deflection of the arms 19, 20. Since the wedge portion 17 no longer prevents such inward deflection of the arms 19, 20 the catches 21, 22 will be moved out of engagement with the collar 23, thereby releasing the piston rod 14 from the interlocking with the piston rod foot 18.

The point where the pin 15 is pulled completely out of the piston rod foot 18 to allow for separation of the piston rod 14 from the piston 8 can be chosen arbitrarily by an adequate design of the central hub 11 and the pin 15, e.g. by varying the axial position of the flange 28 and/or the length of the wedging portion 17. Since in some cases, such as for IV administration, proper engagement between the piston rod 14 and the piston 8 is desired almost throughout the drug delivery phase (to allow for retraction of the piston 8 in connection with aspiration at practically any time following insertion of the delivery element in the body), these design parameters may be chosen such that the automatic release of the piston/piston rod coupling is not effected until immediately prior to complete emptying of the cartridge 4. In other cases where it is not deemed necessary to enable aspiration after an initial vein indication test the design parameters may be chosen such that the automatic release is effected

when e.g. the piston 8 is situated in the cartridge 4 halfway between its pre-use position and its end position.

In Fig. 3 the stopper 7 has been fully advanced in the cartridge 4 and now abuts the shoulder 27. In this state the drug delivery device 1 is emptied of the drug product. Because of the abutment of the pin head 16 with the flange 28 the pin 15 has been stationary with respect to the cartridge 4 during the last part of the drug administration. Thereby, a clearance 29 has been provided between the wedging portion 17 and the arms 19, 20.

Fig. 4 shows the drug delivery device 1 during separation of the dosing assembly from the reservoir assembly. This separation is carried out by mere axial retraction of the housing 6 relative to the cartridge holder 5.

In the above described embodiment the piston rod foot 18 has two radially deflectable arms 19, 20 for interaction with the piston rod 14 and the pin 15. It is noted, however, that a piston rod foot with a single radially deflectable arm may alternatively be used in a like arrangement.

In the following an operation of the drug delivery device 1 leading to the automatic release of the piston/piston rod coupling will be described.

After having removed an outlet end cover (not shown) to expose the Luer connector 3 to the environment the user may hold the drug delivery device 1 in one hand by the housing 6, with the Luer connector 3 pointing upwards, and use the other hand to turn the knob 13 about the central device axis. This will cause the male thread section of the actuator 12 to travel the inner female thread 26 and the inner male thread section 25 to travel the outer female thread 35, producing a telescopic advancement of the piston rod 14.

Because the piston rod 14 and the piston 8 are axially but non-rotationally coupled via the piston rod foot 18, the advancement of the piston rod 14 results in a non-rotational corresponding advancement of the piston 8. At first, the thereby pressurised substance in the rear chamber will exert a force on the stopper 7 and move it into the bypass channel where the substance is free to bypass it and enter the front chamber 9. In the front chamber 9 the two substances mix, whereby an administrable product is provided.

The drug delivery device 1 is designed such that the rear chamber 10 collapses completely (i.e. the piston 8 is brought into abutment with the stopper 7) exactly when the male thread

section of the actuator 12 has travelled to the end of the inner female thread 26. Also at this point the piston rod 14 becomes rotationally locked to the actuator 12 due to a flexible arm (not visible) on the piston rod 14 moving into an opening (not visible) in the wall of the actuator 12.

A suitable delivery element, such as an infusion set or a hypodermic needle, is now attached to the Luer connector 3, and the drug delivery device 1 is inverted for delivery of the mixed product. An axial depression of the knob 13 towards the housing 6 non-rotationally advances the piston 8 and the stopper 7 in the cartridge 4, whereby a volume of drug is expelled through the outlet.

During a first joint advancement of the piston 8 and the stopper 7 the pin 15 is moved axially together with the piston rod 14. At this stage, any retraction of the interlocked actuator 12 and piston rod 14 will cause a corresponding retraction of the piston 8 due to the interaction between the wedge portion 17, the arms 19, 20 and the catches 21, 22. Thereby, a proper vein indication test can be performed to ensure correct placement of the delivery needle in the skin. However, when the piston 8 approaches a certain position in the cartridge 4, e.g. a position corresponding to 90% of the drug having been delivered through the outlet, the pin head 16 abuts the flange 28 and the pin 15 is prevented from further advancement in the cartridge 4. A continued depression of the knob 13 will therefore advance the piston rod 14 relative to both the cartridge 4 and the pin 15, eventually leading to the wedge portion 17 being pulled out of contact with the arms 19, 20, as shown in Fig. 2.

From this point an axial retraction of the actuator 12 will cause the arms 19, 20 to deflect inwardly releasing the piston rod 14 from the piston rod foot 18. Thereby, the dosing assembly, comprising the housing 6, the actuator 12, the piston rod 14 and the pin 15 can be separated from the cartridge assembly by simple pulling, as illustrated in Fig. 4, for discarding in a recyclables bin.

Fig. 5a – 5d show the principles of the present invention embodied in a single chamber drug delivery device 100. Fig. 5a is a cross-sectional view of the proximal portion of a cartridge 104 made of e.g. glass or plastic. A piston 108 which is interlocked with a piston rod foot 118 via a coupling head 131 has been advanced a distance in the cartridge 104 from an initial position next to an adaptor 130, thereby pressing a volume of drug out of a distal end portion (not shown) of a chamber 109. The piston 108 is driven by a segmented piston rod 114 which is attached to the piston rod foot 118 so as to enable both forward and backward joint

motion of the piston 108 and the piston rod 114. A pin 115 is arranged in a space within the boundaries of the piston rod 114 where it extends axially between a pin head 116 and a wedge portion 117. The wedge portion 117 is arranged between a pair of jaws 132 to urge the piston rod 114 into a locking engagement with the piston rod foot 118. A circumferential bead 121 on the piston rod foot 118 thereby provides a catch mechanism for a collar 123 on the piston rod 114.

In Fig. 5b the piston 108 has been moved a further distance distally in the cartridge 104, whereby the pin head 116 has moved into abutment with a flange 128. Further distal movement of the piston rod 114, as shown in Fig. 5c, now leads to a relative motion between the piston rod 114 and the pin 115 because of the flange 128 blocking further distal movement of the pin 115. The pin 115 thus remains stationary with respect to the cartridge 104, leading to the wedge portion 117 being moved out of contact with the jaws 132. A clearance 129 is thereby established between the jaws 132, such that if the piston rod 114 is retracted, as illustrated in Fig. 5d, the slanted interface between the bead 121 and the collar 123 provokes a disengagement of the piston rod 114 from the piston rod foot 118 and thereby allows for separation of the piston drive assembly from the container assembly.

Figs. 6a – 6d show principle sketches of another embodiment of the invention. Fig. 6a is a cross-sectional view of the proximal portion of a cartridge 204 in a single chamber drug delivery device 200. A piston 208 which is interlocked with a piston rod foot 218 via a coupling head 231 has been advanced a distance in the cartridge 204 from an initial position next to an adaptor 230, thereby pressing a volume of drug out of a distal end portion (not shown) of a chamber 209. The piston rod foot 218 has a couple of deflectable arms 219, 220 extending axially in the proximal direction away from the piston 208. The arms 219, 220 are provided with respective catches 221, 222 which are adapted to engage with a narrowing 233 on a piston rod 214, thereby interlocking the piston rod 214 and the piston rod foot 218. A tube 215 longitudinally surrounds a portion of the piston rod 214 as well as a portion of the arms 219, 200 so as to prevent radial deflection of the arms 219, 220. Thus, a piston rod head 223 is accommodated in the piston rod foot 218 between the arms 219, 220, enabling both forward and backward joint motion of the piston rod 214 and the piston 208. The tube 215 is provided with a radially extending flange 216 at its proximal end and is arranged to initially move jointly with the piston rod 214.

In Fig. 6b the piston 208 has been moved a further distance distally in the cartridge 204, whereby the flange 216 has moved into abutment with a contact surface 228 on the adaptor

230. Further distal movement of the piston rod 214, as shown in Fig. 6c, now leads to a relative motion between the piston rod 214 and the tube 215 because of the contact surface 228 blocking further distal movement of the flange 216. In the shown situation the tube 215 has just moved out of contact with the arms 219, 220, whereby the arms 219, 220 are free to deflect radially about respective hinges 239, 240. If the piston rod 214 is retracted following the disengagement of the tube 215 and the arms 219, 220 the piston rod head 223 will urge the arms 219, 220 radially outwards, as illustrated in Fig. 6d, whereby the piston rod 214 is released from the piston rod foot 218.

Figs. 7a – 7d show principle sketches of yet another embodiment of the invention. Fig. 7a is a cross-sectional view of the proximal portion of a drug delivery device 300 comprising a dual chamber cartridge 304 in which a rear piston 308 has been advanced a distance axially from a pre-use position next to an adaptor 330, thereby transferring a volume of fluid from a rear chamber 310 to a front chamber (not shown). The piston 308 is interlocked with a piston rod foot 318 via a coupling head 331. The piston rod foot 318 is in turn interlocked with a two-part piston rod 314, 315 via a flexible hammer-head construction consisting of a catch 321 on a flexible arm 319. The catch 321 engages with a flange 323 on one of the piston rod parts 314, while the other piston rod part 315 provides a lock against radial movement of the catch 321. In this state of the drug delivery device 300 a retraction of the piston rod 314, 315 will cause a like retraction of the piston rod foot 318 and the piston 308.

Throughout Figs. 7a – 7d the arrows indicate the direction of motion of the piston 308 and the piston rod 314, 315 relative to the cartridge 304. In Fig. 7b the piston 308 has been advanced a further distance distally in the cartridge 304 to a point where a catch 316 at the proximal end of one of the piston rod parts 315 abuts a flange 328 on the adaptor 330. Further advancement of the piston 308 will cause a relative motion between the two piston rod parts 314, 315 because of the flange 328 obstructing further distal movement of the piston rod part 315. The piston rod part 315 is thereby axially slid out of contact with the piston rod foot 318, as shown in Fig. 7c. In this state of the drug delivery device 300 a retraction of the piston rod parts 314, 315 will lead to a radial deflection of the catch 321, as illustrated on Fig. 7d, due to the elastic properties of the flexible arm 319 and, consequently, a release of the other piston rod part 314 from the piston rod foot 318. The piston drive assembly can hereafter be separated from the container assembly, leaving the potentially contaminated piston 308 and the piston rod foot 318 in the cartridge 304.

It is noted that the exact point of automatic release of the piston rod from the piston in the respective embodiments shown in Figs. 5 – 7 can be chosen as desired in the device design phase, e.g. by adapting the length of, respectively, the pin 115, the tube 215 and the piston rod part 315 to the length of the employed drug container and the specific arrangement of the obstructing surfaces on the respective adaptors.

CLAIMS

1. A drug delivery device (1, 100, 200, 300) comprising:

- a variable volume reservoir (4, 104, 204, 304) comprising an outlet, a reservoir wall, and a piston (8, 108, 208, 308),
- piston drive means (14, 18; 114, 118; 214, 218; 314, 318) for selective advancement and retraction of the piston (8, 108, 208, 308) in the reservoir (4, 104, 204, 304),
- a release element (15, 115, 215, 315) displaceable relative to the piston drive means (14, 18; 114, 118; 214, 218; 314, 318) from a first position to a second position, the first position defining an attached state in which the piston drive means (14, 18; 114, 118; 214, 218; 314, 318) and the piston (8, 108, 208, 308) are bound to translate jointly, and the second position defining a released state in which at least a portion of the piston drive means (14, 18; 114, 118; 214, 218; 314, 318) is removable from the piston (8, 108, 208, 308), and
- interface means (28, 128, 228, 328) for causing the release element (15, 115, 215, 315) to assume the second position relative to the piston drive means (14, 18; 114, 118; 214, 218; 314, 318) in response to the piston (8, 108, 208, 308) reaching a pre-defined position relative to the reservoir wall, the interface means (28, 128, 228, 328) being arranged proximally of the proximal most use position of the piston (8, 108, 208, 308).

2. A drug delivery device according to claim 1, wherein the interface means (28, 128, 228, 328) is arranged stationarily with respect to the reservoir wall.

3. A drug delivery device according to claim 1 or 2, wherein the interface means (28, 128, 228, 328) comprises a stop surface for interaction with the release element (15, 115, 215, 315), the stop surface being arranged exteriorly of the reservoir (4, 104, 204, 304).

4. A drug delivery device according to any of the preceding claims, wherein the release element (15, 115, 215, 315) is adapted for joint motion with the piston drive means (14, 18; 114, 118; 214, 218; 314, 318) during a first displacement of the piston (8, 108, 208, 308) and for relative motion with respect to the piston drive means (14, 18; 114, 118; 214, 218; 314, 318) during a second displacement of the piston (8, 108, 208, 308).

5. A drug delivery device according to any of the preceding claims, wherein the predefined position of the piston (8, 108, 208, 308) relative to the reservoir wall is a position corresponding to an advancement of the piston (8, 108, 208, 308) in the reservoir a distance which is 50% or more, preferably 75% or more, and more preferably 90% or more, of the distance between the proximal most use position and an end position of the piston (8, 108, 208, 308) in which the reservoir (4, 104, 204, 304) has been emptied.

6. A drug delivery device according to any of the preceding claims, further comprising a housing member (6) adapted to accommodate at least a portion of the reservoir (4), wherein the interface means (28) is arranged in the housing member (6).

7. A drug delivery device according to claim 6, wherein the housing member (6) supports the piston drive means (14, 18; 114, 118; 214, 218; 314, 318) and is releasably coupled with the reservoir (4) and removable from the reservoir (4) in response to the piston (8) reaching the predefined position relative to the reservoir wall.

8. A drug delivery device according to any of the preceding claims, wherein the piston drive means (14, 18; 114, 118; 214, 218; 314, 318) comprises a piston rod (14, 114, 214, 314), one of the piston rod (14, 114, 214, 314) and the release element (15, 115, 215, 315) being structured to at least partially encircle at least a portion of the other of the piston rod (14, 114, 214, 314) and the release element (15, 115, 215, 315).

9. A drug delivery device according to claim 8, wherein the piston drive means (14, 18; 114, 118; 214, 218; 314, 318) further comprises a coupling element (18, 118, 218, 318) for coupling the piston (8, 108, 208, 308) and the piston rod (14, 114, 214, 314), a portion of the coupling element (18, 118, 218, 318) being adapted for interaction with the release element (15, 115, 215, 315).

10. A drug delivery device according to claim 9, wherein the piston rod (14, 114) is hollow, and wherein at least a portion of the release element (15, 115) is slidably arranged in the piston rod (14, 114).

11. A drug delivery device according to claim 10, wherein the coupling element (18) comprises a deflectable arm (19) which extends into the piston rod (14), and wherein the release element (15) is adapted to provoke a locking engagement between the deflectable arm (19) and the inner piston rod wall when assuming a first position relative to the piston rod (14)

and to enable relative motion between the deflectable arm (19) and the inner piston rod wall when assuming a second position relative to the piston rod (14).

12. A drug delivery device according to claim 11, wherein the release element (15) comprises a catch member (16), and wherein during piston advancement the release element (15) is urged to displace from the first position to the second position relative to the piston rod (14) in response to the catch member (16) contacting the interface means (28).

13. A drug delivery device according to any of claims 1 – 7, wherein the piston drive means (314, 318) comprises a two-part piston rod, and wherein one of the two piston rod parts constitutes the release element (315).

14. A drug delivery device according to claim 13, wherein the piston drive means (314, 318) further comprises a coupling member (318) for coupling the piston (308) and the piston rod, a portion of the coupling member (318) being adapted for releasable locking engagement with the other of the two piston rod parts.

15. A drug delivery device according to any of the preceding claims, further comprising:

- a slidable stopper (7) arranged in the reservoir (4) between the outlet and the piston (8), and
- passage means structured to allow fluid flow between a proximal side and a distal side of the stopper (7).

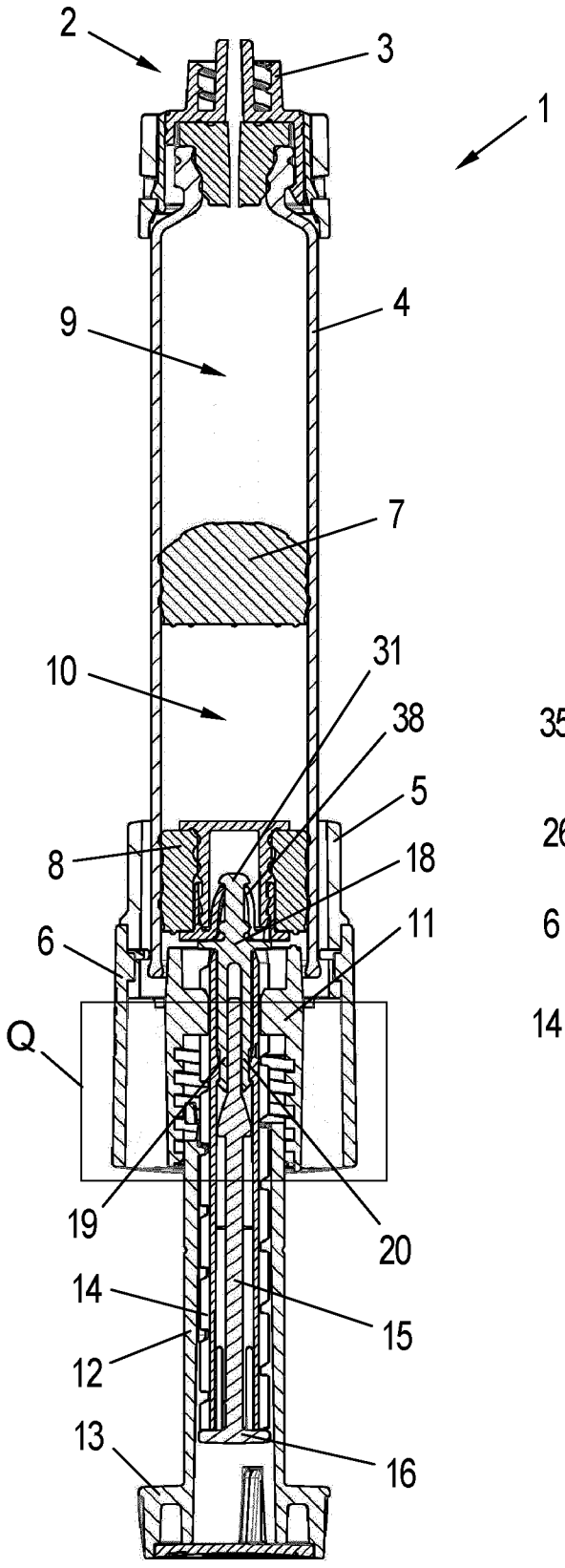
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Fig. 1a

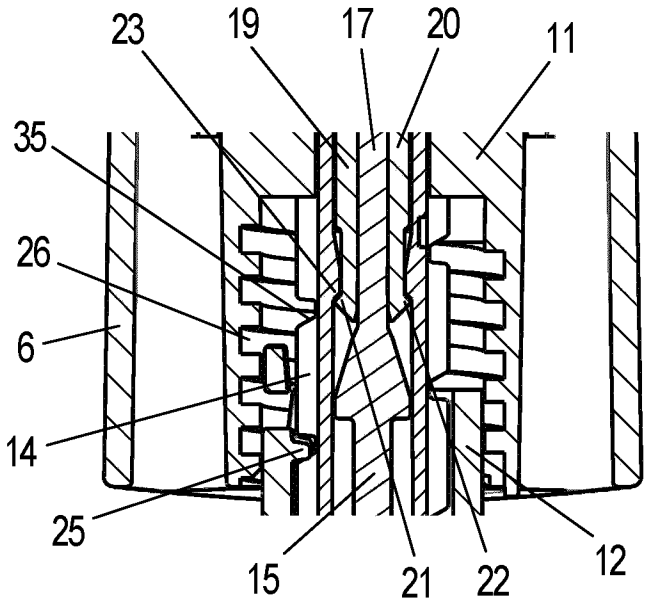
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Fig. 1b

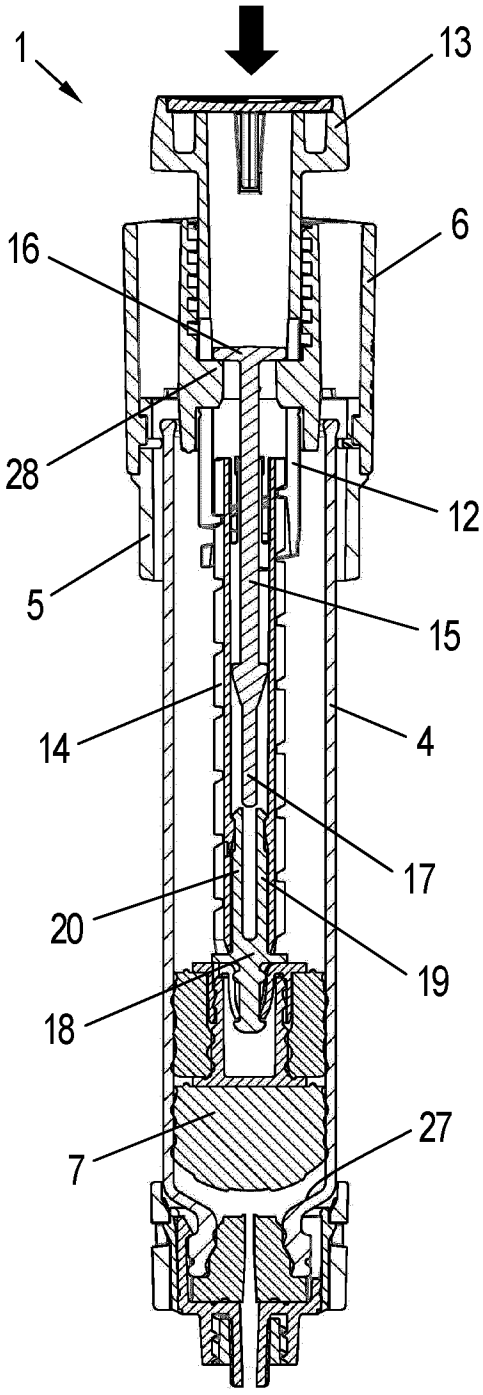

Fig. 2

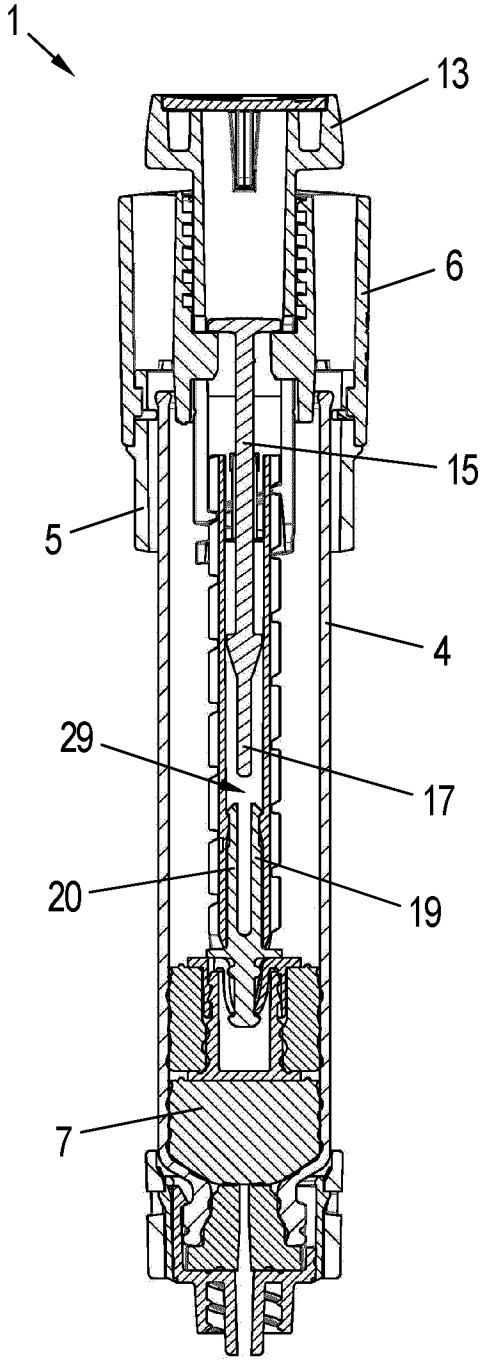

Fig. 3

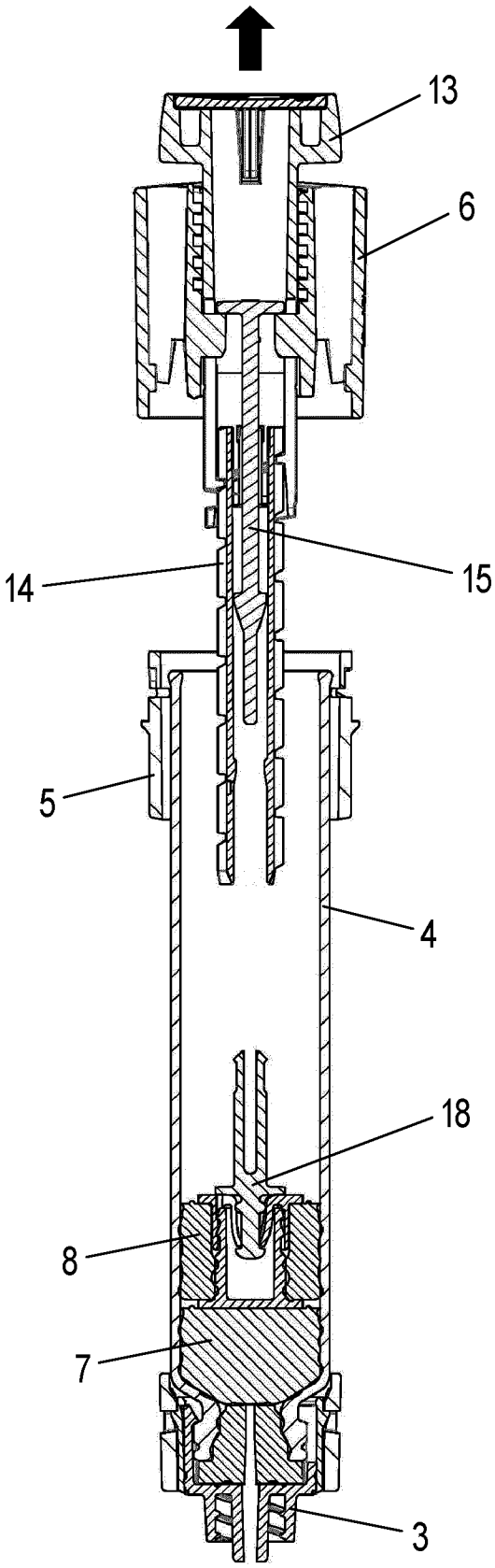

Fig. 4

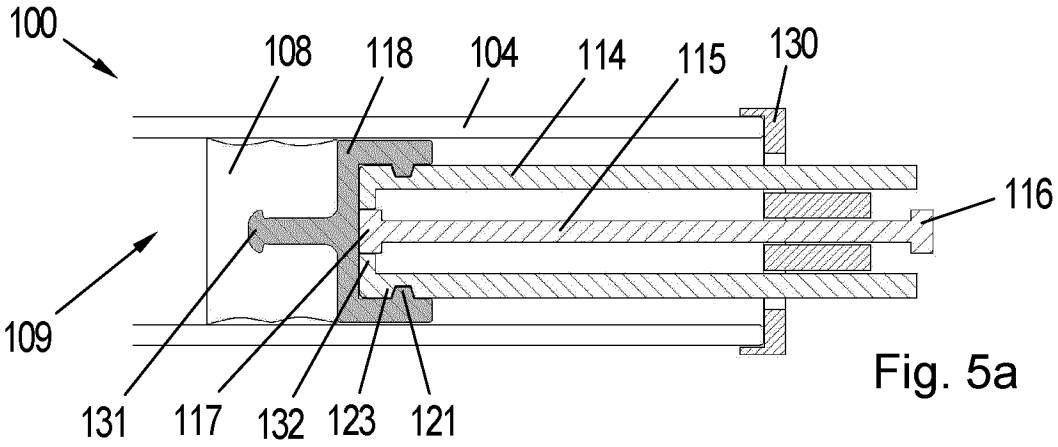

Fig. 5a

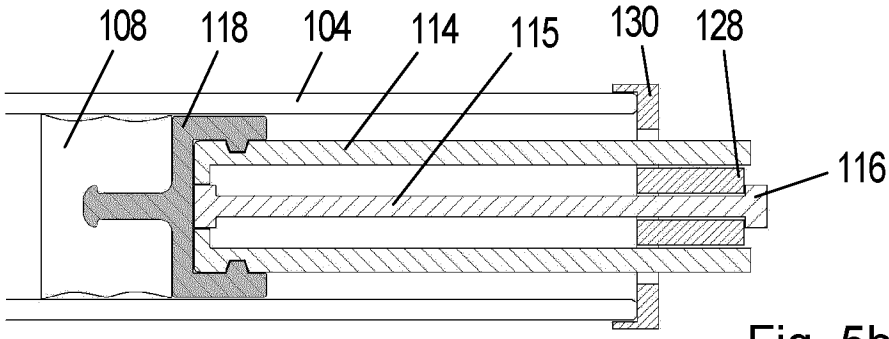

Fig. 5b

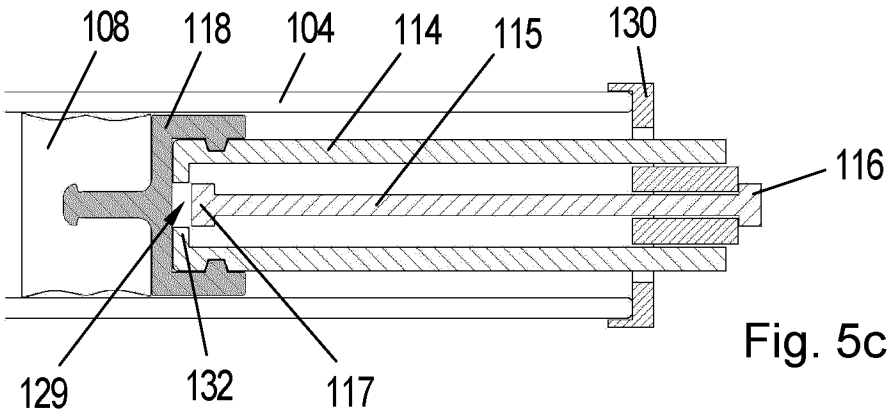

Fig. 5c

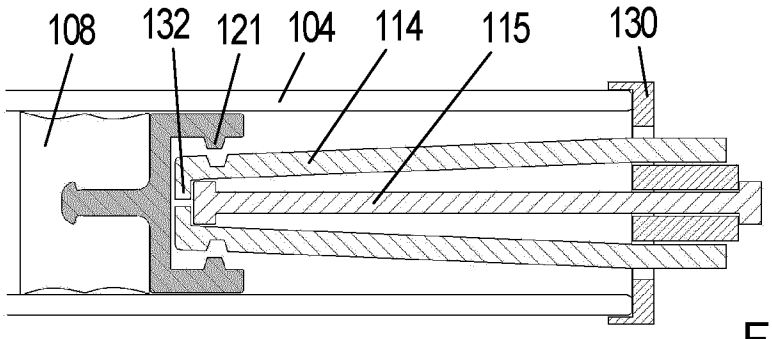

Fig. 5d

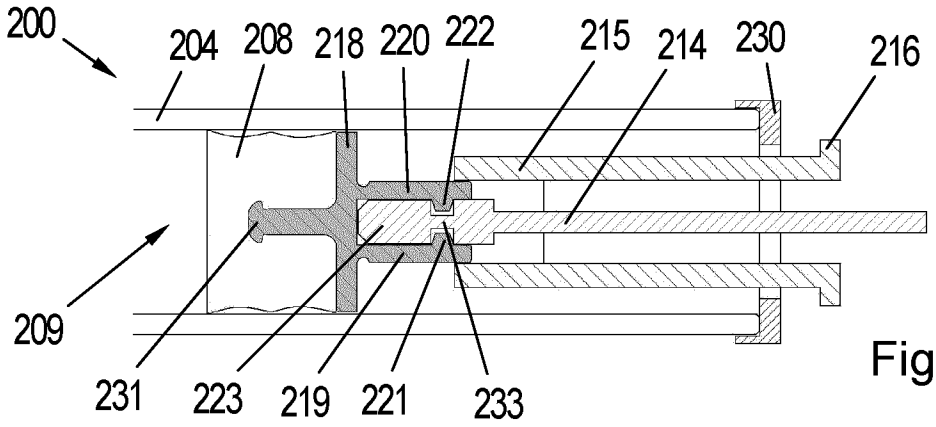

Fig. 6a

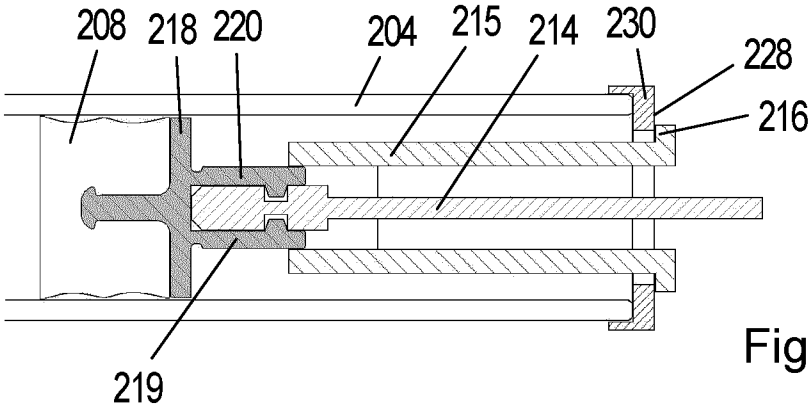

Fig. 6b

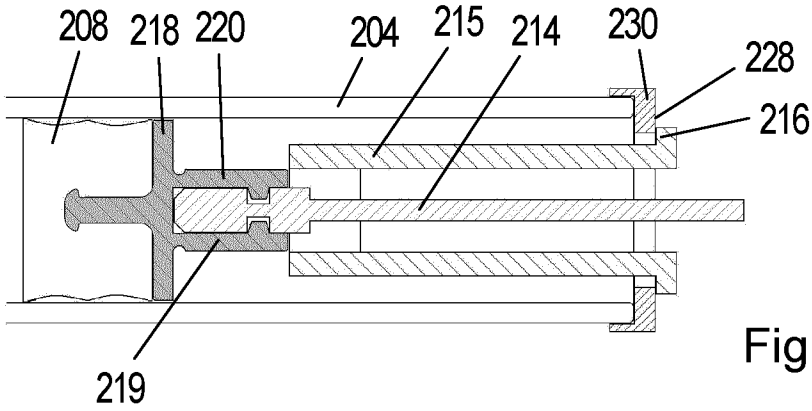

Fig. 6c

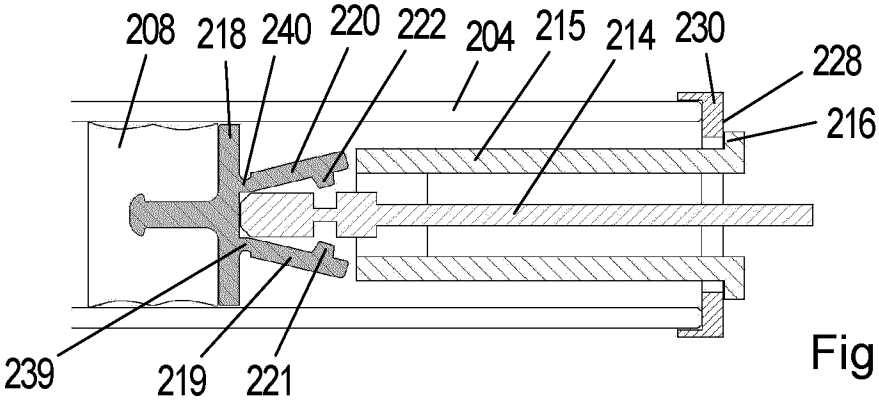

Fig. 6d

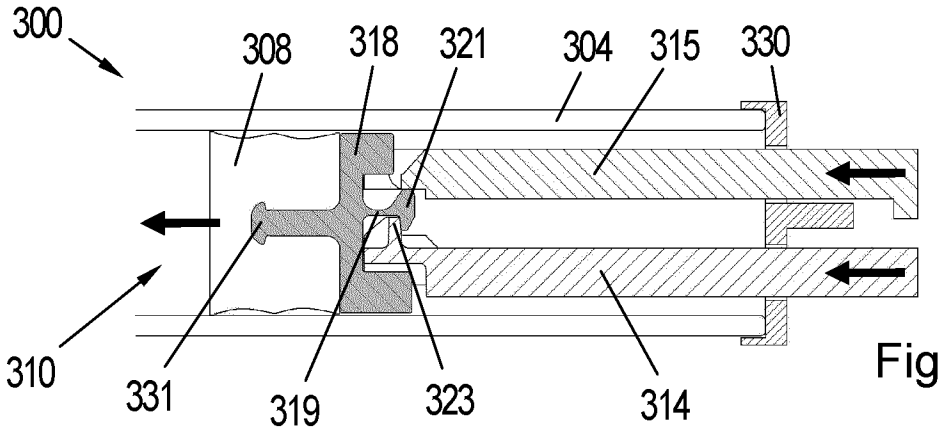

Fig. 7a

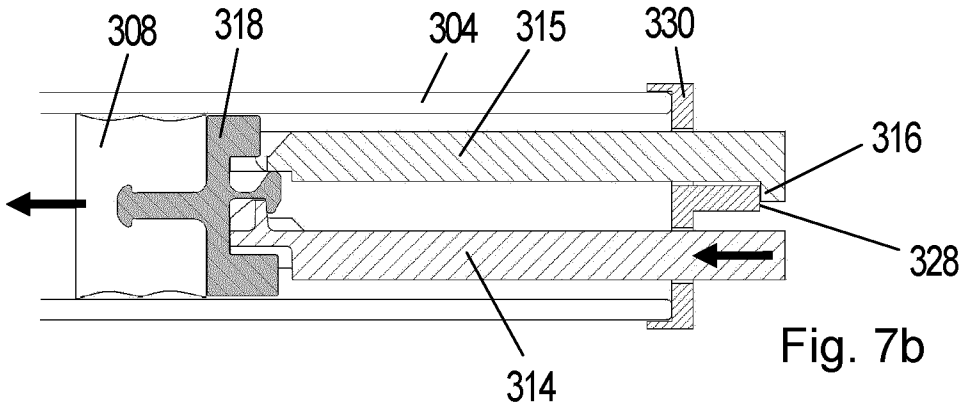

Fig. 7b

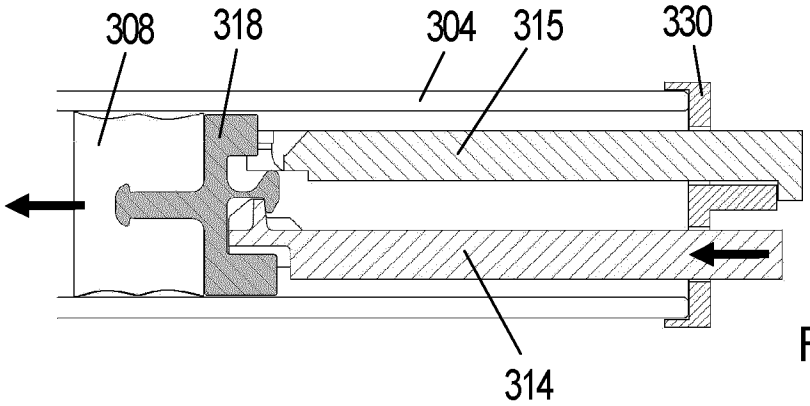

Fig. 7c

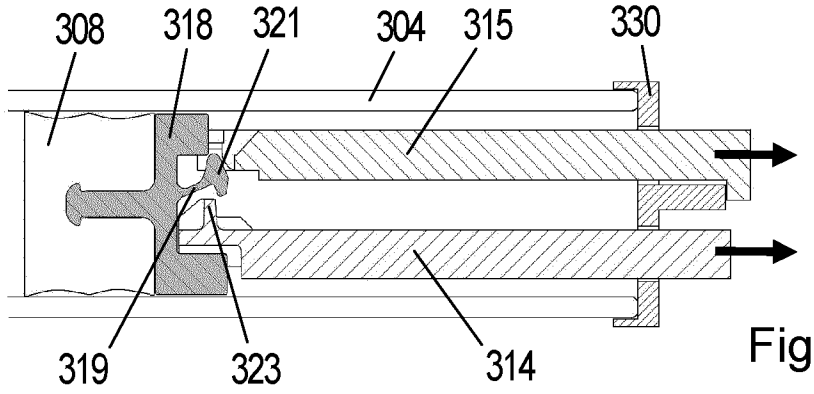

Fig. 7d

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/055712

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61M5/19 A61M5/20 A61M5/50
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/027250 A1 (SURESH SAMUEL [IN] ET AL SURESH SAMUAL [IN] ET AL) 3 February 2005 (2005-02-03)	1-9, 13-15
A	abstract paragraphs [0045], [0046], [0050] - [0051] claims 1,13,14,16 figures 1-18	10-12

X	EP 0 329 358 A2 (R & R INVENTIONS LTD [GB]) 23 August 1989 (1989-08-23)	1,3-7, 13-15
A	claims 1-8 figures 1-8	10-12

X	US 5 738 655 A (VALLELUNGA ANTHONY J [US] ET AL) 14 April 1998 (1998-04-14)	1-9, 13-15
A	claims 1-13 figures 1-18	10-12

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 June 2012	29/06/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Türkavci, Levent

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/055712

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 304 386 A2 (ROVIRA MESTRES RAMON [ES]; THERMACROME DE ESPANA SA [ES]; BORRAS COLLD) 22 February 1989 (1989-02-22)	1-9, 13-15
A	claims 1-16 figures 1-15	10-12

A	US 2003/109831 A1 (ITO ROBERTO Y [BR] ITO ROBERTO YASSUO [BR]) 12 June 2003 (2003-06-12) claims figures	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2012/055712

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