A valve assembly for a metered dose dispenser is described. A metering chamber (70) is formed as a cavity within an elastomeric main body (42) that also includes a flexible, elastic wall (72) as an integral part. That wall (72) forms a common boundary between the metering chamber and a pressurized storage reservoir (40) and includes a first vent (50). An opposing wall of main body (42) includes a second vent. A valve stem (20) is movable via the second vent between depressed positions in which the inside of the metering chamber (70) is in communication with the outside via the valve stem (20) and extended positions in which it is not. As the valve stem is depressed, it bears on the boundary wall (72), causing it to flex and wrap around the inner-most end (26) of the valve stem (20). This seals off the first vent (50) before the stem (20) reaches the threshold between its extended and depressed positions. The pressure within the canister (40) returns the valve stem (20) to its extended position.
VALVE ASSEMBLY FOR METERED DOSE DISPENSERS

BACKGROUND TO THE INVENTION

[0001] The present invention relates to a metered dose dispenser. Metered dose dispensers find many practical applications. One application that is very tightly regulated, placing many restrictions on the design, construction and manufacture of the metered dose dispenser, is the metered dose inhaler. In this application, the metered dose dispenser is typically used to disperse a measured dose of a pharmaceutically active substance from a pressurised aerosol canister into an airway through which inhalation takes place.

[0002] A valve assembly for a typical metered dose inhaler is illustrated in FIG. 1. It is designed for attachment to a pressurized canister within which is contained a drug product and a propellant. The valve assembly constitutes a metered dose dispenser, or metering valve, the purpose of which is to allow doses of the drug product, of a controlled size, to be dispensed into the inhalation airway via a metering chamber 10. The boundary wall 12 between the Metering chamber 10 and the pressurised canister, forming the lower wall of the metering chamber 10, includes a first vent 14 that allows the metering chamber 10 to communicate with the pressurised canister. A second vent 16 is provided in the opposite, upper wall 18 of the metering chamber 10 and both vents 14, 16 are occupied by a valve stem 20 which bears against a circular elastomeric seal in each 22, 24. The valve stem 20 is in the form of a tube that is closed at its lower, innermost end 26 and open at its upper, outermost end 28 and includes a side hole 30 communicating between the inside and the outside of the valve stem 20 and an indented channel 32 towards its lower end 26 that interrupts its normally circular cross-section.

[0003] The valve stem 20 is normally in an elevated or extended position, in which the channel 32 is located within the first vent 14 and allows the canister to communicate with the metering chamber 10. This primes the metering chamber 10. As the valve stem 20 is depressed against the bias of a spring 34, firstly the channel 32 moves below the seal 22 in the first vent 14, isolating the canister from the metering chamber 10. This is the situation as illustrated in FIG. 1. Then the side hole 30 moves below the seal 24 in the second vent 16, allowing the metering chamber 10 to communicate with the outside via the side hole 30 and the open end 28 of the valve stem 20. This discharges the pressurised metering chamber 10 to the outside via the side hole 30 and the open end 28 of the valve stem 20. Typically, the open end 28 of the valve stem 20 is located in a rebate in an inhaler body that acts as a bearing surface for depression of the valve stem 20 and also provides a conduit for the drug to be dispensed into the inhalation airway.

[0004] Such metered dose inhalers have to undergo type approval or product authorisation before they can be put on the market in the US or the EU. In the US, product authorisation is granted by the Food and Drug Administration ("FDA"). Hitherto, the propellant used in aerosol canister for inhalers has been a chlorofluorocarbon ("CFC"). These are inert gases that liquefy under relatively low pressure, allowing a constant vapour pressure within the canister to be maintained throughout the life of the canister. CFC propellants in many aerosol devices, such as domestic aerosols, deodorants, polishes, etc., have been or are shortly to be banned both in the US and the EU. It is expected that the same will happen with metered dose inhaler canisters at some point in the near future and accordingly the industry has for some time been searching for an acceptable alternative to CFC propellants.

[0005] Various alternatives to CFCs have been proposed, such as other fluorinated hydrocarbons, but it has been found that these alternative propellants have their own problems. For example, the drug product may be more inclined to agglomerate, particularly if it is stored in the canister as an emulsion or suspension, or to stick to the surfaces of the inhaler with which it makes contact, such as the inside of the canister. The latter problem has been addressed with some measure of success by coating the inside of the canister with PTFE or other non-stick compounds. The former problem has been addressed by including in the formulation of drug and propellant a surfactant of an appropriate kind. The surfactant can help to keep the droplets of an emulsion stable, to prevent droplets of the drug from adhering to the walls of the canister or to one another and can also act as a lubricant.

[0006] However, it is now suggested that the US FDA will in due course discourage the use of surfactants in drug formulations for metered dose inhalers. This brings to the foreground the deficiencies in conventional dose metering systems that are caused or exacerbated by the switch from CFC propellants. These deficiencies include inconsistent dose sizes, a rate of leakage of product from the canister, usually via a path different from the dispensing path, that is higher than is desirable and friction between the moving parts of the inhaler causing inconsistent dosing, or poor perception of quality on the part of the user. Other deficiencies include the migration or extraction of additives from the materials used in the manufacture of the elastomeric seals into the drug in storage or as it is dispensed. The embodiments of the present invention, as illustrated in and described with reference to FIGS. 2-4, are designed to address a number of these deficiencies.

SUMMARY OF THE INVENTION

[0007] Metered dose inhalers conventionally require a spring to bias the valve stem back to its extended positions once it has been depressed to dispense a dose of drug product. However, the conventional positioning of such springs has left them prone to promote deposition of the drug product. This can lead to poor quality of operation of the valve stem, which may result in incomplete dosing. Uniformity of dosing is compromised when the active drug is deposited, than later released. It can also interfere with the free flow of drug product out of the device. Again, FIG. 1 show just such an arrangement, in which the spring 34 acts between a cup 36, in which the closed end 26 of the valve stem 20 is received, and the base 38 of a perforated cage 40. It is permanently exposed to drug product within the pressurised canister.

[0008] The present invention is designed to deal with this problem. A wholly new design of valve assembly is proposed, in which the common boundary wall between the metering chamber and the pressurised storage reservoir is elastic. Depression of the valve stem flexes the boundary wall, thus closing a vent in it that would otherwise allow the
-metering chamber to communicate with the storage reservoir. Accordingly, a first aspect of the present invention provides a valve assembly for a metered dose dispenser comprising:

[0009] a metering chamber having an elastic wall that is adapted to form a common boundary between the metering chamber and a pressurised storage reservoir to which it is to be attached and in which the elastic wall includes a vent that allows the metering chamber to communicate with the storage reservoir and an opposing wall of the metering chamber includes a second vent; and

[0010] a valve stem that is movable via the second vent between depressed positions in which the inside of the metering chamber is in communication with the outside via the valve stem and extended positions in which the inside of the metering chamber is isolated from the outside;

[0011] in which movement of the valve stem through its extended positions to its depressed positions causes the boundary wall to flex, thus closing the vent before the stem reaches the threshold between its extended and depressed positions.

[0012] In the valve assembly of the present invention, no return spring is required. The reasons are as follows. Depression of the valve stem causes the elastic wall to flex. It therefore has adopted a configuration different from its rest configuration and is subject to stress. The elastic quality of the boundary wall means that it will tend to return to its rest configuration once the forces that are depressing the valve stem are removed. In the rest configuration, of course, the first vent is no longer held closed. The pressurised contents of the canister pass through the first vent, pressurising the metering chamber. Since the valve stem may still be partially depressed within the metering chamber, the pressure differential now existing between the metering chamber and the outside will also serve to extend the valve stem. Since no spring is required, problems concerning the positioning of a spring are no longer of any account. In addition, the number of components required in the valve assembly is reduced, since no bearing surfaces for a spring are required either.

[0013] Clearly, it is advantageous for the valve stem, when extended by the pressure within the metering chamber and/or the elastic recovery of the valve body, to remain within the second vent, so that no separate scaling arrangement for the second vent is required. A stop of an appropriate form might be used to ensure that this happens, but it any case it is preferred that in all extended and depressed positions of the valve stem, an innermost end of the valve stem lies within the metering chamber and an outermost end of the valve stem lies outside it.

[0014] A valve stem of essentially conventional construction can be used, in the form of a tube that is closed at its innermost end and open at its outermost end and including a side hole communicating between the inside and the outside of the valve stem. As is conventional with such a valve stem, when the valve stem is in its depressed positions, the inside of the metering chamber is in communication with the outside via the side hole and the open end of the valve stem. However, there is no need for the valve stem to include an indented channel towards its lower end. This makes it easier to manufacture.

[0015] As described above, the pressure difference between the canister and the outside can be used to extend the valve stem once a dose has been delivered. If the valve assembly is so arranged that the flexing of the boundary wall caused by movement of the valve stem through its extended positions to its depressed positions is brought about by the innermost end of the valve stem bearing against the boundary wall, then a further benefit arises. This benefit is that the pressure within the canister will act against the flexing of the boundary wall and provide an additional restoring force counteracting that flexing. Therefore, the initial return of the boundary wall to its rest configuration is assisted by the pressure difference, in this case between the canister and the metering chamber.

[0016] Indeed, in the arrangement described in the previous paragraph, there is no need for the flexible wall to be elastic at all. Accordingly, a second aspect of the present invention provides a valve assembly for a metered dose dispenser comprising:

[0017] a metering chamber having a flexible wall that is adapted to form a common boundary between the metering chamber and a pressurised storage reservoir to which it is to be attached and in which the flexible wall includes a vent that allows the metering chamber to communicate with the storage reservoir and an opposing wall of the metering chamber includes a second vent; and

[0018] a valve stem that is movable via the second vent between depressed positions in which the inside of the metering chamber is in communication with the outside via the valve stem and extended positions in which the inside of the metering chamber is isolated from the outside;

[0019] in which movement of the valve stem through its extended positions to its depressed positions causes an innermost end of the valve stem to bear against the boundary wall, in turn causing the boundary wall to flex, thus closing the vent before the stem reaches the threshold between its extended and depressed positions.

[0020] Where the innermost end of the valve stem bears against the flexible wall, the simplest possible arrangement is for the vent to be a simple hole in the boundary wall that forms a seat for and is closed by the innermost end of the valve stem. Alternatively, the vent could include a check valve, such as a flap overlying it, that is operated by the innermost end of the valve stem.

[0021] Conventional metered dose inhalers suffer to a greater or lesser degree from the leakage of product from the canister at a higher rate than is desirable, usually via a path different from the dispensing path. This may be caused by ineffective seals, perhaps again attributable to seal material creeping over time. It may on the other hand be caused by what is known as "side-streaming." Side streaming takes place when lateral as opposed to axial forces are applied to the valve stem as it is depressed. Lateral forces cause the valve stem to lever against one or both seals, pushing them in opposite directions. If the pressure is sufficient, the integrity of the seal opposite the side at which it is being pushed by the valve stem can break down, allowing the escape of drug product. This escape is known as "side-
streaming” for obvious reasons. It happens because the seal is made with the side of the valve stem and the lateral forces act to open the seal.

[0022] In the embodiments of the present invention in which the seal is made between the innermost end of the valve stem and the flexible wall, the sealing surface no longer lies perpendicular to the direction of the lateral forces; it lies parallel or substantially parallel. To prevent relative movement between the sealing surfaces altogether, it is preferred that the flexible wall include a hole that is smaller than the diameter of the valve stem that receives and forms a seal with a projection on the innermost end of the valve stem.

[0023] The simplest possible construction of a valve assembly for a metered dose dispenser can be effected if the metering chamber is a cavity within a main body of the valve assembly, of which the flexible or elastic wall forms an integral part. The main body can be constructed to provide sealing contact with the valve stem at the second vent and with the canister.

[0024] The present invention also provides a metered dose dispenser comprising a pressurised storage reservoir and a valve assembly according to the present invention attached to it so that the common boundary wall is a common boundary of the metering chamber and the storage reservoir.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

[0025] The present invention will now be described by way of example with reference to the accompanying drawings in which:

[0026] FIG. 1 is a conventional valve assembly for a metered dose inhaler;

[0027] FIGS. 2-4 show essentially similar metered dose inhalers according to the present invention, of different nominal dosing volumes.

DETAILED DESCRIPTION

[0028] The conventional inhaler of FIG. 1 has already been described. FIG. 2 shows a metered dose inhaler according to the present invention having a nominal dose size of 100 μL. The inhaler consists of a pressurised stainless steel or aluminium alloy canister 40 that acts as a reservoir for a drug product, upon which is mounted a valve assembly that acts as a metered dose dispenser, or metering valve. An engineered elastomer main body 42 of the valve assembly is located over the open end of the canister 40 and provides an annular seal at 46. The main body 42 is secured to the end of the canister 40 by an aluminium ferrule 48. The ferrule 48 shown in FIG. 2 has been partially formed, but requires a further forming operation to conform to the exterior shape of the end of the canister 40, so as to secure the main body 42 in place.

[0029] The main body 42 is made of a suitably engineered elastomer or rubber, designed for long-term dimensional stability, low release of organic or inorganic compounds, low permeability, low swell, high strength and low drug adhesion.

[0030] The main body 42 includes a central cavity 70 that extends neither to the top of the main body 42, nor to its base. The central cavity 70 forms a metering chamber. Between the bottom of the cavity 70 and the base of the main body 42 is formed a flexible, elastic wall 72. Holes 50 in the elastic wall 72 are provided to form a first vent between the metering chamber 70 and the canister 40 and the material surrounding the holes 50 is designed to provide a first seal as will be described later. Thus, the flexible wall 72 provides a boundary wall between the metering chamber 70 and the pressurised canister 40.

[0031] Above the central cavity 70, the material of the main body 42 gives way to a second vent, the exposed sides of which provide a second seal 74. The second vent is occupied by a valve stem 20 which bears against the second seal 74. The valve stem 20 is formed from deep-drawn stainless steel into the form of a tube that is closed at its lower, innermost end 26 and one at its upper, outermost end (not shown) and includes a side hole 30 communicating between the inside and the outside of the valve stem 20. A projection 76 is formed on the lower end 26 and passes through and seals with a central hole 78 of the flexible wall 72. This substantially reduces the likelihood of side-streaming whilst the valve stem 20 is depressed as described above, because the relevant sealing surface is substantially horizontal and the valve stem is centred by the central hole 78 and the projection 76. The valve stem includes a crimped twist 60 that forms an abutment for the upper wall of the cavity 70.

[0032] The valve stem 20 is normally in an elevated or extended position as shown in FIG. 2, in which the innermost end 26 of the valve stem 20 is clear of the first vent 50 and allows the canister 40 to communicate with the metering chamber 70. This primes the metering chamber 70. As the valve stem 20 is depressed, it bears against the flexible wall 72, causing the wall to flex and wrap around the innermost end 26 of the valve stem 20, until the first vent 50 is sealed off by the innermost end 26 of the valve stem 20, isolating the canister 40 from the metering chamber 70. The elastic, flexible wall 72, meanwhile, resists the movement of the valve stem, providing a bias or tangible feedback. Then the side hole 30 moves below the seal 74 in the second vent, allowing the metering chamber 70 to communicate with the outside via the side hole 30 and the open end (not shown) of the valve stem 20. This discharges the pressurised metering chamber 70 to the outside via the side hole 30 and the open end of the valve stem 20.

[0033] As the pressure on the valve stem 20 that causes it to move downwards is released, the elastic, flexible wall 72 tends to return to its rest configuration as shown in FIG. 2 owing firstly to its own elasticity and secondly to the pressure difference that now exists between the canister 40 and the metering chamber 70. At some point in the return stroke, the seal of the first vent 50 is lifted and the metering chamber 70 is primed once more. Priming and pressurisation of the metering chamber 70 causes differential pressures to act now on the valve stem 20 and the valve stem 20 is lifted until its waist 670 abuts the upper wall of the metering chamber 70.

[0034] FIG. 3 shows an inhaler similar to that of FIG. 2, but is designed to a nominal dose size of 50 μL. Many of the same components are used in FIG. 3 as are used in FIG. 2 and the only real difference is the use of a main body 42 with a smaller central cavity 70. FIG. 4 shows an inhaler essen-
1. A valve assembly for a metered dose dispenser comprising:
   a metering chamber having a elastic wall that is adapted to form a common boundary between the metering chamber and a pressurised storage reservoir to which it is to be attached and in which the elastic wall includes a vent that allows the metering chamber to communicate with the storage reservoir and an opposing wall of the metering chamber includes a second vent; and
   a valve stem that is movable via the second vent between depressed positions in which the inside of the metering chamber is in communication with the outside via the valve stem and extended positions in which the inside of the metering chamber is isolated from the outside;
   in which movement of the valve stem through its extended positions to its depressed positions causes the boundary wall to flex, thus closing the vent before the stem reaches the threshold between its extended and depressed positions.

2. An assembly according to claim 1 in which the flexing of the boundary wall caused by movement of the valve stem through its extended positions to its depressed positions is brought about by an innermost end of the valve stem bearing against the boundary wall.

3. A valve assembly for a metered dose dispenser comprising:
   a metering chamber having a flexible wall that is adapted to form a common boundary between the metering chamber and a pressurised storage reservoir to which it is to be attached and in which the flexible wall includes a vent that allows the metering chamber to communicate with the storage reservoir and an opposing wall of the metering chamber includes a second vent; and
   a valve stem that is movable via the second vent between depressed positions in which the inside of the metering chamber is in communication with the outside via the valve stem and extended positions in which the inside of the metering chamber is isolated from the outside;
   in which movement of the valve stem through its extended positions to its depressed positions causes an innermost end of the valve stem to bear against the boundary wall, in turn causing the boundary wall to flex, thus closing the vent before the stem reaches the threshold between its extended and depressed positions.

4. An assembly according to claim 2 or claim 3 in which the vent is a simple hole in the boundary wall that forms a seat for and is closed by the innermost end of the valve stem.

5. An assembly according to any one of claims 2-4 in which the flexible wall includes a hole that is smaller than the diameter of the valve stem and the innermost end of the valve stem includes a projection received by and forming a seal with that hole.

6. An assembly according to any preceding claim in which in all extended and depressed positions of the valve stem, an innermost end of the valve stem lies within the metering chamber and an outermost end of the valve stem lies outside it.

7. An assembly according to claim 6 in which:
   the valve stem is in the form of a tube that is closed at its innermost end and open at its outermost end and includes a side hole communicating between the inside and the outside of the valve stem; and
   when the valve stem is in its depressed positions, the inside of the metering chamber is in communication with the outside via the side hole and the open end of the valve stem.

8. An assembly according to any preceding claim in which the metering chamber is a cavity within a main body of the valve assembly, of which the flexible or elastic wall forms an integral part.

9. An assembly according to claim 8 in which the main body is adapted to provide sealing contact with the valve stem at the second vent and sealing contact with the canister.

10. A valve assembly for a metered dose dispenser substantially as described herein with reference to any one of FIGS. 2-4 of the accompanying drawings.

11. A metered dose dispenser comprising a pressurised storage reservoir and a valve assembly according to any preceding claim attached to it so that the common boundary wall is a common boundary of the metering chamber and the storage reservoir.

12. A metered dose dispenser comprising a pressurised storage reservoir and a valve assembly according to claim 9 or claim 10 attached to it so that the common boundary wall is a common boundary of the metering chamber and the storage reservoir and the main body provides sealing contact with the valve stem at the second vent and sealing contact with the canister.

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