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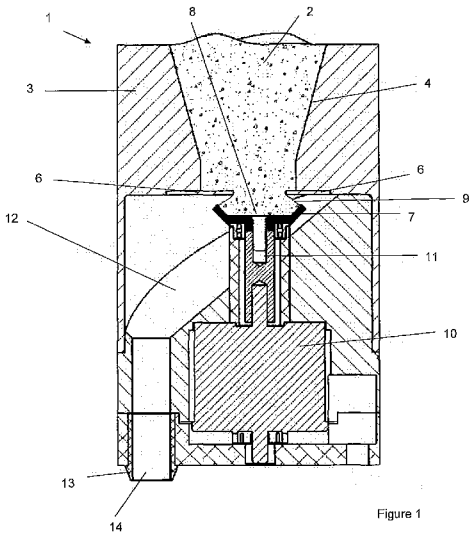

Figure 1

(57) Abstract: The present invention relates to a dispensing device for delivering precise and multiple doses of free-flowing granular material. The device is adaptable to a specific type of free-flowing granular material or to different applications requiring the delivery of precise and multiple doses of free-flowing granular material. Also provided is a method of dispensing precise doses of free-flowing granular material.

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Granular Material Dispensing Device and Method of Dispensing Granular Material

Field of the Invention

The present invention relates to a dispensing device for delivering precise and multiple doses of free-flowing granular material. The device is adaptable to a specific type of free-flowing granular material or to different applications requiring the delivery of precise and multiple doses of free-flowing granular material. Also provided is a method of dispensing precise doses of free-flowing granular material.

Background of the Invention

There are various types of known quantitative granular or powder material dispensers such as that disclosed in US201 02641 70 and US2002000448 that involve granular powder contacting with blades or moving dispensing wheels. However, the downside with such dispensers is that the granular material can come between or jam in a moving part in the dispenser as it is being dispensed. Such jamming can lead to damage and longer term wear and tear of the dispenser and this affects the precision with which future quantities of the powder material is dispensed. It also means that the dispensing devices require a lot of maintenance and upkeep to ensure the dispenser performs to the precision standards expected.

It is an object of the invention to provide a quantitative granular material dispenser that overcomes the abovementioned problem; or which at least provides the public with a useful choice.

Summary of the Invention

In a first aspect the present invention provides a quantitative dispensing device, suitable for dispensing one or more volumes of a free-flowing granular material by gravity feed, comprising:

a device housing that houses

(i) a granular material conduit member that has an entry orifice that in use receives the granular flowable material and an exit orifice through which the granular flowable material flows when in use;

(ii) a dispensing means that is positioned beneath the exit orifice and having a receiving surface onto which, and when in use, a stabilised pile of the granular flowable material is formed as the granular material flows from the exit orifice of the conduit member, the size of the exit orifice and the size of the dispensing means being determined by the specific static angle of repose of the granular material and the desired volume of dispensed granular material,

(iii) a rotary actuator that in use is activated to rotate the dispensing means at a speed and for a time sufficient to displace at least a portion of any granular material on the dispensing means; and

(iv) a receiving means that in use receives the displaced granular material and directs the flowing granular material through an outlet of the device.

In one embodiment the exit orifice is positioned off-centre relative to the central axis of the device.

In a further embodiment the exit orifice is provided by an exit orifice plate defining the exit orifice diameter.

In a further embodiment the exit orifice plate is replaceable with one or more orifice plates having an alternative sized exit orifice diameter.

In a further embodiment the exit orifice plate is replaceable with one or more orifice plates having an alternative thickness.

In one embodiment the conduit member is a hopper.

In another embodiment the conduit member is proximate to a further granular material feed means, such as a hopper or a granular material conveyor means or the like.

In one embodiment the dispensing means is replaceable with an alternative sized dispensing means.

In one embodiment the dispensing means has a side wall that is angled outwardly at about 135 degrees relative to the receiving surface of the dispensing means.

In one embodiment the dispensing means is further adapted to include an impeller on its receiving surface to increase the amount of displacement of the granular material when the device is in use.

In one embodiment the receiving funnel is positioned off-centre relative to the central axis of the entry orifice.

In one embodiment the device does not include any component made from or including silicone.

In another aspect there is provided a method of quantitatively dispensing one or more volumes of a free-flowing granular material by gravity feed, the method including;

loading a conduit member of a device defined above with the free-flowing granular material and allowing the granular material to flow freely to the dispensing means,

activating the rotary actuator at desired periodic intervals to dislodge at least a portion of the granular material from the dispensing means and returning the actuator to rest; and

collecting the dispensed granular material from the device at one or more periodic intervals.

In one embodiment the free-flowing granular material is selected from the likes of x-ray flux, sugar, salt, coffee and other granular materials.

In one embodiment the free-flowing granular material is x-ray flux, comprising lithium tetraborate and lithium metaborate.

In one embodiment multiple volumes of the free-flowing granular material are dispensed by multiple actuations of the rotary actuator.

In one embodiment multiple volumes of the free flowing granular material are dispensed by the device on a continuous basis.

In one embodiment several hundred thousand volumes of the free flowing granular material are dispensed by the device on a continuous basis.

The foregoing brief summary broadly describes the features and technical advantages of certain embodiments of the present invention. Further technical advantages will be described in the detailed description of the invention and examples that follows. Novel features which are believed to be characteristic of the invention will be better understood from the detailed description of the invention when considered in connection with any accompanying figures and examples. However, the figures and examples provided herein are intended to help illustrate the invention or assist with developing an understanding of the invention, and are not intended to limit the invention's scope.

DESCRIPTION OF FIGURES

Figure 1 shows a side cross sectional view of a quantitative dispensing device, having a full hopper of a granular free-flowing material.

Figure 2 shows a side cross sectional view of a quantitative dispensing device, having a full hopper and further showing the dispensing of a granular free-flowing material.

Figure 3 shows a side cross sectional view of a quantitative dispensing device, having an empty hopper.

Figure 4 shows a side cross sectional view of a dispensing means of the present invention.

Figure 5(a) shows a top perspective view of an impeller for use with a dispensing device of the present invention

Figure 5(b) shows a bottom plan view of the impeller shown in Figure 5(a)

Figure 5(c) shows a side view of the impeller shown in Figure 5(a) and Figure 5(b).

Figure 6 shows an exploded perspective view of the components of the device of the present invention and including an impeller shown in Figures 5(a)-5(c).

Figure 7 shows an exploded side view of the components of the dispensing device and the hidden detail of the internally located features of the device.

Figure 8 shows a plot of the results obtained from dispensing 50 samples of x-ray flux from a dispensing device of the present invention.

DETAILED DESCRIPTION

The following description sets forth numerous exemplary configurations, parameters, and the like. It should be recognized, however, that such description is not intended as a limitation on the scope of the present invention, but is instead provided as a description of exemplary embodiments.

Definitions

The term "about" as used herein in connection with a referenced numeric indication means the referenced numeric indication plus or minus up to 10% of that referenced numeric indication. For example, the language "about 90" degrees covers the range of 81 degrees to 99 degrees.

The term "granular material" as used herein means a material that includes discrete, solid particles and includes powder material.

The term "off centre" as used herein means having an axis of rotation deviating from the geometrical center or central axis of the device.

The term "static angle of repose" of a granular material as used herein is the steepest angle of descent or dip of the slope relative to the plane of the receiving surface when granular material on the slope face is on the verge of sliding. This angle is in the range 0°-90°. When bulk granular materials are poured onto a receiving surface, a conical pile will form. The internal angle between the surface of the stationary pile and the receiving surface is known as the static angle of repose and is related to the density, surface area and shape of the particles, and the coefficient of friction of the material. The angle of repose for granular materials determines how high and how wide a material will spread. Material with a low angle of repose forms flatter piles than a material with a high angle of repose.

The term "dynamic angle of repose" of a granular material as used herein is the angle of repose of the slope of the free surface of the material relative to the horizontal measured as the granular material is rotated in a cylinder at a predetermined rate. The dynamic angle of repose is always less than the static angle of repose.

With reference to Figure 1 a quantitative dispensing device 1, suitable for dispensing one or more volumes of a free-flowing granular material 2 by gravity feed is shown. The device 1 includes a housing 3 that houses a hopper 4. The hopper 4 has at its upper end an entry orifice 5 (best seen in Figure 3) that in use receives the granular flowable material 2 and at the lower end an orifice exit plate 6 through which the granular flowable material exits. The device also includes a dispensing means, shown as cup 7 that is positioned beneath the orifice plate 6. The cup 7 has a side wall that is outwardly extending away from the centre of the cup and a receiving surface 8 onto which a stabilised pile of the granular flowable material flows from the orifice exit plate of the hopper. It is to be appreciated that the size of the

orifice exit plate 6 and the size of the cup 7 are determined by the specific static angle of repose 9 of the granular material 2. A rotary connection unit 11 can be activated by a rotation unit 10 to rotate the dispensing cup 7 at a speed and for a time sufficient to displace at least a portion of any granular material in the cup 7. A receiving funnel 12 receives the displaced granular material 2 and directs the flowing granular material 2 out of the lower portion of the device housing 13 through outlet 14.

With reference to Figure 2 the flow of the granular material 2 from the cup 7 to the funnel 12 that occurs on the actuation or rotation 15 of the rotary connection unit 11, is shown. It can be appreciated from the shape of the cup 7 and the offset funnel 12 that the granular material 2 is propelled or displaced from the cup and conveyed away from the rotary connection unitl 1. This means that there is no possibility of the granular material becoming jammed or caught in the rotary connection unit 11 or rotation unit 10.

In Figure 3 a quantitative dispensing device 1, not including any granular material is shown. The hopper inlet 5 is shown and at the lower end of the hopper the orifice exit plate 6 defines the hopper outlet 16 through which any granular flowable material would exit. It is to be appreciated that the amount of granular material that falls from the hopper into the cup can be readily adjusted by replacing the orifice plate 6 with one from a set which is provided in various diameters and thickness. This ability to vary these parameters provides a sufficient range of adjustment to cover a wide range of doses of granular material that are proportionate to the scale of the device. Further, it is also recognized that various cup shapes and cup surface profiles could also be used to adjust the amount of granular material displaced from the cup surface. One such cup profile is shown in Figure 4. The cross sectional view shown in Figure 4 shows that the diameter 7(a) of the receiving surface of the cup is about 16 mm. The diameter 7(b) of the mouth of the cup is about 22 mm. The depth 7(c) of the cup is about 3 mm. The length 7(d) of the side wall is about 5 mm. The thickness 7(e) of the side wall is about 1.5 mm. The angle between the receiving surface of the cup and the side wall of the cup is

about 135 degrees. It is also to be appreciated that the scale of the device can be adjusted to suit the particular application to which the device is to be put.

Furthermore, with reference to Figures 5(a) to 5(c), an impeller 17 can be connected or integrated into the receiving surface of the cup 7 to aid in the dispensing of larger amounts of the granular material from the cup. Without wanting to be bound to any theory, it is thought that when the rotary actuator is activated, the cup rotates through a precise number of rotations or part rotation then it returns to the at rest position. The acceleration of the cup is such that there is slippage between the cup surface and the granular material held in the base of the cup which causes the frictional connection between the cup surface and the granular material at its base to change from a static state to a dynamic state. This change in state reduces the connection between the cup and granular material. Whilst the cup is rotating, the pile of granular material is placed in torsional shear and the pile of granular material is also subjected to centrifugal force. The pile of granular material becomes destabilised as its angle of repose decreases from the static angle to below the dynamic angle. It is thought that these conditions (either singly or together) cause the granular material to flow over the lip of the cup, onto the funnel and out of the device via the outlet port. When an impeller is included or integrated into the receiving surface of the cup it is thought that the effects of the forces involved in destabilizing the granular material are increased and this thereby means that more granular material is displaced from the cup when using an impeller.

Example

In the specific embodiment illustrated in Figures 1 to 7, the central axis of the rotary actuator/rotary mechanism and cup assembly is positioned off-centre from the hopper 4 and orifice plate 6. This positioning is to allow more internal space for the outlet port and minimises the external dimensions of the housing. It is to be appreciated that if space saving is not a vital aspect then such off-centering is an optional feature. The specific embodiment and components illustrated in Figures 6 and 7 has been developed for measuring

precise and reproducible quantities of powdered X-ray flux, comprising 35.3% Lithium Tetraborate and 64.7% Lithium Metaborate.

With reference to Figures 6 and 7, the components of orifice plate 6, impeller 17, the housing base plate 18(may be aluminium), shaft 22, flanged bearing 23 and cup 7 can all be constructed from stainless steel or some other suitable inert material. An o-ring 24 is used between the cup 7 and the flanged bearing 23. The housing 3, hopper 4, funnel 12, solenoid and bearing mount 21 and outlet fitting 19 from the device may be constructed from a polymer material, such as a plastics or thermoplastic polymer such as polyoxymethylene, also known as acetal, polyacetal and polyformaldehyde that can be shaped to provide a polymer surface that can withstand significant levels of wear while offering low friction, good stability and substantial mechanical strength. The rotary solenoid 20 used as the rotary actuator may be an off the shelf solenoid such as a Solenoid G DA 035. The components of the device are secured in place by socket screws 25 or grub screw 26.

Example 1

A device according to Figure 1 was constructed to dispense x-ray flux, comprising 35.3% Lithium Tetraborate 64.7% Lithium Metaborate. The dimensions of the device include the following:

The gap between the orifice exit plate and the cup was 3.6mm;

The dimensions of the cup are as shown in Figure 4.

The diameter of the orifice exit plate was 14 mm.

The solenoid current was repeatedly measured at 0.28A

The target dispensing weight was 0.25 gms per dispensing cycle.

The hopper was filled with the granular x-ray flux material. The solenoid was activated for a cycle of about 0.8 seconds. The cycle includes a 0.3 second "on" phase or rotation phase through which the cup is rotated about 15 degrees and a 0.5 "off phase during which the return spring resets.

The results of 50 cycles are plotted in Figure 7 below. It can be seen that there is a considerable degree of consistency in the amounts of granular material dispensed. The dotted line in the plot shows the target weight of 0.25 grams.

The dispensing device described in this example was operated on a substantially continuous basis, subject to power cuts and earthquakes, for a period of 9 months dispensing over 1.6 million doses of flux.

Advantages

The device has the advantage, when compared to other units available, of being made of effectively inert materials, stainless steel and plastics/polymeric material. The absence of any silicon based materials is a significant advantage. A further advantage of the present invention is that, aside from the friction of the granular material as it flows onto and off the hopper surface, receiving surface of the cup or the funnel surface, no granular material is being trapped or forced against a moving surface or component. The absence of components rubbing or flexing across or against the granular material eliminates wear and tear that is usually seen in quantitative granular dispensing devices.

The present invention and its embodiments have been described in detail. However, the scope of the present invention is not intended to be limited to the particular embodiments of any process, manufacture, composition of matter, compounds, means, methods, and/or steps described in the specification. Various modifications, substitutions, and variations can be made to the disclosed material without departing from the spirit and/or essential characteristics of the present invention. Accordingly, one of ordinary skill in the art will readily appreciate from the disclosure that later modifications, substitutions, and/or variations performing substantially the same function or achieving substantially the same result as embodiments described herein may be utilized according to such related embodiments of the present invention.

Claims:

1 A quantitative dispensing device, suitable for dispensing one or more volumes of a free-flowing granular material by gravity feed, comprising:

a device housing that houses

(i) a granular material conduit member that has an entry orifice that in use receives the granular flowable material and an exit orifice through which the granular flowable material flows when in use;

(ii) a dispensing means that is positioned beneath the exit orifice and having a receiving surface onto which, and when in use, a stabilised pile of the granular flowable material is formed as the granular material flows from the exit orifice of the conduit member, the size of the exit orifice and the size of the dispensing means being determined by the specific static angle of repose of the granular material and the desired volume of dispensed granular material,

(iii) a rotary actuator that in use is activated to rotate the dispensing means at a speed and for a time sufficient to displace at least a portion of any granular material in the dispensing means; and

(iv) a receiving means that in use receives the displaced granular material and directs the flowing granular material through an outlet of the device.

2 The device as claimed in claim 1, wherein the exit orifice is positioned off-centre relative to the central axis of the device.

3 The device as claimed in claim 1 or claim 2 wherein the exit orifice is provided by an exit orifice plate defining the exit orifice diameter.

4 The device as claimed in any one of claims 1 to 3 wherein the exit orifice plate is replaceable with one or more orifice plates having an alternative sized exit orifice diameter.

5 The device as claimed in any one of claims 1 to 4 wherein the exit orifice plate is replaceable with one or more orifice plates having an alternative thickness.

6 The device as claimed in any one of claims 1 to 5 wherein the conduit member is a hopper.

7 The device as claimed in claim 6 wherein the conduit member is proximate to a further granular material feed means, such as a hopper or a granular material conveyor means or the like..

8 The device as claimed in any one of claims 1 to 7 wherein the dispensing means is replaceable with an alternative sized dispensing means.

9 The device as claimed in claim 1 or claim 8 wherein the dispensing means has a side wall that is angled outwardly at about 135 degrees relative to the receiving surface of the dispensing means.

10 The device as claimed in any one of claims 1 to 9 wherein the dispensing means is further adapted to include an impeller on its receiving surface to increase the amount of displacement of the granular material when the device is in use.

11 The device as claimed in any one of claims 1 to 10 wherein the receiving funnel is positioned off-centre relative to the central axis of the entry orifice.

12 The device as claimed in any one of claims 1 to 11 wherein the device does not include any component made from or including silicone.

13 A method of quantitatively dispensing one or more volumes of a free-flowing granular material by gravity feed, the method including;

loading a conduit member of a device defined above with the free-flowing granular material and allowing the granular material to flow freely to the dispensing means,

activating the rotary actuator at desired periodic intervals to dislodge at least a portion of the granular material from the dispensing means and returning the actuator to rest; and

collecting the dispensed granular material from the device at one or more periodic intervals.

14 The method of claim 13 wherein the free-flowing granular material is selected from the likes of x-ray flux, sugar, salt, coffee and other materials.

15 The method of claim 14 wherein the free-flowing granular material is x-ray flux, comprising lithium tetraborate and lithium metaborate.

16 The method as claimed in any one of claims 13 to 15 wherein multiple volumes of the free-flowing granular material are dispensed by multiple actuations of the rotary actuator.

17 The method as claimed in claim 16 where the multiple volumes of the free flowing granular material are dispensed by the device on a continuous basis.

18 The method as claimed in claim 17 wherein several hundred thousand volumes of the free flowing granular material are dispensed by the device on a continuous basis.

Figure 1

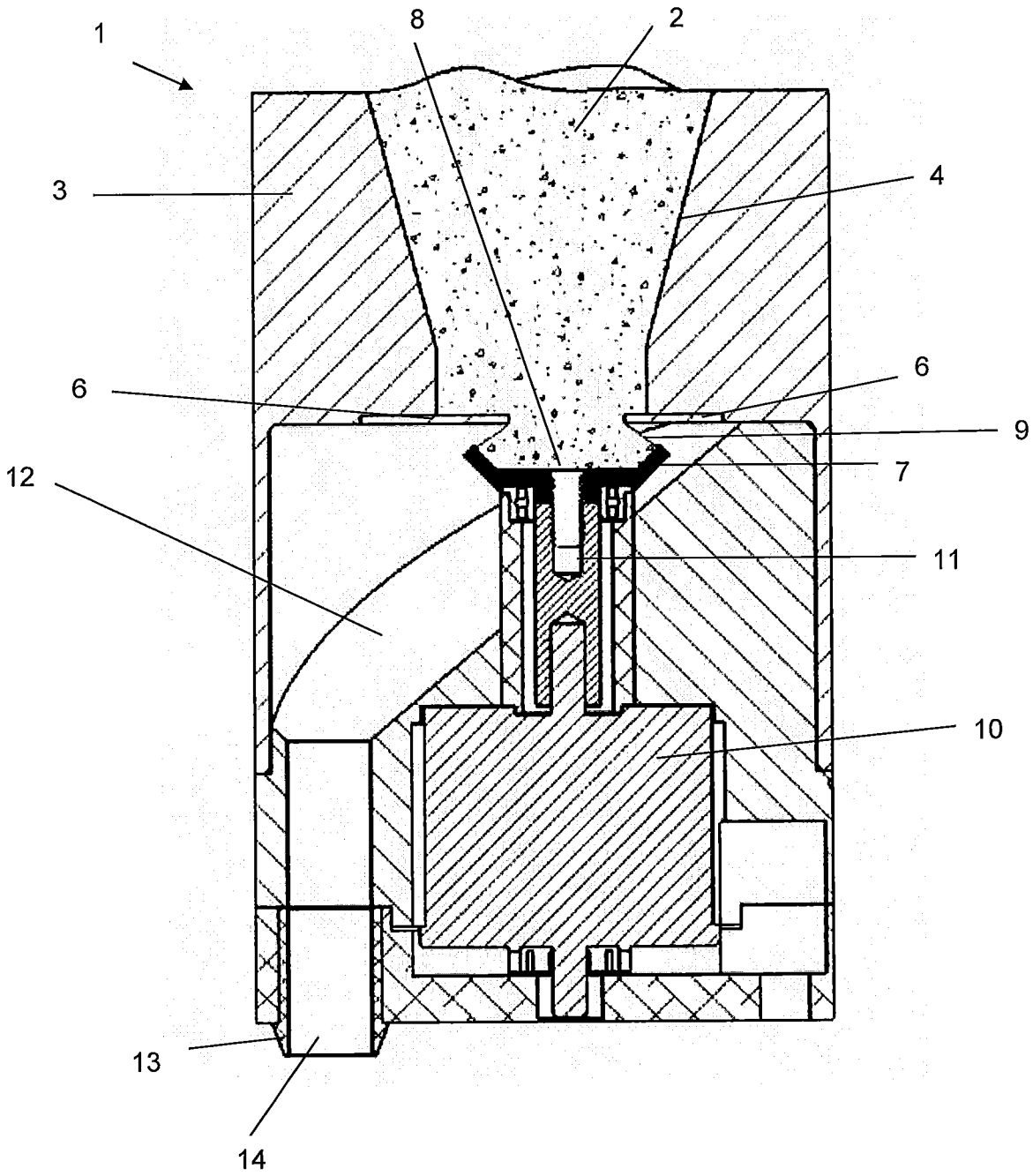


Figure 2

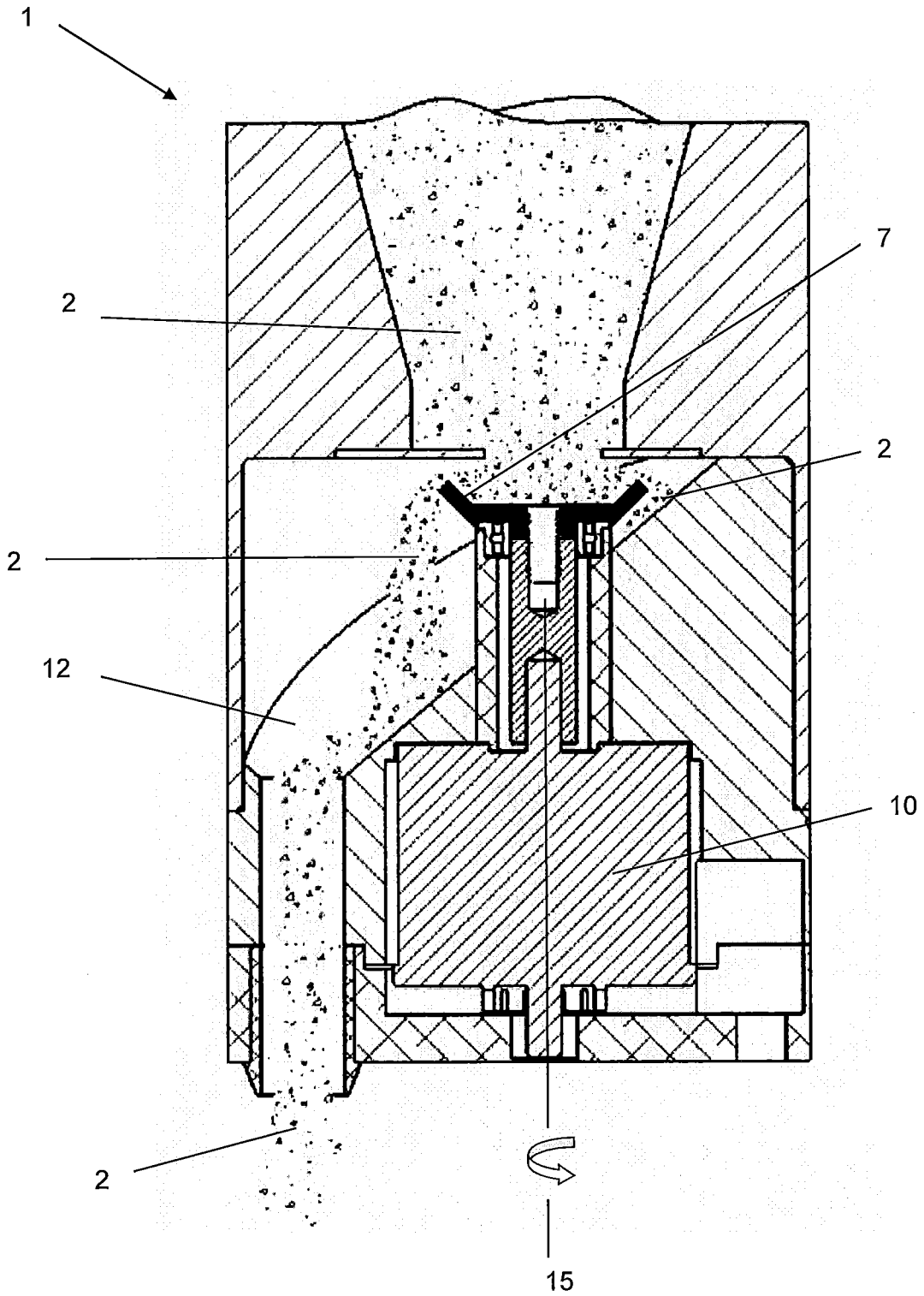


Figure 3

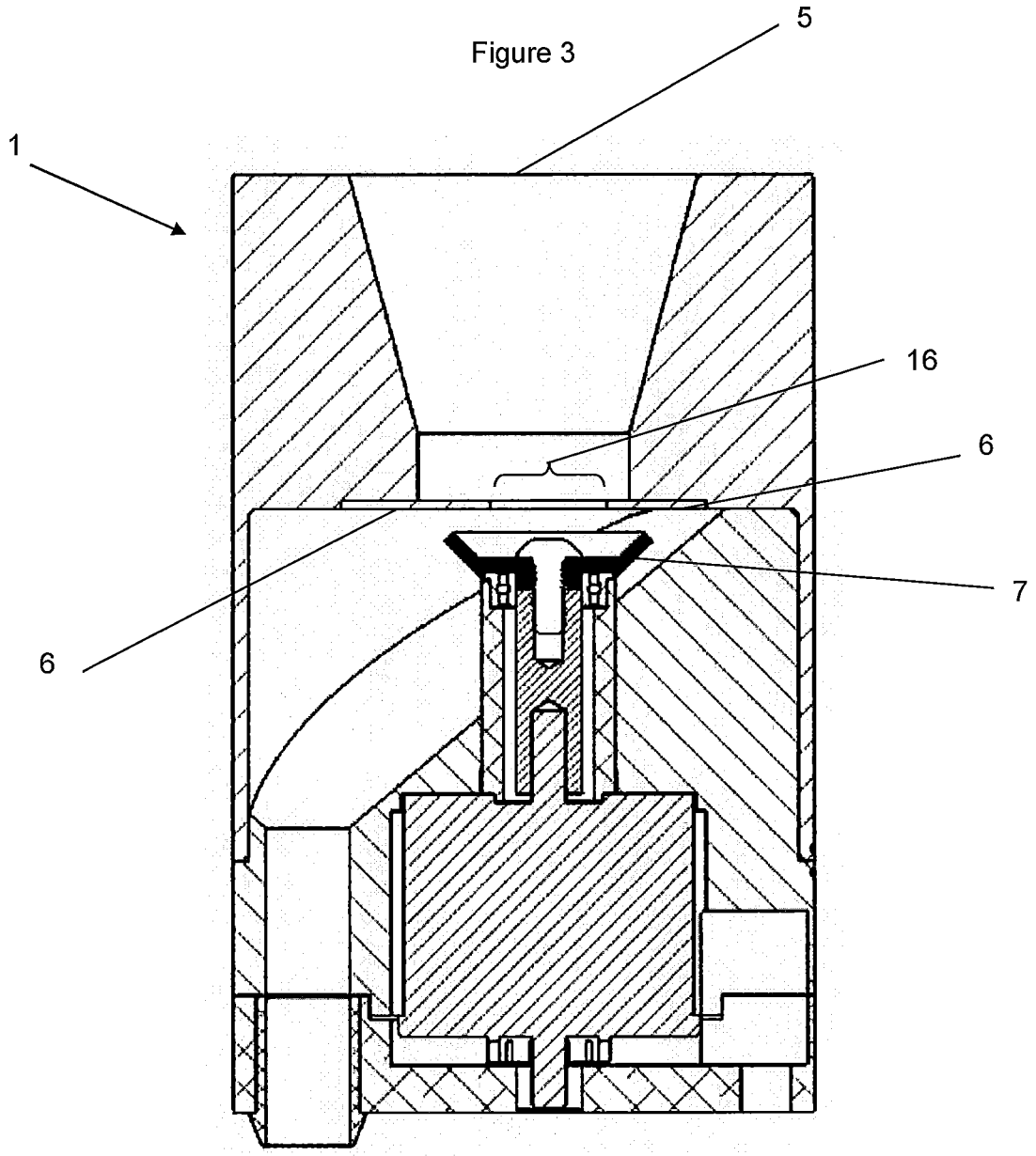


Figure 4

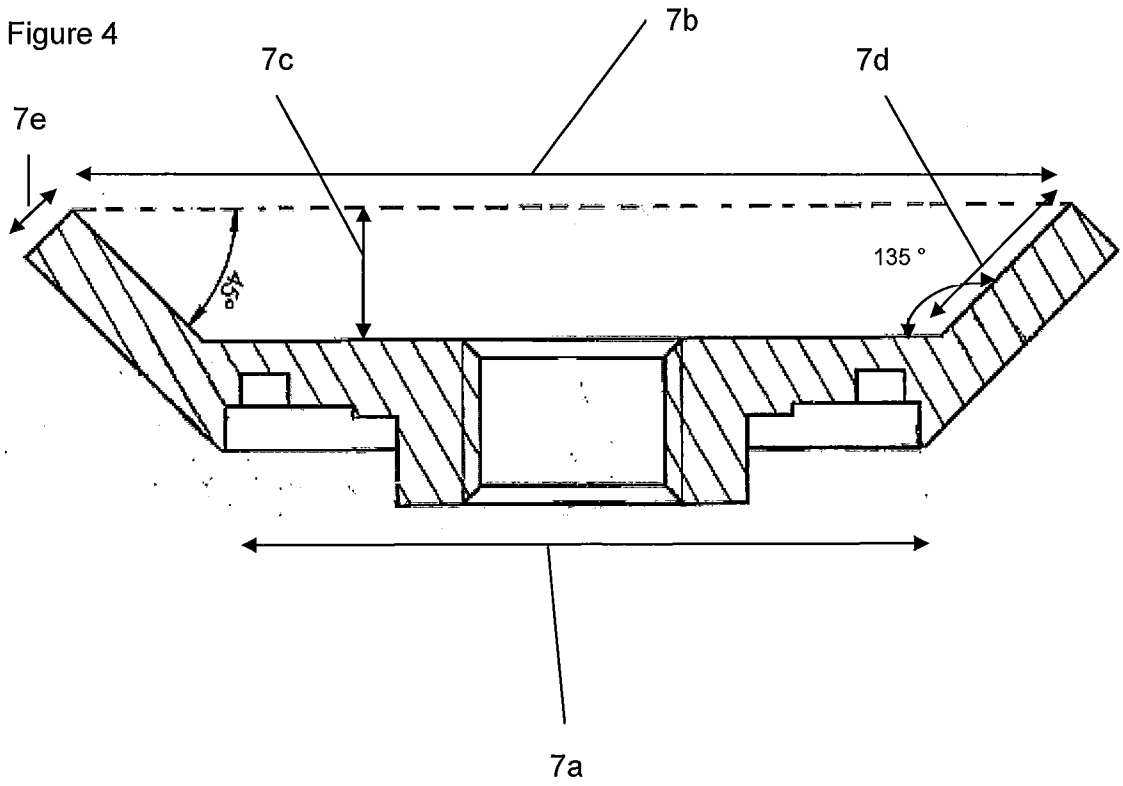


Figure 5(a)

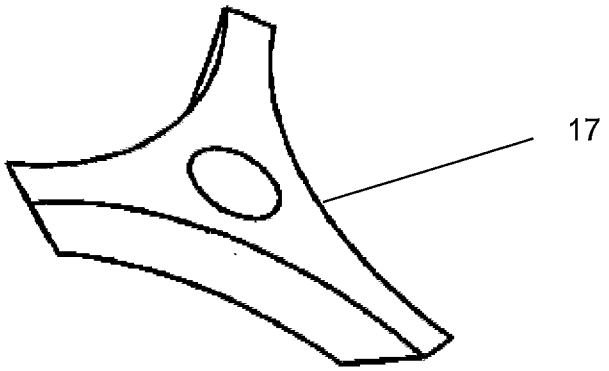


Figure 5(b)

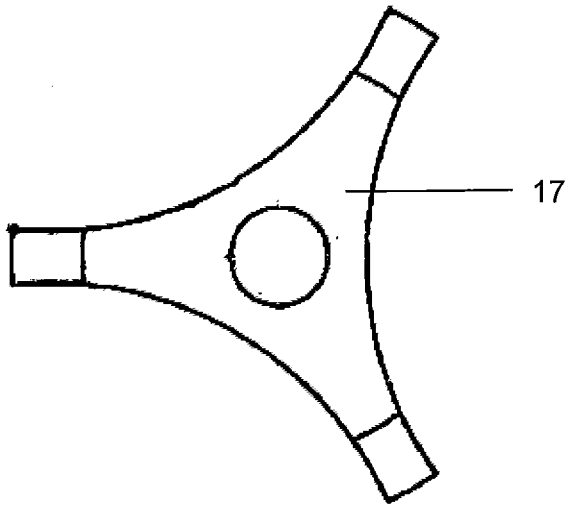


Figure 5(c)

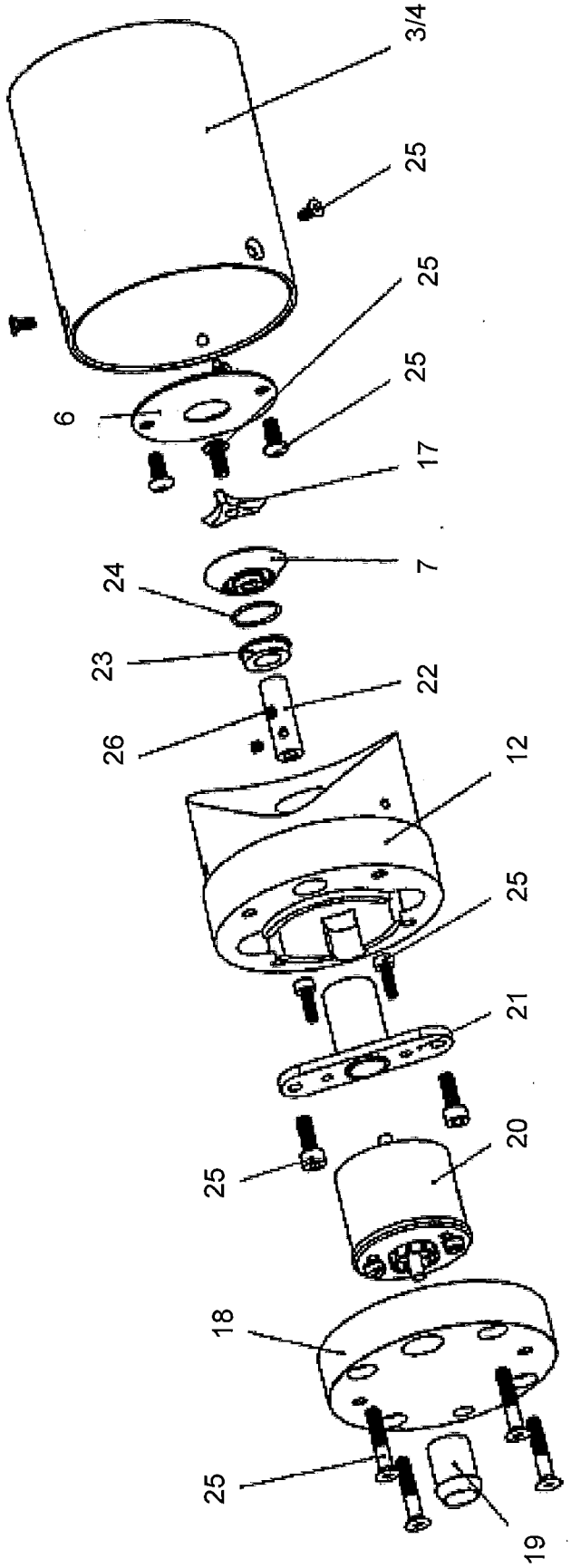


Figure 6

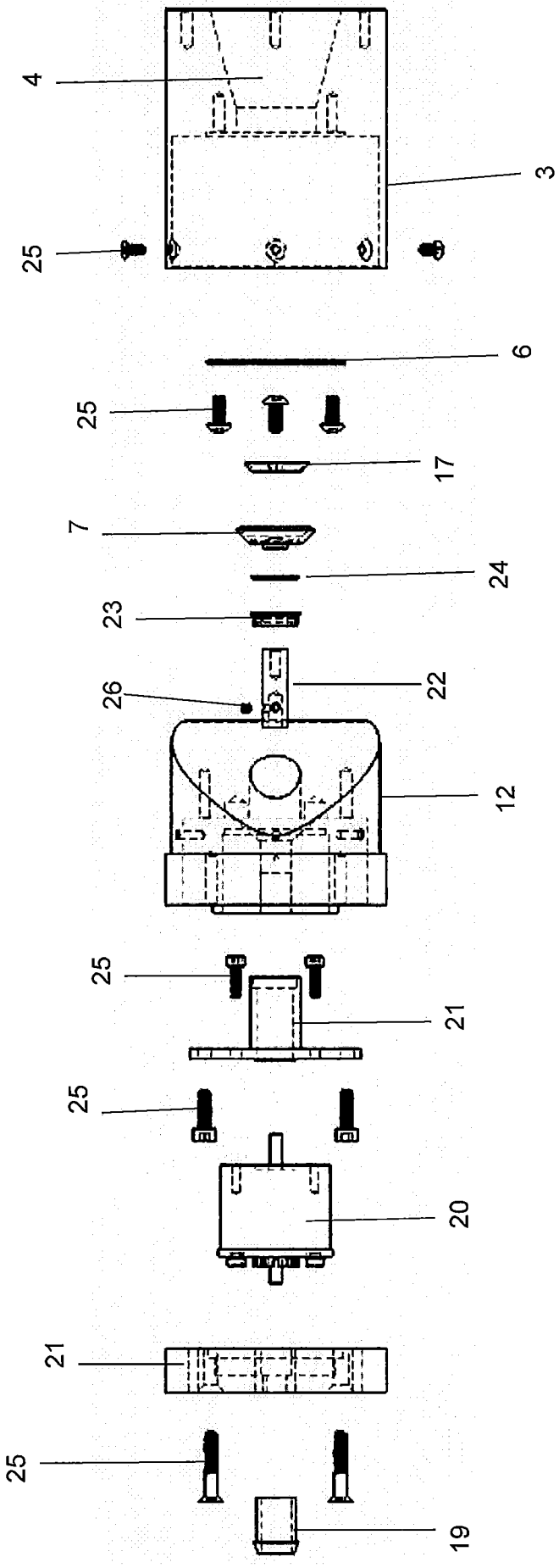
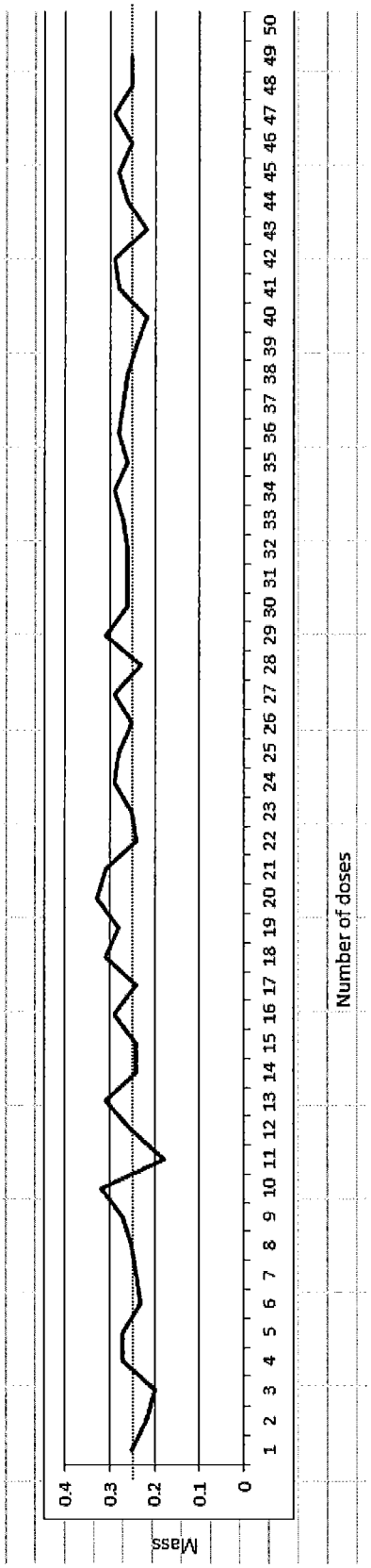


Figure 7

Figure 8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Number of doses