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(71) Applicant (*for all designated States except US*): FREWITT FABRIQUE DE MACHINES S.A. [CH/CH]; Route du Coteau 7, CH-1763 Granges-Paccot (CH).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): LEVEBVRE, Claude [CA/CH]; Ch. d'Eterpy 1, CH-1020 Renens (CH). VIRDIS, Antoine [CH/CH]; Imp. des Biches, CH-1724 Ferpichoz (CH).

(74) Agent: P&TS; Patents & Technology Surveys SA, Rue des Terreaux 7, PO Box 2848, CH-2001 Neuchâtel (CH).

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(54) Title: CONICAL REDUCING APPARATUS

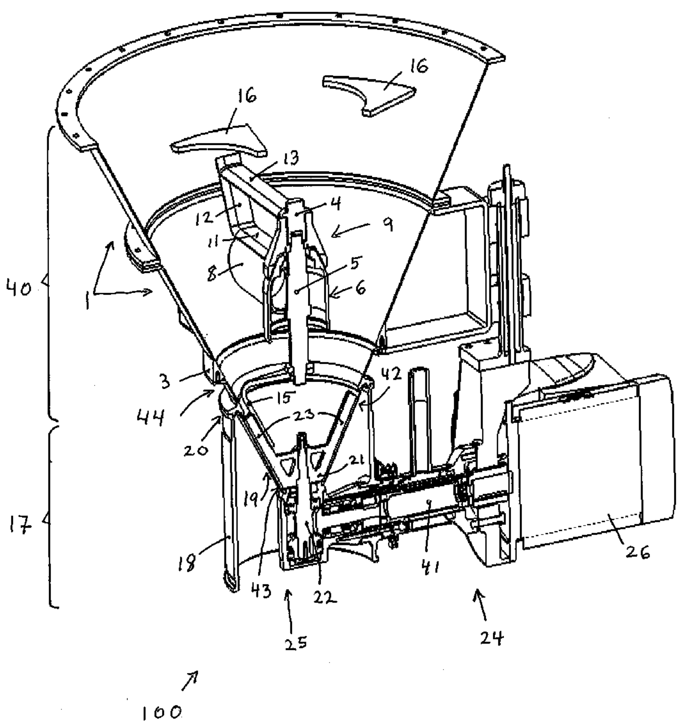

Fig. 2

(57) Abstract: An apparatus (100) for reducing the size of material, comprising a milling device (17) containing a sieve (19) and a milling impeller (21) being rotated relative to the interior wall surface of the sieve (19); and a crusher device (40) containing a hollow part (1) of frusto-conical shape narrowing downwardly, a crusher spindle (5) rotatably mounted coaxial with the hollow part (1), at least one crusher impeller (9, 30) rotatably mounted on the crusher spindle (5), and a crusher driving device for rotatably driving said at least one crusher impeller (9, 30) relative to said first hollow part (2); wherein said milling device (17) is vertically connected below the crusher device (40), and wherein during a reducing operation, said material is first crushed by the crusher device (40) by rotating said at least one crusher impeller (9, 30), and milled by the milling device (17) by rotating the milling impeller (21).

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Conical reducing apparatus

Field of the invention

[0001] The present disclosure relates to an apparatus for reducing the size of large material lumps into fine particles.

Description of related art

[0002] The process of milling solid blocks into small particles suitable for manufacturing downstream operations is a redundant challenge for many industries. This challenge is usually addressed by using cascade of different equipments, each piece of equipment providing the milled material to a certain size reduction and feeding this material to the next piece of equipment in order to continue the milling process until the particle size has been attained.

[0003] Generally, coarse blocks of about 50 cm in size and above are processed on a minimum of two equipments in order to reach approximately particles with a diameter of the order of 500 μm. A crusher is commonly used as a first step in the milling process.

[0004] Because of their design, geometry and operation, the different equipments cannot be easily integrated in an in-line process. In addition, they can be difficult to clean after completion of a milling process of a given material or product. Proper cleaning is a crucial issue especially in the pharmacy, biotechnology and fine chemical industries which require production process to follow good manufacturing practices in order to avoid cross contamination between the different materials processed. Proper cleaning often required to be performed off-site.

[0005] A milling device allowing for an easy and in-place cleaning, that could be smaller and more modular for multi-product manufacturing is still wanted.

Brief summary of the invention

[0006] The above limitations of prior art can be overcome an apparatus and method for reducing material disclosed herein.

[0007] According to preferred embodiments, an apparatus for reducing the size of material, can comprise a milling device containing a sieve and a milling impeller, said milling impeller being rotated relative to the interior wall surface of the sieve; and a crusher device containing a hollow part of frusto-conical shape narrowing downwardly, a crusher spindle rotatably mounted coaxial with the hollow part, at least one crusher impeller rotatably mounted on the crusher spindle, and a crusher driving device for rotatably driving said at least one crusher impeller relative to said first hollow part; wherein said milling device is vertically connected below the crusher device, and wherein during a reducing operation, said material is first crushed by the crusher device by rotating said at least one crusher impeller, and milled by the milling device by rotating the milling impeller.

[0008] In an embodiment, said crusher driving device comprises a crusher motor, a gearbox, and a crusher driving element extending radially between the hollow part and the gearbox, said crusher motor being drivingly connected to the crusher spindle via the gearbox and the crusher driving element.

[0009] In another embodiment, the crusher device comprises a first crusher impeller containing a first crushing blade and a second crushing blade, said first and second crushing blades extending radially from the crusher spindle and being fixedly connected to each other at their distal extremities by a blade member.

[0010] In yet another embodiment, said crusher device further comprises a second crusher impeller.

[0011] The present disclosure also pertains to a method for reducing the size of material using the apparatus disclosed and comprising:

introducing said material into the hollow part of the crusher device;

rotating said at least one crusher impeller to crush said material to provide crushed material; and

rotating said milling impeller of the milling device to mill said crushed material provided by said crusher device.

[0012] The apparatus disclosed herein can be manufactured at low cost and is of compact size. Using the disclosed apparatus, material having a size up to 36000 cm^3 can be reduced effectively to particles having a size below 250 microns in diameter.

Brief description of the drawings

[0013] The preferred embodiments will be better understood with the aid of the description of each embodiment given by way of example and illustrated by the figures, in which:

Fig. 1 is a side view of a system comprising an apparatus comprising a crusher device and a milling device according to an embodiment of the invention;

Fig. 2 is a cross-section view of the apparatus of Fig. 1, according to a cut made in the vertical plan;

Fig. 3 shows the apparatus of Fig. 1 viewed in perspective from above according to an embodiment;

Fig. 4 is a close view of the Fig. 3;

Fig. 5 illustrates a first crusher impeller of the apparatus according to an embodiment;

Fig. 6 illustrates a second crusher impeller according to an embodiment;

Fig. 7 shows the apparatus of Fig. 1 viewed in perspective from above according to another embodiment;

Fig. 8 represents a cross-section view of the crusher according to another embodiment; and

Fig. 9 shows the apparatus of Fig. 1 viewed in perspective from above according to yet another embodiment.

Detailed description of possible embodiments of the invention

[0014] A side view of an apparatus 100 for reducing the size of material according to an embodiment of the invention is shown in Fig. 1, while a cross-section view of the apparatus 100 is shown in Fig. 2 according to a cut made in the vertical plan of the Fig. 1.

[0015] The apparatus comprises a crusher device 40 comprising a hollow part 1 having the shape of a truncated cone revolving around a crusher axis 10, and narrowing downwardly toward a lower end 44. In the example of Figs. 1 and 2, the hollow part 1 consists of a first hollow part 2a and a second hollow part 2b, the second hollow part 2b being fixedly connected to the first hollow part 2a, extending upward the first hollow part 2a. The shape of the hollow part 1, or second hollow part 2b, is advantageous for introducing the material to be reduced into the crusher device 40, and has other functionalities that will be described below. The crusher device 40 further comprises a crusher spindle 5 rotatably mounted coaxial with the hollow part 1, a crusher rotor 4 and a first crusher impeller 9 rotatably mounted on the crusher spindle 5.

[0016] The crusher spindle 5 is driven by a crusher driving device comprising a crusher motor 7 (partially shown in Fig. 3) drivingly connected to the crusher spindle 5 via a gearbox 6, enclosing the spindle 5, and a crusher driving element 8. In the example of Fig. 2, the crusher driving element 8 extends radially between the hollow part 1 and the gearbox 6.

[0017] Other arrangements of the crusher driving device are also possible. For example, the crusher driving element 8 can extend coaxially with the crusher spindle 5. Such arrangement does not necessitate the use of the gearbox 6.

[0018] In an embodiment of the invention shown in Fig. 2, the first crusher impeller 9 comprises a first and a second crushing blade 11, 13, both blades 11, 13 extending radially from the crusher spindle 5 and being fixedly connected to each other at their distal extremities, toward the hollow part 1, by a blade member 12. Preferably, the blade member 12 is inclined substantially parallel to the wall of the hollow part 1, producing a constant gap between the blade member 12 and the internal wall of the hollow parts 1. Other inclination angles of the blade member 12 are however possible.

[0019] In a variant of the embodiment represented in Fig. 5, the first and second crushing blades 11, 13 are offset with an angle θ, where θ can have any value comprised between 0 and 90°. This configuration minimizes the risk that a lump of material remains blocked between the two crushing blades 11, 13 and rotates with the first crusher impeller 9, preventing effective crushing of the material.

[0020] In another variant of the embodiment also represented in Fig. 5, the first and second crushing blades 11, 13 have a sharpened cutting edge 27, diminishing the contact surface between the crushing blades 11, 13 and the material to be crushed, and thus increasing the pressure exerted on the material by the crushing blades 11, 13. This results in an increased crunching efficiency, mainly due to the increased penetration of the crushing blades 11, 13 and enhanced crack initiation in the material. Preferably, at least a portion of the cutting edge 27 of the first and/or the second crushing blades comprises serrations 28. As shown in Fig. 5, the first crusher impeller 9 can further comprise an unbalancing blade 45 fixed on top of the second crushing blade 13. The unbalancing blade 45 allows avoiding the material lump to sit and rotate with the first crusher impeller 9 without being crushed, when introduced into the crusher device 40.

[0021] In another embodiment illustrated in Figs. 3 and 4 showing a the apparatus 100 viewed in perspective from above (Fig. 4 showing a partial view), the first crusher impeller 9 comprises a third crushing blade 14 extending radially from the first rotor 4, below the first and second crushing blades 11, 13. The third crushing blade 14 can improve the crushing efficiency by crushing further fragments of material produced by the first and second crushing blades 11, 13. Preferably, the third crushing blade 14 has a distal end oriented upward possibly inclined substantially parallel to the hollow part 1. The first crusher impeller 9 can also comprise a fourth crushing blade 15 extending radially, below the third crushing blade 14. Preferably, the distal end of fourth crushing blade 15 is bended downward. The fourth crushing blade 15 can be used to further enhance the crushing of the fragments of material produced by the first and second blades 11, 13, and possible by the third crushing blade 14.

[0022] The first crusher impeller 9 can be formed from a single piece. However, the first and second crushing blades 11, the blade member 12, and the crusher rotor 4 can also be made from separate parts assembled by welding or any other suitable means.

[0023] In another embodiment represented in Figs. 6 and 7, the crusher device further comprises a second impeller 30 formed from an outer ring 34 containing one or several outer crushing teeth 340. In the example of Fig. 6, the outer ring 34 is fixedly attached to a second impeller rotor 31 by six arms 33 extending radially from the rotor 31 to the outer ring 34. Any other attachment means are however possible including a disc containing openings sufficiently large to let crushed material fragments pass through them. The second impeller 30 is mounted rotatably and coaxially on the crusher spindle 5 by driving an aperture 32 provided on the rotor 31 onto the crusher spindle 5. Preferably, the number of outer crushing teeth 340 is chosen such as, during the crushing operation, the material to be crunched is seized by only one tooth at a given time. In the example of Fig. 6, the outer ring 34 comprises three outer crushing teeth 340 oriented upward and equally distributed, along the outer ring periphery.

[0024] In a variant of the embodiment also represented in Figs. 6 and 7, the second impeller 30 further comprises an inner ring 35 containing one or several inner crushing teeth 350, the inner ring 35 being fixed to the outer ring 34 and rotating with it. In the example of Fig. 6, the inner ring 35 contains three inner crushing teeth 350 oriented upward and equally distributed, along the inner ring periphery. The outer and inner rings 34, 35 of the second impeller 30 can be made from separate parts assembled by welding or any other suitable means. However, the second impeller 30 is preferably made from a single piece.

[0025] The second impeller 30 is preferably rotatably mounted on the lower extremity of the crusher spindle 5, in the vicinity of the lower end 44 of the hollow part 1, as shown in the example of Fig. 7 representing a perspective view of the crusher device 40.

[0026] The crusher device 40 can comprise a static device able to impede possible rotation of the material with first and/or second impeller 9, 30. Indeed, during the crushing operation, large material lumps can be carried by the first and/or second impeller 9, 30, and start rotating with them. In this case, the material cannot be crushed effectively. Here, the static device can be used to impede the rotation of the material and force the first and/or second impellers 9, 30 to break to material, thus enhancing the crushing efficiency.

[0027] In an embodiment shown in Figs 2 to 4, the static device comprises one or several stator elements 16 fixed on the internal wall of the hollow part 1. In Figs. 2 to 4, the stator elements 16 can be seen extending radially toward the crusher axis 10. More particularly, in Figs. 2 to 4 three stator elements 16 are fixed on the upper end of the hollow part 1, above the first crusher impeller 9.

[0028] In another embodiment shown in Fig. 8, the static device comprises one or several static blades 36 fixed on the crusher driving element 8. Preferably, the static blades 36 are fixed on the lower side of the crusher driving element 8 in a configuration allowing the outer and inner crushing teeth 340, 350 of the second crusher impeller 30 to pass sequentially between the static blades 36 when the second impeller 30 rotates. By blocking possible rotation of the material fragments around the crusher axis 10, the static blades 36 advantageously force the outer and/or inner crushing teeth 340, 350 to seize the material and break it, thus, increasing the crushing efficiency. In a variant of the embodiment, one or several additional static blades 36b can be fixed on the lateral side if the crusher driving element 8 as shown in the example of Fig. 8.

[0029] In yet another embodiment illustrated in Fig. 9, the static device comprises one or several lower stator elements 37 fixed radially around the periphery of the internal wall of the lower part of the hollow part 1, for example, around the lower end 44. Preferably, three lower stator elements 37 are arranged equally spaced. The lower stator elements 37 can be advantageous used to improve fine crushing efficiency, in particular with slippery materials such as ice.

[0030] The apparatus 100 further comprises a milling device 17, formed from a sieve 19 and a tubular frame 18 in which the sieve 19 is coaxially mounted. The sieve 19 has a frusto-conical shape narrowing downwardly, with an open upper wide end 42 and a lower narrow end 43 being at least partially closed. In most uses, it is desirable to have the lower narrow end 43 completely closed. The milling device 17 further comprises a milling impeller 21 mounted on a rotatable milling spindle 22, both milling impeller 21 and milling spindle 22 being vertically mounted within the sieve 19. In the preferred embodiment of Fig. 2 the milling impeller 21 comprises two symmetrical milling blades 23. However, the milling impeller 21 can comprises several blades 23 equally distributed around the milling rotor 21 or distributed according to any other arrangement. Preferably, a constant gap is formed between the peripheral edge of the milling blade 23 and the interior wall of the sieve 19. The milling impeller 21 rotates relative to the interior wall surface of the sieve 19 for milling the material inputted from the upper wide end 42 by passing said material through the sieve 19. The milled material is then leaves the milling device 17 by an exit 25. Such a milling device is described in more details in U.S. Patent No 5,863,004 by the present applicant.

[0031] The milling device 17 is susceptible to various modifications and alternative forms. For example, the sieve 19 can be disk-shaped or have a tubular shape, with the milling blade 23 rotating relative to the disk-shaped or tubular-shaped sieve 19, respectively.

[0032] In an embodiment illustrated in Figs. 1 to 3, the milling device 17 is connected below the crusher device 40, the upper wide end 42 of the sieve 19 being vertically connected to the lower end 44 of the hollow part 1. More particularly, the hollow part 1 of the crusher device 40 can be connected to the sieve 19, by connecting a lower flange 3, comprised at the lower end 44 of the hollow part 1, to an upper flange 20, comprised on the upper side of the tubular frame 18. Preferably, the milling device 17 is connected coaxially with the crusher device 40. In this configuration, the conical sieve 19 of the milling device 17 is prolonged by the conical-shaped hollow part 1 of the crusher device 40.

[0033] The milling rotor 21 can be driven by connecting the fourth crushing blade 15 to the milling impeller 21, for example, by one of the milling blades 23, as shown in Fig. 2. Alternatively, the milling spindle 22 can be connected to the crusher spindle 5.

[0034] In another embodiment also represented in Fig. 2, the milling impeller 21 is driven by a milling driving device 24 comprising a milling motor 26 and a milling driving element 41, the milling driving device 24 driving the milling spindle 22.

[0035] In a preferred embodiment, the different parts of the crusher device 40 and of the milling device 17 are made in stainless steel to make the apparatus 100 compatible for use in a sanitary environment such as in pharmaceutical applications.

[0036] During a reducing operation using the apparatus 100, the material is inputted into the hollow part 1 and is crushed by the action of the first and/or second crusher impeller 9, 30. This crushing operation produces crushed material fragments that enter, by gravity, the milling device 17 disposed below the crusher device 40. The crushed material is then milled in the milling device 17 by being pressed through the sieve 19 when the milling impeller 21 is rotated. The milled material, having the form of fine particles, leaves the milling device 17 through the output 25.

[0037] The crushing efficiency can be increased by using the second impeller 30 and/or by using the static device according to any of the embodiments disclosed herein. For example, in a configuration of the crusher device 40 comprising the second impeller 30 and the static blades 36, the combined action of the second impeller 30 with the static blades 36 produces a flux of crushed material entering the milling device 17 that is more regular than in the absence of the second impeller 30. Moreover, using the second impeller 30, the crushed material entering the milling device 17 is less likely to escape the milling device 17 toward the crusher device 40 under the action of the centrifugal forces.

[0038] Using the apparatus 100 and the reducing operation disclosed herein, and rotating the first and/or second crusher impeller 9, 30 at a rotation speed comprised typically between 5 t/min and 50 t/min, and rotating the milling impeller 21 at a rotation speed comprised typically between 300 t/min to 1500 t/min, large material lump, for example, material lumps having a size up to 60 x 40 x 15 cm, or up to 36000 cm^3, can be reduced to fine particles having a size down to 250 μm, in a single reducing operation.

[0039] Since the crusher device 40 is of simple construction and contains no sieve, the device 40 is very easy to clean, even allowing for easy cleaning-in-place (CIP) and washing-in-place (WIP) processes.

[0040] Due to its conical shape and the geometry if the first and/or second crusher impeller 9, 30, the crusher device 40 is able to prevent clogging of powder materials and/or can be used for disagglomeration of materials that have become hardened and lumpy over time and sizes them into free-flowing powder.

[0041] The disclosed embodiments are susceptible to various modifications and alternative forms, and specific examples thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the disclosed embodiments are not to be limited to the particular forms or methods disclosed, but to the contrary, the disclosed embodiments are to cover all modifications, equivalents, and alternatives.

[0042] For example, in an embodiment not represented, the crusher device 40 further comprises a torque detection device able to detect a predetermined high torque value of the crusher spindle 5. Such high torque value of the crusher spindle 5 can correspond, for example, to the first and/or second impeller 9, 30 being jammed by hard material fragments. Here, the torque detection device can control the crusher driving device, or the crusher motor 7, and adjust the rotation speed and/or rotation direction of the crusher spindle 5 when the predetermined high torque value is detected. For example, upon detection of the predetermined high torque, the first and/or second impellers 9, 30 can be halted, and/or the rotation of the first and/or second impellers 9, 30 can be inversed during a predetermined time period, in order to release the impellers 9, 30. After releasing, the impellers 9, 30 can be rotated to their normal crushing rotation speed and direction to carry on with the crushing operation.

[0043] In another embodiment not represented, the apparatus 100 further comprises a weight metering device able to measure, possibly continuously, a weight of the milled material. The weight metering device can be a gravimetric measurement instrument such as a balance, disposed below the milling device 17 and receiving the material milled by the milling device 17. The weight metering device can possibly control the milling driving device 24, or the milling motor 26, in order to adjust the rotation speed of the milling spindle 22, or milling impeller 21, as a function of a predetermined weight set point. For example, the weight metering device can set a lower rotation speed of the milling impeller 21 when the weight set point corresponds to a lower milling material weight, than when the weight set point corresponds to a higher milling material weight.

Reference numbers

1	hollow part
100	apparatus
2a	first hollow part
2b	second hollow part
3	lower flange of the hollow part
4	crusher rotor
5	spindle
6	gearbox
7	crusher motor
8	crusher driving element
9	first crusher impeller
10	crusher axis
11	first crushing blade
12	blade member
13	second crushing blade
14	third crushing blade
15	fourth crushing blade
16	stator element
17	milling device
18	tubular frame
19	sieve
20	upper flange
21	milling impeller
22	milling spindle
23	milling blade
24	milling driving device
25	exit of the milling device
26	milling motor

27	cutting edge
28	serrations of the first and second crushing blades
30	second crusher impeller
31	second impeller rotor
32	aperture
33	arms of the second impeller
34	outer ring
340	outer crushing teeth
35	inner ring
350	Inner crushing teeth
36	static blades
36b	additional static blade
37	lower stator element
40	crusher device
41	milling driving element
42	upper wide end of the sieve
43	lower narrow end of the sieve
44	lower end of the hollow part
45	unbalancing blade

Claims

1. An apparatus (100) for reducing the size of material, comprising :

a milling device (17) containing a sieve (19) and a milling impeller (21), said milling impeller (21) being rotated relative to the interior wall surface of the sieve (19); and

a crusher device (40) containing a hollow part (1) of frusto-conical shape narrowing downwardly, a crusher spindle (5) rotatably mounted coaxial with the hollow part (1), at least one crusher impeller (9, 30) rotatably mounted on the crusher spindle (5), and a crusher driving device for rotatably driving said at least one crusher impeller (9, 30) relative to said first hollow part (2); wherein

said milling device (17) is vertically connected below the crusher device (40), and wherein

during a reducing operation, said material is first crushed by the crusher device (40) by rotating said at least one crusher impeller (9, 30), and milled by the milling device (17) by rotating the milling impeller (21).

2. The apparatus (100) of claim 1, wherein said crusher driving device comprises a crusher motor (7), a gearbox (6), and a crusher driving element (8) extending radially between the hollow part (1) and the gearbox (6), said crusher motor (7) being drivingly connected to the crusher spindle (5) via the gearbox (6) and the crusher driving element (8).

3. The apparatus (100) of claim 1, wherein the crusher device (40) comprises a first crusher impeller (9) containing a first crushing blade (11) and a second crushing blade (13), said first and second crushing blades (11, 13) extending radially from the crusher spindle (5) and being fixedly connected to each other at their distal extremities by a blade member (12).

4. The apparatus (100) of claim 1, wherein said first crusher impeller (9) further comprise an unbalancing blade (45) to impede the material lump rotating with the first impeller (9).

5. The apparatus (100) of claim 1, wherein said sieve (19) has a frusto-conical shape narrowing downwardly, and said milling impeller (21) is vertically mounted within the sieve (19).

6. The apparatus (100) of claim 3, wherein said blade member (12) is inclined substantially parallel to the wall of the hollow part (1).

7. The apparatus (100) of claim 3, wherein said first crushing blade (11) and second crushing blade (13) are offset angularly.

8. The apparatus (100) of claim 3, wherein said first and second crushing blades (11, 13) comprise a sharpened cutting edge (27).

9. The apparatus (100) of claim 8, wherein said cutting edge (27) further comprises serrations (28) along at least a portion of the cutting edge (27).

10. The apparatus (100) of claim 3, wherein said first crusher impeller (9) comprises a third crushing blade (14) extending radially from the crusher spindle (5), below the first and second crushing blades (11, 13).

11. The apparatus (100) of claim 3, wherein said first crusher impeller (9) further comprises a fourth crushing blade (15) extending radially and downward from the crusher spindle (5), below the third crushing blade (14).

12. The apparatus (100) of any of the claims from 1 to 11, wherein said first crusher impeller (9) is made from a single piece.

13. The apparatus (100) of claim 1, wherein said crusher device (40) further comprises a second crusher impeller (30).

14. The apparatus (100) of claim 13, wherein said second crusher impeller (30) comprises an outer ring (34) mounted rotatably and coaxially on the crusher spindle (5), said outer ring (34) containing one or several outer crushing teeth (340) along its periphery.

15. The apparatus (100) of claim 14, wherein said second crusher impeller (30) further comprises an inner ring (35) fixed to the outer ring (34) and rotating with it, said inner ring (35) containing one or several inner crushing teeth (350) along its periphery.

16. The apparatus (100) of claim 15, wherein said outer and inner rings (34, 35) contain three outer and three inner crushing teeth (340, 350), respectively.

17. The apparatus (100) of claim 15, wherein said second crusher impeller (30) is made from a single piece.

18. The apparatus (100) of claim 2, wherein said crusher driving element (8) is used to impede possible rotation of the material to be crushed with said at least one crusher impeller (9, 30).

19. The apparatus (100) of claim 1, wherein the crusher device (40) comprises a static device (16, 36, 37) to impede possible rotation of the material to be crushed with said at least one crusher impeller (9, 30).

20. The apparatus (100) of claim 19, wherein said static device comprises one or several stator elements (16) fixed on the hollow part (1), above the first crusher impeller (9).

21. The apparatus (100) of claim 19, wherein said static device comprises one or several static blades (36) fixed on the crusher driving element (8).

22. The apparatus (100) of claim 19, wherein said static device comprises one or several lower stator elements (37) arranged radially around the lower end of the hollow part (1).

23. The apparatus (100) of claim 1, wherein the milling spindle (22) is rotatably driven by the crusher spindle (5).

24. The apparatus (100) of claim 11, wherein the milling spindle (22) is rotatably driven by the fourth crushing blade (15).

25. The apparatus (100) of claim 1, wherein said milling device (17) further comprises a milling driving device (24) containing a milling motor (26) and a milling driving element (41), said milling motor (26) being drivingly connected to the milling spindle (22) via the milling driving element (41).

26. The apparatus (100) of claim 1, wherein said crusher device (40) further comprises a torque detection device able to detect a predetermined high torque value of the crusher spindle (5), said torque detection device controlling the crusher driving device to adjust the rotation speed and/or rotation direction of the crusher spindle (5) when the predetermined high torque value is detected.

27. The apparatus (100) of claim 1, wherein the apparatus (100) further comprises a weight metering device able to

measure a weight of the milled material, said weight metering device controlling the milling driving device (24) to adjust the rotation speed of the milling spindle (22) according to a predetermined weight set point.

28. The apparatus (100) of claim 1, wherein the milling spindle (22) is rotated at a rotation speed comprised between 300 t/min and 1500 t/min.

29. The apparatus (100) of claim from 1, wherein the crusher spindle (5) is rotated at a rotation speed comprised between 5 t/min and 50 t/min.

30. The apparatus (100) of claim 1, wherein said material having a size up to 36000 cm^3 can be reduced to particles having a size below 250 microns in diameter.

31. A crusher device (40) comprising a hollow part (1) of frusto-conical shape narrowing downwardly, a crusher spindle (5) rotatably mounted coaxial with the hollow part (1), at least one crusher impeller (9, 30) rotatably mounted on the crusher spindle (5), and a crusher driving device for rotatably driving said at least one crusher impeller (9, 30) relative to said first hollow part (2); wherein

said at least one crusher impeller comprises a first crusher impeller (9) containing a first crushing blade (11) and a second crushing blade (13), each said first and second crushing blades (11, 13) extending radially from the crusher spindle (5) and being fixedly connected to each other at their distal extremities by a blade member (12).

32. The crusher device (40) of claim 31, wherein said crusher driving device comprises a crusher motor (7), a gearbox (6), and a crusher driving element (8) extending radially between the hollow part (1) and the gearbox (6), said crusher motor (7) being drivingly connected to the crusher spindle (5) via the gearbox (6) and the crusher driving element (8).

33. The crusher device (40) of claim 31, wherein said first crusher impeller (9) further comprise an unbalancing blade (45) to impede the material lump rotating with the first impeller (9).

34. The crusher device (40) of claim 31, wherein said blade member (12) is inclined substantially parallel to the wall of the hollow part (1).

35. The crusher device (40) of claim 31, wherein said first crushing blade (11) and second crushing blade (13) are offset angularly.

36. The crusher device (40) of claim 31, wherein said first and second crushing blades (11, 13) comprise a sharpened cutting edge (27).

37. The crusher device (40) of claim 36, wherein said cutting edge (27) further comprises serrations (28) along at least a portion of the cutting edge (27).

38. The crusher device (40) of claim 31, wherein said first crusher impeller (9) comprises a third crushing blade (14) extending radially from the crusher spindle (5), below the first and second crushing blades (11, 13).

39. The crusher device (40) of claim 31, wherein said first crusher impeller (9) further comprises a fourth crushing blade (15) extending radially and downward from the crusher spindle (5), below the third crushing blade (14).

40. The crusher device (40) of any of the claims from 31 to 39, wherein said first crusher impeller (9) is made from a single piece.

41. The crusher device (40) of claim 31, wherein said crusher device (40) further comprises a second crusher impeller (30).

42. The crusher device (40) of claim 41, wherein said second crusher impeller (30) comprises an outer ring (34) mounted rotatably and coaxially on the crusher spindle (5), said outer ring (34) containing one or several outer crushing teeth (340) along the periphery.

43. The crusher device (40) of claim 41, wherein said second crusher impeller (30) further comprises an inner ring (35) fixed to the outer ring (34) and rotating with it, said inner ring (35) containing one or several inner crushing teeth (350) along its periphery.

44. The crusher device (40) of claim 43, wherein said outer and inner rings (34, 35) contain three outer and three inner crushing teeth (340, 350), respectively.

45. The crusher device (40) of claim 43, wherein said second crusher impeller (30) is made from a single piece.

46. The crusher device (40) of claim 32, wherein said crusher driving element (8) is used to impede possible rotation of the material to be crushed with said at least one crusher impeller (9, 30).

47. The crusher device (40) of claim 31, wherein the crusher device (40) comprises at least one static element (16, 36, 37) to impede possible rotation of the material to be crushed with said at least one crusher impeller (9, 30).

48. The crusher device (40) of claim 47, wherein said at least one static element comprises one or several stator element (16) fixed on the hollow part (1), above the first crusher impeller (9).

49. The crusher device (40) of claim 47, wherein said at least one static element comprises one or several static blades (36) fixed on the crusher driving element (8).

50. The crusher device (40) of claim 47, wherein said at least one static element comprises one or several lower stator elements (37) arranged radially around the lower end of the hollow part (1).

51. The crusher device (40) of claim 31, wherein said crusher device (40) further comprises a torque detection device able to detect a predetermined high torque value of the crusher spindle (5), said torque detection device controlling the crusher driving device to adjust the rotation speed and/or rotation direction of the crusher spindle (5) when the predetermined high torque value is detected.

52. The crusher device (40) of claim 31, wherein the crusher spindle (5) is rotated at a rotation speed comprised between 5 t/min and 50 t/min.

53. A method for reducing the size of material using the apparatus (100) having the characteristics of any of the claims from 1 to 30, comprising:

introducing said material into the hollow part (1) of the crusher device (40);

rotating said at least one crusher impeller (9, 30) to crush said material to provide crushed material; and

rotating said milling impeller (21) of the milling device (17) to mill said crushed material provided by said crusher device (40).

54. The method of claim 53, wherein said rotating said at least one crusher impeller (9, 30) and said rotating said milling impeller (21) are performed simultaneously.

55. The method of claim 53, wherein said at least one crusher impeller (9, 30) is rotated at a rotation speed comprised between 5 t/min and 50 t/min.

56. The method of claim 53, wherein said rotating said milling impeller (21) is performed at a rotation speed comprised between 300 t/min and 1500 t/min.

57. The method of claim 53, wherein said material having a size up to 36000 cm^3 is reduced to particles having a size below 250 microns in diameter.

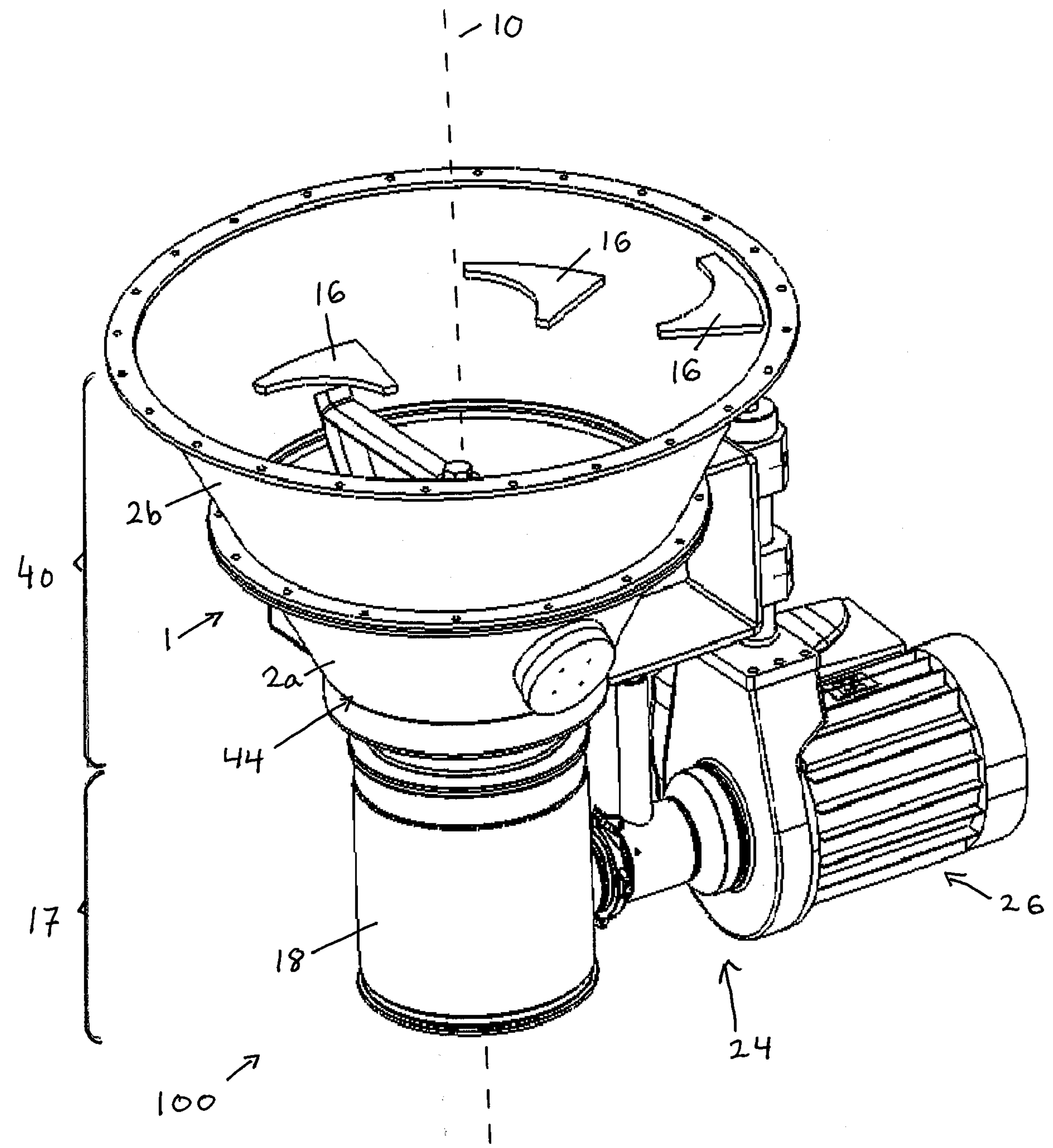

Fig. 1

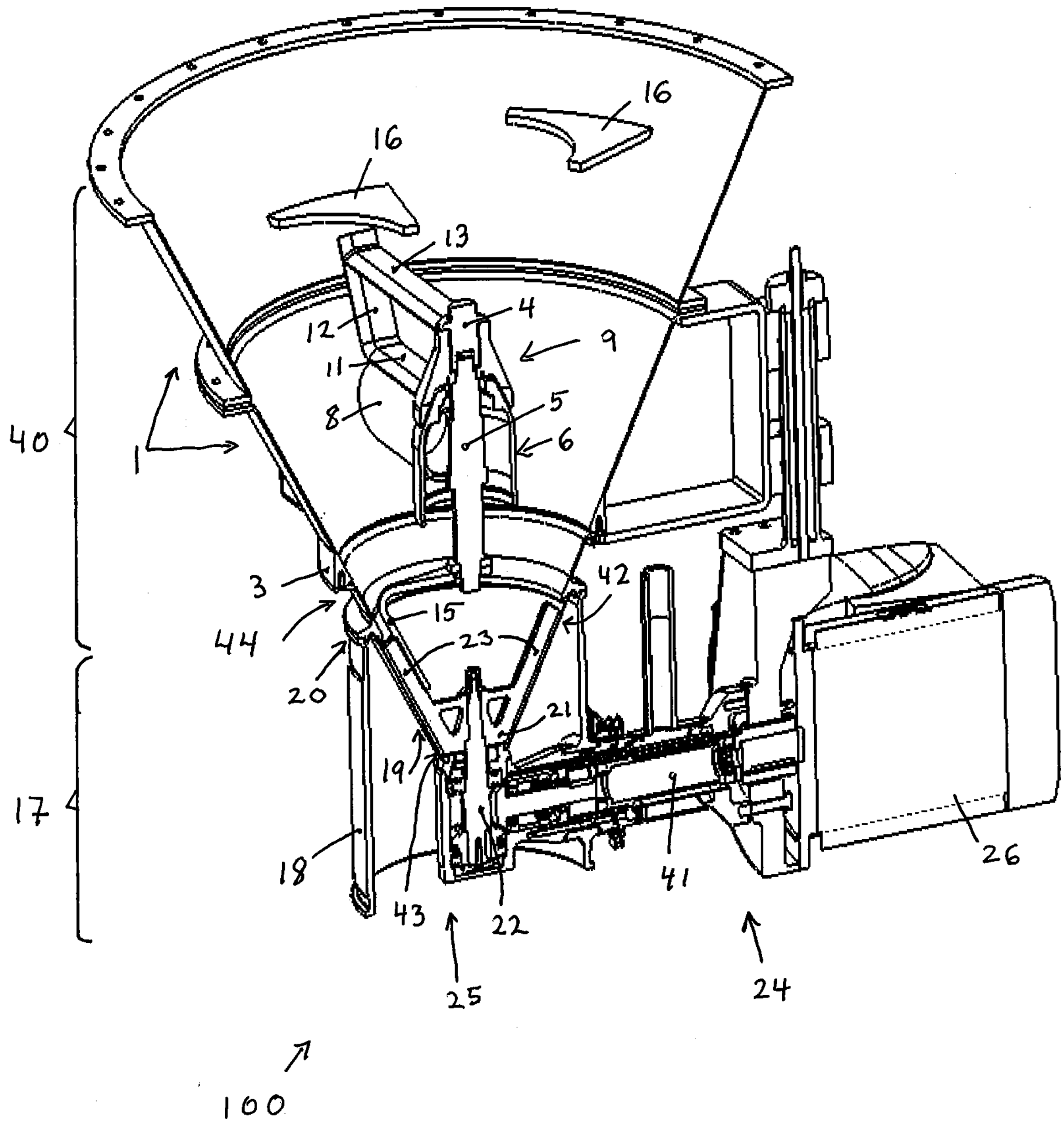
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Fig. 2

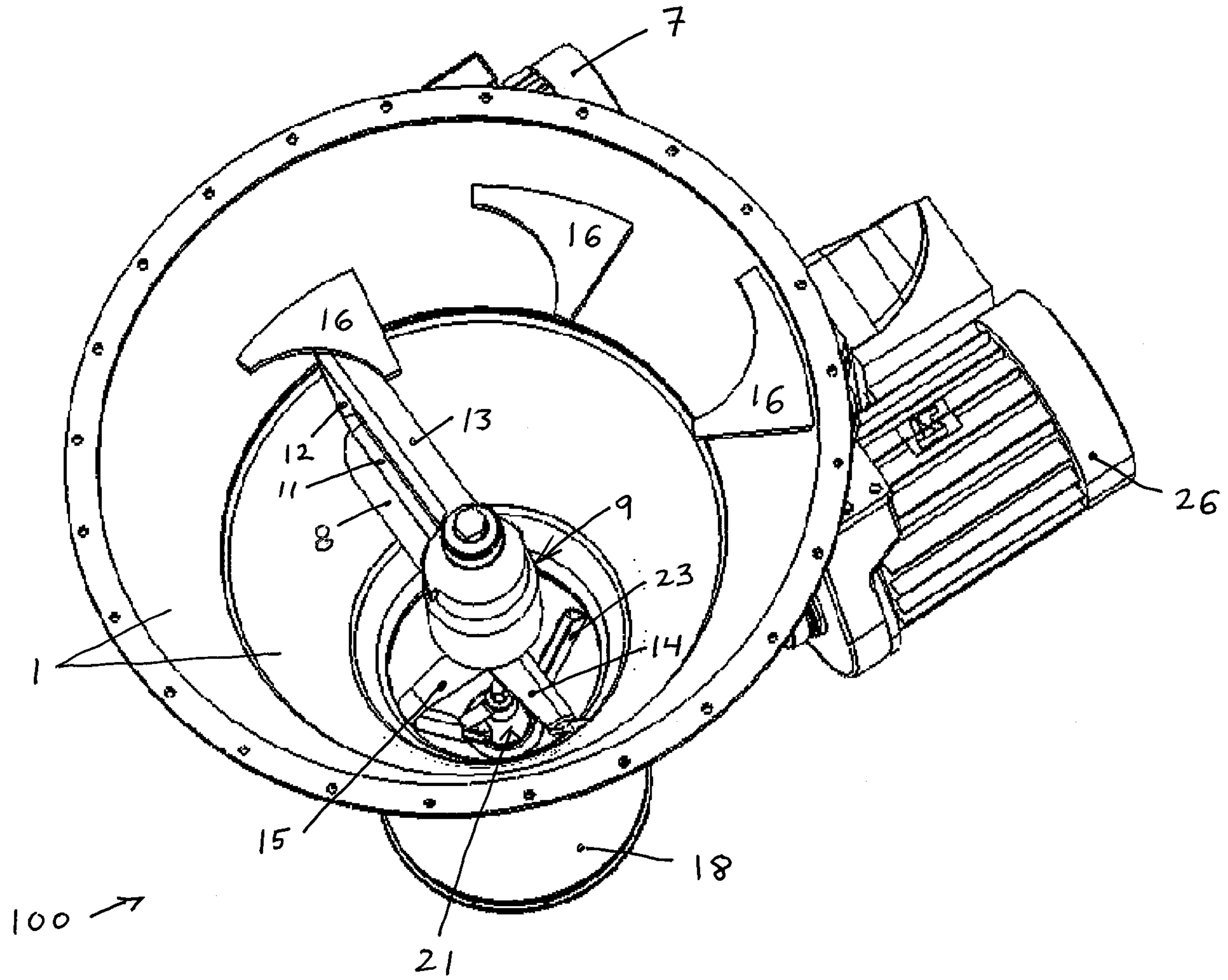

Fig. 3

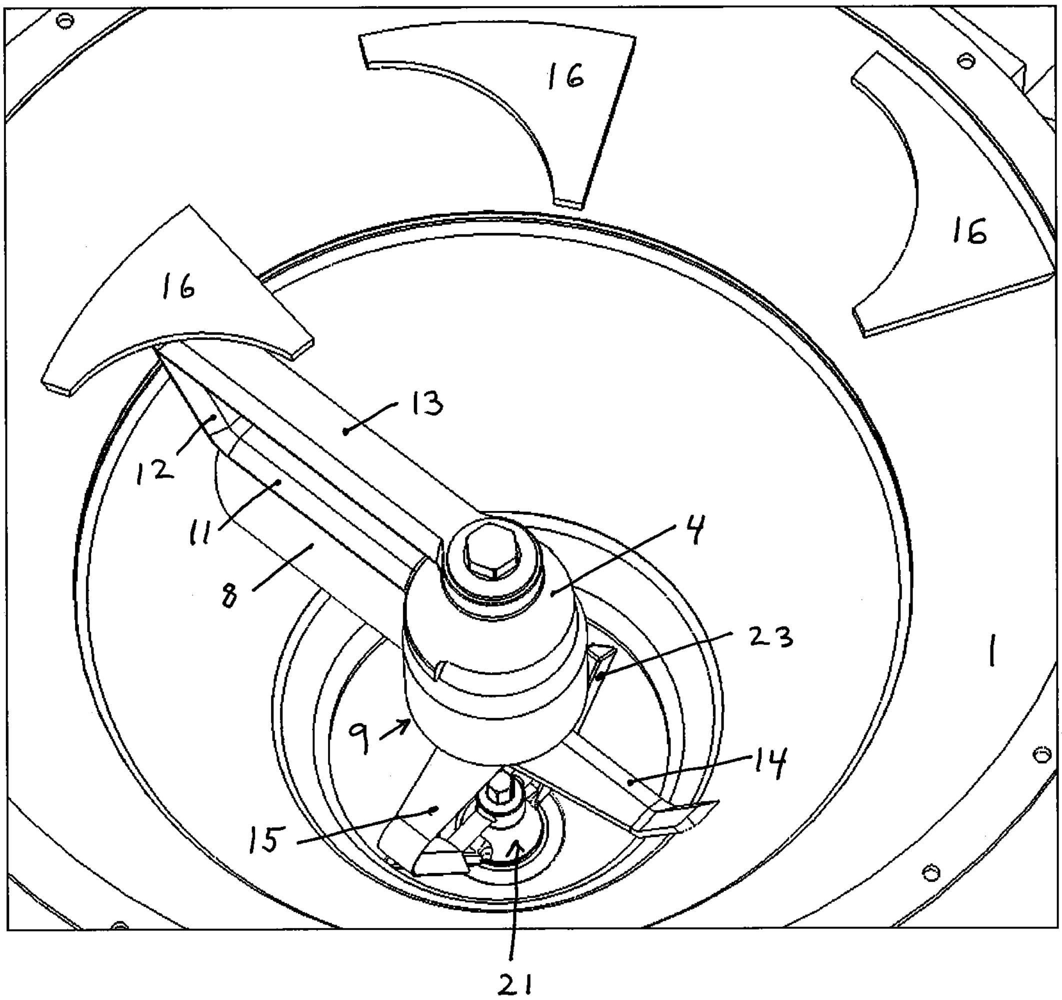

Fig. 4

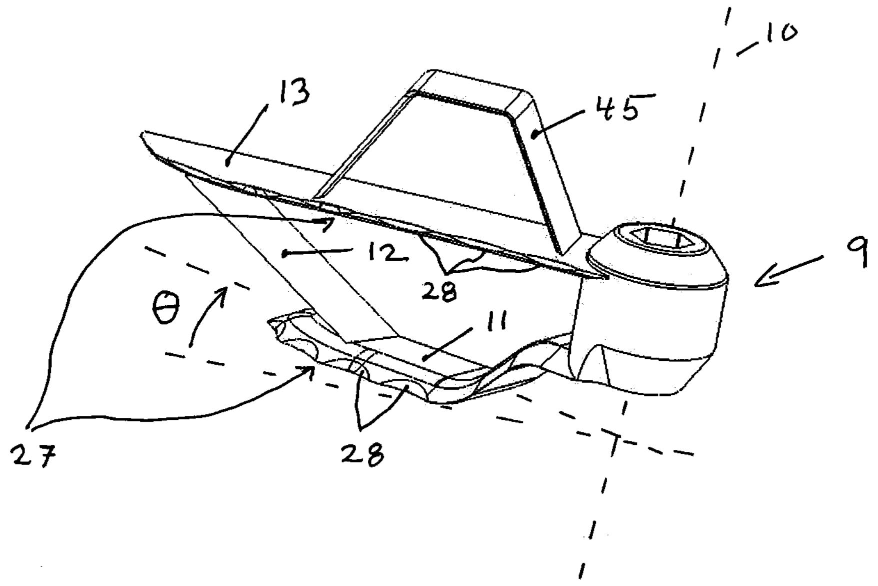

Fig. 5

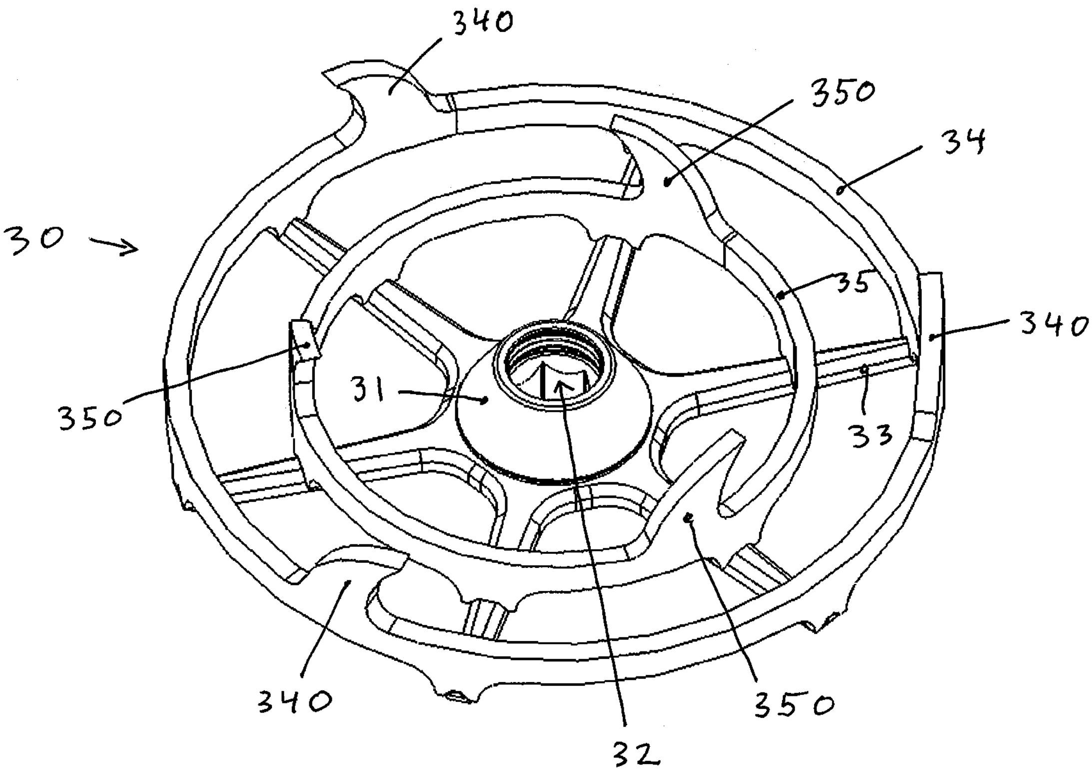

Fig. 6

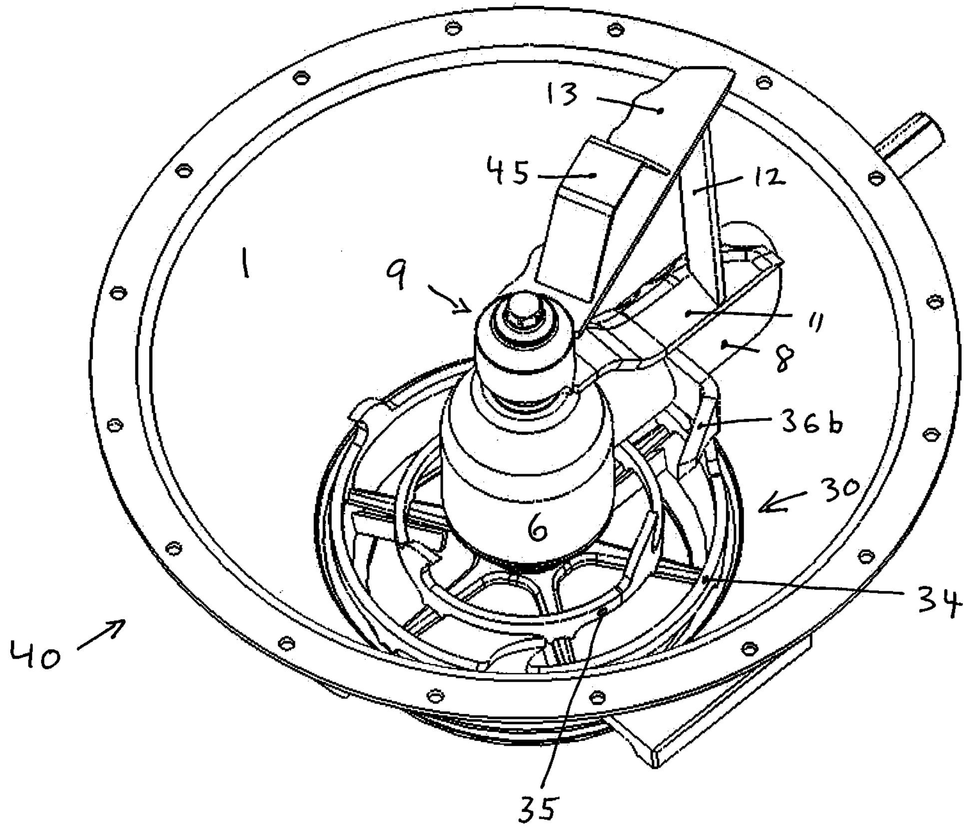

Fig. 7

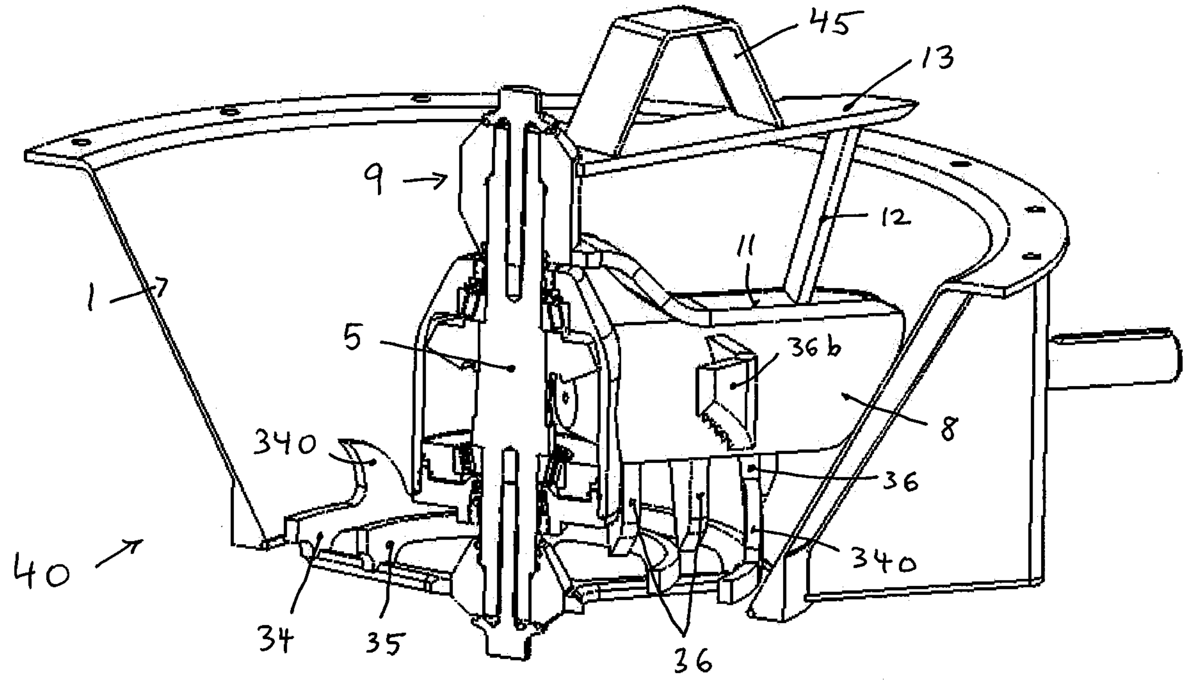

Fig. 8

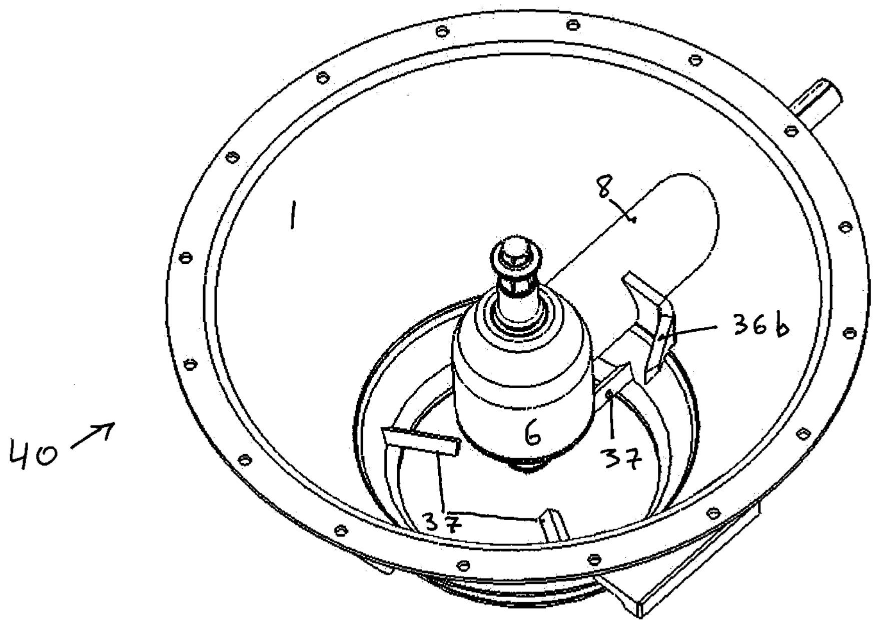

Fig. 9