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(54) MIXER WITH DOUBLE SIDED ROTOR AND METHOD FOR MIXING

(57) An apparatus 100 for mixing fluid food products, comprises a housing 102a, 102b, 102c provided with an inlet 104 and an outlet 106, a first stator 108a, a second stator 108b and a rotor 112 rotatably arranged between the first stator 108a and the second stator 108b such that a first fluid path 124 is formed on a first side 116 of the rotor 112, and a second fluid path 126 is formed on a second side 118 of the rotor 112. Openings 120a-120e are provided in the rotor 112 to thereby form a fluid channel between the first side 116 and the second side 118 of the rotor 112.

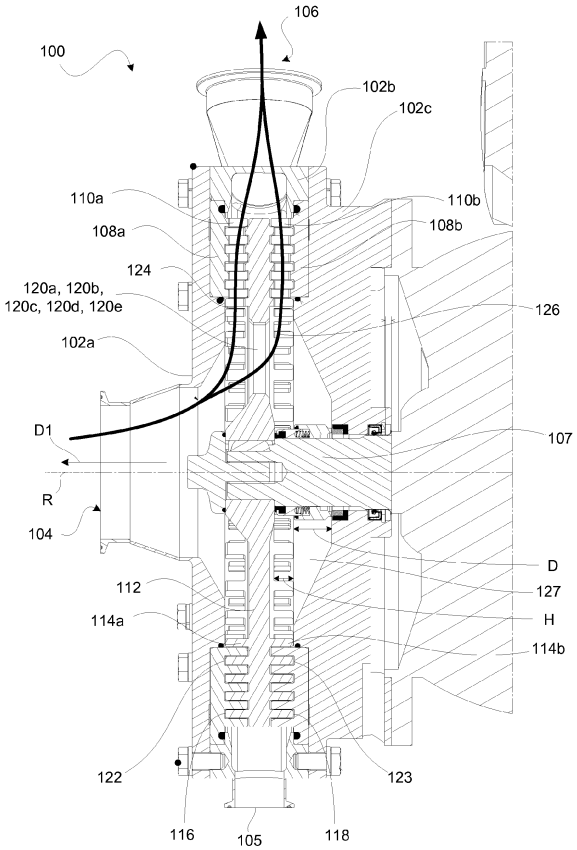


Fig. 2

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Description

Technical Field

[0001] The invention relates to an apparatus and a method for mixing fluid food products. The apparatus has two stators and a rotor that is positioned between the stators.

Background

[0002] In the field of liquid food processing it is known to use mixers for efficiently combining different ingredients. The mixers come in different forms and have different advantages. One type of mixer is the high shear mixer, which may be used in wide range of applications from mixing whole tomatoes into a tomato paste to mixing milk powder and water into recombined milk.

[0003] Unlike many other mixers, the high-shear mixers may be used for mixing ingredients that would normally be immiscible. In a high-shear mixer based on the rotor-stator principle, this can be made possible by that a disc-shaped rotor is rotating with respect to a stator such that flows with different velocities are formed at different distances from a center of the disc-shaped rotor, in small gaps that are formed between the rotor and the stator. The different velocities give rise to a shear, which provides for that ingredients can mix more efficiently. Due to the shear formed in high-shear mixers it is also possible to efficiently create e.g. emulsions and suspensions.

[0004] Even though the high-shear mixers, and other types of mixers based on a rotor-stator principle, are well known and are successfully used in the field of food processing, it is still appreciated that there is a need for improved mixers that offer better mixing intensity.

Summary

[0005] It is an object of the invention to at least partly overcome one or more of the above-identified limitations of the prior art. In particular, it is an object to provide an apparatus for mixing liquid food products, which apparatus can offer relatively higher rotational mixing speeds and increased mixing capacity.

[0006] To solve these objects it is according to a first aspect provided an apparatus for mixing fluid food products. The apparatus comprises a housing provided with an inlet and an outlet, a first stator and a second stator that are fixedly arranged in the housing, and a rotor rotatably arranged in the housing and positioned between the first stator and the second stator, such that a first fluid path is formed between the first stator and a first side of the rotor, and a second fluid path is formed between the second stator and a second side of the rotor. Openings are provided in the rotor, such that the openings form a fluid channel between the first side and the second side of the rotor. The openings are advantageous in that a flow of food product may be efficiently distributed on both sides of the rotor. This facilitates even distribution of pressure levels on both sides of the rotor, which achieves a better balanced rotor that can be run at higher speeds to thereby increase the apparatus' mixing capacity.

[0007] The rotor may be, with respect to the openings, rotationally balanced, which further improves the balancing of the rotor.

[0008] The rotor may comprise a hub connected to a rotational axle of the apparatus, a section that surrounds the hub and which comprises protrusions that face the first and the second stators, and connecting portions that are formed between the openings in the rotor and which connect said section to the hub. This provides a structurally stable rotor that still allows a high flow of fluid through the openings. The connecting portions may in one embodiment be seen as spokes that connect said section to the hub, i.e. the connection portions may be spoke-like connectors.

[0009] The connecting portions may have a radial extension that is at least 25% of a radius of the rotor.

[0010] The connecting portions and the openings may be located within a ring shaped area of the rotor, the openings having a total area that constitutes at least 25% of the ring shaped area.

[0011] The protrusions may comprise a set of peripheral protrusions that are located at periphery of the rotor, the set of peripheral protrusions being separated, as seen in a tangential direction of the rotor, by a number of gaps, and the openings may have a total area that is larger than a total area of the gaps.

[0012] The first flow path may be formed from the inlet, between the first stator and a first side of the rotor, and to the outlet. The second flow path may be formed from the inlet, through the openings in the rotor, between the second stator and a second side of the rotor, and to the outlet.

[0013] The openings may be given a size that allows, of a total amount of fluid food product that is fed through the apparatus from the inlet to the outlet, between 40% and 60% of said total amount of fluid food product to pass through the first fluid flow path. The remaining amount of the fluid food product then passes through the second fluid flow path.

[0014] The apparatus may further comprise a chamber that is located adjacent the second side of the rotor to receive fluid food product that flows through the openings. The chamber has, as seen in an axial direction of the rotor, a depth that is larger than a height of protrusions that are arranged on the second side of the rotor to face the second stator.

[0015] According to a second aspect it is provided a method for mixing a liquid food product by using an apparats according to the first aspect, which apparatus may include any of the features described above. The method comprises: feeding the liquid food product into the apparatus via an inlet; transferring the liquid food product through a first gap formed between by a first side of a rotor provided with protrusions and a first stator provided

with protrusions; transferring via openings in the rotor a second portion of the liquid food product through a second gap formed between a second side of the rotor provided with protrusions and a second stator provided with protrusions; forming a mixed liquid food product by collecting a first mixed portion from the first gap and collecting a mixed second portion of the food product from the second gap; and feeding out the mixed liquid food product via an outlet.

[0016] A total area of the openings in the rotor, optionally also a total area of gaps of the rotor, may be chosen such that hydrodynamic forces from the first gap and the second gap are balanced in an axial direction of the rotor.

[0017] Further objectives, features, aspects and advantages of the invention will appear from the following detailed description as well as from the drawings.

Drawings

[0018] Embodiments of the invention will now be described, by way of example, with reference to the accompanying schematic drawings, in which

Fig. 1 is an exploded perspective view of a mixer,
Fig. 2 is a cross sectional, partial view of the mixer of Fig. 1,
Fig. 3a and 3b illustrate a rotor for the mixer of Fig. 1,
Fig. 4a and 4b illustrate a stator for the mixer of Fig. 1, and
Fig. 5 is a flow chart of a method for mixing a liquid food product.

Description

[0019] Fig. 1 illustrates an apparatus 100 for mixing liquid food products. The apparatus 100 has a motor 101 that is connected to a housing which in the illustrated embodiment comprises a front cover 102a, a main cover 102b and a back cover 102c. The covers 102a-102c are attached to each other by bolts to form the housing. Product can be fed into the apparatus via an inlet 104, which is located in a center portion of the front cover 102a. After being mixed the product is fed out from the apparatus 100 via an outlet 106 that is located in the main cover 102b.

[0020] Inside the housing a first stator 108a and a second stator 108b are provided. The first and the second stator 108a, 108b are provided with protrusions 110a, 110b, also known as teeth or blades, facing in directions towards each other. Between the first and second stator 108a, 108b a rotor 112 is provided. The rotor 112 has protrusions 114a on a first side 116 that are arranged to interact with the protrusions 110a of the first stator 108a. Protrusions 114b are arranged on a second side 118 of the rotor 112 to interact with the protrusions 110b of the second stator 108b. The interaction between the protrusions and how it is accomplished is per se known within the art. Basically, there are small gaps between the protrusions. When liquid is pumped through the apparatus, past these small gaps when the rotor rotates, then the liquid and any other particle or substance in the liquid are subjected to a high shear that effects mixing.

[0021] In order to provide for that product can move from the first side 116 to the second side 118 of the rotor 112, the rotor 112 is be provided with openings 120a, 120b, 120c, 120d, 120e. By making it possible for the product to move from the first side 116 to the second side 118 at least two advantages are achieved.

[0022] Firstly, hydrodynamic forces in an axial direction D1 of the rotor 112 can be balanced. An effect of this is that vibrations can be reduced and that deflection of the rotor 112 can be reduced. This in turn result in that the apparatus 100 can be run at higher speed and with lower tolerances, which is beneficial since higher speed and a more close fit between the protrusions 110a, 110b of the first and second stator 108a, 108b and the protrusions 114a, 114b of the rotor 112 provide for an increased mixing intensity.

[0023] Secondly, having the rotor 112 provided with protrusions 114a, 114b on both the first side 116 and the second side 118 provides for that a height H (see Fig. 2) of the protrusions can reduced compared to a height of protrusions in a single-sided rotor configuration, while still maintaining the same mixing capacity. A positive effect of protrusions 114a, 114b with reduced height is that the apparatus 100 becomes less sensitive for situations that might cause the rotor to vibrate or deflect.

[0024] Fig. 2 illustrates a cross-sectional view of the apparatus 100 in further detail. Because the openings 120a, 120b, 120c, 120d, 120e provide for that the product can move from the first side 116 to the second side 118 of the rotor 112, mixing will occur in a first gap 122 and a second gap 123 that are located on each side of the rotor 112, between the rotor 112 and the respective stator 108a, 108b.

[0025] More particularly, as illustrated in Fig. 2 by a bold arrow, a first part of the product that enters the inlet 104 moves from the inlet 104 to the outlet 106 along a first flow path 124. A second part of the product that enters the inlet 104 moves along a second flow path 126. The first and second flow paths 124,126 follow each other from the inlet 104. Then the first flow path 124 continuous in the first gap 122. The second flow path continuous thorough the openings 120a, 120b, 120c, 120d, 120e and into the second gap 123. When the product in the flow paths 124, 126 leaves that gaps it is rejoined before being fed out via the outlet 106. The product from the first and second flow paths 124, 126 are then joined at a periphery of the rotor 112.

[0026] Even though the protrusions 110a of the first stator 108a, the protrusions 110b of the second stator 108b and corresponding protrusions 114a, 114b of the rotor 112 may all have the same height H, different heights on the first side 116 and the second side 118 is an option.

[0027] In order to provide for that the product can move

efficiently to the second gap 123, a chamber 127 is arranged on the second side 118 of the rotor 112, around a center portion of the rotor 112. A depth D of this chamber 127 may be greater than the height H of the protrusions 114a, 114b.

[0028] A drain outlet 105 is located at a lowermost side of the main cover 102b. The drain outlet is sealed by a valve (not shown) during operation of the apparatus 1. This valve is opened when the apparatus shall be drained from liquid, for example during service and maintenance.

[0029] Fig. 3a illustrates a front view of the first side 116 of the rotor 112 and Fig. 3b illustrates a perspective view of the rotor 112.

[0030] The rotor 112 is in use attached to an shaft 107, which in turn is connected to the motor 101 such that the rotor 112 rotates around its rotational axis R (see Fig. 2) when the motor 101 is started. The rotor 112 has a hub 128 that is connected to the shaft 107. As illustrated in Fig. 3a and Fig. 3b, the hub 128 may be provided with a recess such that it can be assured that the rotor 112 does not slide with respect to the shaft 107 during rotation. The rotor 112 is secured to the shaft 107 by a bolt.

[0031] The protrusions 114a, 114b of the rotor 112 are located on an outer part of the rotor 112, at section 130. The hub 128 and the section 130 are joined to each other via connecting portions 132a, 132b, 132c, 132d, 132e. These connecting portions 132a, 132b, 132c, 132d, 132e are separated by the openings 120a, 120b, 120c, 120d, 120e.

[0032] The rotor 112 illustrated in Fig. 3a and Fig. 3b is a disc-shaped rotor with a radius R1. In this embodiment, the hub 128 is enclosed within an area defined by a circle with radius R3. The section 130 can be defined as a ring-shaped area that has outer radius R1 and an inner radius R2. An area A in which the openings 120a, 120b, 120c, 120d, 120e and the connecting portions 132a, 132b, 132c, 132d, 132e are located is here a ring-shaped area that is defined by an outer radius, here R2, and an inner radius, here R1. The connecting portions 132a, 132b, 132c, 132d, 132e may, as illustrated in Fig. 3a and 3b, have a spoke-like shape that connects the section 130 with the protrusions 114a, 114b to the hub 128.

[0033] The protrusions 114a on the first side 116 of the rotor 112 have at a periphery 134 of the rotor 112 peripheral protrusions 136a, 137a that are, as seen in a tangential direction T of the rotor 112, separated by gaps 138a. Similarly, the protrusions 114b of the second side 118 of the rotor 112 have at the periphery 134 of the rotor 112 peripheral protrusions 136b, 137b that in the tangential direction T are separated by gaps 138b. In order to provide for that the hydrodynamic forces are balanced, a total area of the openings 120a, 120b, 120c, 120d, 120e may be greater than a total area of all peripheral gaps 138a, 138b on the rotor 112. The total area of the gaps is the sum of all peripheral gaps on the rotor 112. The total area of the openings is the sum of the aeas A1, A2, A3, A4, A5 of all openings.

[0034] The rotor may, with respect to the openings 120a, 120b, 120c, 120d, 120e, be rotationally balanced.

[0035] Further, the connecting portions 132a, 132b, 132c, 132d, 132e may have a radial extension R2-R3 that is at least 25% of the radius R1 of the rotor. The radial distance is then calculated as the radius R2 minus the radius R3.

[0036] In order to provide for that the fluid food product can move from the first gap 122 to the second gap 123 the openings 120a, 120b, 120c, 120d, 120e should not be too small. Thus, the openings 120a, 120b, 120c, 120d, 120e may have a total area A1+A2+A3+A4+A5 that constitutes at least 25 % of the area A of a ring in which the openings 120a, 120b, 120c, 120d, 120e and the connecting portions 132a, 132b, 132c, 132d, 132e are located. The area A is calculated as the area of a circle with the radius R2 minus the area of a circle with the radius R3.

[0037] The openings 120a, 120b, 120c, 120d, 120e may be given a size that allows, of a total amount of fluid food product that is fed through the apparatus from the inlet 104 to the outlet 106, between 40% and 60% of said total amount of fluid food product to pass through the first fluid flow path 124. The remaining amount of the fluid food product then passes through the second fluid flow path 126. In practice, for determining exactly which area should be used for obtaining this result, a separating wall between the periphery of the rotor 112 and the outlet 106 may be arranged, so that two separate streams from a respective side of the rotor 112 is received. By measuring the flow rate of the separate streams, for different areas of the openings, the appropriate area may then be empirically determined. Conventional calculations using dynamic fluid principles may also be used for determining the area.

[0038] Fig. 4a illustrates a front view the second stator 108b and Fig. 4b illustrates a perspective view of the second stator 108b. The first stator 108a may be identical to the second stator 108b. The stators 108a, 108b are fixedly attached to the housing 102a, 102b, 102c.

[0039] Fig. 5 provides a flowchart 500 of a method for mixing a liquid food product using for instance the apparatus 100 illustrated in Fig. 1. In the method the liquid food product is fed 502 into the apparatus 100 via the inlet 104. The feeding may be accomplished by any suitable pump, and the apparatus is then, at the inlet 104 and the outlet 106, connected to conventional liquid source respectively liquid recipient.

[0040] A first portion of the liquid food product is transferred 504 through the first gap 122 formed by the first side 116 of the rotor 112 provided with the protrusions 114a and the first stator 108a provided with the protrusions 110a. This effects mixing of the first portion of the liquid food product. A second portion of the liquid food product is transferred 508 via the openings 120a, 120b, 120c, 120d, 120e, and further through the second gap 123 formed by the second side 118 of the rotor 112 provided with the protrusions 114b and the second stator 108b with protrusions 110b. This effects mixing of the

second portion of the liquid food product.

[0041] A mixed liquid food product is then formed 512 by collecting the first (now mixed) portion outside the first gap 122 and the second (now mixed) portion of the food product outside the second gap 123. The mixed liquid food product is fed 514 out via the outlet 106.

[0042] A total area of the openings 120a, 120b, 120c, 120d, 120e in the rotor 112 and a total area of the gaps 138a, 138b of the rotor 112 may be chosen such that the hydrodynamic forces from the first gap 122 and the second gap 123 are balanced in an axial direction D1. This choice may be accomplished by running rotors with different total areas of the openings and by observing any vibrations. It can then be empirically determined which area is most suitable, i.e. which gives the smallest amount of vibrations.

[0043] The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the invention, as defined by the appended patent claims.

Claims

1. An apparatus (100) for mixing fluid food products, the apparatus (100) comprising
a housing (102a, 102b, 102c) provided with an inlet (104) and an outlet (106),
a first stator (108a) and a second stator (108b) that are fixedly arranged in the housing (102a, 102b, 102c), and
a rotor (112) rotatably arranged in the housing (102a, 102b, 102c) and positioned between the first stator (108a) and the second stator (108b), such that a first fluid path (124) is formed between the first stator (108a) and a first side (116) of the rotor (112), and a second fluid path (126) is formed between the second stator (108b) and a second side (118) of the rotor (112), **wherein**
openings (120a-120e) are provided in the rotor (112), such that the openings (120a-120e) form a fluid channel between the first side (116) and the second side (118) of the rotor (112).

2. The apparatus (100) according to claim 1, wherein the rotor (112) is, with respect to the openings (120a-120e), rotationally balanced.

3. The apparatus according to claim 1 or 2, wherein the rotor (112) comprises
a hub (128) connected to a rotational axle (107) of the apparatus (100),
a section (130) surrounding the hub (128) and comprising protrusions (114a, 114b) that face the first and the second stators (108a, 108b), and
connecting portions (132a-132e) that are formed between the openings (120a-120e) in the rotor (112) to connect said section (130) to the hub (128).

4. The apparatus according to claim 3, wherein the connecting portions (132a-132e) have a radial extension (R2-R3) that is at least 25% of a radius (R1) of the rotor (112).

5. The apparatus according to any one of claims 3 - 4, wherein the connecting portions (132a-132e) and the openings (120a-120e) are located within a ring shaped area (A) of the rotor (112), the openings (120) having a total area (A1-A5) that constitutes at least 25% of the ring shaped area (A).

6. The apparatus according to any one of claims 3 - 5, wherein
the protrusions (114a, 114b) comprise a set of peripheral protrusions (136a, 136b) that are located at periphery (134) of the rotor (112), the set of peripheral protrusions (136a, 136b) being separated, as seen in a tangential direction (T) of the rotor (112), by a number of gaps (138a, 138b), and
the openings (120a-120e) have a total area (A1-A5) that is larger than a total area of the gaps (138a, 138b).

7. The apparatus according to any one of the preceding claims, wherein
the first flow path (124) is formed from the inlet (104), between the first stator (108a) and a first side (116) of the rotor (112), and to the outlet (106), and
the second flow path (126) is formed from the inlet (104), through the openings (120a-120e) in the rotor (112), between the second stator (108b) and a second side (118) of the rotor (112), and to the outlet (106).

8. The apparatus according to any one of the preceding claims, wherein the openings (120a-120e) are given a size that allows, of a total amount of fluid food product that is fed through the apparatus from the inlet (104) to the outlet (106),
between 40% and 60% of said total amount of fluid food product to pass through the first fluid flow path (124),
while the remaining amount of the fluid food product passes through the second fluid flow path (126).

9. The apparatus according to any one of the preceding claims, comprising a chamber (127) that is located adjacent the second side (118) of the rotor (112) to receive fluid food product that flows through the openings (120a-120e), the chamber (127) having, as seen in an axial direction (D1) of the rotor (112), a depth (D) that is larger than a height (H) of protrusions (114b) that are arranged on the second side (118) of the rotor (112) to face the second stator

(108b).

10. A method for mixing a liquid food product by using an apparatus (100) according to any one of the preceding claims, the method comprising
feeding (502) the liquid food product into the apparatus (100) via the inlet (104),
transferring (504) a first portion of the liquid food product through a first gap (122) between the first side (116) of the rotor (112) and the first stator (108a) to effect mixing,
transferring (508), via the openings (120a-120e) in the rotor (112), a second portion of the liquid food product through a second gap (123) between a second side (118) of the rotor (112) and a second stator (108b) to effect mixing,
forming (512) a mixed liquid food product by collecting the first portion from the first gap (122) and collecting the second portion from the second gap (123), and
feeding (514) out the liquid food product via an outlet (106).

11. The method according to claim 10, wherein a total area of the openings (120a-120e) in the rotor (112) are chosen such that hydrodynamic forces in the gaps (122, 123) between the rotor (112) and stators (108a, 108b) are balanced in an axial direction (D1) of the rotor (112).

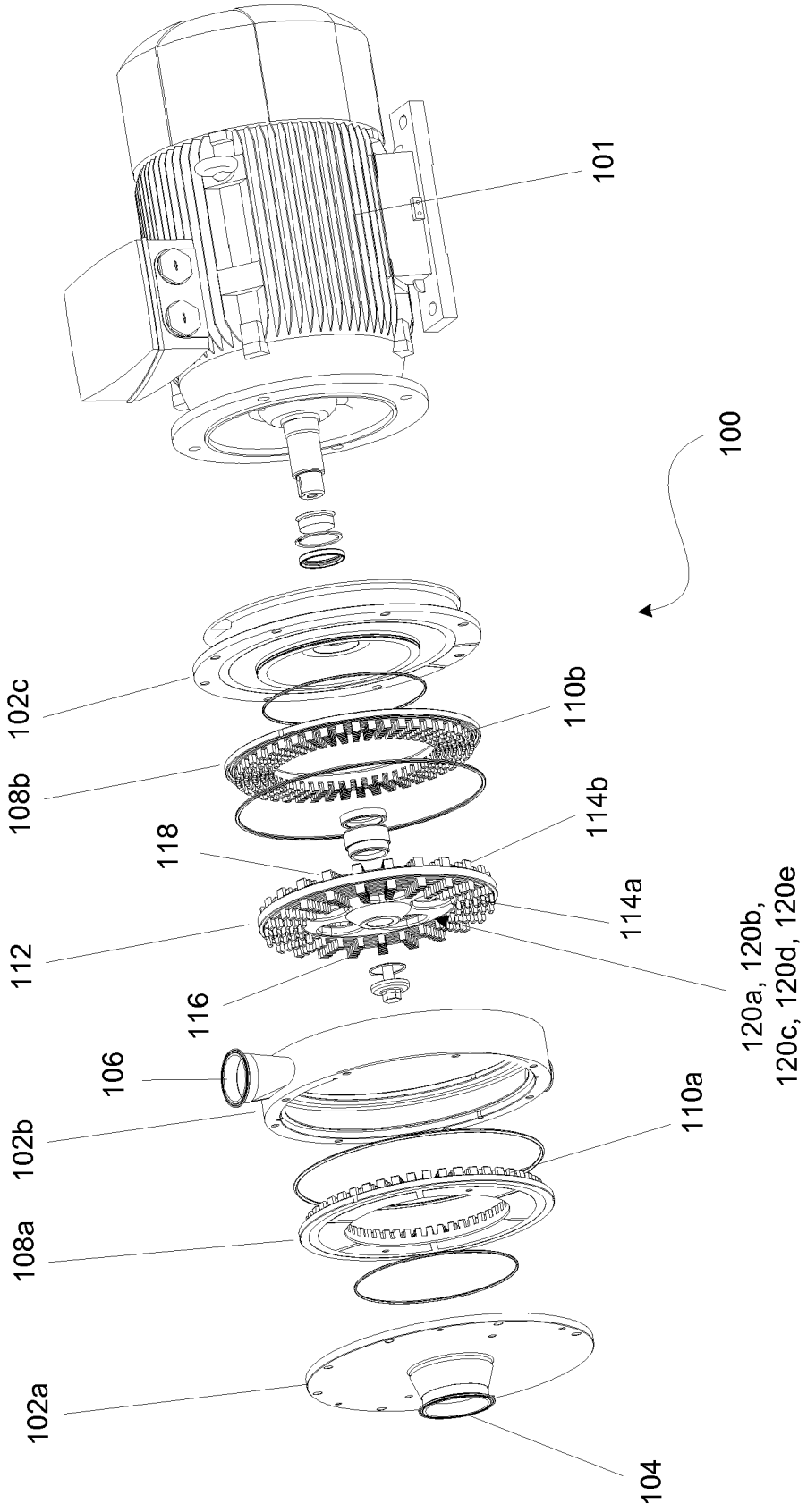

101
100
102c
110b
108b
114b
118
114a
112
120a, 120b,
120c, 120d, 120e
116
106
110a
102b
108a
102a
104

Fig. 1

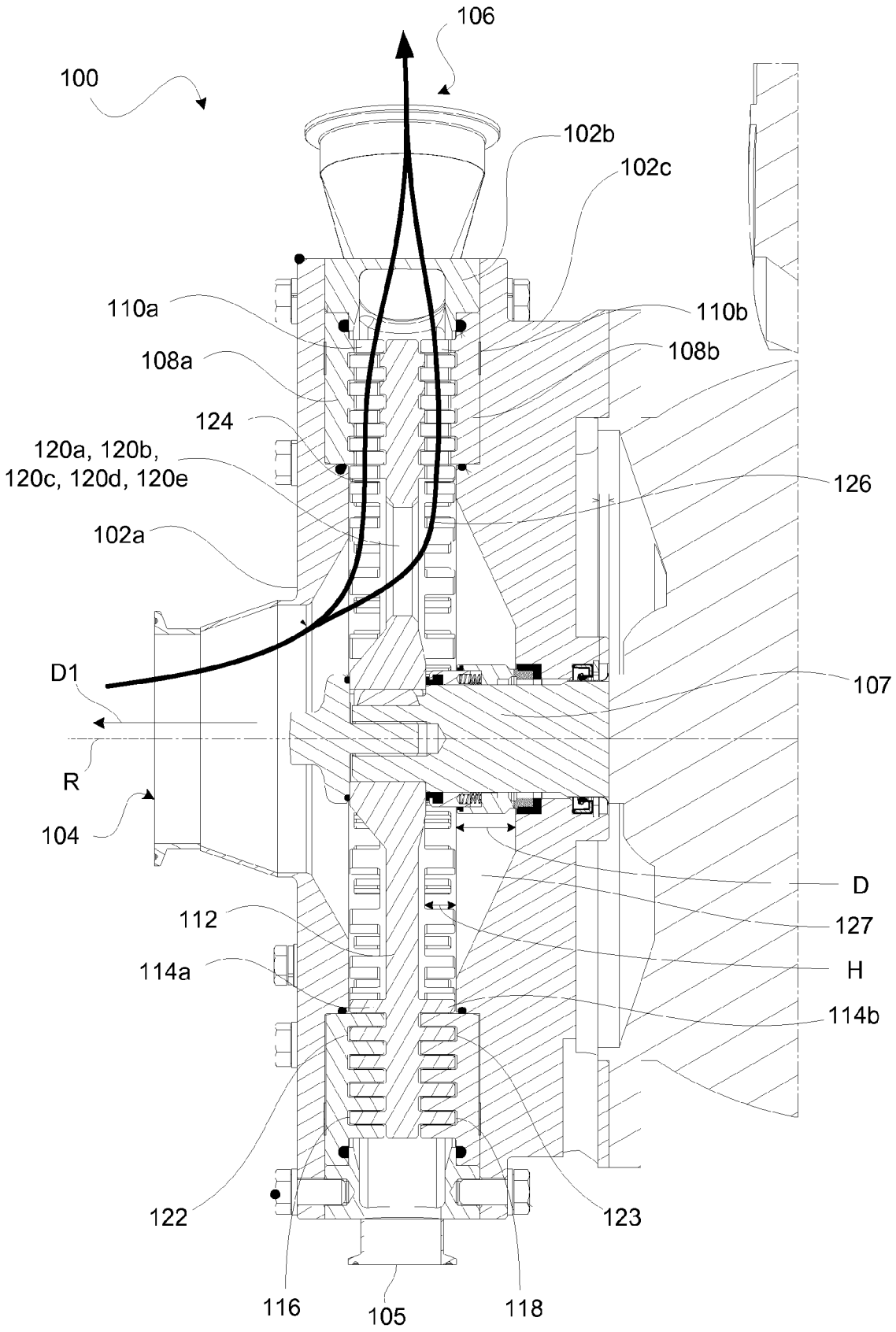

106
100
102b
102c
110a
110b
108a
108b
124
120a, 120b,
120c, 120d, 120e
126
102a
D1
107
R
104
D
112
127
114a
H
114b
122
123
116
105
118

Fig. 2

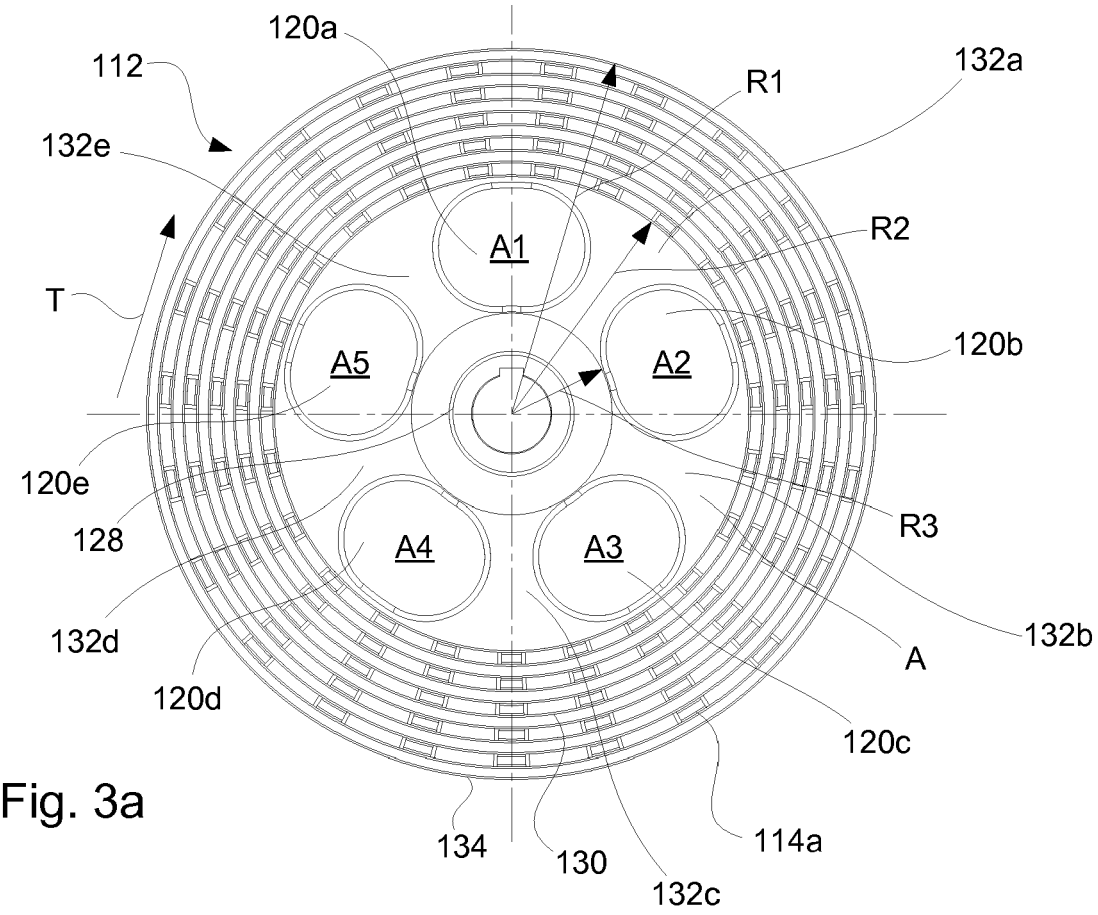

120a
112
132e
T
120e
128
132d
120d
R1
132a
R2
120b
R3
132b
A
120c
114a
132c
130
134
A1
A2
A3
A4
A5

Fig. 3a

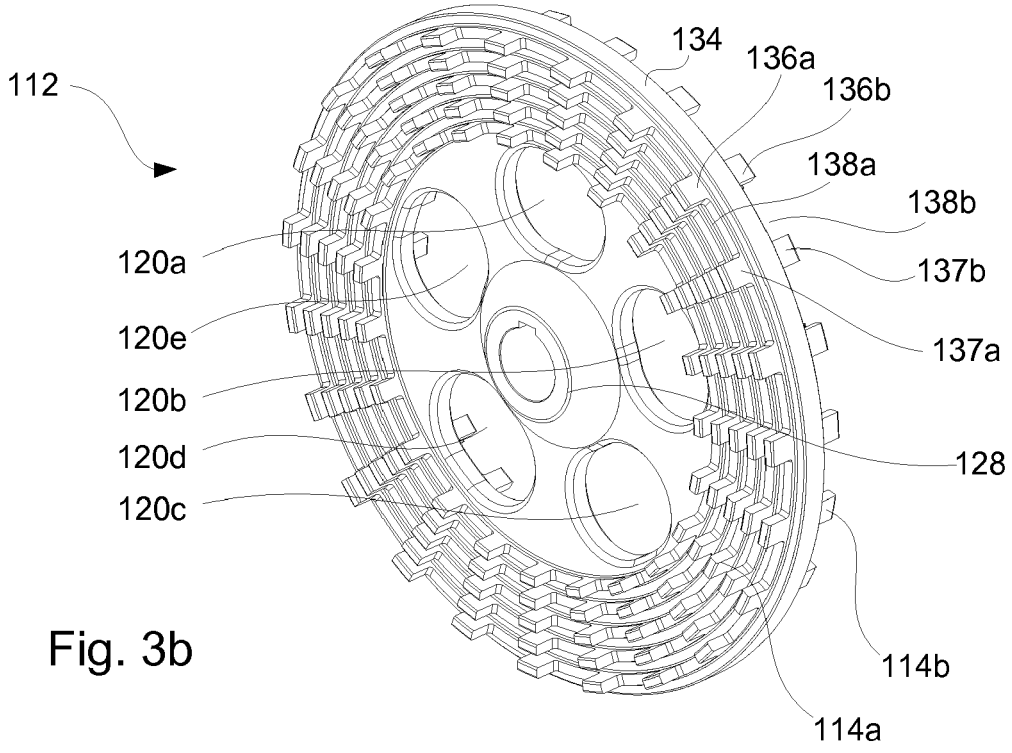

112
120a
120e
120b
120d
120c
134
136a
136b
138a
138b
137b
137a
128
114b
114a

Fig. 3b

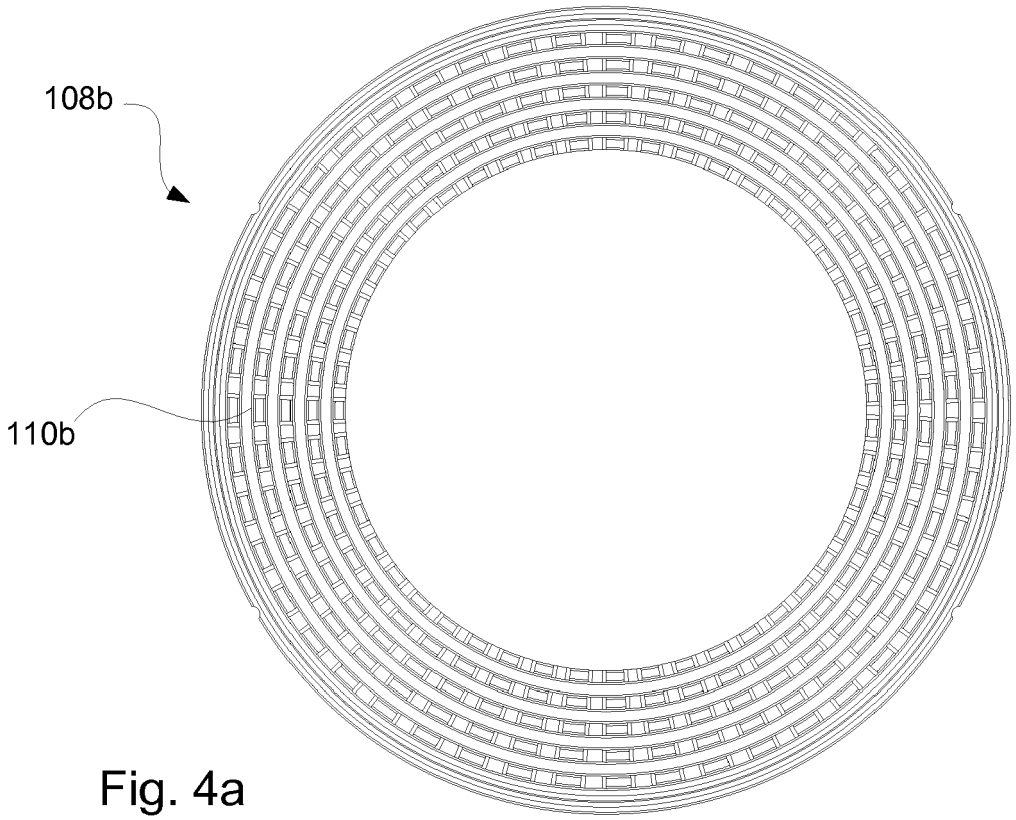


Fig. 4a

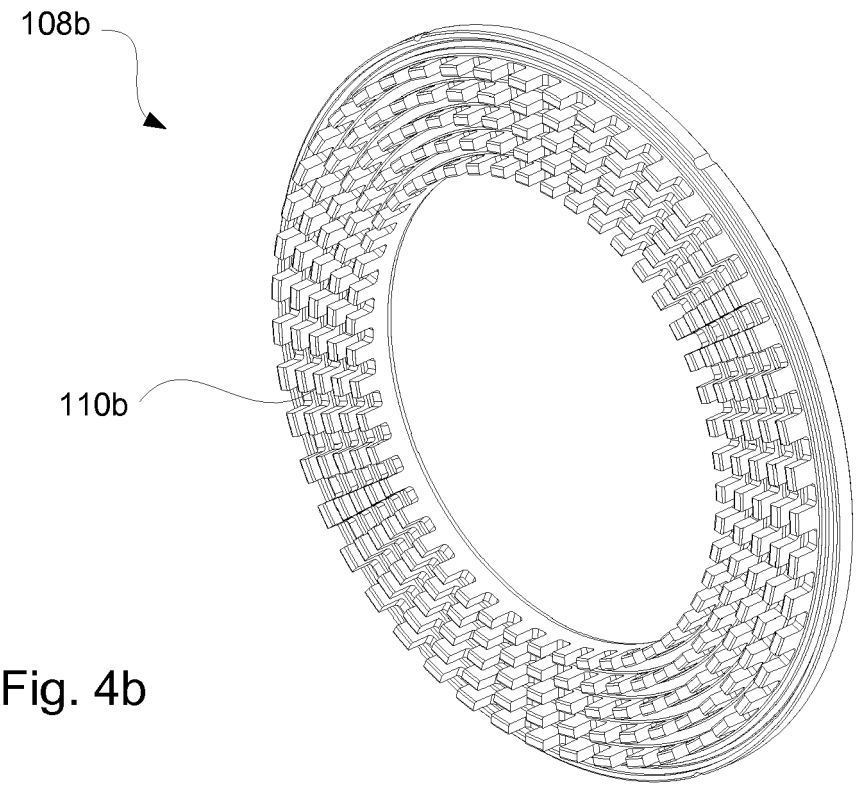


Fig. 4b

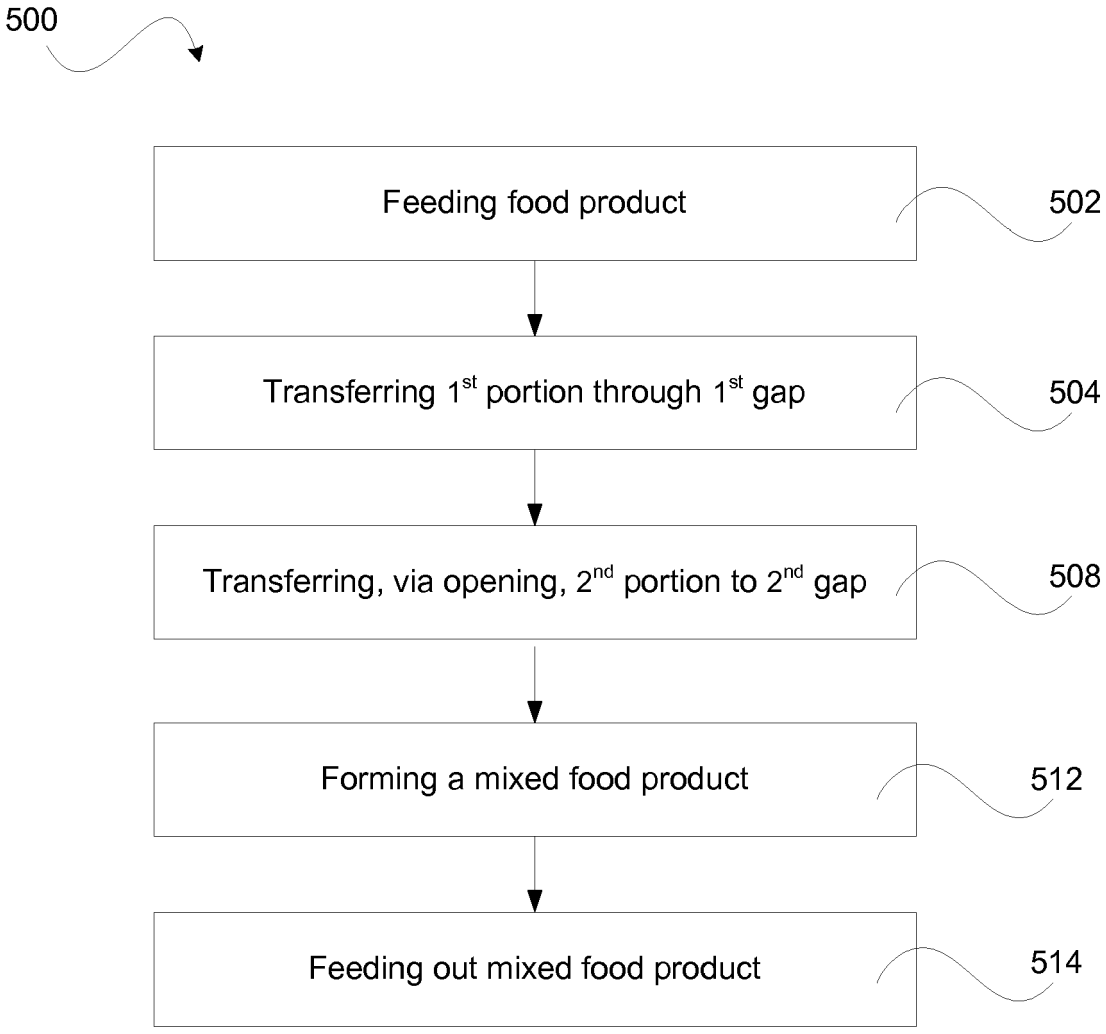

500
Feeding food product
502
Transferring 1st portion through 1st gap
504
Transferring, via opening, 2nd portion to 2nd gap
508
Forming a mixed food product
512
Feeding out mixed food product
514

Fig. 5

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 18 17 4436

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	* figures 1,2 * * column 1, line 44 - column 3, line 2 *	5,6	

TECHNICAL FIELDS SEARCHED (IPC)
B01F
B02C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 November 2018	Krasenbrink, B

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