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(54) A MACHINE AND A METHOD FOR EMULSIFYING A FOOD PRODUCT

(57) A machine (1) for emulsifying a food product. The machine conveys a food product from an upstream section past an emulsifier stack to a downstream section by a pressure difference between a pressure in the upstream section and a pressure in the downstream section. To allow improved control of the emulsifying process and potentially allow better flow control of the emulsified food product, the machine further comprises a pressure regulating structure configured to control the pressure difference between the pressure in the upstream section and the pressure in the downstream section.

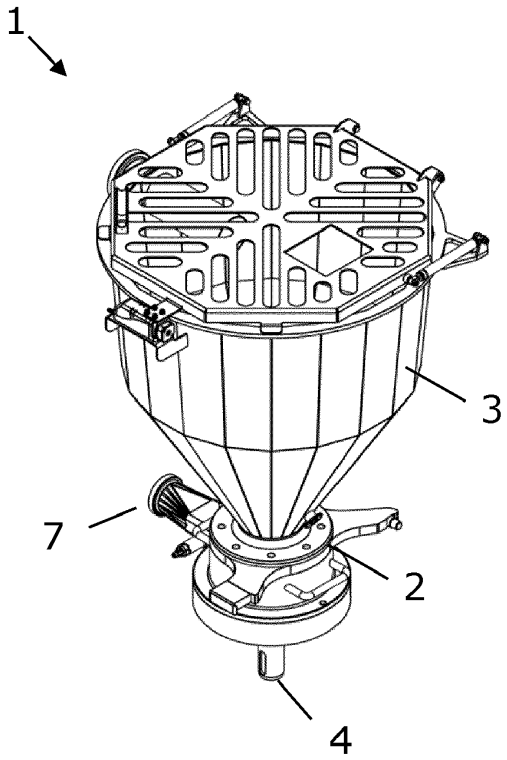

Fig. 1

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Description

INTRODUCTION

[0001] The present invention relates to a machine for emulsifying a food product, to an ejector knife for the machine and to a method for emulsifying a food product.

BACKGROUND

[0002] Emulsifying machines are indispensable for reducing and breaking down food ingredients into a finely uniform product. They are typically used for making sauces, purees or sausage mince in industrial scale.

[0003] Emulsifiers are often very large machines configured for a throughput of several tons of food per hour. In addition to quality of the emulsified food product, noise and safety are important design parameters.

[0004] In one type of emulsifier, the food product is moved across an emulsifier stack by a pressure difference and/or by gravity. Typically, the food is entered into a hopper above the machine. From the hopper, the food enters into an upstream section of the emulsifying part. From the upstream section, it moves by gravity and/or by a pressure difference to a downstream section on an opposite side of the emulsifier stack.

[0005] Variations in the pressure and/or in the structure of the food products may lead to uneven and loud operation and it may, eventually, reduce the quality of the emulsified food product.

SUMMARY

[0006] It is an object to improve the quality, reduce noise, and increase safety in operation of emulsifiers. It is a further object to allow improved control of the emulsifying process and potentially allow better flow control of the emulsified food product. Furthemore, it is an object to obtain less breakdowns of the emulsifier.

[0007] According to these and other objects, the disclosure provides a machine comprising a pressure regulating structure configured to control the pressure difference between the upstream section and the downstream section.

[0008] Since the pressure difference can be controlled, a more stable pressure difference can be obtained leading to a more uniform and potentially better quality of the emulsified product. Additionally, the flow speed can be controlled by controlling the pressure difference and this inter alia allows control of the temperature of the food product. Accordingly, the ability to control the pressure difference improves the process in several different ways.

[0009] The pressure regulating structure may comprise a valve configured to control a fluid flow into or out of the conduit. The valve could be a traditional flow control valve, e.g. a ball-valve etc.

[0010] The valve could be located in the downstream section, e.g. just below the emulsifier stack. This is advantageous since the pressure is low at this location and the pressure difference can therefore be controlled by letting air into the downstream section. This can be done particularly efficiently and simple by a valve arranged to open a passage between ambient space and the downstream section, i.e. simply letting ambient air into the conduit. As an alternative to the ambient space, fluid flow may be provided between the conduit and a pressure source having a reference pressure which is higher or lower than the pressure in the conduit at the location of the valve. In this case, the valve could be located anywhere in the conduit, e.g. in the upstream section, in the downstream section or therebetween. The pressure source could be a pressurised bottle, e.g. with nitrogen or it could be a compressor or a suction pump etc.

[0011] The valve could be electrically controlled, e.g. by a computer. This allows the pressure difference to be controlled based on sensor signals from one or more pressure sensors in the conduit.

[0012] A controller may communicate with such a pressure sensor and with the electrically controlled valve, and it may control the valve based on the electrical pressure signal.

[0013] The outlet may be constantly open. This allows a more robust outlet without the risk of obstructing the flow by a closure mechanism which may have become stuck by emulsified food product sticking to the closure mechanism. The constantly open outlet is enabled by the control of the pressure difference which thereby further simplifies the construction and makes the machine more robust and potentially reduces downtime due to a malfunction in a closure for the outlet.

[0014] The emulsifier stack may comprise at least one hole plate and at least one knife plate arranged towards each other, particularly arranged with a gap between each plate. The food product is allowed to move from the upstream section to the downstream section by penetration of holes in each hole plate and in each knife plate. Since the knife plates rotate relative to the hole plates, the food is emulsified during the passing across the emulsifier stack.

[0015] An ejector knife may be arranged in the downstream section for ejecting the food product towards the outlet. The ejector knife may generally have the shape of a propel, and it may be driven by the shaft via a connection between the shaft and a hub of the ejector knife.

[0016] The ejector knife may comprise ejector arms extending from the hub, and the ejector arms may have a shape such that each ejector arm extends radially outwards and defines a backwards projection extending tangentially backwards relative to a rotation direction of the shaft. The backwards projection may particularly be at the tip of the ejector arms, i.e. furthest away from the hub.

[0017] Each ejector arm may define a radial section and a tangential section. The radial section is located between the hub and the tangential section, i.e. the tangential section is furthest away from the hub. By definition

herein a ratio L_R/L_T is a ratio between a radial length L_R relative to a tangential dimension L_T. This ratio is larger for the radial section than for the tangential section.

[0018] Each ejector arm may have a leading edge and a trailing edge. These edges are defined by the direction of rotation such that the leading edge is ahead of the trailing edge. With this definition, the ejector arms may be shaped such that a thickness in the axial direction is smaller at the trailing edge than at the leading edge.

[0019] The ejector knife may operate more silently and more efficiently if it has a surface with a roughness R_a below 3,5, and even better below 2,5 or 1,5. This may be particularly important on the leading edges and/or near the leading edges.

[0020] The backwards projection may be radially displaced from the hub to define a gap, i.e. a void space along a radial tangent from the centre of the hub to the backwards projection.

[0021] The motor may be configured to rotate the shaft at constant speed. In one embodiment, the speed can be amended, but once it is specified by the operator, the motor will maintain a constant speed until the speed is amended again. In this embodiment, the pressure regulating structure may provide sufficient pressure change to initiate change a flow speed of the food product as a result of the change of the pressure difference between the upstream and downstream pressures. This allows flow control even at constant speed of the motor.

[0022] The ejector knife may be to create the pressure difference or at least a part of the pressure difference as a result of the rotation of the shaft. Another part of the pressure difference may be caused by the layout of the emulsifier stack.

[0023] The emulsifier stack may e.g. comprise a propeller arranged right after the upstream section, i.e. at an upstream part of the emulsifier stack. This propeller may propel the food product into the emulsifier stack. The propeller may be driven by the shaft, and it may comprise a propeller hub and propeller blades each extending from the hup towards a blade tip. To create better flow conditions, the blade tip may be located close to a wall of the conduit. Accordingly, a distance smaller than 10 mm between the conduit wall and the tip may be preferable.

[0024] A housing insert may be releasably received in, or fixedly joined with the housing. The housing insert may extend about the propeller and form a part of the conduit. The housing insert may form the conduit wall at the propeller, and it may thus ensure a short distance between the tip and wall of the conduit.

[0025] The housing insert may separate an inner chamber from an outer chamber such that the propeller, which is housed in the inner chamber is separated from an outer chamber being radially outside the housing insert. Particularly when this outer chamber is void, it may be useful for fluid communication between the conduit and an external pressure source such as the ambience since the void space and the housing insert may isolate the food product in the conduit from the valve and thereby reduce the risk of clogging. Accordingly, the valve may provide fluid communication directly with the outer chamber.

[0026] An inner surface of the housing insert, i.e. a surface facing the propeller may be rifled to improve the flow of the food product against the surface of the housing insert.

[0027] The shaft may enter the conduit via a shaft opening in the bottom of the housing. The shaft may particularly enter directly into the downstream section.

[0028] The machine may comprise a sealing ring arranged between a shaft opening in the housing and the shaft. The sealing ring serves to seal a gap between the shaft and the housing during rotation of the shaft relative to the housing and thus to ensure a stable pressure, particularly in the downstream section.

[0029] The sealing ring may comprise a sealing base arranged in contact with the housing, and at least one lip sealing portion extending radially from the base towards the shaft. To ensure that a low pressure in the downstream section is not disturbed by air leaking from ambient space via the gap between the housing and the shaft, the lip sealing portion may further extend axially along an outer surface of the shaft in a direction away from the emulsifier stack. A low pressure in the downstream section as compared with ambient pressure will thereby push the lip sealing portion against the surface of the shaft and ensure a tight seal and a more stable low pressure in the downstream section. This may further increase the ability to control the pressure difference between the upstream section and the downstream section, and it may therefore further improve the emulsifying process and increase the ability to control flow speed based on the pressure difference.

[0030] In an alternative layout of the sealing ring, the sealing ring is attached oppositely and comprises a sealing base arranged in contact with an outer surface of the shaft, and at least one lip sealing portion extending radially from the base towards the housing. The lip sealing portion may extend axially along a surface of the housing in a direction away from the emulsifier stack.

[0031] In a second aspect, the disclosure provides an ejector knife for an emulsifying machine, the ejector knife comprising a hub engageable by a shaft for rotation about an axially extending rotation axis, and ejector arms extending from the hub. Each ejector arm may extend radially outwards and define a backwards projection extending tangentially backwards relative to a rotation direction of the shaft. This shape may reduce pressure fluctuations in the downstream section and reduce noise during operation.

[0032] Each ejector arm may define a radial section and a tangential section, the radial section located between the hub and the tangential section and a ratio L_R/L_T between a radial length L_R relative to a tangential dimension L_T, of the radial section is larger than the same ratio of the tangential section.

[0033] Each ejector arm may have a leading edge and a trailing edge, and wherein a thickness in the axial direction is smaller at the trailing edge than at the leading edge.

[0034] The backwards projection may be radially displaced from the hub to define a gap between the hub and the backwards projection.

[0035] In a third aspect, the disclosure provides a method of emulsifying a food product in a machine comprising:

- a housing forming a conduit arranged to receive the food product at an inlet and to deliver the food product at an outlet,
- a shaft which is driven by a motor to rotate about a rotation axis thereby defining an axial direction along the rotation axis, a radial direction perpendicular to the axial direction, and a tangential direction defining a tangent to the rotation, and
- an emulsifier stack driven by the shaft and arranged in the conduit to emulsify the food product when it moves from an upstream section of the conduit to a downstream section of the conduit.

[0036] The method comprises conveying the food product from the upstream section to the downstream section by use of a pressure difference across the emulsifier, and controlling a flow speed of the food product through the emulsifier by amending the pressure difference.

[0037] The flow speed may be amended to cause a change in temperature of the food product, and the speed of the shaft may be amended to cause a change in temperature of the food product.

[0038] In a fourth aspect, the disclosure provides a machine for emulsifying a food product comprising:

- a housing forming a conduit arranged to receive the food product at an inlet and to deliver the food product at an outlet,
- a shaft which is driven by a motor to rotate about a rotation axis thereby defining an axial direction along the rotation axis, a radial direction perpendicular to the axial direction, and a tangential direction defining a tangent to the rotation, and
- an emulsifier stack driven by the shaft and arranged in the conduit to emulsify the food product when it moves from an upstream section of the conduit to a downstream section of the conduit,

the machine being configured to convey a food product from the upstream section to the downstream section by a pressure difference between an upstream pressure in the upstream section and a downstream pressure in the downstream section, and wherein the machine further comprises an ejector knife in the downstream section, the ejector knife comprising a hub engageable by a shaft for rotation about an axially extending rotation axis, and ejector arms extending from the hub, wherein each ejector arm extends radially outwards and defines a backwards projection extending tangentially backwards relative to a rotation direction of the shaft.

[0039] The specific shape and the backwards projection of the ejector knife provides a more stable pressure in the downstream section and thus potentially improves the process and improves the ability to control a pressure difference between the upstream section and the downstream section.

[0040] Additionally, the machine may comprise any of the features mentioned relative to the machine according to the first aspect of the disclosure.

[0041] Each ejector arm may define a radial section and a tangential section, the radial section located between the hub and the tangential section and a ratio L_R/L_T between a radial length L_R relative to a tangential dimension L_T, of the radial section is larger than the same ratio of the tangential section.

[0042] Each ejector arm may have a leading edge and a trailing edge, and wherein a thickness in the axial direction is smaller at the trailing edge than at the leading edge.

[0043] The backwards projection may be radially displaced from the hub to define a gap between the hub and the backwards projection.

[0044] The specific details about the ejector knife improves the ability to provide a stable pressure in the downstream section.

LIST OF DRAWINGS

[0045] The drawings illustrate embodiments and together with the description, they explain principles of embodiments. Other embodiments and intended advantages of embodiments will be readily appreciated as they become better understood by reference to the following detailed description. The elements of the drawings are not necessarily to scale relative to each other. Like reference numerals designate corresponding similar parts.

Fig. 1 illustrates an emulsifier in a perspective view;

Fig. 2 illustrates the emulsifier in a sideview including the electrical motor driving the shaft;

Fig. 3 illustrates the emulsifier unit of the emulsifier in Figs. 1 and 2;

Fig. 4 illustrates a cross section of the emulsifier unit in fig. 3.

Fig. 5 illustrates the emulsifier unit in an exploded view;

Fig. 6 illustrates the emulsifier connected to a pressure source and a controller in the form of a computer.

Figs. 7 and 8 illustrate the ejector knife of the emulsifier;

Fig. 9 illustrates details of the ejector arm of the ejector knife;

Fig. 10 illustrates details of a housing insert; and

Fig. 11 illustrates a sealing ring between the housing and the shaft.

DESCRIPTION OF EMBODIMENTS

[0046] Fig. 1 illustrates a machine for emulsifying food products in a perspective view and Fig. 2 illustrates the machine in a sideview including an electrical motor for driving the shaft of the machine.

[0047] The machine comprises a housing 2, e.g. made of stainless steel or a similar durable material. A hopper 3 allows easy loading of food products into the machine, and the shaft 4 is connected to a motor 5 via a belt 6. The emulsified food product leaves the machine via outlet 7.

[0048] Fig. 3 illustrates the emulsifier unit and Fig. 4 illustrates the emulsifier unit in a crosssectional view. Fig. 5 illustrates the emulsifier unit in an exploded view.

[0049] Referring to Figs. 3-5, the housing 2 is constituted by the upper housing part 31 and the lower housing part 32. The housing defines a conduit illustrated by the dotted line 33 in Fig. 4. The conduit extends from an inlet 34 to the outlet 7. At the inlet 34, the conduit 33 receives food products, e.g. lumps of meat (such as a mixture including minced meat) etc. from the hopper 3 (Figs. 1 and 2), such that food product can enter the emulsifier in an efficient manner. The machine is typically, however not necessarily, arranged in an upright orientation such that the gravity supports movement of the food product from the inlet to the outlet. Generally, however, the food product are moved from the inlet to the outlet by a pressure difference between the upstream section and the downstream section.

[0050] The shaft 4 extends through the housing, and particularly through the lower housing part 32 into the conduit where it drives an emulsifier stack 35 and a ejector knife 36.

[0051] The shaft 4 rotates about a rotation axis indicated by the dotted line 37 and thereby define an axial direction along the rotation axis. The arrow 38 indicates a radial direction which is perpendicular to the axial direction. Further, the arrow 39 indicates a tangential direction defining a tangent to the rotation direction and thus a tangent to the rotating parts of the machine.

[0052] The emulsifier stack 35 is driven by the shaft and arranged in the conduit to emulsify the food product when it moves from an upstream section of the conduit to a downstream section of the conduit.

[0053] Herein, the terms "upstream" and "downstream" refers to the flow direction of the food product when it passes through the machine.

[0054] The emulsifier stack 35 comprises a plurality of hole plates 40-41 interleaved between knife plates 42-44. Both the hole plates and the knife plates are circular plates with holes. The hole plates are rotationally fixed by projections of the housing engaging the notch 45 of the hole plates. The knife plates are rotationally locked to the shaft via the hub structure 46 (only indicated on the top knife plate). Accordingly, the knife plates rotate relative to the hole plates, and the food product is emulsified as it moves from the upstream section to the downstream section by penetration of holes in each hole plate and in each knife plate during rotation of the knife plates relative to the hole plates.

[0055] The hole plates and the knife plates are arranged towards each, however, with a gap between them. Accordingly, the plates do not touch each other and wear of the surface of the plates can be reduced.

[0056] The emulsifier stack further comprises a propeller 47 urging the food product into the stack.

[0057] A housing insert 48 is inserted into the upper housing part 31 and encloses circumferentially the propeller 47. By this housing insert 48, the propeller 47 rotates in close vicinity to the wall of the housing insert which may improve the flow of food product. Additionally, the housing insert creates a void outer chamber between the upper housing part 31 and the housing insert 48. The propeller comprises a propeller hub and propeller blades each extending from the hup towards a blade tip. The blade tip is located against a wall of the housing insert at a distance smaller than 10 mm such as smaller than 3 mm or 2 mm.

[0058] The pressure difference between the downstream section and the upstream section is inter alia caused by rotation of the knife plates relative to the hole plates and optionally also by the ejector knife 36 which propels the emulsified food product out of the outlet. This propelling of the food product creates a low pressure in the downstream section as compared with the upstream section, and the pressure difference draws food into the emulsifier stack.

[0059] The machine further comprises a pressure regulating structure configured to control the pressure difference between the upstream section and the downstream section. In the illustrated embodiment, the pressure regulating structure comprises a valve 49 inserted into a port 50 and thereby controlling a fluid flow into or out of the conduit.

[0060] The valve could be located at any location in the conduit, however, the illustrated position at the downstream section may provide an advantage. At this section, the pressure is low, at the valve, when opening a passage e.g. to ambience, may reduce the low pressure. At this position, the pressure reduction will occur by letting ambient air into the conduit, and the risk of contaminating the ambience with the emulsified food product is low, or not existing since the fluid flow is inwards into the conduit.

[0061] Fig. 5 also illustrates that the outlet 7 is con-

stantly open, i.e. there are no control valve arranged to open and close the outlet. This is possible since the flow can be controlled by the pressure regulating structure, e.g. in the form of the valve 49.

[0062] In the bottom of the lower housing part 32, the lower housing part 32 forms a seal-housing closed by the cover 51. The seal housing houses a seal which will be discussed in further details relative to Fig. 11.

[0063] Fig. 6 illustrates an embodiment where the valve 49 is connected to a pressure source having a reference pressure. The pressure source is illustrated by a pressure bottle 60, but it could be a suction pump, a compressor or any similar means for creating a flow out of, or into the conduit, i.e. a pressure which is higher or lower than the pressure in the conduit at the location of the valve. This allows the valve to be located anywhere in the conduit, e.g. in the upstream section or at a location between the upstream section and the downstream section, i.e. at a location of the emulsifying stack.

[0064] Fig. 6 illustrates that the valve could be electrically controlled by a controller 61. The controller may, additionally, communicate with a pressure sensor (not shown). In this way, the electrically controlled valve can be controlled based on a sensed pressure in the conduit. The functions of the controller may be implemented using standard hardware circuits, using software programs and data in conjunction with a suitably programmed digital microprocessor or general-purpose computer, or a cloud computer, and/or using application specific integrated circuitry, and/or using one or more digital signal processors. Software program instructions and data may be stored on a non-transitory, computer-readable storage medium, or in the cloud, and when the instructions are executed by a computer or other suitable processor control, the computer or processor performs the functions associated with those instructions. Accordingly, the disclosure comprises software readable by computer means for carrying out the method and thereby providing the system for controlling the pressure difference between the upstream pressure and the downstream pressure.

[0065] Figs. 7-8 illustrate the ejector knife 36. The ejector knife is located in the downstream section, and it is configured to eject the food product towards the outlet 7.

[0066] The ejector knife comprises a hub 70 which is engaged by the shaft 4 and the ejector knife is thereby rotated by the shaft.

[0067] Ejector arms 71 extend radially from the hub, and each arm defines a backwards projection 72 extending tangentially backwards relative to a rotation direction of the shaft and thus the ejector knife. In addition to the backwards projection, the ejector arms may also comprise a forward projection 73 extending tangentially forwards relative to a rotation direction of the shaft and thus the ejector knife.

[0068] The forward projection 73 extends as a cantilever structure of the leading edge of the ejector knife. The forward projection is preferably located as an upstream part of the ejector knife.Each ejector arm has a leading edge 74 and a trailing edge 75. A thickness in the axial direction indicated by the dotted line 76 is smaller at the trailing edge than at the leading edge.

[0069] The backwards projection 72 is radially displaced from the hub to define a gap 77 between the hub and the backwards projection.

[0070] The rotation direction of the ejector knife 36 is indicated by the arrow 78

[0071] Each ejector arm 71 defines a radial section 90 and a tangential section 91. This is illustrated on one of the ejector arms 71 in the enlarged view of Fig. 9.

[0072] The radial section is located between the hub and the tangential section, and the radial and tangential section can be defined by a ratio, specifically the ratio L_R/L_T between a radial length L_R relative to a tangential dimension L_T. This ratio of the radial section is larger than the same ratio of the tangential section.

[0073] The ejector knife is machined to provide a surface portion with a roughness $R_a<3,5$ such as below 2,5 or 1,5 or even below 1. Particularly this counts for the leading edge and the area around the leading edge.

[0074] Fig. 10 illustrates an enlarged view of the housing insert 48 and the propeller 47. The housing insert is releasably received in the housing and extends circumferentially about the propeller. Alternatively, the housing insert is moulded in one part with the housing or is irreversibly fixed to the housing.

[0075] The housing insert 48 separates an inner chamber 100 from an outer chamber 101. The inner chamber houses the propeller 47, and the outer chamber 101 is radially outside the housing insert and is void. In this embodiment, the valve 49 may provide fluid communication into the void outer chamber 101 thereby allowing release of air from this chamber. Since the chamber is separated from the flow of food product, air may be released from the conduit without contaminating the surroundings with the food product.

[0076] The inner surface 102 of the housing insert, i. e. the surface facing the propeller, may be rifled (not shown).

[0077] Fig. 11 illustrates the bottom of the lower housing part 32, and particularly a seal-housing closed by the cover 51. The seal housing houses a sealing ring 110. By the location in a recess in the bottom of the lower housing part, it becomes located such that the downstream section is between the sealing ring and the emulsifier stack. The sealing ring seals a gap between the shaft 4 and the lower housing part 32 during rotation of the shaft relative to the housing, and it therefore preserves a low pressure in the downstream section compared to the pressure in the upstream section. This ensures a controllable flow of the food product.

[0078] The sealing ring comprises a sealing base 111 arranged in contact with the housing, particularly the lower housing part 32, and two lip sealing portions 112, 113 extending radially from the base towards the shaft 4- The lip sealing portions further extend axially along an outer

surface of the shaft in a direction away from the emulsifier stack, illustrated by the arrow 114.

LIST OF NUMBERED EMBODIMENTS

[0079]

1. A machine (1) for emulsifying a food product comprising:

- a housing (2) forming a conduit (33) arranged to receive the food product at an inlet (34) and to deliver the food product at an outlet (7),
- a shaft (4) which is driven by a motor (5) to rotate about a rotation axis thereby defining an axial direction along the rotation axis, a radial direction perpendicular to the axial direction, and a tangential direction defining a tangent to the rotation, and
- an emulsifier stack (35) driven by the shaft (4) and arranged in the conduit (33) to emulsify the food product when it moves from an upstream section of the conduit to a downstream section of the conduit,

the machine being configured to convey a food product from the upstream section to the downstream section by a pressure difference between an upstream pressure in the upstream section and a downstream pressure in the downstream section, and wherein the machine further comprises a pressure regulating structure configured to control the pressure difference.

2. The machine according to embodiment 1, wherein the pressure regulating structure comprises a valve (49) configured to control a fluid flow into or out of the conduit.

3. The machine according to embodiment 2, wherein the valve is located in the downstream section.

4. The machine according to embodiment 2 or 3, wherein the valve connects the conduit to ambient pressure or to a pressure source having a reference pressure which is higher or lower than the pressure in the conduit at the location of the valve.

5. The machine according to embodiment 2 wherein the downstream valve is an electrically controlled valve.

6. The machine according to embodiment 5, further comprising a controller in communication with a pressure sensor and the electrically controlled valve, the pressure sensor being arranged to provide an electrical pressure signal representing the pressure difference, and the controller being configured to control the valve based on the electrical pressure signal.

7. The machine according to any of the preceding embodiments, wherein the outlet is constantly open.

8. The machine according to any of the preceding embodiments, wherein the emulsifier stack comprises at least one hole plate (40,41) and at least one knife plate (42,43,44) arranged towards each other to allow the food product to move from the upstream section to the downstream section by penetration of holes in each hole plate and in each knife plate during rotation of the at least one knife plate relative to the at least one hole plate about the rotation axis.

9. The machine according to any of the preceding embodiments, comprising an ejector knife (36) configured to eject the food product towards the outlet, the ejector knife being located in the downstream section of the conduit.

10. The machine according to embodiment 9, wherein the ejector knife (36) is driven by the shaft (4).

11. The machine according to embodiment 10, wherein the ejector knife (36) comprises a hub (70) engaged by the shaft (4), and ejector arms (71) extending from the hub, wherein each ejector arm extends radially outwards and defines a backwards projection (72) extending tangentially backwards relative to a rotation direction of the shaft.

12. The machine according to embodiment 11, wherein each ejector arm defines a radial section and a tangential section, the radial section located between the hub and the tangential section and a ratio L_R/L_T between a radial length L_R relative to a tangential dimension L_T, of the radial section is larger than the same ratio of the tangential section.

13. The machine according to any of embodiments 11-12, wherein each ejector arm has a leading edge (74) and a trailing edge (75), and wherein a thickness in the axial direction is smaller at the trailing edge than at the leading edge.

14. The machine according to any of embodiments 11-13, wherein the ejector knife (36) defines a surface portion with a roughness R_a<3,5.

15. The machine according to any of embodiments 11-14, wherein the backwards projection is radially displaced from the hub to define a gap (77) between the hub and the backwards projection.

16. The machine according to any of the preceding embodiments, wherein the motor (5) is configured

to rotate the shaft (4) at constant speed, and the pressure regulating structure is configured to control the pressure difference to change a flow speed of the food product at the constant speed of the motor.

17. The machine according to embodiments 8-16, wherein the ejector knife, is configured to create at least part of the pressure difference as a result of the rotation of the shaft.

18. The machine according to any of the preceding embodiments, further comprising a propeller (47) arranged in an upstream part of the emulsifier stack.

19. The machine according to any of the preceding embodiments, wherein the propeller (47) is driven by the shaft (4).

20. The machine according to embodiments 18-19, wherein the propeller comprises a propeller hub and propeller blades each extending from the hup towards a blade tip, wherein the blade tip is located against a wall of the conduit at a distance smaller than 10 mm.

21. The machine according to embodiment 19 or 20, comprising a housing insert (48) releasably received in the housing and extending circumferentially about the propeller.

22. The machine according to embodiment 21, wherein the housing insert (48) separates an inner chamber (100) from an outer chamber (101), the inner chamber housing the propeller (47), and the outer chamber being radially outside the housing insert (48).

23. The machine according to embodiment 22, wherein the outer chamber (101) is void.

24. The machine according to embodiment 2 and any of embodiments 22-23, wherein the valve (49) provides fluid communication directly with the outer chamber.

25. The machine according to embodiment 21-24, wherein the housing insert has an inner surface facing the propeller and being rifled.

26. The machine according to any of the preceding embodiments, comprising a sealing ring (110) arranged between a shaft opening in the housing (2) and the shaft (4), the sealing ring being arranged to seal a gap between the shaft (4) and the housing (2) during rotation of the shaft relative to the housing.

27. The machine according to embodiment 26, wherein the sealing ring (110) comprises a sealing base (111) arranged in contact with the housing (2), and at least one lip sealing portion (112, 113) extending radially from the base (111) towards the shaft (4), wherein the lip sealing portion further extends axially along an outer surface of the shaft in a direction away from the emulsifier stack.

28. The machine according to embodiment 26, wherein the sealing ring comprises a sealing base arranged in contact with an outer surface of the shaft, and at least one lip sealing portion extending radially from the base towards the housing, wherein the lip sealing portion further extends axially along a surface of the housing in a direction away from the emulsifier stack.

29. An ejector knife for an emulsifying machine, the ejector knife comprising a hub engageable by a shaft for rotation about an axially extending rotation axis, and ejector arms extending from the hub, wherein each ejector arm extends radially outwards and defines a backwards projection extending tangentially backwards relative to a rotation direction of the shaft.

30. The ejector knife according to embodiment 29, wherein each ejector arm defines a radial section and a tangential section, the radial section located between the hub and the tangential section and a ratio L_R/L_T between a radial length L_R relative to a tangential dimension L_T, of the radial section is larger than the same ratio of the tangential section.

31. The ejector knife according to any of embodiments 29-30, wherein each ejector arm has a leading edge and a trailing edge, and wherein a thickness in the axial direction is smaller at the trailing edge than at the leading edge.

32. The ejector knife according to any of embodiments 29-31, wherein the backwards projection is radially displaced from the hub to define a gap between the hub and the backwards projection.

33. A method of emulsifying a food product in a machine comprising:

- a housing forming a conduit arranged to receive the food product at an inlet and to deliver the food product at an outlet,
- a shaft which is driven by a motor to rotate about a rotation axis thereby defining an axial direction along the rotation axis, a radial direction perpendicular to the axial direction, and a tangential direction defining a tangent to the rotation, and
- an emulsifier stack driven by the shaft and arranged in the conduit to emulsify the food product when it moves from an upstream section of the conduit to a downstream section of the con-

duit,

the method comprising conveying the food product from the upstream section to the downstream section by use of a pressure difference across the emulsifier and regulating a flow speed of the food product through the emulsifier by amending the pressure difference.

34. The method according to embodiment 33, wherein the flow speed is amended to cause a change in temperature of the food product.

35. The method according to embodiment 33 or 34, wherein a speed of the shaft is amended to cause a change in temperature of the food product.

36. A machine (1) for emulsifying a food product comprising:

- a housing (2) forming a conduit (33) arranged to receive the food product at an inlet (34) and to deliver the food product at an outlet (7),
- a shaft (4) which is driven by a motor (5) to rotate about a rotation axis thereby defining an axial direction along the rotation axis, a radial direction perpendicular to the axial direction, and a tangential direction defining a tangent to the rotation, and
- an emulsifier stack (35) driven by the shaft (4) and arranged in the conduit (33) to emulsify the food product when it moves from an upstream section of the conduit to a downstream section of the conduit,

the machine being configured to convey a food product from the upstream section to the downstream section by a pressure difference between an upstream pressure in the upstream section and a downstream pressure in the downstream section, and wherein the machine further comprises an ejector knife in the downstream section, the ejector knife comprising a hub engageable by a shaft for rotation about an axially extending rotation axis, and ejector arms extending from the hub, wherein each ejector arm extends radially outwards and defines a backwards projection extending tangentially backwards relative to a rotation direction of the shaft.

Claims

1. A machine (1) for emulsifying a food product comprising:

- a housing (2) forming a conduit (33) arranged to receive the food product at an inlet (34) and to deliver the food product at an outlet (7),
- a shaft (4) which is driven by a motor (5) to rotate about a rotation axis thereby defining an axial direction along the rotation axis, a radial direction perpendicular to the axial direction, and a tangential direction defining a tangent to the rotation, and
- an emulsifier stack (35) driven by the shaft (4) and arranged in the conduit (33) to emulsify the food product when it moves from an upstream section of the conduit to a downstream section of the conduit,

the machine being configured to convey a food product from the upstream section to the downstream section by a pressure difference between an upstream pressure in the upstream section and a downstream pressure in the downstream section, and wherein the machine further comprises a pressure regulating structure configured to control the pressure difference.

2. The machine according to claim 1, wherein the pressure regulating structure comprises a valve (49) configured to control a fluid flow into or out of the conduit.

3. The machine according to claim 2, wherein the valve is located in the downstream section.

4. The machine according to claim 2 or 3, wherein the valve connects the conduit to ambient pressure or to a pressure source having a reference pressure which is higher or lower than the pressure in the conduit at the location of the valve.

5. The machine according to claim 2 wherein the downstream valve is an electrically controlled valve.

6. The machine according to claim 5, further comprising a controller in communication with a pressure sensor and the electrically controlled valve, the pressure sensor being arranged to provide an electrical pressure signal representing the pressure difference, and the controller being configured to control the valve based on the electrical pressure signal.

7. The machine according to any of the preceding claims, wherein the outlet is constantly open.

8. The machine according to any of the preceding claims, wherein the emulsifier stack comprises at least one hole plate (40,41) and at least one knife plate (42,43,44) arranged towards each other to allow the food product to move from the upstream section to the downstream section by penetration of holes in each hole plate and in each knife plate during rotation of the at least one knife plate relative to the at least one hole plate about the rotation axis.

9. The machine according to any of the preceding claims, comprising an ejector knife (36) configured to eject the food product towards the outlet, the ejector knife being located in the downstream section of the conduit.

10. The machine according to claim 9, wherein the ejector knife (36) is driven by the shaft (4).

11. The machine according to claim 10, wherein the ejector knife (36) comprises a hub (70) engaged by the shaft (4), and ejector arms (71) extending from the hub, wherein each ejector arm extends radially outwards and defines a backwards projection (72) extending tangentially backwards relative to a rotation direction of the shaft.

12. The machine according to claim 11, wherein each ejector arm defines a radial section and a tangential section, the radial section located between the hub and the tangential section and a ratio L_R/L_T between a radial length L_R relative to a tangential dimension L_T, of the radial section is larger than the same ratio of the tangential section.

13. The machine according to any of claims 11-12, wherein each ejector arm has a leading edge (74) and a trailing edge (75), and wherein a thickness in the axial direction is smaller at the trailing edge than at the leading edge.

14. The machine according to any of claims 11-13, wherein the ejector knife (36) defines a surface portion with a roughness R_a<3,5.

15. The machine according to any of claims 11-14, wherein the backwards projection is radially displaced from the hub to define a gap (77) between the hub and the backwards projection.

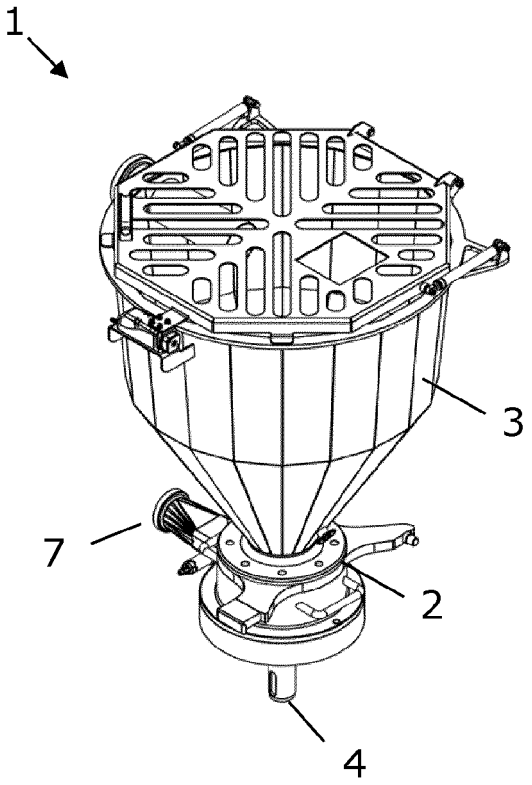

Fig. 1

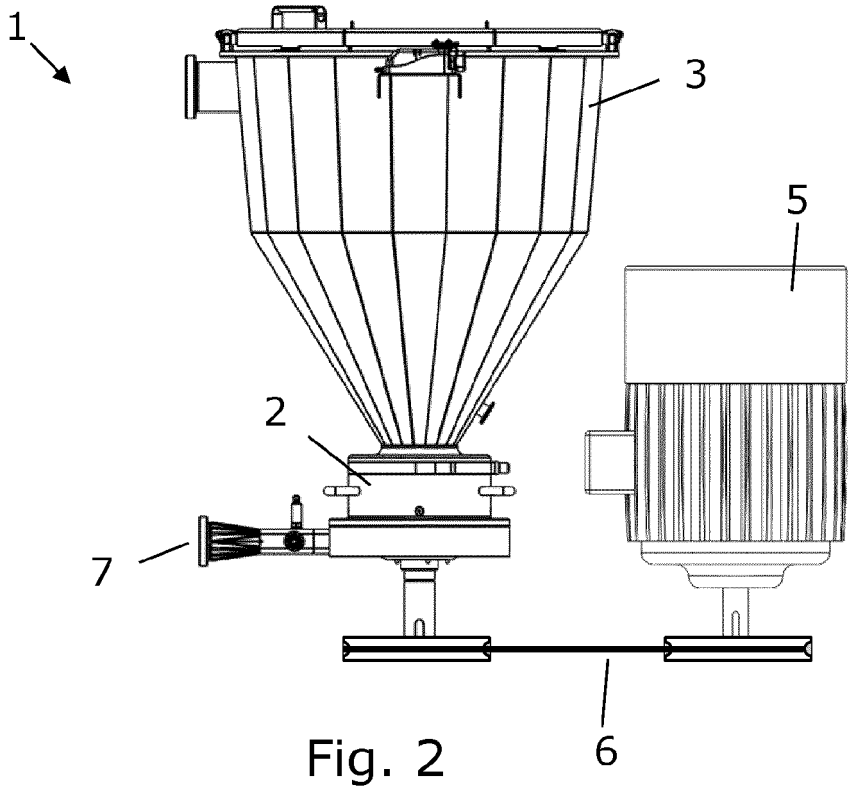

Fig. 2

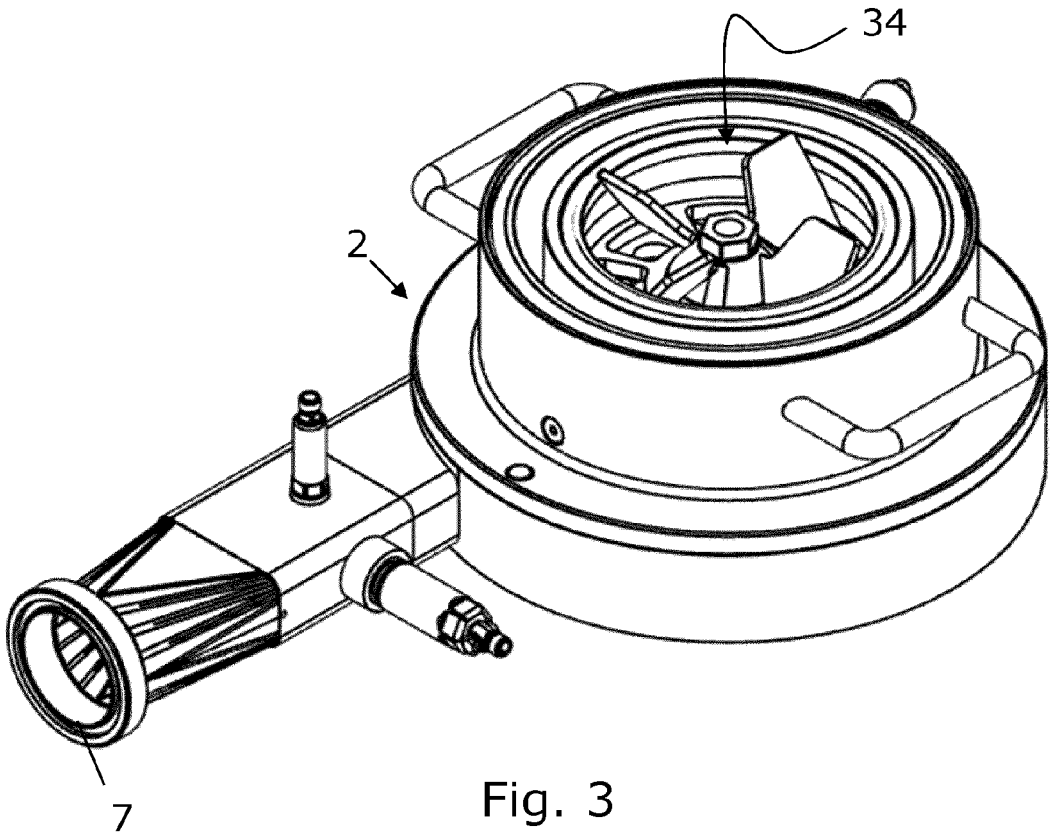

Fig. 3

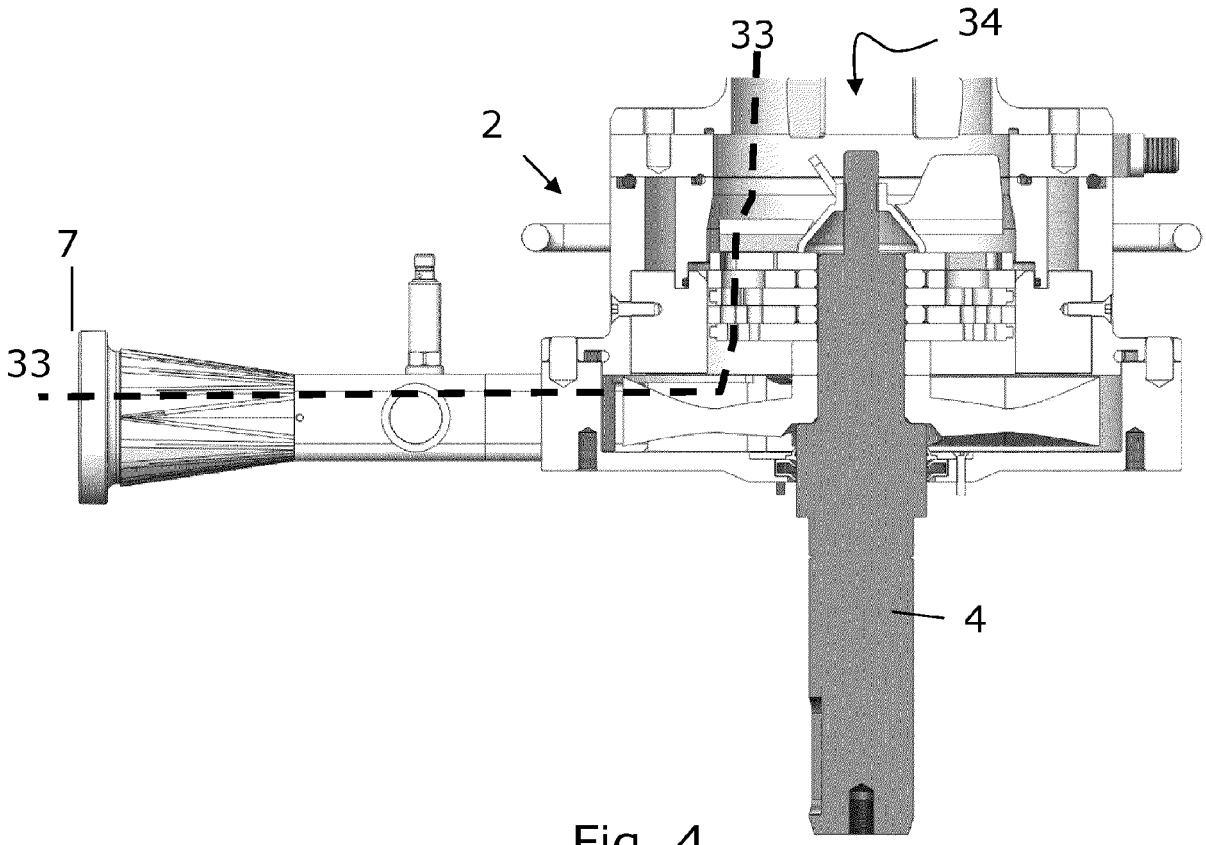

Fig. 4

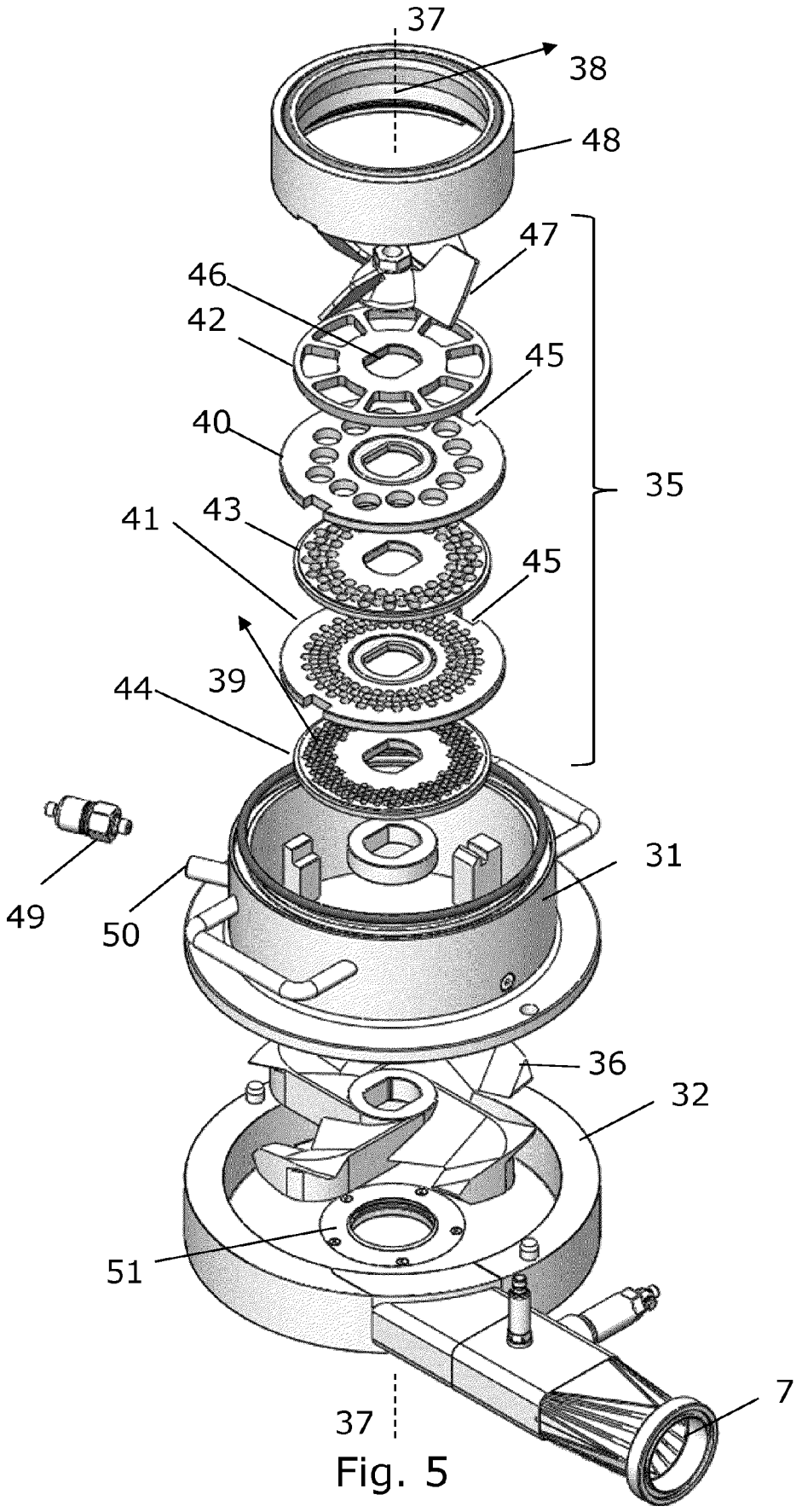

Fig. 5

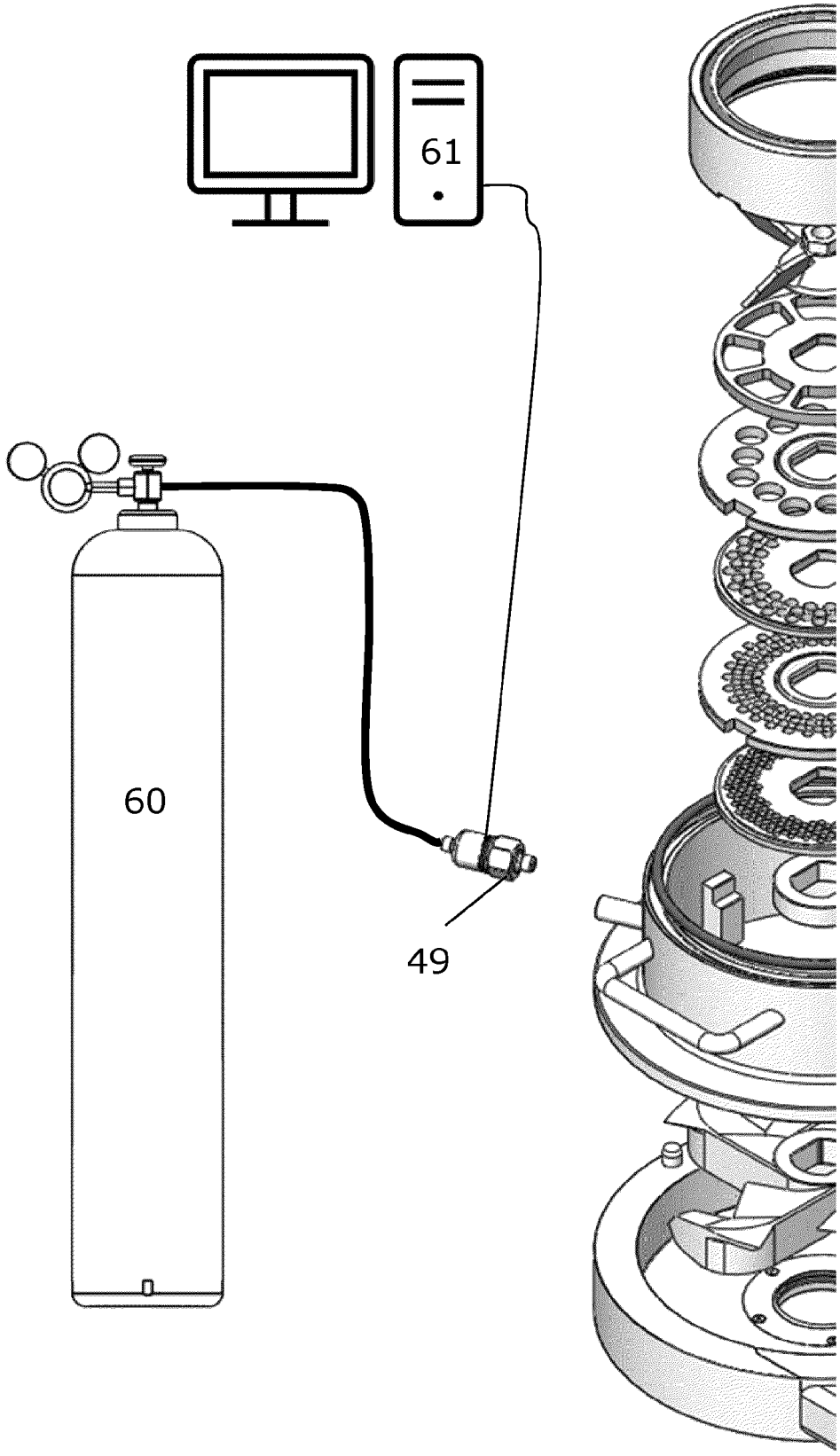

Fig. 6

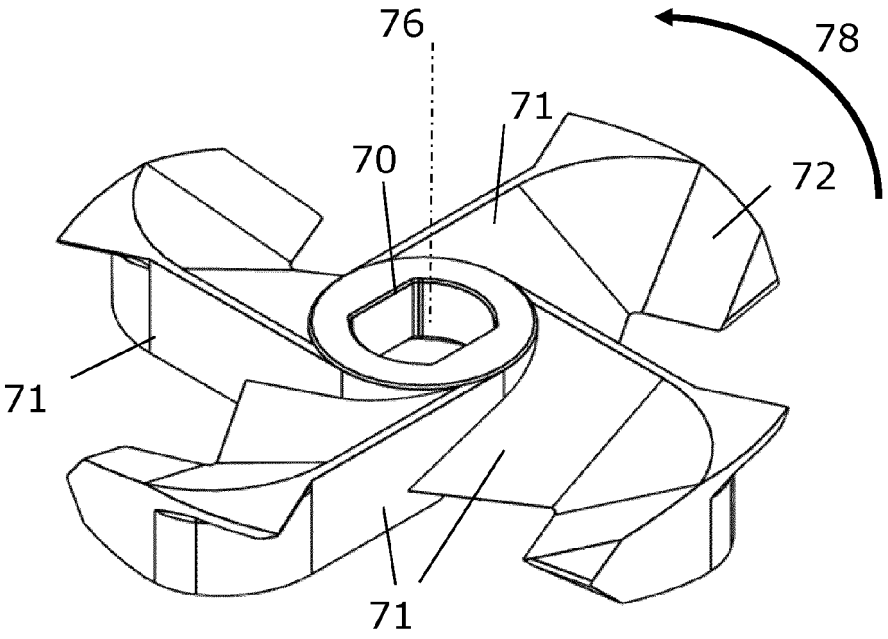

Fig. 7

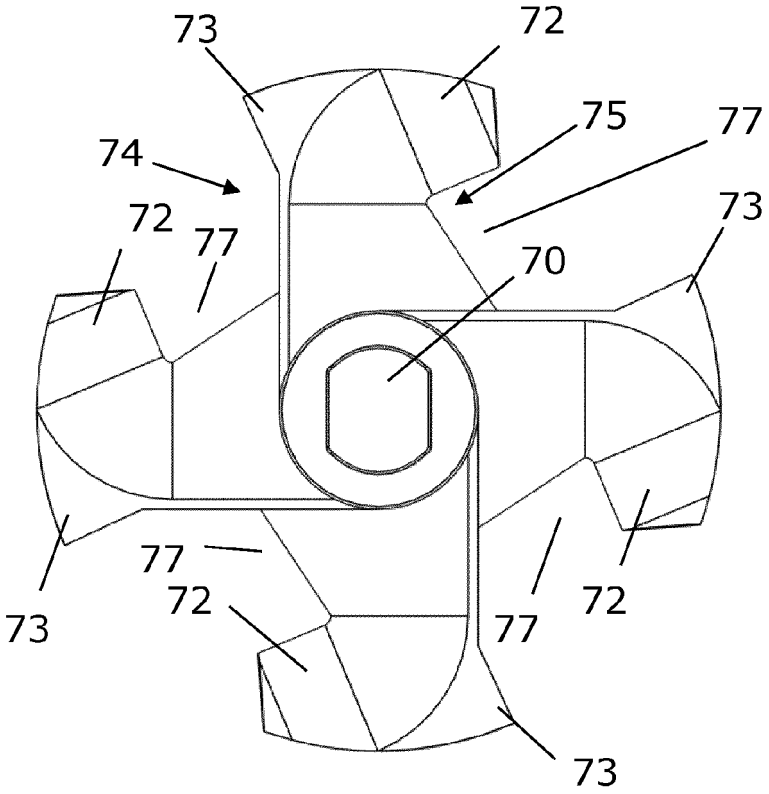

Fig. 8

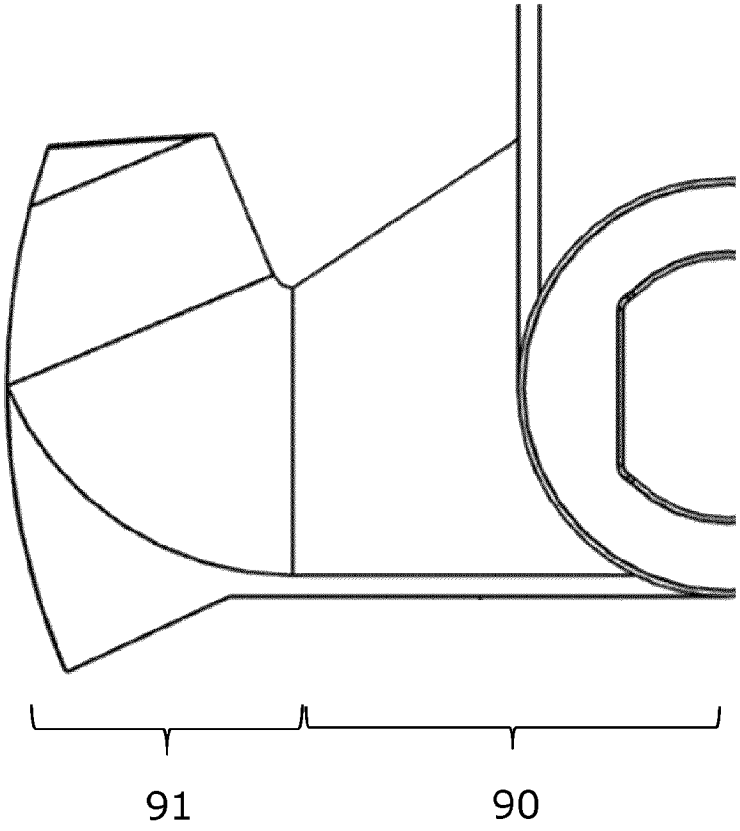

Fig. 9

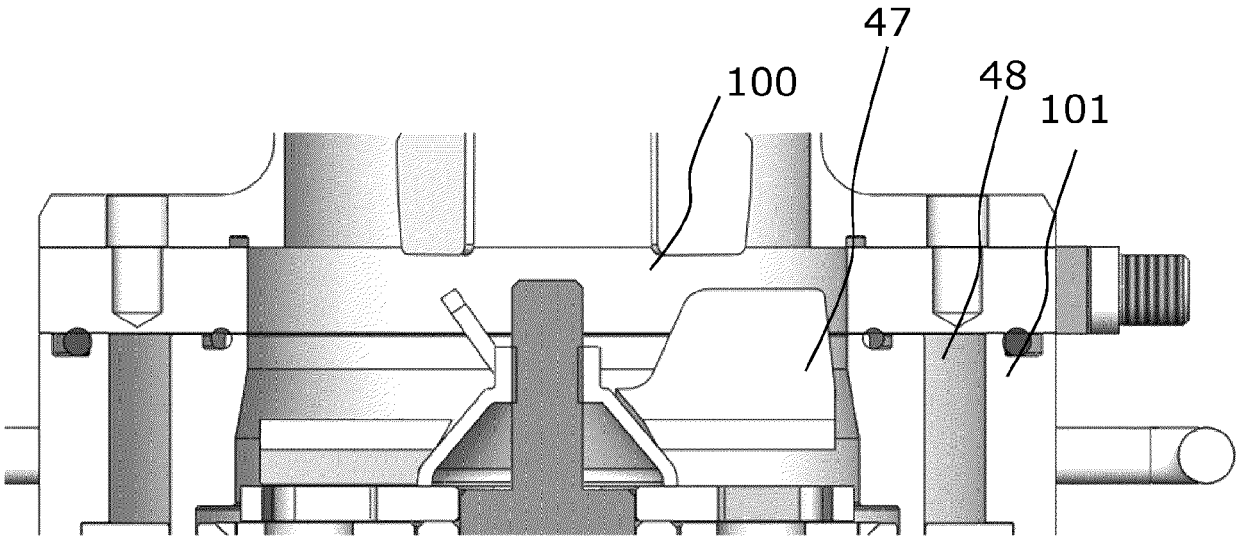

Fig. 10

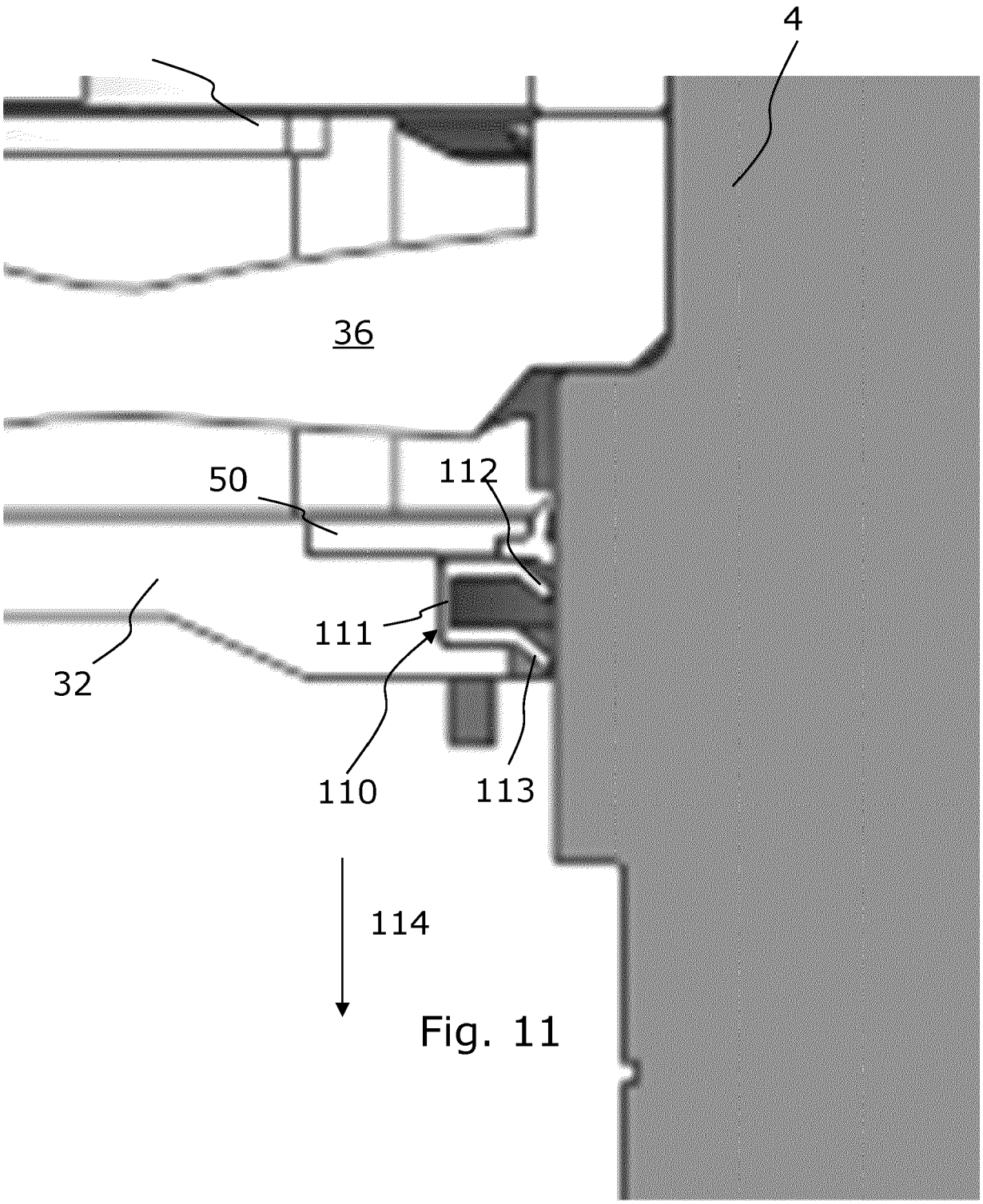

Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 22 18 2605

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 1 307 926 A (PLIZ G MASCHINENFABRIK J S PET) 21 February 1973 (1973-02-21)	1,7	INV. B01F23/41
A	* figure 3 * * page 3, lines 11-24 *	2-6	B01F27/50 B01F27/808 B01F27/172
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A	* figures 1-4 * * column 1, line 64 - column 3, line 64 *	4,6	B01F35/75 B01F35/221
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A	* figures 1-3 * * page 1, line 40 - page 2, line 70 *	6	
X	US 2004/170084 A1 (CHOI WOON SEUNG [KR] ET AL) 2 September 2004 (2004-09-02)	1-3,5,7	
A	* abstract * * figures 1-16 *	4,6	

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	19 December 2022	Krasenbrink, B

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
.....
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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Application Number
EP 22 18 2605

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-7

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 22 18 2605

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-7

   machine comprising a valve as pressure regulating structure
   ---

2. claim: 8

   machine comprising a stack with holes in hole plates and knife plates
   ---

3. claims: 9-15

   machine comprising an ejector knife in the downstream section of the conduit
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 18 2605

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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19-12-2022

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82