(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 520 440 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
12.03.2025 Bulletin 2025/11

(21) Application number: **23195985.9**

(22) Date of filing: **07.09.2023**

(51) International Patent Classification (IPC):
B04B 1/14 *(2006.01)* ***B04B 11/02*** *(2006.01)*
B04B 11/04 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B04B 1/14; B04B 11/02; B04B 11/04; B04B 1/08; B04B 1/18; B04B 7/14

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(71) Applicant: **Alfa Laval Corporate AB**
221 00 Lund (SE)

(72) Inventor: **ASPLUND, Daniel**
141 30 Huddinge (SE)

(74) Representative: **Alfa Laval Attorneys**
Alfa Laval Corporate AB
Group Patent
P.O. Box 73
221 00 Lund (SE)

(54) **A SEPARATOR OPERATING FLUID MODULE, A CENTRIFUGAL SEPARATOR INTERMITTENT DISCHARGE SYSTEM AND A CENTRIFUGAL SEPARATOR**

(57) The disclosure relates to a separator operating fluid module (1) comprising: a cylinder (2) comprising a housing (10) enclosing a cylinder space (4) for holding a fluid (6), the cylinder (2) further comprising at least one opening (8) in the housing (10) for receiving and evacuating the fluid (6) to and from the cylinder space (4); a piston (12) arranged in the cylinder space (4), which piston (12) is arranged to be movable between a first end position (14) and a second end position (16) in the cylinder space (4); a piston rod (18) connected to the piston (12); and an actuator (20) connected to the piston rod (18), which actuator (20) is configured to move the piston (12) between the first end position (14) and the second end position (16) in the cylinder space (4). The actuator (20) is an electrically driven actuator. The disclosure further relates to a centrifugal separator intermittent discharge system (30) and a centrifugal separator (32).

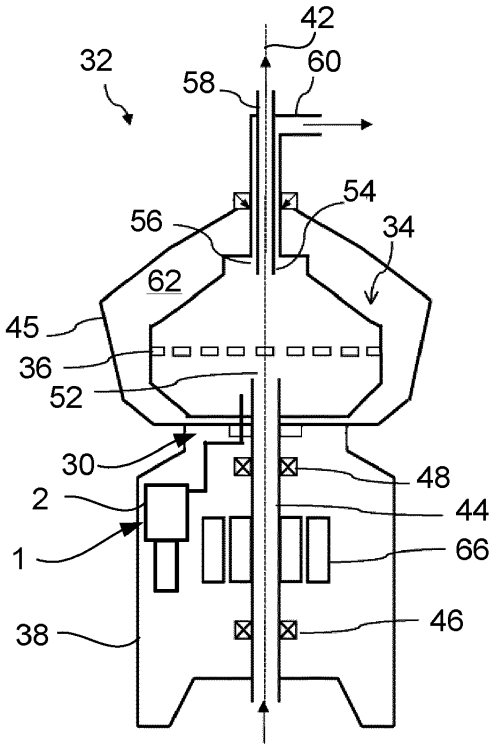

Fig. 2

EP 4 520 440 A1

Description

Technical field

[0001] The present disclosure relates to a separator operating fluid module, a centrifugal separator intermittent discharge system and a centrifugal separator. More specifically, the disclosure relates to a separator operating fluid module, a centrifugal separator intermittent discharge system and a centrifugal separator as defined in the introductory parts of the independent claims.

Background art

[0002] Separator operating fluid modules are used together with a centrifugal separator intermittent discharge system for opening and closing sludge outlets in a centrifuge bowl of a centrifugal separator.

[0003] Centrifugal separators are generally used for separation of liquids and/or for separation of solids from a liquid. During operation, liquid mixture to be separated is introduced into a rotating centrifuge bowl and heavy particles or denser liquid, usually water, accumulates at the periphery of the rotating centrifuge bowl whereas less dense liquid accumulates closer to the central axis of rotation. This allows for collection of the separated fractions, e.g. at sludge outlets arranged at the periphery and close to the rotational axis, respectively. The accumulated sludge at the periphery of the rotating centrifuge bowl is discharged from the rotating centrifuge bowl by a sludge discharge by opening the sludge outlets. Pressurized fluid, such as water, is used to opening of the sludge outlets. The fluid is pressurized by a separator operating fluid module and is conveyed to the centrifugal separator intermittent discharge system for opening and closing the sludge outlets. The fluid is pressurized in the separator operating fluid module by a pneumatically controlled actuator and the opening and closing of the sludge outlets for only a fraction of a second results in a partial or complete emptying of the content in the rotating centrifuge bowl.

[0004] The document EP4101543 A1 discloses a centrifugal separator provided with an intermittent discharge system for discharging a separated sludge phase from a centrifuge bowl of the centrifugal separator. Hydraulic fluid is supplied to the intermittent discharge system by an operating water module (OWM), which is pneumatically controlled by air pressure.

Summary

[0005] The known separator operating water modules, which are actuated with pressurized air are energy consuming. The efficiency to create pressurized air and distributing the pressurized air in the overall system is low. The pneumatic system needs complicated and expensive control systems to achieve accurate control of the opening and closing of the sludge outlets and thus to achieve a predetermined volume of a partial emptying of the content in the rotating centrifuge bowl. The pneumatic system also needs a large space for housing different components related to the system, such as pumps, pressurized air tanks, pipes and control valves.

[0006] There is thus a need for an improved separator operating fluid module. Further, there is a need of a centrifugal separator intermittent discharge system and a centrifugal separator comprising such an improved separator operating fluid module.

[0007] Despite known solutions in the field, it would be desirable to develop a separator operating fluid module, which overcome or alleviate at least some of the drawbacks of the prior art. Further, it would be desirable to develop a centrifugal separator intermittent discharge system and a centrifugal separator comprising such an improved separator operating fluid module, which overcome or alleviate at least some of the drawbacks of the prior art.

[0008] It is an object of the present disclosure to mitigate, alleviate or eliminate one or more of the above-identified deficiencies and disadvantages in the prior art and solve at least the above-mentioned problem.

[0009] An objective of the present invention is thus to achieve a separator operating fluid module with increased efficiency.

[0010] A further objective of the present invention is to achieve a separator operating fluid module which can be controlled by an ordinary control system.

[0011] A further objective of the present invention is to achieve a separator operating fluid module which can achieve accurate control of the opening and closing of the sludge outlets of a centrifugal separator.

[0012] A further objective of the present invention is to achieve a separator operating fluid module, which a needs a small space and can be arranged in a stand of the centrifugal separator.

[0013] These objectives are achieved with the above-mentioned separator operating fluid module according to the appended claims. These objectives are achieved with a centrifugal separator intermittent discharge system and a centrifugal separator comprising such a separator operating fluid module.

[0014] According to a first aspect there is provided a separator operating fluid module comprising a cylinder comprising a housing enclosing a cylinder space for holding a fluid, the cylinder further comprising at least one opening in the housing for receiving and evacuating the fluid to and from the cylinder space; a piston arranged in the cylinder space, which piston is arranged to be movable between a first end position and a second end position in the cylinder space; a piston rod connected to the piston; and an actuator connected to the piston rod, which actuator is configured to move the piston between the first end position and the second end position in the cylinder space. The actuator is an electrically driven actuator. This separator operating flowing module is thus actuated with an electrically driven actuator instead of an

actuator driven by pressurized air. Such a modification of the separator operating flowing module will result in a less energy consuming module. The efficiency increases since the power distributed to the separator operating flowing module is electricity instead of pressurized air. The separator will be more precisely controlled by the electrically driven actuator of the separator operating flowing module, without the need of complicated and expensive control systems, especially when a predetermined volume of a partial emptying of the content in a rotating centrifuge bowl of the separator should be performed. The electrically driven actuator will also reduce the overall space required for mounting the separator operating flowing module at the separator, since the actuator and also electrically components for supporting the actuator are designed with small dimensions.

[0015] The actuator may comprise an electrical motor. The electrical motor can be designed with small dimensions and still be strong enough to actuate the piston rod for moving the piston between the first end position and the second end position in the cylinder space and thus receiving and evacuating the fluid to and from the cylinder space. The electrical motor provides for a simple installation of the separator operating fluid module at the separator due to small space requirements.

[0016] The actuator may be an electrical liner motor. Since the piston rod and the piston driven by the actuator have reciprocating motions, the electrical liner motor does not need any transmission to transform the motion from the motor to the piston. The electrical liner motor can be connected directly to the piston rod for reciprocating the piston in the cylinder, which reduces the dimensions of the separator operating fluid module. Further, the piston rod may be a component of the electrical motor.

[0017] The actuator may be an electrohydraulic motor. Such electrohydraulic motor connected to the piston rod can be designed with small dimensions and still be strong enough to transmit large forces to the piston.

[0018] The actuator may be connected to a control device configured to control the actuator to move the piston. Utilizing an electrically controlled separator operating water module with an electrically driven actuator may result in an efficient energy consumption and new advances for controlling the separator operating water module. The control device can be programmed to instruct the separator operating fluid module to perform repeatable discharges of separated sludge with exactly same volume. This results in an increased quality of the separated product. Further, the volume of discharged sludge can be determined when performing repeatable discharges of separated sludge with exactly same volume. During cleaning in place, CIP, with a complete discharge of the separator bowl at regular cleaning intervals, a cleaning liquid may be introduced into the separator bowl. The control device thereafter instructs the separator operating fluid module to perform repeatable discharges of the cleaning liquid through sludge outlets of the separator bowl.

[0019] The control device may be configured to control the actuator to move the piston to a predetermined position between the first end position and the second end position in the cylinder space. Such controlling of the actuator may result in a complete discharge of the separator. Further, such complete discharge of the separator can be performed at regular intervals for cleaning in place of the separator.

[0020] The control device may be configured to control the actuator to move the piston from the first end position to the predetermined position between the first end position and second end position in the cylinder space and back to the first end position in a predetermined period of time. Such configuration of the control device make it possible to perform a partial discharge of separated sludge. Further, repeatable discharges of separated sludge with exactly same volume will be possible. Also, the volume of discharged sludge can be determined.

[0021] The separator operating fluid module may be an operating water module and the fluid to be held in the cylinder space is water. Water is incompressible and is easy to handle. Unpolluted water can be wasted without the need of cleaning.

[0022] According to a second aspect there is provided a centrifugal separator intermittent discharge system. The system is configured to be supplied by fluid from the separator operating fluid module according to the first aspect. The intermittent discharge system is configured to open and close sludge outlets. The intermittent discharge system may comprise an operating slide that is movable between a closed position, in which the sludge outlets are closed, and an open position, in which the sludge outlets are open. Keeping the operating slide in a closed position may be effected by supplying fluid via at least on channel to a closing chamber between the operating slide and the frame in order to hold the operating slide in the closed position. The intermittent discharge system may further comprise an opening chamber, to which hydraulic fluid is supplied when to change the operating slide to its open position. The intermittent discharge system may thus comprise sludge outlets and an operating slide arranged within the centrifuge bowl to open and close the sludge outlets.

[0023] According to a third aspect there is provided a centrifugal separator comprising a rotatable centrifuge bowl with sludge outlets. The separator comprises the intermittent discharge system arranged for opening and closing the sludge outlets according to the second aspect.

[0024] The centrifugal separator may be used for separation of liquids and/or for separation of solids from a liquid. A liquid mixture to be separated is introduced into the rotating centrifuge bowl and heavy particles or denser liquid and/particles accumulates at the periphery of the rotating centrifuge bowl. Less dense liquid accumulates closer to the central axis of rotation. Separated and accumulated sludge at the periphery of the rotating centrifuge bowl is discharged from the rotating centrifuge

bowl by a sludge discharge by opening the sludge outlets. Fluid from the separator operating fluid module provides to the intermittent discharge system is used to opening of the sludge outlets. A complete emptying of the content in the rotating centrifuge bowl may be performed when opening the sludge outlets. The opening and closing of the sludge outlets for only a short period of time may result in a partial or complete emptying of the content in the rotating centrifuge bowl.

[0025] The separator operating fluid module may be integrated in a stand of the separator. The stand may rest on a surface, such as a floor, and configured to support the rotatable centrifuge bowl. The separator operating fluid module need a small space and can therefore be arranged in a stand of the centrifugal separator. Therefore, the separator operating fluid module may be an integrated component together with the overall components of the centrifugal separator.

[0026] Effects and features of the second and third aspects are to a large extent analogous to those described above in connection with the first aspect. Embodiments mentioned in relation to the first aspect are largely compatible with the second and third aspects.

[0027] The present disclosure will become apparent from the detailed description given below. The detailed description and specific examples disclose preferred embodiments of the disclosure by way of illustration only. Those skilled in the art understand from guidance in the detailed description that changes and modifications may be made within the scope of the disclosure.

Brief descriptions of the drawings

[0028] The above objects, as well as additional objects, features and advantages of the present disclosure, will be more fully appreciated by reference to the following illustrative and non-limiting detailed description of example embodiments of the present disclosure, when taken in conjunction with the accompanying drawings.

Fig. 1 schematically illustrates a section view of separator operating fluid module according to an example;

Fig. 2 schematically illustrates a section view of a centrifugal separator according to an example; and

Fig. 3 schematically illustrates a section view of a centrifuge bowl according to an example.

Detailed description

[0029] The detailed description with reference to the examples depicted are to be viewed as examples comprising a combination of certain features, which features have been described in detail above. It is thus to be understood that additional examples may be achieved by combining other features into examples not depicted herein. The figures are to be viewed as examples and not mutually exclusive combinations. It should also be noted that all figures shown and described are schematically represented, wherein generic parts of machinery or similar is not depicted for the sake of simplicity.

[0030] Fig. 1 schematically illustrates a section view of separator operating fluid module 1 according to an example. The separator operating fluid module 1 comprising a cylinder 2, which comprises a housing 10 enclosing a cylinder space 4 for holding a fluid 6. The cylinder 2 further comprising an opening 8 in the housing 10 for receiving and evacuating the fluid 6 to and from the cylinder space 4. The opening 8 is configured to be connected to a centrifugal separator intermittent discharge system 30, which is schematically indicated in fig. 1, but will be explained more in detail below. A piston 12 is arranged in the cylinder space 4, which piston 12 is arranged to be movable between a first end position 14 and a second end position 16 in the cylinder space 4. A piston rod 18 is connected to the piston 12. Further, the separator operating fluid module 1 is connected to a fluid reservoir 17, such as container with fluid 6 or a community water system, which communicates with the cylinder space 4. A regulator 19 or a check valve can be arranged between the reservoir 17 and the cylinder space 4. An actuator 20 is connected to the piston rod 18. The actuator 20 is configured to move the piston 12 between the first end position 14 and the second end position 16 in the cylinder space 4. The actuator 20 is an electrically driven actuator. The actuator 20 may comprise an electrical motor 22, which may be an electrical liner motor 22 or an electrohydraulic motor 24. The actuator 20 is connected to a control device 26 configured to control the actuator 20 to move the piston 12. The control device 26 is configured to control the actuator 20 to move the piston 12 to a predetermined position 28 between the first end position 14 and the second end position 16 in the cylinder space 4. The control device 26 is configured to control the actuator 20 move the piston 12 from the first end position 14 to the predetermined position 28 between the first end position 14 and second end position 16 in the cylinder space 4 and back to the first end position 14 in a predetermined period of time. The separator operating fluid module 1 may be an operating water module OWM and the fluid 6 to be held in the cylinder space 4 may be water.

[0031] Figure 2 schematically illustrates a section view of a centrifugal separator 32 according to an example. The separator operating fluid module 1 according to fig. 1 is connected to the centrifugal separator 32. The centrifugal separator 32 comprises a centrifuge bowl 34 which is arranged to rotate around an axis of rotation 42 by means of a spindle 44. The spindle 44 is supported in a stationary frame 45 in a bottom bearing 46 and a top bearing 48. The centrifuge bowl 34 is attached the upper portion of the spindle 44 and forms within itself a separation chamber in which centrifugal separation of a liquid feed mixture takes place during operation.

[0032] The spindle 44 is in this example a hollow

spindle for introducing the liquid feed mixture to an inlet 52 of the centrifuge bowl 34. The centrifuge bowl 34 further comprises a liquid outlet 54 for discharging a separated liquid light phase and a liquid outlet 56 for discharging a liquid heavy phase. The liquid light phase outlet 54 is arranged at a smaller radius than the liquid heavy phase outlet 56. There is further a stationary outlet pipe 58 connected to the liquid light phase outlet 54 for receiving the separated liquid light phase, and a stationary outlet pipe 60 connected to the liquid heavy phase outlet 56 for receiving the separated liquid heavy phase.

[0033] The centrifuge bowl 34 further comprises sludge outlets 36 for discharging a separated sludge phase to a surrounding space 62, which is sealed relative the surroundings of the frame 45 and in which the centrifuge bowl 34 is arranged. The sludge outlets 36 takes the form of a set of intermittently openable sludge outlets 36 arranged at the outer periphery of the centrifuge bowl 34, for discharge of sludge from a radially outer portion of a separation space 65 (fig. 3) to the surrounding space 62. The sludge outlets may form part of an intermittent discharge system 30, which also comprises an axially movable operating slide 64 (fig. 3) arranged in the centrifuge bowl 34.

[0034] The centrifugal separator 32 further comprises a drive motor 66 configured to rotate the centrifuge bowl 34 in relation to the frame 45 around the axis of rotation 42.

[0035] The separator operating fluid module 1 is integrated in a stand 38 of the separator 32. The centrifugal separator intermittent discharge system 30 is supplied by fluid 6 from the separator operating fluid module 1.

[0036] Fig. 3 schematically illustrates a section view of a centrifuge bowl according to an example. The separation space 65 within the centrifuge bowl 34 is provided with a stack 74 of separation discs in order to achieve effective separation of the liquid feed mixture. The stack 74 is arranged on a distributor 76 which guides the liquid feed mixture from the inlet 52 to the separation space 65.

[0037] The opening of the sludge outlets 36 of the intermittent discharge system 30 is controlled by means of an operating slide 80 actuated by operating water in a channel 82, as known in the art. In the position shown in fig. 3, the operating slide 80, also called a sliding bowl bottom, abuts sealingly at its periphery against the upper part of the centrifuge bowl 34, thereby closing the separation space 65 from connection with the sludge outlets 36, which are extending through the centrifuge bowl 34.

[0038] The operating slide 80 is movable between a closed position, shown in Fig. 3, in which the sludge outlets 36 are closed, and an open position, in which sludge outlets 36 are open.

[0039] A closing chamber (not shown) is provided between below the operating slide 80. During operation, the closing chamber may contain fluid 6, such as water, acting on the operating slide 80 to close the outlets. The draining of the fluid 6 from the closing chamber, and thereby opening of the sludge outlets 36, is initiated by introducing fluid 6, such as water, to the intermittent discharge system 30 via pipes 84 from the separator operating fluid module 1.

[0040] Supply of fluid 6 into the intermittent discharge system 30 starts the opening of drainage nozzles for drainage of the fluid 6 from the closing chamber. This will in turn cause the operating slide 80 to move to a lower position so that sludge is discharged through sludge outlets 36. When the fluid 6 has been drained from the closing chamber, the operating slide 80 is again moved to an upper position to close the sludge outlets 36.

[0041] The foregoing description of the embodiments has been furnished for illustrative and descriptive purposes. It is not intended to be exhaustive, or to limit the embodiments to the variations described. Many modifications and variations will obviously be apparent to one skilled in the art. The embodiments have been chosen and described in order to best explicate principles and practical applications, and to thereby enable one skilled in the art to understand the invention in terms of its various embodiments and with the various modifications that are applicable to its intended use. The components and features specified above may, within the framework of the disclosure, be combined between different embodiments specified.

Claims

1. A separator operating fluid module (1) comprising: a cylinder (2) comprising a housing (10) enclosing a cylinder space (4) for holding a fluid (6), the cylinder (2) further comprising at least one opening (8) in the housing (10) for receiving and evacuating the fluid (6) to and from the cylinder space (4); a piston (12) arranged in the cylinder space (4), which piston (12) is arranged to be movable between a first end position (14) and a second end position (16) in the cylinder space (4); a piston rod (18) connected to the piston (12); and an actuator (20) connected to the piston rod (18), which actuator (20) is configured to move the piston (12) between the first end position (14) and the second end position (16) in the cylinder space (4), **characterized in that** the actuator (20) is an electrically driven actuator.

2. The module (1) according to claim 1, wherein the actuator (20) comprises an electrical motor (22).

3. The module (1) according to any one of claims 1 and 2, wherein the actuator (20) is an electrical liner motor (22).

4. The module (1) according to any one of the preceding claims 1 and 2, wherein the actuator (20) is an electrohydraulic motor (24).

5. The module (1) according to any one of the preced-

ing claims, wherein the actuator (20) is connected to a control device (26) configured to control the actuator (20) to move the piston (12).

6. The module (1) according to claim 5, wherein the control device (26) is configured to control the actuator (20) to move the piston (12) to a predetermined position (28) between the first end position (14) and the second end position (16) in the cylinder space (4).

7. The module (1) according to claim 6, wherein the control device (26) is configured to control the actuator (20) move the piston (12) from the first end position (14) to the predetermined position (28) between the first end position (14) and second end position (16) in the cylinder space (4) and back to the first end position (14) in a predetermined period of time.

8. The module (1) according to any one of the preceding claims, wherein the separator operating fluid module (1) is an operating water module (OWM) and the fluid (6) to be held in the cylinder space (4) is water.

9. A centrifugal separator intermittent discharge system (30), **characterized in that** the system (30) is configured to be supplied by fluid (6) from a separator operating fluid module (1) according to claim 1.

10. A centrifugal separator (32) comprising a rotatable centrifuge bowl (34) with sludge outlets (36), **characterized in that** the separator (32) comprises an intermittent discharge system (30) according to claim 9 arranged for opening and closing the sludge outlets (36).

11. The separator (32) according to claim 10, wherein the separator operating fluid module (1) is integrated in a stand (38) of the separator (32).

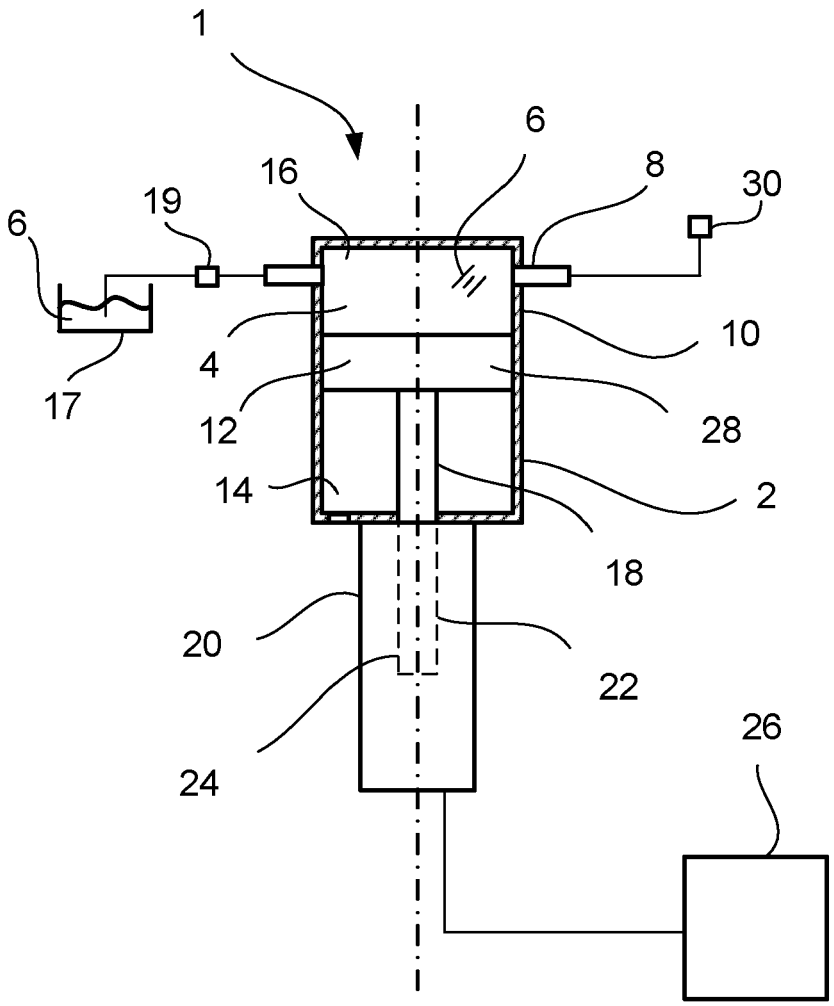

Fig. 1

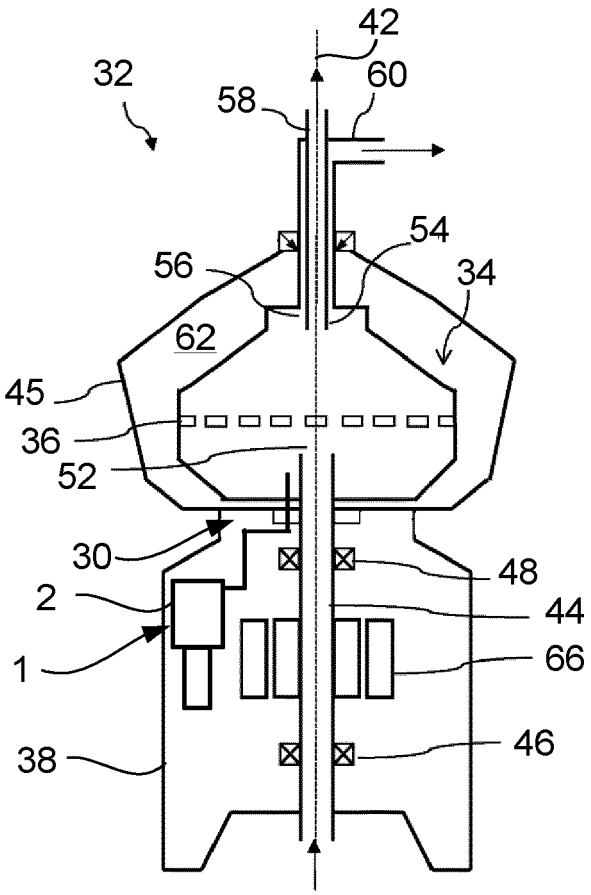

Fig. 2

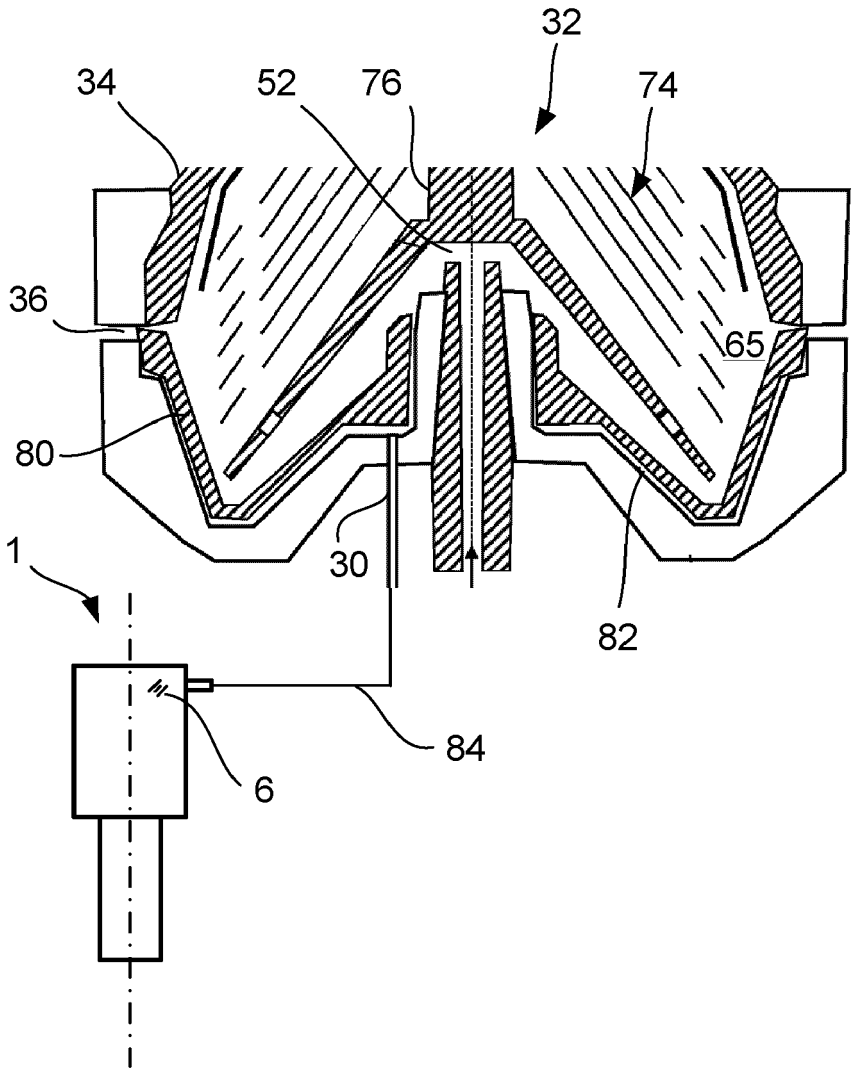

Fig. 3

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 19 5985

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	WO 2007/045595 A1 (WESTFALIA SEPARATOR AG [DE]; HOFMANN WOLFGANG [DE] ET AL.) 26 April 2007 (2007-04-26)	1-10	INV. B04B1/14 B04B11/02
A	* page 4, line 26 - page 5, line 14; claims 1,2,6; figure 1 * * page 2, lines 1-22 *	11	B04B11/04
A	EP 3 485 979 A1 (GEA MECHANICAL EQUIPMENT GMBH [DE]) 22 May 2019 (2019-05-22) * paragraphs [0006] - [0034]; figure 1 *	1-11	

TECHNICAL FIELDS SEARCHED (IPC)

B04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 March 2024	Iuliano, Emanuela

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)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 19 5985

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

18-03-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2007045595 A1	26-04-2007	DE 102005049941 A1	26-04-2007
		WO 2007045595 A1	26-04-2007
EP 3485979 A1	22-05-2019	DE 102017126973 A1	16-05-2019
		EP 3485979 A1	22-05-2019

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 4101543 A1 **[0004]**