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(54) **APPARATUS FOR PUMPING FLUIDS CONTAINING SOLID PARTICLES**

PUMPSYSTEM FÜR FLÜSSIGKEITEN MIT FESTSTOFFEN

SYSTÈME DE POMPAGE POUR LIQUIDES CONTENANT DES PARTICULES SOLIDES

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Description

Technical field

[0001] The object of the present invention is an apparatus and a method for pumping a food fluid containing solid parts.

Background art

[0002] Such types of pumps are used for example for pumping sauces, jams, etc., containing solid parts (for example solid parts of tomatoes in a sauce, solid parts of fruit in jams).

[0003] The use of a piston pump is known for pumping such types of products to a homogeniser. Typically the piston is driven by a connecting rod-crank system, driven by a camshaft or crankshaft. One drawback of such a solution is related to the overall dimensions of such a shaft.

[0004] A further drawback is related to the fact that the law of motion followed by the piston is rigid and pulsating according to sinusoidal law such as to create accelerations and decelerations in the flow, which are thus not flexible and therefore not adaptable to the specific needs which may arise from time to time.

[0005] The pulsations in the flow generate pressure pulses.

[0006] The document DE 27 55 233 A1 discloses a pump for delivering animal food which piston is driven by a balls screw shaft.

Disclosure of the invention

[0007] In this context, the technical task underlying the present invention is to offer a pumping apparatus and a method which allow the dimensions to be optimised. In addition, the present solution allows to improve the operating flexibility of the pumping apparatus.

[0008] The defined technical task and the specified objects are substantially achieved by a pumping apparatus and a method for pumping a fluid containing solid parts comprising the technical features set forth in one or more of the appended claims.

Brief description of the drawings

[0009] Further features and advantages of the present invention will become more apparent from the following indicative, and hence non-limiting, description of a preferred, but not exclusive, embodiment of a pumping method and an apparatus, as illustrated in the accompanying drawings, in which:

- figures 1, 2, 3 show a side, front, and plan view respectively of an apparatus according to the present invention;
- figure 4 shows a sectional view of a part of figure 2;

- figure 5 shows an enlargement of figure 4.

Detailed description of preferred embodiments of the invention

[0010] In the accompanying drawings, reference number 1 indicates a pumping apparatus for pumping a food fluid containing solid parts. Such a fluid is typically viscous, e.g., sauces, jams etc. Suitably the solid parts can reach longitudinal dimensions up to 50 millimetres.

[0011] The apparatus 1 comprises a pumping assembly 2. The pumping assembly 2 in turn comprises a jacket 23 and a piston 24 which is movable alternately backwards and forwards in the jacket 23 in order to pump and suction the fluid. The jacket 23 is substantially cylindrical. Suitably, it is made of stainless steel. Suitably, the pumping assembly 2 comprises three lubrication points. All the parts of the pumping assembly 2 in contact with the product are made of FDA certified material.

[0012] The apparatus 1 further comprises an electric motor 3 driving said pumping assembly 2. Preferably, the electric motor 3 is an induction motor with a circular crown stator. Suitably, the electric motor 3 is an asynchronous motor (typically three-phase) or a DC motor or a brushless motor. The motor 3 comprises a rotor 31 and a stator 32. The stator 32 suitably surrounds at least a part of the rotor 31. The stator 32 comprises electrical windings for generating a rotating magnetic field which rotates the rotor 31. Suitably, the electric motor 3 is a commercial motor. Suitably, the electric motor 3 is servo-ventilated. Suitably, the electric motor 3 comprises/is coupled to a frequency converter. Such a frequency converter allows the rotation speed of the rotor 31 to be adjusted. For example, such a converter allows to adjust the rotation speed of the rotor 31 instant by instant. This allows considerable flexibility of use. For example, it allows to control the acceleration and deceleration ramps of the rotor 31 and/or the piston 24. Suitably, the pumping assembly 2 comprises a position control system of the piston 24. The position of the piston 24 along the jacket 23 is thus understood. This typically occurs by means of an encoder. Preferably, such a control system (e.g., the encoder) is applied to the motor 3 (in particular the rotor) or to the piston 24 or to another portion of a motion transmission system from the motor 3 to the piston 24.

[0013] Advantageously, the position control system of the piston 24 is operatively associated with the frequency converter. The frequency converter is suitably actuated as a function of the position of the piston 24 detected by the control system. Thereby, the speed of the piston 24 can be controlled as the position of the piston varies along the stroke thereof. In particular, the frequency converter allows the piston to follow specific acceleration and/or deceleration profiles straddling the inversion of the motion of the piston 24 itself.

[0014] The apparatus 1 further comprises means for managing the acceleration ramps of the piston 24. This is done by electronic control of the axes, which prevents

water hammers in the downstream circuit. The electric motor 3 is therefore capable of controlling the acceleration ramps.

[0015] The apparatus 1 can suitably further comprise a speed adapter 4 operatively interposed between the electric motor 3 and said pumping system 2. The speed adapter 4 allows to provide a different angular speed in output relative to the input speed given by the rotor 31 of the electric motor 3. The adapter 4 is a mechanical system, typically geared. The speed adapter 4 is typically a speed reducer. It therefore allows to provide a power take-off at the output with a lower angular speed relative to that of a rotor of the electric motor 3. The reducer can also be integrated/combined in the electric motor 3 so as to define a gear motor.

[0016] Suitably, said speed adapter 4 (in particular said reducer) has a power output (typically by means of a drive shaft) in a direction orthogonal to that of the input of the rotor 31.

[0017] The pumping assembly 2 comprises a drive shaft 21 actuated by said adapter 4. The drive shaft 21 comprises a groove 211 extending spirally. Such a groove 211 extends along at least one section of a radially outermost side surface of the drive shaft 21.

[0018] The pumping assembly 2 comprises a driven actuator 22 which is slidable forwards and backwards. Suitably, the driven actuator 22 is a linear actuator. It suitably translates forwards and backwards moved by the drive shaft 21. The driven actuator 22 comprises a recess 221 extending spirally about at least one section of said actuator 22. The recess 221 is at least partially facing the groove 211.

[0019] The pumping assembly 2 comprises a plurality of rolling elements 25 which engage in both said groove 211 and in said recess 221. Such rolling elements 25 are typically spheres. It is thereby possible to transfer the motion from the drive shaft 21 to the driven actuator 22. A rotary motion of said drive shaft 21 may then be transferred into a forward or return stroke of said driven actuator 22.

[0020] Suitably, the drive shaft 21 with the groove 211, the driven actuator 22 with the recess 221, the rolling means 25 define a ball recirculation system. In particular, they define a system known in other applications as a recirculating ball screw.

[0021] The driven actuator 22 is constrained to the piston 24. Preferably they are assembled together. In particular, the piston 24 could be integral with the driven actuator 22. Possibly, the piston 24 and the driven actuator 22 could also be a single monolithic body. As a function of the rotation direction of the drive shaft 21, the driven actuator 22 moves in one direction or the other.

[0022] The rotor 31 is rotatable about a first axis 310 which is orthogonal to a second axis 26 along which said driven actuator 22 and said drive shaft 21 extend. In particular, the actuator 22 translates along said second axis 26. The second axis 26 also identifies a translation direction of the piston 24. The driven actuator 22 is typically

coaxial with the drive shaft 21. Suitably, the driven actuator 22 surrounds the drive shaft 21. The driven actuator 22 preferably surrounds and is positioned externally to said drive shaft 21. The driven actuator 22 comprises a cavity in which said drive shaft 21 protrudes. However, there could be an opposite solution in which the drive shaft 21 surrounds at least one section of the driven actuator 22. Suitably, the drive shaft 21 and the driven actuator 22 define a telescopic structure. As a function of the rotation direction of the drive shaft 21, such a telescopic structure lengthens or shortens. In particular, as a function of the rotation direction of the drive shaft 21, an insertion or extraction of one between the shaft 21 or the actuator 22 relative to the other is caused. In the solution illustrated in the accompanying figures, an extraction of the actuator 22 from the shaft 21 corresponds to a pumping stroke of the piston 24. Similarly, an insertion of the actuator 22 into the shaft 21 corresponds to a suction stroke of the piston 24. Suitably, the stroke of the piston 24 is adjustable by acting on the control of the electric motor 3. Suitably, the maximum stroke of the piston 24 is comprised between 0.7 and 1.2 metres.

[0023] Suitably, the axial position of the drive shaft 21 is fixed along said second axis 26. Instead, the actuator 22 moves, in particular translates, along said axis 26. In this regard, the pumping assembly 2 comprises a guiding means which inhibits the rotation of said driven actuator 22 allowing the translation thereof along the second axis 26.

[0024] The pumping system 2 comprises an outer casing 27 which wraps around at least a part of the drive shaft 21 and the driven actuator 22. The motor 3 is external to the casing 27. The motor 3 is also external to the jacket 23. The casing 27 is suitably external, preferably adjacent, to the jacket 23.

[0025] The pumping assembly 2 comprises a pumping chamber 230 positioned in said jacket 23 and in which the fluid is suctioned and pumped by said piston 24.

[0026] The pumping assembly 2 comprises an intake valve 231 which, in an open configuration, permits the entry of said fluid into the pumping chamber 230. The pumping assembly 2 comprises a delivery valve 232 which, in an open configuration, permits the pumping of the fluid present in the pumping chamber 230. Suitably, the intake valve 231 and/or the delivery valve 232 is/are ball valves. The suction valve 231 and the delivery valve 232 are pneumatically controlled. The suction valve 231 and the delivery valve 232 are remotely controlled. In particular, remotely controlled pneumatic means are present for controlling the valves 231 and 232. In an alternative solution, the valves 231, 232 could be operated in another manner, for example by a solenoid. The use of remotely controlled valves is interesting, as it facilitates large passage sections. In particular, the intake valve 231, if open, has a passage section which is at least 60% (preferably 75%) of the section of the intake duct immediately upstream of the valve 231. Similarly, the delivery valve 232 allows to free a passage section which is at

least 60% (preferably 75%) of the section of the delivery duct immediately downstream of the valve 232. This is useful for facilitating the passage of solid parts. The jacket 23 can suction axially and pump orthogonally to a movement direction of the cylinder 23. But also vice versa. The pumping assembly 2 has reversible operation.

[0027] The driven actuator 22 comprises an annular sleeve 220 which wraps around a section of said drive shaft 21 and in which said rolling elements 25 are contained. The jacket 220 extends axially for less than 1/5 of a stroke of the driven actuator 22.

[0028] Suitably, the pumping apparatus 1 also comprises an additional pumping assembly 20 suitably actuated by an additional electric motor 30. This description for the pumping assembly 2, for the electric motor 3 and the reciprocal interactions thereof can be respectively repeated for the additional pumping assembly 20, for the additional electric motor 30 and the reciprocal interactions thereof.

[0029] Suitably, the additional pumping assembly is a pump provided with a piston which moves alternately along a direction parallel to the second axis 26 described above. Suitably, the pumping assembly 2 and the additional pumping assembly 20 are side by side. The use of two pumping assemblies allows to give greater regularity to the fluid flow rate. In fact, when the pumping assembly 2 is in the suction step, the pumping assembly 20 will be in the pumping step.

[0030] Advantageously, the additional electric motor 30 comprises a frequency converter which allows the rotor speed to be promptly adjusted as a function of a signal provided by a piston position control system of the additional pumping assembly 20.

[0031] Suitably, the frequency converter of the motor 3 and the frequency converter of the motor 30 are able to control the movement of the piston of the pumping assembly 2 and the piston of the pumping assembly 20 so as to have a compressive fluid flow rate processed by the sum of the pumping assembly 2 and the pumping assembly 20 which is constant over time (regardless of the inversion of the motion of the respective pistons). The frequency converter of the motor 3 and the frequency converter of the motor 30 are therefore synchronised.

[0032] An object of the present invention is also a system 10 for treating a food fluid containing solid particles. In fact, such a system 10 comprises a pumping apparatus 1 having one or more of the features described previously.

[0033] The system 10 further comprises a fluid heating means 5 positioned downstream of said delivery valve 232. There is no fluid homogenising valve or narrow gap present between the delivery valve 232 and the heating means 5. More generally, and regardless of the presence of the heating means 5, there is no fluid homogenising valve or narrow gap for crushing the solid parts.

[0034] An object of the present invention is further a pumping method for pumping a food fluid containing solid parts by means of a pumping assembly 2. Suitably, such

a method is implemented by a pumping apparatus 1 and/or a treatment system 10.

[0035] The pumping assembly 2 comprises a jacket 23 and a piston 24 slidable alternately in the jacket 23. Such a piston 24 alternately moves forwards and backwards in the jacket 23. The movement of the piston 24 causes the pumping and/or suction of the fluid with respect to the jacket 23.

[0036] The method comprises the step of actuating a drive shaft 21 of the pumping assembly 2 by means of at least one electric motor 3 and suitably a speed adapter 4. The speed adapter 4 rotates the drive shaft 21 at a different angular speed relative to that of a rotor 31 of the motor 3.

[0037] The method further comprises the step of transferring motion from said drive shaft 21 to a driven actuator 22 positioned in said pumping assembly 2 by means of a plurality of rolling elements 25. The rolling elements 25 suitably engage:

- both in a spiral-shaped groove 211 extending along said drive shaft 21;
- and in a recess 221 obtained in a section of the driven actuator 22.

[0038] The driven actuator 22 is constrained to the piston 24. The piston 24 suctions and pumps the fluid.

[0039] The method can optionally comprise the step of pumping the fluid to a heating means 5 of said fluid without passing it through a homogenising valve or narrow gap intended to crush said solid parts.

[0040] Suitably, the pumping method for pumping a food fluid containing solid parts is implemented by means of at least:

- the pumping assembly 2 driven by the electric motor 3;
- an additional pumping assembly 20 driven by an additional motor 30. Suitably, the rotation speed of the electric motor 3 and the electric motor 30 can be synchronised with each other. For example, such a synchronisation allows to have a constant flow rate over time in an area which is downstream of both the first and the second pumping assembly 2, 20. In particular, the pumping assembly 2 immediately before the inversion of the stroke direction of the piston 24 thereof pumps a gradually decreasing flow rate which is compensated by an increased flow rate pumped by the additional pumping assembly 20. In fact, the piston 24 of the pumping assembly 2 towards the end stroke begins to decrease the pumped flow rate and this is compensated by the additional pumping assembly 20. Then the additional pumping assembly 20 could for example pump a constant flow rate and this will correspond to a suction step of the pumping assembly 2 (which therefore does not pump anything downstream). Subsequently, the additional pumping assembly 20 decreases the pumped flow

rate and this corresponds to an increase in the flow rate pumped by the pumping assembly 2. During a step in which the pumping assembly 2 pumps a constant flow rate, the additional pumping assembly 20 5
suctions fluid and does not pump anything downstream. The process can then be repeated iteratively.

[0041] However, the pumping assembly 2 and the additional pumping assembly 20 could follow different profiles of the flow rate - time curve. 10

[0042] The present invention achieves important advantages.

[0043] First of all, it allows to obtain a pump which is optimised in the components thereof, while at the same time minimising the overall dimensions. In particular, it has a predominant longitudinal dimension, but a limited height and width (the solution exemplified in the accompanying figures has a longitudinal length of about 4 metres, a width of about 0.8 metres and a height of less than 0.2 metres; it can allow a flow rate of about 10,000 litres/hour with a pressure of about 6 bar). 15 20

[0044] The invention as it is conceived is susceptible to numerous modifications and variants, all falling within the scope of the inventive concept characterised by the accompanying claims. 25

Claims

1. A system for treating a food fluid containing solid parts comprising:

- the food fluid containing said solid parts;
- a pumping apparatus for pumping the food fluid containing solid parts in turn comprising: 35

- i) a pumping assembly (2) comprising a jacket (23) and a piston (24) that is movable alternately in the jacket (23) in order to suction and pump the fluid; 40
- ii) an electric motor (3) driving said pumping assembly (2);
- iii) a speed adaptor (4) operatively interposed between the electric motor (3) and said pumping assembly (2); 45

said pumping assembly (2) comprising:

- a drive shaft (21) actuated by said adaptor (4) and comprising a groove (211) extending spirally; 50
- a driven actuator (22) slidable forwards and backwards and comprising a recess (221) extending spirally about at least one section of said actuator (22); 55
- a plurality of rolling elements (25) that engage both in said groove (211) and in said recess

(221) in order to transfer a rotary motion of said drive shaft (21) into a forward or return stroke of said driven actuator (22); said driven actuator (22) being constrained to said piston (24);

- a pumping chamber (230) positioned in said jacket (23) and in which the fluid is suctioned and pumped by said piston (24);

- an intake valve which, in an open configuration, permits the entry of said fluid into the pumping chamber (230) and a delivery valve which, in an open configuration, permits the pumping of the fluid present in the pumping chamber (230); **characterised in that** the intake valve and the delivery valve are actuated by a remotely controlled actuator.

2. The system according to claim 1, **characterised in that** said electric motor (3) comprises a rotor (31) rotatable about a first axis (310) which is orthogonal to a second axis (26) along which said drive shaft (21) is rotatable.

3. The system according to claim 2, **characterised in that** the axial position of said drive shaft (21) is fixed along said second axis (26).

4. The system according to any one of the preceding claims, **characterised in that** said driven actuator (22) is coaxial with, surrounds and is positioned externally to said drive shaft (21). 30

5. The system according to any one of the preceding claims, **characterised in that** said pumping assembly (2) comprises an outer casing (27) that wraps around at least a part of the drive shaft (21) and the driven actuator (22); said motor (3) being external to said casing (27).

6. The system according to any one of the preceding claims, **characterised in that** said driven actuator (22) comprises an annular sleeve (220) that wraps around a section of said drive shaft (21) and in which said rolling elements (25) are contained; said sleeve (220) extending axially for less than 1/5 of a stroke of the driven actuator (22).

7. The system according to any of the previous claim comprises a heating means (5) for heating the fluid, positioned downstream of said pumping apparatus (1); no homogenising valve or narrowing for homogenising the fluid being present between said pumping apparatus (1) and said heating means (5).

8. The system according to any of the previous claim, **characterised in that** the intake valve, if open, having a passage section which is at least 60% of the section of an intake duct immediately upstream of the intake valve; the delivery valve allowing to free

a passage section which is at least 60% of the section of the delivery duct immediately downstream of the delivery valve.

9. The system according to any of the previous claim, **characterised in that** the electric motor (3) comprises/is coupled to a frequency converter; the pumping apparatus (1) also comprises an additional pumping assembly (20) actuated by an additional electric motor (30); the additional electric motor (30) comprising a frequency converter which allows the rotor speed to be promptly adjusted as a function of a signal provided by a piston position control system of the additional pumping assembly (20); the frequency converter of the motor (3) and the frequency converter of the motor (30) are able to control the movement of the piston of the pumping assembly (2) and the piston of the pumping assembly (20) so as to have a compressive fluid flow rate processed by the sum of the pumping assembly (2) and the additional pumping assembly (20) which is constant over time regardless of the inversion of the motion of the respective pistons.

Patentansprüche

1. System zum Behandeln einer Nahrungsmittelflüssigkeit mit Feststoffen, umfassend:

- die Nahrungsmittelflüssigkeit mit Feststoffen;
- ein Pumpsystem für die Nahrungsmittelflüssigkeit mit Feststoffen, das wiederum Folgendes umfasst:

- i) eine Pumpanordnung (2), umfassend einen Mantel (23) und einen Kolben (24), der wechselweise im Mantel (23) bewegbar ist, um die Flüssigkeit anzusaugen und zu pumpen;
- ii) einen Elektromotor (3), der die Pumpanordnung (2) antreibt;
- iii) einen Drehzahladapter (4), der betriebswirksam zwischen dem Elektromotor (3) und der Pumpanordnung (2) eingesetzt ist,

wobei die Pumpanordnung (2) Folgendes umfasst:

- eine Antriebswelle (21), die vom Adapter (4) betätigt wird und eine Rille (211) umfasst, die sich spiralförmig ausdehnt;
- einen angetriebenen Aktuator (22), der vorwärts und rückwärts verschiebbar ist und eine Ausnehmung (221) umfasst, die sich spiralförmig um mindestens eine Sektion des Aktuators (22) ausdehnt;
- eine Vielzahl von Wälzkörpern (25), die sowohl in die Rille (211) als auch die Ausnehmung (221)

eingreifen, um eine rotatorische Bewegung der Antriebswelle (21) in einen Vorwärts- oder Rückwärtshub des angetriebenen Aktuators (22) zu transferieren, wobei der angetriebene Aktuator (22) am Kolben (24) befestigt ist;

- eine Pumpkammer (230), die im Mantel (23) positioniert ist und in die die Flüssigkeit vom Kolben (24) angesaugt und gepumpt wird;
- ein Einlassventil, das in einer offenen Auslegung das Einströmen der Flüssigkeit in die Pumpkammer (230) erlaubt, und ein Förderventil, das in einer offenen Auslegung das Pumpen der in der Pumpkammer (230) vorhandenen Flüssigkeit erlaubt, **dadurch gekennzeichnet, dass** das Einlassventil und das Förderventil von einem ferngesteuerten Aktuator betätigt werden.

2. System nach Anspruch 1, **dadurch gekennzeichnet, dass** der Elektromotor (3) einen Rotor (31) umfasst, der um eine erste Achse (310) drehbar ist, die rechtwinkelig zu einer zweiten Achse (26) angeordnet ist, entlang derer die Antriebswelle (21) drehbar ist.

3. System nach Anspruch 2, **dadurch gekennzeichnet, dass** die axiale Position der Antriebswelle (21) entlang der zweiten Achse (26) fixiert ist.

4. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der angetriebene Aktuator (22) koaxial zur Antriebswelle (21) angeordnet ist, diese umgibt und außerhalb dieser positioniert ist.

5. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Pumpanordnung (2) ein Außengehäuse (27) umfasst, das mindestens einen Teil der Antriebswelle (21) und des angetriebenen Aktuators (22) umhüllt, wobei der Motor (3) außerhalb des Gehäuses (27) angeordnet ist.

6. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der angetriebene Aktuator (22) eine ringförmige Hülse (220) umfasst, die eine Sektion der Antriebswelle (21) umhüllt und in der die Wälzkörper (25) enthalten sind, wobei sich die Hülse (220) axial um weniger als 1/5 eines Hubs des angetriebenen Aktuators (22) ausdehnt.

7. System nach einem der vorhergehenden Ansprüche, umfassend Heizmittel (5) zum Erhitzen der Flüssigkeit, die stromabwärts des Pumpsystems (1) positioniert sind, wobei zwischen dem Pumpsystem (1) und den Heizmitteln (5) kein Homogenisierungsventil bzw. keine Verengung zum Homogenisieren der Flüssigkeit vorhanden ist.

8. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Einlassventil, wenn es offen ist, einen Durchgangsquerschnitt aufweist, der mindestens 60 % des Querschnitts einer Einlassleitung unmittelbar stromaufwärts des Einlassventils aufweist, wobei das Förderventil erlaubt, einen Durchgangsquerschnitt freizumachen, der mindestens 60 % des Querschnitts der Förderleitung unmittelbar stromabwärts des Förderventils aufweist. 5 10
9. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Elektromotor (3) einen Frequenzumrichter umfasst/mit diesem gekoppelt ist, wobei das Pumpsystem (1) auch eine zusätzliche Pumpanordnung (20) umfasst, die von einem zusätzlichen Elektromotor (30) betätigt wird, wobei der zusätzliche Elektromotor (30) einen Frequenzumrichter umfasst, der erlaubt, dass die Rotordrehzahl umgehend abhängig von einem von einem Kolbenpositionssteuerungssystem der zusätzlichen Pumpanordnung (20) bereitgestellten Signal geregelt werden kann, 15 20
- wobei der Frequenzumrichter des Motors (3) und der Frequenzumrichter des Motors (30) in der Lage sind, die Bewegung des Kolbens der Pumpanordnung (2) und des Kolbens der Pumpanordnung (20) zu steuern, sodass eine kompressible Flüssigkeitsdurchflussmenge, verarbeitet durch die Summe der Pumpanordnung (2) und der zusätzlichen Pumpanordnung (20), vorliegt, die im Lauf der Zeit konstant ist, ungeachtet der Umkehrung der Bewegung der jeweiligen Kolben. 25 30

Revendications

1. Système pour traiter un liquide alimentaire contenant des parties solides, comprenant : 40
- le liquide alimentaire contenant lesdites parties solides ;
 - un système de pompage pour liquide alimentaire contenant des parties solides, comprenant à son tour : 45
- i) un ensemble de pompage (2), comprenant une chemise (23) et un piston (24) qui est mobile alternativement dans la chemise (23) afin d'aspirer et de pomper le liquide ; 50
 - ii) un moteur électrique (3) entraînant ledit ensemble de pompage (2) ;
 - iii) un adaptateur de vitesse (4) interposé de manière opérationnelle entre le moteur électrique (3) et ledit ensemble de pompage (2) ; 55

ledit ensemble de pompage (2) comprenant :

- un arbre d'entraînement (21) actionné par ledit adaptateur (4) et comprenant une rainure (211) s'étendant en spirale ;
- un actionneur entraîné (22) couissant vers l'avant et vers l'arrière et comprenant un évidement (221) s'étendant en spirale autour d'au moins une section dudit actionneur (22) ;
- une pluralité d'éléments roulants (25) qui s'engagent à la fois dans ladite rainure (211) et dans ledit évidement (221) afin de transférer un mouvement rotatif dudit arbre d'entraînement (21) dans une course avant ou arrière dudit actionneur entraîné (22) ; ledit actionneur entraîné (22) étant contraint audit piston (24) ;
- une chambre de pompage (230) positionnée dans ladite chemise (23) et dans laquelle le liquide est aspiré et pompé par ledit piston (24) ;
- une soupape d'admission qui, dans une configuration ouverte, permet l'entrée dudit liquide dans la chambre de pompage (230) et une soupape de refoulement qui, dans une configuration ouverte, permet le pompage du liquide présent dans la chambre de pompage (230) ; **caractérisé en ce que** la soupape d'admission et la soupape de refoulement sont actionnées par un actionneur commandé à distance.

2. Système selon la revendication 1, **caractérisé en ce que** ledit moteur électrique (3) comprend un rotor (31) pouvant tourner autour d'un premier axe (310) qui est orthogonal à un second axe (26) le long duquel ledit arbre d'entraînement (21) peut tourner. 35
3. Système selon la revendication 2, **caractérisé en ce que** la position axiale dudit arbre d'entraînement (21) est fixe le long dudit deuxième axe (26). 35
4. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit actionneur entraîné (22) est coaxial avec, entoure et est positionné à l'extérieur dudit arbre d'entraînement (21). 40
5. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit ensemble de pompage (2) comprend un carter extérieur (27) qui entoure au moins une partie de l'arbre d'entraînement (21) et de l'actionneur entraîné (22) ; ledit moteur (3) étant externe audit carter (27). 45
6. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit actionneur entraîné (22) comprend un manchon annulaire (220) qui s'enroule autour d'une section dudit arbre d'entraînement (21) et dans lequel lesdits éléments roulants (25) sont contenus ; ledit manchon (220) s'étendant axialement sur moins de 1/5 d'une course de l'actionneur entraîné (22). 50 55

7. Système selon l'une quelconque des revendications précédentes comprend des moyens de chauffage (5) pour chauffer le liquide, positionnés en aval dudit système de pompage (1) ; aucune vanne d'homogénéisation ou rétrécissement pour homogénéiser le liquide n'étant présent entre ledit système de pompage (1) et lesdits moyens de chauffage (5). 5
8. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la soupape d'admission, si elle est ouverte, a une section de passage qui est au moins 60% de la section d'un conduit d'admission immédiatement en amont de la soupape d'admission ; la soupape de refoulement permettant de libérer une section de passage qui est au moins 60% de la section du conduit de refoulement immédiatement en aval de la soupape de refoulement. 10 15
9. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le moteur électrique (3) comprend/est couplé à un convertisseur de fréquence ; le système de pompage (1) comprend également un ensemble de pompage supplémentaire (20) actionné par un moteur électrique supplémentaire (30) ; le moteur électrique supplémentaire (30) comprenant un convertisseur de fréquence qui permet d'ajuster rapidement la vitesse du rotor en fonction d'un signal fourni par un système de commande de position de piston de l'ensemble de pompage supplémentaire (20) ; 20 25 30 35 40
- le convertisseur de fréquence du moteur (3) et le convertisseur de fréquence du moteur (30) sont capables de commander le mouvement du piston de l'ensemble de pompage (2) et du piston de l'ensemble de pompage (20) de manière à avoir un débit de liquide de compression traité par la somme de l'ensemble de pompage (2) et de l'ensemble de pompage supplémentaire (20) qui est constant dans le temps indépendamment de l'inversion du mouvement des pistons respectifs. 45 50 55

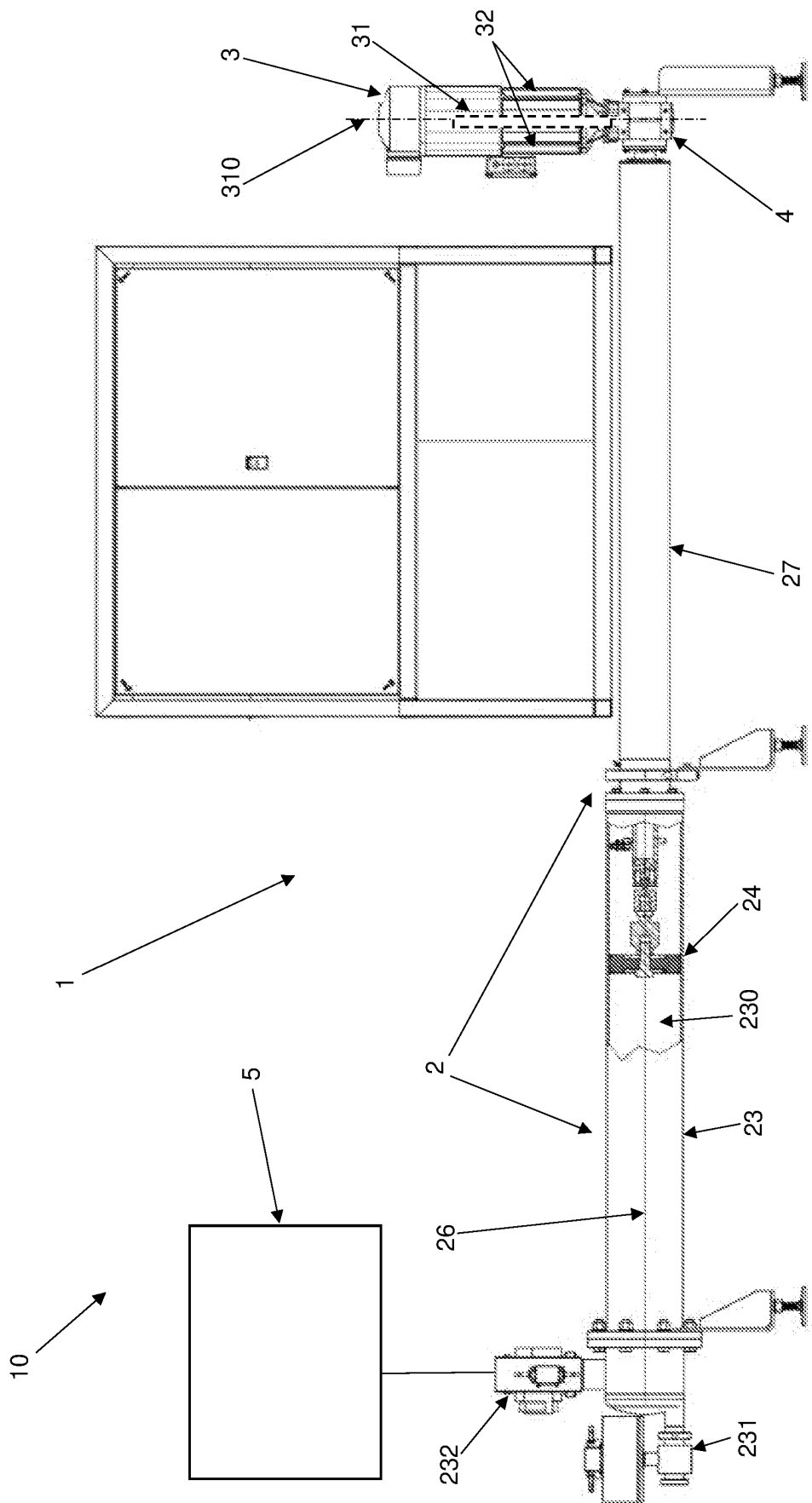


Fig. 1

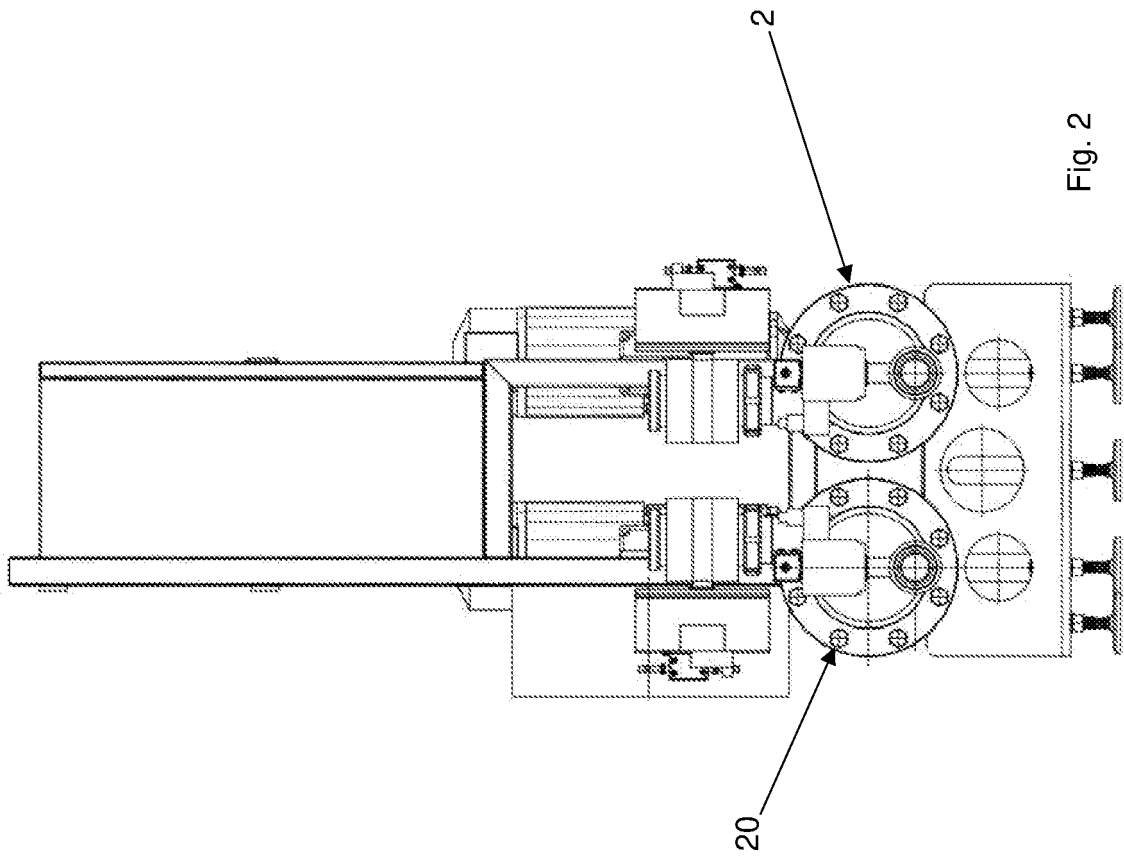
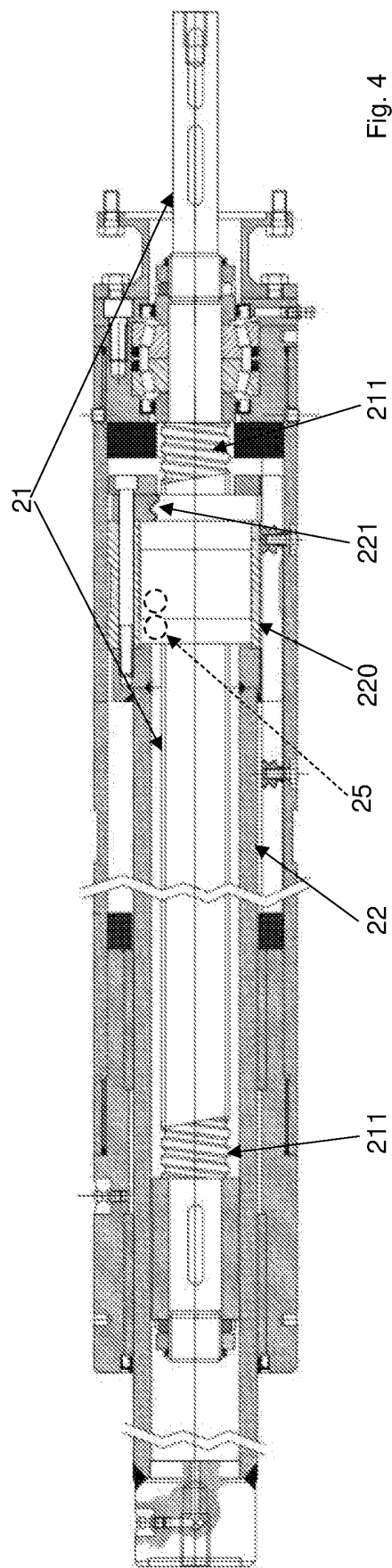
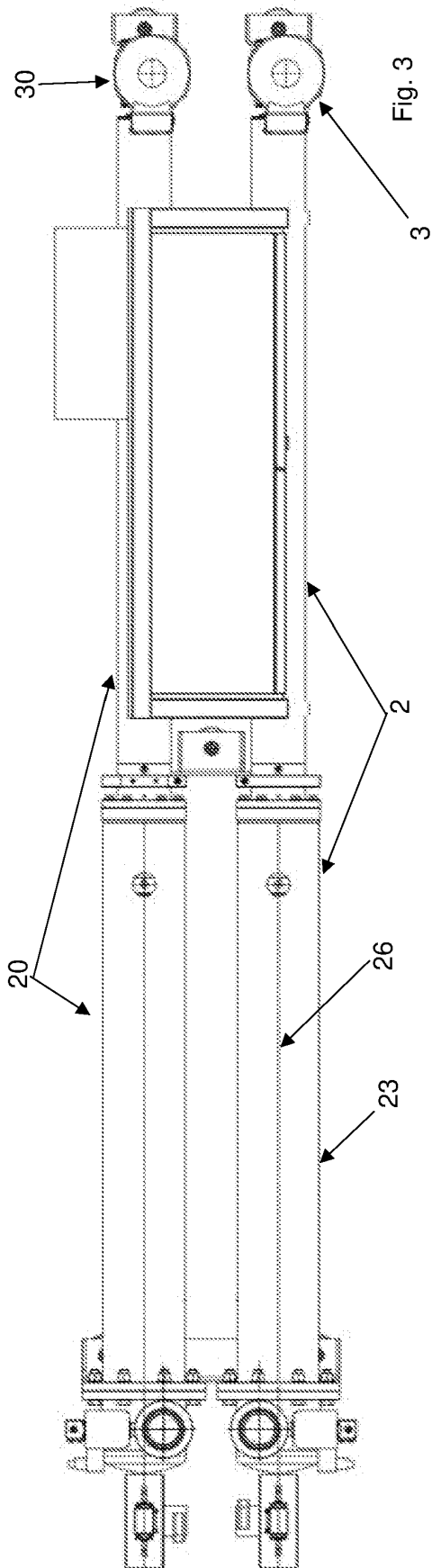


Fig. 2



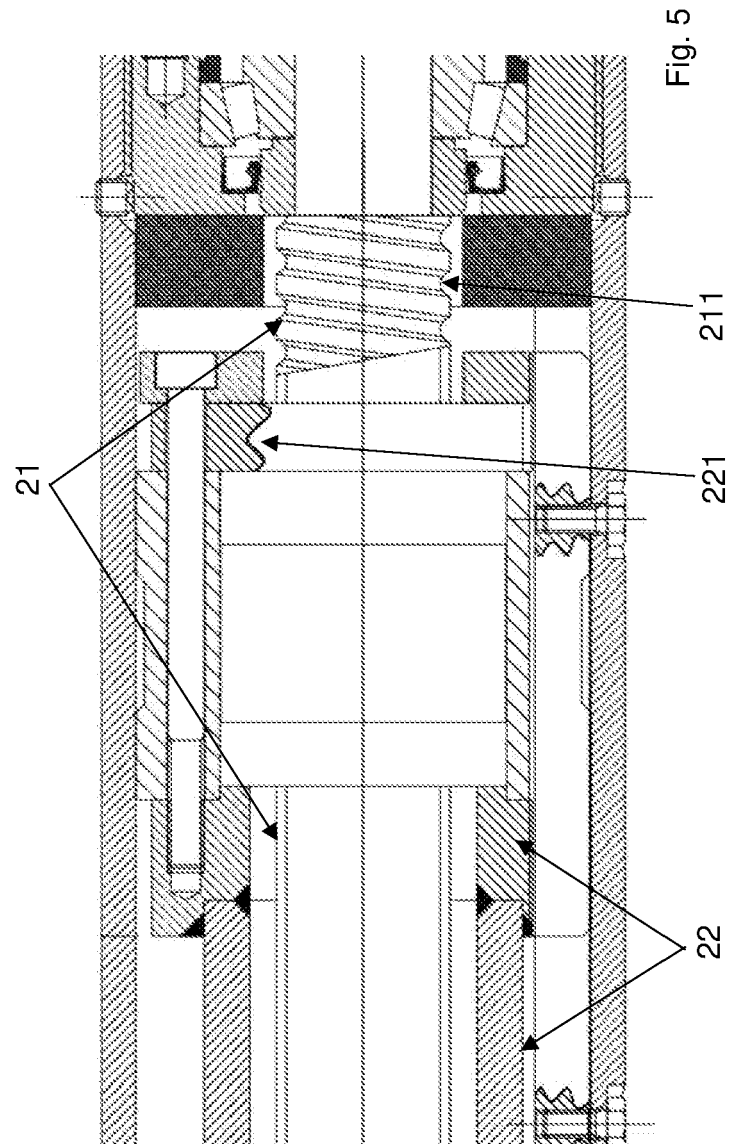


Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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