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(71) Applicant: **TETRA LAVAL HOLDINGS & FINANCE S.A.** [CH/CH]; 70, Avenue Général-Guisan, CH-1009 Pully (CH).

(72) Inventors: **LINDAU, Jeanette**; Almvägen 2, S-247 36 Södra Sandby (SE). **SKOGLUND, Tomas**; Stenåldersvägen 21, S-226 54 Lund (SE). **INNINGS, Fredrik**; Byvägen 1B, S-247 45 Torna Hällestad (SE). **VOS, Jan**; Eindhovense weg 39, B-3941 Eksel (BE).

(74) Agent: **ASSOCIATION TETRA PAK - ATTORNEYS SE**; AB Tetra Pak, Patent Department, Ruben Rausings gata, S-22186 Lund (SE).

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(54) Title: IMPROVED FILTRATION UNIT HAVING A PRESSURE VOUME ADJUSTING BODY

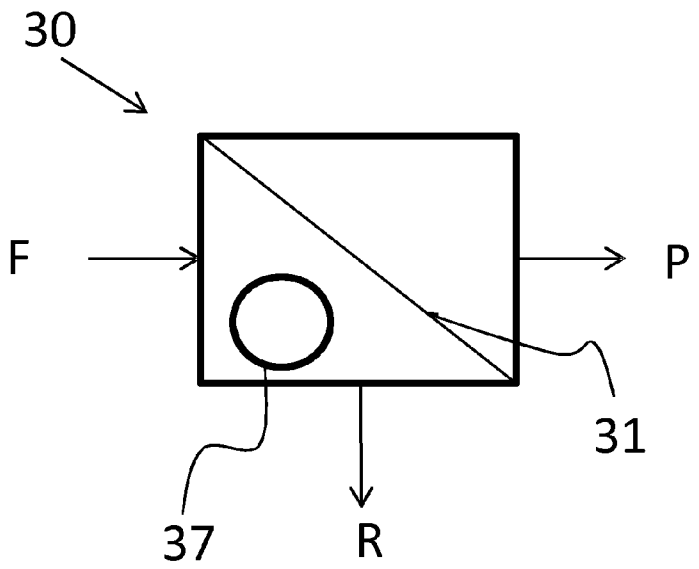

Fig. 3

(57) Abstract: A filtration unit (2, 30, 50) for filtration of a liquid food product is provided. The filtration unit (2, 30, 50) comprises a feed inlet (F) and a permeate outlet (P), arranged down streams the feed inlet (F). A filter (31, 51) is arranged in between the feed inlet (F) and the permeate outlet (P) to divide the filtration unit (2, 30, 50) into at least a feed side and a permeate side. A pressure volume adjusting body (37, 57), capable of varying in volume in response to pressure in the liquid food product, is arranged in the filtration unit (2, 30, 50). A method of operating such a filter in washing mode is also provided.

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IMPROVED FILTRATION UNIT HAVING A PRESSURE VOUME ADJUSTING BODY

Technical Field of the invention

The present invention relates to an arrangement in a cross flow filtration unit, such as a microfiltration unit, having a feed inlet, a permeate outlet and retentate outlet, for improving washing action of the filter. More specifically, the present invention pertains to an arrangement in a cross flow filtration unit, such as a microfiltration unit, having a feed inlet, a permeate outlet and retentate outlet, such filtration unit comprising several membranes sandwiched between membrane support plates, which are arranged in stacks.

Background

Cross flow membrane filtration technology has been used widely and globally in industry. A feed is supplied to the cross flow membrane unit, wherein a permeate exits the unit on the other side of the filter while a retentate exits the unit on the same side of the filter as the feed enters. Filtration membranes can be organic, such as polymeric, or inorganic, such as ceramic, depending upon the application. The principles of cross-flow filtration are used in reverse osmosis, i.e. concentration of solutions by removing water, nanofiltration, i.e. concentration of organic components by removal of ions like sodium and chlorine, ultrafiltration, i.e. concentration of large and macromolecules, for example proteins, and microfiltration, i.e. removal of bacteria.

Up to this point, reverse osmosis is performed on a plate and frame design, tubular design with polymers, and spiral-wound; nanofiltration is performed in spiral wound; ultrafiltration is performed on plate and frame design, tubular design with polymers, tubular design with ceramics, spiral-wound, and hollow-fiber; and microfiltration on tubular design with ceramics.

In the field of dairy industry, it has thus been common practice to remove bacteria through microfiltration on tubular design with ceramics. Normally, skim milk is treated in microfiltration, since otherwise also fat would be removed with bacteria.

Filters in cross flow membrane filtration are periodically cleaned/washed through backwashing. In backwashing, the transmembrane pressure is periodically

inverted by the use of a secondary pump, so that permeate flows back into the feed, lifting the fouling layer from the surface of the membrane, which is disclosed in Figure. 2. Backwashing results in a pressure increase on the feed/retentate side of the filter, which affects the system negatively.

It would thus be advantageous if maintenance of a microfiltration system could be improved, while simultaneously obtaining higher cost efficiency. It would additionally be advantageous if these positives could be obtained simultaneously as providing a system wherein backwashing is improved.

Microfiltration is a membrane technical filtration process which removes contaminants from a fluid (liquid or gas) by passage through a microporous membrane. A typical microfiltration membrane pore size range is 0.1 to 10 micrometers (μm). The use of microfilters is widespread in food processing where the pore size is ideal for separating unwanted dissolved solids, such as pores for example.

In crossflow filtration, the feed is passed across the filter membrane (tangentially) at positive pressure relative to the permeate side. A proportion of the material which is smaller than the membrane pore size passes through the membrane as permeate or filtrate; everything else is retained on the feed side of the membrane as retentate.

Over time deposition of various components in the feed will build up and accumulate on, within and around the pores. The pores will then become clogged which will cause the flux through the filter to decline and eventually the filter will become blocked. Such membrane fouling thus shortens the time a filter can be actively used.

To prevent, or at least delay, such clogging and thereby increase the time a filter can actively be used, various techniques have been proposed. One technique is to periodically block the forward feed short times periodically allowing the pores to be unclogged as the blocking of the permeate flow will cause a backwards flow that rinses the pores. However, it is difficult to ascertain that the backwards flow will actually occur and it is also hard to control it. Another technique is to periodically push the permeate flow backwards for a short time period for example using a piston basedpumping device. This will aid in unclogging the pores by causing a rinsing effect. However, such back-flow is difficult to control.

These problems are also present in Ultrafiltration, Nanofiltration and Reverse Osmosis.

Summary of the invention

Consequently, the present invention seeks to mitigate, alleviate, eliminate or circumvent one or more of the above-identified deficiencies in the art and disadvantages singly or in any combination by providing a filtration unit for filtration of a liquid food product, said filtration unit comprising a feed inlet, a permeate outlet, arranged down streams the feed inlet, a filter, arranged in between the feed inlet and the permeate outlet to divide the filtration unit into at least a feed side and a permeate side, and a pressure volume adjusting body, capable of varying in volume in response to pressure in the liquid food product.

Further advantageous features of the invention are defined in the dependent claims. In addition, advantageous features of the invention are elaborated in embodiments disclosed herein.

Brief description of the drawings

The invention will below be described more in detail, having reference to a preferred embodiment thereof shown on the accomplishing drawings, in which:

Figure 1 illustrates schematic view of a filter unit according to the prior art;

Figure 2 illustrates schematic view of a filter unit according to the prior art during backwashing;

Figure 3 illustrates schematic view of a filter unit according to one embodiment of the invention;

Figure 4 illustrates schematic view of a filter unit according to one embodiment of the invention during backwashing;

Figure 5a illustrates a perspective view of a filter unit according to one embodiment of the invention;

Figure 5b illustrates a cross-sectional view of a filter unit according to one embodiment of the invention;

Figure 6 shows a schematic view of a filter apparatus according to one embodiment of the teachings of this application;

Figure 7 shows a schematic, cross-sectional view of the general structure of a filter apparatus according to one embodiment of the teachings of this application; and

Figure 8 shows a partial view of a connecting rod arrangement according to one embodiment of the teachings of this application.

Detailed description of preferred embodiments

The disclosed embodiments will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

According to one aspect, the present invention relates to an arrangement in a cross flow filtration unit, such as a microfiltration unit, having a feed inlet, a permeate outlet and retentate outlet, for improving performance/washing action of the filter. The filter is preferably inorganic, such as ceramic or silica-based, since organic, such as polymeric, membranes tend to delaminate during backwashing.

More specifically, the present invention pertains to an arrangement in a cross flow filtration unit 30, such as a microfiltration unit, having a feed inlet stream F, a permeate outlet stream P and retentate outlet stream R, in accordance with Figures. 3 and 4, in a dairy system. The filtration unit 30 is positioned in the dairy system for removal of microorganisms and bacteria.

The filter unit 30 comprises at least one feed/retentate channel, extending from the inlet to the retentate outlet, through which feed F gradually turns into retentate R, exiting the filter unit 30. The feed/retentate channel extends adjacent a filter 31, such as a microfiltration filter, such that the feed/retentate channel not has to cross the filter 31 on its way from the feed inlet to the retentate outlet. The filter unit 30 further comprises at least one permeate channel, extending from the filter 31 to the permeate outlet. Liquid passing from the feed F over the filter 31 will enter the permeate channel to become permeate P, which in turn exits the filter unit 30 at the permeate outlet. In the feed/retentate channel a pressure volume adjusting body 37 is positioned.

The pressure volume adjusting body 37 may in one embodiment be a flexible membrane with hollow inner volume, such as a balloon or balloon-like body. Suitable materials for the balloon or balloon-like body 37 are thus plastics and rubbers. The plastics and rubbers are preferably of food-grade, due to the requirements on food production facilities. In use, the balloon or balloon like body 37 is inflated, such that the balloon or balloon like body 37, in production mode of the dairy system, has a first volume. The first volume may be kept by inflating the balloon or balloon-like body 37 with a suitable gas or liquid, such as air, through a conduit outside the filter unit 30. When backwashing of the dairy filter unit 30 of the dairy system is performed, the pressure on the feed/retentate side of the filter unit 30 wants to increase. When the pressure on the feed/retentate side of the filter 31 in the filter unit 30 wants to increase, the balloon or balloon-like body 37 will decrease in volume into a second volume to compensate for the pressure derivate, such that the backflow through the filter 31 and on the feed retentate side not is adversely affected by an increase in pressure. Thus, the liquid volume on the feed F/retentate R side of the filter will effectively be increased. In this way, the pressure on the feed/retentate side of the filter 31 in the filter unit 30 may be kept substantially constant.

In another embodiment, the pressure volume adjusting body 37 may be a coated sponge-like body with a first volume. The coating of the coated sponge-like body 37 is not permeable to the dairy product. Suitable materials for the coated sponge-like body 37 are thus plastics and rubbers. The plastics and rubbers are preferably of food-grade, due to the requirements on food production facilities. Due to the sponge-like and compressible core of the sponge-like body 37, the first volume may be kept without application of a pressure through a separate conduit, connected to a pressure supply outside the filter unit 30. Simultaneously, the sponge-like body will be compressed during backwash in the same manner as the balloon or balloon-like body described above into a second volume, to compensate for the positive pressure derivate on the feed/retentate side of the filter 31 in the filter unit 30. Thus, the structure of the core sponge should be selected such that it – under the circumstances – substantially holds the first volume during production mode, while it during backwashing is

compressed into the second volume as a result of positive pressure derivate on the feed/retentate side.

In Figures. 5a and 5b a filtration unit 50 in a dairy system is disclosed. The filtration unit 50 comprises several membranes 51 sandwiched between membrane support plates 52, which are arranged in stacks. The membranes may be microfiltration membranes. The feed F is forced through narrow channels 53. The narrow channels 53 may be configured for parallel flow or as a combination of parallel and serial channels.

The filter unit 50 comprises at least one feed/retentate channel, extending from the inlet to the retentate outlet, through which feed F gradually turns into retentate R when exiting the filter unit 50. The feed/retentate channel extends adjacent the filter membrane 51, such as a microfiltration filter, such that the feed/retentate channel not has to cross the filter on its way from the feed inlet to the retentate outlet. The filter unit 50 further comprises at least one permeate channel, extending from the filter to the permeate outlet. Liquid passing from the feed F over the filter will enter the permeate channel to become permeate P, which in turn exits the filter unit 50 at the permeate outlet.

The filtration unit 50 may be divided into sections, in each of which the flow between pairs of membranes 51 is parallel. The sections are separated by a special membrane support plate 52 in which one hole is closed with a stop disc to reverse the direction of flow, giving serial flow between successive sections. The sizes of the modules may vary, depending on the size and capacity of the dairy system using the filtration unit 50.

Retentate channels 54 extend into the filtration unit 50 to intersect with the planes in which the membranes 51 are arranged, sandwiched between membrane support plates 52. The retentate channels 54 may extend perpendicularly to the planes in which the membranes 51 are arranged. These retentate channels 54 provide close proximity to the membranes 51, while simultaneously providing good volume for the retentate R on its way to leave the filter unit 50.

At the top and the bottom, respectively, of the filtration unit 50, a top support plate 55 and a bottom support plate 56 are arranged. In at least one of these, but also possibly in both, feed inlets and retentate outlets are arranged.

In at least one, but possibly two of the feed/retentate channels 54 a pressure volume adjusting body 57 is positioned. The pressure volume adjusting body 57 may be a flexible membrane with hollow inner volume, such as the balloon or balloon-like body described above, or the pressure volume adjusting body 57 may be a coated sponge-like body in accordance with above. Suitable materials for the balloon or balloon-like body 31 and/or the coated sponge-like body are plastics and rubbers.

The pressure volume adjusting body 57 extends into the filtration unit 50, in said feed/retentate channel 54 to intersect with the planes in which the membranes 51 are arranged, sandwiched between membrane support plates 52. Thus, the pressure volume adjusting body 57 may – just as the retentate channels 54 – extend perpendicularly to the planes in which the membranes 51 are arranged. The pressure volume adjusting body 57 is then provided in close proximity to the membranes 51, whereby it can adjust in volume in fast response and in good correlation with the increased pressure derivate caused by the backwashing.

In use, the pressure volume adjusting body 57 is inflated, such that the pressure volume adjusting body 57, in production mode of the dairy system, has a first volume. The first volume may be kept by inflating the pressure volume adjusting body 57 with a suitable gas or liquid, such as air, through a conduit outside the filter unit 50. When backwashing of the dairy filter unit 50 of the dairy system is performed, the pressure on the feed/retentate side of the filter unit 50 wants to increase. When the pressure on the feed/retentate side of the filter in the filter unit 50 wants to increase, the pressure volume adjusting body 57 will decrease in volume into a second volume to compensate for the pressure derivate, such that the backflow through the filter membrane 51 and on the feed retentate side not is adversely affected by an increase in pressure. In this way, the pressure on the feed/retentate side of the filter in the filter unit 50 may be kept substantially constant.

According to another aspect the present invention relates to a filter arrangement for generating a back-pulse of a flow through a membrane of said filter. The volume adjusting body according to the embodiments above can be combined with the embodiments of the filter arrangement for generating a back-pulse of a flow through a membrane of said filter according to the embodiments disclosed below.

Figure 6 shows a filtration system 1 according to the teachings herein. A filter unit 2 comprises a piston based pumping device which is controlled by a connecting rod 3. In the example embodiment of figure 6 the filter unit 2 comprises a plurality of filters all connected to the same connecting rod 3. This enables for controlling a plurality of filter membranes in an efficient manner. The connecting rod 3 is driven by a motor 4 to move back and forth (up or down in the figure). As the connecting rod 3 moves back and forth (up or down in the figure), the flow through the filter membranes of the filter unit 2 is pushed or pumped backwards and forwards correspondingly through the filter unit 2. As the flow is pushed forwards the TMP (Trans Membrane Pressure) is kept at a high level. The level is dependent on the type of filtration as would be apparent to a skilled person. As the flow is pushed backwards the TMP is allowed to fall.

The filter is preferably a non-polymeric filter, even though traditional polymeric filter membranes commonly used in devices for ultra filtration, nano filtration or reverse osmosis will also work within the context of the invention. However, non-polymeric filters are less prone to be delaminated by the two-way flow of the device according to embodiments of the invention.

In one embodiment the connecting rod 3 is arranged to allow a level of flow in a direction in relation to the distance of the connecting rod 3 from a midpoint of the connecting rod 3. In the exemplifying embodiment of figure 6, the connecting rod 3 controls the flow so that when the piston is in the bottom-most position the flow is at a maximum forwards flow. When the connecting rod 3 is in its top-most position the flow is at a maximum backwards flow.

To enable an improved prevention of clogging the filter membranes of the filter unit 2, the connecting rod 3 is controlled to cause a slow forward flow being interrupted with a fast, periodical backward flow or backpulse for a repeated rinsing effect.

Figure 7 shows a cutout view of the piston arrangement of figure 6. The arrangement is adapted to provide an improved control of a flow. The connecting rod 3 of figure 6 is springloaded by a spring 5 to push against a cam 6. This causes the movement of the connecting rod 3 to be controlled by the shape of the cam 6. In a specific embodiment, the spring 5 is adapted to be suitable for a 15 to 30 Hz application. The cam 6 is drivingly connected to the motor 4 of figure 6 through a

spindle 7. As the spindle 7 revolves so does the cam 6 and based on the shape or profile of the cam 6 the connecting rod 3 is moved up and down (up and down directions refer to the directions in the figures) causing the forwards and backwards flow accordingly.

As can be seen in figure 7, the cam 6 is shaped to have low profile for most of its circumference enabling a slow forward flow. The low profile is interrupted by a short peak. The low profile causes the connecting rod 3 to drive the piston based pumping device slowly in a forwards direction, while the peak will cause the connecting rod 3 to be raised thereby causing the piston based pumping device to pump the flow backwards for a short time period. In an alternative embodiment the piston based pumping device is solely arranged to generate the backpulse. When the piston is moved from a low position the raising the piston, the piston based pumping device causes a reverse or backwards flow. If the peak is short and rises quickly enough the reverse flow will be in the form of a short backpulse.

As can be seen in figure 7, the uppermost (in the figure) surface portion of the cam 6 has a peak, whereas the bottommost (in the figure) surface portion of the cam 6 has a lower profile.

By designing the cam profile the speed and direction of the flow – in either direction – can be precisely controlled. The period of the backward flow is determined by the length of the peak. The speed of the flow is controlled by the height of the cam profile. The lower, the faster the forwards flow, the higher, the faster the backwards flow.

It is thereby possible to design a cam 6 which has a profile that enables a precise control of the connecting rod 3 and the piston based pumping device so that the flow through the filter membranes of the filter unit 2 can be precisely controlled. This allows for rinsing the pores of the filter membranes of the filter unit 2 and thereby extends the effective life time of the filters, which extends overall production time. This also leads to a decreased need for cleaning-in-place (CIP) and a decreased need for cleaning chemicals during operation.

In figure 7 the connecting rod 3 is supported by a first support 8 and a second support 9. The connecting rod 3 is connected to the supports 8 and 9 by bearings 11, 12, 13. The bearings 11, 12, 13 supporting the connecting rod 3 are adapted to cancel side

forces, prevent rotation and limit bending forces on the connecting rod 3, The spindle 7 is attached to a casing 10 by pendel bearings 14 (in one specific embodiment the bending of the pendel bearing is 0.3) and to the cam 6 by axial angle contact bearings 15.

The system comprising the connecting rod 3 and its drive system (spindle, motor) can be implemented as a micro-electromechanical system, as in figure 7. The system comprising the connecting rod 3 and its drive system (spindle 7, motor 4) can also be implemented as a pneumatic system.

The connecting rod 3 is further arranged with a cam follower 16, see figure 8, which is adapted to operate being subjected to forces up to about 20 kN. In one embodiment the force in the tube (not shown) enclosing the connecting rod 3 is limited to 7 kN to prevent bending of the connecting rod 3.

In one embodiment, as mentioned above, the connecting rod 3 is arranged to drive a piston based pumping device to only cause a backpulse in the transmembrane flow. In such an embodiment the flow through the membrane of the filter would also be controlled by other, conventional filter components (not shown).

It should be noted that the up/down movement of the connecting rod 3 and corresponding control of the flow can be reversed to down/up by a corresponding change in the shape of the cam 6.

In an alternative embodiment the connecting rod 3 is controllably driven by a hydraulics system. Be regulating the pressure in a hydraulic system operably connected to the connecting rod 3, the connecting rod 3 can be caused to move up and down according to the pressure changes. As the pressure increases in the hydraulic system, the connecting rod 3 is forced upwards and as the pressure decreases, the connecting rod 3 is allowed to retreat downwards, possibly biased by a spring 5. The pressure in the hydraulic system can be affected with a pump or by other means and such means can be controlled by a Programmable Logic Circuit or other control means to increase and decrease the pressure at specific intervals and at specific rates, thereby enabling an accurate and precise control of the movement of the connecting rod 3.

In one embodiment a piston based pumping device based filter system according to herein is connected to a pipe system for providing the filter unit 2 with

feed and for transporting the permeate from the filter unit 2. As the permeate flow has an inertia and the time period for the reveres flow is kept short, the small volume of the flow from the piston based pumping device does not significantly affect the overall permeate flow. Simulations have shown that when the pipes transporting the permeate are long, the piston displacement in the piston based pumping device is superimposed on the flow through a filter membrane in the filter unit 2 without affecting the downstream flow in the permeate. This enables a steady delivery of the permeate even though a backwards flow through the membrane is generated for short time periods.

In one particular embodiment designed for a flux of 45 ml/min with a 15 Hz cam cycle, the cam 6 is designed to cause a fall time for the TMP of 44 ms and a wait time of 17 ms. The rise time is 6 ms. In an alternative embodiment the fall time is 61 ms and the wait time is 0 ms.

The rinsing caused by the backwards or reverse flow depends on at least two factors. The first factor is the maximum negative flow length (s_{neg}) through the pores. The second factor is the maximum negative flow velocity (v_{neg}) through the pores. These can be determined through the following equations:

$$s_{neg} = V'_r / A_{pores} \quad (1)$$

and

$$v_{neg} = Q'_r / A_{pores} \quad (2)$$

where A_{pores} is the area of the pores, Q'_r is the negative flow through the membrane and V'_r is the negative volume of flow through the membrane. V'_r and Q'_r are determined through:

$$Q'_r = V_r * (1/t_r - 1/T) - Q_{aveperm} \quad (3)$$

and

$$V'_r = V_r * (1 - 1/T) - t_r * Q_{aveperm} \quad (4)$$

where $Q_{aveperm}$ is the average flow of the permeate, V_r is the volume flow of the permeate, t_r is the fall time and T is the cycle time. Through these equations it is possible to design the piston based pumping device. For the piston based pumping device driven by the connecting rod 3 we have:

$$V_r = A_{pump} * S_{pump} \quad (5)$$

where $V_r = A_{pump}$ is the area of the piston based pumping device, and S_{pump} is the amplitude for the piston based pumping device.

In an embodiment, A_{pump} is 13 cm^2 and the stroke of the piston is about 0.15 cm.

The necessary setting for the piston and the piston based pumping device can thus be calculated through:

$$S_{pump} = (V'r + tr * Q_{aveperm}) / (A_{pump} * (1 - t_r/T)) \quad (6).$$

One benefit of the teachings herein is that a precise control of the reverse flow causing the rinsing effect can be achieved. The control is provided through the use of a cam which is simple to design. The lifespan of a filter is thereby effectively increased in a predictable manner.

It should be noted that a filtration unit, such as the filtration unit 30, 50 having been disclosed with reference to figures 1 to 5, can beneficially be arranged in a filter unit, such as the filter unit 2 in the filter apparatus 1 having been disclosed with reference to figures 6 to 8.

The invention has mainly been described above with reference to a few embodiments. However, without further elaboration, it is believed that one skilled in the art can, using the preceding description, utilize the present invention to its fullest extent. The preferred specific embodiments described herein are, therefore, to be construed as merely illustrative and not limitative of the remainder of the description in any way whatsoever. Further, although the present invention has been described above with reference to specific embodiments, it is not intended to be limited to the specific form set forth herein.

In the claims, the term "comprises/comprising" does not exclude the presence of other elements or steps. Additionally, although individual features may be included in different claims, these may possibly advantageously be combined, and the inclusion in different claims does not imply that a combination of features is not feasible and/or advantageous. In addition, singular references do not exclude a plurality. The terms "a", "an", "first", "second" etc do not preclude a plurality.

CLAIMS

1. A filtration unit (2, 30, 50) for filtration of a liquid food product, said filtration unit (2, 30, 50) comprising:

a feed inlet (F);

a permeate outlet (P), arranged down streams the feed inlet (F);

a filter (31, 51), arranged in between the feed inlet (F) and the permeate outlet (P) to divide the filtration unit (2, 30, 50) into at least a feed side and a permeate side; and

a pressure volume adjusting body (37, 57), capable of varying in volume in response to pressure in the liquid food product.

2. The filtration unit (2, 30, 50) according to claim 1, wherein said pressure volume adjusting body (37, 57) is positioned on the feed side of the filtration unit (30, 50).

3. The filtration unit (2, 30, 50) according to claim 1 or 2, wherein the filter (31, 51) is a microfiltration filter.

4. The filtration unit (2, 30, 50) according to any of the preceding claims, wherein the pressure volume adjusting body (37, 57) is a flexible membrane with hollow inner volume or a coated sponge-like body.

5. The filtration unit (2, 30, 50) according to claim 4, wherein the flexible membrane with hollow inner volume is connected to a gas or liquid supply.

6. The filtration unit (2, 30, 50) according to any of the preceding claims, wherein the filtration unit (2, 30, 50) is a cross flow filtration unit (2, 30, 50), such that the filtration unit (2, 30, 50) further comprises a retentate outlet (R), such that the filter unit (2, 30, 50) comprises at least one feed/retentate channel (54), extending from the

feed inlet (F) to the retentate outlet (R), through which feed gradually turns into retentate (R), exiting the filter unit (2, 30, 50).

7. The filtration unit (30, 50) according to claim 6, wherein the pressure volume adjusting body (31, 51) is arranged in the feed/retentate channel (54).

8. The filtration unit (50) according to claim 6 or 7, wherein the filtration unit (50) comprises several membranes (51) sandwiched between membrane support plates (52), and the at least one retentate channel (54) extend into the filtration unit (50) to intersect with the planes in which the membranes (51) are arranged.

9. The filtration unit (50) according to claim 8, wherein at least one pressure volume adjusting body (57) extends in a retentate channel (54), respectively, such that the at least one pressure volume adjusting body (57) intersects with the planes in which the membranes (51) are arranged.

10. The filtration unit (50) according to any of the preceding claims, further comprising an apparatus (1) to be attached to the filter unit (2, 30, 50) for generating a back-pulse of a flow through a membrane of said filter unit (2, 30, 50), said apparatus comprising means for causing a connecting rod (3) to move in a first forward direction at a first speed and in a second backwards direction at a second speed, wherein the second speed is not the same as the first speed.

11. A dairy system for producing a dairy food product, comprising the filtration unit (30, 50) according to any of claims 1 to 10, for removal of microorganisms and bacteria.

12. A method for washing a filter membrane (31, 51) in a filter unit (2, 30, 50) for filtration of a liquid food product, said filter unit (2, 30, 50) being arranged in a system with a first operational flow direction from a feed inlet (F) to a permeate outlet (P), comprising the steps of:

(i) pushing a fluid through the filter membrane (31, 51) from the permeate outlet (P) to the feed inlet (F) in an opposite direction to the operational flow direction; and

(ii) increasing the liquid volume of said filter unit (2, 30, 50) down streams said filter membrane (31, 51) during step (i).

13. The method according to claim 12, wherein step (ii) is performed by decreasing the volume of a pressure volume adjusting body (37, 57), capable of varying in volume in response to pressure in the liquid food product, said pressure volume adjusting body (37, 57) being arranged in said filter unit (2, 30, 50).

14. The method according to claim 13, wherein the pressure volume adjusting body (37, 57) is positioned down streams said filter membrane (31, 51) during step (i).

15. A filter apparatus (1) comprising a filter (2) where said filter comprises a filtration unit (2, 30, 50) according to any of claims 1 to 10.

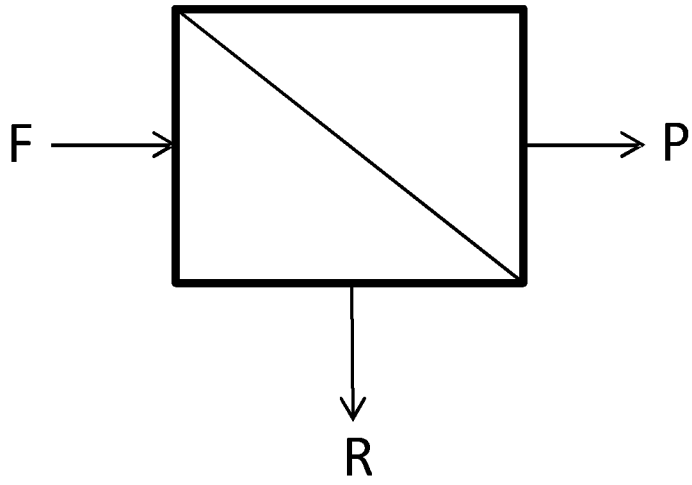

Fig. 1

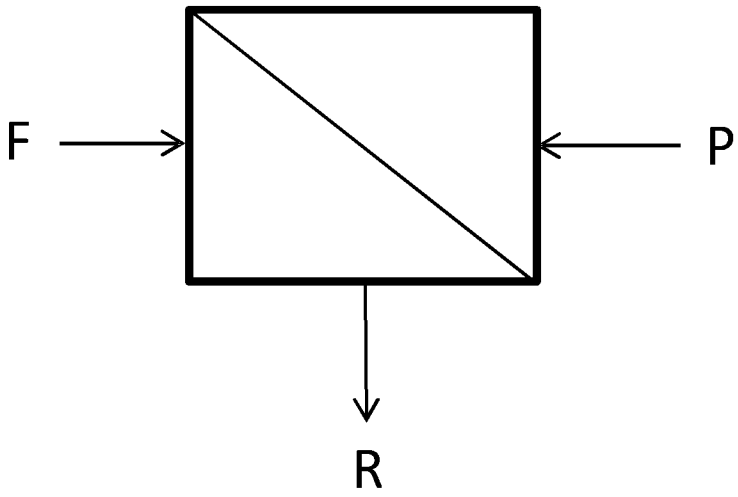

Fig. 2

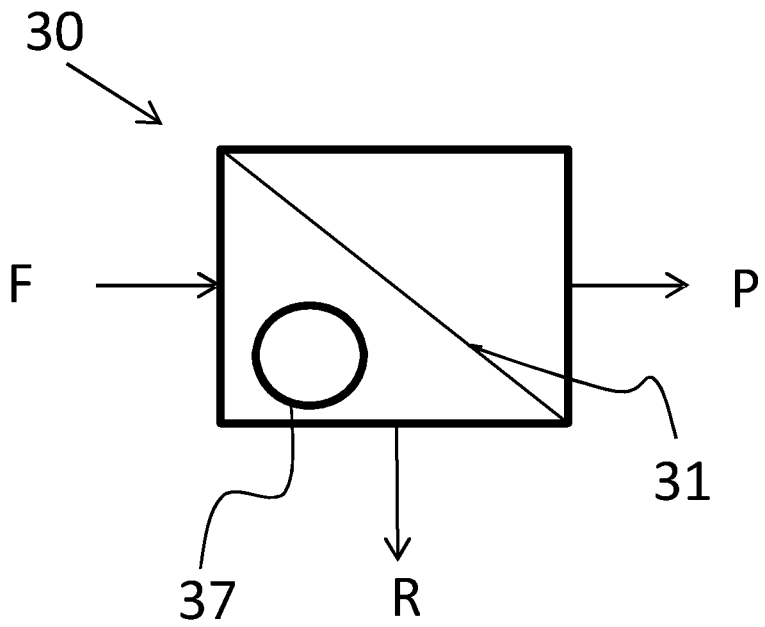

Fig. 3

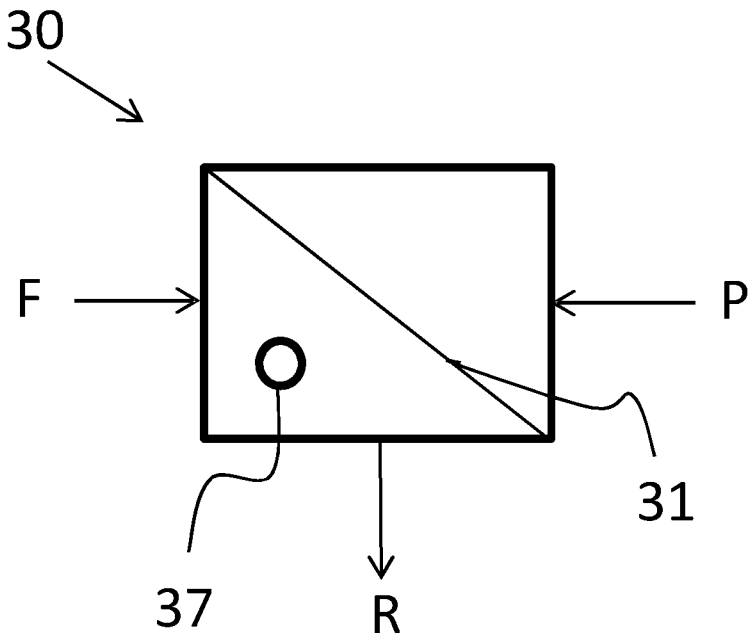

Fig. 4

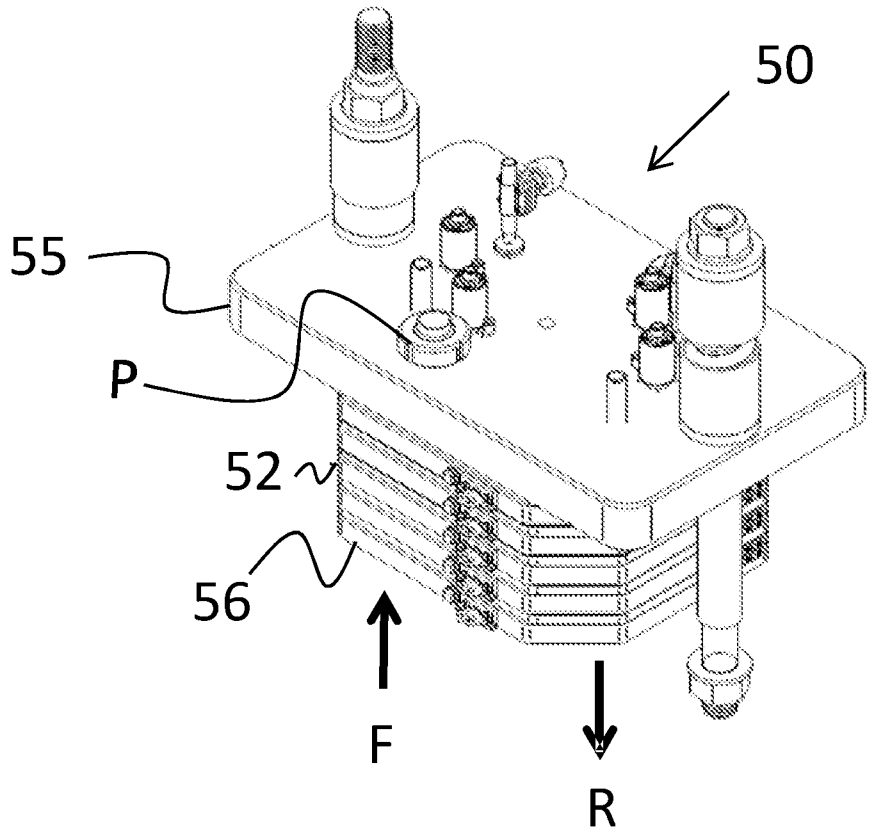

Fig. 5a

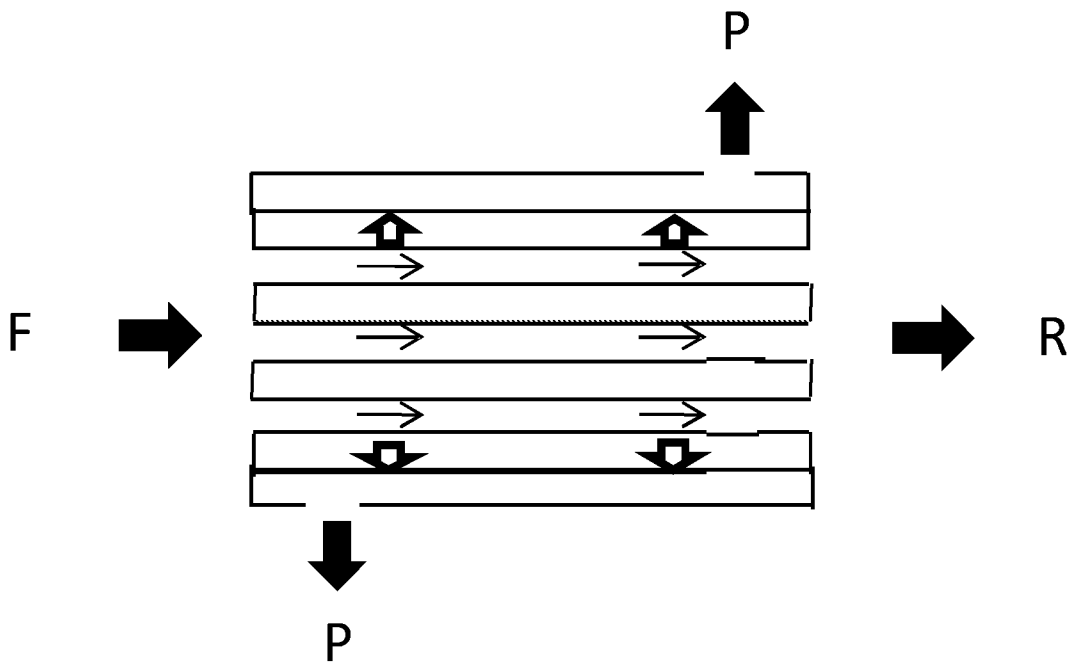

Fig. 5b

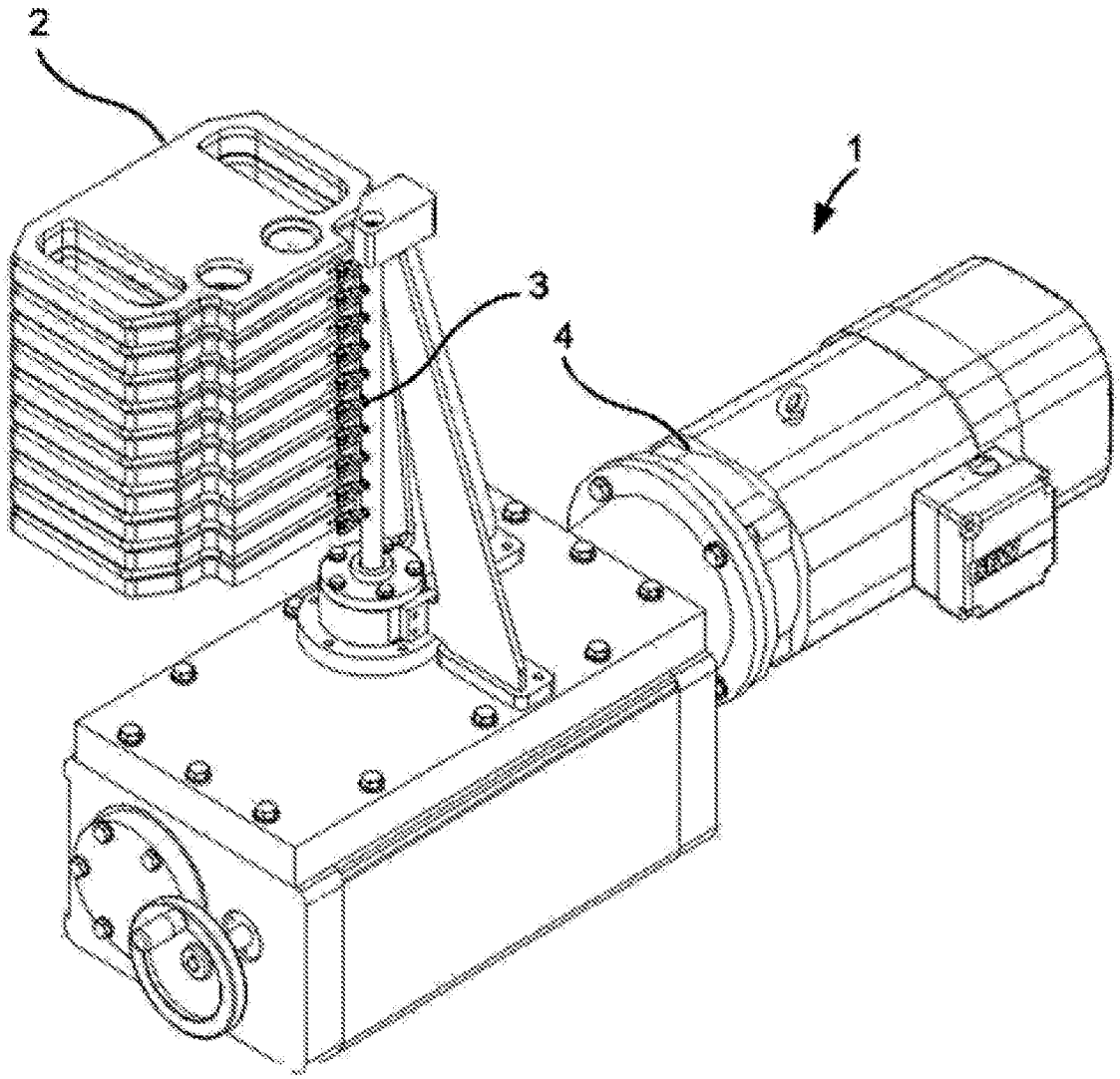

Fig. 6

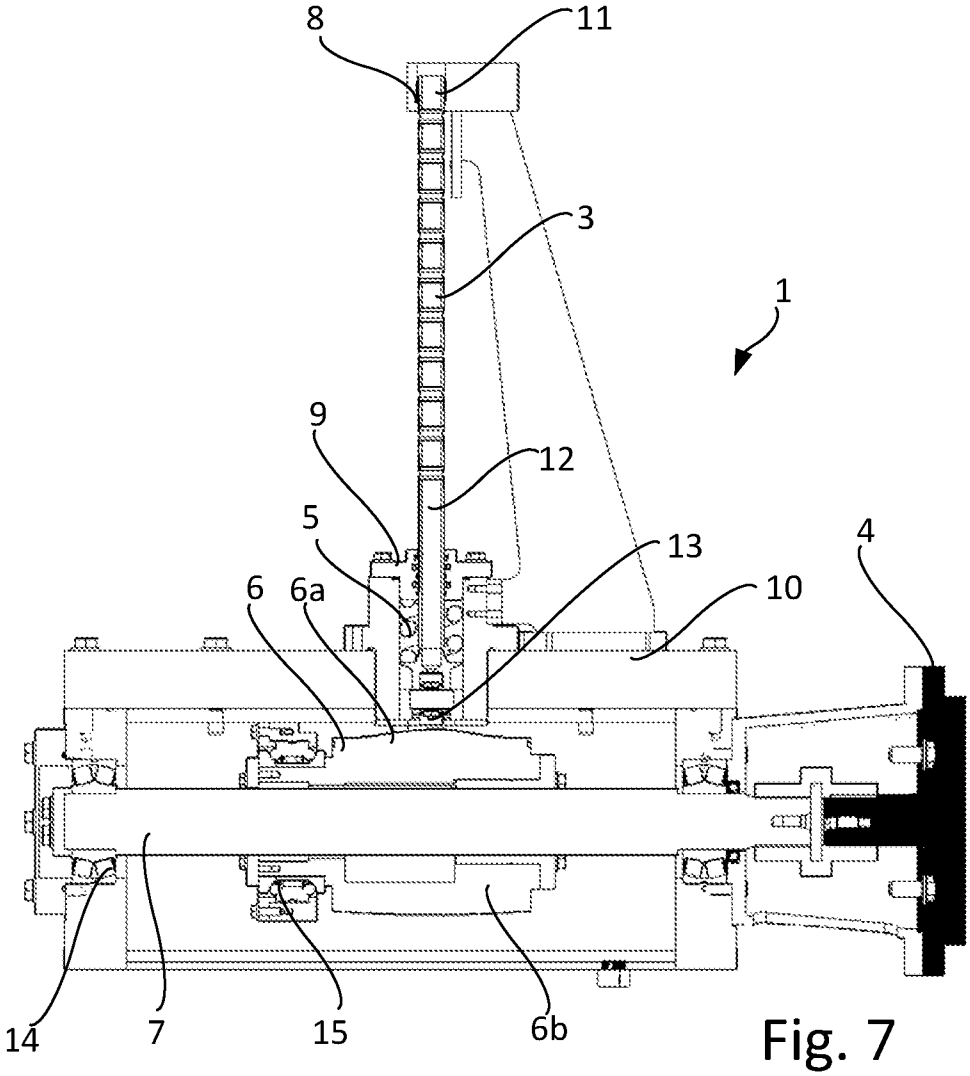

Fig. 7

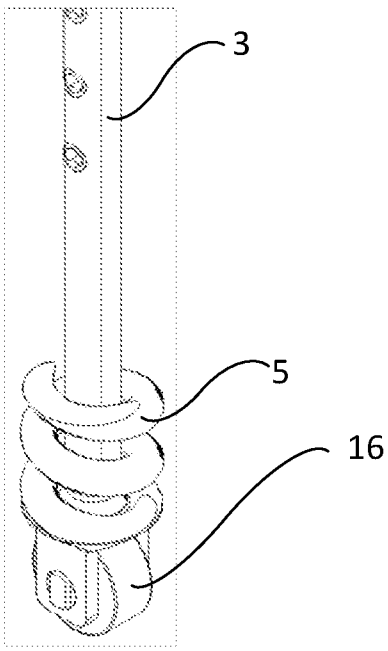

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2013/064182

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/064182

A. CLASSIFICATION OF SUBJECT MATTER
INV. B01D63/08 B01D65/02 A23C3/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B01D A01J A23C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/127098 A1 (FLUXXION B V [NL]; VOS JAN [BE]; ADRIAANS PETRUS JOHANNES MARTINUS [NL]) 23 October 2008 (2008-10-23) the whole document	1-9, 11-15
X	WO 01/10540 A2 (MICROFILTRATION TECHNOLOGY APS [DK]; MOELLER HANNE ELLEN [DK]; JONSSON) 15 February 2001 (2001-02-15) the whole document	1-7,10, 12-15
X	WO 00/57997 A1 (TECHNOLOGY FINANCE CORP [ZA]; FULS PAUL FRITZ [ZA]; JOUBERT ANDRE KEIT) 5 October 2000 (2000-10-05) the whole document	1-7, 12-15
X	US 4 592 848 A (PABST RICHARD E [US]) 3 June 1986 (1986-06-03) the whole document	1,3-6, 10,12-15

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 September 2013	16/09/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Marti, Pedro

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/064182

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DATABASE WPI Week 200382 Thomson Scientific, London, GB; AN 2003-894460 XP002711312, -& NL 1 020 180 C1 (AQUAMARIJN HOLDING BV) 16 September 2003 (2003-09-16) abstract	1-15
A	BRANS G ET AL: "Membrane fractionation of milk: state of the art and challenges", JOURNAL OF MEMBRANE SCIENCE, ELSEVIER SCIENTIFIC PUBL.COMPANY. AMSTERDAM, NL, vol. 243, no. 1-2, 1 November 2004 (2004-11-01), pages 263-272, XP004572543, ISSN: 0376-7388, DOI: 10.1016/J.MEMSCI.2004.06.029 the whole document	1-15
A	WO 02/18058 A1 (AQUAMARIJN HOLDING BV [NL]; RIJN VAN CORNELIS JOHANNES MAR [NL]; NIJDA) 7 March 2002 (2002-03-07) the whole document	1-15
A	GB 2 273 885 A (PALL CORP [US]) 6 July 1994 (1994-07-06) the whole document	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2013/064182

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FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-11, 15

Claims 1-10: Filtration unit (2, 30, 50) for filtration of a liquid food product, said filtration unit (2, 30, 50) comprising:a feed inlet (F); a permeate outlet (P), arranged down streams the feed inlet (F); a filter (31, 51), arranged in between the feed inlet (F) and the permeate outlet (P) to divide the filtration unit (2, 30, 50) into at least a feed side and a permeate side; and a pressure volume adjusting body (37, 57), capable of varying in volume in response to pressure in the liquid food product.
Claim 11: Dairy system for producing a dairy food product, comprising the filtration unit (30, 50) according to any of claims 1 to 10, for removal of microorganisms and bacteria.
Claim 15: Filter apparatus (1) comprising a filter (2) where said filter comprises a filtration unit (2, 30, 50) according to any of claims 1 to 10

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2. claims: 12-14

Method for washing a filter membrane (31, 51) in a filter unit (2, 30, 50) for filtration of a liquid food product, said filter unit (2, 30, 50) being arranged in a system with a first operational flow direction from a feed inlet (F) to a permeate outlet (P), comprising the steps of:(i) pushing a fluid through the filter membrane (31,51) from the permeate outlet (P) to the feed inlet (F) in an opposite direction to the operational flow direction; and (ii) increasing the liquid volume of said filter unit (2, 30, 50) down streams said filter membrane (31, 51) during step (i)
