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(54) METHOD AND APPARATUS FOR THE WASHING OF FEATHERS AND REMOVING OF EXTRANEOUS MATERIAL

(57) This invention relates to a washing system suitable for continuous processing, for the pretreatment of keratinaceous material, preferably feathers, hair or wool. The washing system comprises an infeed device for feeding the keratinaceous material to the washing system and a washing space for washing the keratinaceous material with an aqueous washing liquid. A washing liquid system for supplying and extracting the washing liquid to and from the washing space is comprised in the washing system. The washing space comprises a sinking zone wherein material with a higher density than the washing liquid sinks below the keratinaceous material. An extracting system is placed at the bottom of the sinking zone for extracting the material with a higher density than the washing liquid. Furthermore, at least one washing structure that sloshes the washing liquid and/or causes turbulence in the washing liquid is present in the washing space. Finally, an outfeed device is provided for extracting the keratinaceous material from the washing system.

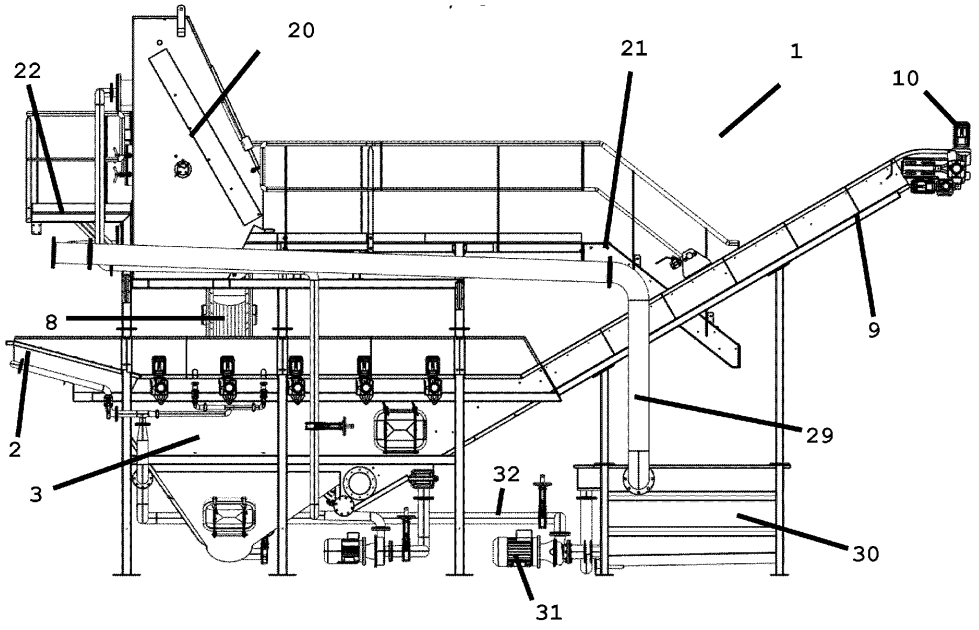

FIG.2

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Description

TECHNICAL FIELD

[0001] This disclosure generally relates to washing of keratinaceous material before being subjected to further processing, such as a hydrolysis process, or used in the down industry.

BACKGROUND

[0002] Animal feathers, hair, wool, hooves, nails and the like are a source of keratinaceous material. Such keratinaceous material, which is generally a by-product from the slaughter of poultry, pigs, cattle, sheep and the like is high in protein content but much of the protein is indigestible as such, e.g. as low as 20% only of the protein is digestible. Poultry feathers typically contain approximately 80 to 90% protein in the form of β-keratin. Keratin contains a relatively high amount of cysteine that results in cross-links in the protein.

[0003] However, this keratinaceous material is hardly digestible for animals or humans, the reason being the high degree of cross-linking with (di-)sulfide bridges. Keratin must hence be cleaved before its protein content can be digested by animals (McCasland and Richardson 1966, Poult. Sci., 45:1231-1236; Moran et al. 1966 Poult. Sci., 45: 1257-1266).

[0004] Hydrolyzed feathers can therefore provide an inexpensive source of digestible proteins and amino acids. Accordingly feather hydrolyzate (i.e. hydrolyzed feathers) can be utilized in a numbers of ways, such as in animal feed.

[0005] Methods for processing feathers or hair to increase digestibility and to allow their use as a protein source for feeding poultry and livestock are known in the art. Generally, such methods involve using hydrolysis to break the disulfide bridges (as well as at least part of the peptide bonds) in the keratinaceous proteins and incorporating the resulting hydrolyzed proteins into feeds. The commonly used methods of processing keratin-containing stock are subdivided into 1) hydrothermal and pressurized treatment methods, 2) acid, alkaline and/or enzymatic hydrolysis methods or 3) combinations thereof. The keratinaceous material generally is not completely hydrolysed to mono-amino acids, as that is not necessary to improve the digestibility.

[0006] Several methods for producing partially hydrolyzed keratinaceous material such as feather meal are known in the art; including US5772968, US4286884, US4172073, EP 2832236 and EP 2832237 that use steam and pressure only. The resultant material from the partial hydrolysis of the keratinaceous material is partly insoluble in water, and may comprise a mixture of liquid (dissolved) and solid (insoluble material). Generally the resulting product is subsequently dried to obtain a solid product. Drying can significantly impact digestibility of the material according to for example the pepsin and/or ileal digestibility test. Recently, improved keratinaceous material processing and drying methods have been developed resulting in hydrolyzed keratinaceous material with improved digestibility, these are for example described in EP 3 192 377 A1 and EP 3 402 340 A1.

[0007] In the down industry, down and feathers need to be properly cleaned and sorted in order for the down to be used, for example in jackets, pillows and blankets. In this process, down and feathers are first put through a dust removal system for elimination of fine dust and other foreign particles. Next, the down and feathers are washed in a washing system, and subsequently dried in a drying system. A sorting system separates the down from the feathers such that the down and feathers can be bagged and further processed. While the down is washed during this process, and some foreign material is removed, only fine dust and bacteria are removed and this method is not suited to remove for example larger foreign material.

[0008] Document WO2014180681A1 discloses a feather washing machine comprising a washing cylinder mounted rotating about a horizontal axis and divided into successive treatment chambers by means for transferring feathers from one chamber to another. Each treatment chamber comprises a space for receiving a predefined volume of feathers to be treated, which undergo four treatment operations implemented successively while the cylinder rotates about the horizontal axis and by means of four respective treatment zones included in the chamber. This document is related to treatment of only small batches of feathers. No specific impurities are mentioned, nor their effect on the quality of the keratinaceous material.

[0009] The present inventors found that the keratinaceous starting material, which is typically obtained from slaughterhouses, varies a lot in quality and may be of low quality due to the presence of foreign material and/or signs of microbial spoilage (as indicated by a high biogenic amine content). This has a significant negative impact on process efficiency and/or on the quality of the final hydrolyzed keratinaceous material or of the down used in the down industry.

[0010] It is therefore an object of the invention to provide a solution, such as an apparatus and method, for managing the varying quality of keratinaceous starting material, resulting in an increased process efficiency and/or quality of the final hydrolyzed keratinaceous material or of the down used in the down industry. This applies in particular to feather meal obtained after hydrolysis with steam and pressure, or after chemical hydrolysis.

SUMMARY

[0011] To address the above discussed drawbacks of the prior art, and in particular to lower the amount of unwanted particles, the invention provides, according to a first aspect, a washing system suitable for continuous processing, for the pre-treatment of keratinaceous ma-

terial, preferably feathers, hair or wool. The washing system comprising:

an infeed device for feeding the keratinaceous material to the washing system;
a washing space for washing the keratinaceous material with an aqueous washing liquid;
a washing liquid system for supplying and extracting the washing liquid to and from the washing space;
wherein the washing space comprises a sinking zone wherein material with a density higher than the washing liquid sinks below the keratinaceous material;
an extracting system placed at the bottom of the sinking zone for extracting the material with a higher density than the washing liquid;
at least one washing structure that sloshes the washing liquid and/or causes turbulence in the washing liquid present in the washing space;
an outfeed device for extracting the keratinaceous material from the washing system.

[0012] The washing system provides for an efficient way to continuously process keratinaceous material. Unwanted material denser than the washing liquid is effectively removed from the keratinaceous material, and the keratinaceous material is subsequently extracted from the washing system..

[0013] In an embodiment the sinking zone comprises a flow system which is adapted to impart a flow to the washing liquid in the sinking zone, wherein the magnitude and direction of the flow is such that the keratinaceous material is kept in suspension and moved away from the extracting system whilst the material denser than the washing liquid still sinks towards the extracting system.

[0014] In an embodiment, the washing space further comprises a cleaning zone for cleaning of the keratinaceous material, the sinking zone and cleaning zone positioned such that the keratinaceous material first enters the sinking zone before entering the cleaning zone, wherein at least one washing structure is located in the cleaning zone.

[0015] In an embodiment, the washing liquid system further comprises a washing liquid recycling system for reusing the washing liquid after use in the washing space, wherein the washing liquid recycling system comprises a washing liquid solid separation system, preferably a filter, for cleaning the washing liquid.

[0016] In an embodiment, the washing system further comprising an excess washing liquid removal device for extracting excess washing liquid from the keratinaceous material after the keratinaceous material has been washed in the washing space, preferably wherein the excess washing liquid removal device extracts the excess washing liquid at the outfeed device and/or wherein the extracted excess washing liquid is reused in the washing space.

[0017] In an embodiment, the washing structure is cylindrically shaped and comprises one or more protrusions on the cylindrical surface, and wherein the washing structure is rotatably mounted on the washing system, preferably mounted such that when the washing structure rotates, the keratinaceous material is at least partially submerged due to the action of the protrusi ons.

[0018] In an embodiment, a bottom surface of the sinking zone is slanted towards the extracting system, and/or wherein the extracting system comprises a cork screw extractor.

[0019] According to a second aspect of the invention, a method for the pre-treatment of keratinaceous material, preferably feathers, hair or wool is proposed. The method comprises the steps of:

feeding the keratinaceous material to a washing system, the keratinaceous material comprising one or more contaminants;
washing the keratinaceous material in an aqueous washing liquid using the washing system, wherein the one or more contaminants are dissolved into the washing liquid and/or removed at least partly from the keratinaceous material by the washing liquid;
obtaining the pre-treated keratinaceous material from the washing system;
characterized in that washing is performed such that the amount of at least one of the contaminants comprised in the pre-treated keratinaceous material is below a pre-determined threshold.

[0020] In an embodiment, washing is performed such that the amount of at least one of the contaminants comprised in the pre-treated keratinaceous material is less than 50%, of its amount in the keratinaceous material before washing, preferably less than 40%, more preferably less than 30%, more preferably less than 20%, wherein the amounts are determined as weight/weight (w/w) on dry weight basis.

[0021] In an embodiment, the one or more contaminants are selected from a group consisting of biogenic amines, preferably tyramine, putrescine, cadaverine, histamine, phenylethylamine, spermidine, and/or agmatine

[0022] In an embodiment, washing is performed such that the amount of at least one of tyramine, putrescine, cadaverine, histamine, phenylethylamine, spermidine, and agmatine, preferably the amount of putrescine and/or cadaverine and/or tyramine, comprised in the pre-treated keratinaceous material is less than 50% of its amount in the keratinaceous material before washing, preferably less than 40%, more preferably less than 30%, more preferably less than 20%, wherein the amounts are determined as w/w on dry weight basis.

[0023] In an embodiment, the combined amount of tyramine, putrescine, cadaverine, histamine, phenylethylamine, spermidine, and agmatine, preferably the combined amount of putrescine and/or cadaverine and/or tyramine, comprised in the pre-treated keratinaceous material is less than 50% of the amount in the

keratinaceous material before washing, preferably less than 40%, more preferably less than 30%, more preferably less than 20%, wherein the amounts are determined as w/w on dry weight basis.

[0024] In an embodiment, the washing of the keratinaceous material comprises a sinking step wherein material denser than the washing liquid sinks lower than the keratinaceous material and is subsequently extracted at a lower point than the location of the keratinaceous material.

[0025] In an embodiment, the washing of the keratinaceous material comprises maintaining the amount of at least one biogenic amine, preferably maintaining the amount of at least one biogenic amine selected from the group consisting of tyramine, putrescine, cadaverine, histamine, phenylethylamine, spermidine, and agmatine, dissolved in the washing liquid below a predetermined threshold by extracting used washing liquid, and supplying fresh washing liquid, preferably by continuously bleeding out used washing liquid and continuously supplying fresh washing liquid.

[0026] In an embodiment, the washing liquid further comprises a surfactant and/or a biocide and/or a degreasing agent and/or a bleaching agent and/or an organic solvent.

[0027] In an embodiment, the amount of keratinaceous material per hour that is pre-treated is greater than or equal to 0.5 metric ton per hour, preferably greater than or equal to 1 metric ton per hour, more preferably greater than or equal to 2 metric ton per hour and wherein washing is performed in a washing space wherein the amount of washing liquid present in the washing space is greater than or equal to 1 m^3, preferably greater than or equal to 2 m^3, greater than or equal to 2.5 m^3, and wherein the complete volume of washing liquid is recirculated at least 5 times per hour, preferably at least 10 times per hour, more preferably at least 15 times per hour.

[0028] In an embodiment, the washing system is the washing system according to the first aspect of the invention.

[0029] According to a third aspect of the invention, a method for the production of hydrolyzed keratinaceous material is disclosed, comprising the steps of:

(i) washing the keratinaceous material using the washing system according to the first aspect of the invention, or the method according to the second aspect of the invention;
(ii) hydrolyzing the keratinaceous material;
(iii) drying the hydrolyzed keratinaceous material, thereby obtaining dried hydrolyzed keratinaceous material.

[0030] According to a fourth aspect of the invention, a method for processing keratinaceous material for the down industry is disclosed, comprising the steps of:

(i) washing keratinaceous material comprising down using the washing system according to the first aspect of the invention, or the method according to the second aspect of the invention;
(ii) drying the washed keratinaceous material;

and wherein either before or after the washing step the down is separated from other keratinaceous material.

[0031] According to a fourth aspect of the invention, a method is disclosed for washing keratinaceous material, preferably feathers, hair or wool, wherein the keratinaceous material is contaminated with material denser than the keratinaceous material, the method comprising:

washing the keratinaceous material in a washing system using a washing liquid in which the keratinaceous material floats and in which the material denser than the washing liquid sinks;
extracting the material denser than the washing liquid at the bottom of the washing system using an extracting system.

[0032] In an embodiment, the method further comprises imparting a flow on the washing liquid in the washing system, wherein the magnitude and direction of the flow is such that the keratinaceous material is kept in suspension and moved away from the extracting system whilst the material denser than the washing liquid still sinks towards the extracting system.

[0033] In an embodiment, the magnitude and direction of the flow is such that an object with a density of more than 1.01 g/cm3, preferably more than 1.08 g/cm3 sinks while the majority of the keratinaceous material remains suspended in the washing liquid.

[0034] The present inventors have found that foreign, unwanted material often will be presented in the keratinaceous starting material. For example, for feathers, poultry carcasses are plucked via robotic fingers made of rubber. These rubber plucking fingers are often detached from the plucking robot and end up as foreign material in the feathers. When the feathers are used as keratinaceous starting material, the rubber plucking fingers may block or even damage processing equipment such as hydrolyzers (in particular continuous hydrolyzers). Other foreign material which is often present are metal pieces detached from the slaughterhouse processing line and unwanted other body parts. This can form a problem in the down industry, since the unwanted other body parts might contaminate a batch of down. A common solution for removing foreign material, such as a metal detector on the processing line, has several disadvantages. For example, the rubber plucking fingers are not detected, and in case metal is detected this results in large inefficiencies since either a processing line needs to be halted and an operator needs to search for, and remove the metal particle, or a part of the feed material is automatically ejected, resulting in a large/disproportionate loss of feed material.

[0035] Additionally, the present inventors have found a high variability of the amount of biogenic amines

present in the keratinaceous starting material. These biogenic amines, for example tyramine, putrescine, cadaverine, histamine, phenylethylamine, spermidine, and agmatine may be anti-nutritional and/or a sign of microbial spoilage. Furthermore, some biogenic amines (in particular putrescine and cadaverine) impart a strong malodour on the keratinaceous starting material. The present inventors found it to be advantageous to decrease the amount of biogenic amines in the keratinaceous starting material (and consequently in the final product, such as hydrolyzed keratinaceous material intended for the food or feed sectors or down for the down industry). The present inventors have found that the regular processing steps, such as hydrolysis of the keratinaceous material, does not suffice to lower the biogenic amine content, especially in case the keratinaceous starting material has a relatively high biogenic amine content.

[0036] The present invention provides a method and apparatus for filtering such unwanted foreign material in an efficient way, while concomitantly decreasing the amount of biogenic amines in the keratinaceous starting material (and consequently for example in the hydrolyzed keratinaceous material).

BRIEF DESCRIPTION OF DRAWINGS

[0037] Embodiments will now be described, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, and in which:

FIG. 1-5 show a schematic overview of a washing apparatus for washing keratinaceous material, from front, back, side and perspective view.

FIGS. 6-7 schematically show the washing space and the infeed and outfeed to the washing space 3.

FIGS. 8A, 8B, 9 and 10 shows a detailed schematic view of the sinking zone 6.

FIG. 11 shows a detailed schematic side-view of the sinking zone 6.

FIG. 12 shows an exemplary exterior of the sinking zone.

FIG. 13 shows a flow diagram describing various steps in the (pre-)processing of keratinaceous material.

[0038] The figures are intended for illustrative purposes only, and do not serve as restriction of the scope or the protection as laid down by the claims.

DESCRIPTION OF EMBODIMENTS

[0039] Hereinafter, certain embodiments will be described in further detail. It should be appreciated, however, that these embodiments may not be construed as limiting the scope of protection for the present disclosure.

[0040] FIG. 1-5 show a schematic overview of a washing apparatus 1 for washing keratinaceous material from various sides.

[0041] Keratinaceous material can be for example feathers, hair, wool, hooves and/or nails. Before the keratinaceous material is subjected to a rendering treatment, preferably before it is hydrolysed, the keratinaceous material is washed according to the present invention.

[0042] The keratinaceous material is preferably feathers, hair and/or wool. The present inventors have found that the separation between the foreign material (e.g. plucking fingers, metal parts, sand etc.) is more efficient for these materials. The keratinaceous material most preferably is feathers (large feathers, down feathers and mixtures thereof). Feather can be from chicken, duck, goose, turkey and the like. Preferably, chicken feathers are washed in the method or apparatus of the invention, as chicken feathers are a very common waste stream.

[0043] The keratinaceous material can be fed into the washing apparatus 1 using an infeed device (not shown). The infeed device can comprise a screw conveyor, conveyor belt, pumps, revolving screens and/or rotary screens. A conveyor belt can comprise sieves or perforations. The infeed device feeds the keratinaceous material into the washing apparatus 1 at an infeed location 2. The infeed location 2 can comprise for example an infeed funnel.

[0044] The washing apparatus 1 contains an aqueous washing liquid. The washing liquid is present in a washing space 3. A constant water flow can be present at the infeed location 2, such as to rinse all the keratinaceous material into the washing apparatus 1.

[0045] The washing liquid comprises a major amount of water (e.g. more than 80, 90 or 95 wt.%) and optional other ingredients such as one or more surfactants. In an embodiment, the washing liquid comprises a surfactant, for example in order to remove fat from feathers. A washing liquid comprising a surfactant is preferred when washing feathers and/or down for the down industry. In a preferred embodiment, the washing liquid does not comprise a surfactant, more preferably the washing liquid consists of water. A surfactant-free washing liquid is preferred when the keratinaceous material is subsequently subjected to a hydrolysis process as described herein elsewhere, which is typically the case when rendering the keratinaceous material for use in the animal feed or pet food industry. The skilled person will understand that during use, the washing liquid becomes contaminated, such that here the composition of fresh washing liquid before use is referred to.

[0046] The biogenic amines present in the keratinaceous material will at least partially dissolve into the washing liquid. Furthermore, the washing liquid can be used as a conveying material to separate material denser than the washing liquid. For example, feathers will generally float in the water, while denser objects such as other body parts or sand particles sink in water. The material denser than the washing liquid as referred to herein is typically body parts, plucking fingers, sand, and/or dirt.

In preferred embodiments the material denser than the washing liquid are plucking fingers.

[0047] The infeed device can include a singulator, such that the keratinaceous material is fed into the washing apparatus 1 as discrete pieces, e.g. such that the keratinaceous material does not stick to each other. In this way, the contact surface of the keratinaceous material is increased, and the washing liquid present in the washing apparatus 1 can reach all around the discrete pieces of keratinaceous material.

[0048] As another way to increase contact between unwanted material in the keratinaceous material and water particles, a high flow-through rate of the washing liquid can be used. For example, the water inside the washing apparatus 1 is refreshed fully ten to twenty times per hour, or more. For example, in a washing apparatus 1 comprising a washing space 3 containing six cubic metres of water, 100 cubic metres of water can be refreshed per hour. A washing liquid system comprises inlets and outlets to the washing space 3. Multiple inlets and outlets can be present, such that the inlets and outlets not only serve to feed water into the washing space 3 and extract water from the washing space 3 respectively, but that these can also be used to shape the water flow in the washing space, and/or to exert a force on the keratinaceous material via inlets with high pressure to remove unwanted particles.

[0049] The washing liquid that exits the washing space 3 can be disposed of, or more preferably partly, largely and/or fully recycled using a recycling system. The recycling system can be a part of the washing liquid system. The recycling system can return the washing liquid back into the washing space 3, or also actively filter and clean the washing liquid before returning it to the washing space 3. The washing liquid that is to be recycled can go through several filters first, such that the recycled washing liquid is cleaner than when it exited the washing space, i.e. less unwanted material is present in the washing liquid. The filters can be made of one or several sieves placed in a sequence along the flow path and/or substances that extract unwanted molecules from the washing liquid via a chemical reaction. The sieves can have openings of different sizes, for example decreasing along the sequence of sieves.

[0050] A water reservoir 30 can be present, which holds a particular volume of water which can be used in the washing space 3. Fresh water which has not been used by the washing apparatus 1 to clean the keratinaceous material can be fed into the water reservoir 30. The water level in the water reservoir 30 can be controlled, for example by a supply valve, an overflow system and an outlet valve. A water pump 31 can work together with a valve system and a piping system 32 to feed washing liquid from the water reservoir to the washing space 3.

[0051] By using the water reservoir 30, a particular inflow of washing liquid into the washing space can be maintained. Furthermore, if the water reservoir 30 is used in conjunction with a filter, for example filter system 20 detailed below, water can be circulated from the washing space 3 via filter piping 29 to the water reservoir 30 and back to the washing space 3 by reusing the filtered washing liquid.

[0052] The washing liquid, preferably water, can be introduced into the washing space 3 using dosing nozzles, which make sure the water level within the washing space 3 remains constant during operation of the washing apparatus 1. To prevent blocking the dosing nozzles with the keratinaceous material or larger particles of unwanted material when recycled water is used, a sieve can be used at the inlet to the recycling system.

[0053] The washing liquid that exits the washing space 3 can be removed continuously from the washing apparatus 1 in a continuous bleeding and simultaneously fresh washing liquid can be continuously added to the washing space 3. In this way, the washing liquid comprised in the washing space 3 is continuously being rid of contaminants and thus cleaned. This process of continuous bleeding of washing liquid 3 and simultaneous continuous addition of fresh washing liquid can be performed while the washing liquid that exits the washing space 3 is partly or largely recycled using the recycling system.

[0054] The water level in the washing apparatus 1 can be monitored by for example a pressure sensor. When the water level is determined to be too low, clean water is added to the washing apparatus 1. This clean water can come from an external waterpipe, or be recycled water.

[0055] In a preferred embodiment, a washing liquid solid separation system, e.g. a filter system 20 is installed above the washing space 3. The filter system 20 can comprise a static screen with a wedge wire having a particular slot size such that water can go through, but keratinaceous material in general cannot go through the wedge wire. For example, the static screen can form a bow sieve. Any other filter system can be used. A water pump pumps washing liquid from the washing space 3 and feeds it to the filter. The cleaned washing liquid can flow back to the washing space 3 or the water reservoir 30. The filtered keratinaceous material is reintroduced into the washing space 3.

[0056] The integrated filter can have an automatic cleaning system. The automatic cleaning system can comprise of a reciprocating spray-arm with jet nozzles, e.g. flat jet nozzles, which can periodically move along the rear of the filter in a horizontal direction. The spray-arm can be driven by a spindle which is connected to a motor, for example placed on a side of the machine. The rotation direction of the motor and the linear motion of the spray-arm can be controlled by two inductive proximity switches.

[0057] In the preferred embodiment, a staircase 21 and platform 22 is present, which gives access to the washing liquid solid separation system, e.g. the filter system 20, installed above the washing space 3. In this way the filter system 20 can be easily maintained.

[0058] In a preferred embodiment, by placing the

washing liquid solid separation system, e.g. the filter system 20 having large mesh screen, directly above the washing space 3, the reject of the filter system 20 can fall back into the washing space 3. The reject of the filter system 20 can include keratinaceous material, e.g. feathers. The keratinaceous material is then reintroduced back into the washing space 3. The washing liquid which passes through the filter system 20 can be recycled and reintroduced into the washing space 3, e.g. via one or more spraying bars 40 introduced below, and may be filtered through a small mesh screen. The large mesh filter can be used to prevent the nozzles 41 of the spraying bars 40 from getting blocked. The foreign material is eventually 'permanently' removed when it sinks low enough to reach the extracting system 8 discussed below. The keratinaceous material keeps circulating, and the feathers eventually get removed by moving on in the process, and material with a high density eventually sinks and is removed by the extracting system 8.

[0059] Furthermore, by placing the washing liquid solid separation system, e.g. the filter system 20, directly above the washing space 3 factory floor space can be saved. In another embodiment, the washing liquid solid separation system, e.g. the filter system 20, can be placed next to the washing space 3, or any other placement configuration can be used. In another embodiment, by placing the washing liquid solid separation system, e.g. the filter system 20, directly above the washing space 3, the washing liquid can partly flow through the filters in the filter system 20 and then fall back into the washing space 3. In this way, a recirculation flow and turbulence is created in the upper layer of the washing space 3, where generally the most keratinaceous material can be found. The washing liquid solid separation system, e.g. the filter system 20, can block foreign material and thus clean the washing liquid that is reintroduced into the washing space 3. In this way, the keratinaceous material is subjected to recycled washing liquid comprising less unwanted material, such as for example biogenic amines, and can thus absorb the unwanted material better.

[0060] FIGS. 6-7 schematically show the washing space 3 and the infeed and outfeed to the washing space 3.

[0061] The washing space 3 comprises at least one washing structure that sloshes the washing liquid and/or causes turbulence in the washing liquid present in the washing space. Suitable and preferred washing structures are washing rollers 4 that rotate either via a motor 43 imparting rotational movement on the washing roller 4, or via the washing liquid flow. The washing rollers 4 are formed as partly and/or fully submerged cylinders in the washing liquid, and are made of stainless steel, or any other metal, or hard wear-resistant plastic. The longitudinal axis of the cylinders can lay for example horizontally or vertically, preferably horizontally. Any other shape or material is within the scope of the invention. Preferably the material does not react with the washing liquid. The washing rollers 4 comprise for example paddles, brushes or other protrusions 5 in a radial outward direction, made preferably from the same material as the washing rollers 4. The protrusion 5 can be used to push forward the keratinaceous material along the washing space, to push the keratinaceous material under water and/or to impart turbulence on the washing liquid. In this way, the keratinaceous material is better separated, and the chaotic water flow makes for a better separation of keratinaceous material and unwanted particles and parts. The inventors have found that an advantage of using such a system is that a better separation of the keratinaceous material is achieved, which is particularly useful when unwanted material is trapped inside agglomerates of feathers. In the embodiment, five washing rollers 5 are used, however the invention is not restricted in this way.

[0062] The rotational speed of the washing rollers 4 can be controlled. The higher the rotational speed, the more turbulence is induced in the washing liquid. The rotational speed can be set to about 30 rounds per minute or more, preferably to about 40 rounds per minute or more, more preferably to 50 rounds per minute or more, more preferably to about 60 rounds per minute or more. The rotational speed generally can be about 5 rounds per minute or more, preferably about 10 rounds per minute or more.

[0063] The washing rollers 4 can impart a partial and/or substantial cyclonic movement at certain locations in the washing space 3 on the washing liquid and the keratinaceous material, or in any other way impart a movement on the washing liquid such that the keratinaceous material passes multiple times through the same point in the washing space 3. In this way, the keratinaceous material stays longer in the washing space 3, thus lengthening the time the keratinaceous material stays in the washing liquid, and thus increasing the chance that unwanted molecules or particles can be absorbed or separated by the water.

[0064] Instead of washing rollers 4, other washing structures can be used that slosh the washing liquid comprising the keratinaceous material, push the keratinaceous material under water, and/or in another way cause turbulence within the washing liquid's flow.

[0065] The washing space 3 can be divided into one or multiple functional zones. In this preferred embodiment, the washing space 3 is divided into a sinking zone 6 and a further cleaning zone 7. Preferably, the sinking zone 6 and cleaning zone 7 are positioned such that the keratinaceous material first enters the sinking zone 6 before entering the cleaning zone 7. In other words, preferably the sinking zone 6 and the cleaning zone 7 are sequential to one another.

[0066] When the keratinaceous material first enters the washing space 3, it enters the sinking zone 6. In the sinking zone 6, the keratinaceous material therefore still has the highest amount of unwanted material present. If the keratinaceous material is for example feathers, down, or

a similar light material, it will float in water or remain higher up in the sinking zone 6. However, denser materials, such as for example chicken heads or plucking fingers, will sink to the bottom of the sinking zone 6 where these can be extracted.

[0067] FIGS. 8A, 8B, 9, 10 show a detailed schematic view of the sinking zone 6. FIG. 11 shows a detailed schematic side-view of the sinking zone 6.

[0068] The sinking zone 6 can comprise one or more spraying bars 40, or any other flow system which can impart a flow on the washing liquid in the sinking zone. The flow can be imparted by liquid and/or gas, preferably water and/or air. In general, the flow system can comprise one or more nozzles which direct the flow of the liquid and/or gas which impart the flow on the washing liquid in the sinking zone. This flow of the washing liquid is preferably directed upwards, but can also be for example directed sideways. The liquid and/or gas flowrate is chosen in such a way that the keratinaceous material is suspended in the bulk washing liquid while heavier particles and/or objects still sink to the bottom of the sinking zone such that these can be extracted by the extracting system 8. The magnitude and direction of the flow can be such that an object with a density of more than 1.01 g/cm3, preferably more than 1.08 g/cm3 sinks while the majority of the keratinaceous material remains suspended in the bulk washing liquid.

[0069] In order to achieve a good suspension while material with a higher density sinks, the flow rate imparted by the flow system on the washing liquid and/or the specific nozzle design and/or the specific nozzle placement can be adapted.

[0070] In a preferred embodiment, where the washing liquid solid separation system, e.g. the filter system 20, is placed directly above the washing space 3, the washing liquid can fall from the filter system 20 directly into the washing space 3. This creates a downward flow of washing liquid in that area. The spraying bars 40 can be arranged as to counter this downward flow, such that the keratinaceous material does not sink towards the extracting system because of the downward flow created by washing liquid coming from the filter system 20.

[0071] In a preferred embodiment the flow system, e.g. the spraying bars, are removable without the need of completely emptying the washing space 3. This increases the ease of maintaining the washing apparatus 1, since the spraying bars 40 can be easily cleaned or replaced without removing all the washing liquid from the washing space 3. One or more spraying bars 40 are connected to a flow system valve 42. The flow system valve 42 can be opened or closed, allowing or disallowing washing liquid to flow towards the one or more spraying bars 40 respectively. Once the flow system valve 42 is closed, the one or more spraying bars 40 connected thereto can be dismounted and removed.

[0072] The sinking zone 6 can preferably have a conical or pyramidical shape, or can have another shape which converges towards the bottom, and/or which forms a trench 61 at the bottom. In this way, denser material accumulates at the bottom of the sinking zone 6 and is more easily extracted from the washing space 3 by an extracting system 8. If the bottom surface 62 of the sinking zone 6 further than the extracting system 8 is also slanted towards the extracting system 8, material that sinks at a later stage during the washing can still be extracted by the extracting system 8.

[0073] The extracting system 8 can be for example a cork screw extractor which only recovers solid material via an apparent upward rotational movement, but which does not extract water or which recovers the water at a later stage and returns it via a recycling system to the washing space 3. The extracting system 8, such as the cork screw extractor can run continuously or occasionally, e.g. if a sensor indicates that the amount of material to be extracted reaches a pre-determined threshold or if a certain control time has passed at which the extracting system 8 is activated. The material extracted by the extracting system 8 can be transported to a waste disposal unit such as a waste container. In this way, foreign material is removed when it sinks low enough to reach the extracting system 8.

[0074] FIG. 12 shows an exemplary exterior of the sinking zone 6.

[0075] Exemplary piping of the liquid supply system is shown, leading to the spraying bars which form the flow system in this example. Two manually controlled valves 42 are shown for limiting the flow rate to the flow system, or indeed shutting the flow system off completely. These valves 42 could also be made to be electronically controlled, for example by an operator or a control system.

[0076] Furthermore, a motor 43 used to rotate the washing rollers 4 can be mounted on the exterior wall of the washing space 3. The motor 43 can be controlled manually or electronically, and can thus be frequency controlled.

[0077] The cleaning zone 7 is formed further away from the entrance point where the infeed device feeds the keratinaceous material into the washing space. The cleaning zone 7 and the sinking zone 6 can be partly separated by a separation structure, such that the washing space 3 is physically partitioned into two zones. This separation structure can be placed high enough such that denser material, such as certain unwanted particles that sink in the washing liquid, cannot flow beyond the separation structure. However, the keratinaceous material that needs to be further processed can flow beyond the separation structure, for example because it flows over the separation structure. The separation structure can be a wall-like structure, or a sudden change in height of the bottom of the washing space 3. If the sinking zone 6 is long enough and is shaped in such a way that unwanted particles sink towards the extracting system 8, e.g. by a slanted bottom surface, no such partition is necessary; since it will be unlikely that any dense material remains in the washing liquid when it reaches the cleaning zone 7.

[0078] The at least one washing structure described herein earlier may be located in the sinking zone 6 and/or the cleaning zone 7. It is preferred that the sinking zone and the cleaning zone each comprise at least one washing structure, which may be the same or different washing structures. Highly preferably, the sinking zone 6 and the cleaning zone 7 each comprise at least one washing roller 4 as described herein earlier for the washing space 3.

[0079] The cleaning zone 7 can comprise additional washing rollers 4, or other washing structures, as used for the sinking zone 6. Since the sinking zone 6 comprises an extracting system for dense unwanted particles, the washing liquid will comprise less of these dense unwanted particles. The washing liquid flow can circle around the cleaning zone 7, such that the keratinaceous material stays in the cleaning zone 7 longer.

[0080] The sinking zone 6 and the cleaning zone 7 can have a shared inlet and outlet for the washing liquid, as part of the washing liquid system. Alternatively, the sinking zone 6 and the cleaning zone 7 have separate inlets and outlets. In this way, the cleaning zone 7 comprises mostly washing liquid that has not been contaminated by the initial cleaning in the sinking zone 6 and can clean more effectively. The sinking zone 6 and the cleaning zone 7 can share a recycling system for the washing liquid, or the sinking zone 6 and the cleaning zone 7 can have separate recycling systems. The washing liquid can have a different composition in the cleaning zone 7 than in the sinking zone 6. The sinking zone 6 and the cleaning zone 7 can be connected in such a way that the washing liquid flows from the cleaning zone 7 to the sinking zone 6. Alternatively, the washing liquid flow can be such that unwanted particles remain in the sinking zone 6 and do not enter the cleaning zone 7. Alternatively, the sinking zone 6 and the cleaning zone 7 do not share a fluid connection, i.e. the washing space 3 comprises unconnected zones. In this case, the keratinaceous material can travel between the unconnected zones via a transportation system such as a conveyor belt.

[0081] The washing liquid can remove one or more contaminants from the keratinaceous material. Contaminants can be preferably selected from the group consisting of compounds contributing to the total volatile nitrogen (TVN) content; H_2S; fat; and/or combinations thereof. Preferably the one or more contaminants are selected from the group consisting of biogenic amines, H_2S, fat, ammonia (NH_3/NH_4) and/or combinations thereof. More preferably, the one or more contaminants are selected from the group consisting of biogenic amines. The biogenic amines are for example tyramine, putrescine, cadaverine, histamine, phenylethylamine, spermidine, and agmatine.

[0082] By washing the keratinaceous material in the washing liquid using the washing system, the one or more contaminants can be dissolved into the washing liquid and/or at least partially removed from the keratinaceous material by the washing liquid. In a preferred embodiment, the washing liquid can dissolve one or more biogenic amines.

[0083] In a preferred embodiment, washing is performed such that the amount of at least one of the contaminants comprised in the pre-treated keratinaceous material are less than 50%, of its amount in the keratinaceous material before washing, preferably less than 40%, more preferably less than 30%, more preferably less than 20%, wherein the amounts are determined as w/w on dry weight basis.

[0084] In a preferred embodiment, the one or more contaminants are selected from a group consisting of biogenic amines, preferably tyramine, putrescine, cadaverine, histamine, phenylethylamine, spermidine, and/or agmatine

[0085] In a preferred embodiment, washing is performed such that the amount of at least one of tyramine, putrescine, cadaverine, histamine, phenylethylamine, spermidine, and agmatine, preferably the amount of putrescine and/or cadaverine and/or tyramine, comprised in the pre-treated keratinaceous material is less than 50% of its amount in the keratinaceous material before washing, preferably less than 40%, more preferably less than 30%, more preferably less than 20%, wherein the amounts are determined as w/w on dry weight basis.

[0086] In a preferred embodiment, the combined amount of tyramine, putrescine, cadaverine, histamine, phenylethylamine, spermidine, and agmatine, preferably the combined amount of putrescine and/or cadaverine and/or tyramine, comprised in the pre-treated keratinaceous material is less than 50% of the amount in the keratinaceous material before washing, preferably less than 40%, more preferably less than 30%, more preferably less than 20%, wherein the amounts are determined as w/w on dry weight basis.

[0087] The keratinaceous material travels through the washing space 3 in such a way that when the keratinaceous material is extracted from the washing space 3, at least 50 percent, preferably at least 60 percent, more preferably at least 70 percent, more preferably at least 80 percent of a total of one or more contaminants is removed.

[0088] Generally, not more than 95% of the total of the one or more contaminants, in particular one or more biogenic amines, will be removed, and often about 80% removal may be sufficient to obtain for example high quality hydrolysed feathers or down suitable for the down industry. In absolute amounts, preferably less than 250 ppm of the total of the one or more contaminants, in particular one or more biogenic amines remains after washing, more preferably less than 100 ppm, more preferably less than 50 ppm. The amounts of can be determined with standard HPLC methods.

[0089] In a preferred embodiment, the operator selects a predetermined threshold for different biogenic amines, such that when the amount of the one or more biogenic amines falls below this pre-determined threshold, the pre-treated keratinaceous material is obtained from the washing system. For example, the operator selects a pre-

determined threshold for putrescine, cadaverine and/or histamine respectively. The pre-determined thresholds for putrescine, cadaverine and/or histamine do not have to be equal to one another. The predetermined threshold for putrescine can be 50 ppm, more preferably 40 ppm, more preferably 25 ppm, more preferably 10 ppm. The pre-determined threshold for cadaverine can be 50 ppm, more preferably 40 ppm, more preferably 25 ppm, more preferably 10 ppm. The predetermined threshold for histamine can be 50 ppm, more preferably 40 ppm, more preferably 25 ppm, more preferably 10 ppm.

[0090] The operator can perform experiments during a setup phase, such that the time necessary in the washing space 3 at specific machine operating settings for reaching the predetermined threshold for the contaminant (e.g. the total amount of biogenic amines, e.g. the amount of a specific biogenic amine) can be determined. For example, the operator can determine the amount of the contaminant in the keratinaceous material before washing (e.g. based on dry matter), next wash the keratinaceous material for a certain amount of time using a particular recirculation rate and bleed rate for the washing liquid, e.g. for the washing liquid present in the washing space 3, and finally determine the amount of the contaminant left in the keratinaceous material after the expiration of said certain time.

[0091] As a further alternative, further processing steps, for example hydrolysation, can be performed before determining the contaminant content of the washed keratinaceous material, and the amount of contaminant present in the semi-finalized product or finalized product can be determined. Based on this measurement the amount of time the keratinaceous material needs to spend in the washing space 3 using a particular recirculation rate and bleed rate for the washing liquid, e.g. for the washing liquid present in the washing space 3, in order for the pre-determined threshold to be reached can be determined. A recalibration process can be performed after a certain amount of time to ensure that the washing apparatus 1 is still operating with the correct settings.

[0092] Alternatively, the amount of biogenic amines dissolved in the washing liquid can be determined. This can for example be compared with the amount of biogenic amines present in the keratinaceous material before the keratinaceous material entered the washing apparatus 1.

[0093] In a preferred embodiment, the amount of biogenic amines in the washing liquid present in the washing space 3 can be measured, e.g. by using a sensor, and this measurement can be used in a control loop of the washing liquid system and the recycling system. Sensors placed in the washing apparatus 1, either in the washing space 3 or in the washing liquid system, can determine the amount of absorbed biogenic amines in the washing liquid during operation of the device, and the flow speed, infeed speed or extraction speed can be adapted on the basis of the sensor readings. The inflow and outflow of washing liquid can be controlled in such a way that the amount of biogenic amines in the washing liquid stays below a certain pre-determined threshold. The washing liquid flowing into the washing space 3 can be washing liquid that has not yet been used or recycled washing liquid, such that this washing liquid flowing into the washing space 3 comprises less biogenic amines than the used washing liquid in the washing space 3. Since the washing liquid flowing into the washing space 3 comprises less biogenic amines, and since the used washing liquid in the washing space 3 can be removed, in this way the amount of biogenic amines comprised in the washing liquid in washing space 3 can be reduced and effectively controlled.

[0094] The amount of keratinaceous material per hour that is pre-treated by the washing apparatus 1 can be greater than or equal to 0.5 metric ton per hour, preferably greater than or equal to 1 metric ton per hour, more preferably greater than or equal to 2 metric ton per hour. The mass of keratinaceous material that is pre-treated is defined here on total weight basis, including moisture.

[0095] Washing can be performed in a washing space wherein the amount of washing liquid present in the washing space is greater than or equal to 1 m^3, preferably greater than or equal to 2 m^3, greater than or equal to 2.5 m^3. The complete volume of washing liquid can be recirculated at least 5 times per hour, preferably at least 10 times per hour, more preferably at least 15 times per hour. Preferably the recirculation is performed by withdrawing washing liquid at the end of the washing space 3, e.g. at or substantially near the outfeed location where the outfeed device 9 is situated, and reintroducing the washing liquid simultaneously at the infeed location 2 and via the flow system. Preferably the washing liquid is reintroduced simultaneously at the infeed location 2 and via the spraying bars 40 located in the sinking zone 6.

[0096] In the preferred embodiment (i) the washing liquid is reintroduced at the infeed location and via the flow system, e.g. the spraying bars; (ii) the washing liquid is withdrawn at the end of the washing space 3, e.g. at or substantially near the outfeed location; and (iii) the washing structure, in particular the washing rollers 4, more particular the rotating paddle cylinders, impart a flow from infeed location towards the outfeed location. These three effects cause a flow moving from the infeed location to the outfeed location, propagating the feathers through the washing space 3. The flow can be a linear flow.

[0097] The keratinaceous material can flow through the washing space 3 multiple times, but it is preferred that one passage is sufficient for obtaining consistent high quality.

[0098] The outfeed device 9 obtains the keratinaceous material from the washing apparatus 1 after washing has been completed. The outfeed device 9 can comprise a screw conveyor, a conveyor belt, pumps, revolving screens and/or rotary screens. A conveyor belt can comprise sieves or perforations, such that for example any washing liquid taken by the outfeed device 9 can be returned to the washing space 3. A spraying bar or another type of nozzle can be used to rinse the product with clean

washing liquid, for example water.

[0099] The moisture content of the keratinaceous material, e.g. feathers, is generally higher than 50% at the outfeed device 9, and may be up to 80% moisture. This high moisture content may be less favourable in further processing, for example with some types of hydrolysers. In a preferred embodiment, the keratinaceous material, preferably feathers, are subjected to a physical dewatering step. Such dewatering can take place on a perforated belt, or be pressing keratinaceous material in a screw press. For example, one or more feeding screws can be used to properly feed the feathers into a hydrolyser. In the dewatering step, preferably the water content is reduced to below 70 wt% relative to the amount of keratinaceous material, even more preferable to below 65 wt%.

[0100] Furthermore, in a preferred embodiment a liquid extractor 10 can be positioned such that it acts on the keratinaceous material extracted by the outfeed device from the washing space 3. The liquid extractor 10 extracts excess liquid from the keratinaceous material and thus acts as an excess washing liquid removal device. The excess washing liquid removal device, e.g. the liquid extractor 10 can help lower the moisture content of the keratinaceous material at the outfeed device 9 after leaving the washing space 3. The liquid extractor 10 can comprise a pressing device, a drying system, an air knife or air blade, an aspiration system underneath the outfeed device 9 (for example a belt), any other suitable device that can extract excess liquid from the keratinaceous material before it is processed further, or any combination thereof. If for example a conveyor belt is used as the outfeed device 9, the length of the outfeed belt can be oversized such as to dewater the washed product as much as possible. In order to clean the belt a rotary scraper can be installed.

[0101] The excess liquid extracted from the keratinaceous material by the excess washing liquid removal device, e.g. the liquid extractor 10, can be recirculated into the washing space 3 by recycling the water using the recycling system. The recycling system can return the excess liquid back into the washing space 3, or also actively filter and clean the excess liquid before returning it to the washing space 3. The excess liquid is thus included in the overall mass balance of the washing liquid being circulated in the machine.

[0102] A collection bin 11 can be used to collect the keratinaceous material after washing. The keratinaceous material can also be directly positioned from the outfeed device 9 on a transportation system, which transports the keratinaceous material towards for example a hydrolysation system.

[0103] FIG. 13 shows a flow diagram describing various steps in the (pre-)processing 100 of keratinaceous material according to the invention.

[0104] In a first step 101, the keratinaceous material is fed into washing apparatus 1. The keratinaceous material can already have undergone various processing steps, either chemical or physical in nature. It is however preferred that the first step 100 is performed first, before any other processing steps have occurred after gathering the keratinaceous material at for example a slaughterhouse.

[0105] In a second step 102, the keratinaceous material is washed in the washing device 1 using an aqueous washing liquid as described herein earlier. This can be done for example as described in relation to the working of the washing apparatus 1. The washing liquid may dissolve and/or at least partially remove certain contaminants present on the keratinaceous material. For example, the washing liquid may dissolve certain biogenic amines that can be present in the keratinaceous material, and which can be antinutritional when digested. The washing can be done in multiple substeps. A substep can be a sinking step where material denser than the washing liquid sinks lower than the keratinaceous material and is subsequently extracted at a lower point than the location of the keratinaceous material. A substep can be a washing step where keratinaceous material that has already undergone a rougher cleansing is further cleaned. The different substeps can be independent in terms of the washing liquid used, flow speed, and other settings of the washing apparatus 1.

[0106] In a third step 103, it is checked whether the amount of the one or more contaminants, e.g. biogenic amines, present in the keratinaceous material falls below a predetermined threshold. The amount of the one or more contaminants, e.g. biogenic amines, can be measured either by measuring the amount of contaminants absorbed by or present in the washing liquid, or by measuring the one or more contaminants, e.g. biogenic amines, present in the keratinaceous material from - for example - a sample. When it is detected that the predetermined threshold is reached, the keratinaceous material can be extracted from the washing apparatus 1. Furthermore, tests can be performed beforehand, to determine the settings of the washing apparatus 1 and the washing time necessary for keratinaceous material to have an amount of the one or more contaminants below the pre-determined threshold. After this pre-determined time has been exceeded, the keratinaceous material can be extracted from the washing apparatus 1.

[0107] In an optional fourth step 104, further processing steps can be performed on the keratinaceous material. The material can be dried to extract excess washing liquid from the keratinaceous material. In a preferred embodiment, further methods that can be performed include hydrothermal and pressurized treatment methods; acid, alkaline and/or enzymatic hydrolysis methods; or combinations thereof. The keratinaceous material generally is not completely hydrolysed to mono-amino acids to improve the digestibility. In another embodiment aimed at down for the down industry, other processing steps include for example bagging the down for transport to be used, and/or using the down in for example clothes, blankets, and other textiles.

[0108] The present invention therefore also relates to

a method for the production of hydrolyzed keratinaceous material, comprising the steps of:

(i) washing the keratinaceous material using the washing system as described above, or the method as described above;
(ii) hydrolyzing the keratinaceous material;
(iii) drying the hydrolyzed keratinaceous material, thereby obtaining dried hydrolyzed keratinaceous material.

[0109] Hydrolysis and drying may be performed as described for example in US5772968, US4286884, US4172073, EP 2832236, EP 2832237, EP3192377.

[0110] A suitable hydrolysis process using steam and pressure is as follows: Partial hydrolysis of the keratinaceous material in step (i) of the process of the invention, in a preferred process will be the following: (a) loading of a continuous or discontinuous vertical or horizontal hydrolyser with raw feathers or other keratinaceous material, optionally with raw blood, (in case of raw feathers, these have e.g. between 55% and 70% moisture; (b) heating up of the hydrolyser by means of steam jackets (and/or injection of direct steam), pressure build up due to water evaporation and/or direct steam injection, maintaining pressure at about 2 bar to about 100 bar, preferably between about 2 and about 15 bar, and more preferably between 2 to 8 bars during 5 seconds up to 240 min, preferably between 90 seconds up to 30 min, more preferably between 5 min to 40 min and most preferably between 10 to 30 min, (c) depressurizing and discharging to a drying section. A lower pressure generally requires a longer treatment time, while high pressures require shorter treatment times to obtain a suitable hydrolysis.

[0111] Drying can be performed in a number of ways, like in a press, disk dryer, drying belt, fluidised bed, air turbulence mill and the like. In one preferred embodiment of the invention, the mixture leaving the hydrolyser, of which part of the water is evaporated because of the reduction in pressure, is subjected to a pressing step. In this step, part of the water from the keratinaceous material is removed, to bring the water content from, for example, about 65 wt% to about 45 wt%.

[0112] In one preferred embodiment, the partly hydrolyzed material resulting from step (i) is dried with a method allowing low heat damage, such that the reduction of the digestibility of the keratinaceous material is limited and characterized by a pepsin and/or ileal digestibility remaining higher than respectively 80% and 85%, preferably about 85% or higher, respectively 82% and 90%, and more preferably about 85% and 92% or higher. More preferably, the reduction in pepsin and/or ileal digestibility measured before and after the drying step is preferably less than 5%. To obtain such material with low heat damage, drying is to be carried out with a gas flow while at the same time grinding the material. High in vitro digestibility and very suitable material characteristics of keratinaceous material are achievable by using an air turbulence mill, because the small particles that result from the grinding action aid in quickly drying the hydrolyzed material.

[0113] Hence, preferably, the partly hydrolyzed material resulting from step (i) is concurrently dried and ground with a gas stream, generally air (that may be low in oxygen), using an air turbulence mill. The air turbulence mill has the benefit of a fast grinding and drying-effect, and the use of an air turbulence mill according to the invention results in drying and simultaneously milling or grinding the keratinaceous material by introducing the material to dry and a flow of gas, generally air, into a high speed rotor in a confined chamber.

[0114] In an alternative embodiment the drying process comprises drying at reduced pressure, such that the temperature of the material remains at a temperature below about 90 °C, preferably at a temperature of about 80 °C or lower, and more preferably at about 75 °C or lower, such as for example between about 60 to about 75 °C, or for example at a temperature of about 70 °C or lower. Such drying processes can be performed in a disk dryer under vacuum.

[0115] In another embodiment, the drying process comprises effective turbulence of the keratinaceous material in a flow of hot air, such as in a fluidized bed dryer, ring type dryer, rotating drum dryer and the like. Also in such cases it is important to limit the heat exposure to a minimum. Hence, during a short period of time, e.g. about 60 sec, or about 30 sec, the material may be at a temperature of about 100 °C, or about 120 °C. Generally, the maximum temperature with short time heat exposure will be about 150 °C or lower, or preferably about 120 °C or lower. A relatively high temperature may be present when relatively low water is present, as the combination of water and heat appears to be most damaging.

[0116] In another embodiment, the method for processing keratinaceous material for the down industry, comprising the steps of:

(i) washing keratinaceous material comprising down using the washing system described above, or the method as described above;
(ii) drying the washed keratinaceous material;

and wherein either before or after the washing step the down is separated from other keratinaceous material.

[0117] Two or more of the above embodiments may be combined in any appropriate manner

Examples

[0118] Biogenic amines can be measured with HPLC methods, known in the art. Total volatile basic nitrogen according to EC regulation 2074/2005 or 152/2009. Ammoniacal nitrogen can be measured according EC regulation 152/2009.

[0119] Feathers were washed using the washing apparatus described above and shown in the figures. A

good separation was found between foreign material and feathers. Furthermore, a large reduction of biogenic amine content in the feathers was observed. The amount of putrescine and cadaverine was reduced from more than 100 and more than 180 ppm respectively to less than 30 ppm each. The total amount of biogenic amines, as represented by agmatine, cadaverine, histamine, phenylethylamine, putrescine, spermidine and tyramine was reduced from more than 400 ppm before washing to less than 200 ppm after washing. The ppm values mentioned in this example are w/w and based on dry weight.

Claims

1. A washing system suitable for continuous processing, for the pre-treatment of keratinaceous material, preferably feathers, hair or wool, comprising:

   an infeed device for feeding the keratinaceous material to the washing system;
   a washing space for washing the keratinaceous material with an aqueous washing liquid;
   a washing liquid system for supplying and extracting the washing liquid to and from the washing space;
   wherein the washing space comprises a sinking zone wherein material with a higher density than the washing liquid sinks below the keratinaceous material;
   an extracting system placed at the bottom of the sinking zone for extracting the material with a higher density than the washing liquid;
   at least one washing structure that sloshes the washing liquid and/or causes turbulence in the washing liquid present in the washing space;
   an outfeed device for extracting the keratinaceous material from the washing system.

2. The washing system of claim 1, wherein the sinking zone comprises a flow system which is adapted to impart a flow to the washing liquid in the sinking zone, wherein the magnitude and direction of the flow is such that the keratinaceous material is kept in suspension and moved away from the extracting system whilst the material denser than the washing liquid still sinks towards the extracting system.

3. The washing system of claim 1 or 2, wherein the washing space further comprises a cleaning zone for cleaning of the keratinaceous material, the sinking zone and cleaning zone positioned such that the keratinaceous material first enters the sinking zone before entering the cleaning zone, wherein at least one washing structure is located in the cleaning zone.

4. The washing system of any one of claims 1-3, wherein the washing liquid system further comprises a washing liquid recycling system for reusing the washing liquid after use in the washing space, wherein the washing liquid recycling system comprises a washing liquid solid separation system, preferably a filter, for cleaning the washing liquid.

5. The washing system of any one of claims 1-4, further comprising an excess washing liquid removal device for extracting excess washing liquid from the keratinaceous material after the keratinaceous material has been washed in the washing space, preferably wherein the excess washing liquid removal device extracts the excess washing liquid at the outfeed device and/or wherein the extracted excess washing liquid is reused in the washing space.

6. The washing system of any one of claims 1-5, wherein the washing structure is cylindrically shaped and comprises one or more protrusions on the cylindrical surface, and wherein the washing structure is rotatably mounted on the washing system, preferably mounted such that when the washing structure rotates, the keratinaceous material is at least partially submerged due to the action of the protrusions.

7. The washing system of any one of claims 1-6, wherein a bottom surface of the sinking zone is slanted towards the extracting system, and/or wherein the extracting system comprises a cork screw extractor.

8. A method for the pre-treatment of keratinaceous material, preferably feathers, hair or wool, comprising the steps of:

   feeding the keratinaceous material to a washing system, the keratinaceous material comprising one or more contaminants;
   washing the keratinaceous material in an aqueous washing liquid using the washing system, wherein the one or more contaminants are dissolved into the washing liquid and/or removed at least partly from the keratinaceous material by the washing liquid;
   obtaining the pre-treated keratinaceous material from the washing system;
   characterized in that washing is performed such that the amount of at least one of the contaminants comprised in the pre-treated keratinaceous material is below a pre-determined threshold.

9. The method of claim 8, wherein washing is performed such that the amount of at least one of the contaminants comprised in the pre-treated keratinaceous material is less than 50%, of its amount in the keratinaceous material before washing, preferably less than 40%, more preferably less than 30%, more

preferably less than 20%, wherein the amounts are determined as w/w on dry weight basis.

10. The method of claims 8 or 9, wherein the one or more contaminants are selected from a group consisting of biogenic amines, preferably tyramine, putrescine, cadaverine, histamine, phenylethylamine, spermidine, and/or agmatine

11. The method of claims 8-10, wherein washing is performed such that the amount of at least one of tyramine, putrescine, cadaverine, histamine, phenylethylamine, spermidine, and agmatine, preferably the amount of putrescine and/or cadaverine and/or tyramine, comprised in the pre-treated keratinaceous material is less than 50% of its amount in the keratinaceous material before washing, preferably less than 40%, more preferably less than 30%, more preferably less than 20%, wherein the amounts are determined as w/w on dry weight basis.

12. The method of any one of the claims 8-11, wherein the combined amount of tyramine, putrescine, cadaverine, histamine, phenylethylamine, spermidine, and agmatine, preferably the combined amount of putrescine and/or cadaverine and/or tyramine, comprised in the pre-treated keratinaceous material is less than 50% of the amount in the keratinaceous material before washing, preferably less than 40%, more preferably less than 30%, more preferably less than 20%, wherein the amounts are determined as w/w on dry weight basis.

13. The method of any one of the claims 8-12, wherein the washing of the keratinaceous material comprises a sinking step wherein material denser than the washing liquid sinks lower than the keratinaceous material and is subsequently extracted at a lower point than the location of the keratinaceous material.

14. The method of any one of the claims 8-13, wherein the washing of the keratinaceous material comprises maintaining the amount of at least one biogenic amine, preferably maintaining the amount of at least one biogenic amine selected from the group consisting of tyramine, putrescine, cadaverine, histamine, phenylethylamine, spermidine, and agmatine, dissolved in the washing liquid below a predetermined threshold by extracting used washing liquid, and supplying fresh washing liquid, preferably by continuously bleeding out used washing liquid and continuously supplying fresh washing liquid.

15. The method of any one of the claims 8-14, wherein the washing liquid further comprises a surfactant and/or a biocide and/or a degreasing agent and/or a bleaching agent and/or an organic solvent.

16. The method of any one of the claims 8-15, wherein the amount of keratinaceous material per hour that is pre-treated is greater than or equal to 0.5 metric ton per hour, preferably greater than or equal to 1 metric ton per hour, more preferably greater than or equal to 2 metric ton per hour and wherein washing is performed in a washing space wherein the amount of washing liquid present in the washing space is greater than or equal to 1 m^3, preferably greater than or equal to 2 m^3, greater than or equal to 2.5 m^3, and wherein the complete volume of washing liquid is recirculated at least 5 times per hour, preferably at least 10 times per hour, more preferably at least 15 times per hour.

17. The method of any one of the claims 8-16, wherein the washing system is the washing system of any one of claims 1-7.

18. Method for the production of hydrolyzed keratinaceous material, comprising the steps of:

(i) washing the keratinaceous material using the washing system of claims 1-7, or the method of any one of claims 8-17;
(ii) hydrolyzing the keratinaceous material;
(iii) drying the hydrolyzed keratinaceous material, thereby obtaining dried hydrolyzed keratinaceous material.

19. Method for processing keratinaceous material for the down industry, comprising the steps of:

(i) washing keratinaceous material comprising down using the washing system of claims 1-7, or the method of any one of claims 8-17;
(ii) drying the washed keratinaceous material;

and wherein either before or after the washing step the down is separated from other keratinaceous material.

20. Method for washing keratinaceous material, preferably feathers, hair or wool, wherein the keratinaceous material is contaminated with material denser than the keratinaceous material, the method comprising:

washing the keratinaceous material in a washing system using a washing liquid in which the keratinaceous material floats and in which the material denser than the washing liquid sinks;
extracting the material denser than the washing liquid at the bottom of the washing system using an extracting system.

21. The method of claim 20, wherein the method further comprises imparting a flow on the washing liquid in

the washing system, wherein the magnitude and direction of the flow is such that the keratinaceous material is kept in suspension and moved away from the extracting system whilst the material denser than the washing liquid still sinks towards the extracting system.

22. The method of claim 21, wherein the magnitude and direction of the flow is such that an object with a density of more than 1.01 g/cm3, preferably more than 1.08 g/cm3 sinks while the majority of the keratinaceous material remains suspended in the washing liquid.

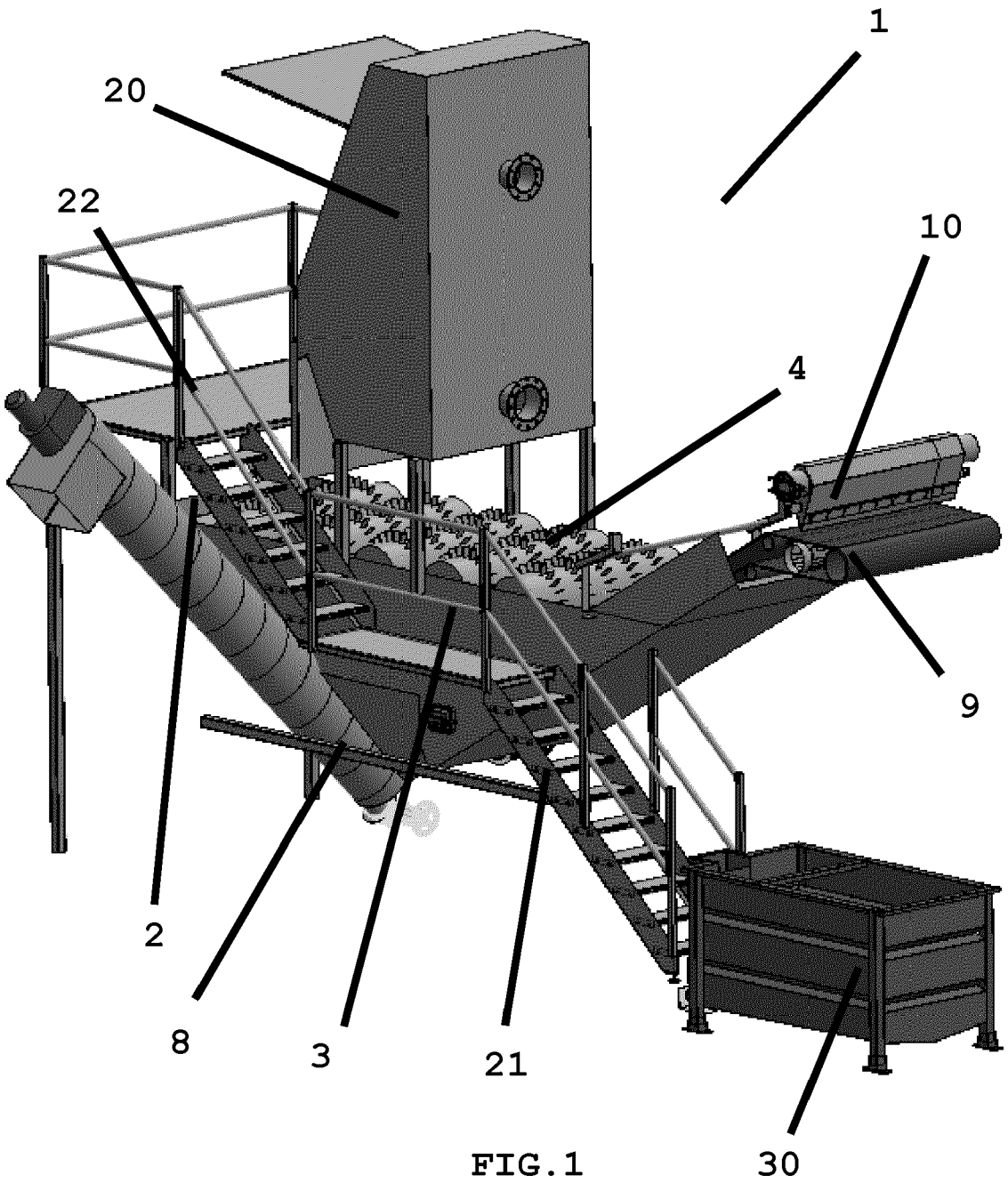
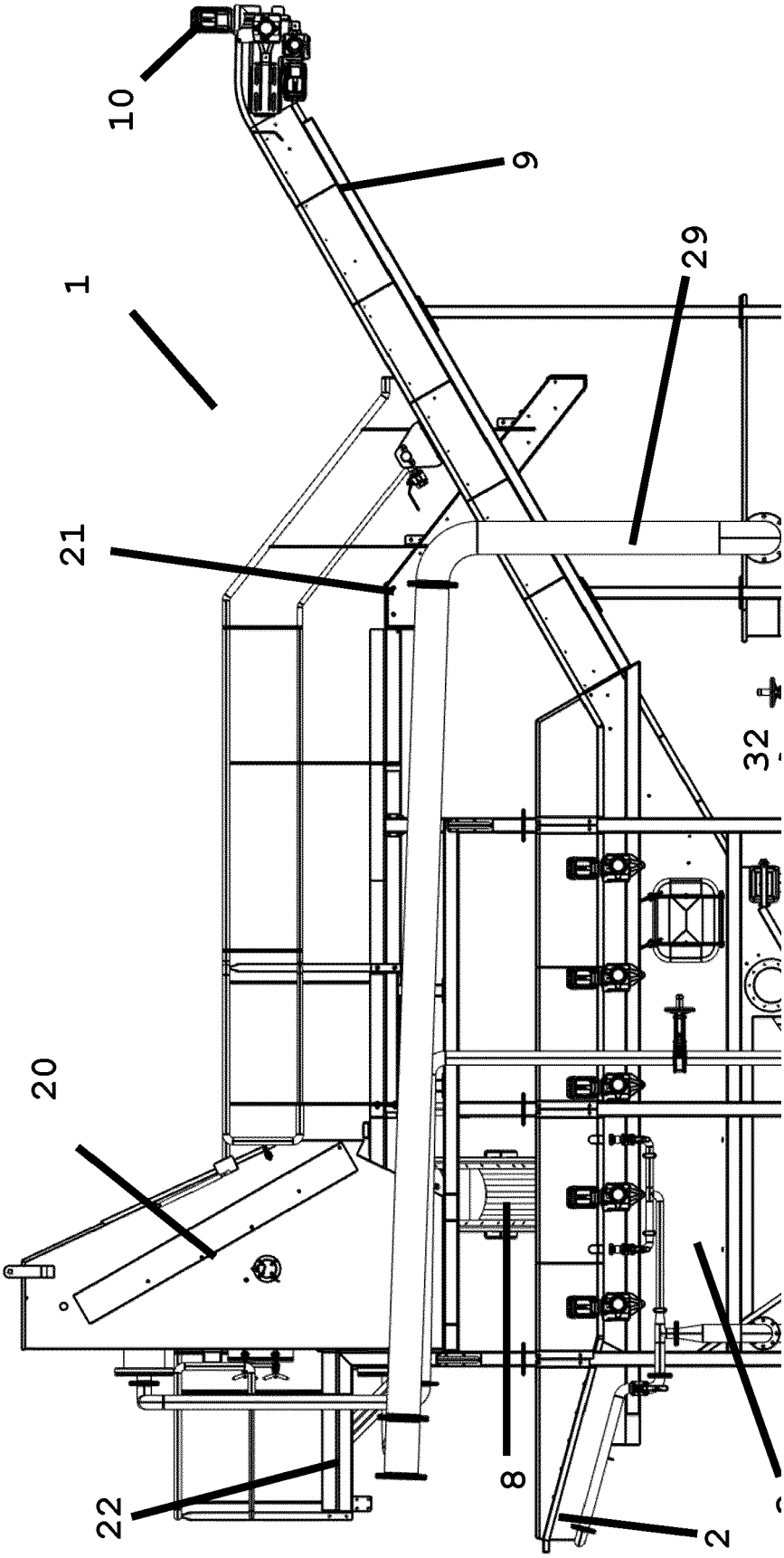


FIG.1


10
9
29
1
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32
20
22
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2

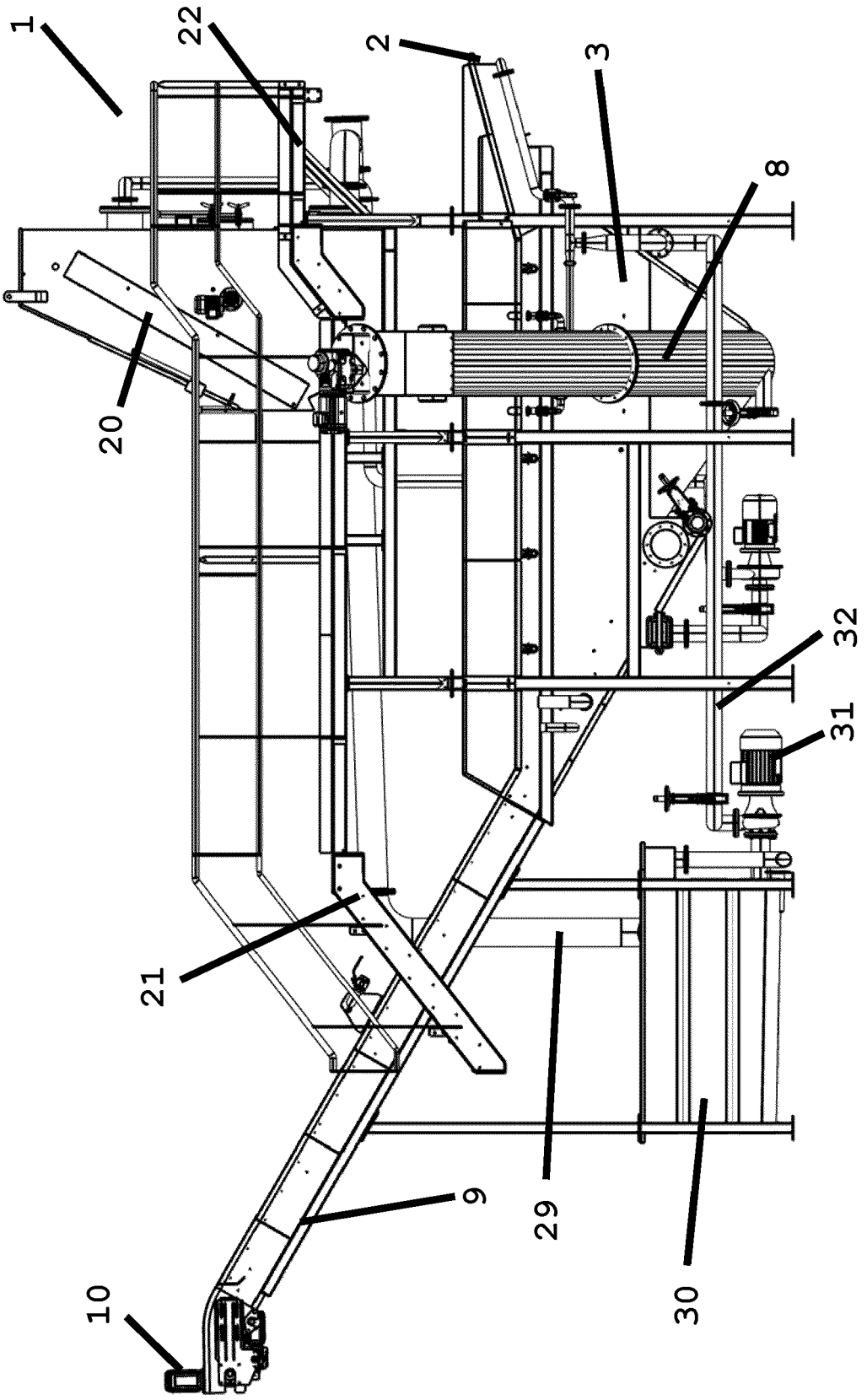

FIG.3

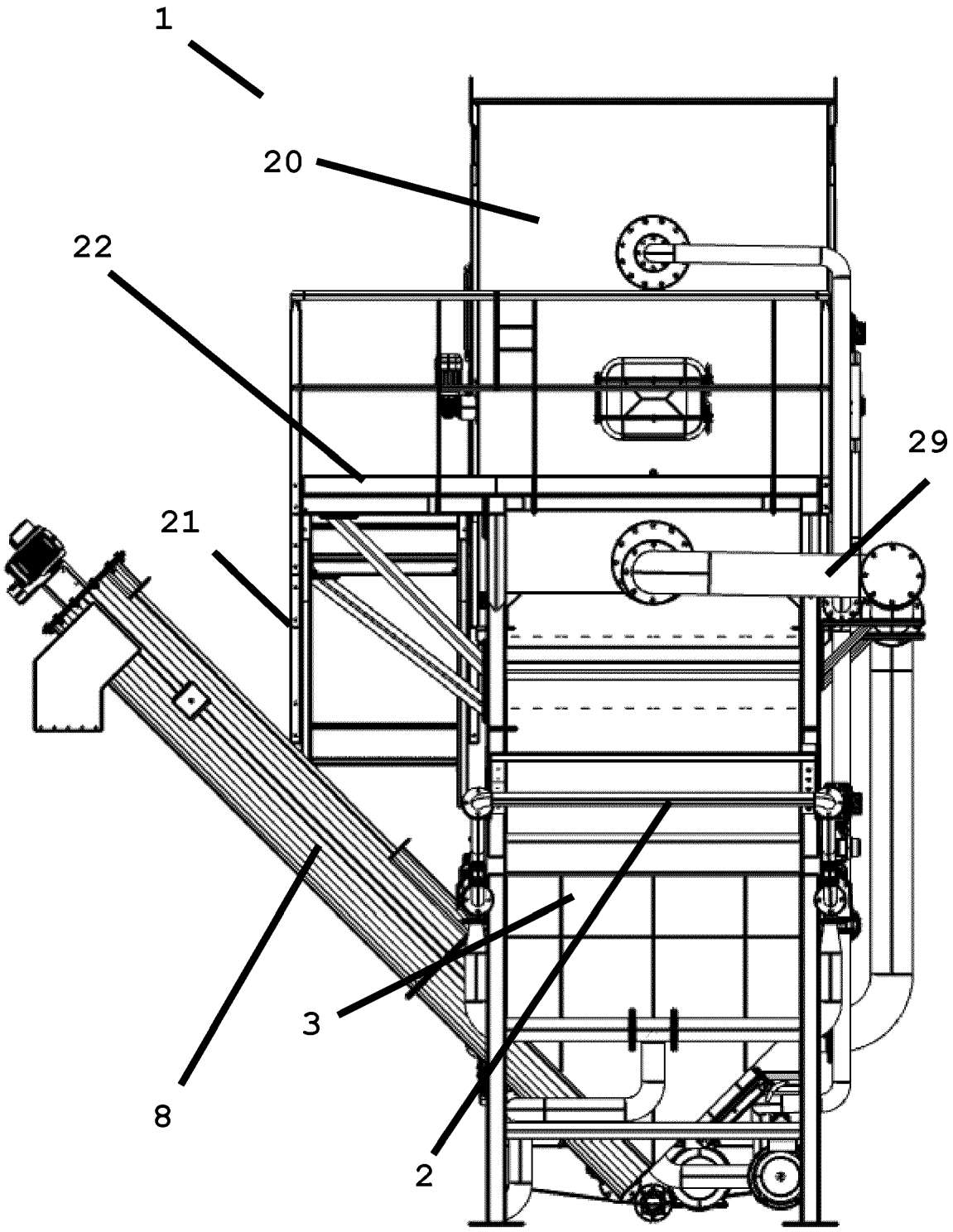

FIG. 4

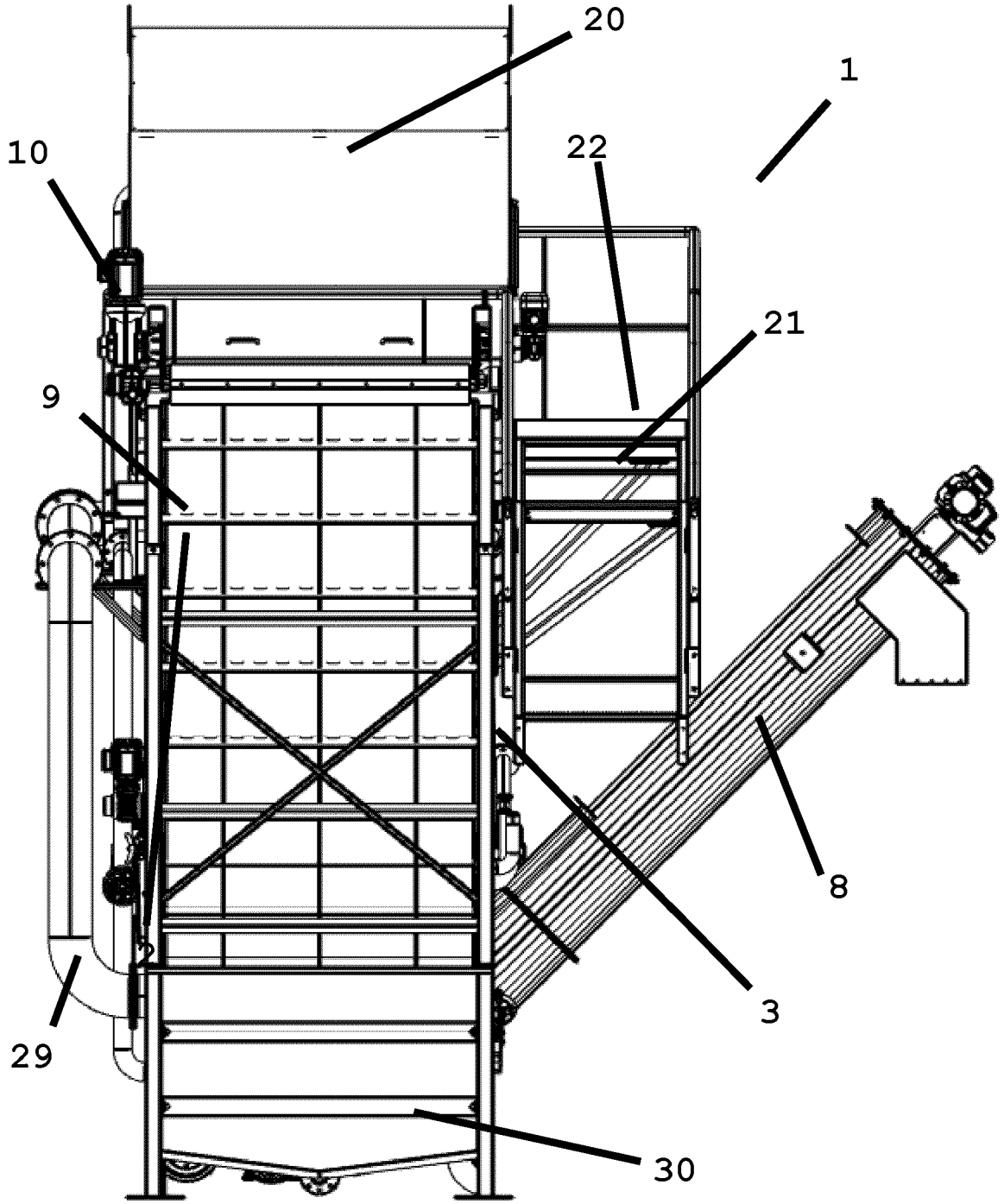

FIG.5

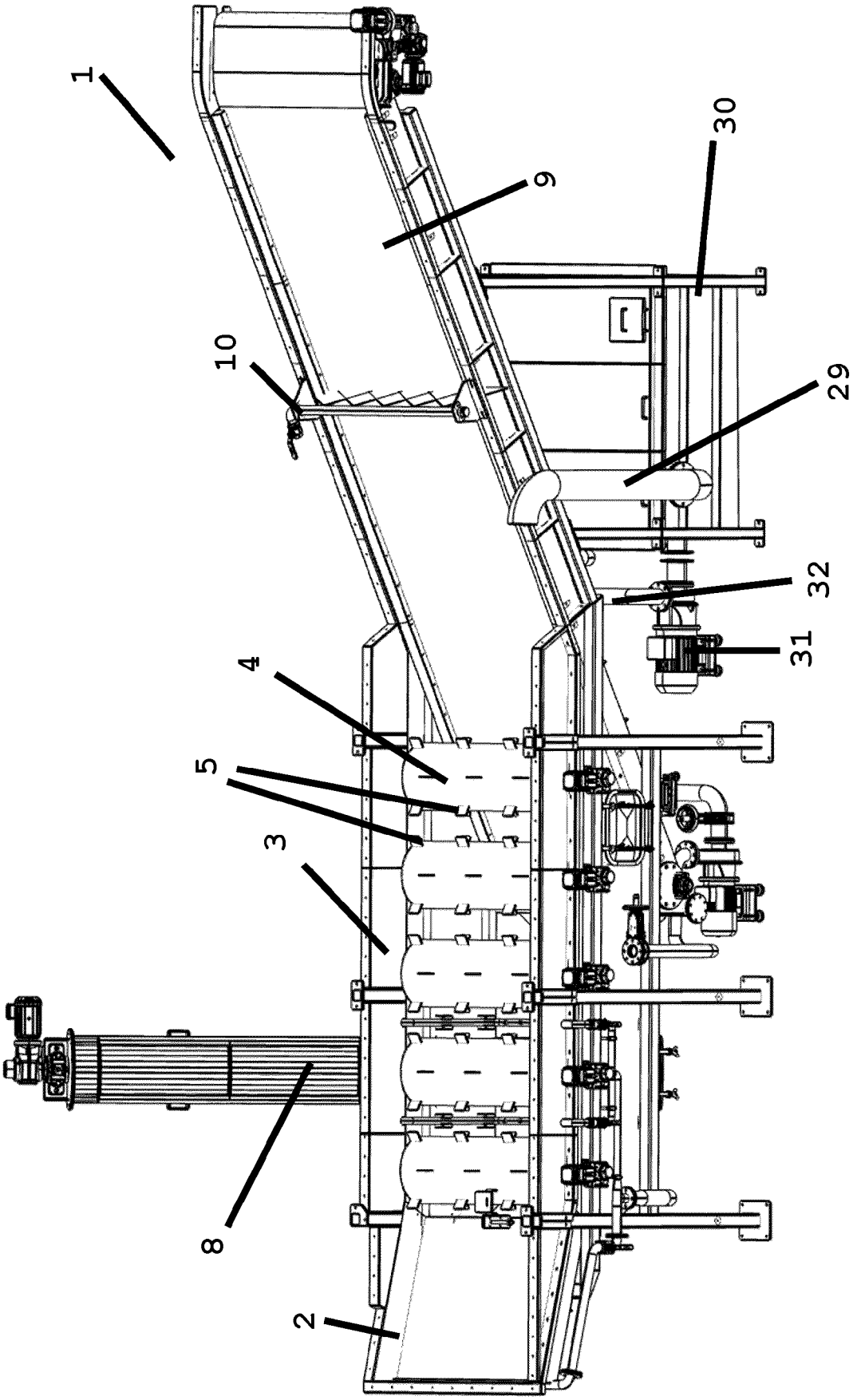

FIG.6

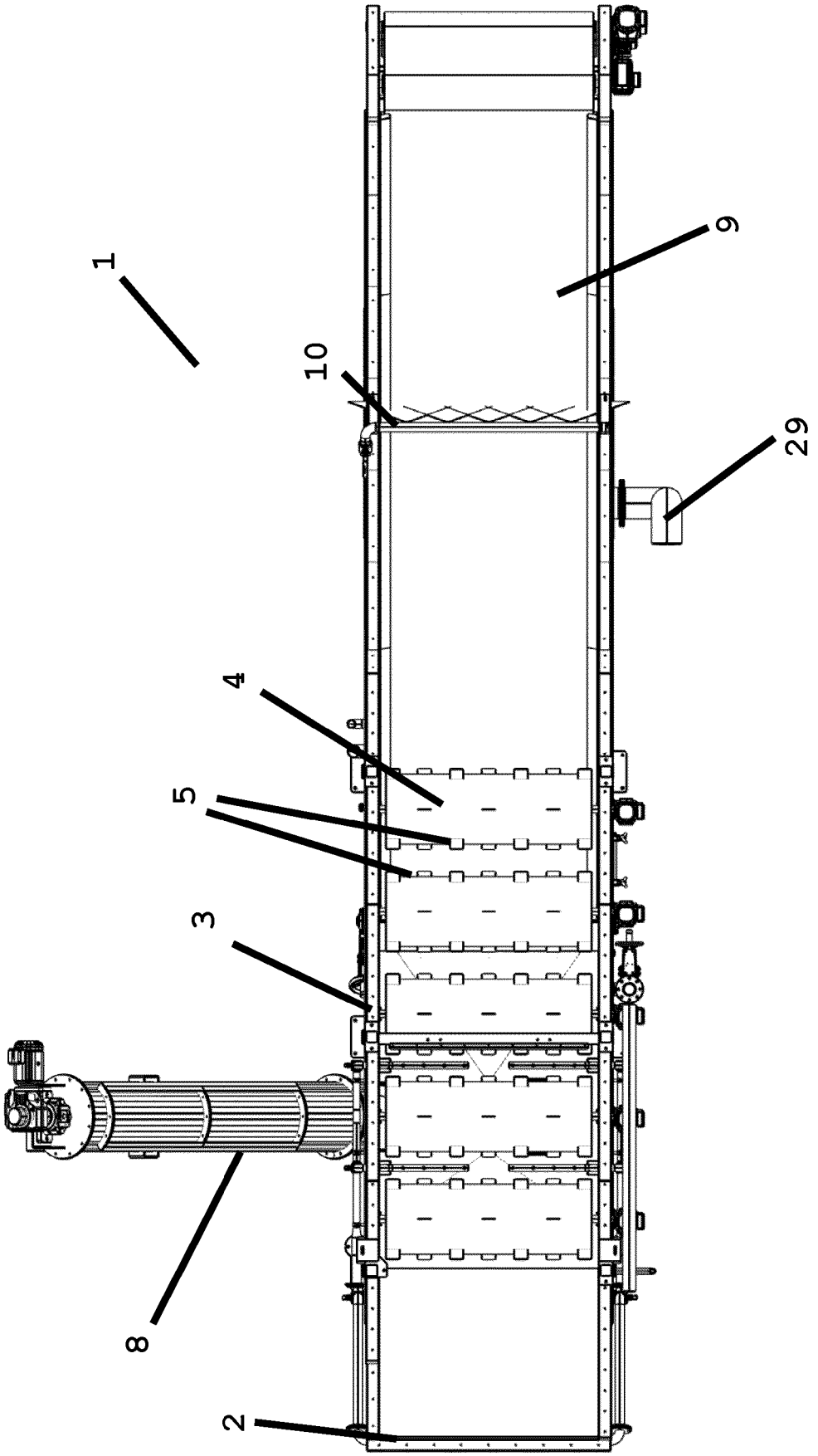

FIG.7

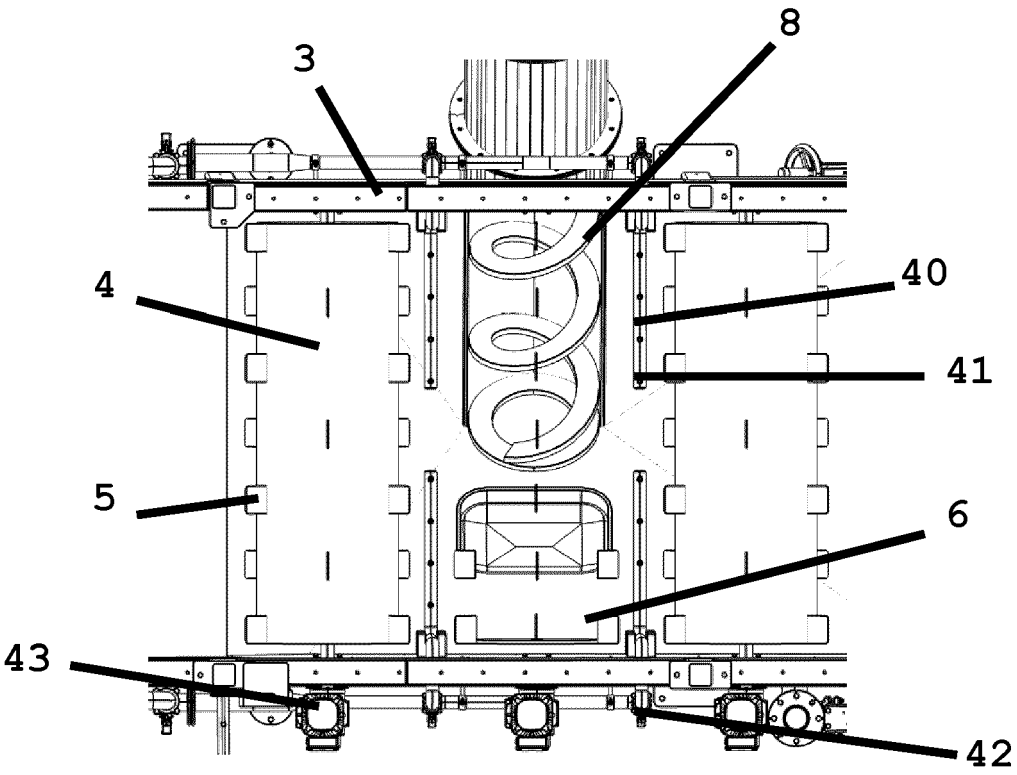

FIG.8A

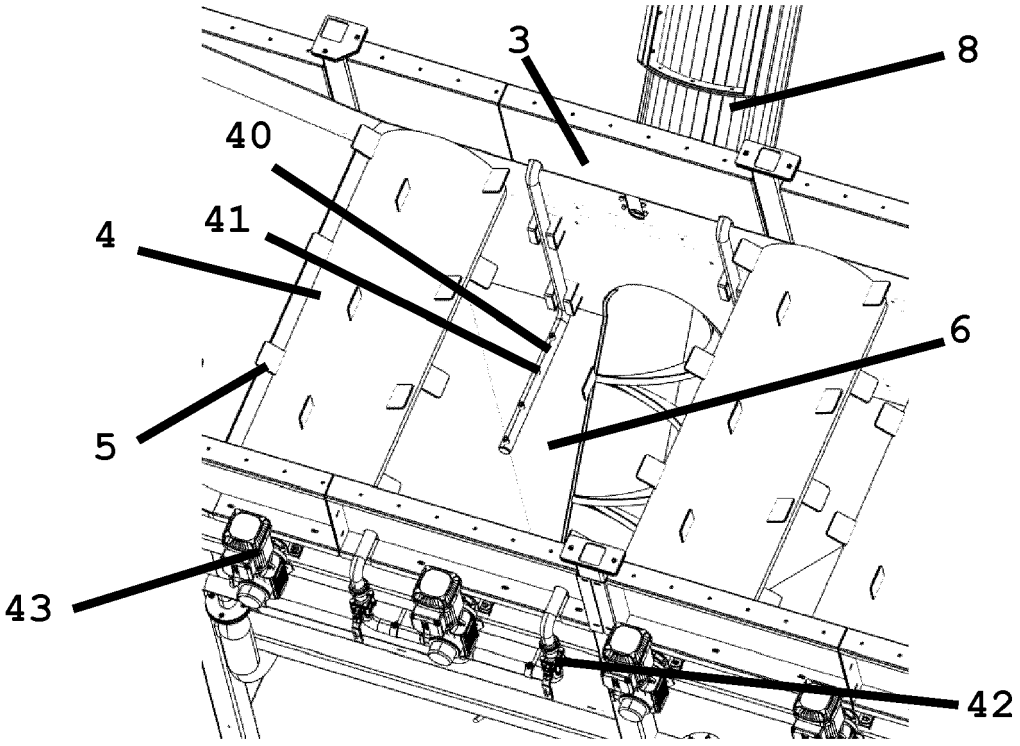

FIG.8B

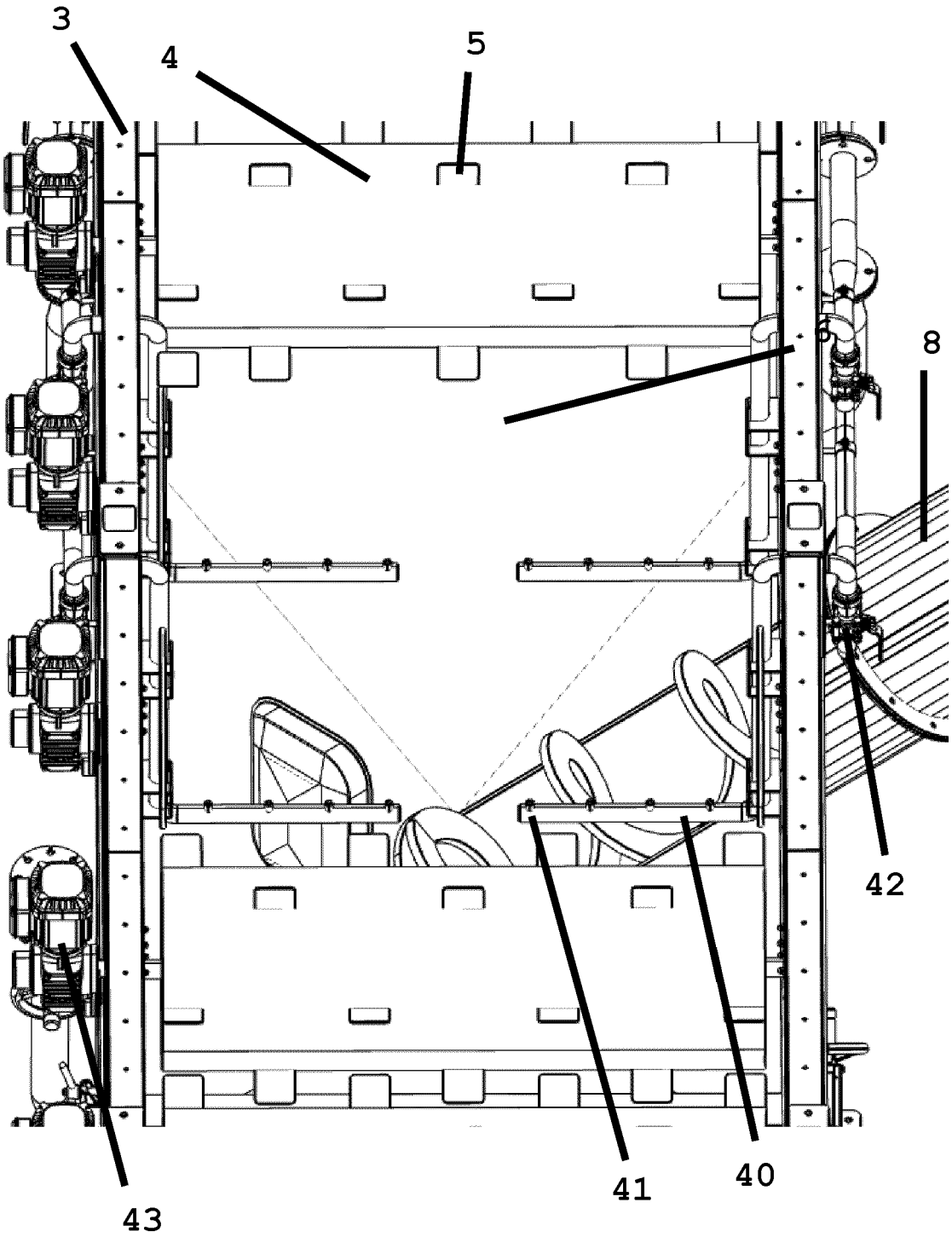

FIG.9

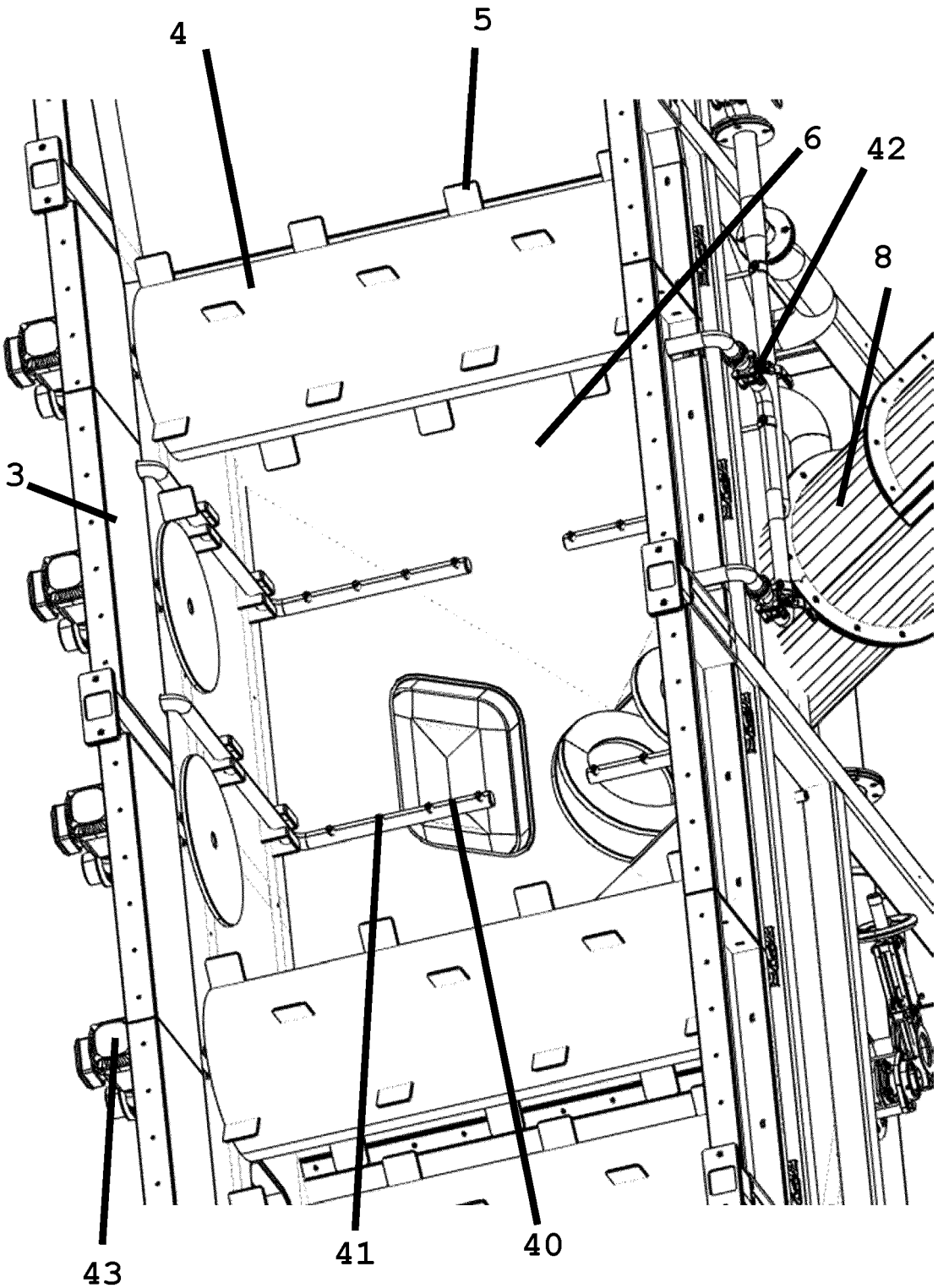

FIG.10

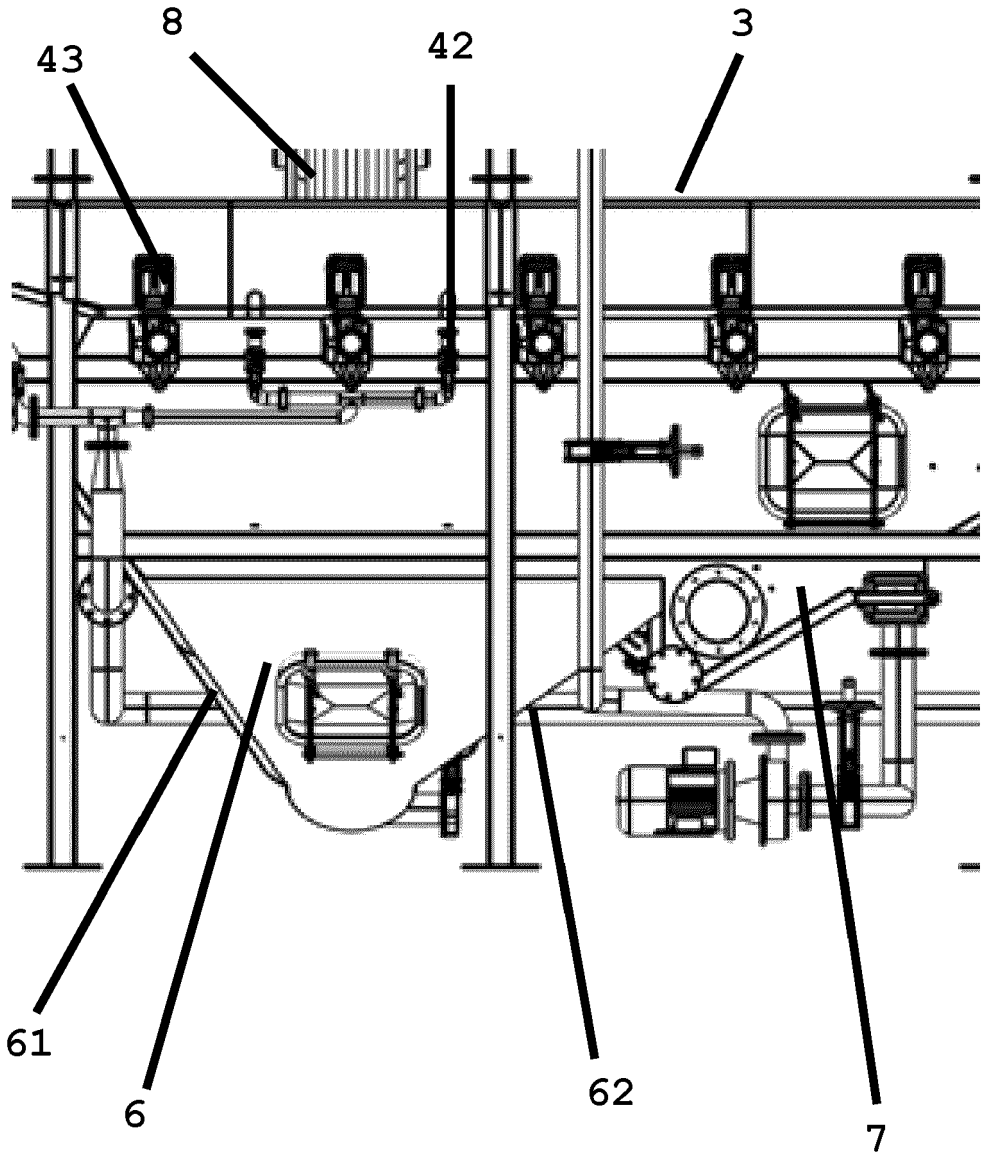

FIG.11

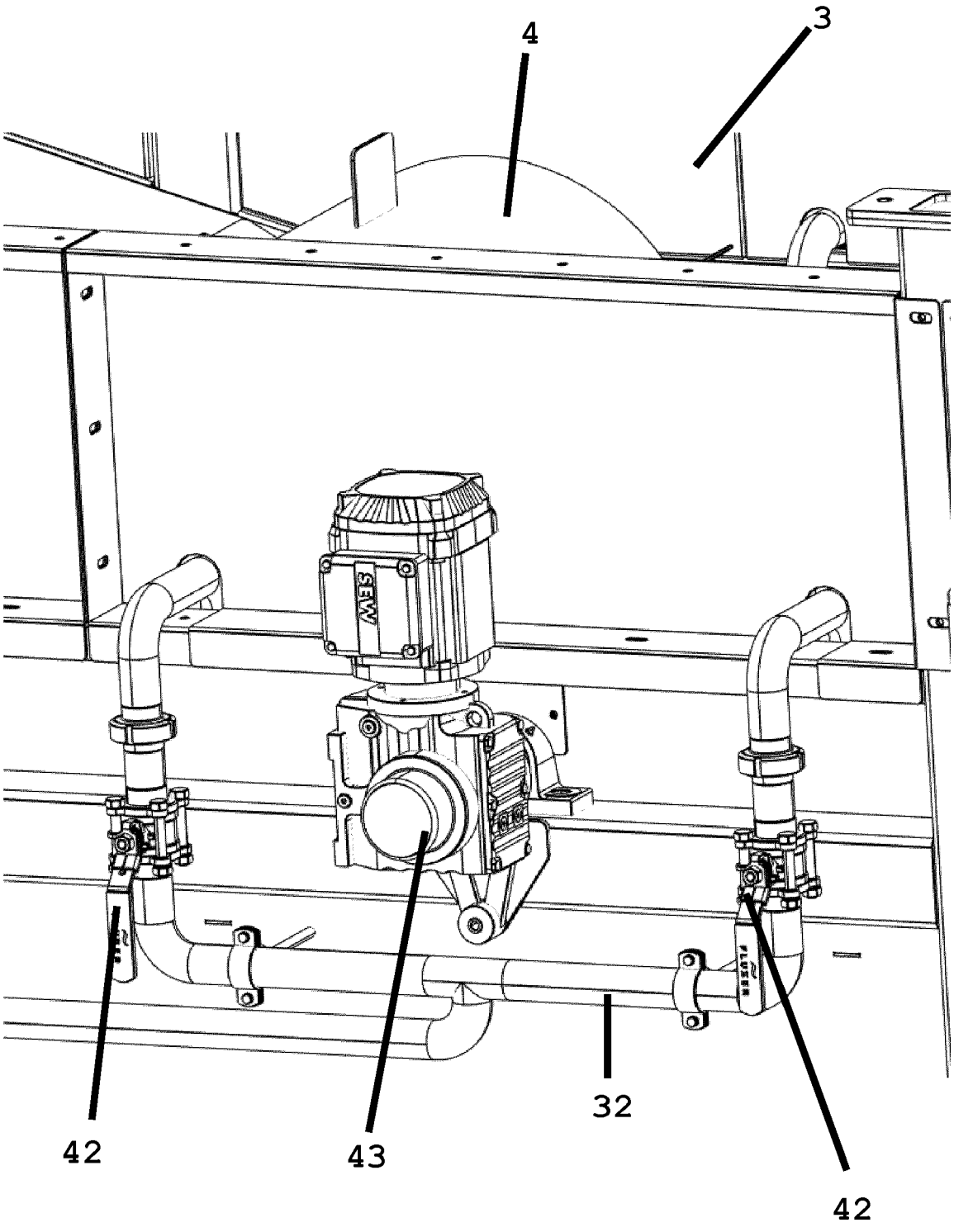

FIG.12

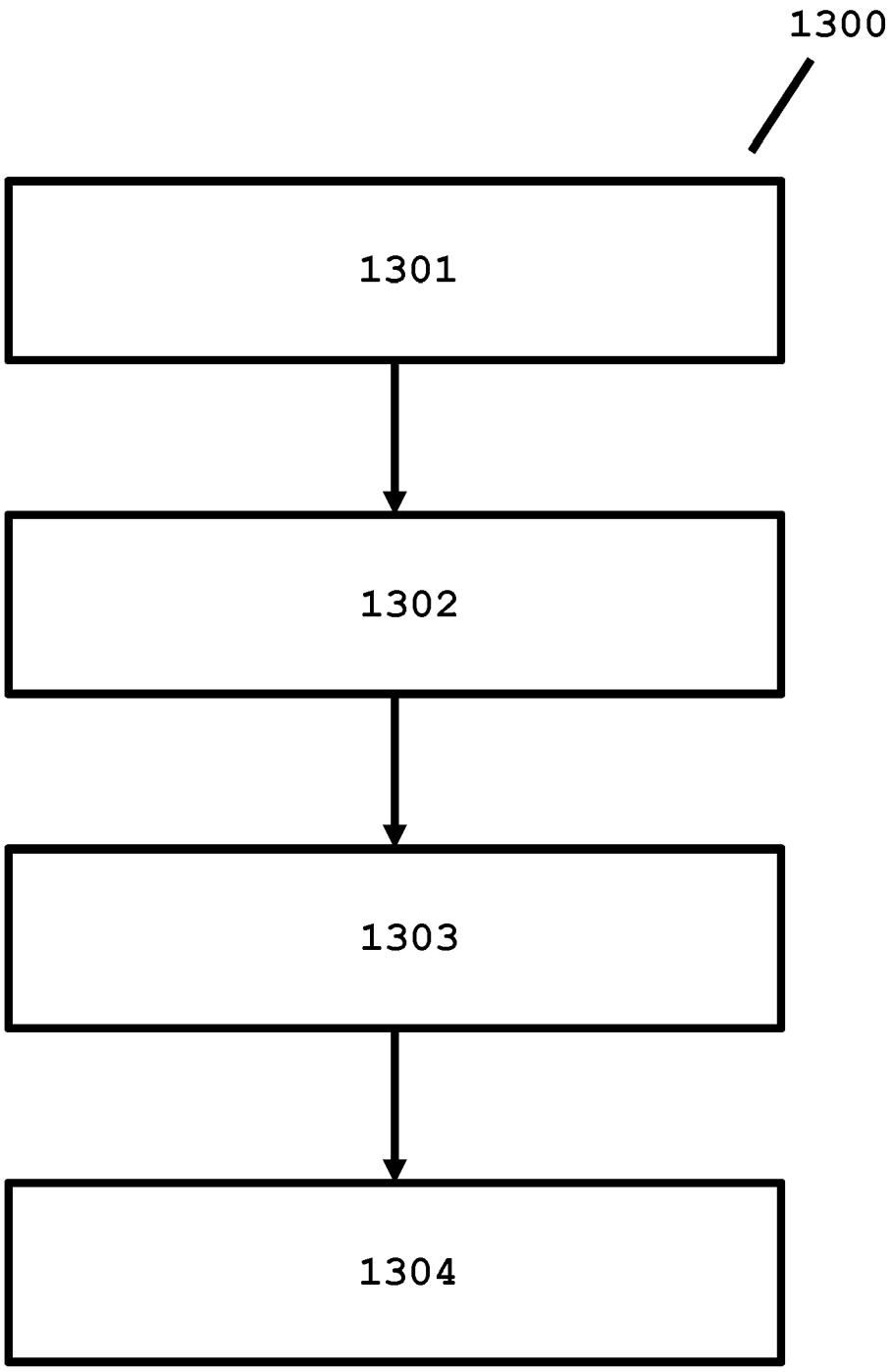

FIG.13

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EUROPEAN SEARCH REPORT

Application Number
EP 21 17 1369

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 September 2021	Clivio, Eugenio

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21-09-2021

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