United States Patent

Osterman

[15] 3,646,688

[45] Mar. 7, 1972

[54] APPARATUS FOR COUNTERCURRENT HEAT TREATMENT OF BIOLOGICAL TISSUE

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[22] Filed: July 1, 1968

[21] Appl. No.: 741,511

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 662,819, Aug. 23, 1967, Pat. No. 3,565,634.

[30] Foreign Application Priority Data

June 30, 1967 Sweden 10215/67

[52] U.S. Cl. 34/168

[51] Int. Cl. F26b 17/12

[58] Field of Search....................34/73, 166, 168, 173, 175, 34/176, 177, 182, 60, 64, 65, 241; 23/270; 99/348

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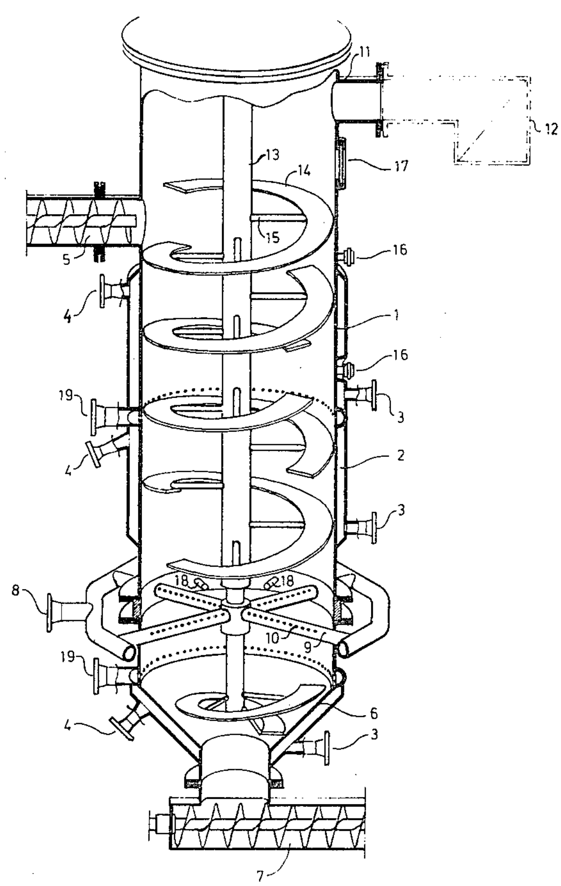
[57] ABSTRACT

A device and a method for a continuous heat treatment of biological tissue material that may or may not be disintegrated, such material comprising, e.g., fish, wherein the material is treated with heat in countercurrent to the material flow using a vertically arranged container provided with at least one vertically arranged shaft mounted for rotation. The shaft is provided with stirrers each having a vertical and helical pitch and being adapted to work the material zone by zone in vertical and horizontal directions.

14 Claims, 12 Drawing Figures



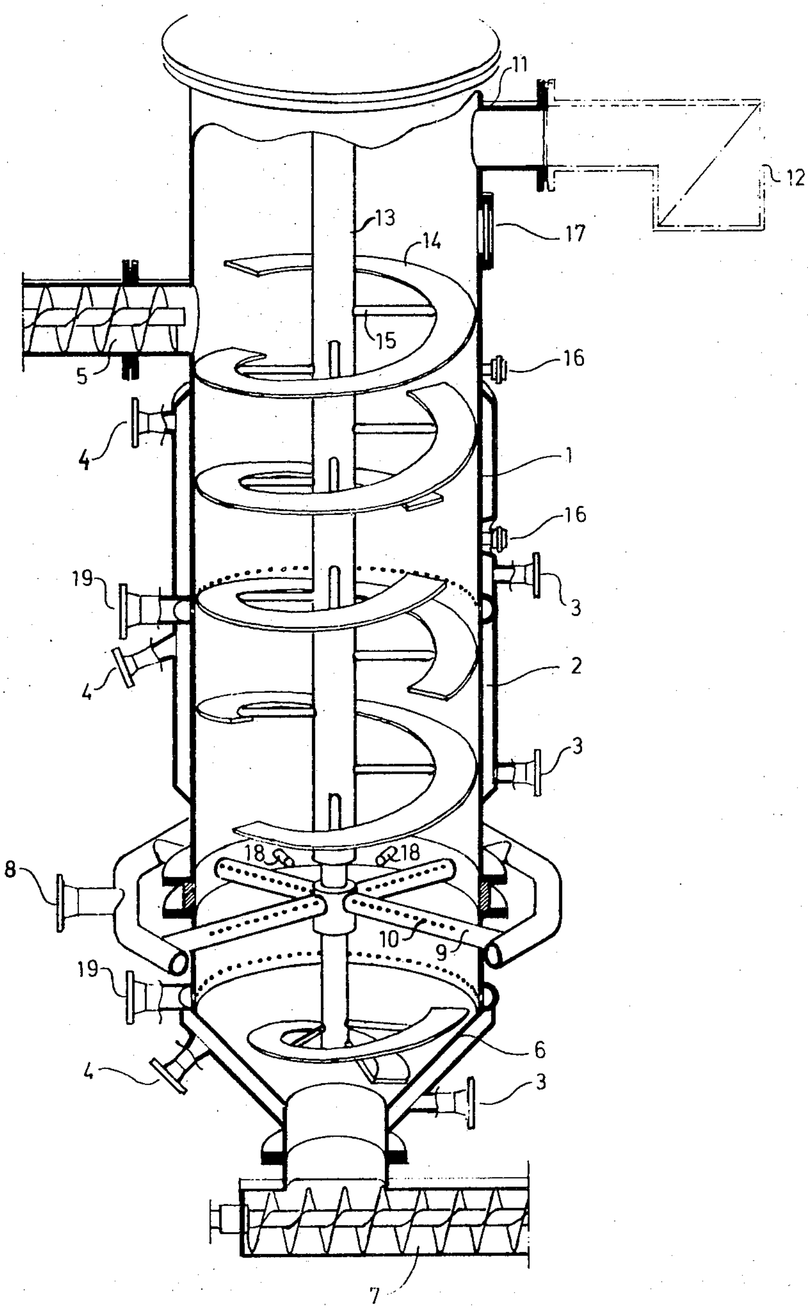


Fig.1

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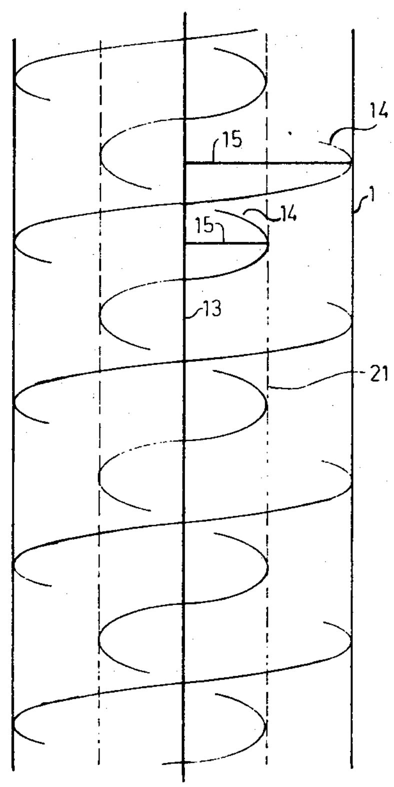

Fig. 2

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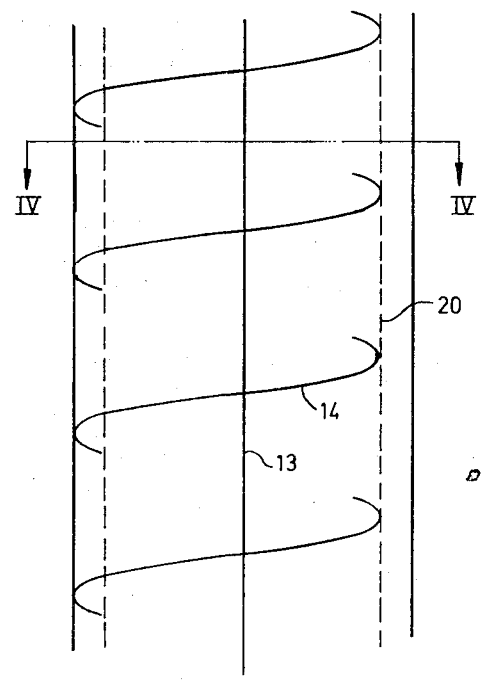

Fig. 3

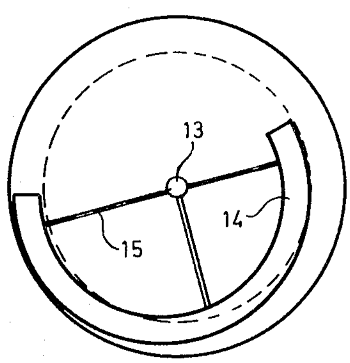

Fig. 4

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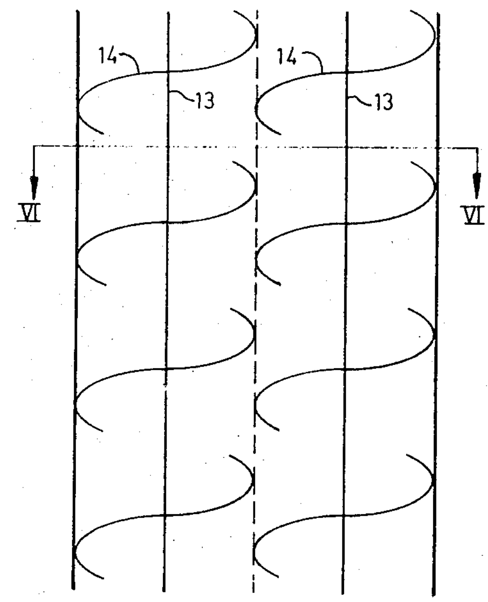

Fig. 5

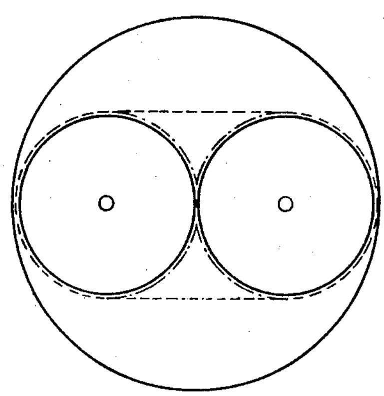

Fig. 6

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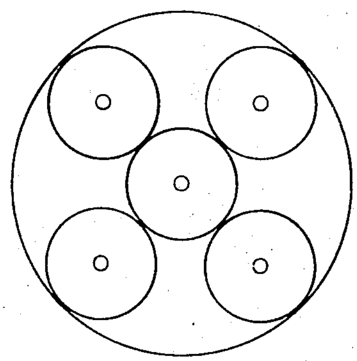

Fig. 7

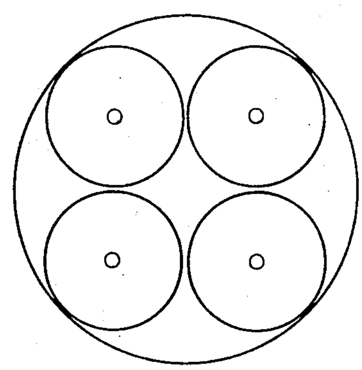

Fig. 8

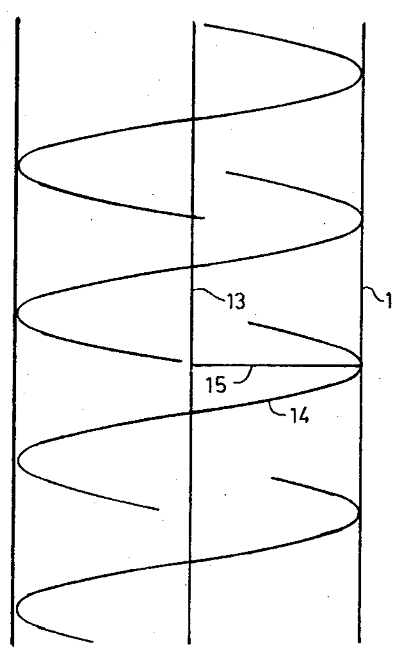

Fig. 9

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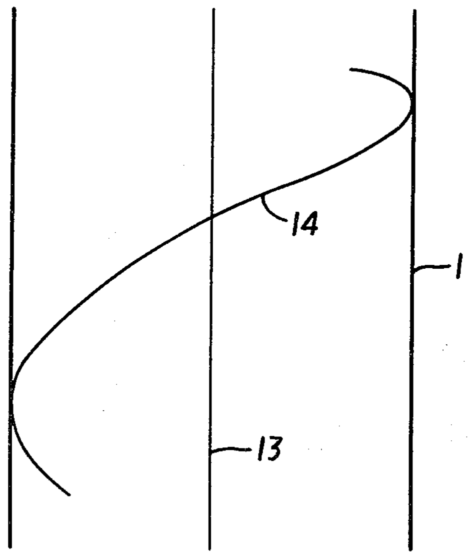

FIG. 10

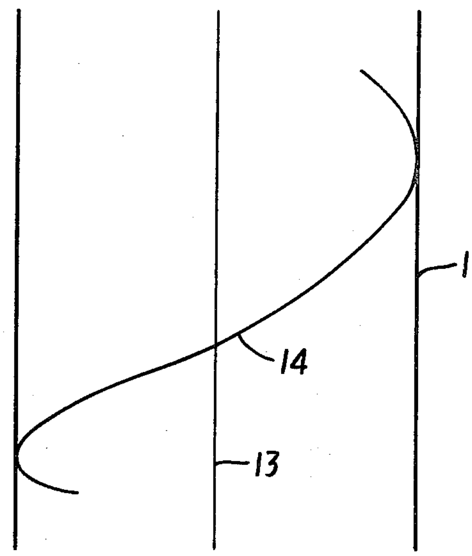

FIG. 11

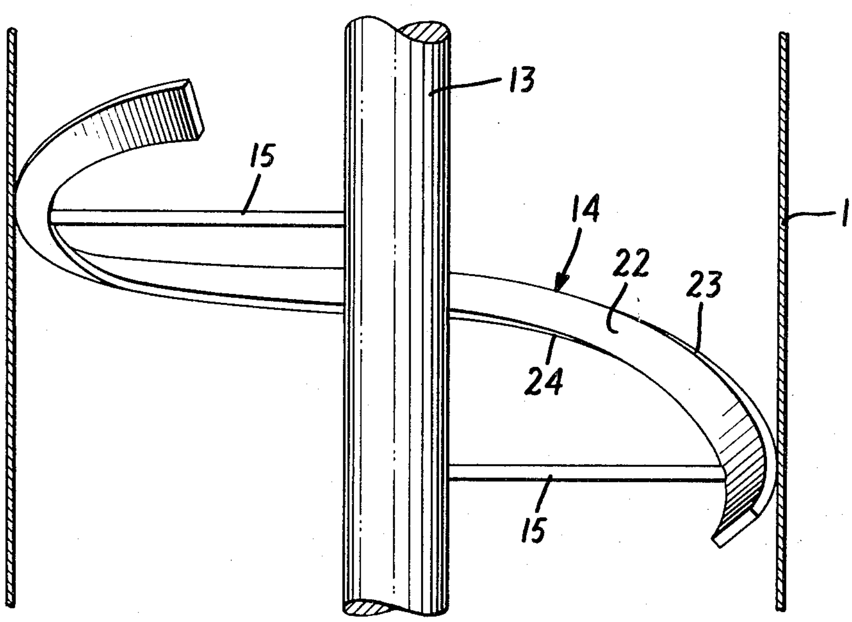

FIG. 12

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APPARATUS FOR COUNTERCURRENT HEAT TREATMENT OF BIOLOGICAL TISSUE

The present invention is a continuation-in-part application of United States application Ser. No. 662,819, filed Aug. 23, 1967, now U.S. Pat. No. 3,565,634, and relates to a device for a continuous heat treatment of biological tissue material, this material being or not being disintegrated, by means of a gaseous heat transmission medium in countercurrent to the material flow, said device comprising a vertically arranged container provided with at least one vertical shaft mounted for rotation, the container being provided with a feeding device connected to its upper portion and a discharge device connected to its lower portion for the material and at least one lower feeding conduit and at least one upper discharge conduit for the gaseous heat transmission medium.

The object of the present invention is to provide a continuously operating device having high efficiency with regard on the one hand to the quantity per time unit and on the other hand to the heat treatment of the treated material.

Another object of the invention is to provide a device in which there is obtained an indulgent treatment of the material, which is a very important requirement as otherwise heat-sensitive biological tissue material easily is decomposed.

Still another object of the invention is to provide a device that is easily cleaned which is an indispensable condition as the device is used for heat treatment of biological material which is to be consumed by human beings and by animals.

Further, the object of the device according to the invention is that it should be used for many purposes such as boiling and coagulating of the treated material by means of direct or for the evaporation of volatile substances, which are chemically or physically bonded to the material in question, by means of a direct heating.

Hitherto, for such purposes devices have been used (see e.g., U.S. Pat. Nos. 2,264,390 and 2,536,345), said devices comprising one or several cylindrical containers provided with on the one hand a mantle arranged about the container for indirect heating of the container with its contents and on the other hand with a feeder screw arranged in the interior of the container and provided with a conveyor for the conveyance and stirring of the material. However, these devices present considerable drawbacks for the reason that the mantle surface of the container by the indirect heating must be very hot if a high efficiency is to be obtained and thereby the biological material which often is very sensitive, is exposed to the risk of being decomposed. Moreover, there is not obtained an even packing of the treated material over the whole area but the material will be gathered towards the lower portion of the container. Direct stream that may be introduced will thus pass over the material and the close contact required between the material and the steam is not obtained. Further, the risk increases for a decomposition of sensitive material by means of the high contact pressure against the lower portion of the container and thereby a larger contact against the hot mantle surface.

Another known device (German "Auslegeschrift" No. 1,011,270 and U.S. Pat. NO. 2,776,894) comprises a vertically arranged cylindrical container provided with horizontal planes at mutual distances. In this device where a zone is formed between two planes, each plane is provided with an opening for connection to the zones defining the zones. Further, arranged on a vertical shaft mounted for rotation, there are, wings running along the upper sides of the planes. These wings feed the material past the openings through which the material falls down such that there is obtained a conveyance of the material. The material is exposed to heat treatment in counterflow by means of direct gas during the conveyance from an upper plane to a lower plane, the gas being introduced through openings arranged in each plane, these openings being in connection with feeding conduits for the direct gas. This device presents in the first hand the drawback that it is very difficult to clean the same, which is a very important inconvenience at the manufacture of products which are to be consumed by human beings or animals.

Further, there is not formed any quite continuous bed of material but there is obtained a kind of series treatment stations which further restricts the range of use.

In another known construction (U.S. Pat. No. 2,806,298), the device comprises a cylindrical, vertically arranged container provided with a vertical shaft mounted for rotation, this shaft carrying radially directed and helically arranged vanes of varying lengths. This device presents the drawback that there is not obtained any efficient feeding movement from the wall of the container such that there occurs a lower heat transmission to the material. The device, which is intended for a batchwise treatment of the material, is constructed for a treatment of the material by means of high-pressure steam which is injected in the container with an important force and there is obtained a fluid bed.

Another known device (U.S. Pat. No. 3,075,298) comprises a vertically arranged cylindrical container, which has a double mantle and is provided with feeding and discharging devices for the material. It is further provided with a vertical shaft mounted for rotation and carrying radially arranged vanes inclining in relation to the horizontal plane, said vanes shaped as sectors. The material is heat treated in counterflow at a force conveyance from above and downward by means of the inclining vanes and for the reason that the inclining vanes are shaped as sectors there is obtained no open center. There is thus no possibility for a treatment zone by zone of the material with a radially directed displacement of the same but the material is only vertically displaced along a helical path. Thus, the material will not be loosened but instead be compressed. Further, the device presents the drawback that certain material to a great extent is stuck to the vanes such that the material is exposed to a long heat treatment, whereat the same may be decomposed. According to this sticking to the vanes the device is further hard to clean and the material will for this reason form a favorable surrounding for an undesired growth of bacteria.

The drawbacks explained in the aforegoing have been completely eliminated by means of the device according to the present invention which is characterized thereby that the shaft carries a number of stirring devices arranged at a distance from the shaft, said stirring devices having a vertical helicoidal pitch and being adapted to treat the material zone by zone in vertical and horizontal direction.

The stirrers present a smooth surface toward the direction of material flow, this surface being substantially straight in a radial direction from the shaft. The stirrers are preferably shaped as blades or vanes having a rectangular cross section. For the reason that the helical stirrers are plane, there is obtained a better lifting surface and a better vertical displacement of the material.

The helical stirrers should according to a preferred embodiment of the invention operate in the direction opposite to the flow of material.

By means of the described embodiments there is obtained a stirring and homogeneous mixing of the material at every level defined by the helical stirrers. Thereby the material is lifted by the stirrers and moved against the center such that there is obtained an efficient heat transmission.

According to another preferred embodiment the helical stirrers are arranged such that they form at least one interrupted open helix.

In the device according to the invention the lifting ability of the stirrers should be essentially equal to the streaming through in downward direction in the free area. The lifting force is thereat depending on the width of the helical stirrers, their pitch and speed.

According to a further embodiment the helical stirrers are arranged to run along an imaginary cylindrical mantle surface being coaxial to the shaft, the stirrers being preferably adapted to rotate in the vicinity of the internal surface of the container and the imaginary mantle surface will essentially coincide with the inner surface of the container.

Further, the upper end portions of the helical stirrers may with advantage be situated in one imaginary cylindrical mantle surface and the lower end portions of the stirrers be situated in another imaginary mantle surface, the imaginary mantle surfaces being concentric to the shaft and present different radii and the lower end portions of the stirrer are preferably adapted to rotate in the vicinity of the inner surface of the container, the other mantle surface preferably coinciding with the inner surface of the container.

The upper surface of a stirrer may be inclined so that a point on its outer edge is in a different horizontal plane from a corresponding point on its inner edge.

As mentioned in the aforegoing the lifting force should be essentially equal to the streaming through in the free area. Thus, the width of the stirrer is one of the factors influencing the lifting force and the stirrers, for this reason, preferably have a width between 5 and 25 percent of the inner diameter of the container.

In respect to the pitch of the stirrers it can be constant or vary vary within each stirrer as well as the pitch can be different for different stirrers arranged in different parts of the container. The vertical pitch may decrease in an upward direction or in a downward direction.

According to still a preferred embodiment of helical stirrers are arranged on an axially displaceable shaft with a movement back and forth.

The invention will now be described with reference to the accompanying drawings. In the drawings:

FIG. 1 shows an axial section through a preferred embodiment of the invention;

FIG. 2 shows a preferred embodiment in particular at a large diameter of the container;

FIG. 3 shows an axial section through another preferred embodiment;

FIG. 4 shows a section on the line IV—IV in FIG. 3;

FIG. 5 shows an axial section of a third embodiment of the invention;

FIG. 6 shows a section on the line VI—VI in FIG. 5;

FIGS. 7 and 8 show embodiments similar to the one shown in FIGS. 5 and 6; and

FIGS. 9, 10, 11, and 12 show further embodiments of the invention.

The embodiment of the device according to the invention shown in FIG. 1 comprises a vertically arranged cylindrical container 1 provided with a mantle 2 for an indirect heating of the container 1. The heat quantity fed to the mantle is then adjusted for giving the inner wall of the container the same temperature as the treated material and such that only pure heat losses by means of radiation and steam formation are compensated for. The mantle 2 is here provided with a supply conduit 3 connected to the lower portion of the container 1 and a discharge conduit 4 connected to the upper portion of the container 1 for heating medium for heat transmission the mantel, this medium may, e.g., comprise water steam. Further, arranged at the top of the container 1 is a horizontally extending feeding screw 5 with a stream mantle for feeding biological material. The lower portion 6 of the container 1 is tapering conically downward and a horizontally arranged discharge screw 7 with a steam mantle is connected to this conical portion 6 so as to discharge the heat-treated biological material. The feeding and discharging screws 5 and 7 are provided with a mantle in order that the material either shall maintain a temperature already obtained or for an addition of heat such that direct steam does not have to be fed in excess for a pure heating. In the lower portion of the container 1 above the conical portion 6 there is arranged a feeding conduit 8 for a gaseous heat transmission medium. The feeding conduit 8 is preferably connected to a distribution means 9 comprising for instance two tubes crossing each other and provided with a number of apertures 10 to give an even distribution of the gaseous heat transmission medium. At the upper end of the container 1 there is, above the feeding screw 5, further arranged a conduit 11 for the discharge of the gaseous heat transmission medium. The conduit 11 is then with advantage connected to a heat exchanger 12 taking the shape, e.g., of a condenser for cooling the heat transmission medium. Further a vertical shaft 13 mounted for rotation is arranged in the container 1 and the axis of the shaft 13 coincides with the central axis of the container 1. The shaft 13 carries at a distance from the same helical stirrers 14 arranged along the inside of the container 1, each stirrer 14 presenting a vertical helicoidal pitch. The pitch of the stirrers 14 is in this embodiment shaped in such a way and the stirrers 14 arranged in such a way that they form an open helix having interruptions at certain intervals. The helical stirrers 14 are in this embodiment attached to the shaft 13 by means of stays 15 which are arranged about the shaft with an angular distance of 90°. The helical stirrers 14 are in this case arranged such that they form a complete turn about the shaft 13 whereupon an opening corresponding to a quarter of a turn is arranged before the beginning of the subsequent helical stirrer. By means of a motor, not shown, the shaft 13 is brought to rotate such that the helical stirrers tend to lift the material fed to the container 1.

Level sensors 16 are arranged below the mouth of the feeding screw 5 in the container 1, these level sensors having for their object to control the feeding of the material to the container such that a rather constant material quantity all the time is contained in the container during a continuous operation. Further, an inspection window 17 is arranged in the wall of the container to allow a visual inspection.

Temperature and pressure indicators 18 are arranged at different levels to control the feeding of the gaseous heat transmission medium.

Feeding conduits 19 are arranged at different distances from the feeding conduit 8 along the container 1 through which conduits more gaseous heat transmission medium can be fed at need.

At large diameters of the container 1 it might be advisable, as shown in FIG. 2, to arrange the helical stirrers 14, such that some of them run along the inner surface of the container 1 and such that the rest run along an imaginary mantle surface 21, which has a diameter that is smaller than the radius of the container 1. In the embodiments of FIGS. 1 and 2, the edge of the stirrers 13 and 14 which encircle the shaft 13 partially define the surface of a cylinder which is concentric with the rotational axis of the shaft 13. Also in this case the helical stirrers 14 should be arranged in such a way that all of them at their rotation lift the material fed to the container 1. In this embodiment it is advisable that the outer as well as the inner helical stirrers have the same pitch, i.e., such that the pitch measured in meters will be the same for the outer as well as the inner helical stirrers.

The FIGS. 3 and 4 show another embodiment of the invention according to the invention in which the helical stirrers 14 as a difference to the embodiment shown in FIG. 1 do not run along a cylindrical surface having its center in the center of the shaft 13 but run along and partially define the surface of an imaginary truncated cone tapering towards the top of the container 1, the center axis of this cone coinciding with the rotating shaft 13. This could also be explained in such a way that the upper limitation of the helical stirrers 14 runs along an imaginary cylindrical mantle surface 20, which has a smaller radius than the cylindrical mantle surface along which the lower end portion of the helical stirrers 14 runs. In a corresponding way the helical stirrer 14 may with its lower end portion run along a cylindrical mantle surface, which has a smaller radius than the imaginary cylindrical mantle surface, along which the upper end portion of the helical stirrer 14 runs.

As obvious from the FIGS. 5 and 6, the container 1 is provided with two shafts 13 mounted for rotation, the helical stirrers 14 then being arranged at a distance from their respective shafts. However, if the cylinder 1 is cylindrical, a large part of the cross section will be situated outside the operation area of the helical stirrers 14. For this reason it might be advisable to shape the container with an oblong cross section, which has been indicated in FIG. 5 by means of a phantom line which gives a better correspondence between the container 1 and the operation area of the helical stirrers. It might in certain cases also be advisable further to adjust the cross section of the container 1 to the operation area of the helical stirrers 14 as indicated by means of the dash-and-dot line in FIG. 6. According to this embodiment the shafts 13 may rotate in the same or in opposite directions. However, the helical stirrers 14 should always be arranged in such a way that they, at the rotation, lift the material fed to the container 1.

It is further obvious from FIGS. 7 and 8 that more than two shafts 13 may be arranged in the container. It might then be preferred to arrange the shaft such that they can be rotated to describe a circular path such that all the material in the container is influenced by the rotating stirrers.

In the embodiment shown in FIG. 9 the helical stirrers 14 are displaced in relation to each other such that they work within the operation area or level of the neighboring stirrer.

Of course, it might also be advisable, in certain cases, to arrange the stirrers with larger mutual distances such that there is obtained an untouched layer between each level of mixing and loosening.

The stirrers 14 may be constructed as shown in FIG. 10 so that the pitch decreases in an upward direction, or as shown in FIG. 11 so that the pitch decreases in a downward direction. Another arrangement is illustrated in FIG. 12 in which the surface 22 of the stirrer 14 is inclined so that a point 23 on its outer edge is in a different horizontal plane from a point 24 on its inner edge.

So as further to lift and thus to loosen the biological material during the heat treatment the shaft or the shafts may be adapted to be axially displaced. They may then be mounted, e.g., in such a way that they after a rotation of one revolution have completed one or several movements up and down.

In certain cases it may of course also be advisable to arrange the helical stirrers such that they have different rotation speeds in relation to each other. One may then arrange the stirrers on two concentric shafts which are rotated with different speeds or arrange some helical stirrers on the inner side of the container and some on the shaft, the container then being rotated with one speed and the shaft with another speed.

Due to the fact that the helical stirrers are arranged at a distance from the shaft there is obtained a device at which it is very easy to remove residues of the material such that an undesired bacteria growth is prevented. The open center of the device about each shaft contributes to the easiness of access to each stirrer at the cleaning.

The embodiment described in the aforegoing according to FIG. 1 will in the following be described with respect to its way of operation at some different ranges of use but it is of course in no way limited thereto.

EXAMPLE 1

A fish material, which has been extracted in an extraction plant (not shown) with sec-butanol is, after a primary separation of the solvent by means of a centrifugation fed into the upper end of the container 1 by means of the horizontally arranged feeding screw 5. The protein material, which contains 45 percent dry substance, 40 percent water and 15 percent solvent is humid but not dripping. Due to the fact that the container 1, which has a diameter of 300 millimeters and an effective height of 2.5 meters, is open about the center, it is readily filled with the material. Direct steam is then introduced on the one hand through the conduit 3 to the mantle 2 for indirect heating of the container 1 and the material and on the other hand through the conduit 8, the distribution means 9 and the openings 10 to the interior of the container 1 for direct heating of the material. When the direct steam entered into the container 1 contacts the protein material a part of the steam will condense and at the same time the solvent present in the protein material will evaporate and be brought along by the remaining steam flow. The upwards streaming mixture of solvent and steam will at optimal conditions, i.e., with correctly added steam quantity in relation to the quantity of solvent in the protein material, only after a short passage through the protein material, comprise the azeotropic mixture of solvent and water steam. Repeated condensation and evaporation of the solvent-water steam will occur in all the protein material in the container. The protein material will thus serve as filler bodies in a destillation column. When the azeotropic steam mixture leaves the protein material, it is fed via the conduit 11 to the heat exchanger 12 taking the shape of a condenser, where it is condensed. As the solvent has been removed from protein material by means of the heat treatment the protein is conveyed away from the container 1 by means of the horizontally arranged discharge screw 7 connected to the conical part 6, to a drier plant, not shown. By means of this discharge the protein material will move continuously downward in the container 1 under the influence of the gravity. Said distillation effect will then be reinforced thereby that a recirculation is created by means of the movement downwards of the protein material.

Simultaneously with the feeding of the protein material into the container 1 by means of the feeding screw 5, the shaft 13 mounted for rotation is started and is given such a rotation that the helical stirrers 14 arranged on the shaft 13 tend to lift the protein material fed to the container 1. The stirring speed may then be varied but should not exceed 45 revolutions per minute. The width of the stirrers is 30 millimeters and they are arranged at a distance of about say 5 millimeters from the inner surface of the container. Further, the pitch of the stirrers is 200 millimeters per revolution.

Due to the fact that the stirrers 14 are not arranged such that they form a continuous path they will operate within a defined area or within a defined level. For the reason that they operate opposite to the movement direction of the material, there will further be obtained a lifting and thus also a loosening of the protein material within several defined levels and thereby that the protein material is lifted from the periphery and is moved inward and toward the center and returned towards the periphery there is prevented a channel formation in the material bed. For the reason that the area closest to the shaft is open, the material closest to the shaft is forced to participate in the horizontal, essentially radial displacement within the material. Thereby, there takes place a continuous material exchange along the side of the container 1 such that there is prevented a channel formation due to a material shrinking by means of solvent removal also along this side. For the reason that the helical stirrers 14 give this lifting and conveyance towards the center at each level, there does not occur any total mixing in the whole of the container 1 but only a homogenization within the level. It is thereby obtained a concentration gradient of the mixture of solvent and steam such that a material completely free from solvent can be discharged from the container.

During the heat treatment and the homogenization and as the protein material is conveyed away the level sensors 16 indicate the highest point of the material bed such that when the highest point of the material bed reaches the lower level sensor 16*a*, the feeding screw 5 is started whereby new material is fed to the container. When the highest point of the material bed reaches the upper level sensor 16*b*, the feeding of protein material is stopped. Thus, it is hereby possible to have a constant quantity of material in the container 1, which renders continuous process possible.

Further, in order to insure that a material completely freed from solvent leaves the container 1, it is possible to adjust the addition of direct steam by means of impulses from a temperature and/or pressure indicator at different levels within the material bed. The steam addition can then be adjusted in such a way that a pressure compensated temperature of 100° C., i.e., a material completely freed from solvent, is present in the container 1 at a suitable level above the feeding place 9 for the direct steam and the discharge screw 6 for the material.

In order further to increase the distillation effect, it is possible to introduce, through the secondary feeding conduits **19** arranged at different levels, a mixture of solvent and steam with a composition corresponding to the mixture of solvent and steam at the actual level in the material bed.

The humid protein material discharged from the container at a rate of 400 kilograms per hour, which by means of heat has been freed from solvent, contains only 100 p.p.m. solvent, i.e., 100 milligrams solvent per kilogram of discharged humid protein material, which at the feeding to the container contained up to 15 percent solvent. One hundred p.p.m. solvent in humid material means then that the solvent residue is only 40 p.p.m. when the material has been dried. Thus, an efficient solvent removal has been obtained by means of the use of the process described.

EXAMPLE 2

Also this test had reference to the removal of solvent from extracted fish material. Fishmeal extracted by means of isopropanol in which the proportions were 65 percent dry substance and 15 percent water and 20 percent solvent was fed to the container. The heat treatment was carried out in the same way as in Example 1.

The humid fish protein freed from solvent contained only 80 p.p.m. solvent, which when the fish protein was dried gave a residual content of 35 p.p.m.

In the Examples 1 and 2 hereabove it has been illustrated the solvent removal of a protein material from fish but of course other materials may be used, such as extracted soybean meal, rape, cocoa.

The fish protein obtained according to Examples 1 and 2 had a good quality and did not show any destruction, which is an indication of that an indulgent treatment is obtained at a solvent removal in the device according to the invention.

The device according to FIG. 1 was in the following example used as a boiler and biological material, such as fish, animal muscle tissue or cellulose material was heat treated by means of direct steam.

EXAMPLE 3

In this case fresh fish was fed in the same way as in Example 1 into the container 1 while direct steam was fed in counterflow to the material flow. By means of the shaft **13** arranged in the container 1 and provided with the stirrers **14**, there is obtained a complete mixing and homogenization at every level such that a complete boiling of the material is obtained thereby that the steam is forced to pass through and brought to close contact with the material fed therein. The continuity at the feeding and the discharge is obtained in the same way as in the Example 1, and also in this case it is obtained, by means of the pressure and temperature indicators, a completion of the boiling before the material leaves the container **1** via the discharge screw **7**.

The material discharged from the container in the above Example 3 is completely boiled. There has been obtained by means of the boiling a complete denaturation of the protein of the fish such that the protein has been given a suitable form for further treatment such as extraction. The material obtained did not show any tendency for destruction.

The fish protein obtained in Examples 1 and 2 has by means of the heat treatment carried out been deodorized. Amines hard to condense have been removed from the material. There are of course other methods of deodorizing animal material. It is, e.g., suitable to use a mixture of ethanol and water in gaseous form for this deodorization.

EXAMPLE 4

In order to deodorize fish protein which contains amines that are hard to condensate, the material was inserted through the feeding screw **5** into the container **1** in the same way as in Example 1. However, instead of introducing only direct steam through the distributor **9**, there was introduced a gaseous mixture of ethanol and water (95/5). For the rest, the material was treated in the same way as in Example 1. By means of the helical stirrers **14** arranged on the shaft **13**, there is obtained at the rotation of the shaft, a complete mixing and homogenization at each level such that the introduced steam mixture of ethanol and water is brought to contact all the material and there is achieved a complete deodorization thereby that the amines having a bad smell are removed. The continuity of the feeding and the discharge is obtained in the same way as in Example 1. By use of the device described there is obtained a fish protein free from smell as freed from amines of bad smell.

The examples here above have been described with reference to the device shown in FIG. **1** but treatments according to the examples can be carried through by means of the embodiments of the invention shown in FIGS. **2–9**. The use of the latter is merely depending on the rate per time unit required from the device, which is obtained by means of the increased area of the container.

The devices described in the foregoing may operate also at negative pressure when a very heat-sensitive material is to be freed from solvent or to be deodorized. Also a boiling may be carried out at a lower pressure and temperature but in such a case the temperature for a coagulation is to be maintained in case a coagulation is necessary for the continued treatment of the material.

I claim:

1. An apparatus for the continuous treatment of disintegratable biological tissue material with a gaseous heat transmission medium moving in countercurrent relationship to the flow of the tissue material comprising a vertically disposed container, a material-feeding means for supplying material to the upper portion of said container, a material discharge means for removing material from the lower portion of said container, a heat transmission medium distribution means for supplying a gaseous heat transmission medium to the lower portion of the container, and a lifting means for circulating the material within a series of successive vertical zones by interrupting the downward flow of the material and displacing it upwardly whereafter it is allowed to repeat its downward movement through the zone in countercurrent relationship to the gaseous heat transmission medium, said lifting means comprising a vertically disposed shaft arranged for continuous rotation in one direction and at least one separate stirrer attached to said shaft within each zone, each stirrer being spaced from said shaft, having a helicoidal pitch, and being arranged so that its downward edge is its leading edge as it rotates with said shaft.

2. The apparatus according to claim **1** wherein each stirrer presents a smooth surface toward the direction of material flow, said surface being substantially straight in a radial direction from said shaft.

3. An apparatus according to claim **2** wherein each stirrer is vane shaped and rectangular in cross section.

4. An apparatus according to claim **1** wherein the edge of each stirrer which encircles said shaft partially defines the surface of a cylinder which is concentric with the rotational axis of said shaft.

5. An apparatus according to claim **1** wherein the edge of each stirrer which encircles said shaft partially defines the surface of a truncated cone which is concentric with said shaft and which tapers toward the top of said container.

6. An apparatus according to claim **5** wherein the outer edge of the lower part of each stirrer substantially coincides with the inside surface of said container.

7. An apparatus according to claim **1** wherein the width of each stirrer is equal to more than 5 percent of the inside diameter of said container and less than 25 percent of the inside diameter of said container.

8. An apparatus according to claim **1** wherein the vertical pitch of each stirrer is constant.

9. An apparatus according to claim **1** wherein the vertical pitch of each stirrer decreases in an upward direction.

10. An apparatus according to claim **1** wherein the vertical pitch of each stirrer decreases in a downward direction.

11. An apparatus according to claim 1 wherein the vertical pitch of each stirrer varies from one part of said stirrer to another.

12. An apparatus according to claim 1 wherein the outer edge of each stirrer partially defines the surface of a cylinder concentric with said shaft and substantially coinciding with the inner surface of said container.

13. An apparatus according to claim 1 wherein the upper surface of each stirrer is inclined so that a point on its outer edge is in a different horizontal plane from a corresponding point on its inner edge.

14. **An apparatus according to claim 21 wherein said shaft is axially movable in a vertical direction within said container whereby the stirrers can be caused to reciprocate.**

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,646,688 Dated March 7, 1972

Inventor(s) Sven Olof Osterman

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 3, line 20, "vary vary" should read --can vary--;

Col. 3, line 25, "of" should read --the--;

Col. 3, line 58, "stream" should read --steam--;

Col. 6, line 12, after "protein" (second occurrence) insert --material--;

Col. 10, line 4, "claim 21" should read --claim 1--.

Signed and sealed this 21st day of November 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents