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(54) Apparatus and method for dehumidifying products in pulp form by intensive evaporation.

(57) The apparatus comprises a housing (1) inside which the pulp is transported, with a hood (9) for the extraction of vapours ; means of heating the pulp by a heat-supplying fluid ; and a device (10) for pulp conveyance through the housing (1), which consists in a rotating tubular core (11), on the outer surface of which is wound a spiral member (13) forming a worm screw for transportation of the pulp in the housing. In the tubular core (11) is a pipe (14) for feeding vapour, while on the spiral member (13) is fitted at least one coiled tube (16) through which there circulates steam from a connection with the pipe (14) to a cylindrical chamber (15) where it is collected and from which the condensate is discharged to the exterior.

The method consists in providing heat to the pulp as it advances, making steam circulate through the interior of the advance mechanism (11,13) and/or through the coiled tube (16) and/or on the exterior of the housing (1).

The apparatus has a very high overall heat transmission coefficient, and therefore good thermal performance, achieving highly satisfactory degrees of drying.

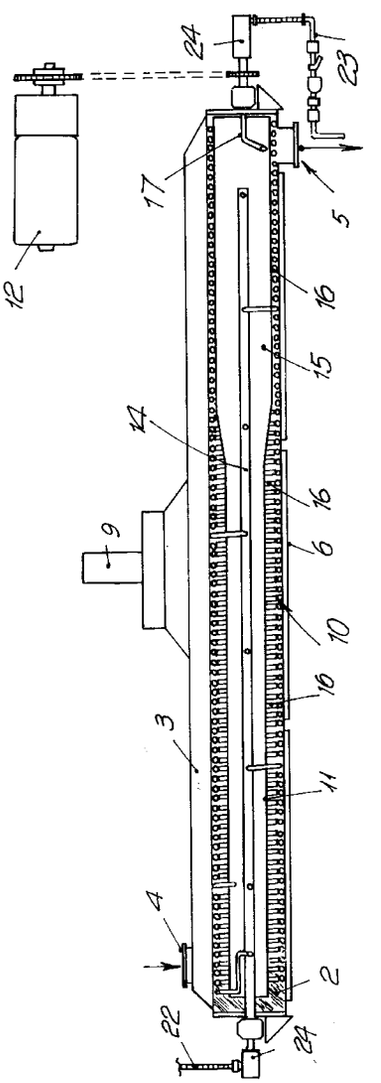

FIG.2

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The present invention refers to an apparatus and a method for dehumidifying products in pulp form and in suspension by intensive evaporation, having applications in various fields such as the dehumidifying of paper or wood pulps, sludges from waste water purification plants and others; they can be used for any humid and/or pulp product whose humidity must be reduced substantially.

BACKGROUND OF THE INVENTION

Various methods are used at present for drying, for example, sludges from waste water purification plants, since legislation in respect of waste limits acceptance of such sludges at controlled dumping sites to a maximum humidity content.

These methods, which are generally based on the use of filter presses, sheet-grating filters or centrifugal pumps, have several disadvantages, amongst which should be mentioned high electrical power consumption and the fact that they do not achieve a substantial reduction in the humidity content of the treated pulp.

Other methods are based on the use of different heating devices, for example rotatory kilns, but they involve very high installation costs and low overall heat transmission coefficients, so that they require large heat exchange surfaces and their performance is not satisfactory.

DESCRIPTION OF THE INVENTION

The main objective of the present invention is to provide an apparatus for dehumidifying or drying pulp-like humid products, such as paper or wood pulps, purification plant sludges and the like, with high performance, to permit the pulp to be dried to adequate maximum levels of humidity.

The apparatus for dehumidifying products in pulp form by intensive evaporation in accordance with the invention is provided with means of heating the pulp by a heat-supplying fluid, and is characterized in that it further includes:

a substantially tubular housing, inside which the pulp is transported, provided with at least one hood for the extraction of vapours, and inlet and outlet mouths for the input and output of the pulp; and

a device for advance of the pulp through the housing, between the inlet and outlet mouths.

This apparatus has a very high overall heat transmission coefficient, so that its thermal performance is optimum and it does not take up a large amount of space; furthermore, its installation cost is relatively low, while its running cost is also lower than that of known systems, as it has lower primary thermal fluid requirements.

In a preferred embodiment of the apparatus, the pulp-advance device comprises a rotating tubular core, around the exterior surface of which is wound a spiral member of a diameter slightly smaller than the diameter of the bottom part of the tubular housing, so that the tubular core and spiral member assembly constitutes a worm screw for transportation of the pulp along the housing, while inside the tubular core and attached thereto is arranged a feed pipe for a heat-supplying fluid, which constitutes at least part of the heating means.

The pulp therefore receives heat from the fluid over all the inner surface area of the same worm screw which transports it through the housing.

Advantageously, onto the spiral member is fitted at least one coiled tube, inside which there circulates a heat-supplying fluid, such that the exterior diameter of the assembly formed by the spiral member and the coiled tube is slightly smaller than the diameter of the bottom of the housing.

The fact that the product to be dried is forced to rotate together with the heat-supplying fluid circuits favours the release of the condensation liquid film in contact with said fluid, when in the form of condensed vapour, which improves the overall heat transmission coefficient.

More preferably, a plurality of coiled tubes are fitted sequentially along the spiral member, each of the tubes having one end connected to the heat-supplying fluid feed pipe and the opposite end connected to a cylindrical chamber which is located between the tubular core and the heat-supplying fluid feed pipe; means are also envisaged for extraction of condensates from within the cylindrical chamber.

This characteristic permits heat-supplying fluid to be fed at high temperature throughout the entire length of the housing with a single feed pipe, thus avoiding the supply of heat reducing as the pulp advances through the housing.

According to one embodiment, the diameter of the tubular core is larger in the region near the pulp outlet mouth than in the region near the inlet mouth thereof, so that the space available for pulp transportation diminishes between the inlet mouth and the outlet mouth.

This system facilitates transportation of the pulp and its contact with the heat-exchange surfaces throughout the entire housing.

In accordance with a preferred embodiment of the apparatus, the housing is made up of a lower part with a U-shaped cross-section and by a cover bearing the vapour extraction hoods. This construction facilitates assembly and maintenance of the apparatus, while the inner shape of the housing further assists evacuation of vapours from the pulp.

One important characteristic of the invention provides for the bottom part of the tubular housing to be surrounded along at least part of its length by at least one outer sleeve, through which heat-supplying fluid circulates, thus allowing heat to be supplied to the

pulp through all its contact surfaces and thereby increasing the overall heat transmission coefficient of the apparatus.

To avoid heat losses in so far as possible, at least part of the exterior surfaces are covered with a heat-insulation material.

Advantageously, the apparatus includes means of drainage of condensates from the coiled tube, the tubular core and the sleeve.

In a particularly advantageous embodiment, the apparatus further includes means for cleaning the pulp-advance device, set in the interior of the housing at least along a region close to the pulp inlet mouth, thus avoiding the pulp adhering while it dries and becoming encrusted on the pulp advance device.

Advantageously, when the pulp-advance device comprises a worm screw, the cleaning means comprise a secondary worm screw arranged to rotate parallel to the pulp-advance worm screw, so that the spiral members of both worm screws overlap at least partially.

There thus arises a cutting effect in respect of the pulp contained between the spiral members of both worm screws, and this helps to avoid pulp encrustation.

In a preferential embodiment of the present improvements, the apparatus also includes a plurality of scraping elements, which during rotation enter into contact with the pulp-advance worm screw.

Some of the scraping elements can be attached to the housing, while others are secured to the secondary worm screw; advantageously, they comprise spiral springs.

Preferably, the apparatus is also provided with a device for spraying vapour onto the cleaning parts and the advance device; the assembly can thereby be cleaned periodically.

Also preferably, the apparatus includes a pulp level detector located in the region near the pulp inlet mouth; this detector allows system feed to be regulated in accordance with the amount of pulp present in the apparatus at any given time.

In accordance with one embodiment, the apparatus further includes means for heating at least part of the housing, fitted on the outside thereof.

The adoption of this characteristic improves draft and therefore the evacuation of vapours.

The invention also refers to a method for dehumidifying products in pulp form by intensive evaporation, in which the pulp is heated by means of a heat-supplying fluid. It is characterized in that the pulp is transported inside a housing, from an inlet mouth to an outlet mouth, by means of a rotating worm screw assembly, and in that during this transportation heat is supplied to the pulp by at least one of the following means:

a) causing a heat-supplying fluid to circulate through the inside of the worm screw;

b) causing a heat-supplying fluid to circulate through at least one tube coiled around the worm screw;

c) causing a heat-supplying fluid to circulate on the outside of said housing.

Circulation of the heat-supplying fluid through the coiled tube can take place in the same direction as transportation of the pulp along the housing, or in the opposite direction, and the same applies to circulation of the fluid inside the worm screw.

The relative directions of the various currents of heat-supplying fluid have an influence on the convection of the water vapour and of the air in the region of the material to be dried.

Preferably, the heat-supplying fluid should be chosen between saturated water vapour, overheated water vapour, hot gases or thermal oil.

In an advantageous embodiment of the method of the invention, hot air is also blown inside the area occupied by the pulp in order to facilitate extraction of the vapours produced and to avoid cooling and condensation in the material to be dried.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of all that has been set out, some drawings are attached in which, schematically and solely by way of non-restrictive example, a practical embodiment of the apparatus is shown.

In said drawings,

Figures 1a and 1b show an elevation view of an embodiment of the apparatus;

Figure 2 is a longitudinal section view of the apparatus of Figures 1a,1b;

Figure 3 shows a detail of Figure 2, on a larger scale;

Figure 4 is a cross-section view of the same region of Figure 3, also on a larger scale;

Figure 5 is a cross-section view of the apparatus provided with cleanign means; and

figure 6 is a schematic side-elevation view of a detail of the pulp-advance worm screw and of the secondary worm screw.

DESCRIPTION OF A PREFERRED EMBODIMENT

Figures 1a and 1b, taken together, show an elevation view of the apparatus of the invention, for partial or total drying of products such as pulps, sludge, muds and the like.

As can be seen, the apparatus comprises a substantially tubular fixed housing 1, which the drawings show to be made up of a lower part 2 of "U" section (as can best be seen in Figure 4), and a cover 3.

The housing 1 presents an inlet mouth 4 and an outlet mouth 5 for the product to be dried, situated at opposite ends of the apparatus; on the cover is a hood 9 for extraction of the vapours given off by the

product as it is dried.

To the exterior of the housing 1 the apparatus presents three sleeves 6, whose function will be explained below, provided with longitudinal 7 and transversal 8 reinforcement means.

Particular reference is made now to Figure 2, which shows a longitudinal section of the apparatus. Inside the housing 1 is a device 10 for forward movement of the pulp or sludge introduced through the inlet mouth 4 on to the outlet mouth 5.

This device for pulp advance will be described in greater detail below with reference to Figures 3 and 4, which show two sections (longitudinal and transversal, respectively) at larger scale.

The pulp advance device comprises a tubular core 11 which rotates driven by a motor 12 (Figures 1b, 2) and which has a helicoidal winding 13 on its outer surface, forming a worm screw which forces the pulp to advance through the housing.

Inside the tubular core 11 is a feed pipe 14 for a heat-supplying fluid, for example saturated or overheated water vapour. This pipe 14 is integral with the tubular core, and between them is defined a cylindrical chamber 15.

In the preferred embodiment shown in the figures, along the helicoidal winding 13 are fixed a number of coiled tubes 16, each one of which, as can be seen in Figures 3 and 4, is connected at one end 16a to the vapour feed pipe 14 and at the other end 16b to the interior of the cylindrical chamber 15; for the purposes of greater clarity, the entire coiled tube 16 is shown in section view in Figure 4.

The vapour thus circulates through the pipe 14 and the coiled tubes 16, which are in contact with the pulp to be dried. The vapour travels through each coiled tube from 16a to 16b, releasing heat to the pulp for evaporation of the water contained therein, discharging finally into the chamber 15, ideally in the form of condensate; as will be described below, the condensates collected in the chamber 15 are eliminated through a drain trap.

As shown in Figure 2, the tubular core 11 can increase in diameter between the region of the pulp input and the region of pulp output, so that the space available between the tubular core 11 and the housing 1, that is, the space occupied by the pulp, diminishes gradually as the pulp dries, thus facilitating its transportation.

As can be seen more clearly in Figures 1 and 4, the sleeves 6 surround the exterior of the housing 1; in one embodiment of the invention vapour or another heat-supplying fluid also circulates inside these sleeves, thereby improving the overall heat transmission coefficient of the apparatus.

A pipe 17 which forms a drain trap inside the chamber (Figures 1b and 2) is also provided for elimination of the condensed vapour which accumulates in the cylindrical chamber 15.

The direction of circulation of each one of the different vapour currents described can coincide or be different from the direction of pulp advance.

Figures 1a and 1b show in highly schematic form the ends of the apparatus: the tubular core is attached to a spindle 20 mounted between bearings blocks 21 and driven in rotation at a speed which can be variable from the motor 12.

Through the spindle 20 there pass the pipe for vapour feed to the pipe 14 (on the side of Figure 1a) and the pipe 17 for elimination of condensates from the chamber 15 (on the side of Figure 1b). These pipes are connected to the vapour supply 22 and to the exterior discharge pipe 23 through rotary valves 24.

The apparatus is provided at the most appropriate locations with valves for draining off the condensates, which valves can be rotary, depending on their position.

The exterior surface of the apparatus can be covered with an insulating material, in order to improve its thermal performance.

As figures 5 and 6 show, within housing 1, above the worm screw 10 which constitutes the described pulp-advance device, the apparatus further incorporates a secondary worm screw 100, also rotary, whose purpose is to avoid the pulp adhering to the tubular core 11, to the helicoidal winding 13 and the coiled tube 16, which together make up the worm screw 10.

The worm screw 100 can be fitted along the region of the apparatus near the pulp inlet mouth, although it is preferable that it occupies substantially the entire inner length of the apparatus.

For its rotation, the worm screw 100 can be driven, for example, by a toothed chain transmission from the main worm screw of the apparatus. It can rotate in the same direction as the pulp advance worm screw, or in the opposite direction.

As shown in Figure 5, the apparatus also includes scraping parts 110,110' in the form of spiral springs of relatively high stiffness, some fixed to the inner wall of the housing 1 and others integral with the worm screw 100.

For greater clarity in the drawing, Figure 5 shows only two scraping elements 110,110', although the apparatus includes a plurality of these elements fitted throughout its length on both sides of the pulp-advance device and, for example, distributed so that they form a spiral around the spindle of the worm screw 100.

With the rotation of the worm screw 10, which makes the pulp advance, the winding 13 and the coiled tube 16 gradually come into contact with the scraping parts 110, 110', which therefore exercise a supplementary cleaning and scouring effect; in order to maintain suitable contact with the winding 13 and the coiled tube 16, while at the same time allowing them to rotate, the scraping parts 110,110' can bend.

In slightly modified embodiments, the secondary

worm screw 100 can also be fitted laterally with respect to the device 10.

In order to avoid the pulp adhering to the cleaning means described, the interior of the apparatus has a pressurized vapour tube 120 with a plurality of spray nozzles (Figure 5); periodically, for example every 24 hours, vapour can be projected under pressure against the worm screw 100 and the scraping parts 110,110'.

Likewise, to permit automatic regulation of the speed of rotation of the worm screws 10 and 100 and the feed speed of pulp to the interior of the apparatus, the latter is provided with a device 130 of a known type to detect the level of the pulp.

Finally, to improve evacuation of the vapours produced by the drying of the pulp, provision is made for heating means for at least part of the housing, fitted to the outside thereof. Specifically, provision is made for projecting hot air against the exterior of the housing, in the region of the extractor hood 9; thanks to the convective effect so achieved, this greatly improves the natural draft of the hood, at very low cost.

With regard to the specific geometry of the apparatus, both the worm screw 10 and the secondary worm screw 100 can be of variable pitch and of the same or different diameters.

The operation of the apparatus is clear from the above description: the pulp or sludge to be dried is fed into the housing through the inlet mouth 4, and the worm screw forces it to advance through the housing to the outlet mouth 5. During this course the pulp receives the heat provided by the fluid circulating through pipe 14 and through the coiled tubes 16 and the sleeves 6, so that the water contained in the pulp evaporates and emerges through the extractor hood 9.

In the method of the invention for dehumidifying a pulp or sludge by intensive evaporation, the pulp is transported through the interior of the housing 1, from the inlet mouth 4 to the outlet mouth 5, by means of the rotating worm screw assembly 11,13; during this transportation heat is supplied to the pulp by at least one of the following means:

a) causing a heat-supplying fluid to circulate through the inside of the worm screw;

b) causing a heat-supplying fluid to circulate through at least one tube 16 coiled around the worm screw;

c) causing a heat-supplying fluid to circulate on the outside of said housing, for example through the sleeves 6.

Despite the fact that reference has been made to specific embodiments of the invention, it will be obvious to an expert in this field that the apparatus and method described admit of many variations and modifications, and that all the details can be replaced by others which are technically equivalent, without departing from the scope of protection defined in the appended claims.

For example, instead of a helicoidal winding on the tubular core, to which the coiled tubes are attached, the latter could be wound directly on the tubular core and themselves constitute the thread of the worm screw; the pitch of the windings and/or of the coiled tubes can be variable, for example in order to provide greater heat at some points of their travel than at others.

A system (not shown) could likewise be provided to facilitate evacuation of the vapours which evaporate from the pulp, for example by blowing air into the area occupied by the pulp through one or more inlets made in the housing.

The shape and the number of the sleeves, together with the proportion of surface area they occupy, can be different from those shown; similarly, the number of coiled tubes and the way of feeding them with heat-supplying fluid can be different from those described.

Claims

1. An apparatus for dehumidifying products in pulp form by intensive evaporation, provided with means of heating the pulp by means of a heat-supplying fluid, characterized it that it also includes:

   a substantially tubular housing (1), inside which the pulp is transported, provided with at least one hood (9) for the extraction of vapours, and inlet (4) and outlet (5) mouths for the pulp; and

   a device (10) for advance of the pulp through the housing (1), between the inlet (4) and outlet (5) mouths.

2. An apparatus as claimed in claim 1, characterized in that the pulp-advance device (10) comprises a rotating tubular core (11), around the exterior surface of which is wound a spiral member (13) of a diameter slightly smaller than the diameter of the bottom part (2) of the tubular housing (1), so that the tubular core and spiral member assembly constitute a worm screw for transportation of the pulp through the housing (1), and in that inside the tubular core (11) and attached thereto is arranged a feed pipe (14) for a heat-supplying fluid, which constitutes at least part of the heating means.

3. An apparatus as claimed in claim 2, characterized in that onto the spiral member (13) is fitted at least one coiled tube (16), inside which there circulates a heat-supplying fluid, so that the exterior diameter of the assembly formed by the spiral member (13) and the coiled tube (16) is slight-

ly smaller than the diameter of the bottom of the housing (1).

4. An apparatus as claimed in claim 2, characterized in that a plurality of coiled tubes (16) are fitted sequentially along the spiral member (13), each of the tubes having one end (16a) connected to the heat-supplying fluid feed pipe (14) and the opposite end (16b) connected to a cylindrical chamber (15) which is located between the tubular core (11) and the heat-supplying fluid feed pipe (14).

5. An apparatus as claimed in claim 4, characterized in that means (17) are also envisaged for extraction of condensates from the interior of the cylindrical chamber (15).

6. An apparatus as claimed in any of claims 2 to 5, characterized in that the diameter of the tubular core (11) is larger in the region near the pulp outlet mouth (5) than in the region near the inlet mouth (4) thereof, so that the space available for pulp transportation diminishes between the inlet mouth (4) and the outlet mouth (5).

7. An apparatus as claimed in claim 1, characterized in that the substantially tubular housing (1) is constituted by a lower part (2) with a U-shaped cross-section and by a cover (3) bearing the vapour extraction hoods (9).

8. An apparatus as claimed in claim 7, characterized in that the bottom part (2) of the tubular housing (1) is surrounded along at least part of its length by at least one outer sleeve (6), through which heat-supplying fluid circulates.

9. An apparatus as claimed in any of the preceding claims, characterized in that at least part of the exterior surfaces are covered with a heat-insulation material.

10. An apparatus as claimed in any of the preceding claims, characterized in that it includes means of drainage of condensates from the coiled tube (16), the tubular core (11) and the sleeve (6).

11. An apparatus as claimed in any of the preceding claims, characterized in that it further includes means (100,110,110') for cleaning the pulp-advance device (10), set in the interior of the housing (1) at least along a region close to the pulp inlet mouth.

12. An apparatus as claimed in claim 11, characterized in that the aforesaid cleaning means comprise a secondary worm screw (100) arranged to rotate parallel to the pulp-advance worm screw (11,13), so that the spiral members of both worm screws overlap at least partially.

13. An apparatus as claimed in claim 12, characterized in that it also includes a plurality of scraping elements (110.110'), which during rotation enter into contact with the pulp-advance worm screw (11,13,16).

14. An apparatus as claimed in claim 13, characterized in that some (110) of the scraping elements are attached to the housing (1), while others (110') are attached to the secondary worm screw (100).

15. An apparatus as claimed in claims 13 or 14, characterized in that the aforesaid scraping elements comprise spiral springs (110,110').

16. An apparatus as claimed in any of claims 11 to 15, characterized in that it is also provided with a device (120) for spraying vapour onto the cleaning parts and the advance device.

17. An apparatus as claimed in any of the preceding claims, characterized in that it also includes a pulp level detector (130) situated in the region near the pulp inlet mouth.

18. An apparatus as claimed in any of the preceding claims, characterized in that it further includes means for heating at least part of the housing, fitted on the outside thereof.

19. A method for dehumidifying products in pulp form by intensive evaporation, in which the pulp is heated by means of a heat-supplying fluid, characterized in that the pulp is transported inside a housing (1), from an inlet mouth (4) to an outlet mouth (5), by means of a rotating worm screw assembly (11,13), and in that during this transportation heat is supplied to the pulp by at least one of the following means:
    a) causing a heat-supplying fluid to circulate through the inside of the worm screw assembly (11,13);
    b) causing a heat-supplying fluid to circulate through at least one tube (16) coiled around the worm screw;
    c) causing a heat-supplying fluid to circulate on the outside of said housing (1).

20. A method as claimed in claim 19, characterized in that circulation of the heat-supplying fluid through the coiled tube (16) takes place in the same direction as transportation of the pulp through the housing (1).

21. A method as claimed in claim 19, characterized in that circulation of the heat-supplying fluid through the coiled tube (16) takes place in opposite direction to that of transportation of the pulp through the housing (1).

22. A method as claimed in claims 20 or 21, characterized in that circulation of the heat-supplying fluid within the worm screw assembly (11,13) takes place in the same direction as transportation of the pulp through the housing (1).

23. A method as claimed in claims 20 or 21, characterized in that circulation of the heat-supplying fluid within the worm screw assembly (11,13) takes place in opposite direction to that of transportation of the pulp through the housing (1).

24. A method as claimed in any of claims 19 to 23, characterized in that the heat-supplying fluid is chosen between saturated water vapour, overheated water vapour, hot gases or thermal oil.

25. A method as claimed in any of claims 19 to 24, characterized in that hot air is also blcwn inside the area occupied by the pulp in order to facilitate extraction of the vapours produced.

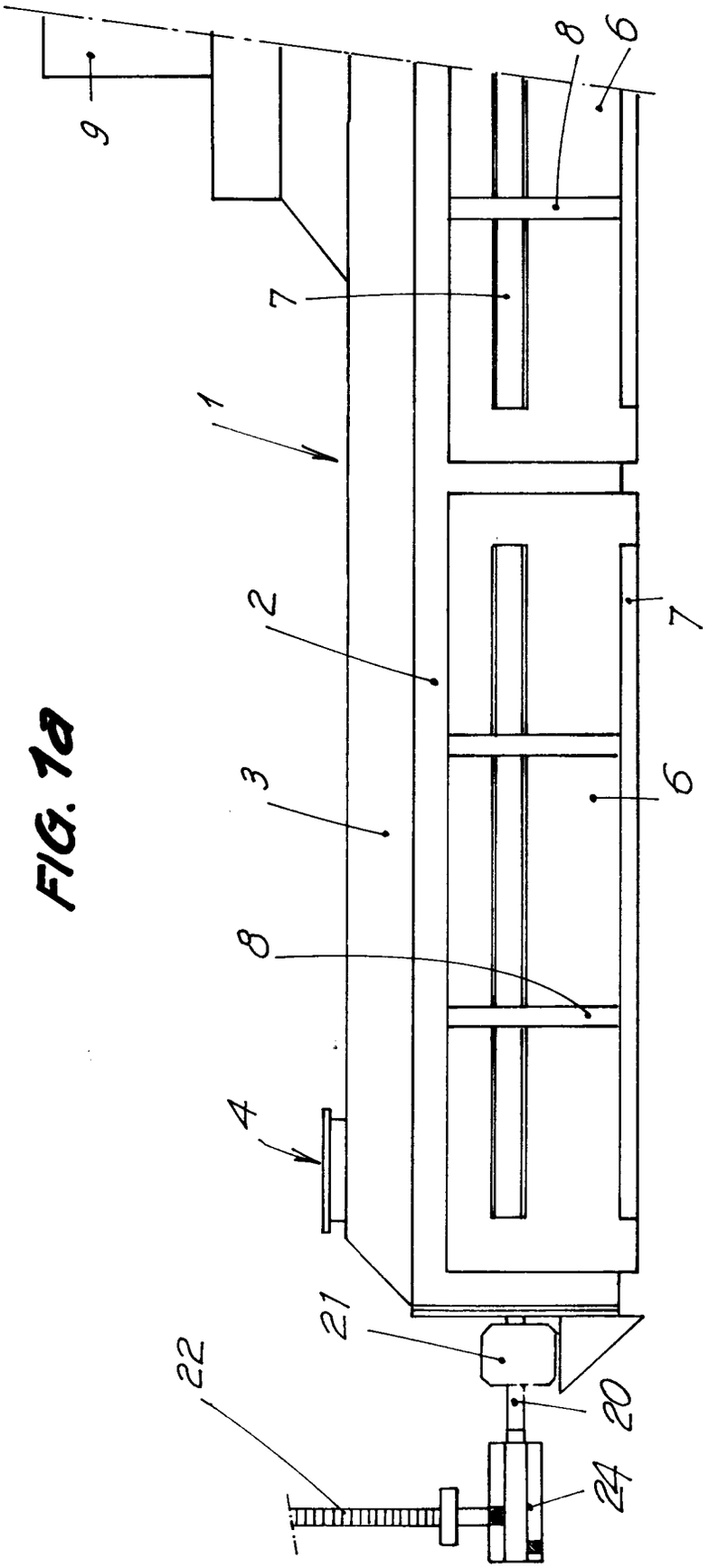


FIG. 1a

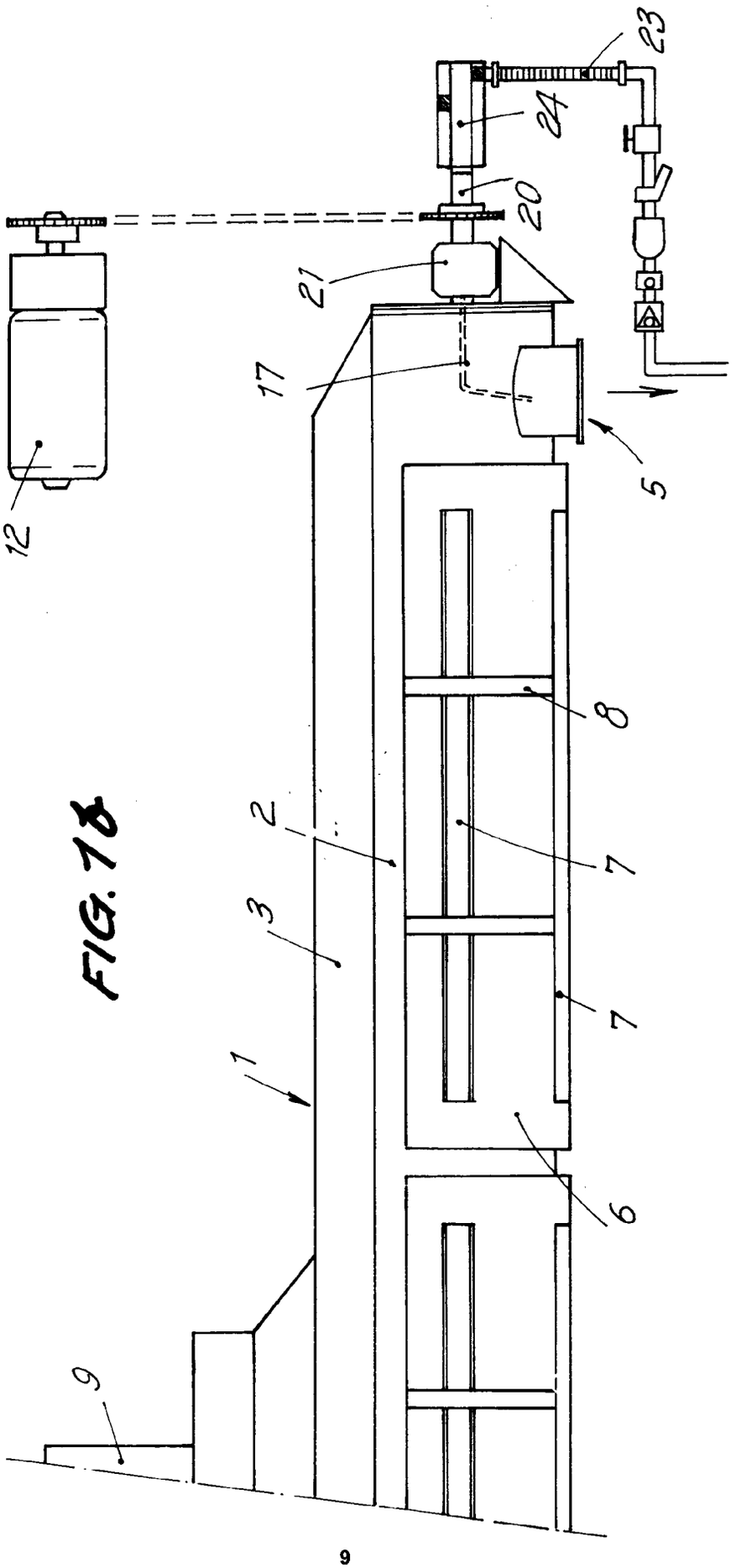


FIG. 18

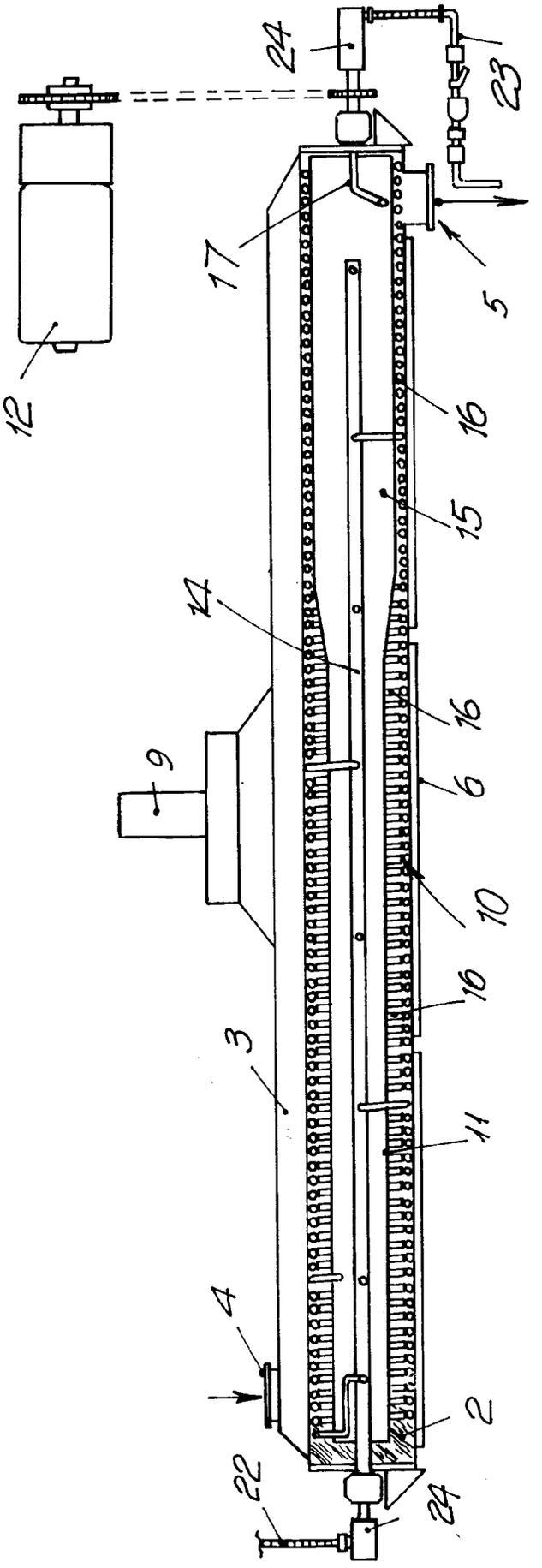


FIG.2

FIG.3

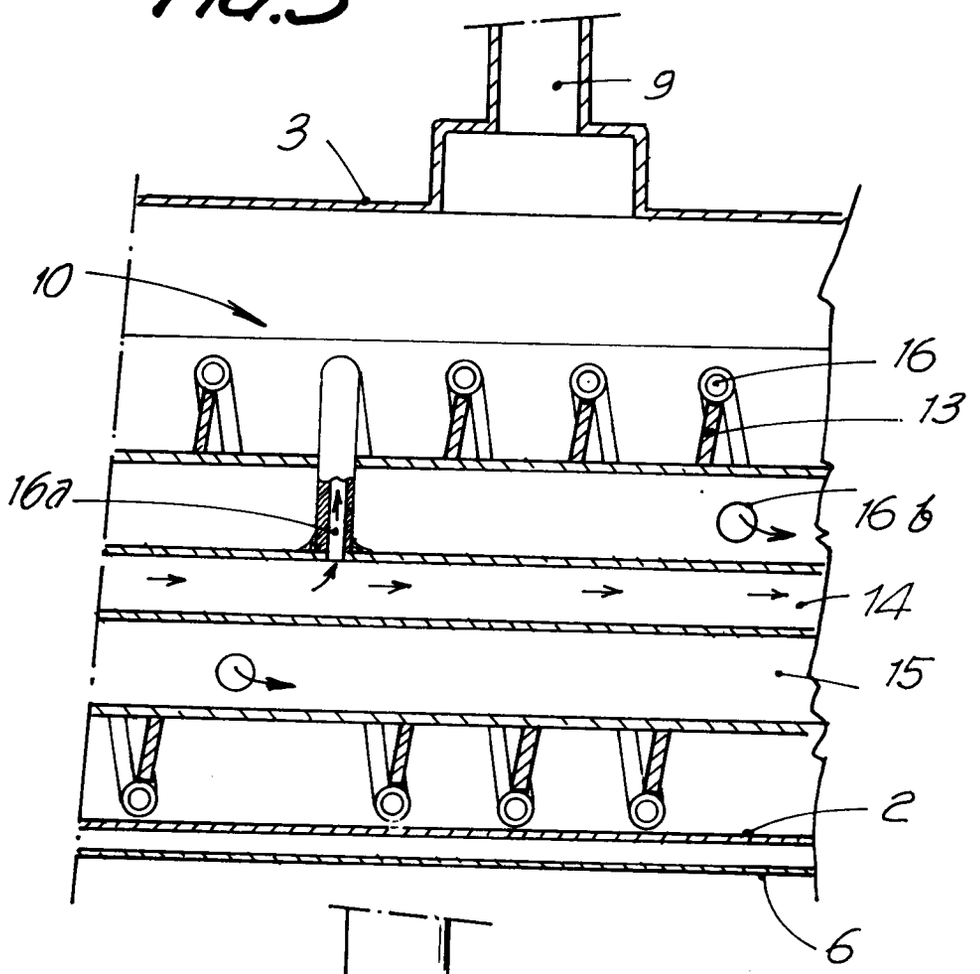


FIG.4

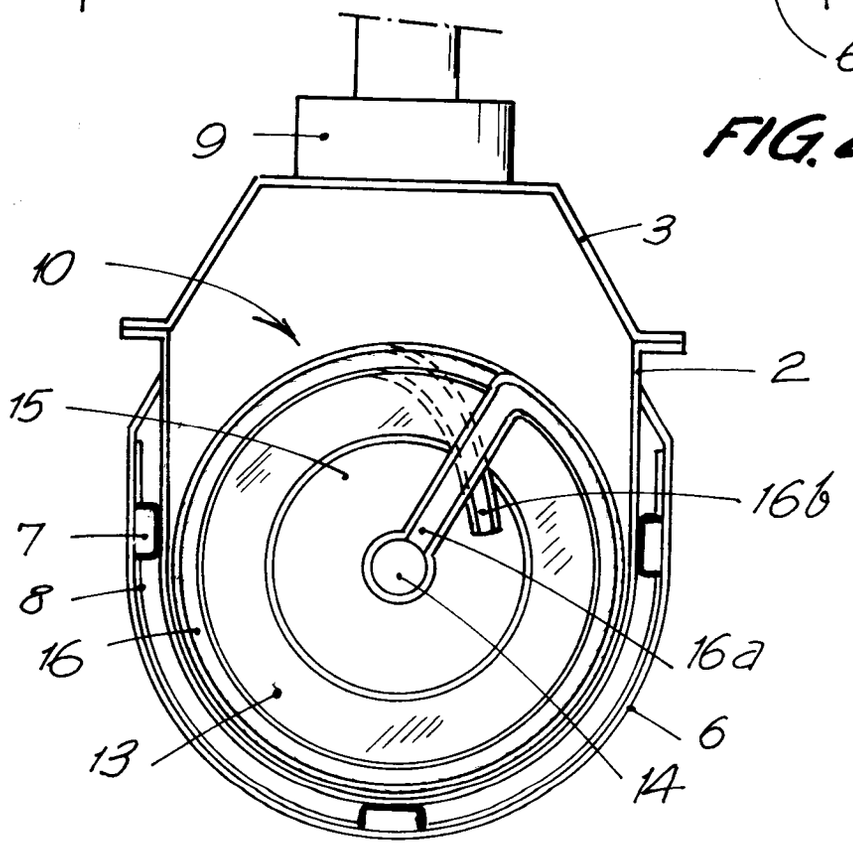
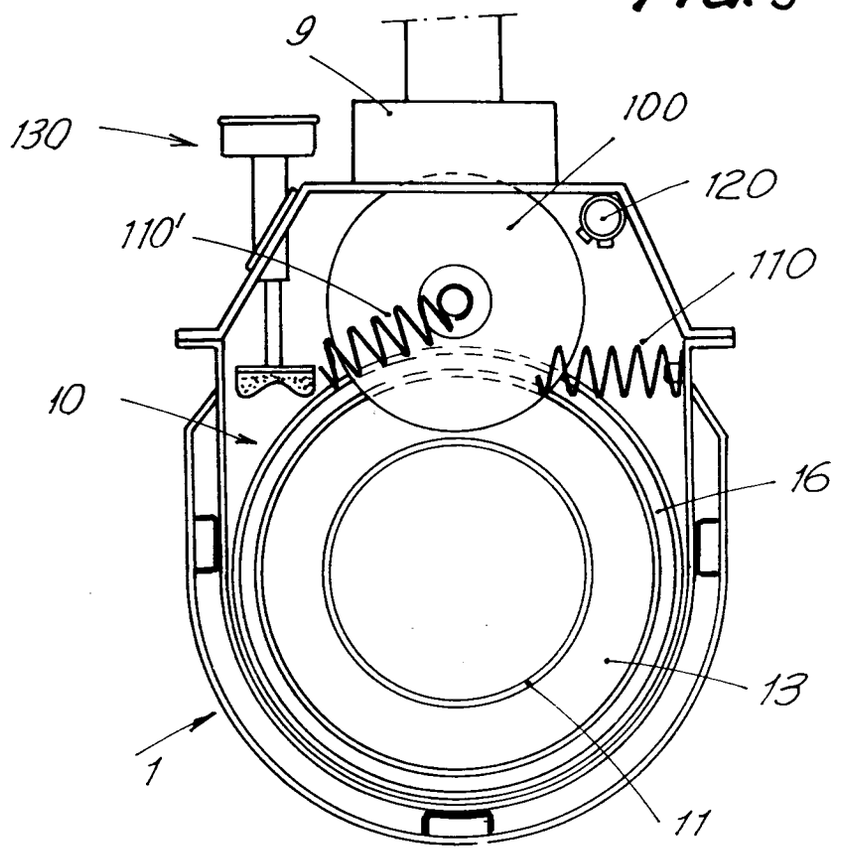


FIG. 5



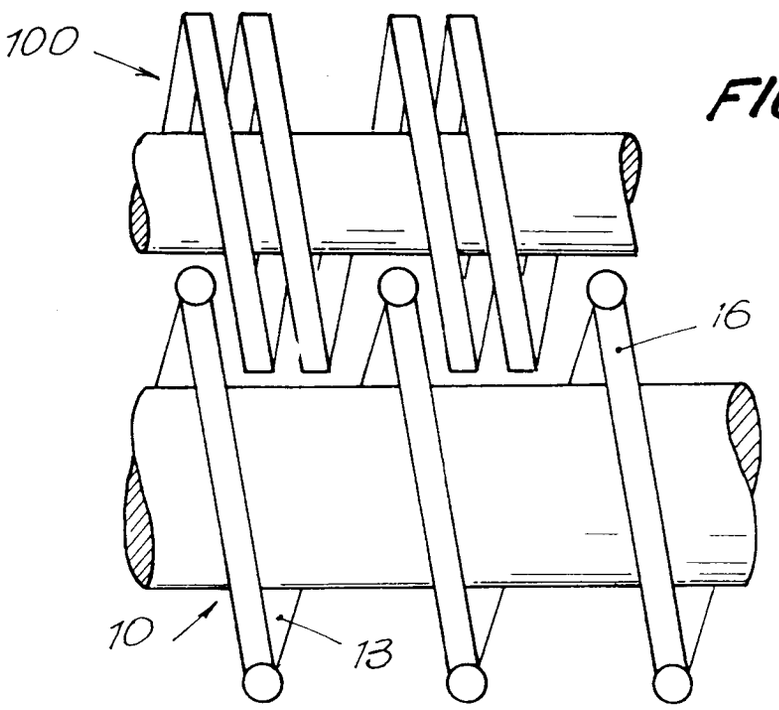


FIG. 6