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(72) Inventors:
• **Brocchini, Cristina**
I-5012 Verciano (IT)
• **Raffaelli, Paolo**
I-55100 Lucca (IT)

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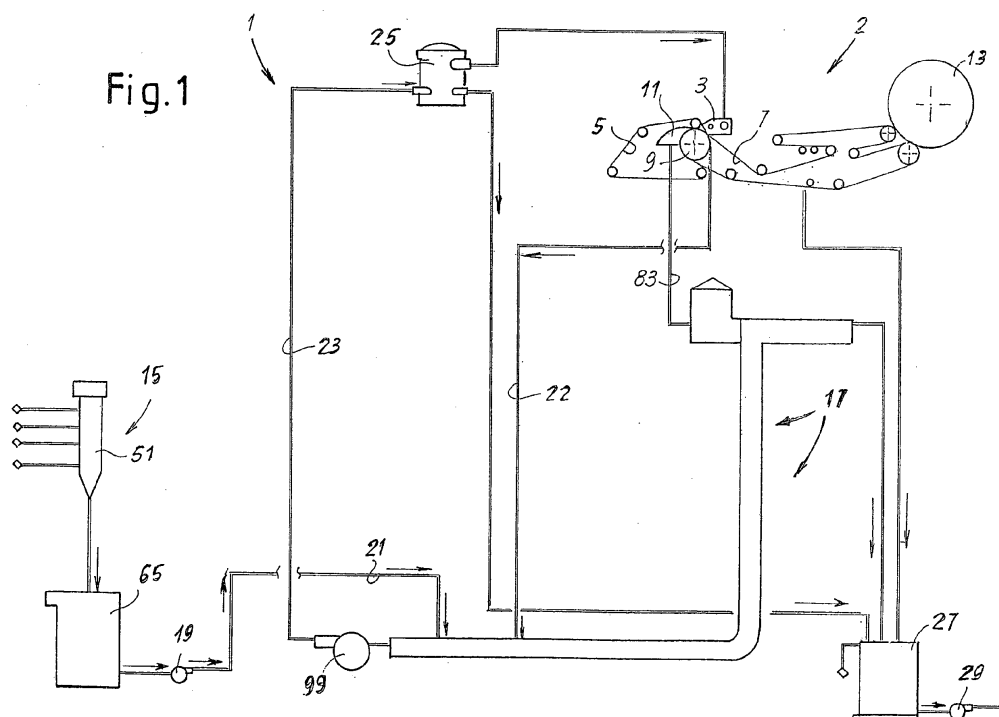
(74) Representative: **Mincone, Antimo**
Viale Europa 101
IT-50126 Firenze (IT)

(71) Applicant: **Toscotec S.P.A.**
55014 MARLIA (LU) (IT)

(54) **System for producing a cellulose web from an aqueous suspension of cellulose fibers**

(57) System for producing a cellulose web or sheet from an aqueous suspension of cellulose fibers, comprising a paper machine with at least one headbox (3) and one forming wire (5); a mixing section (15) for a slurry of cellulose fibers; a dilution section (17), wherein the slurry of cellulose fibers, coming from said mixing section (15), is diluted with water coming from the paper machine (2), to form the aqueous suspension of cellulose fibers; a fluid

connection (23) from the dilution section (17) to the paper machine (2). The mixing section comprises a mixer (51) with a vertically extending tubular body, into which at least two feed pipes of flows of water and fibers and/or water and chemical additives lead tangentially. The flows entering the tubular body of the mixer are mixed and are fed to a machine tank (65) provided with a mechanical mixer.



Description

Technical field

[0001] The present invention concerns the production of a web or sheet of cellulose material, in particular paper, such as (but not exclusively) tissue paper, or the like, with a wet system, ie, starting from an aqueous suspension of cellulosic fibers. More particularly the invention relates to innovations concerning the mixing of the fibers in suspension and the dilution of the mixture for the production of the cellulose web.

State of the art

[0002] The production of paper using the traditional wet systems provides for the formation of an aqueous suspension of cellulosic fibers, with possible further additives, such as dyes, wet-resistant resins or the like, and the supply of this suspension on a forming wire. The suspension includes a weight percentage of solid material very low, typically between 0.1 and 1.2%, depending on the type of paper to be produced. Through drainage, suction, compression and/or heating systems, the water content is gradually reduced until a web of cellulosic fibers between them cohesive is obtained, which can be further processed, for example, wound to form rolls intended for subsequent processing for the production of articles intended for consumption. The suspension of cellulosic fibers in water is fed to the forming wire through a so called headbox. The headbox is supplied with a very high flow of suspension, from which is extracted a large amount of water that, drained in the area of web formation, is made to recirculate, to dilute a slurry of cellulosic fibers containing a relatively high amount, of the order of 2.5-4% by weight, of cellulosic fibers in water.

[0003] The entire cycle of production involves the use of a high number of plant components, such as mixing tanks and collection systems, systems for dilution of the mixture with the water from the drainage area associated with the forming wire, machinery for varying the quality of the fibers, and so on.

[0004] In the production of cellulose materials is frequent the need to switch from one type of production to another, for example by changing the color of the veil in cellulosic production, the nature of the fibers and / or chemical additives, paper weight, and more. When the production of a cellulose web or web of a certain type switches to the production of a different cellulosic web, for example of different color, or even containing different chemical additives, in some cases is necessary to empty the entire system to avoid mutual contamination between the suspension for the production of the first type of material and the suspension for the production of the second type of material. This occurs in particular in the case of color change. In other cases, in the transition from one production to another, for example by changing the nature of the fibers, there is a transitory phase in which the

plant continues to produce, but the cellulosic material thus produced is unusable and must be discarded. In both cases, the high volumes of the various machinery and plant components, such as tanks, vats, etc., involves the release of significant amounts of fibers, chemical additives, water and more.

[0005] There is therefore the need to develop a compact plant, with a smaller number of components and/or with a reduced volume of the same components, so that the overall quantity of water and fibers present in the system is lower, thus reducing the problems mentioned above.

[0006] EP-A-0969142 discloses a system configured to reduce the amount of water in circulation, for the purposes indicated above. According to the content of this publication, it is in particular eliminated a collection tank of the raw water, i.e. the water coming from the zone of formation of the cellulose web, extracted from the aqueous suspension of cellulosic fibers after it has been dispensed from the headbox on the forming wire. This known system provides for the replacement of the collection and accumulation tank of the raw water, i.e. the water coming from the zone of formation of the cellulose web or sheet, with a simple tube or pipe which feeds the raw water to a centrifugal pump for recirculation, commonly called fan pump. In the tube one or more mixtures of cellulosic fibers with a higher concentration of solid coming from, for example, a preparation tank and/or from the headbox, are mixed to the main flow of raw water.

[0007] This plant and the corresponding method for the production of paper does not solve efficiently the problem of the amount of fiber circulating in the plant, which always remains very high due to the presence of many plant components wherein takes the accumulation and stationing of aqueous slurries of fibers cellulosic takes place.

[0008] Another known system for the production of a web of cellulosic fibers, such as a web of tissue paper, is shown in Fig.15. The plant is generally designated by 200. The plant comprises a paper machine 201. Such a machine may have different configurations depending on the type of paper to be produced. In the illustrated example, the paper machine 201 includes a headbox 203, a first forming wire 205, a felt 206 and a Yankee cylinder 207. Said machine may also have a different configuration; for example, it may have a twin wire or a flat board, with one or more forming wires, a conveying wire and one or more cylinders for drying the paper.

[0009] The reference numeral 210 designates a section of mixing of the aqueous slurry of cellulosic fibers. The section 210 comprises a first mixing tank 211 with a stirrer and a second feeding tank 213 for feeding the machine, also equipped with a stirrer. In the mixing tank are conveyed the mixing suspensions of long fibers, short fibers, scraps, recovered fibers, chemical additives or other. In the mixing tank the stirrer homogenizes the mixture which is then extracted from the bottom of the mixing tank 211 and raised by a pump 215 for feeding the ma-

chine tank 213. With 219 is indicated a dilution section, in which the raw water coming from the paper machine is mixed with the aqueous slurry of cellulosic fibers fed from section 210. The dilution section 219 includes an air eliminator 221 which reduces the air content in the raw water coming from the area of web formation in paper machine 201. From the air eliminator 221 the raw water flows in a settling channel of calm 223 and is collected in a collecting tank 225. From there, through a centrifugal pump 227 (fan pump), a flow of water is sucked and mixed, along a duct 229, with the aqueous slurry of cellulosic fibers for example from a constant level tank 231, to which said mixture is conveyed by a pump 233 from the machine tank 213, and with the mixture of recirculation of the headbox. The ratio between the flow of water from the collecting tank 225 and the flow of slurry from the constant level tank 231 is set so as to obtain a suspension of cellulosic fibers that to be fed to the headbox 203 with the desired percentage of solid matter. For example, from a water flow substantially free of fibers coming from the tank 225 and an aqueous slurry of cellulosic fibers with a solid content of about 2,5-4% it is obtained a suspension of cellulosic fibers with a content of solid in the order of 0.1 to 1.2%. This suspension is fed to the headbox 203 through a so-called strainer 239 connected to the centrifugal pump 227 via a conduit 241.

Summary of the invention

[0010] According to a first embodiment of the invention, it is provided a plant for producing a cellulose web or sheet from an aqueous suspension of cellulose fibers, comprising:

- a paper machine comprising at least one headbox and one forming wire;
- a mixing section for a slurry of cellulose fibers;
- a dilution section, wherein the slurry of cellulose fibers, coming from said mixing section, is diluted with water coming from the paper machine, to form the aqueous suspension of cellulose fibers;
- a fluid connection from the dilution section to the paper machine.

[0011] Said mixing section comprises a mixer with a vertically extending tubular body, into which at least two feed pipes of flows of water and fibers and/or water and chemical additives lead tangentially. The flows introduced by said at least two feed pipes are mixed with each other in said tubular body thanks to the descending and tangential movement, without the need of static or dynamic agitators. The tubular body is in fluid connection with an underlying tank machine, i.e. a tank or container collecting the slurry obtained by the mixing that takes place in the mixer and in the underlying pipe connecting the mixer and the tank. The machine tank is advantageously provided with at least a mechanical mixer, for example having vertical or horizontal axis, and is in fluid

connection with the dilution section. The plant then presents lower volumes compared to a traditional system, and therefore in the event of emptying of the system to change the product or in the case of transition between a type of production and another, there will be lower losses of fibers, chemical compounds and water. Indeed, as will be explained below, the total volume of the mixer and the machine tank is substantially less than the volume of the two tanks normally used in series in conventional plants for the mixing of the slurry. The different configuration also allows considerable energy savings, since it is entirely eliminated one of the agitators of the two tanks present in traditional plants. The mixing that takes place in the mixer and the transfer of the slurry in the next machine tank does not require rotating bodies, such as stirrers or impellers of pumps.

[0012] According to advantageous embodiments, between said machine tank and said dilution section no further intermediate tanks are present.

[0013] For a more efficient operation of the plant, the mixer can be advantageously connected to the machine tank below through a curved connection pipe preferably having a multiple curvature, i.e. two or more curves connected in series with each other. According to advantageous embodiments the mixer has an empty interior volume, for example cylindrical, or conical or partly cylindrical and partly conical, delimited by substantially smooth walls, free of baffles, fins, diverters or other static mixing elements. The mixing of the flows that enter the mixer is obtained thanks to the tangential or substantially tangential orientation of the flows. For tangential it is meant an orientation in which the flow is inclined, preferably of about 90° with respect to the axis of the tubular body, and is arranged in proximity of the peripheral wall of the tubular body of the mixer.

[0014] The mixer has at least two supply conduits. The two supply conduits can be used to enter a flow of an aqueous suspension of fibers and a flow containing agents or chemical additives. Alternatively, the two conduits can be used to feed two flows of two different aqueous suspensions of fibers, for example containing long fibers and short fibers, respectively. Preferably, in some embodiments, the mixer has more than two supply conduits, so as to be able to feed, for example two or more aqueous suspensions of cellulosic fibers of different types, and a flow containing chemical agents, such as dyes, wet-resistant resins or other.

[0015] In some embodiments, the tubular body of the mixer comprises a cylindrical cavity having a substantially circular cross section and substantially vertical axis, in correspondence of which are connected tangentially the said conduits for supplying the flows. In advantageous embodiments, the cylindrical cavity is inferiorly connected to a hollow truncated cone, with a cross section reducing downwards and inferiorly defining an outlet opening towards the underlying machine tank. The hollow truncated cone constitutes an extension of the cylindrical cavity and a junction onto an underlying pipe con-

necting it with the machine tank advantageously lying at a lower level with respect to the mixer.

[0016] Advantageously, the dilution section may comprise a settling channel for the water coming from the paper machine. The settling channel can be advantageously provided with an anti-foam plate in a first zone of the settling channel, in order to retain the foams that forms on the surface of the recirculation water coming from the paper machine. This avoids any recirculation of said foams.

[0017] In advantageous embodiments, the dilution section comprises at least one tube, extending from top to bottom, with an input connected to the settling channel, and an output, connected to a pump that feeds the aqueous suspension of cellulosic fibers from the dilution section to the headbox of the paper machine. Advantageously, between the inlet and the outlet is inserted a duct feeding the slurry aqueous cellulosic fibers coming from said mixing section. In advantageous embodiments, it is also foreseen to enter a recirculation pipe for the water coming from the headbox.

[0018] The headbox may be of the simple layer or multiple layers type, for example, double-layer, depending on the type of web or sheet cellulose material that the plant must produce. When the headbox is of the multiple layers type, there are advantageously provided pipes for water supply and dilution of the suspension in a number corresponding to the number of layers of the headbox.

[0019] In advantageous embodiments, the pipe is in fluid connection with the bottom of the settling channel and extends downwards from the bottom of the settling channel.

[0020] In some preferred embodiments, the system provides, in the dilution section, at least one air eliminator to remove air from the flow of raw waters coming from the paper machine, before they are placed in the settling channel. The air eliminator may for example comprise an outer wall and an inner wall defining an intermediate volume between them, said inner wall being pervious and in fluid connection with a substantially tangential water inlet and an air vent.

[0021] Further characteristics and embodiments are described below and further defined in the appended claims, which form an integral part of the present description. The above brief description identifies characteristics of the various embodiments of the present invention so that the following detailed description can be better understood and in order that the contributions to the technique can be better appreciated. There are, of course, other features of the invention that will be described later and that will be exposed in the appended claims. It should be understood that the various embodiments of the invention are not limited in their application to the details of construction and the arrangements of components described in the following description or illustrated in the drawings. The invention can be implemented in other embodiments and placed into practice in various ways. Furthermore it should be understood that the phraseology

and terminology used herein are for descriptive purposes only and should not to be considered limitative.

[0022] The skilled in the art will understand, therefore, that the concept on which the invention is based may be used as a basis for designing other structures, other methods and/or other systems to implement the various purposes of this invention. It is important, therefore, that the claims be regarded as including equivalent constructions of those which do not depart from the spirit and scope of this invention.

Brief Description of Drawings

[0023] The invention will be better understood by following the description and the attached drawing, which shows a practical embodiment of the system according to the invention. More particularly:

Fig.1 is a block diagram of a system embodying the present invention;

Figs 2 and 3 are two side views according to two observation points rotated by 90° relative to one another of a machine tank and the overlying fibers mixer at its inlet side, Fig.2 being a view along line II-II of Fig.3 and Fig.3 being a view along line III-III of Fig.2; Fig.4 is an enlarged side view of the mixer of Figs 2 and 3;

Fig.5 is a section along line V-V of Fig.4;

Fig.6 is a front view of the section for dilution of the cellulose slurry with the raw waters coming from the zone of formation of the paper, along line line VI-VI of Fig.7, in a configuration for feeding a double layer headbox;

Fig.7 is a side view along line VII-VII of Figure 6;

Fig.8 is a section along the midline of the terminal part of a tube for the dilution of the cellulose slurry, coming from the section for mixing the aqueous slurry, with the raw waters;

Fig.9 is a plan view along line IX-IX in Fig.7;

Figs 10 and 11 are two side views along lines XX and XI-XI of Fig.12 of the dilution section, in a configuration for the supply of the aqueous suspension of cellulosic fibers to a single-layer headbox;

Fig.12 is a plan view along line XII-XII of Figs.10 and 11;

Fig.13 is a local section along line XIII-XIII of Fig.12;

Fig.14 is a perspective view of a section of an air eliminator of the dilution section; and

Fig.15, already described, is a block diagram of a prior art plant.

Detailed description of an embodiment

[0024] The following detailed description of exemplary embodiments refers to the accompanying drawings. The same reference numbers in different drawings identify the same or similar elements. Furthermore, the drawings

are not necessarily to scale. The following detailed description does not limit the invention. Rather, the scope of the invention is defined by the appended claims.

[0025] The reference in the description to "an embodiment" or "the embodiment" or "some embodiments" refers to a particular feature, structure or element described in relation to an embodiment included in at least an embodiment of the 'object described. Therefore, the phrase "in an embodiment" or "in the embodiment" or "in some embodiments" in various points along the description does not necessarily refer to the same or to the same embodiments. Furthermore, the particular features, structures or elements may be combined in any suitable manner in one or more embodiments.

[0026] Fig.1 shows a block diagram of the plant according to an embodiment of the invention. The plant is generally designated by 1. The reference number 2 indicates the paper machine for the production of a cellulose ply, such as a web of tissue paper. The paper machine 2 may have various configurations, depending on the type of cellulose sheet or web to be produced. In Fig. 1 is schematically shown a paper machine 2 for the production of a web of tissue paper, but it should be understood that the invention can be implemented also in plants for the production of other types of cellulose sheets or webs, including the cardboard. The structure and configuration of the paper machine and the components downstream of it, in particular the drying system, will be implemented depending on the nature or type of the finished product.

[0027] In the example shown in Fig.1, the paper machine 2 includes a formation zone, where there is a headbox 3. Through the headbox an aqueous suspension of cellulose fibers is fed in a formation zone, defined between a forming wire 5 and a conveying felt 7, closed on driving rollers appropriately arranged to define two closed paths. The conveying felt 7 is driven around a formation drum 9. Due to the centrifugal force, most of the water of the aqueous suspension fed from the headbox 3 is ejected from the formation zone through a collection channel 11, from which the water is returned in the circuit.

[0028] The felt 7 follows a supply path of the cellulose web up to a drying body, such as a Yankee cylinder 13. The web is removed from the felt 7 and transferred to the cylindrical surface of the Yankee cylinder 13 to be dried. The dried web is removed from the Yankee cylinder and is made to advance towards further winding elements, not shown.

[0029] The plant 1 also comprises a section 15 for mixing with each other one or more aqueous slurries of different types of cellulose fibers and possibly with chemical additives, such as dyes, wet-resistant resins, or other additives. In general, in the mixing section 15 are fed at least two distinct flows, at least one of which is a suspension of cellulose fibers and the other can be a suspension of fibers different from those of the first flow, or a flow containing one or more chemical agents. In some cases, more suspensions of different fibers are mixed

with each other and with a flow of water containing one or more chemical agents.

[0030] The section 15 for mixing the aqueous slurry of cellulose fibers comprises, as main elements, a mixer and a machine tank or accumulation tank, described below in greater detail.

[0031] The reference numeral 17 indicates a dilution section, wherein the water coming from the zone of formation of the cellulose web in the paper machine 2 (the so-called "raw waters" of the plant), is mixed with the mixture coming from the section 15 for mixing the aqueous slurry of cellulose fibers, to obtain an aqueous suspension of cellulose fibers with the desired solid content, which is fed to the headbox 3.

[0032] In the illustrated embodiment, the section dilution 17 includes a de-aerator or air eliminator, a settling channel and a dilution tube, which will be described in greater detail below.

[0033] In the scheme of Fig 1, the reference numeral 19 indicates a pump for feeding the slurry from the machine or accumulation tank of the section 15 for mixing the aqueous slurry of cellulose fibers to section dilution 17. The reference numeral 21 indicates the connection line between the sections 15 and 17. From the dilution section 17 the aqueous suspension is pumped through a centrifugal pump (fan pump) 99 along a line 23 and through a strainer 25. From the latter, the suspension is supplied to the headbox 3 of the paper machine 2.

[0034] In the embodiment schematically shown in Fig. 1, the plant 1 comprises also a tank 27 which collects the overflow water from the settling channel of the dilution section 1, the scraps of the strainer 25 and the water drained from the felt 7 of the paper machine 2. Through a pump 29, the water containing fibers and impurities is fed to a clarifier (not shown in the drawings).

[0035] Figures 2 to 5 show in greater detail the main components of the section 15 for mixing the aqueous slurry.

[0036] The reference numeral 51 indicates a mixer in which are conveyed at least two flows, at least one of which contains cellulose fibers and the other contains cellulose fibers of a different type, or one or more chemical agents. In some cases, the mixer 51 receives more than two flows. In the illustrated example, the mixer 51 can be supplied with four streams of water containing fibers of varying length, from separate conduits and/or chemical agents. With 52, 53, 55 and 57 are indicated four different supply conduits. These conduits may be used for example to feed respectively: long fibers, short fibers, fibers coming from scraps produced by the paper machine 2 that produces the cellulose web or sheet and/or fibers recovered from the clarifier. Furthermore, one or more conduits can be used to possibly feed further chemical substances, such as dyes, wet-resistant resins or other. The number of ducts disclosed is intended solely as an example and is not limitative. In other configurations, the number of conduits may be greater or lesser than in the example illustrated here.

[0037] The structure of the mixer 51 is illustrated in greater detail in Figs 4 and 5. As shown in these figures, and in particular in the section of Fig.5, in this embodiment, the mixer 51 comprises a tubular body 61 which has two overlapping portions, indicated with 61A and 61B respectively. The upper portion 61A has a substantially cylindrical shape whose cross section is preferably circular. The lower portion 61B has a trunk-conical shape tapering downwards. In the lower zone, the tubular body 61 of the mixer 51 is joined to a connecting duct towards the machine tank 65 of the section 15 for mixing the aqueous slurry of cellulose fibers. The machine tank 65 is placed at a lower level compared to the output of the mixer 51.

[0038] The interior of the tubular body 61 is advantageously free of dynamic (eg. rotary) and static (i.e. consisting of diaphragms, walls or baffles fixed inside the tubular volume) agitators. Inside the cylindrical cavity defined by the upper portion 61A of the tubular body 61 of the mixer 51 there are the outputs of the connections 52A, 53A, 55A and 57A of the ducts 52, 53, 55, 57 that feed the fibers and/or chemical additives, with a substantially tangential orientation, as shown by the section of Fig.5. In this way the flow of water in which the suspended fibers and/or the flow of water containing chemical additives are forced to follow a swirling path inside the cylindrical portion 61A of the tubular body 61, as they fall down by gravity. In the frustoconical portion 61B the flow which is obtained by the mixing of the partial flows coming from the conduits 52, 53, 55 and 57 C is collected at the exit 61 of the tubular body 61.

[0039] The tubular body 61 is connected with the underlying machine or accumulation tank by means of a connecting duct 63. Inside the machine tank 65 there is an agitator 67 driven, for example, by an electric motor 69. Said agitator may have a vertical or horizontal rotation axis. According to the example shown in the drawings, said agitator has a vertical axis A-A and comprises a rotor that is indicated by the reference numeral 70 in Fig.2.

[0040] The connecting duct 63 has a curvilinear shape.

[0041] In the illustrated example the connecting duct comprises a first curve 63A, a second curve 63B and a third curve 63C. The first curve 63A connects a first substantially vertical connecting portion 63D of the duct 63 to a first substantially horizontal portion 63E. The curve 63B connects the first substantially horizontal portion 63D to a second substantially horizontal portion 63F, and the curve 63C connects the second substantially horizontal portion 63F to a second substantially vertical section 63G of the connecting duct 63. In other embodiments there may be provided a different number (higher or lower) of curves.

[0042] In this way the flow of aqueous slurry of cellulosic fibers is conveyed from the bottom of the tubular body 61 in the machine tank 65 where the slurry forms a stock that is kept in motion by the agitator 67 to prevent the settling of the fibers and possibly to allow the chemicals contained in the mixture to react.

[0043] The mixer 51 together with its discharge duct 63 allows the formation of a homogeneous mixture of different cellulose fibers and any chemical additives combining and mixing multiple flows from various areas of the slurry preparation, without the need of a double tank as normally required in conventional plants (see Fig.15). The internal volume of the mixer 51 is substantially less than the internal volume of the tanks normally used for this purpose.

[0044] The machine tank 65, placed under the mixer 51 and in fluid connection with it through the connecting duct 63, can present a smaller volume compared to the volume of the machine tanks normally used in conventional plants. Since the mixer 51 is located in a position above the machine tank 65, there is no need of pumping organ between the mixer 51 and the machine tank 65 contrary to what happens in conventional plants (Fig. 15).

[0045] Maintaining a machine tank, although of smaller sizes, and eliminating the mixing tank (211 in Fig.15) of the traditional plant, it is obtained a substantial reduction of the total volume of slurry present in the system, while retaining the advantage of an attenuation of consistency variations and pressure pulsations in the headbox and the advantage of maintaining the retention time the slurry apt to allow the chemicals to react.

[0046] Compared to the traditional configuration (Fig. 15), with the configuration of Fig. 1 is obtained a reduction in both the total volume of slurry, and then of fibers and water present in the plant, and of the electric power absorbed by the plant.

[0047] To quantify the benefits in terms of reducing the power consumption and the volumes involved, consider for example a plant of 100 tons per day of cellulose material tissue. In a traditional system the stirrer present in mixing tank can absorb eg. around 15-20 kW of power and the lifting pump that lifts the slurry from the mixing tank to the machine tank absorbs eg. about 5-7 kW. Both these elements are omitted in the system described here with consequent considerable energy saving.

[0048] The mixing tank used in a traditional plant of 100 tons per day of tissue paper may for example have a volume variable from 30 to 60 m³. Conversely, the internal volume of the mixer 51 can be of the order of 0.2 -0.5 m³ and therefore much smaller than the volume of the traditional mixing tank. Consequently, there is a considerable saving in terms of volume slurry present in the plant.

[0049] Moreover, the absence in the mixer 51 of static and dynamic agitators allows not only an energy saving, but also a considerable ease of cleaning and requires no maintenance.

[0050] Again with reference to a plant of 100 tons per day of tissue production, the machine tank 65 can have a volume comprised, for example between 6 and 20 m³, substantially smaller than the volume of the machine tank of a traditional plant, that in equal daily production can be exemplified in the order of 30-40 m³.

[0051] From this reduction of the volume of the ma-

chine tank is obtained a further reduction of the amount of slurry in the plant. The smaller volume of the machine tank 65 compared to conventional plants also leads to a reduction of about 20-30% of the power absorbed by the agitator 67 with respect to the power absorbed by the agitator in an equivalent machine tank of traditional plants.

[0052] Ultimately, the system described here allows a substantial economy in terms of the volume of slurry, and in terms of power consumption in the slurry mixing section.

[0053] The Figs 6 to 9 show the main components of the section 17 of dilution of the slurry with the raw waters, that is the slurry coming from the mixing section 15, fed by pump 19 along line 21, and the recirculation flow of the headbox with water coming from the paper machine 2.

[0054] In the embodiment of Figs. 6 to 9 the dilution section 17 is configured to supply a double layer headbox 3. In the following figures is illustrated, and will be described below, a configuration for the supply of the aqueous suspension of cellulose fibers to a single-layer headbox.

[0055] The raw waters coming from the area of formation of the cellulose web, extracted through the forming wire 5, are conveyed towards the dilution section 17 via a conduit 83 (see also Fig.1) that enters the water in an air eliminator or de-aerator 85. In some embodiments, the air eliminator can be omitted, although it is particularly advantageous in plants capable of higher performances.

[0056] The de-aerator reduces the amount of air contained in the raw waters coming from the zone of formation of the cellulose web or sheet.

[0057] In the illustrated embodiment, see in particular Figs. 13 and 14, the air eliminator 85 comprises an outer body delimited by a substantially cylindrical wall 85A, which surrounds a cavity, inside which is placed a pervious cylindrical wall 85B, provided with slotted openings 87, only some of which are illustrated by way of example in Fig. 14.

[0058] The water coming from the zone of formation of the cellulose web enters through the conduit 83 into the volume defined by the substantially cylindrical pervious wall 85B with a substantially tangential flow. The water, having a greater density, tends by effect of the centrifugal force to exit the interior volume defined by the wall pervious 85B through the openings 87 and is collected in the annular volume formed between the outer wall 85A and the pervious inner wall 85B. The air entrained by the water tends to separate from the water and exits through a vent conduit 89.

[0059] The water that collects in the annular volume between the walls 85A and 85B flows in a settling channel generally designated by 91. This settling channel 91 may have a rectangular section of limited height compared to its width. In it, it is established a slow flow of the raw waters. Along the development of the settling channel 91 there is a further separation of the air carried by the water,

before the water is discharged in two exhaust pipes 93A, 93B arranged in a substantially symmetrical way and protruding from the settling channel 91 downwards, to feed water to two centrifugal pumps (fan pumps).

[0060] The two pipes 93A, 93B each have preferably a vertical falling portion, an intermediate curve and a substantially horizontal portion, at the end of which is placed a respective connection 95A, 95B that is substantially frusto-conical, or anyway tapered, to gradually reduce the cross section of flow and convey the flow of water coming from the settling 91 to the respective centrifugal pumps 99A, 99B (fan pumps) driven in rotation by respective motors 101 A and 101 B. The pumps 99A, 99B push the flow through the strainer 25 (see Fig.1). When, as in the example illustrated in Figs. 6 and 7 there are two pumps 99A, 99B, there are also two pipes 23 (23A, 23B) and two strainers 25 (25A and 25B).

[0061] In the plan view of Fig. 9 the motors, the centrifugal pumps and the supply pipes 23 (23A, 23B), have been omitted for simplicity of representation.

[0062] In general the flow of water that from the settling channel 91 is conveyed downwards along the pipes 93A and 93B is mostly free of solid suspensions, since the fibers present in the suspension from which the flow of water comes have been largely retained by the forming wire 5 of the paper machine 2.

[0063] Before being conveyed to the respective pump 99A or 99B, the water coming from the settling channel 91 is added with the slurry coming from the said mixing section. This mixture is fed through ducts that are indicated overall by 21 in Fig 1 and that in the case of a double layer headbox configuration splits into two ducts 21A, 21B, each associated with the respective pipe 93A, 93B. Fig.8 shows a section along the midline of the terminal portion of one of the ducts 93A, 93B in the junction zone of the respective duct 21A or 21B that feeds the cellulose slurry.

[0064] In the illustrated embodiment, each tube 93A, 93B is also connected with a further duct 22A, 22B which feeds a flow of recirculated water directly from the headbox 3. In Fig.1 this connection is indicated schematically as a single conduit 22 between the headbox 3 and the dilution section 17.

[0065] In other embodiments provision may be made for a so-called constant level tank, as shown in Fig 15. Such a constant level tank has been omitted in Fig 1, but could be provided as a component interposed between the mixing section 15 and dilution section 17.

[0066] In the illustrated embodiment, each conduit 21A, 21B, 22A, 22B is grafted to the tube 93A, 93B without extending inside. The mixing between the flow of raw waters descendants along the tube 93A, 93B and the aqueous slurry of cellulosic fibers fed through the duct 21A, 21B, 22A, 22B occurs due to the difference in speed between the two flows, without the aid of static mixing elements, so that in the centrifugal pump 99A, 99B and in the delivery duct 23 (23A, 23B) is injected a substantially homogeneous flow forming the aqueous suspen-

sion of cellulose fibers to be fed to the headbox. The suspension may comprise a mixture of long and short fibers prepared from the mixer 51, with the possible presence of chemical additives added along the path followed by the slurry, and preferably in the mixer 51, as described above.

[0067] Figs. 10 to 12 show the dilution section 17 in a configuration designed to supply a plant with a single-layer headbox. Equal numbers indicate parts identical or equivalent to those already described with reference to the embodiment of Figs 7, 8 and 9. The difference between the two configurations lies in that in the second embodiment the dilution section 17 provides for a single descending tube 93 which is connected to the settling channel 91 for conveying the flow of raw waters to a centrifugal pump 99 (not shown in Figs. 10 to 12 for simplicity of representation) through a joint 95. The reference number 83 is still used to designate the pipe which feeds the raw waters from the area of formation of the paper to a possible air eliminator 85 connected to a vent 89 for the evacuation of air entrained by the raw waters coming from the forming wire. The air eliminator can be realized as disclosed with reference to Fig.14.

[0068] The section in Fig.13 shows the shape of the settling channel 91 the height of which is indicated with H and the width constituting the water passageway is indicated with L. 91A denotes an anti-foam plate, which retains the foam that forms on the free surface of the water discharged from the air eliminator 85, to prevent its entry into the settling channel 91, and make sure that within the tube 93 is supplied water as much as possible free of air bubbles and foam.

[0069] In this embodiment (see in particular Fig.12) the settling channel 91 has a curvilinear shape in plan, to increase the length of the path followed by the water between the first air eliminator 85 and the connection with the pipe 93 below. Along this path, the air that has not been separated from the water into the air eliminator 85 goes back on the water surface due to the air/water difference in density. The embodiments described above and illustrated in the drawings have been discussed in detail as examples of implementation of the invention. The skilled in the art will appreciate that many modifications, variations, additions, and omissions are possible without departing from the principles, the concepts and teachings of the present invention as defined in the appended claims. Therefore, the scope of the invention should be determined solely on the basis of the broadest interpretation of the appended claims, comprising in it such modifications, variations, additions, and omissions. The terms "include" and its derivatives do not exclude the presence of other elements or steps than those explicitly specified in a given claim. The terms "a" or "an" preceding an element, means or characteristic of a claim does not exclude the presence of a plurality of such elements, means or features. When a claim of device lists a number of "means", some or all of these "means" can be implemented by a single component, element or struc-

ture. The enunciation of certain elements, characteristics or means in $\neg$ dependent claims does not exclude the distinct possibility of combining together said elements, characteristics, or means. When a method claim lists a sequence of steps, the sequence in which these steps are listed is not binding, and can be changed, if the particular sequence is not indicated as binding. The presence of any reference numbers in the attached claims has the purpose of facilitating the reading of the claims with reference to the description and the drawings, and do not limit the scope of protection represented by the claims.

15 Claims

1. A system for producing a cellulose web or sheet from an aqueous suspension of cellulose fibers, comprising: a paper machine comprising at least one headbox and one forming wire; a mixing section for a slurry of cellulose fibers; a dilution section, wherein the slurry of cellulose fibers, coming from said mixing section, is diluted with water coming from the paper machine, to form the aqueous suspension of cellulose fibers; a fluid connection from the dilution section to the paper machine; **characterized in that:** the mixing section for the slurry of cellulose fibers comprises a mixer with a vertically extending tubular body, into which at least two feed pipes of flows of water and fibers and/or water and chemical additives lead tangentially, the flows introduced by said at least two feed pipes being mixed with each other in said tubular body; said tubular body is in fluid connection with a machine tank below, equipped with a mechanical mixer; and said machine tank is in fluid connection with said dilution section.

2. The system according to claim 1, **characterized in that** between said machine tank and said dilution section no further intermediate tanks are present.

3. The system according to claim 1 or 2, **characterized in that** the mixer is connected to the machine tank below through a curved connection pipe.

4. The system according to claim 3, **characterized in that** the connection pipe between the mixer and the machine tank has a multiple curvature.

6. The system according to claim 4, **characterized in that** said connection pipe has: a first vertical length in fluid connection with an outlet of the vertical body of the mixer, a second substantially horizontal length, a third substantially vertical length, in fluid connection with an inlet of the machine tank; and **in that** a first curvature is arranged between the first length and the second length and a second curvature is arranged between the second length and the third

length.

7. The system according to claim 5, **characterized in that** no static and dynamic agitators are provided inside said mixer.

8. The system according to one or more of the preceding claims, **characterized in that** said tubular body of the mixer comprises a cylindrical cavity with substantially circular section and substantially vertical axis, into which said pipes for introducing flows of water, fibers and/or chemical products lead tangentially.

9. The system according to claim 7, **characterized in that** the bottom of said cylindrical cavity is connected a truncated-cone shaped cavity, with a cross section decreasing downwardly and defining at the bottom an outlet toward the machine tank below.

10. The system according to one or more of the preceding claims, **characterized in that** one or more pipes for introducing flows of water and fibers and optionally one or more pipes for introducing chemical additives lead into said tubular body of the mixer.

11. The system according to one or more of the preceding claims, **characterized in that** said dilution section comprises a settling channel for the water coming from the paper machine.

12. The system according to claim 10, **characterized by** a de-foaming plate in an initial zone of the settling channel.

13. The system according to one or more of the preceding claims, **characterized in that:** said dilution section comprises at least one tube, extending from above downward, with an inlet and an outlet, said outlet being in fluid connection with a pump that feeds the aqueous suspension of cellulose fibers from the dilution section toward the headbox of the paper machine; and **in that** a feed pipe of the slurry of cellulose fibers coming from said mixing section is inserted between said inlet and said outlet.

14. The system according to claim 12, **characterized in that** a recirculation pipe from the headbox is inserted between the inlet and the outlet of the tube.

15. The system according to claim 12 or 13, **characterized in that** the tube is in fluid connection with the bottom of the settling channel and extends from the bottom of the settling channel downward.

16. The system according to one or more of the preceding claims, **characterized in that** the dilution section comprises a de-aerator.

16. The system according to claim 15, **characterized in that** said de-aerator comprises an external wall and an internal wall defining an intermediate volume therebetween; said internal wall being pervious and in fluid connection with an inlet substantially tangential water inlet and an air vent.

17. The systems according to claims 10 and 15, **characterized in that:** said de-aerator has an outlet positioned at a flow inlet into the water settling channel and at a greater height with respect to said settling channel.

18. The system according to claim 12, 13 or 14, **characterized in that** said tube comprises a first portion with a constant cross section and a second portion with a variable cross section decreasing in the direction of the flow inside the tube, said second portion being positioned downstream of the first portion with respect to the direction of flow in the tube.

19. The system according to claim 18, **characterized in that** the outlet of said feed pipe of the slurry of cellulose fibers is positioned upstream of the second portion of said tube, with respect to the direction of flow in the tube.

20. The system according to one or more of claims 12 to 19, **characterized in that** said tube has a substantially circular cross section.

21. The system according to one or more of claims 10 to 20, **characterized in that** no storage tank is provided between the settling channel and said pump.

22. The system according to one or more of claims 10 to 21, **characterized in that** said dilution section comprises at least a second tube extending from above downward, with an inlet and an outlet, said outlet being in fluid connection with a second pump that feeds the aqueous suspension of cellulose fibers from the dilution section toward the headbox of the paper machine; and that a second feed pipe of the slurry of cellulose fibers coming from said mixing section and the recirculation pipe of the headbox is inserted between said inlet and said outlet of the second tube.

Amended claims in accordance with Rule 137(2) EPC.

1. A system for producing a cellulose web or sheet from an aqueous suspension of cellulose fibers, comprising: a paper machine comprising at least one headbox and one forming wire; a mixing section for a slurry of cellulose fibers; a dilution section, wherein

the slurry of cellulose fibers, coming from said mixing section, is diluted with water coming from the paper machine, to form the aqueous suspension of cellulose fibers; a fluid connection from the dilution section to the paper machine; **characterized in that:** the mixing section for the slurry of cellulose fibers comprises a mixer with a vertically extending tubular body, into which at least two feed pipes of flows of water and fibers and/or water and chemical additives lead tangentially, the flows introduced by said at least two feed pipes being mixed with each other in said tubular body; said tubular body is in fluid connection with a machine tank below, equipped with a mechanical mixer; and said machine tank is in fluid connection with said dilution section.

2. The system according to claim 1, **characterized in that** between said machine tank and said dilution section no further intermediate tanks are present.

3. The system according to claim 1 or 2, **characterized in that** the mixer is connected to the machine tank below through a curved connection pipe.

4. The system according to claim 3, **characterized in that** the connection pipe between the mixer and the machine tank has a multiple curvature.

5. The system according to claim 4, **characterized in that** said connection pipe has: a first vertical length in fluid connection with an outlet of the vertical body of the mixer, a second substantially horizontal length, a third substantially vertical length, in fluid connection with an inlet of the machine tank; and **in that** a first curvature is arranged between the first length and the second length and a second curvature is arranged between the second length and the third length.

6. The system according to claim 5, **characterized in that** no static and dynamic agitators are provided inside said mixer.

7. The system according to one or more of the preceding claims, **characterized in that** said tubular body of the mixer comprises a cylindrical cavity with substantially circular section and substantially vertical axis, into which said pipes for introducing flows of water, fibers and/or chemical products lead tangentially.

8. The system according to claim 7, **characterized in that** the bottom of said cylindrical cavity is connected a truncated-cone shaped cavity, with a cross section decreasing downwardly and defining at the bottom an outlet toward the machine tank below.

9. The system according to one or more of the pre-

ceding claims, **characterized in that** one or more pipes for introducing flows of water and fibers and optionally one or more pipes for introducing chemical additives lead into said tubular body of the mixer.

10. The system according to one or more of the preceding claims, **characterized in that** said dilution section comprises a settling channel for the water coming from the paper machine.

11. The system according to claim 10, **characterized by** a de-foaming plate in an initial zone of the settling channel.

12. The system according to one or more of the preceding claims, **characterized in that:** said dilution section comprises at least one tube, extending from above downward, with an inlet and an outlet, said outlet being in fluid connection with a pump that feeds the aqueous suspension of cellulose fibers from the dilution section toward the headbox of the paper machine; and **in that** a feed pipe of the slurry of cellulose fibers coming from said mixing section is inserted between said inlet and said outlet.

13. The system according to claim 12, **characterized in that** a recirculation pipe from the headbox is inserted between the inlet and the outlet of the tube.

14. The system according to claim 12 or 13, **characterized in that** the tube is in fluid connection with the bottom of the settling channel and extends from the bottom of the settling channel downward.

15. The system according to one or more of the preceding claims, **characterized in that** the dilution section comprises a de-aerator.

16. The system according to claim 15, **characterized in that** said de-aerator comprises an external wall and an internal wall defining an intermediate volume therebetween; said internal wall being pervious and in fluid connection with an inlet substantially tangential water inlet and an air vent.

17. The systems according to claims 10 and 15, **characterized in that:** said de-aerator has an outlet positioned at a flow inlet into the water settling channel and at a greater height with respect to said settling channel.

18. The system according to claim 12, 13 or 14, **characterized in that** said tube comprises a first portion with a constant cross section and a second portion with a variable cross section decreasing in the direction of the flow inside the tube, said second portion being positioned downstream of the first portion with respect to the direction of flow in the tube.

19. The system according to claim 18, **characterized in that** the outlet of said feed pipe of the slurry of cellulose fibers is positioned upstream of the second portion of said tube, with respect to the direction of flow in the tube.

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20. The system according to one or more of claims 12 to 19, **characterized in that** said tube has a substantially circular cross section.

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21. The system according to one or more of claims 10 to 20, **characterized in that** no storage tank is provided between the settling channel and said pump.

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22. The system according to one or more of claims 10 to 21, **characterized in that** said dilution section comprises at least a second tube extending from above downward, with an inlet and an outlet, said outlet being in fluid connection with a second pump that feeds the aqueous suspension of cellulose fibers from the dilution section toward the headbox of the paper machine; and that a second feed pipe of the slurry of cellulose fibers coming from said mixing section and the recirculation pipe of the headbox is inserted between said inlet and said outlet of the second tube.

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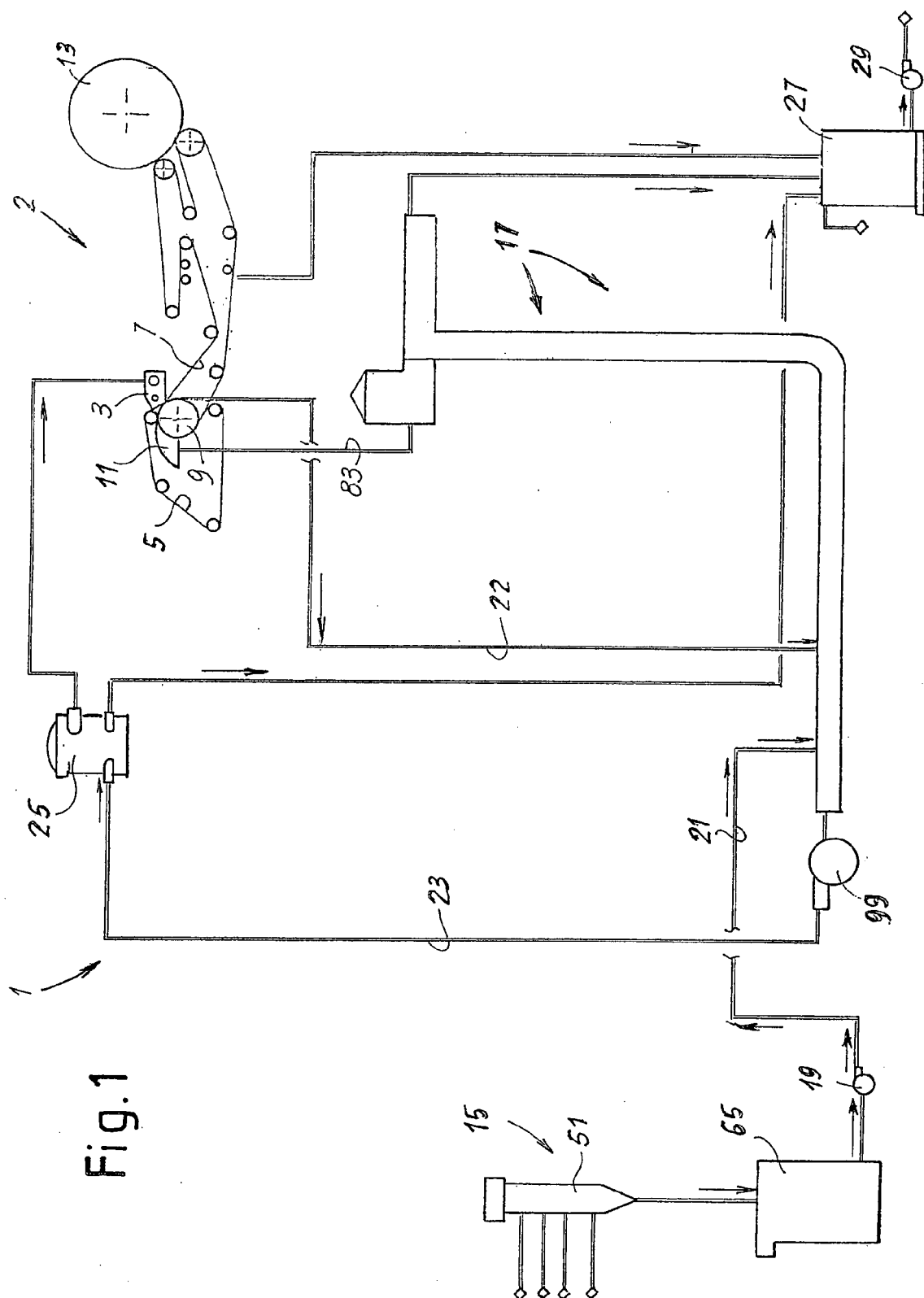


Fig. 1

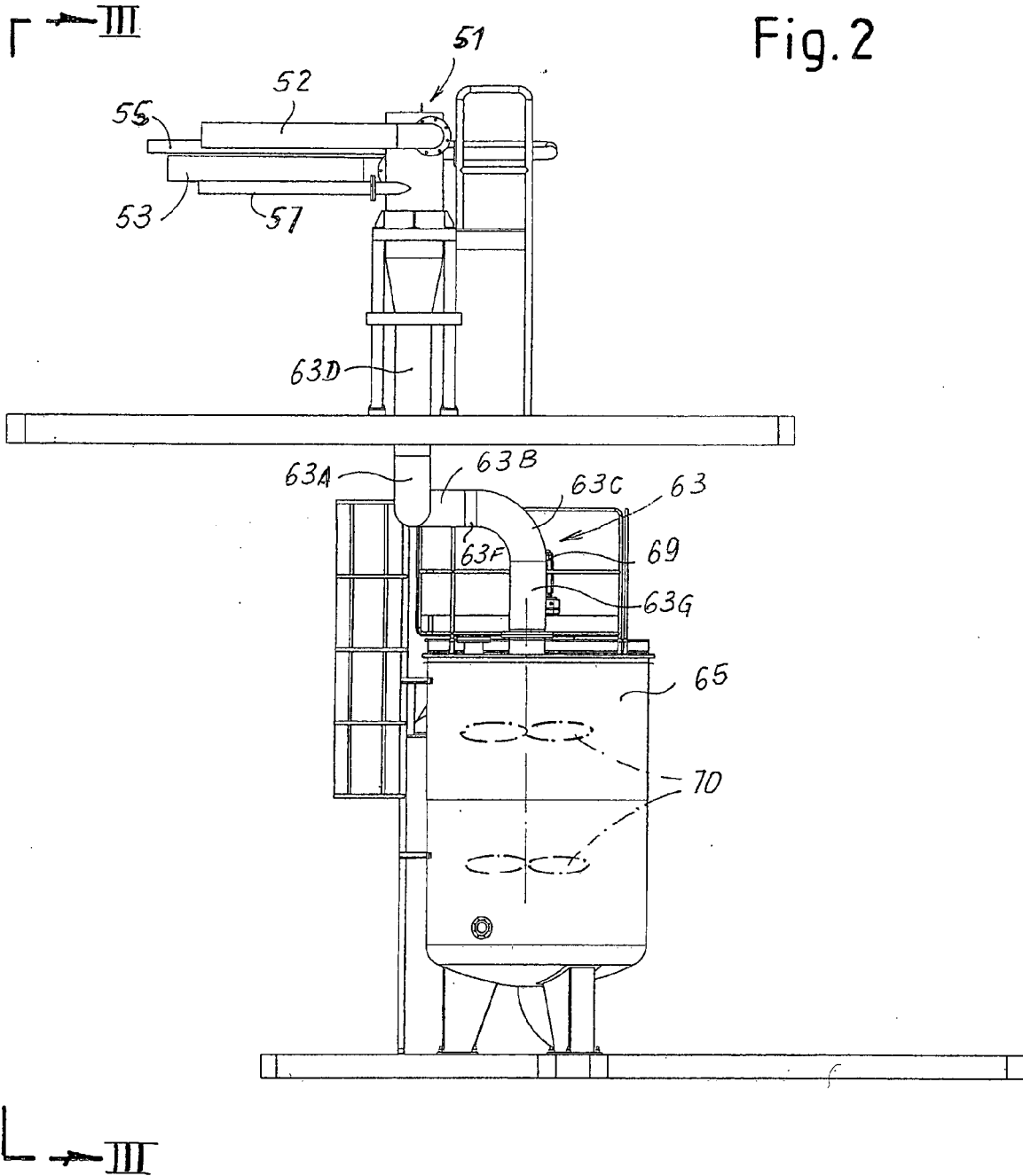


Fig.3

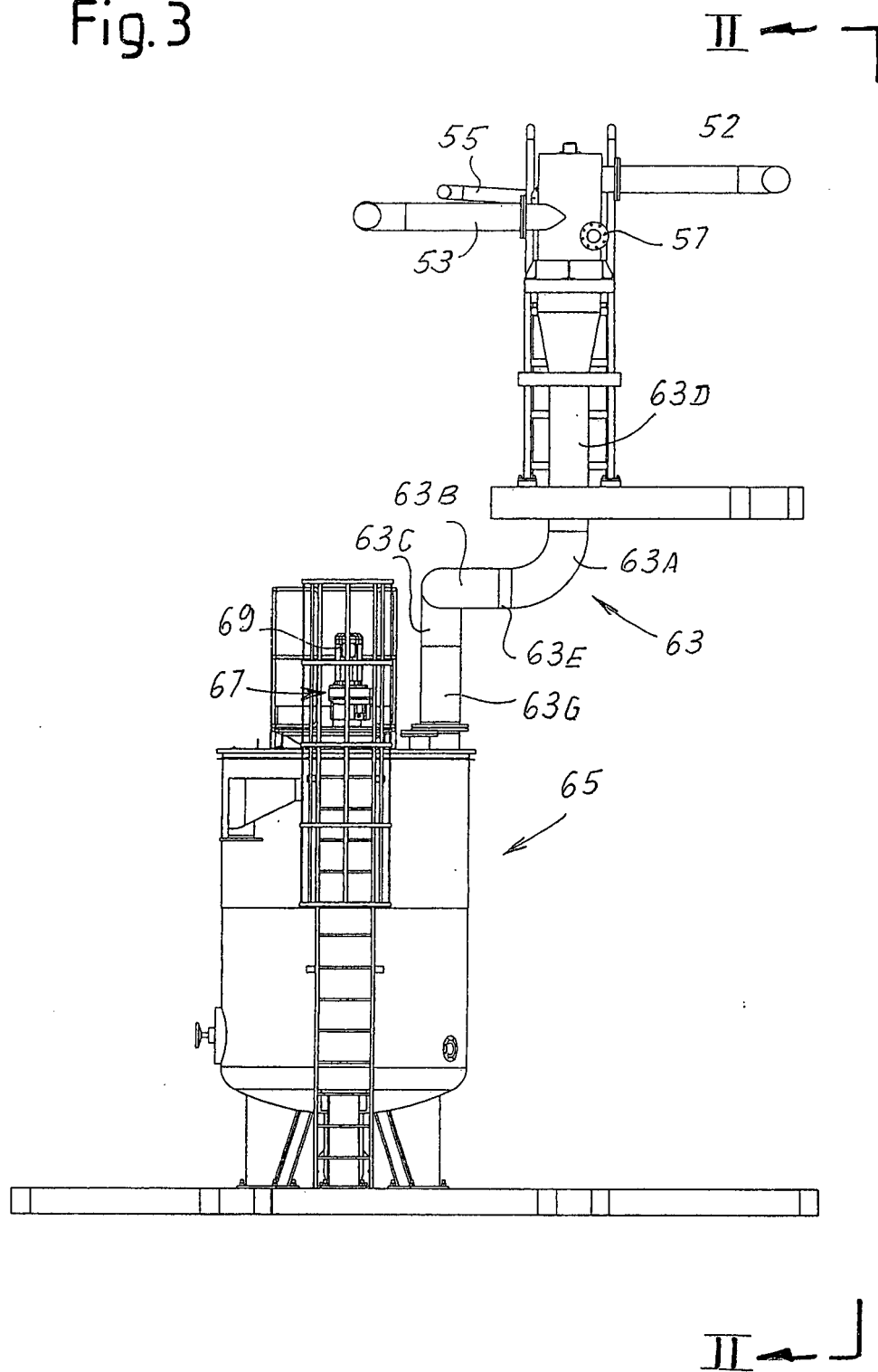


Fig. 4

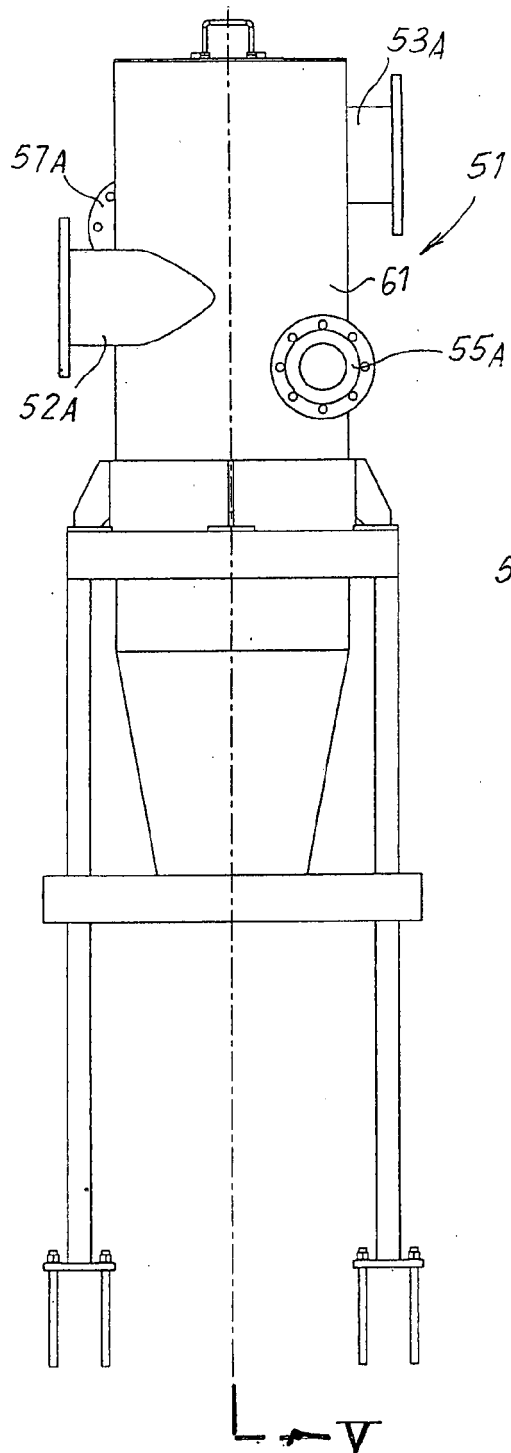


Fig. 5

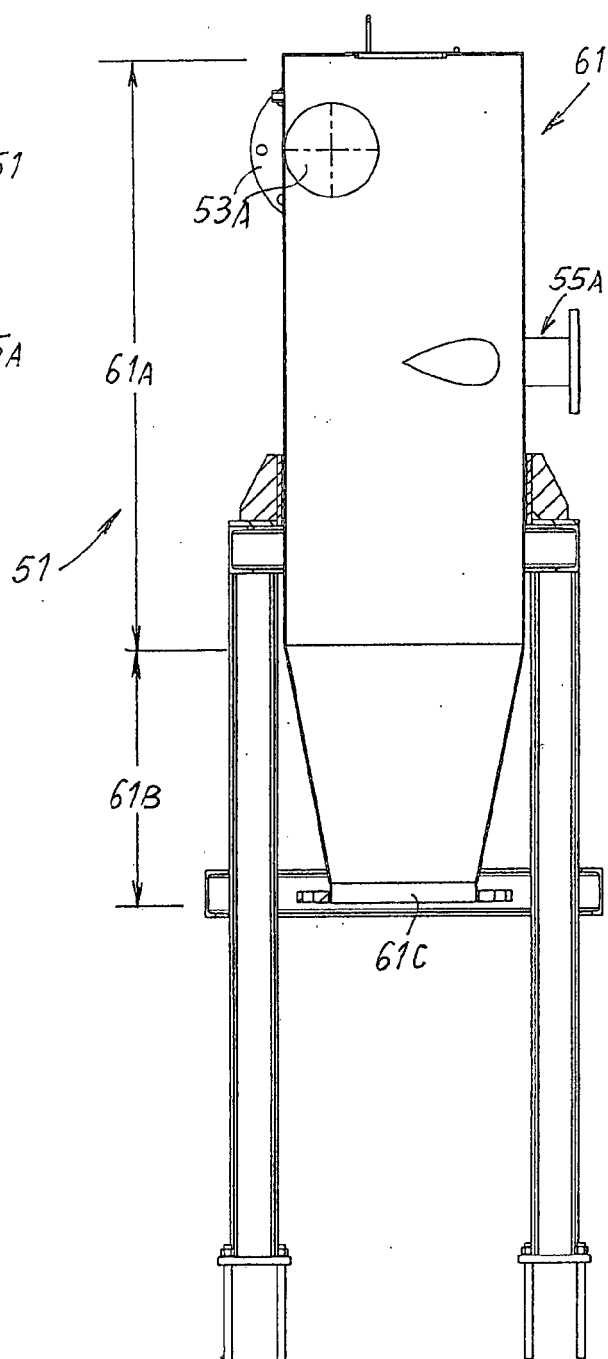
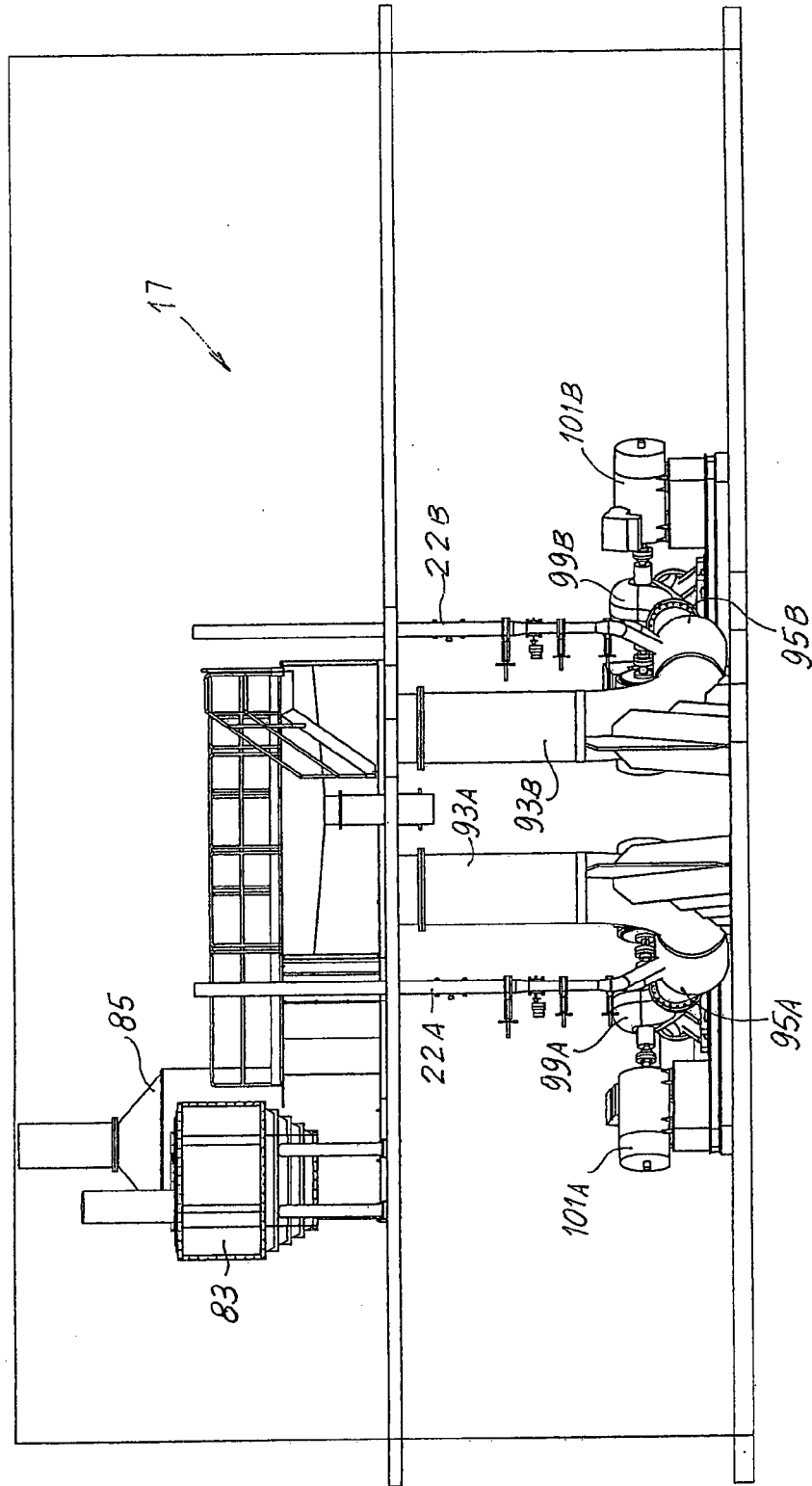
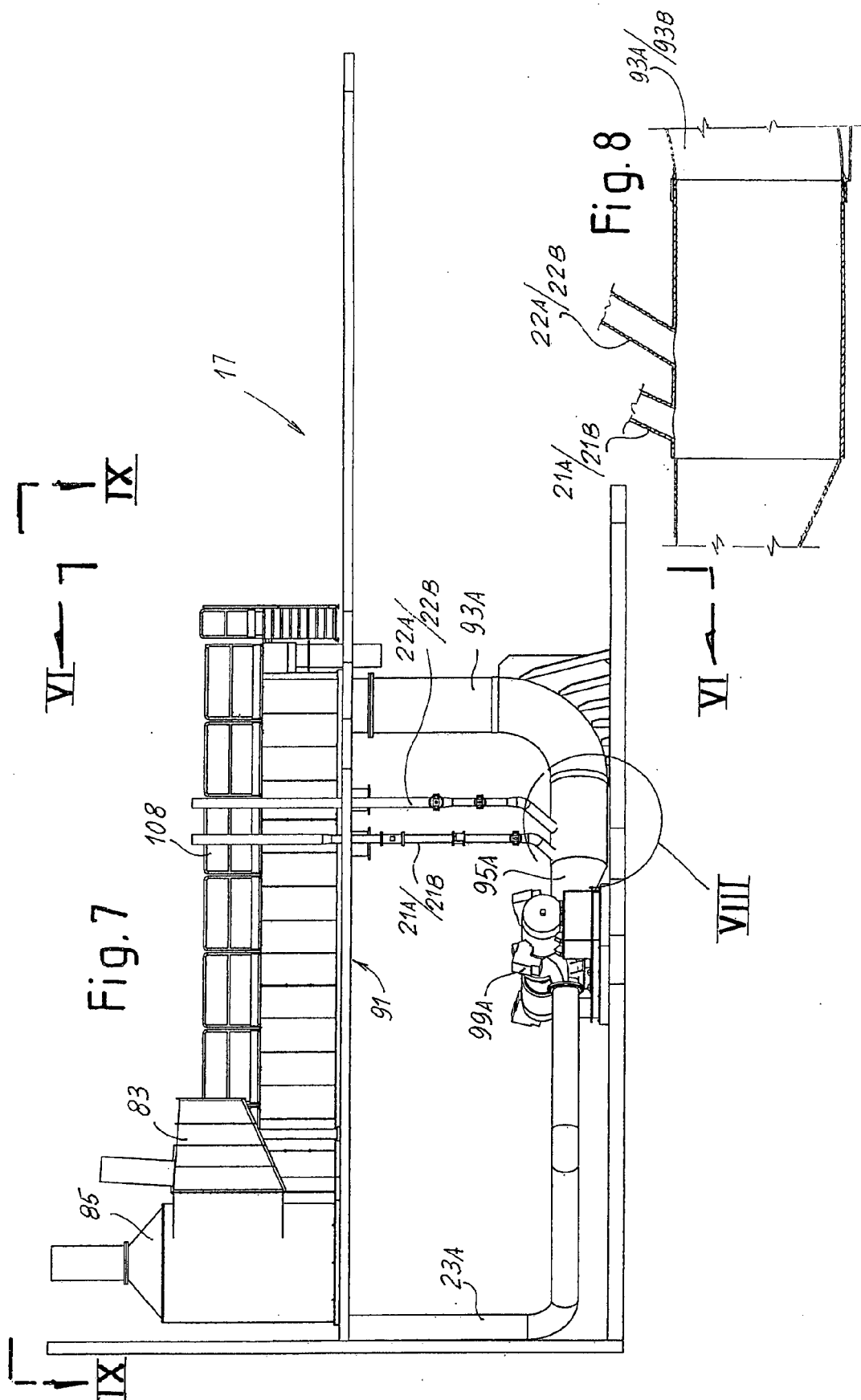


Fig.6

— VII



— VII



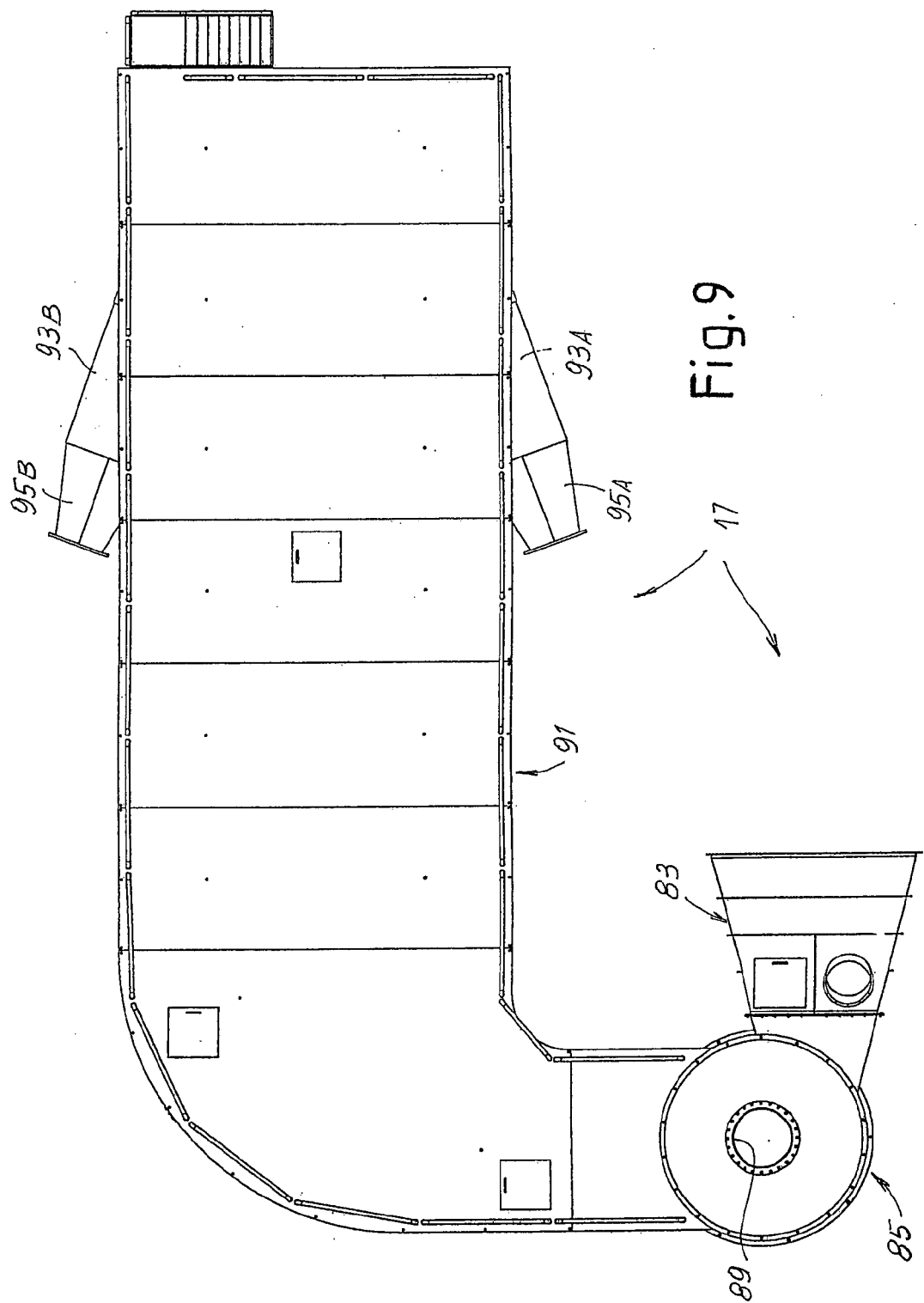


Fig.10

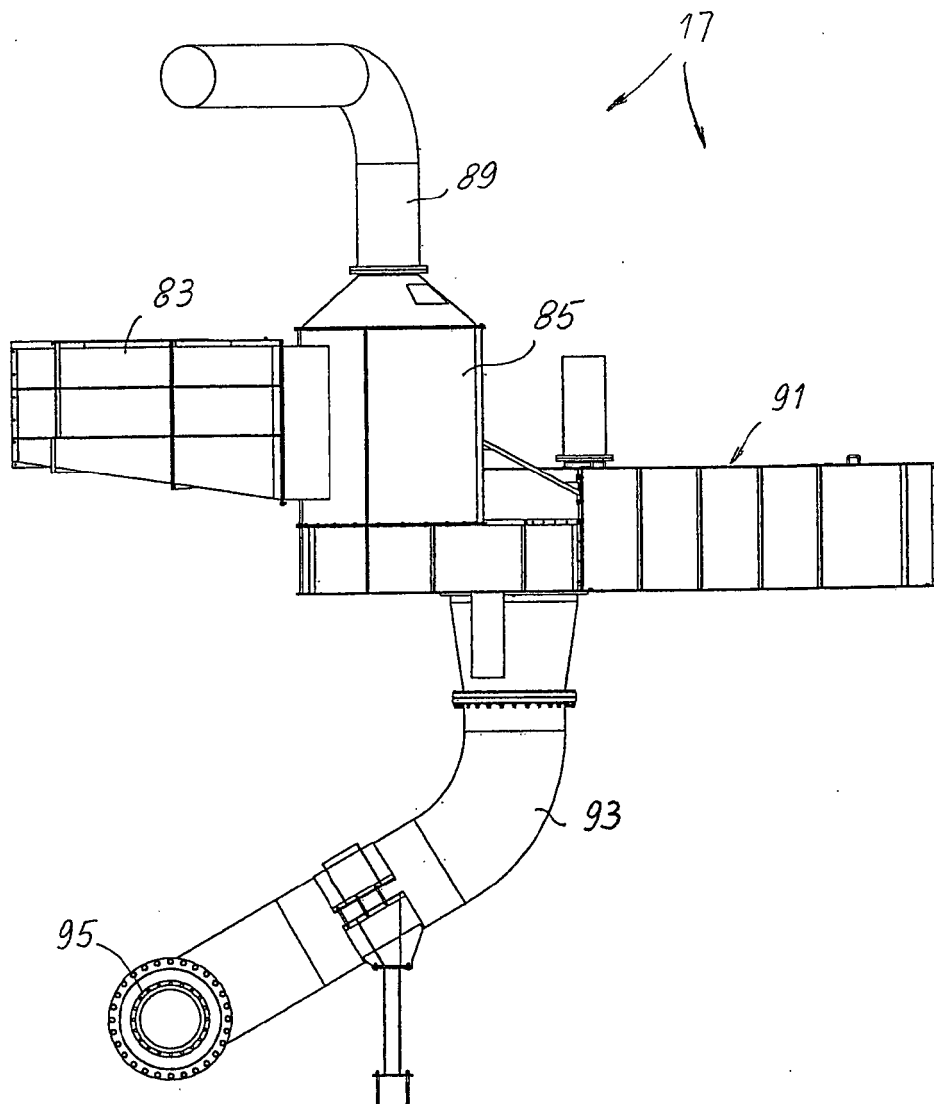


Fig. 11

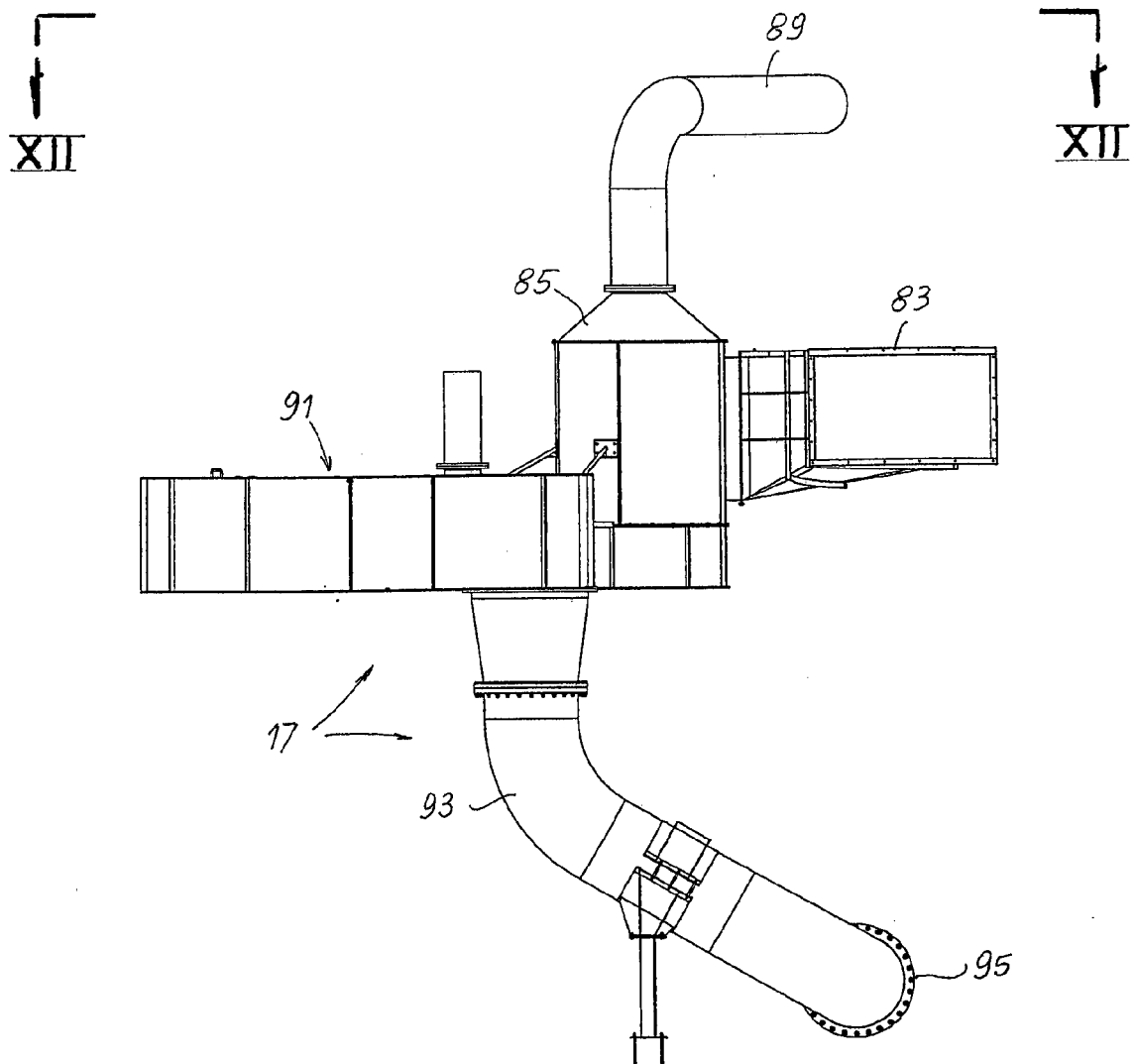


Fig. 12

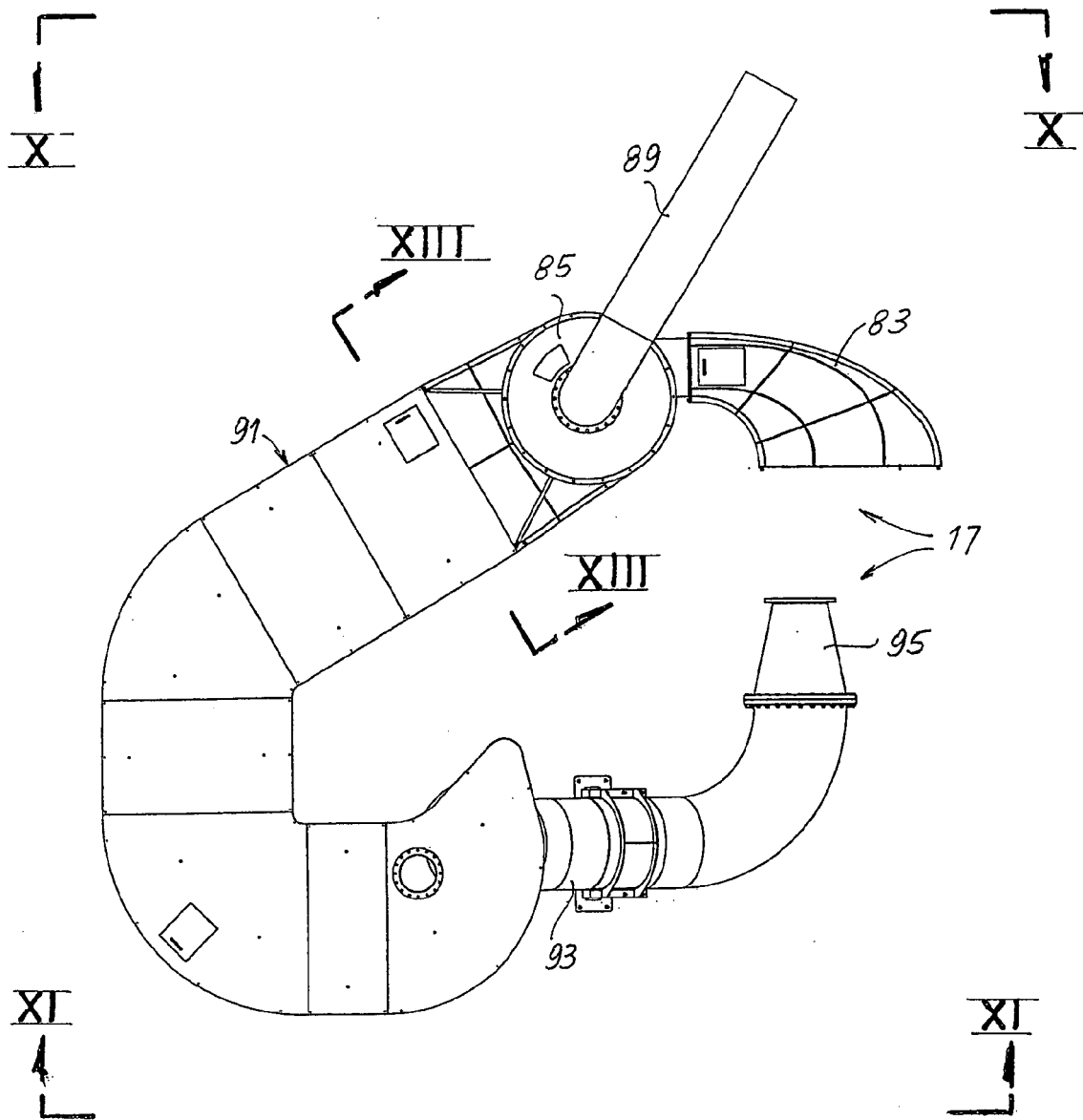


Fig.13

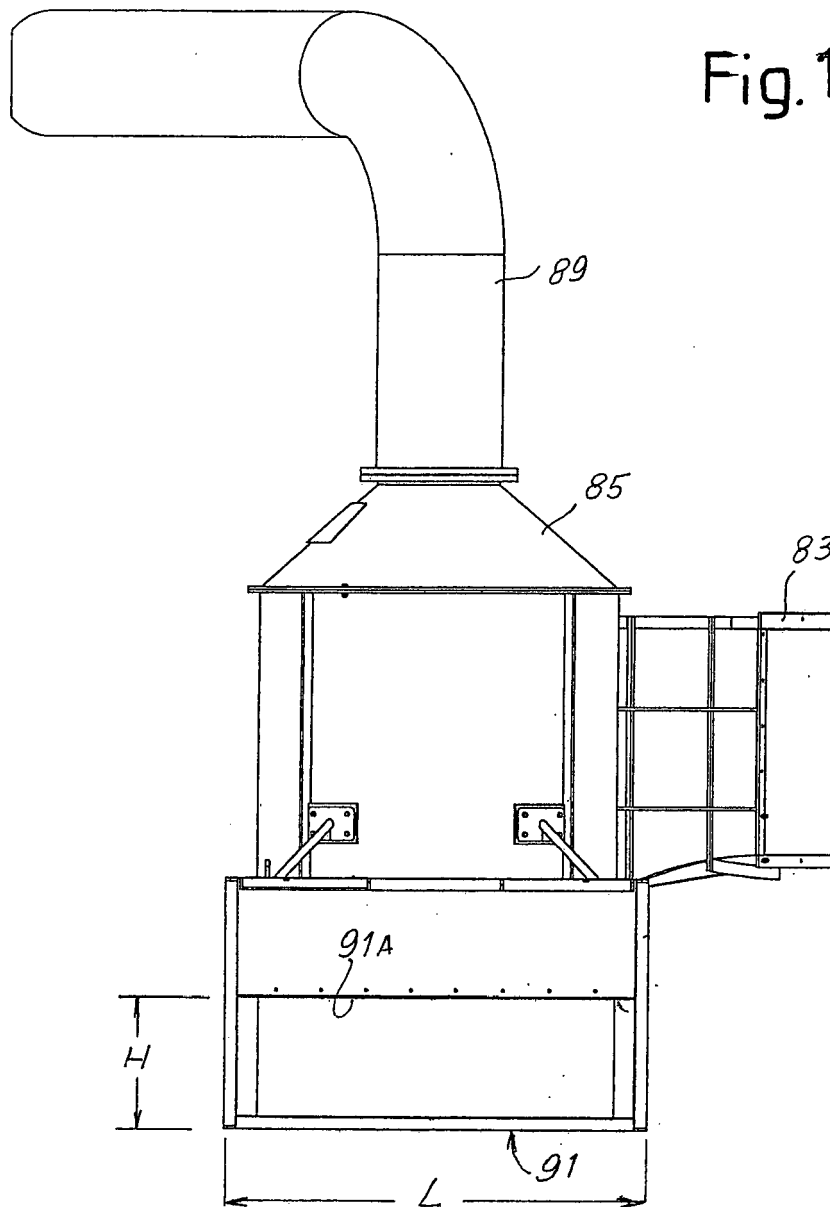
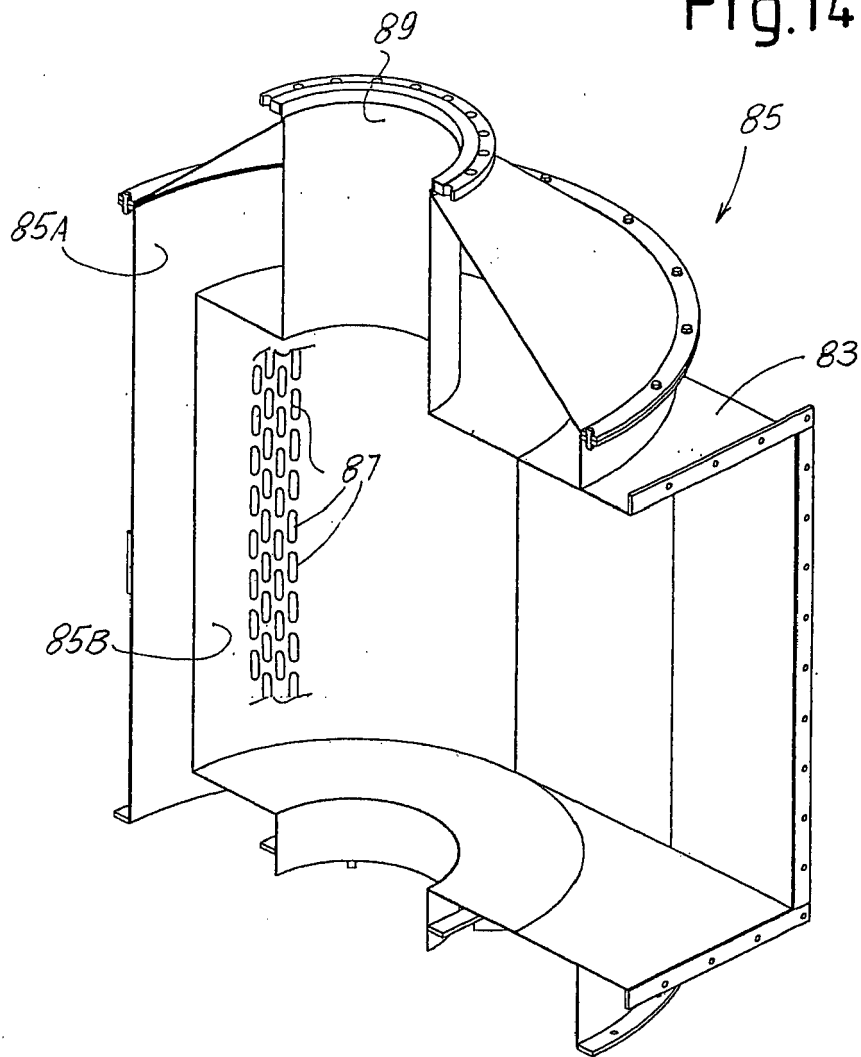


Fig.14



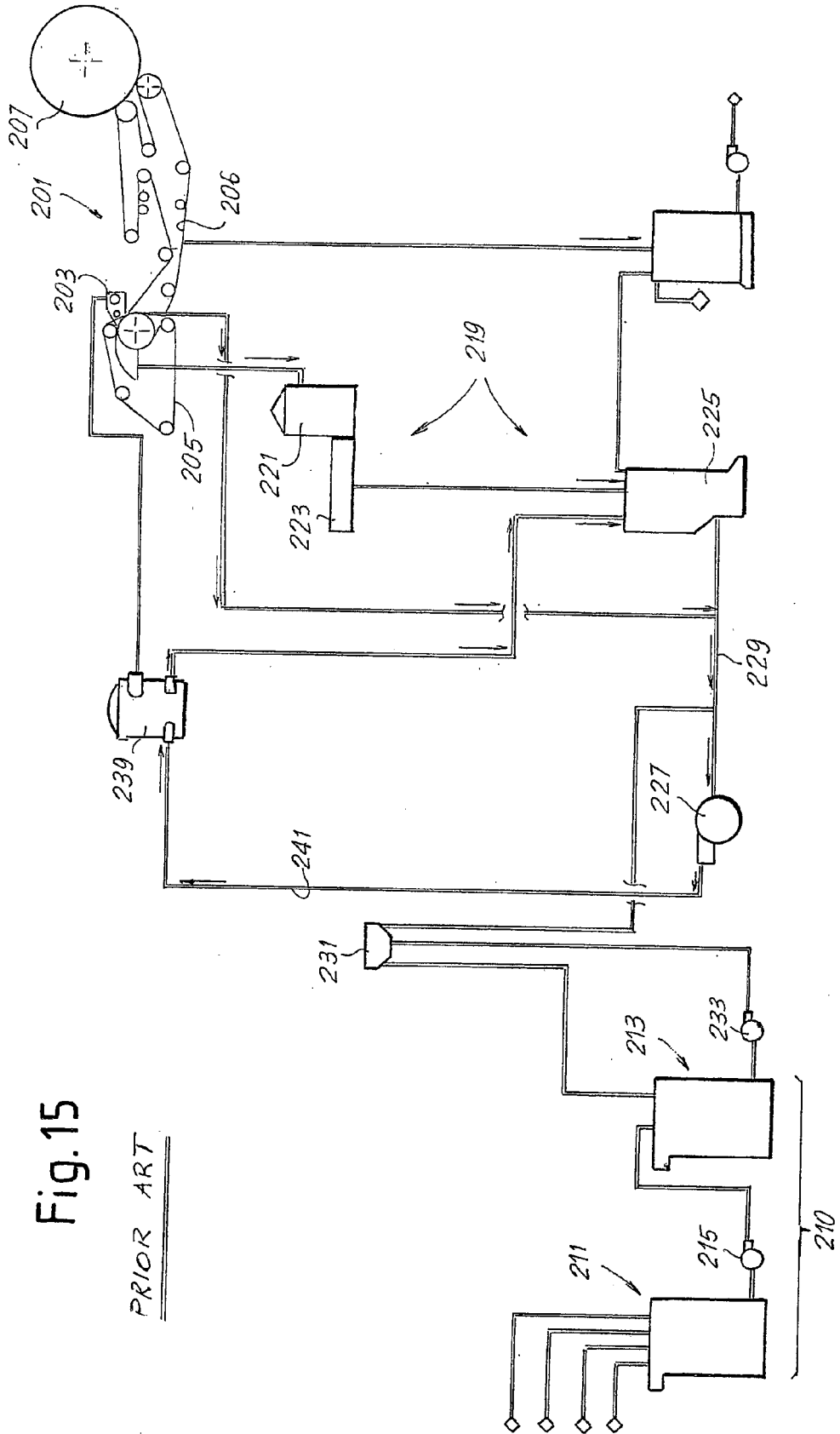


Fig.15

PRIOR ART



EUROPEAN SEARCH REPORT

Application Number
EP 13 00 3626

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A	DE 10 2006 008760 A1 (VOITH PATENT GMBH [DE]) 6 September 2007 (2007-09-06) * paragraph [0001] - paragraph [0003] * * paragraph [0010] - paragraph [0012] * * paragraph [0025] - paragraph [0030]; figure 1 *	1	
A	EP 1 884 592 A1 (VOITH PATENT GMBH [DE]) 6 February 2008 (2008-02-06) * paragraph [0009] - paragraph [0011]; figure 1 *	1	
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 9 October 2013	Examiner Sabatucci, Arianna
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 13 00 3626

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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