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(54) **MIXING SYSTEM FOR THE INTRODUCTION OF CHEMICAL SUBSTANCES IN A FLUID TO BE TREATED**

(57) The present invention concerns a mixing system (10) for the introduction of chemical substances in a fluid to be treated, comprising: a container (11) comprising an external wall (12), an internal wall (13), a bottom (14) and a cover (15); at least two concentric mixing chambers in communication with each other, a first central chamber (16) defined within the internal wall (13) and a second chamber (17) defined outside the internal wall (13); an inlet duct (19) for a fluid to be treated, configured for the introduction of the fluid in the first chamber (16); an outlet duct (20) for the treated fluid, configured for the outflow of the fluid from the second chamber (17) to the outside of the container (11); the inlet duct (19), the first chamber (16), the second chamber (17) and the outlet duct (20) defining a labyrinthine mixing path (30); stirring blades (18) positioned inside the first chamber (16); at least one injection passage (22) for the introduction of a chemical additive in one or more points of the labyrinthine mixing path (30).

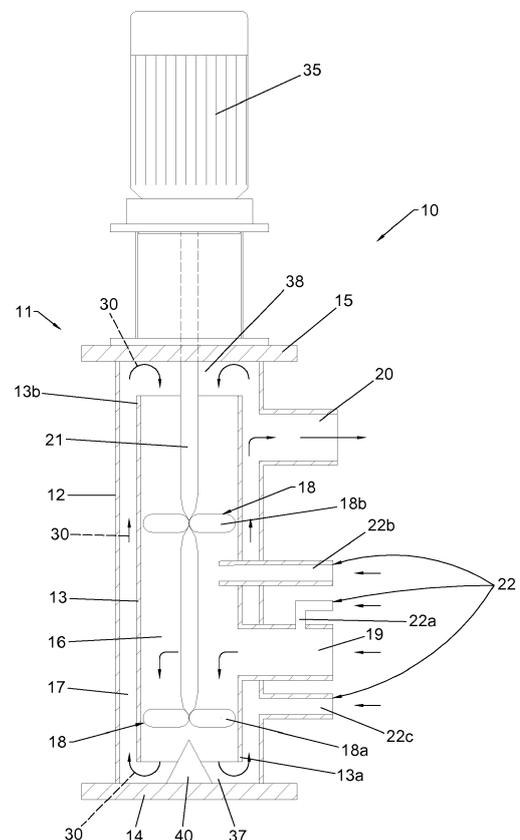


Fig.1

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## Description

**[0001]** The invention concerns a mixing system designed to introduce chemical substances in a fluid to be treated.

**[0002]** Nowadays clean water is considered a valuable resource which must be preserved and used only in the cases where its consumption is absolutely necessary.

**[0003]** For example, the paper industry has always used huge quantities of fresh water, meaning new water, in order to be able to obtain high quality products.

**[0004]** However, in the last few years environmental regulations and a greater environmental awareness at a global level have been increasingly leading people to reduce water consumption.

**[0005]** Today, for example, paper sludge is becoming increasingly important and is increasingly used for producing other paper, in the tile and cement industry, in environmental restoration projects, for covering dumps and in building mixes.

**[0006]** Some steps of a process for the treatment of the waste water of a paper mill include the use of a polyelectrolyte, for example a cationic flocculant powder, or even, for example, a cationic polyacrylamide, suited to be applied in the clariflocculation of water containing organic substances, in sludge thickening treatments, in sludge dehydration processes and also in other processes carried out in paper mills, such as froth flotation.

**[0007]** During these process steps it is necessary to maximize the yield of the polymer, that is, of the cationic flocculant, in order to improve the quality of the dry residue in the case of sludge or to improve froth flotation in the case of a froth flotation step.

**[0008]** In order to be activated, these polymers need premixing with water at a preestablished concentration.

**[0009]** Nowadays, said premixing step is carried out in static mixing tanks, in which the polymer is introduced after being taken from a small storage container; said polymers are normally diluted in solutions between 0.2% and 1%, therefore they are very demanding in terms of water usage.

**[0010]** In the static mixing tank mixing is obtained from the simple turbulence of water. Successively, a booster pump introduces the water with the polymer into a pipe leading to a tank or a channel for the treatment of waste sludge.

**[0011]** Thus, as already mentioned, these systems using a cationic flocculant, even if widely used and appreciated, require the use of considerable quantities of water and of specific mixing equipment, together with the corresponding ducts for preparation for use and for introduction in a sludge treatment line.

**[0012]** Another limitation of the sludge treatment systems currently known lies in that the polyelectrolytes are culture media for bacteria, therefore a polymer that remains in a storage tank for long is very likely to foster the proliferation of bacteria.

**[0013]** The patent document US5314076 describes a

system for mixing two fluid phases, more specifically for mixing a treatment fluid with a fluid to be treated; said system comprises two concentric chambers that communicate with each other at least with their ends, the central chamber being provided with two turbines whose rotation axis is equal to the axis of symmetry of the installation.

**[0014]** In this technical solution known in the art, the fluid to be treated flows in from the top, flows out from the bottom and the turbines are interposed between the inlet and the outlet.

**[0015]** The patent document US2012/0199524 describes a clarifier silo comprising a closed container with an internal mixer surrounded by a diffuser with a cylindrical tube.

**[0016]** The diffuser and the mixer define three internal chambers that are superimposed in vertical direction, an upper chamber, a central chamber and a lower chamber, as well as an external annular region. Each of the three internal chambers is in fluid communication with the annular region.

**[0017]** Even in this technical solution known in the art, the fluid to be treated flows in from the top, flows out from the bottom and the turbines are interposed between the inlet and the outlet.

**[0018]** Even in the mixer described in patent document US3392963, the fluid to be treated flows in from the top, flows out from the bottom and the turbines are interposed between the inlet and the outlet.

**[0019]** The patent documents US2577856 and US3737288, instead, describe mixing equipment in which the fluid to be treated flows in from the bottom and flows out from the top, and a propeller is interposed between the inlet and the outlet.

**[0020]** The mixers and the equipment described in the above-mentioned patent documents are not able to overcome the drawbacks and the limitations illustrated above.

**[0021]** It is the task of the present invention to provide a mixing system for the introduction of chemical substances in a fluid to be treated, which can overcome the above-mentioned drawbacks and limitations of the known art.

**[0022]** More specifically, it is an object of the invention to provide a mixing system that makes it possible to drastically reduce the use of water for the preparation of a polyelectrolyte suited to be introduced in the flow of waste fluid to be treated.

**[0023]** It is another object of the invention to provide a mixing system that favours the reduction of energy consumption in waste water treatment processes.

**[0024]** It is a further object of the invention to provide a mixing system that improves water retention from sludge, thus increasing the quantity of dry product obtainable from sludge.

**[0025]** It is another object of the invention to provide a mixing system that can reduce the waiting times for the beginning of the action of the polymer in solution on the fluid to be treated, consequently improving the effective-

ness of the polymer itself.

**[0026]** It is another object of the invention to provide a mixing system that is compact and can be easily set up also in already existing waste water purification or treatment plants or sludge drying plants.

**[0027]** It is another object of the invention to provide a mixing system that limits the proliferation of bacteria on the same polyelectrolytes.

**[0028]** The task and the objects illustrated above are fulfilled by a mixing system for the introduction of chemical substances in a fluid to be treated according to claim 1.

**[0029]** Further characteristics of the mixing system according to claim 1 are described in the dependent claims.

**[0030]** The task and the objects illustrated above, together with the advantages described below, are highlighted in the description of two embodiments of the invention, which are provided by way of non-limiting example with reference to the attached drawings, wherein:

- Figure 1 shows a schematic side sectional view of a first embodiment of a mixing system according to the invention;
- Figure 2 shows a schematic side sectional view of a second embodiment of a mixing system according to the invention.

**[0031]** With reference to Figure 1, in the context of a first embodiment, a mixing system according to the invention is indicated by the numeral 10.

**[0032]** Said mixing system 10 comprises:

- a container 11 comprising an external wall 12, an internal wall 13, a bottom 14 and a cover 15,
- two concentric mixing chambers, a first central chamber 16 defined within the internal wall 13 and a second chamber 17 defined outside the internal wall 13, the first chamber 16 and the second chamber 17 being in communication with each other,
- an inlet duct 19 for a fluid to be treated, configured to introduce said fluid from the outside into said first chamber 16,
- an outlet duct 20 for the treated fluid, said outlet duct 20 being configured to allow the outflow of said fluid from said second chamber 17 to the outside of said container 11,

said inlet duct 19, first chamber 16, second chamber 17 and outlet duct 20 being configured to define a labyrinthine mixing path 30,

- stirring blades 18 positioned inside the first chamber 16, operated by drive means through a rotation shaft 21,
- at least one injection passage 22 for the introduction of a chemical additive in one or more points of the labyrinthine mixing path 30.

**[0033]** In the present example of embodiment, the second chamber 17 is to be understood as ring-shaped.

**[0034]** The labyrinthine mixing path 30 is indicated by arrows that schematically show the possible paths of the fluid being treated between the inlet duct 19 and the outlet duct 20.

**[0035]** The drive means comprise, for example and not exclusively, a motor 35 configured to set the rotation shaft 21 rotating.

**[0036]** Said rotation shaft 21 carries the stirring blades 18.

**[0037]** The rotation axis of the rotation shaft 21 is parallel to the direction of extension of the internal wall 13.

**[0038]** More specifically, in the present non-limiting example of embodiment of the invention, the external wall 12 has a cylindrical shape.

**[0039]** In the present non-limiting example of embodiment of the invention, also the internal wall 13 has a cylindrical shape.

**[0040]** More specifically, the second chamber 17 surrounds the first chamber 16.

**[0041]** More specifically, the second chamber 17 is concentric and coaxial with the first chamber 16.

**[0042]** In said example of embodiment, the inlet duct 19 is positioned below the outlet duct 20 with respect to a configuration of use of the mixing system 10.

**[0043]** In said example of embodiment, the stirring blades 18 comprise a first group of blades 18a positioned at the lower end of the rotation shaft 21.

**[0044]** More specifically, said first group of blades 18a is positioned below the inlet duct 19 with respect to a configuration of use of the mixing system 10.

**[0045]** Said first group of blades 18a is to be understood as capable of being arranged also in another position along the rotation shaft 21.

**[0046]** It is to be understood that the stirring blades 18 can be constituted by a single group of blades 18a.

**[0047]** In said example of embodiment, the stirring blades 18 comprise also a second group of blades 18b positioned in a central area of the rotation shaft 21.

**[0048]** More specifically, said second group of blades 18b is positioned above the inlet duct 19 with respect to a configuration of use of the mixing system 10.

**[0049]** The first chamber 16 and the second chamber 17 are in communication with each other through at least one passage opening 37 defined at the level of one end of the internal wall 13.

**[0050]** More specifically, but not exclusively, in said example of embodiment a first passage opening 37 is defined by a lower recirculation space between a lower end 13a of the internal wall 13 and the bottom 14.

**[0051]** More specifically, but not exclusively, in said example of embodiment a second passage opening 38 is defined by an upper recirculation space between an upper end 13b of the internal wall 13 and the cover 15.

**[0052]** In a variant embodiment, not illustrated for the sake of simplicity, the first chamber 16 and the second chamber 17 are in communication only through a lower

passage opening **37**; in said variant the upper end **13b** of the internal wall **13** is in contact with the cover **15** and there is no upper passage opening **38**.

**[0053]** In a further variant embodiment, not illustrated for the sake of simplicity, either, the first chamber **16** and the second chamber **17** are in communication only through an upper passage opening **38**; in said variant the lower end **13a** of the internal wall **13** is in contact with the bottom **14** and there is no lower passage opening **37**.

**[0054]** In said further variant embodiment, the inlet duct **19** and the outlet duct **20** are both advantageously positioned in proximity to the bottom **14** with respect to a configuration of use of the mixing system **10**.

**[0055]** The mixing system **10** comprises a flow deviation element **40** configured to deviate the fluid flowing out of the first chamber **16** towards the second chamber **17**.

**[0056]** Said flow deviation element **40** is placed on the bottom **14**.

**[0057]** Said flow deviation element **40** is constituted by a body in the shape of a cone or truncated cone, configured to deviate the flow towards the outside in radial direction, where the term 'radial' is intended with respect to an axial direction of the axis of symmetry of the internal wall **13**, wherein the flow is flowing downwards from the first chamber **16**.

**[0058]** The at least one injection passage **22** comprises a first injection pipe **22a** directly connected to the inlet duct **19**.

**[0059]** In a variant embodiment, said at least one injection passage **22** comprises, in addition or as an alternative, a second injection pipe **22b** directly connected to the first chamber **16**.

**[0060]** In a further variant embodiment, said at least one injection passage **22** comprises, in addition or as an alternative to one or both of the first injection pipe **22a** and second injection pipe **22b**, a third injection pipe **22c** directly connected to the second chamber **17**.

**[0061]** A second embodiment of a mixing system is schematically represented in Figure 2 and therein indicated by the numeral **110**.

**[0062]** The specific characteristic of the mixing system **110** lies in that the container **111**, comprising an external wall **112**, an internal wall **113**, a bottom **114** and a cover **115**, comprises also an intermediate wall **150**.

**[0063]** Said intermediate wall **150** defines, together with the external wall **112** and the internal wall **113**, three concentric mixing chambers, a first central chamber **116** defined within the internal wall **113**, a second intermediate chamber **117** that surrounds the first chamber **116** and a third external chamber **153** that surrounds the second chamber **117**.

**[0064]** In said second embodiment of the mixing system **110** according to the invention:

- the first chamber **116** and the second chamber **117** are in communication with each other through at least one passage opening **137** defined at the level of one end of the internal wall **113**, and at the same

time

- the second chamber **117** and the third chamber **153** are in communication with each other through at least one passage opening **154** defined at the level of one end of the intermediate wall **150**.

**[0065]** More specifically, but not exclusively, in said example of embodiment a first passage opening **137** between the first chamber **116** and the second chamber **117** is defined by an upper recirculation space between an upper end **113a** of the internal wall **113** and the cover **115**.

**[0066]** More specifically, but not exclusively, in said example of embodiment a second passage opening **138** between the first chamber **116** and the second chamber **117** is defined by a lower recirculation space between a lower end **113b** of the internal wall **113** and the bottom **114**.

**[0067]** More specifically, but not exclusively, in said example of embodiment a first passage opening **154** between the second chamber **117** and the third chamber **153** is defined by a lower recirculation space between a lower end **150a** of the intermediate wall **150** and the bottom **114**.

**[0068]** More specifically, but not exclusively, in said example of embodiment a second passage opening **155** between the second chamber **117** and the third chamber **153** is defined by an upper recirculation space between an upper end **150b** of the intermediate wall **150** and the cover **115**.

**[0069]** In a variant embodiment, not illustrated for the sake of simplicity, the first chamber **116** and the second chamber **117** are in communication only through an upper passage opening **137**, and the second chamber **117** and the third chamber **153** are in communication only through a lower passage opening **154**.

**[0070]** In a further variant embodiment, not illustrated for the sake of simplicity, either, the first chamber **116** and the second chamber **117** are in communication only through a lower passage opening **138**, and the second chamber **117** and the third chamber **153** are in communication only through an upper passage opening **155**.

**[0071]** In said further variant embodiment, the inlet duct **119** and the outlet duct **120** are both advantageously positioned in proximity to the bottom **114** with respect to a configuration of use of the mixing system **110**.

**[0072]** The mixing system **110** comprises a flow deviation element **140** configured to deviate the fluid flowing out of the first chamber **116** or the second chamber **117** towards the third chamber **153**.

**[0073]** Said flow deviation element **140** is placed on the bottom **114**.

**[0074]** Said flow deviation element **140** is constituted by a body in the shape of a cone or truncated cone, configured to deviate the flow towards the outside in radial direction.

**[0075]** Analogously to what has been described above with reference to the first embodiment of the invention,

the mixing system **110** comprises an injection passage **122** for the introduction of a chemical additive in one or more points of the labyrinthine mixing path **130**.

**[0076]** According to its first embodiment illustrated in Figure 1, the mixing system **10** operates in such a way that the fluid to be treated, for example sludge, flows into the first chamber **16** through the inlet duct **19** and, thanks to gravity and to the action of the stirring blades **18**, flows downwards, towards the passage opening **37**, in which it is deviated upwards into the second chamber **17**; while flowing upwards along the second chamber **17** the treated fluid meets the outlet duct **20** and is conveyed into it.

**[0077]** A chemical additive, for example cationic polyacrylamide, is injected in the fluid to be treated during its passage through said labyrinthine mixing path **30**.

**[0078]** According to its second embodiment illustrated in Figure 2, the mixing system **110** operates in such a way that the fluid to be treated flows into the first chamber **116** through the inlet duct **119** and is conveyed upwards thanks to the action of the stirring blades **118**.

**[0079]** Successively, the fluid follows a labyrinthine mixing path **130** in which it passes through all of the three chambers, the first **116**, the second **117** and the third **153**, and from the latter passes into the outlet duct **120**.

**[0080]** It has practically been shown that the mixing system **10** and **110** according to the invention fulfils its task and achieves the set objects.

**[0081]** In fact, the invention provides a mixing system thanks to which the fluid to be treated and the chemical additive are mixed with no need for the chemical additive to be prepared, meaning diluted, in advance in costly and bulky water tanks, thus drastically reducing water consumption.

**[0082]** The chemical additive, for example a cationic flocculant polymer, is activated when it comes in direct contact with a fluid to be treated, and this happens directly inside the first, the second and, if necessary, the third chamber.

**[0083]** Furthermore, the invention provides a mixing system which, thanks to the stirring effect produced by the stirring blades, improves the effectiveness and the efficiency of the chemical additive; for example, in the case of organic sludge, in which the sludge has an apolar surface membrane, the strong stirring action favours the breakage of said membrane and makes anionic sites available; the introduction of and the mixing with a cationic polyelectrolyte make the anionic sites react with the cationic polyelectrolyte releasing water molecules, which favours a greater separation of the solid fraction of the fluid being treated from the liquid fraction.

**[0084]** Therefore, the invention provides a mixing system that makes it possible to drastically reduce the use of water when preparing a polyelectrolyte intended to be introduced in a flow of waste fluid to be treated.

**[0085]** In addition to the above, the invention provides a mixing system that favours the reduction of energy consumption in waste water treatment processes, since it is no more necessary to manage a mixing and storage tank

and the efficiency in terms of separation of the dry fraction from the liquid fraction is improved compared to the known treatment systems.

**[0086]** In fact, the invention provides a mixing system that improves water retention from sludge, thus increasing the quantity of dry product obtainable.

**[0087]** Moreover, the invention provides a mixing system that is capable of reducing waiting times before the beginning of the action of the polymer in solution on the fluid to be treated, consequently improving the effectiveness of the polymer itself; this has been obtained by introducing the chemical additive directly in the fluid to be treated and subjecting both of them to a mixing action produced by the stirring blades.

**[0088]** Furthermore, the invention provides a compact mixing system that can be easily set up also in existing waste water purification or treatment systems or sludge drying systems.

**[0089]** Furthermore, the invention provides a mixing system that limits the proliferation of bacteria on the same polyelectrolytes, thanks to the direct introduction of the same polyelectrolytes directly in the fluid to be treated, without providing for a storage period before use.

**[0090]** The invention conceived in this way can be subjected to several modifications and variants, all falling within the inventive concept disclosed herein; furthermore, all the details can be replaced by other technically equivalent elements.

**[0091]** In practice, any components and any materials can be used, provided that they are compatible with the intended use, and any shape and size can be selected, according to the needs and the state of the art.

**[0092]** Where the characteristics and techniques mentioned in any of the claims are followed by reference signs, it must be understood that these reference signs are used only for the purpose of making the claims easier to understand, and consequently these reference signs do not have any limiting effect on the interpretation of each element identified by way of example by the same reference signs.

## Claims

1. Mixing system (10) for the introduction of chemical substances in a fluid to be treated, comprising:

- a container (11) comprising an external wall (12), an internal wall (13), a bottom (14) and a cover (15),

- at least two concentric mixing chambers, a first central chamber (16) defined within said internal wall (13) and a second chamber (17) defined outside said internal wall (13), said first chamber (16) and second chamber (17) being in communication with each other,

- an inlet duct (19) for a fluid to be treated, configured for the introduction of said fluid from the

outside into said first chamber (16),  
 - an outlet duct (20) for said treated fluid, configured for the outflow of said fluid from said second chamber (17) to the outside of said container (11),

said inlet duct (19), first chamber (16), second chamber (17) and outlet duct (20) being configured to define a labyrinthine mixing path (30),

- stirring blades (18) positioned inside said first chamber (16), operated by drive means through a rotation shaft (21),  
 - at least one injection passage (22) for the introduction of a chemical additive in one or more points of said labyrinthine mixing path (30),

**characterized in that** said inlet duct (19) is positioned below said outlet duct (20) with respect to a configuration of use of said mixing system (10),

- said stirring blades (18) comprising at least one first group of blades (18a),  
 - said first group of blades (18a) being positioned below said inlet duct (19) with respect to a configuration of use of the mixing system (10).

2. Mixing system according to claim 1, **characterized in that** said drive means comprise a motor (35) configured to set said rotation shaft (21) rotating, wherein said rotation shaft (21) carries said stirring blades (18). 30
3. Mixing system according to one or more of the preceding claims, **characterized in that** said first chamber (16) and second chamber (17) are in communication with each other through at least one passage opening (37) defined at the level of one end of said internal wall (13). 35
4. Mixing system according to claim 3, **characterized in that** a first passage opening (37) is defined by a lower recirculation space between a lower end (13a) of said internal wall (13) and said bottom (14). 40
5. Mixing system according to one or more of claims 3 and 4, **characterized in that** a second passage opening (38) is defined by an upper recirculation space between an upper end (13b) of said internal wall (13) and said cover (15). 45
6. Mixing system according to one or more of the preceding claims, **characterized in that** it comprises a flow deviation element (40) configured to deviate said fluid flowing out of said first chamber (16) towards said second chamber (17). 50
7. Mixing system according to one or more of the pre-

ceding claims, **characterized in that** said at least one injection passage (22) comprises an injection pipe (22a) directly connected to said inlet duct (19).

- 5 8. Mixing system according to one or more of the preceding claims, **characterized in that** said at least one injection passage (22) comprises an injection pipe (22b) directly connected to said first chamber (16). 10

9. Mixing system according to one or more of the preceding claims, **characterized in that** said at least one injection passage (22) comprises an injection pipe (22c) directly connected to said second chamber (17). 15

10. Mixing system according to one or more of the preceding claims, **characterized in that** said container (111) comprising an external wall (112), an internal wall (113), a bottom (114) and a cover (115) comprises also an intermediate wall (150), said intermediate wall (150) defining, together with said external wall (112) and with said internal wall (113), three concentric mixing chambers, a first central chamber (116) defined within said internal wall (113), a second intermediate chamber (117) that surrounds said first chamber (116) and a third external chamber (153) that surrounds said second chamber (117). 20

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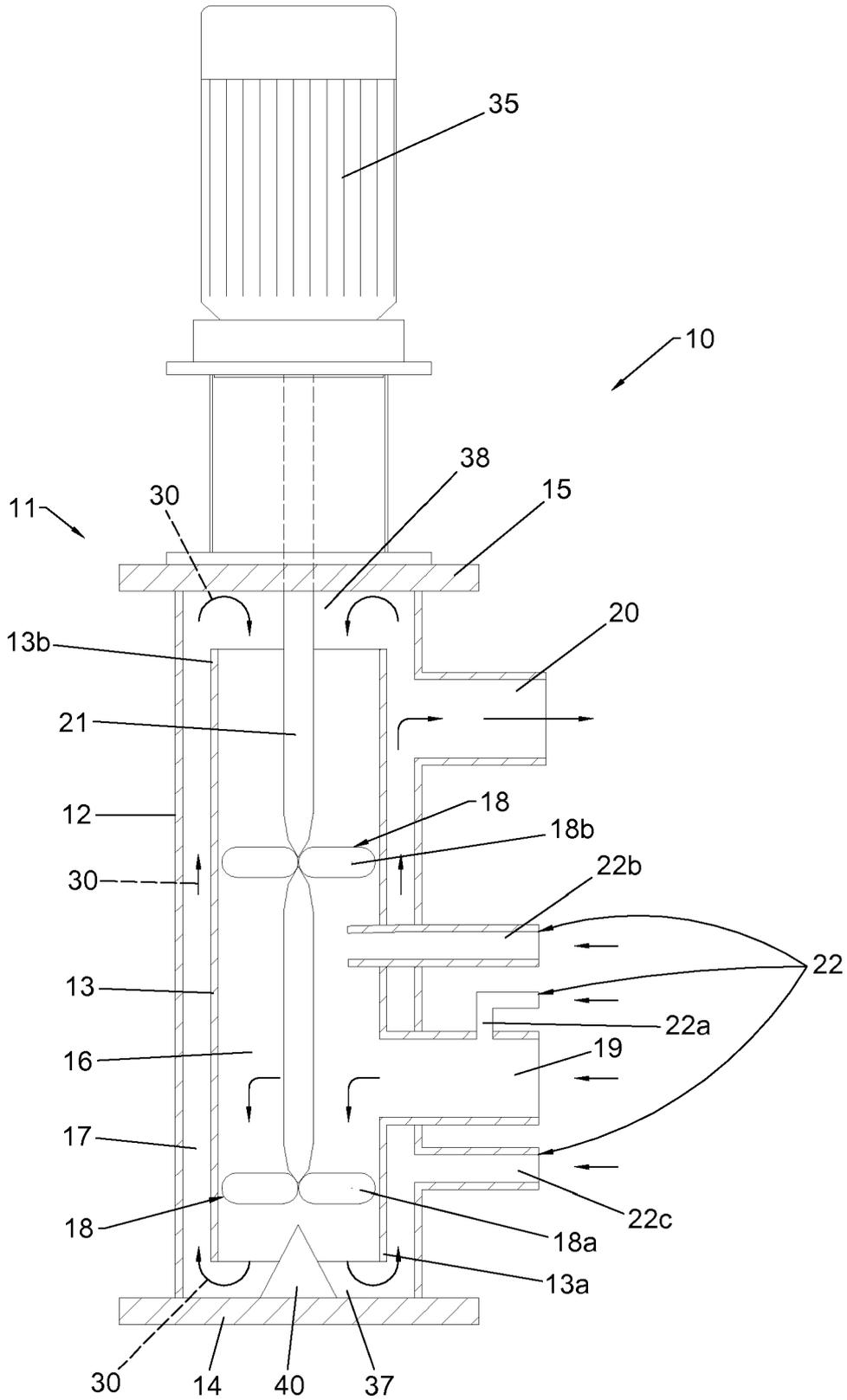


Fig.1

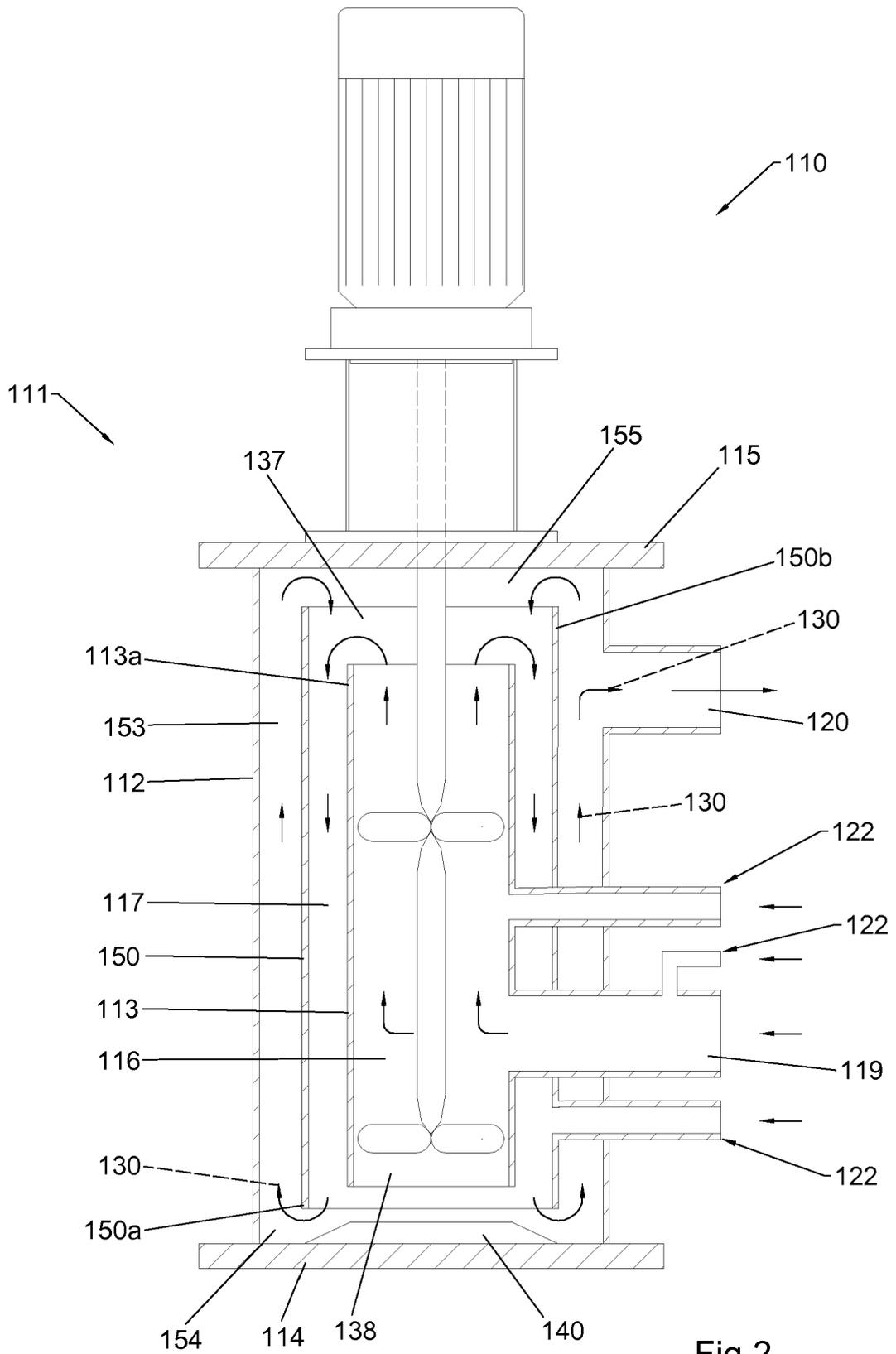


Fig.2



EUROPEAN SEARCH REPORT

Application Number  
EP 19 19 8702

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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A,D	----- US 2012/199524 A1 (BLY JR JOSEPH M [US] ET AL) 9 August 2012 (2012-08-09) * paragraph [0002] * * paragraph [0041] - paragraph [0047] * * paragraph [0051] * * figure 2 *	1-10	
A,D	----- US 3 392 963 A (DIERENDONCK LAURENTIUS L VAN ET AL) 16 July 1968 (1968-07-16) * column 2, line 38 - line 55 * * column 2, line 68 - line 71 * * figures *	1-10	TECHNICAL FIELDS SEARCHED (IPC) B01F
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A,D	----- US 3 737 288 A (HOCHMAN J) 5 June 1973 (1973-06-05) * column 2, line 15 - line 46 * * figure 1 *	1-10	
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1 The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 6 February 2020	Examiner Real Cabrera, Rafael
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	

EPO FORM 1503 03.82 (P04C01)

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EUROPEAN SEARCH REPORT

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 6 February 2020	Examiner Real Cabrera, Rafael
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	

EPO FORM 1503 03.02 (P04/C01)

ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.

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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
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