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(54) **A CYCLONE SEPARATOR**

(57) A cyclone separator, comprising a vessel and a pipe arrangement. The pipe arrangement comprises a pipe inlet, a pipe outlet, and a blocking wall located between the pipe inlet and the pipe outlet, preventing at least a major part of the liquid from flowing directly from a first pipe portion to a second pipe portion. A first opening is provided in the first pipe portion between the pipe inlet and the blocking wall, and a second opening is provided in the second pipe portion. Liquid received through the pipe inlet is diverted by the blocking wall to exit through the first opening. The liquid then flows in a spiral cyclone motion in the separation chamber so as to separate non-liquid matter from the liquid. Liquid re-enters into the pipe arrangement through the second opening, enabling at least a part of the re-entered liquid to leave the arrangement through the pipe outlet.

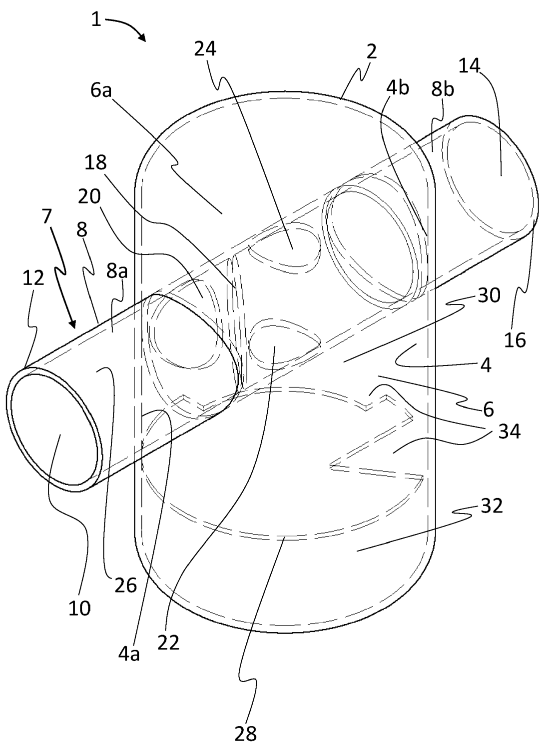

Fig. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a cyclone separator. In particular, the present disclosure relates to a cyclone separator comprising a vessel having a circumferentially extending wall defining a separation chamber in which non-liquid matter can be separated from liquid.

BACKGROUND ART

[0002] Systems for separating non-liquid matter from liquid are known in various industries. One type of separator is the type in which a cyclone is induced. The cyclone motion of the liquid generates centrifugal forces in the liquid flow, whereby particles become separated. In for example pressure vessels or pressure pipes, those particles hit the vessel wall and precipitate.

[0003] In the HVAC industry, cyclone separators are used to separate dirt from heating and cooling water pipes. Such cyclone separators are often provided with an insert that redirects the incoming flow of water to induce a cyclone in the water flow and which has some type of vortex finder to guide the flow towards the outlet. Such known inserts, however, have a rather complex shape, and they are made by welded and/or laser-cut bent sheets of metal. Due to its complex shape, it may have tolerance issues, such as roundness. Furthermore, for the insert to be accommodated in the vessel, the actual separation chamber needs to be quite long.

[0004] It would be desirable to provide a cyclone separator which is less complex and which can have a more compact separation chamber than the prior art.

SUMMARY OF THE INVENTION

[0005] An object of the present inventive concept is to at least partly alleviate the above-mentioned drawbacks of the prior art. This and other objects, which will become apparent in the following disclosure, are accomplished by a cyclone separator presented in the independent claim. Some non-limiting exemplary embodiments are presented in the dependent claims.

[0006] According to a first aspect of this disclosure, there is provided a cyclone separator, comprising:

- a vessel having a circumferentially extending wall defining a separation chamber,
- a pipe arrangement comprising a first pipe portion and a second pipe portion,

  wherein the first pipe portion penetrates the vessel to extend linearly inside the separation chamber from a first wall portion of said circumferentially extending wall towards a centre area of the separation chamber, in particular linearly in a radial direction of the separation chamber,
  wherein the second pipe portion penetrates the vessel to extend linearly inside the separation chamber from a second wall portion of said circumferentially extending wall towards said centre area of the separation chamber, in particular linearly in a radial direction of the separation chamber,
  wherein the second wall portion is located opposite the first wall portion,

    wherein the pipe arrangement comprises
    a pipe inlet for receiving, into the first pipe portion, liquid to be processed in
    the cyclone separator, and
    a pipe outlet for outputting, from the second pipe portion, liquid that has been processed in the cyclone separator,
    wherein the pipe arrangement further comprises a blocking wall preventing at least a major part of the liquid from flowing
    directly from the first pipe portion to the second pipe portion,
    wherein the first pipe portion comprises a first opening, the first opening being provided between the pipe inlet and the blocking wall, and

  wherein the second pipe portion comprises a second opening,
  wherein liquid received through the pipe inlet is diverted by the blocking wall to exit the pipe arrangement through said first opening, which is oriented such that the liquid exiting through the first opening is caused to flow in a spiral cyclone motion in the separation chamber along the circumferentially extending inner wall of the vessel so as to separate non-liquid matter from the liquid, the spiral cyclone motion of the liquid being followed by an axial returning motion of the liquid towards the second pipe portion, wherein the second opening is oriented to receive the liquid flowing in said axial returning motion so that the liquid flowing in said axial returning motion re-enters the pipe arrangement by entering through the second opening into the second pipe portion, enabling at least a part of the re-entered liquid to leave the pipe arrangement through the pipe outlet.

[0007] By including such a pipe arrangement in a cyclone separator instead of a traditional insert, a less complex construction is achieved, and the separation chamber can be made more compact, thus allowing the cyclone separator as a whole to be made more compact.

[0008] Although the first pipe portion and the second pipe portion each extend from a respective wall portion towards a centre area of the separation chamber (in a respective direction), they do not necessarily have to be in contact with each other. For instance, there may be a slight gap between the first pipe portion and the second pipe portion. Such a gap, however, would be relatively small, e.g. less than 10% of the total length of extension of the first and second pipe portions inside the separation chamber, for example less than 5 %. Allowing the first pipe portion and the second pipe portion to be formed and installed as separate components is advantageous from a manufacturing and mounting perspective. As should be understood from above, although the first pipe portion does not need to be in contact with the second pipe portion, they will together extend across the separation chamber from said first wall portion to said second wall portion (except for an optional small gap between the first pipe portion and the second pipe portion).

[0009] The first pipe portion and the second pipe portion may suitably be formed as substantially circular cylindrical pipe portions. Furthermore, the first wall portion and the second wall portion may suitably be located diametrically opposite each other with respect to the circumferentially extending wall, although there may be a small offset from the diameter. In other words, although the first and the second pipe portions may extend radially with respect to the circumferentially extending wall, a slight offset from such a radial extension may also be conceivable.

[0010] In some exemplary embodiments and other aspects of this disclosure the first pipe portion and the second pipe portion may be in contact with each other, together forming an integral pipe structure. Such an integral pipe structure may be formed in one piece, or it may be formed by joining the first pipe portion to the second pipe portion (for example by welding).

[0011] Below such an aspect of this disclosure is presented in which an integral pipe structure is provided.

[0012] Thus, according to a second aspect of this disclosure, there is provided a cyclone separator, comprising:

- a vessel having a circumferentially extending wall defining a separation chamber, and
- a pipe structure extending from one portion of said circumferentially extending wall, linearly across the separation chamber, suitably diametrically across the separation chamber, to an opposing portion of said circumferentially extending wall, wherein the pipe structure comprises

    a pipe inlet for receiving liquid to be processed in the cyclone separator, the pipe inlet being located at a first end of the pipe structure,

    a pipe outlet for outputting liquid that has been processed in the cyclone separator, the pipe outlet being located at an opposite second end of the pipe structure,

    a blocking wall located between the pipe inlet and the pipe outlet, preventing at least a major part of the liquid from flowing directly from the pipe inlet to the pipe outlet,

    a first opening provided between the pipe inlet and the blocking wall, and

    a second opening provided between the blocking wall and the pipe outlet,

wherein liquid received through the pipe inlet is diverted by the blocking wall to exit the pipe structure through said first opening, which is oriented such that the liquid exiting the first opening is caused to flow in a spiral cyclone motion in the separation chamber along the circumferentially extending wall of the vessel so as to separate non-liquid matter from the liquid, the spiral cyclone motion of the liquid being followed by an axial returning motion of the liquid towards the pipe structure, wherein the second opening is oriented to receive the liquid flowing in said axial returning motion so that the liquid re-enters into the pipe structure, enabling at least a part of the re-entered liquid to leave the pipe structure through the pipe outlet.

[0013] By including such a pipe structure in a cyclone separator instead of a traditional insert, a less complex construction is achieved, and the separation chamber can be made more compact, thus allowing the cyclone separator as a whole to be made more compact.

[0014] As understood from above, by providing a pipe arrangement (irrespective of if it comprises two separate pipe portions, or two pipe portions that form an integral pipe structure) with a blocking wall and the first and second openings, the pipe arrangement can serve both as inlet/outlet from the separation chamber, as well as a diverter to cause the spiral cyclone motion.

[0015] The blocking wall may, in at least some exemplary embodiments, prevent all liquid from flowing directly from the first pipe portion to the second pipe portion, in particular from flowing directly from the pipe inlet to the pipe outlet. In such embodiments, all liquid coming through the pipe inlet needs to leave the pipe arrangement through the first opening. Liquid can then re-enter through the second opening to pass to the pipe outlet. However, in at least some other exemplary embodiments, the blocking plate may be provided with a small through hole, allowing a small leakage flow to pass through the blocking plate from the inlet side of the blocking plate to the outlet side of the blocking plate (i.e. from the side of the blocking plate facing the pipe inlet to opposite side of the blocking place facing the pipe outlet). Such a leakage flow has the advantageous effect of reducing the pressure drop across the pipe arrangement.

[0016] As mentioned above, the cyclone separator may separate non-liquid matter from liquid. In particular, the cyclone separator may advantageously be used for separating solid particles, such as dirt, from the liquid. Another advantageous implementation may be to separate air from liquid. The liquid may suitably be water, such as heating or cooling water in a HVAC system. Thus, the cyclone separator may suitably, in at least some implementations, be used as a hydrocyclone separator.

[0017] The pipe arrangement may be made by any suitable manufacturing method including moulding, welding, 3D-printing, etc. The selection of type of material may also be chosen as desired. Some or all parts of the pipe arrangement may, for example, be made of metal, such as steel. Some or all parts of the pipe arrangement may for example be made of a plastic material.

[0018] The pipe arrangement may suitably be provided with flanges at the pipe inlet and pipe outlet for allowing convenient connection to connecting pipes of a pipe system in which the cyclone separator is to be installed. The blocking plate may either be formed in one piece with one or both pipe portions, such as through moulding or 3D-printing, or it can be joined to one or both pipe portions by for example welding.

[0019] The first opening may be oriented in such way that it directs the liquid flow that exits through the first opening tangentially along the circumferentially extending wall. The vessel and its circumferentially extending wall may have a geometrical centre axis, i.e. an imaginary centre axis extending through the vessel and around which the wall extends circumferentially. The first opening may suitably be oriented in such way that it directs the liquid flow that exits through the first opening at an angle of inclination relative to a geometrical plane that is perpendicular to the geometrical centre axis. For instance, if the cyclone separator is installed such that the geometrical centre axis extends in a vertical direction, the first opening may direct the liquid flow to exit at angle of inclination relative to a horizontal plane. The angle of inclination may, for example be up to 15°, or a smaller angle. This may improve the creation of a good spiral cyclone movement.

[0020] The circumferentially extending wall of the vessel may in at least some exemplary embodiments be a cylindrical wall. In other exemplary embodiments it may be a conical/tapered wall. In still other exemplary embodiments, it may be a combination of a cylindrical wall portion and a conical wall portion. For instance, the vessel may have a first, such as an upper, cylindrical wall portion and an adjacent second, such as a lower, conical/tapered wall portion. From the above, it can be understood that the circumferentially extending wall may in at least some exemplary embodiments have a substantially constant circular cross-section along its length (or at least along part of its length), and in at least some exemplary embodiments it may have a varying circular cross-section along its length (or at least along part of its length).

[0021] According to at least some exemplary embodiments, the second pipe portion may further comprise a third opening located opposite to the second opening, thereby enabling a part of the liquid that has re-entered the pipe arrangement through the second opening to exit through the oppositely located third opening for continued processing of the liquid.

[0022] Analogously, in case of the pipe arrangement comprising the previously discussed integrally pipe structure, according to at least some exemplary embodiments, the pipe structure may further comprise a third opening located between the blocking wall and the pipe outlet, and opposite to the second opening, thereby enabling a part of the liquid that has re-entered through the second opening to exit through the oppositely located third opening for continued processing of the liquid.

[0023] In the case of particle separation, it may be advantageous to provide the above discussed third opening, as all particles suspended in the liquid may not yet have been separated from the liquid when the liquid returns into the pipe arrangement through the second opening. By allowing a part of the returned liquid to exit the third opening, the liquid may fall into another swirling motion due to the torque in the separating chamber, whereby further particles may become precipitated.

[0024] The first and second openings, and the optional third openings may be regarded as lateral openings as they are provided in the enveloping surface of the first and second pipe portions rather than at the ends of the pipe arrangement. The pipe inlet and the pipe outlet are, however, located at the ends of the pipe arrangement, and could therefore be regarded as end openings.

[0025] The interior part of the pipe arrangement that extends between from the pipe inlet to the blocking plate may be regarded as an inlet zone of the pipe arrangement. This inlet zone is provided in the first pipe portion. The interior part of the pipe arrangement on the other side of the blocking plate, extending to the pipe outlet, may be regarded as an outlet zone. The outlet zone is provided in the second pipe portion. The interior of the pipe arrangement can thus be regarded as split into an inlet zone and an outlet zone. The inlet zone is configured to guide liquid into the volume of the vessel surrounding the pipe arrangement so as to provide said spiral cyclone motion of the liquid in the separation chamber. The outlet zone is configured to receive the returning flow of liquid (following after the spiral cyclone motion) and to guide at least a part of the received liquid out of the cyclone separator. In exemplary embodiments in which the pipe arrangement includes the above-mentioned third opening, the outlet zone may present an inverted T-junction for the liquid.

[0026] According to at least one exemplary embodiment, the vessel has a geometrical centre axis, wherein the second opening is intersected by said geometrical centre axis. By providing the second opening centrally, a good vortex finder function is achieved for the second opening. However, it should be understood that, depending on e.g. the size of the vessel, it may in some cases be more convenient to have the second opening slightly off-centre with respect to the geometrical centre axis. Thus, the resulting vortex does not necessarily need to be coaxial with the geometrical centre axis of the vessel, but can have its own geometrical axis which may be more or less parallel with the geometrical centre axis of the vessel.

[0027] According to at least one exemplary embodiment, the third opening is also intersected by said geometrical centre axis. Thus, the second opening as well as the third opening may function well as vortex finders. Similarly to the above explanation, in some exemplary embodiments, the third opening may be slightly off-centre with respect to the geometrical centre axis of the vessel.

[0028] The diameter of the second opening may be selected such that a desired pressure drop is achieved from pipe inlet to pipe outlet. A relatively smaller diameter results in a relatively larger pressure drop, whereas a relatively larger diameter results in a relatively smaller pressure drop. Similarly, the diameter of the third opening may also be selected to control the pressure drop. The diameter of the first opening may also be selected to control the pressure drop.

[0029] According to at least one exemplary embodiment, the blocking plate diverts the liquid to the first opening to exit in a direction substantially perpendicular to the geometrical centre axis, but without intersecting the geometrical centre axis. This is beneficial as it causes cyclone torque.

[0030] According to at least some exemplary embodiments, each one of the first and second pipe portions penetrates the vessel such that the pipe inlet and pipe outlet are located outside the vessel on respective opposite sides of the vessel, in particular on respective diametrically opposite sides of the vessel. Analogously, in case of the first and second pipe portions forming part of an integral pipe structure, the pipe structure may penetrate the vessel such that the pipe inlet and the pipe outlet are located outside the vessel on respective (suitably diametrically) opposite sides of the vessel. This is beneficial as it facilitates assembling of the cyclone separator and also the connection of the cyclone separator to the piping system in which it is to be installed. The vessel of the cyclone separator may for instance be provided with oppositely located holes, and the pipe structure may be inserted through one of the holes and then partly pushed through the opposite hole so that the pipe inlet and pipe outlet are provided on respective opposite sides of the vessel, and subsequently both holes may be appropriately sealed. As mentioned previously, flanges may then suitably be added to the pipe inlet and pipe outlet. Other assembling methods are, of course also conceivable, such as inserting the first and second pipe portions through respective holes in the vessel and then, optionally, join the portions into one integral pipe structure, e.g. by welding the portions together inside the vessel (this can be done by a circular weld, or just by applying spot welds to allow for some tolerances between the first and second pipe portions). In either case, the manufacturing of the cyclone separator of the present disclosure is more convenient than the manufacturing of cyclone separators having traditional inserts.

[0031] According to at least one exemplary embodiment, the first and second pipe portions may extend in a direction perpendicular to the geometrical centre axis.

[0032] Analogously, in case of the first and the second pipe portions forming an integral pipe structure, the pipe structure may extend across the separation chamber in a direction perpendicularly to the geometrical centre axis. This facilitates manufacturing and allows for satisfactory control of the flow through the cyclone separator.

[0033] According to at least one exemplary embodiment, each one of the first and second pipe portions has a substantially cylindrical outer surface, wherein said openings (the first, second and the optional third opening) are provided in the cylindrical outer surface.

[0034] Analogously, in case of the first and the second pipe portions forming an integral pipe structure, the pipe structure may have a substantially cylindrical outer surface which extends across the separation chamber, wherein said openings (the first, second and the optional third opening) are provided in the cylindrical outer surface.

[0035] Such a cylindrical form is convenient from a manufacturing perspective. The cylindrical outer surface may also be referred to as an enveloping surface. The cylindrical outer surface may suitably be a circular cylindrical surface in which said openings are provided.

[0036] As mentioned above, the pipe arrangement may in some exemplary embodiments be installed such that the first pipe portion and the second pipe portion are separate pieces that have not been joined together into an integral pipe structure (but still collectively extend substantially across the entire separation chamber, apart from an optional small gap between the two pipe portions). As also mentioned above, the pipe arrangement may in other exemplary embodiments include one integral pipe structure in which said first and second openings are provided, wherein in those exemplary embodiments the first pipe portion and the second pipe portion can either be formed in one piece or be formed as two pieces that have been joined together. Below, some exemplary embodiments of a pipe arrangement having an integral pipe structure will be discussed in more detail.

[0037] As mentioned previously, the pipe structure may be provided in different ways, for example the cylindrical outer surface discussed above may be formed in one piece, or it may be formed by joining two or more pieces. Some exemplary embodiments that at least partly reflects such different options will be presented below.

[0038] According to at least one exemplary embodiment, the pipe structure comprises a cylindrical structure provided with said openings and said blocking wall, wherein the cylindrical structure extends in one piece. This provides a simple and convenient way to present a pipe structure.

[0039] Thus, according to at least one exemplary embodiment, the first pipe portion may be formed in one piece with the second pipe portion, and together they may define a continuous cylindrical outer surface extending in one piece all the way across the separation chamber, wherein the continuous cylindrical outer surface is provided with said openings and wherein said blocking wall is located between the pipe inlet and the pipe outlet.

[0040] According to at least one exemplary embodiment, the pipe structure comprises two cylindrical pipe portions that have been joined together, wherein the first opening is provided in one of the cylindrical pipe portions (first pipe portion), and wherein the second opening is provided in the other one of the cylindrical pipe portions (second pipe portion). By providing the pipe structure in this way, any flanges at the pipe inlet and pipe outlet, or other connecting means, may conveniently be provided to the cylindrical pipe portions before they are mounted to the vessel and joined to each other. It should be understood that the cylindrical pipe portion that is provided with the first opening will also be the one that forms the pipe inlet. Conversely, the other cylindrical portion, which has the second opening (and the optional third opening), will form the pipe outlet. Either one of the two cylindrical pipe portions may be provided with the blocking plate. The cylindrical pipe portions are suitably joined together when the blocking plate is already provided in one of the cylindrical pipe portions.

[0041] As already mentioned above, it is not necessary in all embodiments to join the first and second pipe portions. This is reflected in at least one exemplary embodiment, according to which the first and second pipe portions are formed as two separate pieces, in particular as two pieces that are not joined together, wherein said blocking wall is a first blocking wall provided in the first pipe portion, wherein the pipe arrangement further comprises a second blocking wall provided in the second pipe portion, wherein the second opening is provided between the second blocking wall and the pipe outlet. This allows for a simple manufacturing and mounting. Each one of the pipe portions may suitably be inserted through respective to holes in the vessel so that they extend into the central area of the separating chamber.

[0042] According to at least one exemplary embodiment, the cyclone separator may further comprise a separation plate extending across the separation chamber and dividing the separation chamber into a cyclone zone on one side of the separation plate and a settling zone on the other side of the separation plate, wherein when the liquid in its spiral cyclone motion reaches said one side of the separation plate, the liquid turns to follow said axial returning motion towards the pipe arrangement, wherein one or more orifices are present at the separation plate to allow precipitated solid particles to reach and be collected in the settling zone on said other side of the separation plate. This facilitates sedimentation of solid particles. The separation plate may be regarded as an intermediate floor which is perforated by one or more orifices, suitably at the periphery of the separation plate. Solid particles, such as sludge, may settle on this intermediate flow and then pass through the orifices. Suitably, the collected solid particles may then be removed from the settling zone through a drain valve. The settling zone can be regarded as a low flow or slow flow zone, since the liquid will move considerably slower than in the cyclone zone.

[0043] According to at least one exemplary embodiment, the cyclone separator may comprise a magnet for trapping magnetic particles. It is possible to install such a magnet at various locations. Suitably, the magnet may be placed near the circumferentially extending wall, as most particles will be present there. The magnet may in some exemplary embodiments be placed near the pipe arrangement. For instance, in some exemplary embodiments having the optional third opening, the magnet may be provided in the vicinity of that third opening. Furthermore, in some exemplary embodiments the cyclone separator may comprise two or more magnets, suitably located at different locations.

[0044] According to at least one exemplary embodiment, the magnet may be provided in the settling zone of the separation chamber. Since magnetic particles are normally relatively small, placing the magnet in the settling zone may counteract the risk of the magnetic particles returning to the cyclone zone. The magnet is suitably provided in the settling zone off-centre, such as near the wall where many of the particles will be present.

[0045] As has been discussed above, the general inventive concept may be used for separating non-liquid matter from a liquid. In particular, the non-liquid matter may be in the form of solid particles or it may be in gaseous form, such as air. Such different implementations will be discussed in the following in relation to some exemplary embodiments.

[0046] According to at least one exemplary embodiment, the cyclone separator may be configured to separate solid particles from liquid, in particular from water, wherein the pipe arrangement is arranged in such way that the side of the second pipe portion that presents the second opening faces a relatively larger volume of the separation chamber, whereas the opposite side of the second pipe portion faces a relatively smaller volume of the separation chamber. For instance, if the vessel and its circumferentially extending wall is installed in an upright manner, i.e. the central geometrical axis extending vertically, the arrangement may suitably be arranged closer to the upper end of the vessel than the lower end. The second opening would, in such case, face downwardly towards the lower end. The liquid exiting through the first opening would flow in a spiral cyclone motion downwards and then the axial returning motion would be upwards to the second opening. In case the pipe arrangement is provided with the optional third opening, that third opening would, in this example, face upwardly towards the upper end of the vessel. The first opening may be arranged in an angle of inclination so as to direct the exiting liquid in a slight downwards direction, rather than horizontally. However, due to gravitation, a horizontally exiting flow of liquid will also result in a spiral cyclone motion downwards. It should be noted that for the purpose of particle separation, the vessel does not have to be installed in this exemplified upright manner. Depending on available space at the site of installation and/or the extension of the piping system to which the cyclone separator is to be connected, it may in some cases be desirable to let the vessel lie down in a horizontal manner rather than standing upright in a vertical manner. Particle separation works in either case.

[0047] According to at least one exemplary embodiment, the cyclone separator may be configured to separate air from liquid, in particular from water, wherein the cyclone separator is configured to be installable such that the circumferentially extending wall extends vertically and the pipe arrangement extends horizontally and is located near the lower end of the vessel, wherein the first opening directs the liquid exiting the pipe arrangement in an upwards spiral cyclone motion. The first opening may suitably be slightly inclined to achieve an upwards directed exit of the liquid from the pipe arrangement so as to create an upwards spiral cyclone motion. The second opening may suitably face upwards to receive a downwardly returning axial liquid motion. In the case of air separation, it may be advantageous to omit the optional third opening in order to increase the cyclone speed and improve air separation. It should thus be understood that, in comparison to the above example of the a vertically upright standing vessel for particle separation, in the case of air separation the vessel can suitably be turned upside down (still vertically upright). Thus, the pipe arrangement may suitably be located at an upper part of the separation chamber in the case of particle separation, whereas the pipe arrangement may suitably be located at a lower part of the separation chamber in the case of air separation. Air collected at the top of the vessel may suitably be removed through a vent, such as a controllable vent.

[0048] According to a third aspect of this disclosure, there is provided a method of separating solid particles from liquid, in particular from water, using a cyclone separator according to the first aspect, including any exemplary embodiment thereof, wherein the method comprises orienting the vessel such that the spiral cyclone motion is a downwards spiral motion or a horizontal spiral motion.

[0049] According to a fourth aspect of this disclosure, there is provided a method of separating air from liquid, in particular from water, using a cyclone separator according to the first aspect, including any exemplary embodiment thereof, wherein the method comprises orienting the vessel such that the spiral cyclone motion is an upwards spiral motion.

[0050] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the part, portion, element, component, arrangement, device, etc." are to be interpreted openly as referring to at least one instance of the part, portion, element, component, arrangement, device, etc., unless explicitly stated otherwise. Further features of, and advantages with, the present inventive concept will become apparent when studying the appended claims and the following description. The skilled person realizes that different features of the present inventive concept may be combined to create embodiments other than those described in the following, without departing from the scope of the present inventive concept.

BRIEF DESCRIPTION OF THE DRAWINGS

[0051]

Fig. 1 illustrates a cyclone separator according to at least one exemplary embodiment of the present disclosure.

Fig. 2 illustrates a cross-sectional view of the cyclone separator in Fig. 1.

Fig. 3 illustrates a pipe structure for use in a cyclone separator in accordance with at least one exemplary embodiment of the present disclosure.

Fig. 4 illustrates a pipe structure for use in a cyclone separator in accordance with at least another exemplary embodiment of the present disclosure.

Fig. 5 illustrates a cyclone separator according to at least another exemplary embodiment of the present disclosure.

Fig. 6 illustrates a cyclone separator according to at least yet another exemplary embodiment of the present disclosure.

Fig. 7 illustrates a cyclone separator according to at least a further exemplary embodiment of the present disclosure.

Fig. 8 illustrates a cross-sectional view of the cyclone separator in Fig. 7.

Fig. 9 illustrates a cyclone separator according to at least a still further exemplary embodiment of the present disclosure.

Figs. 10 and 11 illustrate a pipe arrangement for use in a cyclone separator in accordance with at least some exemplary embodiments of the present disclosure.

DETAILED DESCRIPTION

[0052] The present inventive concept will now be described more fully hereinafter with reference to the accompanying drawings, in which certain aspects of the present inventive concept are shown. The present inventive concept may, however, be embodied in many different forms and should not be construed as limited to the embodiments and aspects set forth herein; rather, the embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Accordingly, it is to be understood that the present inventive concept is not limited to the embodiments described herein and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the appended claims. Like reference numerals refer to like elements throughout the description.

[0053] Fig. 1 illustrates a cyclone separator 1 according to at least one exemplary embodiment of the present disclosure. The cyclone separator 1 comprises a vessel 2. The vessel 2 has a circumferentially extending wall 4 which defines a separation chamber 6. In the present example, the circumferentially extending wall 4 is a cylindrical wall 4 having a circular cross-section. Although the circumferentially extending wall 4 is illustrated as a cylindrical wall 4 in this and other drawing figures, it should be understood that the general inventive concept may also be implemented for a cyclone separator having a vessel with a conical/tapered wall, or a combination of a cylindrical wall portion and a conical/tapered wall portion.

[0054] The cyclone separator 1 further comprises a pipe arrangement 7. The pipe arrangement 7 comprises a first pipe portion 8a and a second pipe portion 8b. In this example, the first pipe portion 8a and the second pipe portion 8b together make up an integral pipe structure 8. In other examples, however, the first pipe portion 8a and the second pipe portion 8b may be installed as two separate, and not connected, pieces, e.g. with a small gap between them.

[0055] In Fig. 1, the pipe structure 8 extends from one portion of the circumferentially extending wall 4, linearly and diametrically across the separation chamber 6, to an opposing portion of the circumferentially extending wall 4. In other examples, the pipe structure 8 does not necessarily need to be aligned with the diameter of the circumferentially extending wall 4, but may if desired be slightly offset. Irrespective of if the first pipe portion 8a and the second pipe portion 8b form an integral pipe structure 8 as in Fig. 1, or if they are present as individual pieces, the first pipe portion 8a extends linearly towards a centre area 6a (or centre volume) of the separation chamber 6 from a first wall portion 4a of the circumferentially extending wall 4, in particular in a radial direction of the separation chamber 6 (or of the vessel 2). Similarly, the second pipe portion 8b extends towards the centre area 6a linearly from a second wall portion 4b of the circumferentially extending wall, in particular in a radial direction of the separation chamber 6 (or of the vessel 2). The second wall portion is 4b located opposite to the first wall portion 4a.

[0056] In the present example, the vessel 2 and its circumferentially extending wall 4 are illustrated in an upright, "standing", position. With reference to Fig. 2, which illustrates a cross-sectional view of the cyclone separator 1 in Fig. 1, a geometrical centre axis X is indicated. In the illustrated upright position, the geometrical centre axis X is a vertical axis. The pipe structure 8 extends across the separation chamber 6 in a horizontal direction. Indeed, in any exemplary embodiment, the longitudinal extension of the pipe structure 8 may suitably be perpendicular to the geometrical centre axis X of the vessel 2. Although these and other drawing figures illustrate a vertically standing vessel 2, and a horizontally extending pipe structure 8, it should be understood that the cyclone separator 1 may also be in use if the vessel 2 is tilted, such as tilted 90° so that it extends horizontally and the pipe structure 8 (and thus the pipe arrangement 7) extends vertically.

[0057] Continuing with reference to Figs. 1 and 2, the pipe arrangement 7, and in this case the pipe structure 8, comprises a pipe inlet 10 for receiving liquid (such as water) to be processed in the cyclone separator 1. The liquid is received into the first pipe portion 8a. The pipe inlet 10 is located at a first end 12 of the pipe arrangement 7. More specifically, in this example, it is a first end 12 of the pipe structure 8. The pipe arrangement 7, and in this case the pipe structure 8, also comprises a pipe outlet 14 for outputting liquid that has been processed in the cyclone separator 1. The liquid is output from the second pipe portion 8b. The pipe outlet 14 is located at an opposite second end 16 of the pipe arrangement 7. More specifically, in this example, it is the opposite second end 16 of the pipe structure 8. Here the pipe inlet 10 and pipe outlet 14 are illustrated as being located in the same horizontal plane. In installations where the vessel 2 is installed in a 90° lying position and the pipe structure 8 extends vertically across the separation chamber 6, the first end 12 having the pipe inlet 10 may suitably represent an upper end and the second end 16 having the pipe outlet 14 may suitably represent a lower end.

[0058] The pipe arrangement 7 further comprises a blocking wall 18. In this example, the blocking wall is located in the pipe structure 8 between the pipe inlet 10 and the pipe outlet 14. The blocking wall 18 prevents at least a major part of the liquid from flowing directly from the first pipe portion 8a to the second pipe portion 8b. In particular, the blocking wall 18 prevents at least a major part of the liquid from flowing directly from the pipe inlet 10 to the pipe outlet 14. The blocking wall 18 may be completely blocking or may, in at least some exemplary embodiments, have a small through hole for allowing a leakage flow to reduce the pressure drop of the liquid from the pipe inlet 10 to the pipe outlet 14.

[0059] The first pipe portion 8a comprises a first opening 20. The first opening 20 is provided between the pipe inlet 10 and the blocking wall 18. The second pipe portion 8b comprises a second opening 22. In this example, in which the first pipe portion 8a and the second pipe portion 8b form an integral pipe structure 8, the second opening 22 can be seen as being provided between the blocking wall 18 and the pipe outlet 14. Liquid received through the pipe inlet 10 is diverted by the blocking wall 18 to exit the pipe arrangement 7 through said first opening 20. Although Fig. 1 illustrates that the blocking wall 18 extends diagonally relative to the inner diameter of the pipe structure 8, in other examples the blocking wall 18 may extend without any angle relative to the pipe structure 18 diameter (or relative to the inner diameter of either one of the pipe portions 8a, 8b). The main purpose of the blocking wall 18 is to force the flowing liquid (or at least the major part thereof) to take another way than straight to the pipe outlet 14, i.e., to force the liquid to exit through the first opening 20.

[0060] The first opening 20 is oriented such that the liquid exiting the first opening 20 is caused to flow in a spiral cyclone motion in the separation chamber 6 along the circumferentially extending wall 4 of the vessel 2 so as to separate non-liquid matter from the liquid. The first opening 10 may therefore suitably be oriented such that the liquid exiting the first opening 20 exits in a direction which is near and close to tangential to the wall 4 of the vessel 2. If desired, the first opening 20 may also be angled in a direction towards which it is desired to form the spiral cyclone motion. For instance, in Fig. 1, the spiral cyclone motion is intended to be a downwards spiral cyclone motion. Therefore, the first opening 20 may, though not required, be inclined downwardly at an angle of for example up to 15°. Larger angles are, however, also conceivable, and any angle of inclination may be suitably chosen based on for example the length of the cyclone and vessel dimensions.

[0061] After the spiral cyclone motion of the liquid the liquid will flow in an axial returning motion towards the second pipe portion 8b. The second opening 22 is oriented to receive the liquid flowing in the axial returning motion so that the liquid re-enters into the pipe arrangement 7, enabling at least a part of the re-entered liquid to leave the pipe arrangement 7 through the pipe outlet 14. In the present example in Fig. 1, the axial returning motion will be upwards. Thus, in the example in Fig. 1, the liquid will follow a path from the pipe inlet 10, then through the first opening 20, then a downwards spiral cyclone motion along the wall 4, then an upwards returning motion centrally within the spiral, then entering through the second opening 22 and then being output through the pipe outlet 14. Although the second opening 22 is illustrated in Fig. 2 as being substantially co-axial with the geometrical centre axis X of the vessel 2, in other exemplary embodiments the second opening may have a central axis which is offset from (but suitably still parallel with) the geometrical centre axis X of the vessel 2. This may, for instance depend on the various dimensions of the vessel 2.

[0062] The illustrated cyclone separator 1 may suitably be used for separating solid particles from liquid (e.g., dirt, sludge, etc.), in particular from water. The pipe arrangement 7 is arranged in such way that the side of the second portion 8b that presents the second opening 22 faces a relatively larger volume of the separation chamber 6, whereas the opposite side of the second portion 8bfaces a relatively smaller volume of the separation chamber 6. Nevertheless, this smaller volume inside the separation chamber 6 (the top volume above the first and second pipe portions 8a, 8b in the example illustrated in Fig. 1) may also may be of use, as will be discussed in the following.

[0063] As illustrated in Figs. 1 and 2, the second pipe portion 8b may further comprise an optional third opening 24. In this example, the third opening 24 is, similarly to the second opening 22, located between the blocking wall 18 and the pipe outlet 14. More specifically, the third opening 24 may suitably be located opposite to the second opening 22. In the illustrated example, the second opening 22 is facing downwardly, while the third opening 24 is facing upwardly. Providing a third opening 24 enables a part of the liquid that has re-entered through the second opening 22 to exit through the oppositely located third opening 24 for continued processing of the liquid (i.e., in this case the top volume of the processing chamber 6). This may, in particular be used if the cyclone separator 1 is used for particle separation. Particles that are still suspended in the liquid may, after passing through the second opening 22 and third opening 24, get another chance of becoming separated. The liquid will follow a swirling motion above the third opening 24 which may promote particle separation by particles reaching and falling along the wall 4. The liquid may also rejoin liquid exiting the first opening 20 in its spiral cyclone motion.

[0064] From the above explanation it should be understood that in exemplary embodiments having the optional third opening 24, a part of the liquid that re-enters pipe arrangement 7 through the second opening 22 will be output through the pipe outlet 14 and another part of the liquid will pass through the third opening 24.

[0065] As best seen in Fig. 2, the geometrical centre axis X of the vessel 2 may suitably intersect the second opening 22 as well as the optional third opening 24. The second opening 22 and the third opening 24 function as vortex finders, promoting the axial returning flow centrally within the spiral cyclone motion. Analogously with previous explanations, in other exemplary embodiments the second and third openings 22, 24 may have a central axis which is offset from (but suitably still parallel with) the geometrical centre axis X of the vessel 2. This may, for instance depend on the various dimensions of the vessel 2.

[0066] As can be understood from Figs. 1 and 2, the presence of the blocking plate 18 in the pipe arrangement 7 causes the liquid to be diverted to the first opening 20, and the first opening 20 is oriented such that the liquid exits in a direction substantially perpendicularly to the geometrical centre axis X, but without intersecting the geometrical centre axis X, hereby causing cyclone torque.

[0067] As further illustrated in Figs. 1 and 2, the pipe arrangement 7 may suitably penetrate the vessel 2 such that the pipe inlet 10 and the pipe outlet 12 are located outside the vessel 2 on respective opposite sides of the vessel 2, suitably diametrically opposite sides of the vessel 2. In particular, the first pipe portion 8a penetrates the vessel 2 to extend linearly inside the separation chamber 6 from said first wall portion 4a towards said centre area 6a, and similarly the second pipe portion 8b penetrates the vessel 2 to extend linearly inside the separation chamber 6 from said second wall portion 4b towards said centre area 6a. Therefore, as can be understood from Figs. 1 and 2, the length of the pipe structure 8 may suitably be larger than the external diameter of the vessel 2. In a general sense, the aggregate length of the first pipe portion 8a and the second pipe portion 8b may suitably be larger than the external diameter of the vessel 2, irrespective of if the first pipe portion 8a and the second pipe portion 8b have been joined together or are mounted as individual non-connected pieces. Although not illustrated in the drawings the first end 12 having the pipe inlet 10, as well as the second end 16 having the pipe outlet 14, may suitably be provided with annular flanges for connecting to mating flanges of pipes to which the cyclone separator 1 is to be connected.

[0068] As shown in the drawings, see in particular Fig. 1, the pipe structure 8 may have a substantially cylindrical outer surface 26 which extends across the separation chamber 6, wherein the first, second and optional third openings 20, 22, 24 are provided in the cylindrical outer surface 26. In particular, the outer surface 26 of the pipe structure 8 may have the shape of a circular cylinder (provided with said openings 20, 22, 24) extending diametrically across and through the vessel 2 and protruding on diametrically opposite sides of the vessel 2. In a more general sense, it can be understood that each one of the first and second pipe portions 8a, 8b may have a substantially cylindrical outer surface, wherein said openings 20, 22, 24 are provided in the cylindrical outer surface.

[0069] As has been discussed elsewhere in this disclosure, in the case of an integral pipe structure 8, the cylindrical extension of the pipe structure 8 may be formed in one integral cylindrical piece, or it may be formed by joining two or more cylindrical pieces. Such different alternatives are illustrated in Figs. 3 and 4.

[0070] Fig. 3 illustrates a pipe structure 8 for use in a cyclone separator in accordance with at least one exemplary embodiment of the present disclosure. In this example the pipe structure 8 is formed as a single through-pipe configured to extend all the way across the separation chamber of the vessel, i.e. the first pipe portion 8a and the second pipe portion 8b may be formed seamlessly in one piece. Thus, the pipe structure 8 comprises a cylinder shape provided with said openings 20, 22, 24 and said blocking wall 18, wherein the cylinder is intended to extend in one piece all the way across the separation chamber.

[0071] Fig. 4 illustrates a pipe structure 8 for use in a cyclone separator in accordance with at least another exemplary embodiment of the present disclosure. In this example the pipe structure 8 is formed as two pipe pieces that have been joined together. In particular, the pipe structure 8 is formed by the two cylindrical pipe portions 8a, 8b having been joined together. From a manufacturing perspective, this provides the advantage that any connecting flange at the first end having the pipe inlet and at the second end having the pipe outlet may conveniently be provided to the respective pipe portion 8a, 8b before the pipe portions 8a, 8b are mounted to the vessel from a respective side and then joined inside the vessel. The two pipe portions 8a, 8b may, for example, be joined with grooves, cold pressing, welding, etc. Suitably, one of the pipe portions 8a, 8b may be provided with the blocking wall 18, the other one does then not need to have an additional blocking wall. Once assembled, the function of the pipe structure 8 will be the same in the example of Fig 4 as in the example of Fig. 3. The two examples just represent two different ways to provide a pipe structure 8 with an inlet zone on one side of the blocking wall 18 and an outlet zone on the other side of the blocking wall 18. From the above discussion, and the example shown in Fig. 4, it can thus be understood that, in at least some exemplary embodiments, the pipe structure 8 may comprise two cylindrical pipe portions 8a, 8b that have been joined together, wherein the first opening 20 is provided in one of the cylindrical pipe portions 8a and wherein the second opening 22 (and the optional third opening 24) is provided in the other one of the cylindrical pipe portions 8b.

[0072] Turning back to Figs. 1 and 2, an optional separation plate 28 may be provided which extends across the separation chamber 6 and divides the separation chamber 6 into a cyclone zone 30 on one side of the separation plate 28 and a settling zone 32 on the other side of the separation plate 28. When the liquid in its spiral motion reaches said one side (facing the cyclone zone 30) of the separation plate 28, the separation plate 28 will cause the liquid to turn to follow said axial returning motion towards the pipe arrangement 7 (in particular towards the second opening 22 of the pipe arrangement 7). One or more orifices 34 are present at the separation plate 28 to allow precipitated solid particles to reach and be collected in the settling zone 32 on the other side of the separation plate 28. Since the particles, due to the cyclone effect, will mainly be located near the circumferentially extending wall 4 of the vessel 2, the one or more orifices 34 are suitably located at the periphery of the separation plate 28.

[0073] Fig. 5 illustrates a cyclone separator 50 according to at least another exemplary embodiment of the present disclosure. In addition to the components included in the cyclone separator 1 in the example of Fig. 1, the cyclone separator 50 in Fig. 5 further comprises a magnet 52 for trapping magnetic particles. The magnet 52 is provided in the settling zone 32 of the separation chamber 6. Suitably, the magnet 52 may be located near the wall 4 where most particles will be present. As most ferrite particles are very small in size, typically between 1 to 50 μm in diameter, they may not precipitate as easily as heavier particles. By trapping such small ferrite particles with the magnet 52, the risk of re-entrainment of those small ferrite particles into the cyclone zone 30 is reduced.

[0074] It should, however, be understood that such a magnet 52 may also be placed in other locations within the vessel 2, and that there may be provided more than one magnet 52 in the vessel 2. Fig. 6 illustrates a cyclone separator 60 according to at least yet another exemplary embodiment of the present disclosure. In this example, a magnet 52 is provided at the other end of the vessel 2, where liquid exits the pipe arrangement 7 through the third opening 24. In the example of Fig. 6 there is not illustrated a separation plate, however, it should be understood that a separation plate may, of course, be included also in this example.

[0075] Fig. 7 illustrates a cyclone separator 70 according to at least a further exemplary embodiment of the present disclosure. Fig. 8 illustrates a cross-sectional view of the cyclone separator 70 in Fig. 7. In installations where the vessel 2 is installed in the illustrated upright standing manner, gas bubbles may become gathered at the top of the vessel 2. Therefore, the vessel 2 may suitably be provided with a vent 72 at the end of the vessel 2 which will be the upper end when the cyclone separator 70 is installed. The vent 72 may, for example, be provided in a removable lid of the vessel 2. Conversely, for removing particles that have been collected at the opposite end of the vessel 2, such as in a settling zone 32, the vessel 2 may suitably be provided with a drain 74, through which particles may be removed. Any suitable valves may also be provided at the vent 72 and the drain 74. Furthermore, as illustrated in Figs. 7 and 8, there may be provided an access port 76 through the vessel 2 allowing access from outside of the vessel 2 to the inside of the vessel 2, here illustrated as mouthing at the circumferentially extending wall 4 and in the settling zone 32. The access port 76 may, for instance, be used for inserting and mounting a magnet into the vessel 2. In case the vessel 2 is to be installed in a horizontally lying manner, then the access port 76 may suitably face downwards and be used as a drain, e.g., by mounting a suitable valve to the access port 76, wherein collected particles may be removed through the access port 76 instead of through the previously discussed drain 74.

[0076] The provision of a vent 72, a drain 74 and/or an access port 76 may be included in other exemplary embodiments as well. For instance, in some exemplary embodiments the optional separation plate and/or the optional third opening may be omitted.

[0077] Fig. 9 illustrates a cyclone separator 80 according to at least a still further exemplary embodiment of the present disclosure. In comparison to the example of Fig. 1, the cyclone separator 80 in Fig. 9 has been turned upside-down. Furthermore, the cyclone separator 80 in Fig. 9 does not have the third opening, but only the first opening 20 and the second opening 22. This upside-down installation may be particularly useful for air separation. The vortex induced by the second opening 22 allows air separation by increasing air coalescence in the cyclone, which in turn facilitates bubbles to float into a top air venting (not illustrated). Since the vessel 2 has been turned upside down, a relatively large volume of the separation chamber 6 is available above the pipe structure. This relatively large volume increases the probability of coalescence. The first opening 20 may suitably have an upwards angle of inclination relative to the horizontal to promote an upwards spiral cyclone motion of the liquid exiting the first opening 20.

[0078] Thus, from the above explanation, and with reference to Fig. 9, it should be understood that, in at least some exemplary embodiments, the cyclone separator 80 may be configured to separate air from liquid, in particular from water, wherein the cyclone separator 80 is configured to be installable such that the circumferentially extending wall 4 extends vertically and the pipe arrangement extends horizontally and is located near the lower end of the vessel 2, wherein the first opening 20 directs the liquid exiting the pipe structure in an upwards spiral cyclone motion.

[0079] Figs. 10 and 11 illustrate a pipe arrangement for use in a cyclone separator in accordance with at least some exemplary embodiments of the present disclosure. Figs. 10 and 11 illustrate that the first pipe portion 8a and the second pipe portion 8b are separate pieces that are not fastened to each other. Therefore, each one of the pipe portions 8a, 8b, may suitably be provided with a respective blocking wall 18a, 18b. A first blocking wall 18a is provided in the first pipe portion 8a, and a second blocking wall 18b is provided in the second pipe portion 8b. The first opening 20 will still be located in the first pipe portion 8a, and more specifically between the first blocking plate 18a and the pipe inlet 10. The second opening 22 and the optional third opening 24 will still be located in the second pipe portion 8b, and more specifically between the second blocking plate 18b and the pipe outlet 14. As furthermore illustrated in Figs. 10 and 11, the first pipe portion 8a and the second pipe portion 8b do not necessarily need to be perfectly aligned with each other. For instance, in Fig. 10 they are shown with a small lateral offset relative to each other, and in Fig. 11 with a small vertical offset.

Claims

1. A cyclone separator, comprising:

- a vessel having a circumferentially extending wall defining a separation chamber,
- a pipe arrangement comprising a first pipe portion and a second pipe portion, wherein the first pipe portion penetrates the vessel to extend linearly inside the separation chamber from a first wall portion of said circumferentially extending wall towards a centre area of the separation chamber, in particular linearly in a radial direc-

tion of the separation chamber,
wherein the second pipe portion penetrates the vessel to extend linearly inside the separation chamber from a second wall portion of said circumferentially extending wall towards said centre area of the separation chamber, in particular linearly in a radial direction of the separation chamber,
wherein the second wall portion is located opposite the first wall portion,
wherein the pipe arrangement comprises

a pipe inlet for receiving, into the first pipe portion, liquid to be processed in the cyclone separator, and
a pipe outlet for outputting, from the second pipe portion, liquid that has been processed in the cyclone separator,

wherein the pipe arrangement further comprises

a blocking wall preventing at least a major part of the liquid from flowing directly from the first pipe portion to the second pipe portion,
wherein the first pipe portion comprises a first opening, the first opening being provided between the pipe inlet and the blocking wall, and
wherein the second pipe portion comprises a second opening,

wherein liquid received through the pipe inlet is diverted by the blocking wall to exit the pipe arrangement through said first opening, which is oriented such that the liquid exiting through the first opening is caused to flow in a spiral cyclone motion in the separation chamber along the circumferentially extending wall of the vessel so as to separate non-liquid matter from the liquid, the spiral cyclone motion of the liquid being followed by an axial returning motion of the liquid towards the second pipe portion, wherein the second opening is oriented to receive the liquid flowing in said axial returning motion so that the liquid flowing in said axial returning motion re-enters the pipe arrangement by entering through the second opening into the second pipe portion, enabling at least a part of the re-entered liquid to leave the pipe arrangement through the pipe outlet.

2. The cyclone separator as claimed in claim 1, wherein the second pipe portion further comprises a third opening located opposite to the second opening, thereby enabling a part of the liquid that has reentered the pipe arrangement through the second opening to exit through the oppositely located third opening for continued processing of the liquid.

3. The cyclone separator as claimed in any one of claims 1-2, wherein the vessel has a geometrical centre axis, wherein the second opening is intersected by said geometrical centre axis.

4. The cyclone separator as claimed in claim 3 when dependent on claim 2, wherein the third opening is also intersected by said geometrical centre axis.

5. The cyclone separator as claimed in any one of claims 3-4, wherein the blocking plate diverts the liquid to the first opening to exit in a direction substantially perpendicularly to the geometrical centre axis, but without intersecting the geometrical centre axis.

6. The cyclone separator as claimed in claim 3 or any one of claims 4-5 when dependent on claim 3, wherein the first and second pipe portions extend in a direction perpendicularly to the geometrical centre axis.

7. The cyclone separator as claimed in any one of claims 1-6, wherein the each one of the first and second pipe portions has a substantially cylindrical outer surface, wherein said openings are provided in the cylindrical outer surface.

8. The cyclone separator as claimed in any one of claims 1-7, wherein the first pipe portion is formed in one piece with the second pipe portion, and together they define a continuous cylindrical outer surface extending in one piece all the way across the separation chamber, wherein the continuous cylindrical outer surface is provided with said openings and wherein said blocking wall is located between the pipe inlet and the pipe outlet.

9. The cyclone separator as claimed in any one of claims 1-7, wherein the first and second pipe portions are formed as two pieces that have been joined together.

10. The cyclone separator as claimed in any one of claims 1-7, wherein the first and second pipe portions are formed as two separate pieces, in particular as two pieces that are not joined together, wherein said blocking wall is a first blocking wall provided in the first pipe portion, wherein the pipe arrangement further comprises a second blocking wall provided in the second pipe portion, wherein the second opening is provided between the second blocking wall and the pipe outlet.

11. The cyclone separator as claimed in any one of claims 1-10, further comprising a separation plate

extending across the separation chamber and dividing the separation chamber into a cyclone zone on one side of the separation plate and a settling zone on the other side of the separation plate, wherein when the liquid in its spiral cyclone motion reaches said one side of the separation plate, the liquid turns to follow said axial returning motion towards the pipe arrangement, wherein one or more orifices are present at the separation plate to allow precipitated solid particles to reach and be collected in the settling zone on said other side of the separation plate.

12. The cyclone separator as claimed in any one of claims 1-11, further comprising a magnet for trapping magnetic particles.

13. The cyclone separator as claimed in claim 12 when dependent on claim 11, wherein the magnet is provided in said settling zone of the separation chamber.

14. The cyclone separator as claimed in any one of claims 1-13, wherein the cyclone separator is configured to separate solid particles from liquid, in particular from water, wherein the pipe arrangement is arranged in such way that the side of the second pipe portion that presents the second opening faces a relatively larger volume of the separation chamber, whereas the opposite side of the second pipe portion faces a relatively smaller volume of the separation chamber.

15. The cyclone separator as claimed in any one of claims 1-13, wherein the cyclone separator is configured to separate air from liquid, in particular from water, wherein the cyclone separator is configured to be installable such that the circumferentially extending wall extends vertically and the pipe arrangement extends horizontally and is located near the lower end of the vessel, wherein the first opening directs the liquid exiting the pipe arrangement in an upwards spiral cyclone motion.

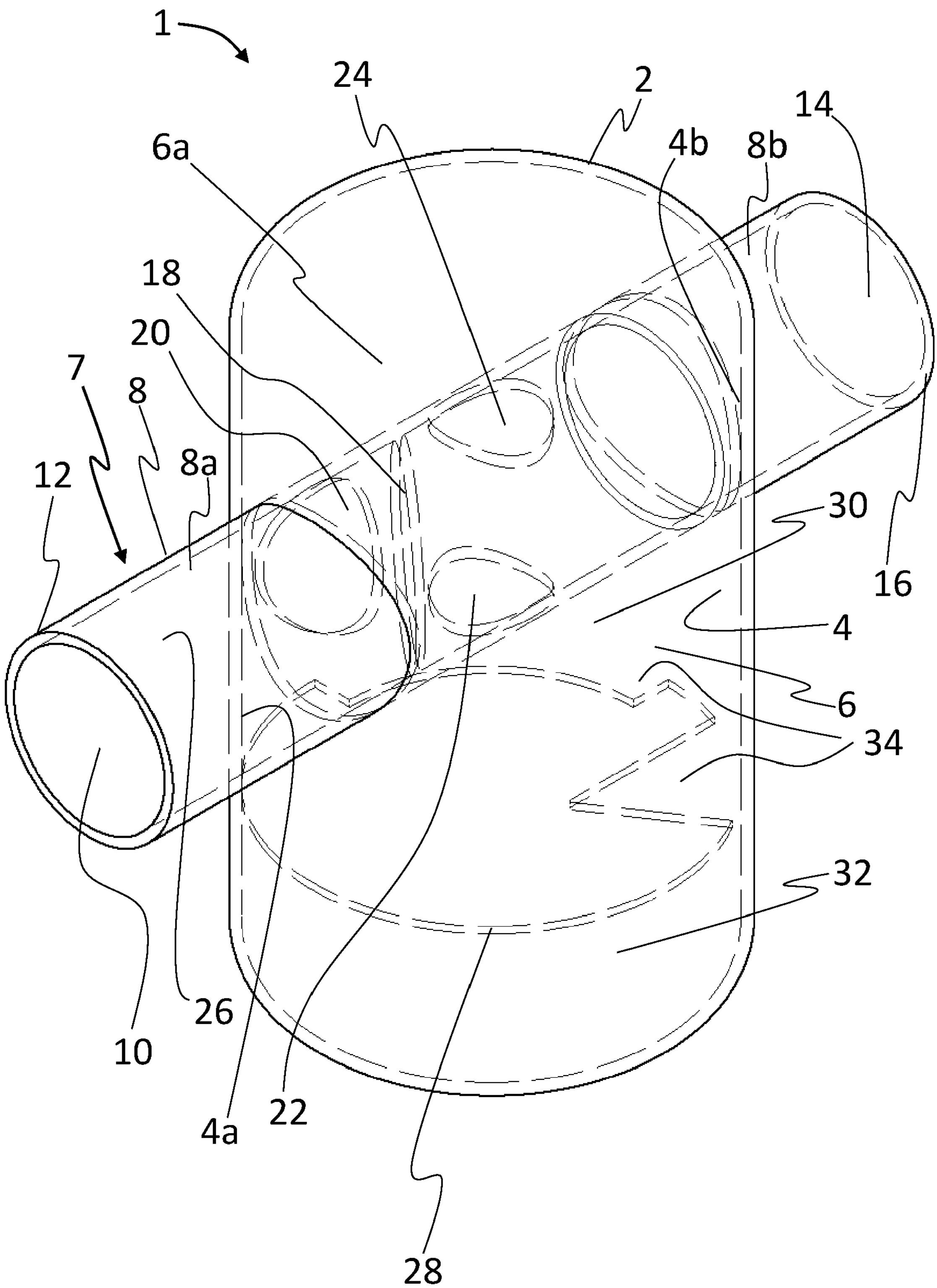

Fig. 1

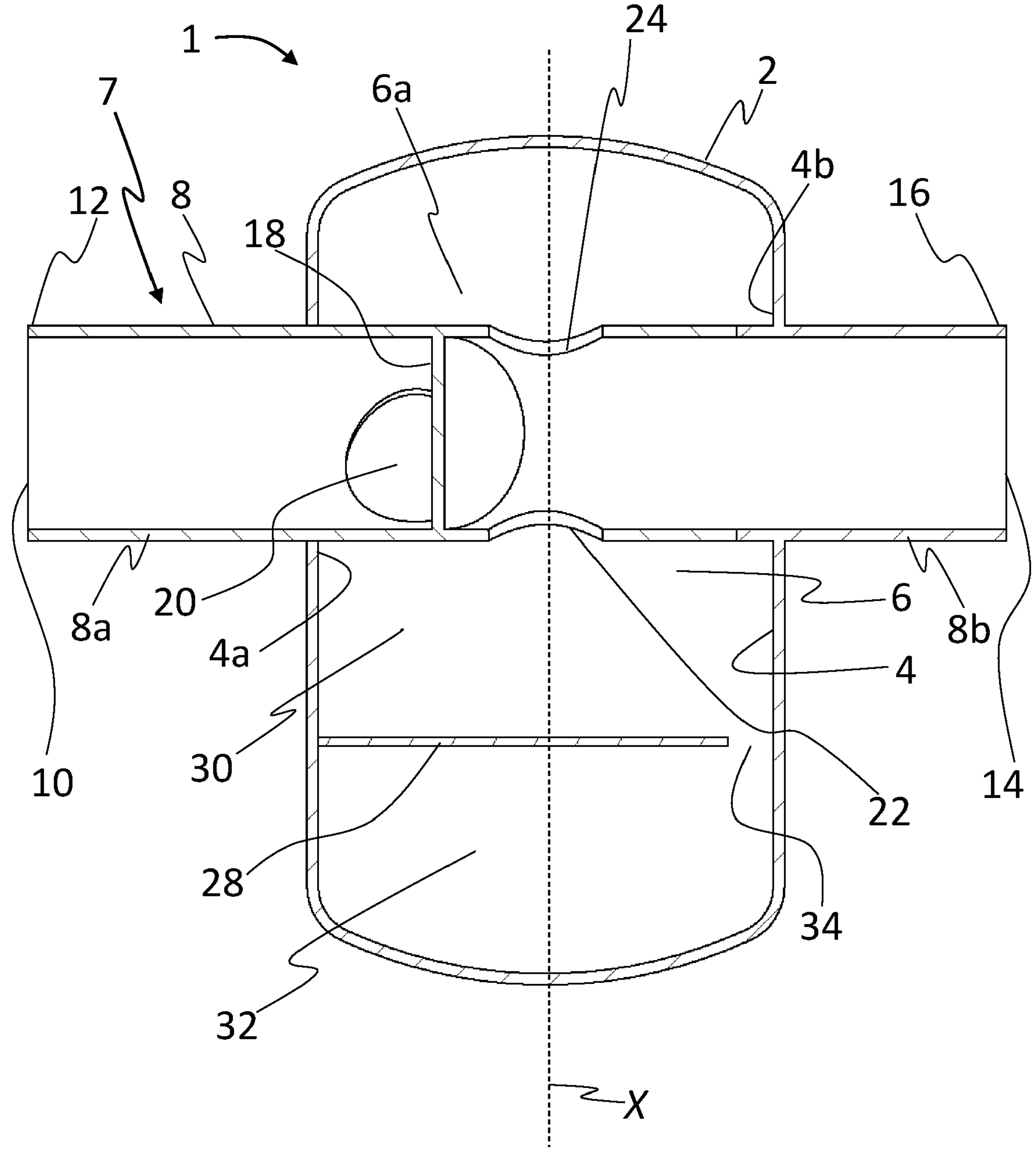

Fig. 2

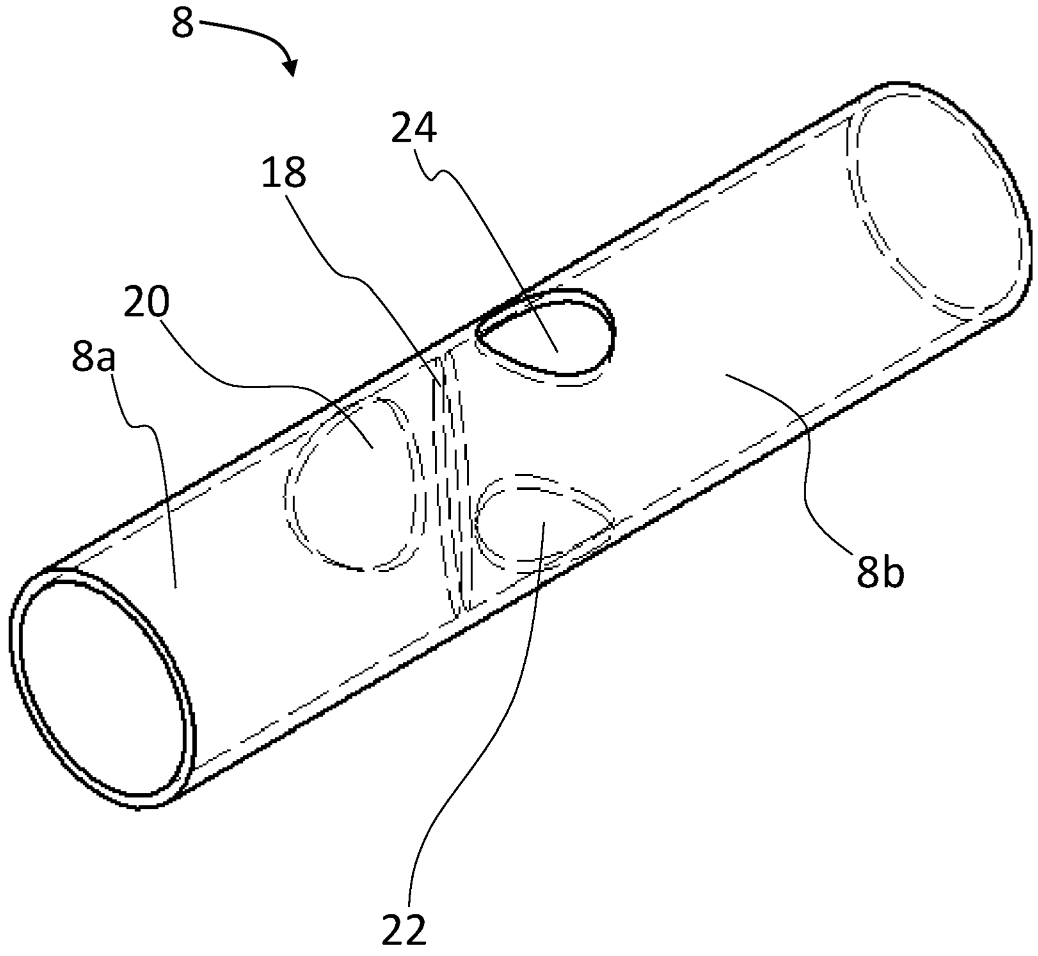

Fig. 3

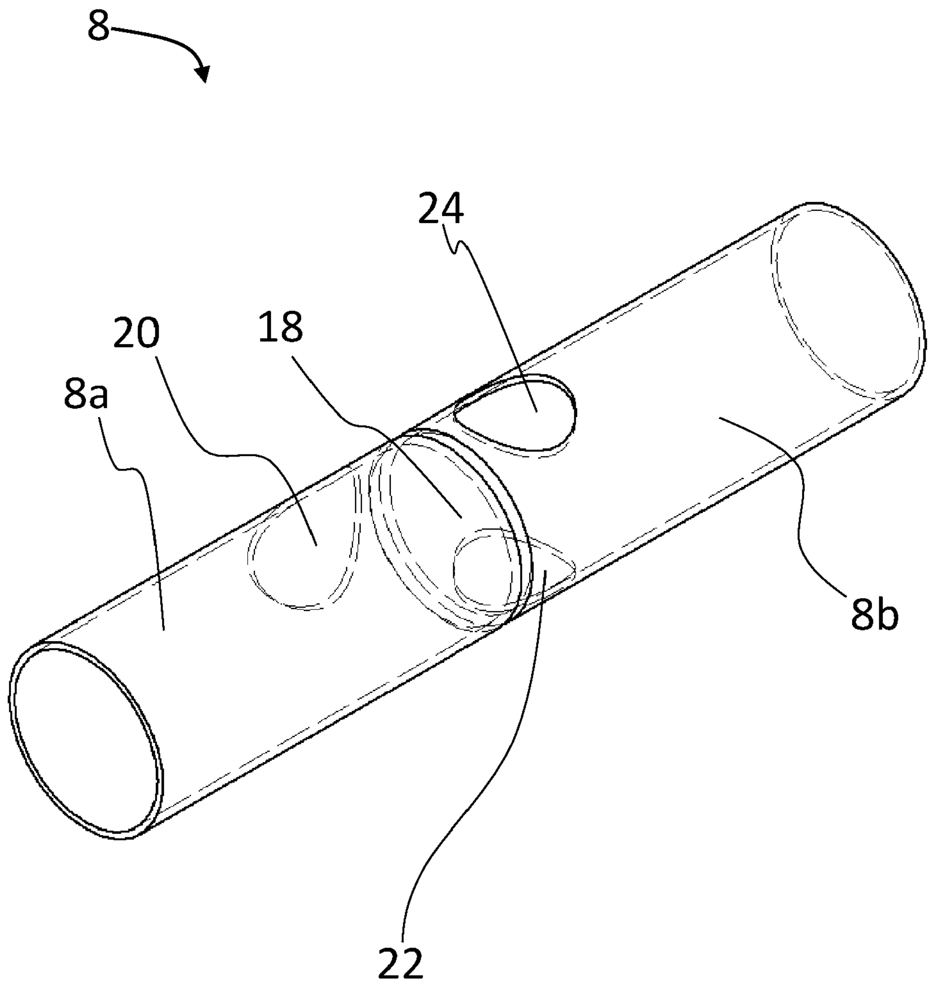

Fig. 4

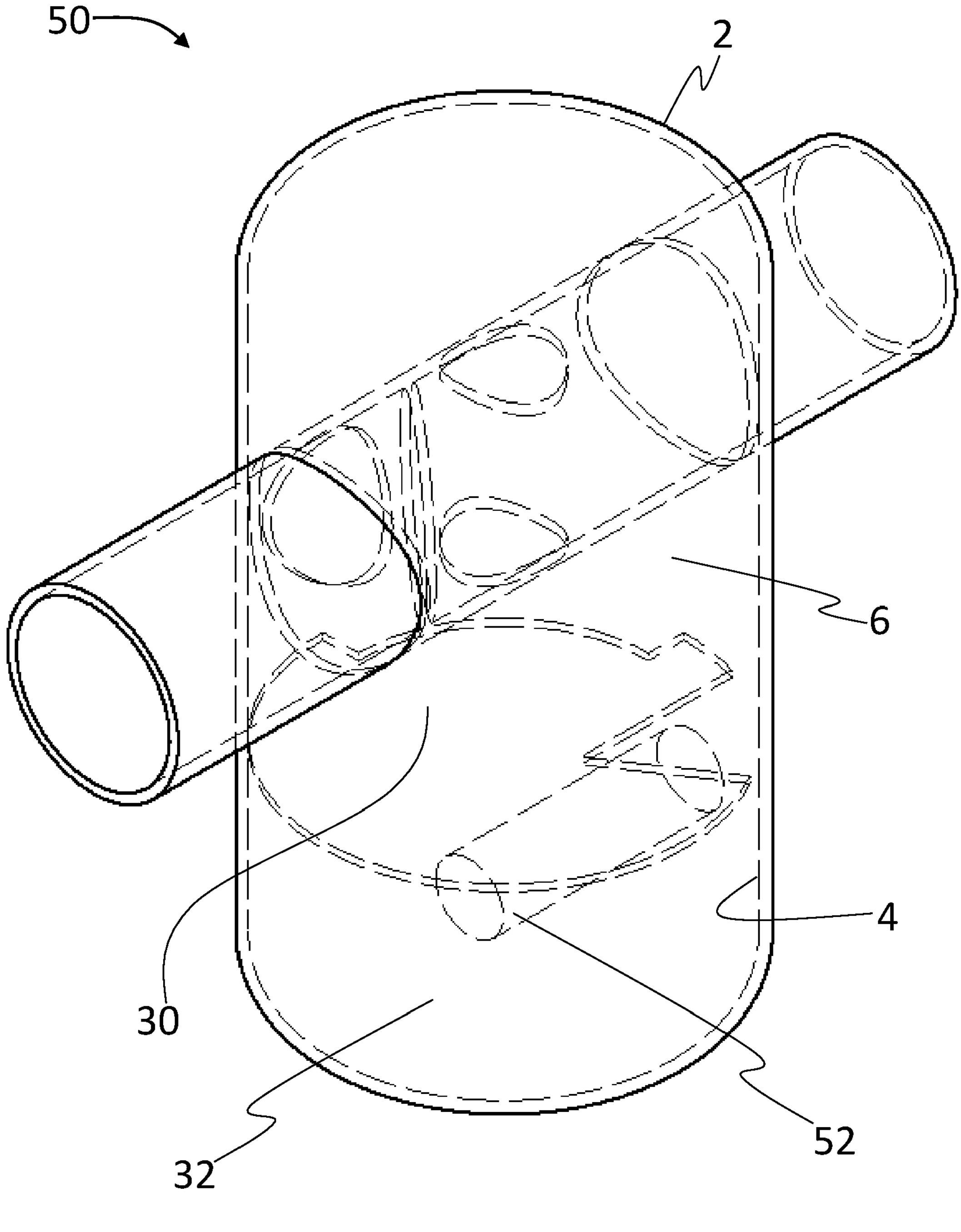

Fig. 5

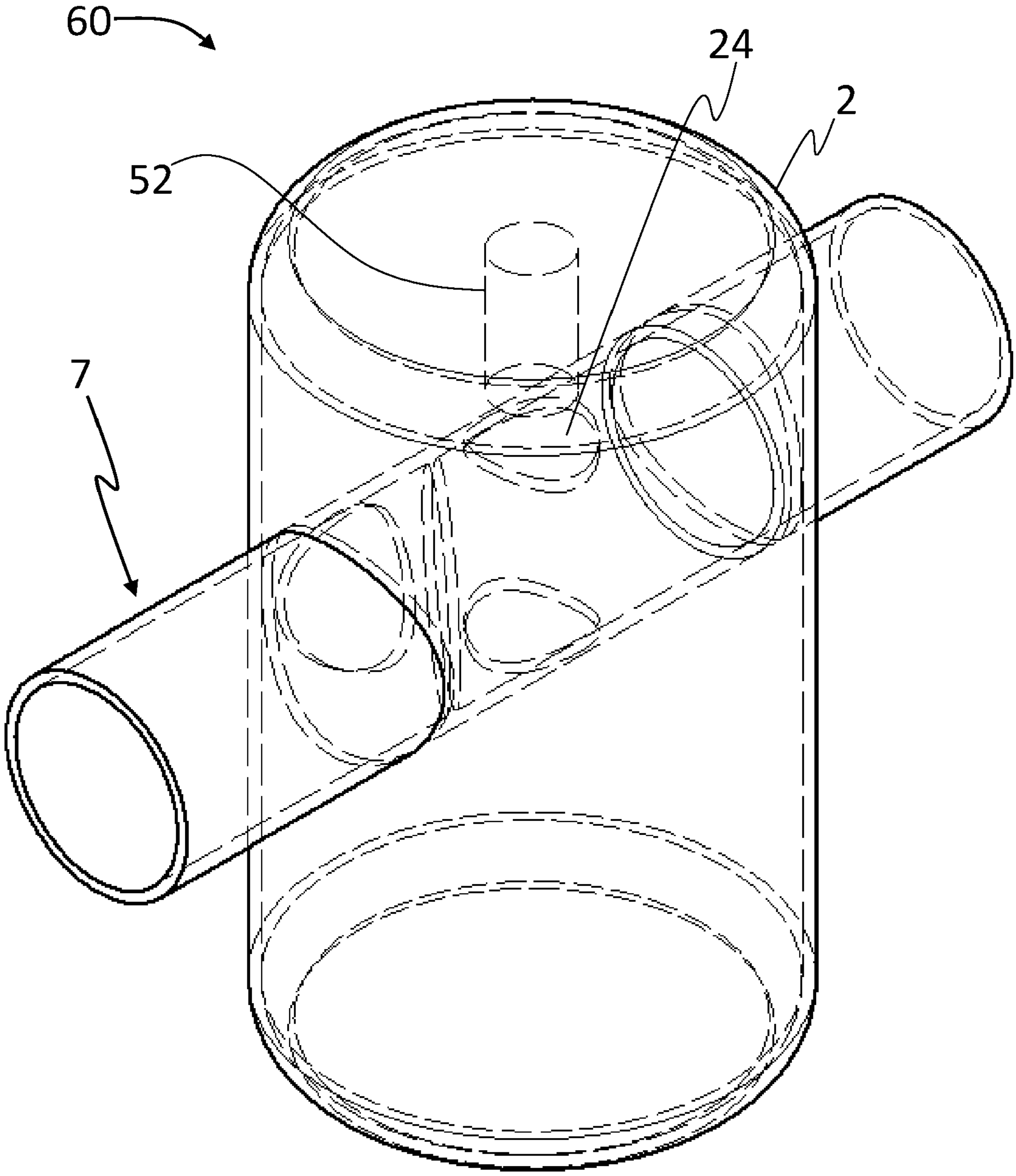

Fig. 6

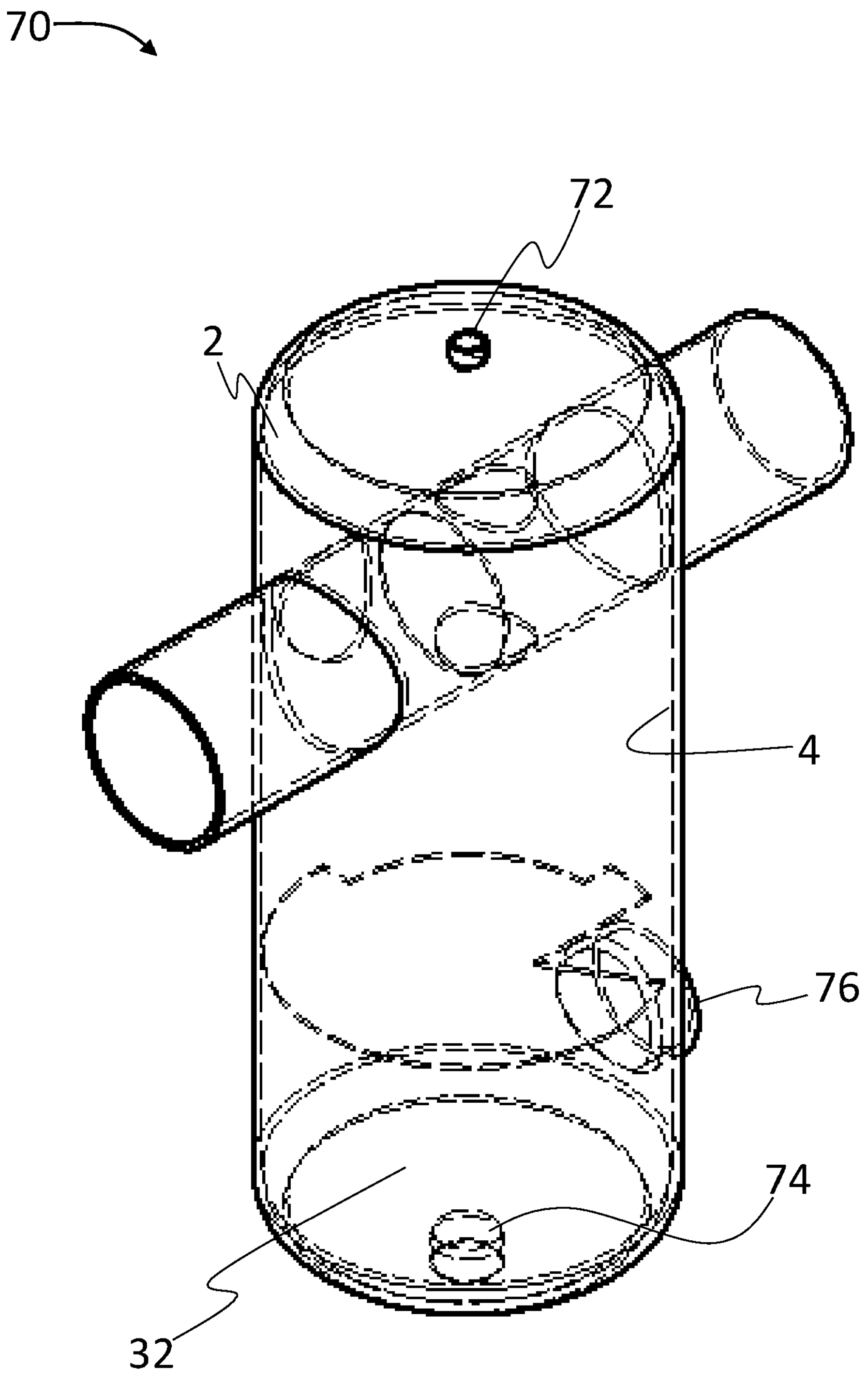

Fig. 7

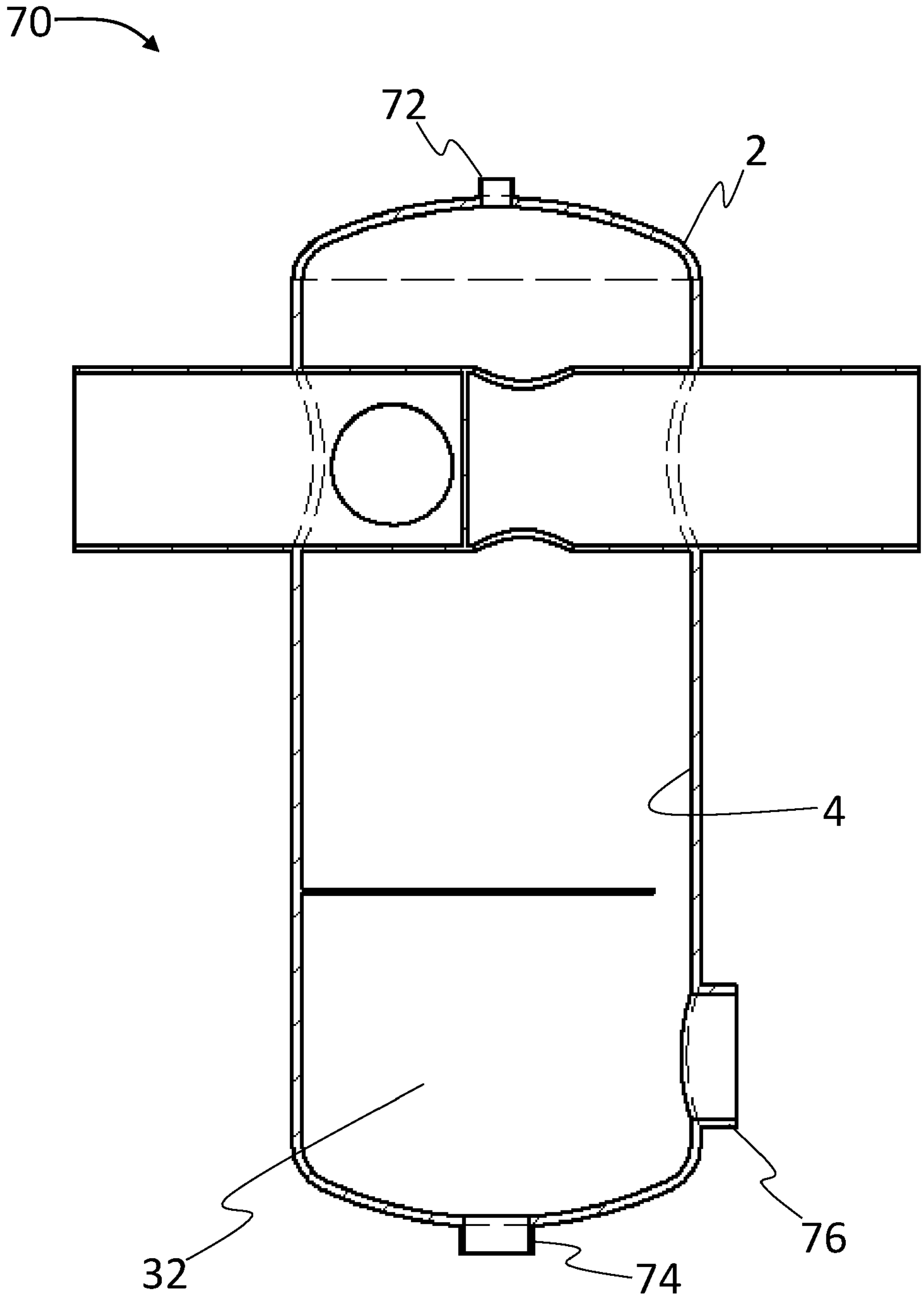

Fig. 8

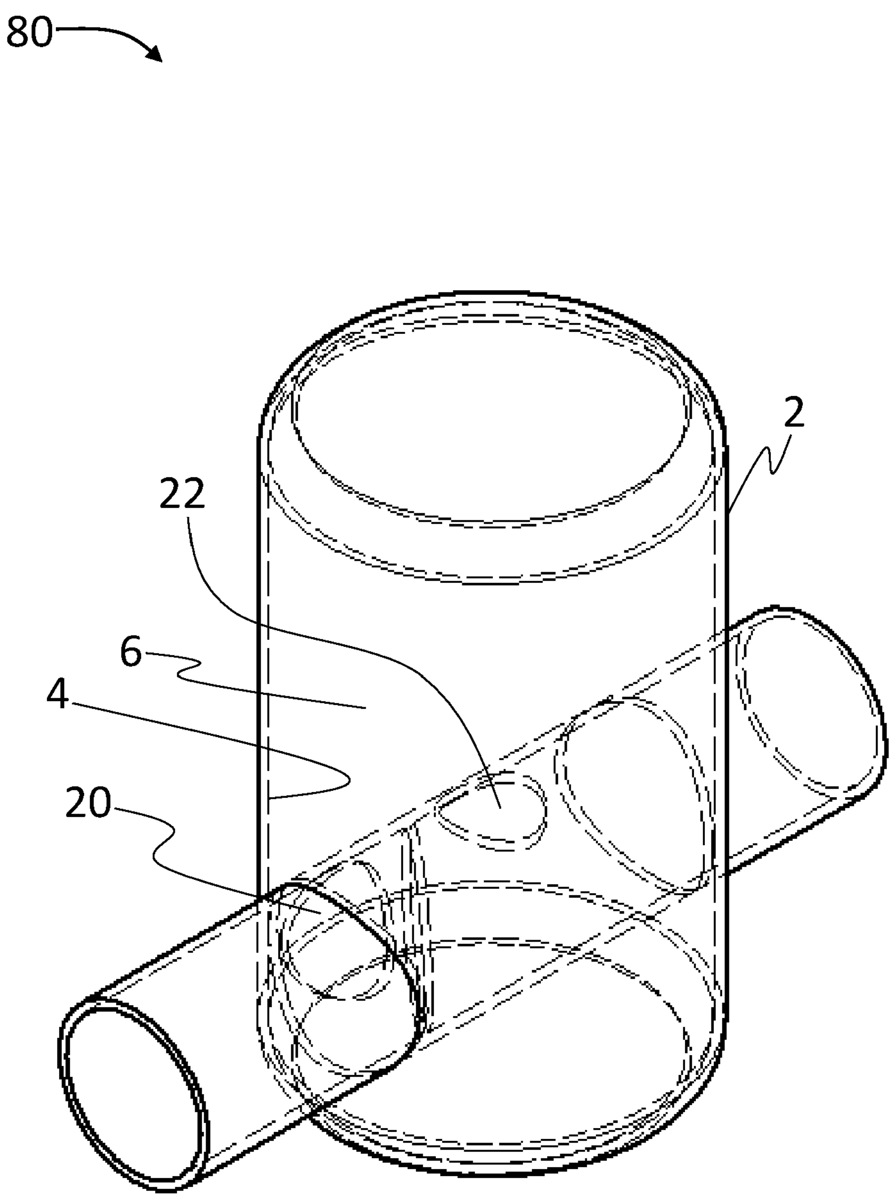

Fig. 9

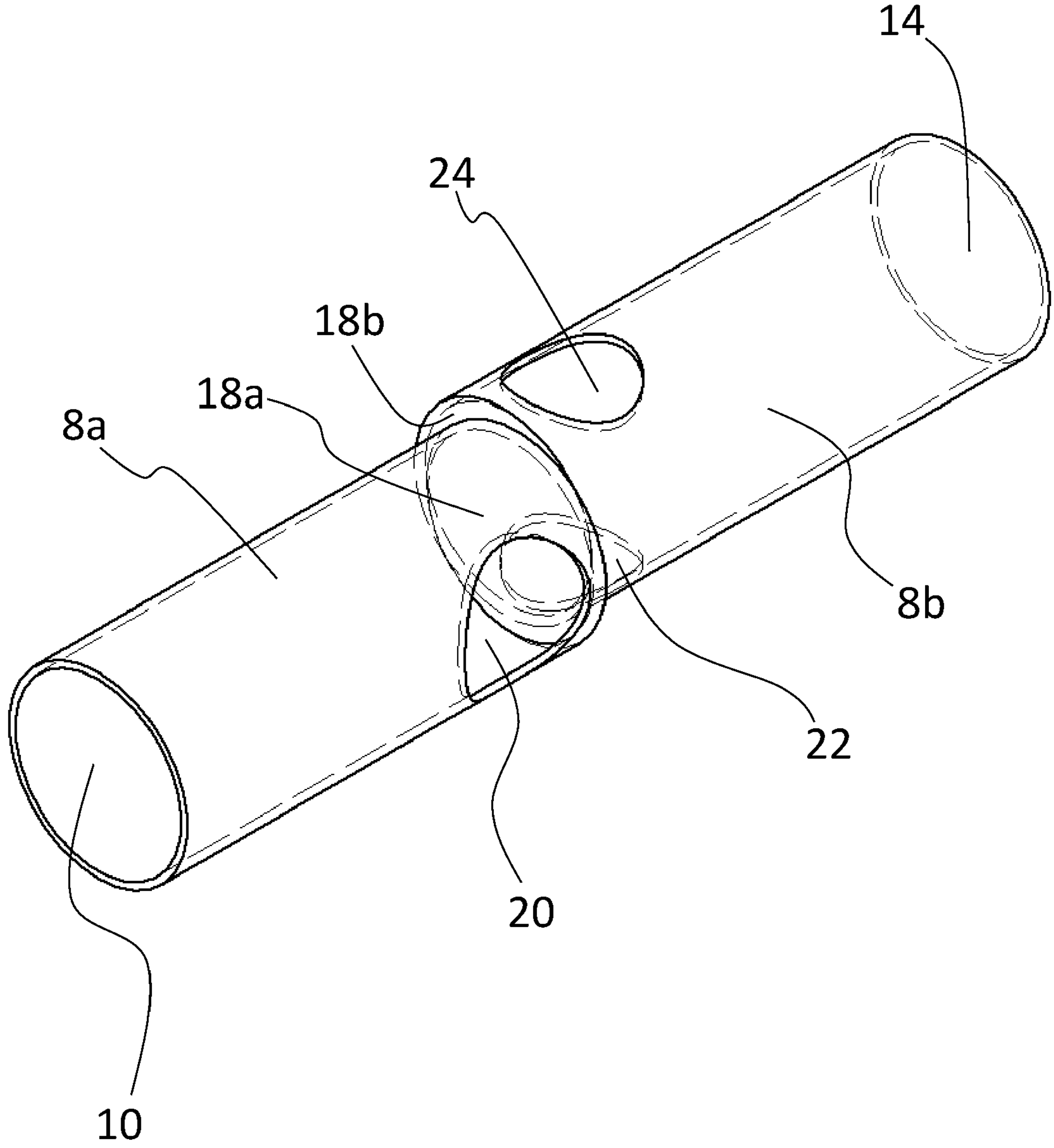

Fig. 10

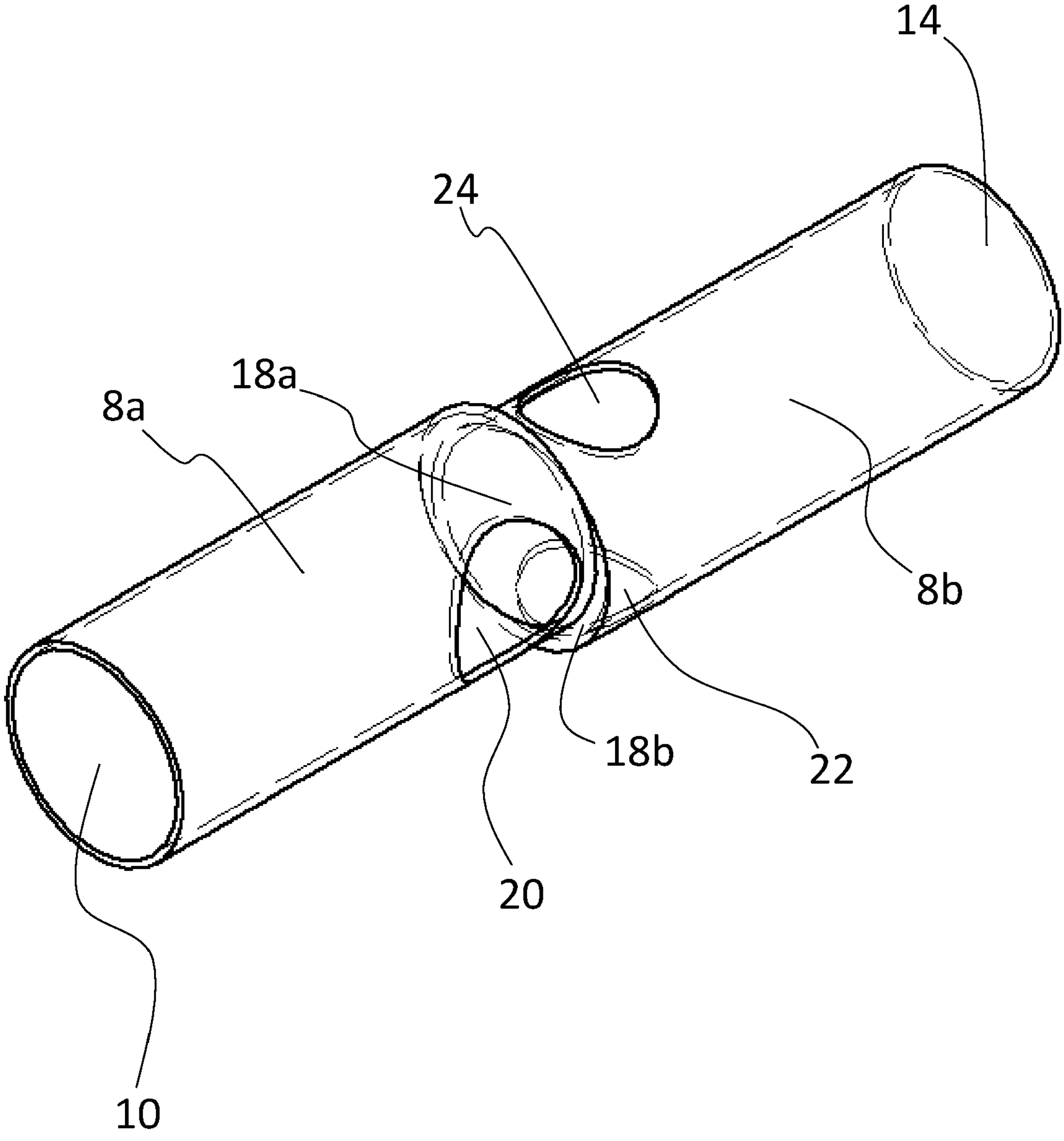

Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 23 19 0215

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y A	US 3 898 068 A (MCNEIL JOHN A) 5 August 1975 (1975-08-05) * column 2, line 25 - column 5, line 22; figures 1-3 * -----	1,3 5,6,9, 11-15 2,4,7,8, 10	INV. B04C5/04 B04C5/08 B04C5/103 B04C5/14
Y A	US 2017/274300 A1 (BOBBERT MARKUS [CH] ET AL) 28 September 2017 (2017-09-28) * paragraphs [0007] - [0044], [0059] - [0082]; figures 1-6,12-16 * -----	5,6,9, 11-15 2,4,7,8, 10	
			TECHNICAL FIELDS SEARCHED (IPC)
			B04C B01D

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	12 February 2024	Iuliano, Emanuela

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 19 0215

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12-02-2024

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US 2017274300 A1	28-09-2017	EP 3222357 A1	27-09-2017
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