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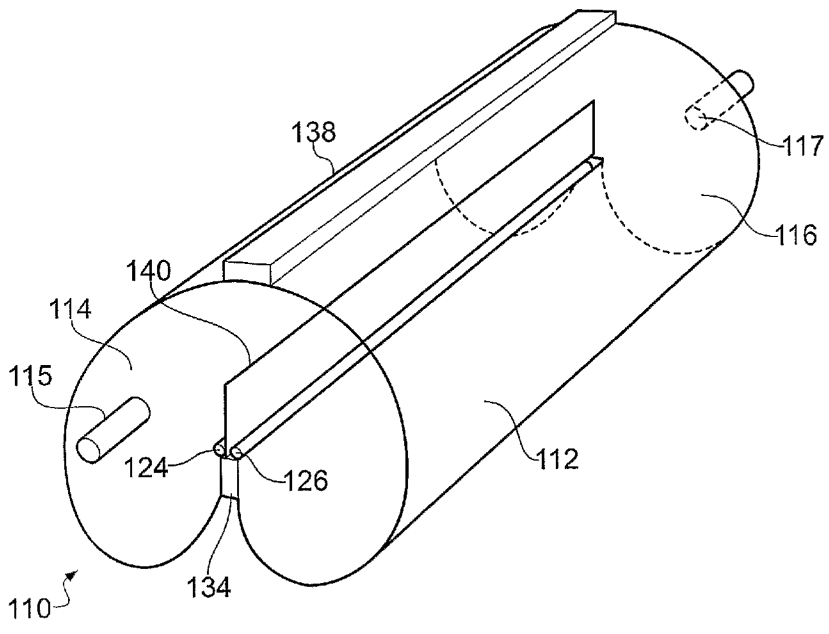

Fig. 3

(57) Abstract: Apparatus for treating a process fluid, comprising: a treatment chamber (10); means (24, 26) for introducing a fluid into the chamber to drive circulation of process fluid therein; and at least one longitudinal baffle plate (20, 22) extending along at least part of the length of the chamber.

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APPARATUS FOR PROCESSING FLUIDS

The present invention relates generally to apparatus for processing fluids and particularly, although not exclusively, to apparatus for the treatment of slurries comprising solids in liquids.

One technical field in which such slurries occur is in the treatment of organic material by bacteriological action, especially the so-called slurry digestion processes which are known for the treatment of organic waste materials.

The present invention provides improved apparatus in which complex treatment processes, particularly biological processes can take place.

The present invention provides apparatus for treating a process fluid, comprising:

- a treatment chamber;
- means for introducing a fluid into the chamber to drive circulation of process fluid therein; and
- at least one longitudinal baffle plate extending along at least part of the length of the chamber.

By providing one or more baffle plates the circulation of process fluid can be improved.

The container may be at least partly curved. For example the container may comprise a minimum energy shape tank of the type described in GB2355673.

Curved containers may comprise or include roulette curves such as trochoids.

A twin-lobe structure with a cusp is possible, with driving fluid being introduced at or in the region of the cusp.

In a preferred, elongate form of the container, a baffle arrangement extends longitudinally along the container and flows are set up in opposite senses in two halves of the chamber on opposite sides of a plane defined by the baffle.

For example, the chamber may have a generally cardioid (but not necessarily a trochoid) cross-sectional shape. The fluid delivery means may introduce fluid at or in the vicinity of the cusp of the cardioid chamber.

The or each baffle plate may be curved. For example the plate may be concavely curved.

Two opposing baffle plates may be provided and extend from either end of the chamber. In one embodiment two concavely curved plates extend towards each other from each end of the chamber.

The or each baffle plate may be a generally triangular wing-like stabilising member.

The or each baffle plate may be connected to an end wall of the chamber. This can serve to strengthen the end wall.

The means for introducing fluid, such as a gas and/or a liquid, into the chamber may comprise one or more elongate fluid delivery tubes. The fluid delivery tube/s may run alongside the baffle plate/s. In some embodiments the curvature of the baffle arrangement defines at least in part the positioning of the tubes, with the tubes following the curvature.

The introduction of a fluid into the treatment chamber may be undertaken simply to drive the circulation of the process fluid within the vessel, in which case the fluid may be chosen as one contributing to the maintenance of aerobic or anaerobic conditions as the case may require, or alternatively the fluid may be one which takes part in the reaction proceeding within the vessel.

Embodiments of the present invention may be formed as a treatment vessel for a process involving biological action on organic process materials comprising a solid/liquid or liquid/liquid slurry or mixture, in which circulation of the process material is driven by introducing fluid at a low level within the vessel and allowing bubbles thereof to rise.

The fluid delivery means comprising one or more fluid outlets could be along or adjacent one side of the chamber but, for ease of manufacture, the chamber may be mirror-imaged about a longitudinal plane of symmetry, the fluid being introduced along the plane of symmetry so as to set up two circulatory flows in the two halves of the container, one on either side of the plane of symmetry. The two flows are driven in opposite senses by the rising fluid stream, in use, with a vertically upward flow in the centre of the container which diverges in the upper layers of the liquid into the two halves, each flow being constrained by the shape of the chamber wall to fall along an outer wall portion and then being directed back to the centre along the bottom of the container. Although two flows are set up in the opposite halves, there may be an exchange of material between the two halves across the central plane of symmetry so that the entire contents of the container mix homogeneously while they are in the container.

The or each baffle plate may extend, in use, from the region of the lowest part of the treatment chamber.

As mentioned above, the fluid outlets need not be in the lowermost part of the chamber. In a mirror-imaged chamber they may be located between two curved wall portions forming the bottoms of the two halves, the ends of these wall portions projecting upwardly towards the centre of the chamber where they are interconnected with fluid-supply means located between them. The outer ends of the wall portions are preferably interconnected by a wall portion which forms the top of the tank and which forms continuous curves with the lower wall portions. The very top of the chamber may define a header space in which fluid can accumulate before leaving the chamber through an upper outlet. The wall portion defining this space may have any configuration but may be formed as a continuous curve with the remaining parts of the upper wall such that the chamber as a whole has a generally cardioid section.

An inlet and an outlet for process fluid may be in opposite halves of the chamber and may be at opposite ends, although they could be in the same half and/or at the same end of the chamber. A combined inlet/outlet is also possible.

Regardless of the form of the chamber a treatment system for a process fluid may comprise a plurality of such chambers in sequence, and may be so arranged that different processes take place in different vessels.

The present invention also provides a treatment system comprising a plurality of chambers, as described herein. The chambers may be serially connected and/or may be cross-connected to allow transfer of process fluid therebetween.

The present invention will now be more particularly described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is an end elevation of a treatment chamber formed according to a first embodiment of the present invention;

Figure 2 is a side view of the chamber of Figure 1;

Figure 3 is a perspective view of a treatment chamber formed according to an alternative embodiment;

Figure 4 is a section of the chamber of Figure 3;

Figure 5 is a perspective view of a baffle arrangement and fluid delivery system formed according to an alternative embodiment of the present invention;

Figure 6 is a perspective view of the baffle/fluid delivery assembly of Figure 5 shown incorporated into a treatment chamber; and

Figure 7 is a perspective view of a plurality of treatment chambers of the type shown in Figure 6 assembled together to form a treatment system.

Referring first to Figures 1 and 2 there is shown a treatment chamber generally indicated 10. The chamber 10 comprises a cylindrical sidewall 12 closed at both ends by flat end walls 14, 16. The end wall 14 comprises an inlet 15 and the end wall 16 comprises an outlet 17.

Along the bottom of the sidewall 12, a support stand 18 runs longitudinally between the end walls 14, 16. Two generally triangular wing-like baffle plates 20, 22 extend longitudinally from respective end walls 14, 16 supported on the stand 18. The baffle plates 20, 22 approach each other, but do not meet, towards the centre of the sidewall 12 and are generally concave so that a generally arcuate baffle arrangement is formed along the length of the chamber 10.

A fluid delivery system is provided in the form of a pair of elongate fluid delivery pipes 24, 26. The pipes 24, 26 are routed so as to run along the length of the chamber, commencing at one end wall, running down the end wall and then alongside the plates 24, 26 and then up the other end wall.

In use, the baffle plates 20, 22 serve to strengthen the end walls 14, 16. Furthermore, when fluid is introduced to the interior of the chamber through the pipes 24, 26, process fluid which enters through the inlet 15 is caused to circulate and the plates 20, 22 help with the circulation of process fluid so that it can be processed and exit through the outlet 17. The plates 20, 22 stop transfer of fluid from one side to another in the lower sections of the container; mixing therefore occurs higher up.

Referring now to Figures 3 and 4, the embodiment illustrated comprises a single elongate chamber 110 of uniform continually curved cross-section. The chamber 110 has a peripheral wall 112, an end wall 114 with an inlet duct 115, and an opposite end wall 116 with an outlet duct 117.

As can be seen best in Figure 4 the cross-sectional shape of the vessel 110 as illustrated gives rise to two separate regions generally indicated 130, 132 separated by a central median plane of symmetry on either side of which are located two rectilinear elongate fluid delivery pipes 124, 126 having rows of holes from which, in use, two rows of bubbles rise. The pipes 124, 126 are separated by a rectangular baffle plate 140 which extends longitudinally between the end walls 114, 116. The plate 140 helps to regulate the circulation of process fluid in the region of the cusp 134.

The inlet duct 115 at one end 114 of the chamber 110 opens into the first region 130, and the outlet duct 117 leads from the other region 132.
As the fluid rises through the slurry it drives an upward movement of the slurry in the region of the central median plane of the chamber 110. From the top of this central region, the slurry then flows in opposite directions towards the peripheral wall 112 which is so shaped as to direct the flows downwardly to the bottom portions of the container where the wall curvature, returning upwardly, also returns the flows upwardly back to the central region of the container. Thus two circulatory flows are set up in the opposite senses in the two regions 130, 132 of the chamber 110, these being indicated S1 and S2, the two flows converging and mixing in the central region. Thus there is exchange of material between the two halves and the entirety of the flow fed in through inlet 115 in one half in due course exits through the outlet 117 in the other half. In other words, process material introduced into the chamber 110 is caused to circulate first in one direction (anticlockwise as shown in Figure 4) as it passes along the first region and is caused to transit from one region 130 to the other region 132 across the bubbles where it circulates in the opposite direction (clockwise as viewed in Figure 4) as it passes through this region before exiting from the chamber 110 through the outlet 117.

The flow of slurry through the chamber 110 may be controlled by suitable pumps and/or valves (not shown) at the inlet 115 and outlet 117, as may the flow of fluid through the fluid inlet pipes 124, 126 the equipment being controllable manually or automatically. In the latter case in particular, the slurry flow within the chamber 110 may be monitored by suitable sensor and the results used to control the inflow of fluid to regulate it to the minimum required to maintain the circulatory flows S1 and S2 within the chamber 110. The fluid flow may be minimised either by maintaining a constant fluid flow at a low rate or by supplying the fluid intermittently at a higher rate, whichever is the most energy efficient for a given installation.

In use of the apparatus described in relation to Figures 3 and 4, particularly in relation to a process fluid comprising a slurry of organic waste material, aerobic or anaerobic breakdown of the organic animal and/or plant materials takes place giving rise to simple substances. These may include a high proportion of fluideous and soluble products. The fluideous products, which in particular may include methane and carbon dioxide, are drawn off from the manifold 138 at the top of the chamber 110.

Referring now to Figure 5 there is shown a baffle/fluid delivery arrangement generally indicated 250. The arrangement 250 comprises a base plate 252 from which upstand two baffle plates 254, 256 with concavely curved edges 254a, 256a similar to the plates 20, 22 shown in Figure 1. The plates 254, 256 are spaced from each other at the centre of the base plate 252 by a gap 258.

Four fluid delivery tubes 260a-d are associated with the baffle plates 254, 256. The tubes are arranged in two pairs 260a, 260b and 260c, 260d on either side of the baffle plates. Each tube passes down from above a respective baffle plate and follows the curvature of its curved edge until the gap 258 is reached. Thereafter the tube runs along the base plate. This means that the two tubes of a pair cross roughly in the region of the gap 250 and continue along the base plate 252.

Referring now to Figure 6 there is shown a chamber 210 formed according to an alternative embodiment. The chamber 210 is of a section similar to that shown in Figures 3 and 4.

At the cusp of the peripheral chamber wall 212 a baffle/fluid delivery arrangement 250 of the type shown in Figure 5 is provided. In this embodiment the baffle plates 254, 256 of the arrangement are connected to flat end walls (not shown) of the chamber 210.

Figure 7 illustrates a system 370 comprising a plurality of chambers of the type shown in Figure 6 (in this embodiment eight are illustrated although the array may comprise, for example, 4, 6 or a larger number of vessels. Each chamber 310 in the array has been identified with an appropriate suffix $_1$ through $_8$ to identify its position in the sequence. In this embodiment the chambers are arranged serially.

Each chamber comprises at each end a rectangular end plate 365 which abuts the end plate of the adjacent chambers. The juxtaposed end plates of the first two chambers 310_1, 310_2 in the series are shown ghosted so as to show the interior of the chamber 310_2. The end plates 365 contain inlet/outlet valve arrangements (not shown) to allow transfer of process fluid between successive chambers.

The chambers may be contained within a bath or lagoon (not shown) which is filled with a liquid to the same level as the process fluid in the tanks to equalise the pressures across the tank wall making it possible to use relatively thin sheet material, typically plastics, to contain the process fluid without requiring extremely high mechanical strength. The lagoon may be formed as a pit for this reason.

Different processes may take place in different chambers, for example preliminary aeration, anaerobic digestion or fermentation.

Different chambers may be colonised by different bacteria due to different conditions existing or set up therein, such as temperature, pressure, flow rate etc.. These bacteria may for example metabolise ethanol, lactate and other products of the initial fermentation resulting in acetate and hydrogen.

The rate at which fluids are introduced into the fluid delivery pipes determines the speed of circulation of the process fluid within the vessels and can be controlled independently (by means not illustrated). The residence time of the process fluid within the various vessels may also be controlled by means (not shown) such as bypass valves, shunt valves, subsidiary holding vessels, shut off valves, feedback or recirculation loops and the like.

The choice of fluid to be introduced as the circulation-driving fluid through the duct may be air, for example in the first and last of the chambers 310_1 and 310_8 whereas methane may be introduced into the intermediate chambers 310_2 and 310_7 and an inert fluid into chambers 310_3 to 310_6. The methane may of course be that generated by the digestion process itself. This may be recycled directly or drawn from storage containers.

The resulting digested slurry output from the last chamber 310_8 in the series can be passed to a separator where the solids are separated from the liquids to yield an odourless fertiliser rich in nutrients and a liquid which may also be used as a fertiliser (depending on the process fluid in question and the precise treatment process) or may be discharged perhaps after further final purification treatment.

It is noted by the inventor that in a treatment system comprising a plurality of vessels, when process fluid moves between tanks it moves between the relatively large cross-sectional area of the tank itself to a relatively smaller cross-sectional area in the form of connecting pipes or the like; in doing so the fluid accelerates. The act of acceleration of the fluid leaves behind solids in the previous tank.

The final products from the treatment of slurry in one or more of the chambers 310 are the fluid withdrawn from the manifolds 338 and the mixture of solids and liquids withdrawn from the outlet. Some of the fluid may be recycled to the fluid inlet while, in the case of methane, any excesses may be used as a fuel, for example for electricity generation. The slurry, on the other hand, may be separated into its solid and liquid components both of which, in the case of organic waste, may be usable as fertilisers, possibly after further treatment. The solids may, for example, require composting whilst the liquids may require chelation.

CLAIMS

1. Apparatus for treating a process fluid, comprising:
   - a treatment chamber;
   - means for introducing a fluid into the chamber to drive circulation of process fluid therein; and
   - at least one longitudinal baffle plate extending along at least part of the length of the chamber.

2. Apparatus as claimed in Claim 1, in which the baffle plate is curved.

3. Apparatus as claimed in Claim 1 or Claim 2, in which the baffle plate is a generally triangular wing-like member.

4. Apparatus as claimed in any of Claims 1 to 3, in which the baffle plate is connected to an end wall of the chamber.

5. Apparatus as claimed in any preceding claim, in which the means for introducing fluid into the chamber comprise one or more elongate fluid delivery tubes.

6. Apparatus as claimed in Claim 5, in which the fluid delivery tube/s run alongside the baffle plate/s.

7. Apparatus as claimed in any preceding claim, in which two opposing baffle plates are provided and extend from either end of the chamber.

8. Apparatus as claimed in any preceding claim, in which the or each baffle plate extends, in use, from the region of the lowest part of the chamber.

9. Apparatus as claimed in any preceding claim, in which the chamber has a generally cardioid cross-sectional shape.

10. Apparatus as claimed in Claim 9, in which the fluid delivery means introduce fluid at or in the vicinity of the cusp of the cardioid chamber.

11. A treatment system comprising a plurality of chambers as claimed in any preceding claim.

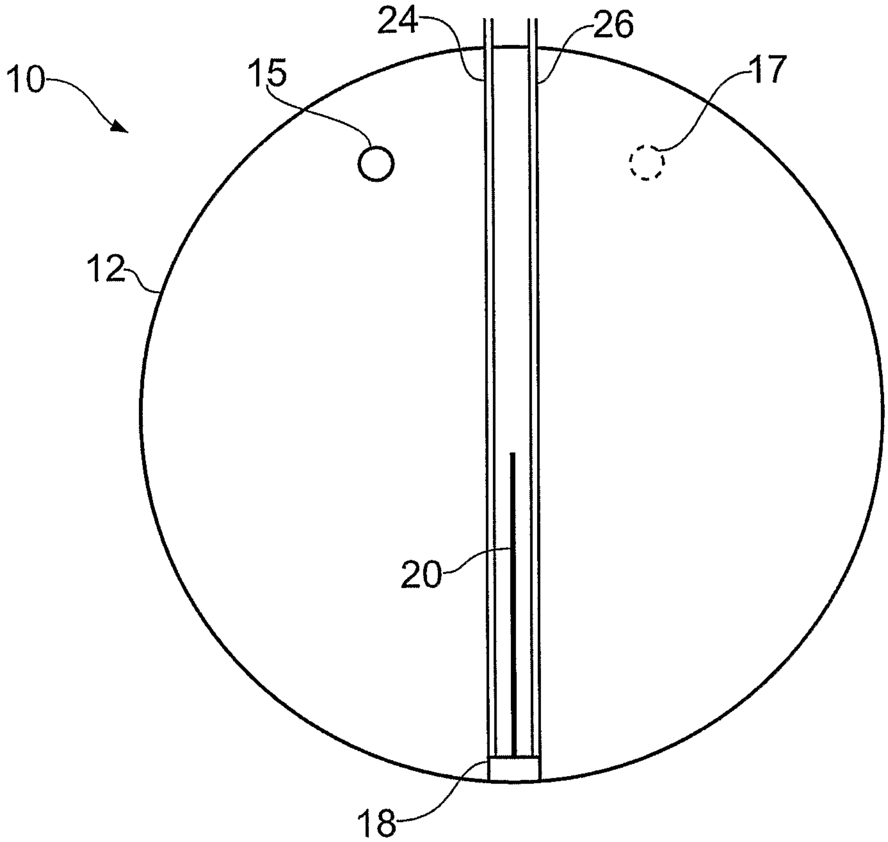


Fig. 1

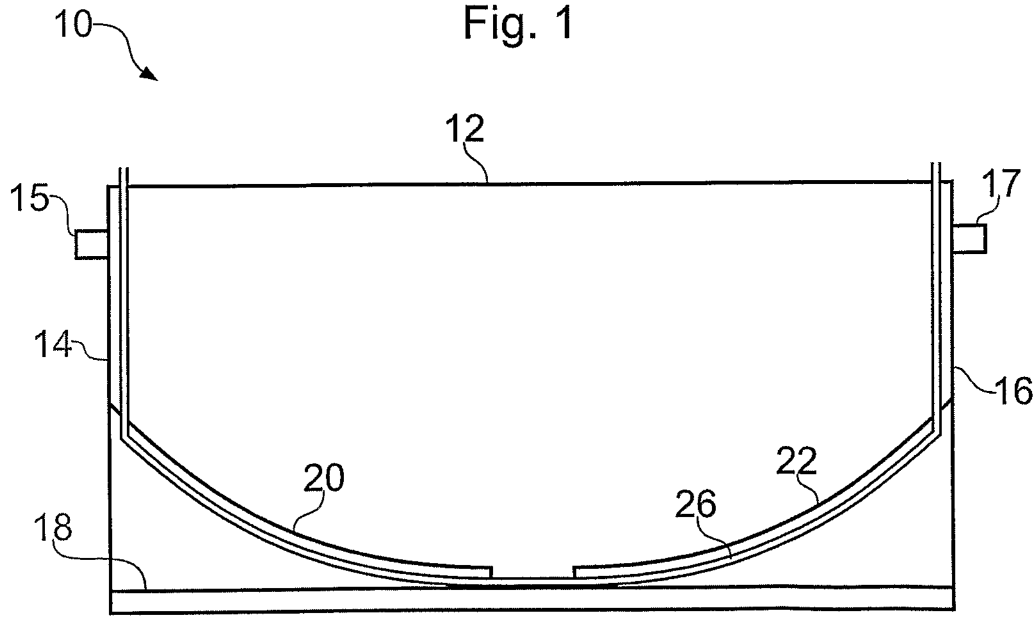
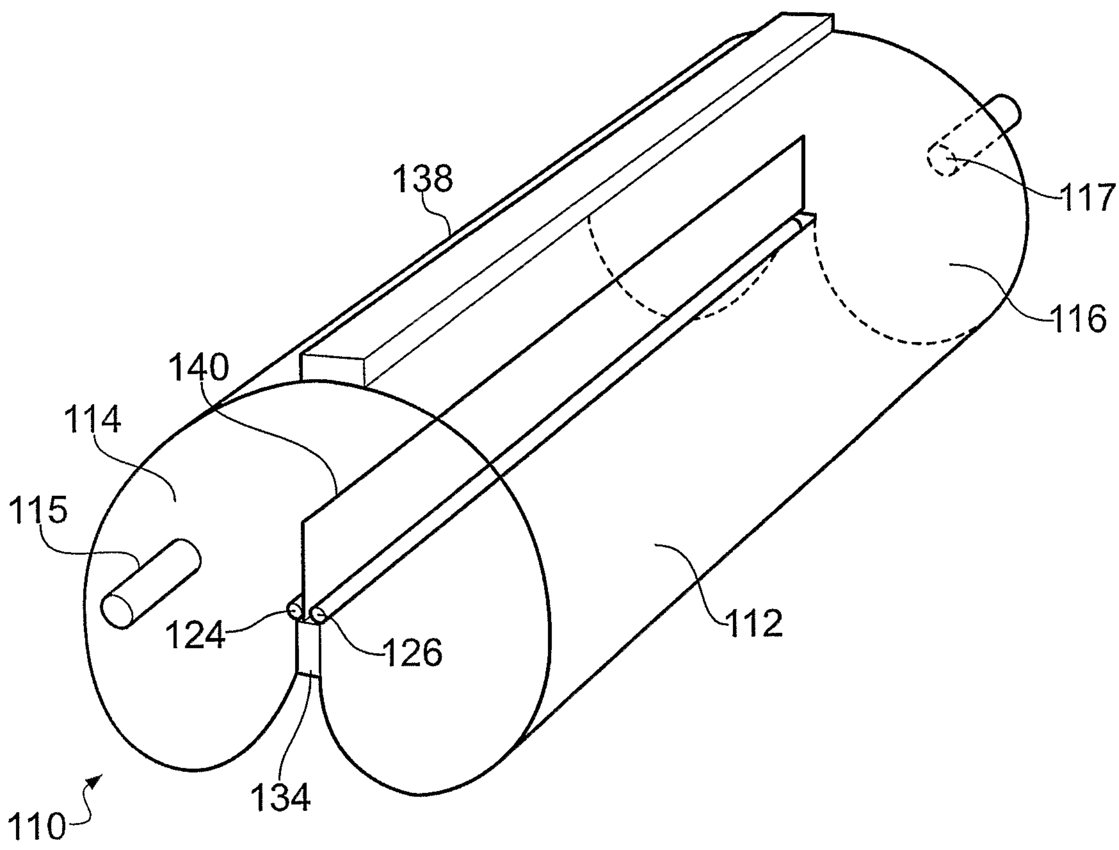


Fig. 2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116
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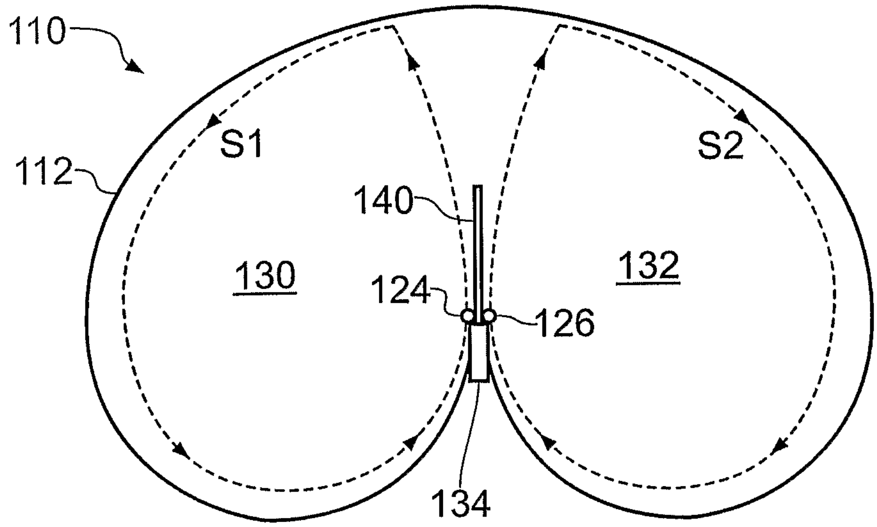
110

Fig. 3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S1
S2
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134

Fig. 4

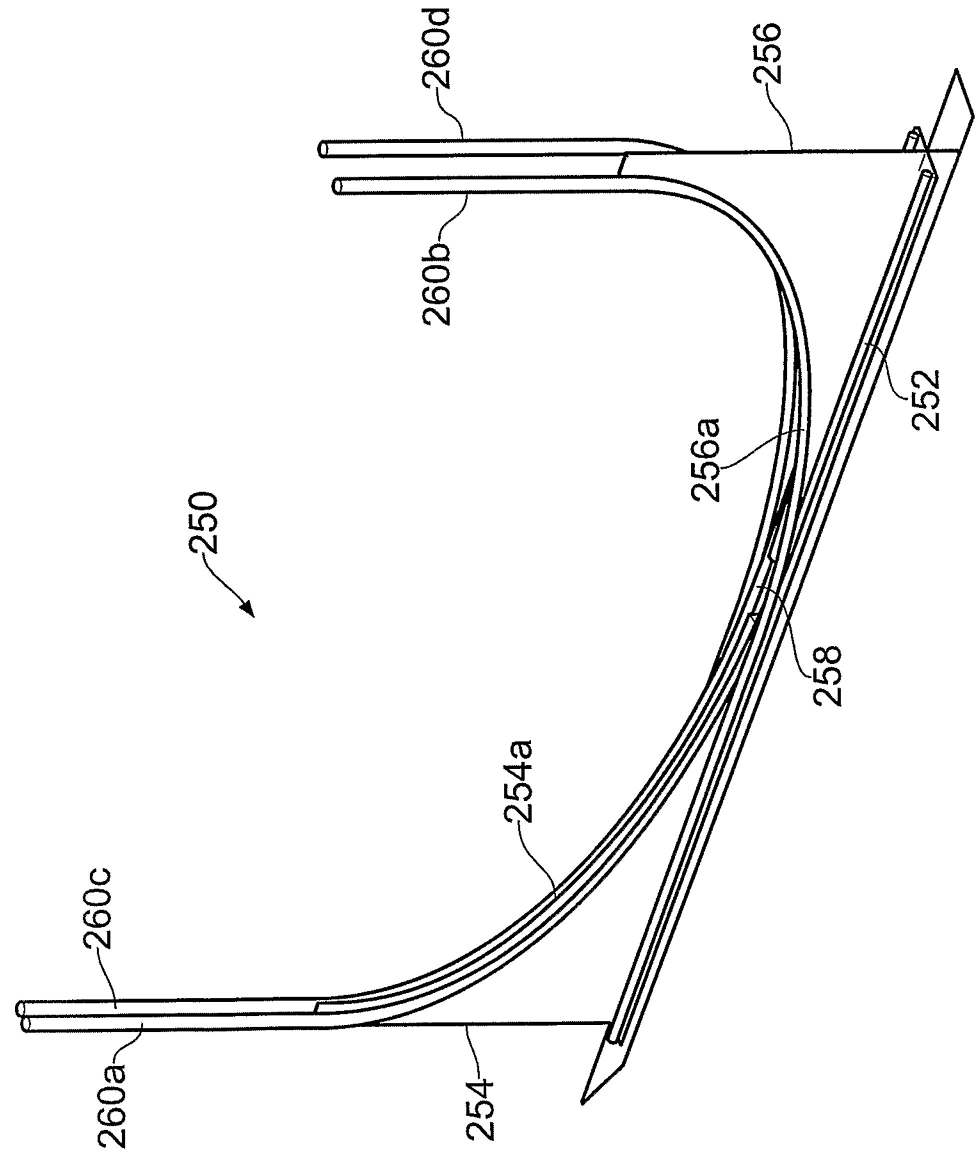

Fig. 5

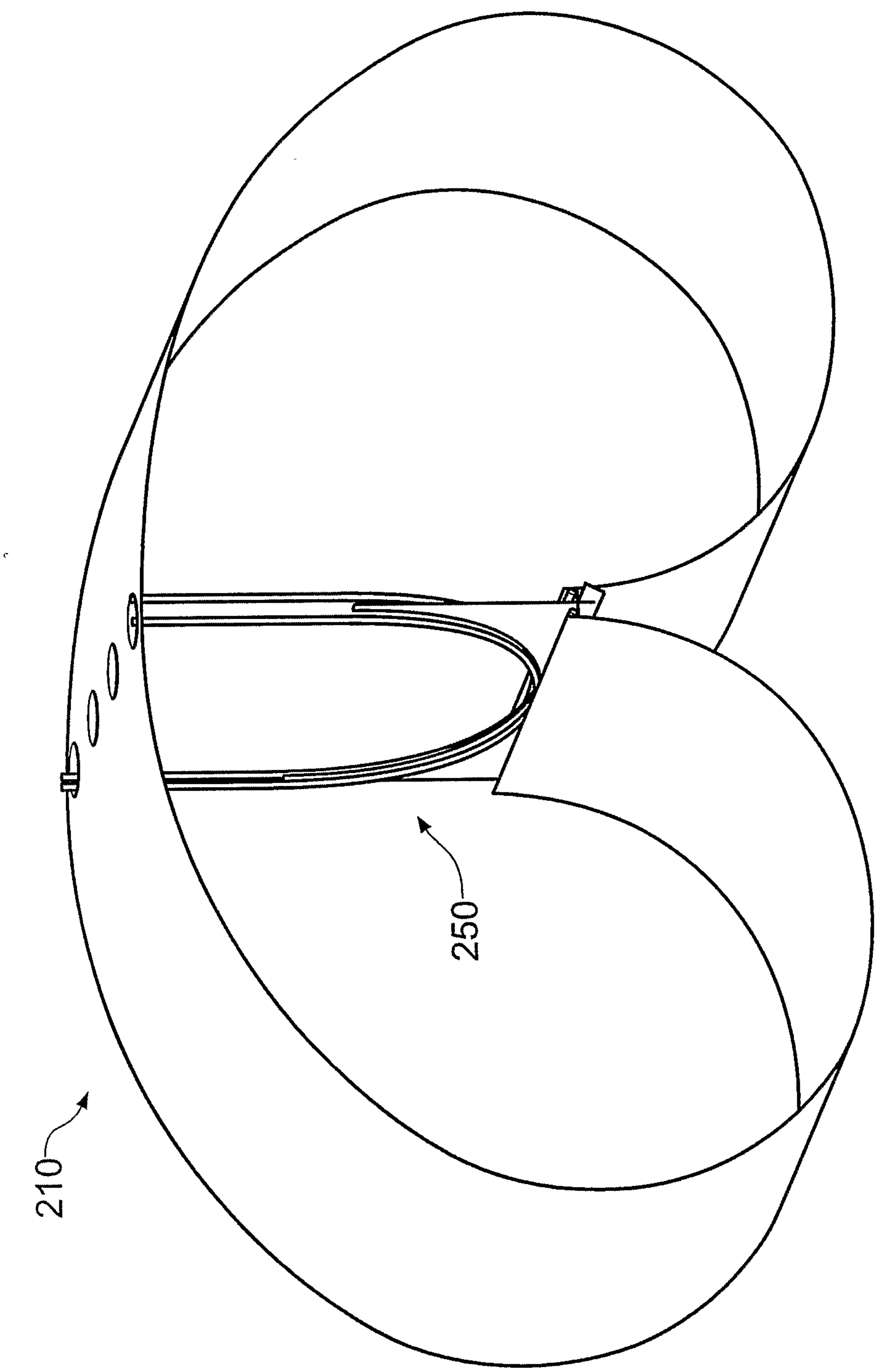

Fig. 6

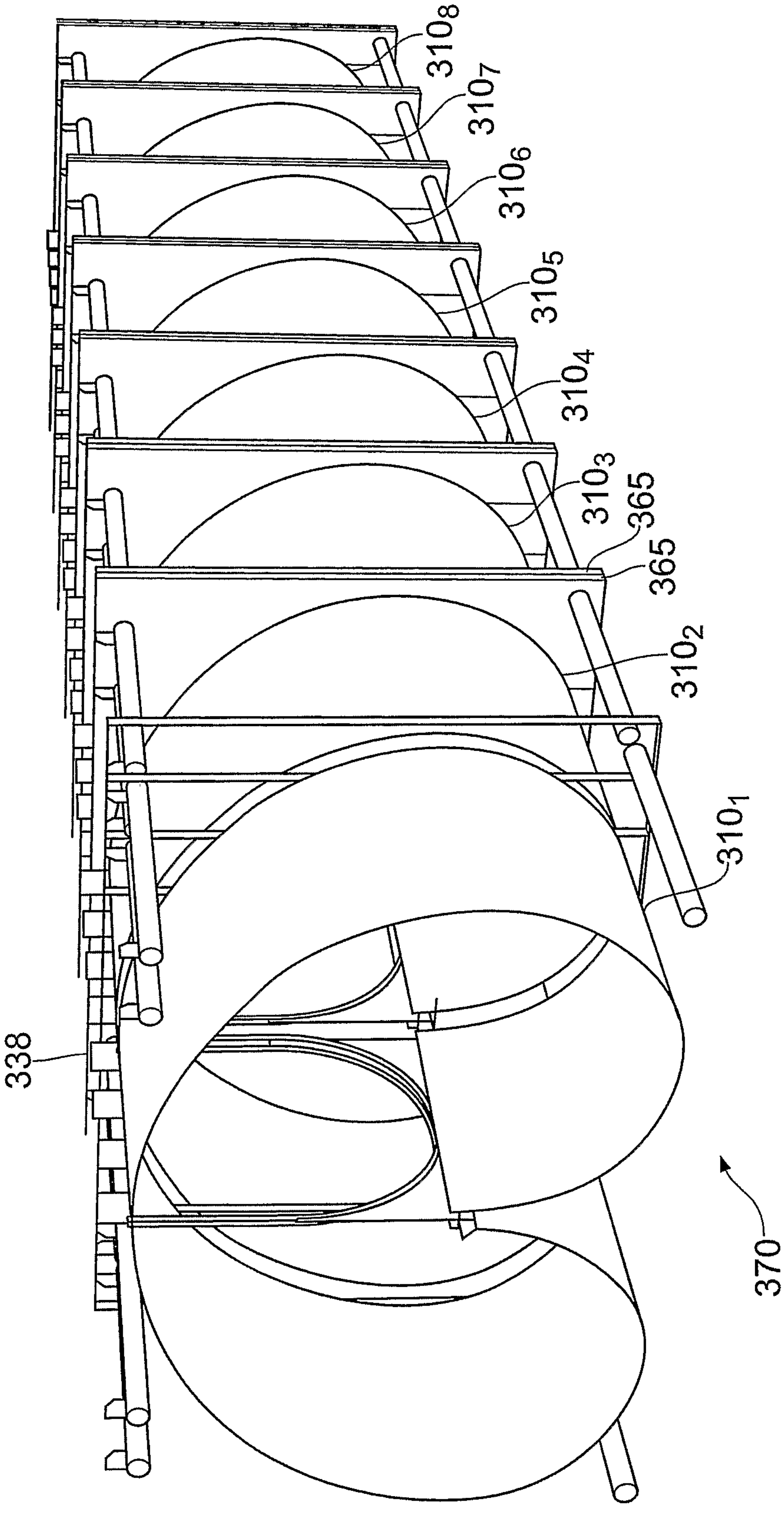

Fig. 7