German utility model no. DE202021102883U1

Industrial-Scale Seawater Desalination or Water Deionization Using Piping Systems through Electricity and/or Magnetic Fields

Description

The usable freshwater reserves on Earth are limited and scarce because 97.5% of the total water is saltwater, and of the remaining 2.5%, only about 3% is accessible, depending on the publication. Water with a salt content of less than 0.1-0.2% is often referred to as freshwater and still requires further treatment to be suitable as drinking water. There are many methods for seawater desalination, but only a few processes produce the vast majority of freshwater (evaporation, pressure, etc.). Pressure and heat, for example, account for 25-50% of the costs. Given the more than two billion people worldwide who do not have access to drinking water, new energy-efficient, cost-effective, and simple solutions are needed. The effects of magnetic and electric fields (including electrochemical processes) and their combinations on salt solutions are well known. Their efficiencies are often described as not very high.

Many different methods for seawater desalination exist; here are just a few examples:

- Electrodialysis: Electrochemically separates ions from uncharged particles in ion-exchange membranes combined with an applied electric voltage. Stacks of alternating electric membranes consist of many pairs. This leads to a concentration of salts in some areas of the stack and a reduction of salts in other areas. The energy consumption of electrodialysis separations is proportional to the salt concentration. For this reason, electroosmosis is better at low salt concentrations than, for example, reverse osmosis, where the salt solution is pressed through a semipermeable membrane under high pressure.
- Capacitive deionization: Only porous carbon electrodes and electricity are needed. It is based on a reversible electrochemical principle. Ions are absorbed in the electrode material. Ideally, one cation and one anion are absorbed for each electron at the anode and a positive charge at the cathode. Research is also being conducted on new carbon nanomaterials, such as graphene or "carbon nano-onions," in terms of ion storage as an energy store.
- Other approaches: Desalination by a gel (Institute for Technical Chemistry and Polymer Chemistry of the Karlsruhe Institute of Technology (KIT), "Hydrogel"). Electrically charged molecular groups in the gel hold back the salts dissolved in the water as it penetrates the gel.

If the swollen absorber is squeezed out, the water that escapes is much lower in salt than before. Another interesting idea is to use less energy to remove salt than to produce water (Adionics SAS: AquaOmnes).

The general problem of seawater desalination or water deionization is producing freshwater cheaply, energy-efficiently, and in large quantities.

There are many solutions for seawater desalination (deionization), for example:
- DE202007009615U1: Also with capacitor electrodes in a magnetic field passage.
- CN000211445106U: Likewise with evaporation.
- CN000208667184U: Further with membranes.
- CN000206278964U: By reverse osmosis.
- CN000112062233A: Only partially with the return of saltwater.
- CN000106800329A: Also with alternating polarization.
- CN000002755079Y: Combines magnetic and electric fields.
- DE000004334317A1: Electrochemical membrane process.
- WO002018157327A1: Also wound electrodes with alternating polarity, including water-bearing layers.
- WO002018080567A1: MHD principle (magnetohydrodynamic) with graphene and CNT (carbon nanotubes).
- WO002012098059A1: Many cathodes and anodes in a compact device.
- WO002008047084A2: Electrodialysis and cavitation.
- WO001998022203A1: Cascading electrodialysis.

My invention is based on the further development of seawater desalination (deionization of salt solutions) using special piping systems to obtain freshwater in an energy-efficient, cost-effective, and simple way.
The existing solutions fulfill their respective functions under the given circumstances but do not have the capabilities of the above-mentioned invention.

An effective seawater desalination or water deionization system is desired, and the invention for the rapid production of a plant using piping systems and electricity and/or magnetic fields, as indicated in claim 1, meets these requirements.

Example Implementation

The actual desalination is carried out (according to claim 2) using electricity (electric fields, applied [high] voltage, electrochemical separation, including electroosmosis, electrodialysis, electrophoresis) and/or magnetic fields. A combination of methods can be advantageous in certain situations.

As shown in claim 3, the consistent return of more ionized water in pipes/pipelines of different diameters saves resources in several respects. This uses less energy and less salt water. The lower efficiency compared to other seawater desalination methods is compensated for by the larger distance or reaction surface, which can almost completely make up the inside of the pipeline, as shown in claim 4. Ideally, the desalination pipes run as straight as possible in the direction of the target area (apart from measures for thermal expansion).

Many returns 2, 3 of the already partially desalinated solution through a previous section of the pipe save energy and make the deionization more efficient (Fig. 1). For example, after an ion separation, the more concentrated solution can flow back into a point of the pipeline with the same ion concentration in a return pipeline (according to claim 5). The return pipes can be installed above, below, left, or right of the forward line, as shown in claim 6. For clarity, in Fig. 1, the return pipes flow back two sections; the electrodes/magnets are only partially shown on the top and bottom and are not equipped with cables for the electrodes/electromagnets. The pumps are also not shown, and the lighter the gray tone, the lower the salt content.

Per deionization section, one, two, or more pipelines with backward-flowing, higher-concentration ions branch off from a pipeline with forward-flowing saltwater (according to claim 7). The backward-flowing liquids with a higher concentration of positive or negative ions ideally flow in at the edge of the pipe, i.e., near the corresponding electrode or the electric or magnetic field, to increase efficiency, as shown in claim 8. The length of the pipes for the backward-flowing saltwater depends on many factors and cannot be determined here. A single pipe with backward-flowing, more concentrated saltwater would have the advantage of less material consumption but the clear disadvantage of mixing the more concentrated positive and negative ions. It is advantageous if the positive and negative ions flow into the forward line separately to enable better separation. This is particularly effective (according to claim 9) through (longitudinal) webs/flow aids (see below).

The separation of higher-concentration solutions on the left or right, or above or below, and the passage of lower-concentration solutions in the middle should occur in straight pipes to minimize turbulence and mixing. Furthermore, measures to reduce turbulence are generally useful (e.g., several [longitudinal] webs in the pipeline).

Both round, oval, and square pipes and their combinations are conceivable, as shown in claim 10. If the pipeline uses electricity for deionization and acts as an electrode, additional insulation is required between the pipe sections 5 and on the outside 6 (according to claim 11). The most important insulation thus consists of separating the electrically conductive pipe sections (in the middle, top, and bottom, Fig. 2). Additionally, insulation between entire pipeline sections can also be advantageous, as shown in claim 12. Thus, the special pipeline system will desalinate the seawater gradually over long distances (also hundreds of meters or more).

In addition to differences in manufacturing, cleaning robots can be introduced into square, round, or oval pipes (according to claim 13) to clean the pipeline as needed. If this type of pipeline cleaning proves disadvantageous in certain situations, a mechanism for opening the pipes is useful, as shown in claim 14 (Fig. 3, 7 and 8). Opening the pipes would also allow for the replacement of any electrodes or other consumables and the cleaning process.

The separation of differently concentrated solution components can be carried out with vertical 9, 12 or horizontal 10, 13 or even slanted partitions (according to claim 15) (also adapted to the course of the pipeline). Of course, the direct branching of the backward-flowing pipelines without using special partitions is also possible.

The webs to avoid turbulence can also act as additional electrodes in the pipeline (depending on the position, also differently polarized), as shown in claim 16, to increase the efficiency of the separation. In round pipes, a central, round, forward-flowing pipe 11 is also possible at the end of a deionization section, and the ions solution flowing around it is returned (according to claim 17, Fig. 4). In square pipes, two partitions 12, 13 are useful, as shown in claim 18.

Another advantage of the above invention is that no significant factory site is required. If the desalinated water is not piped to a target area and only a small area is available for seawater desalination, the pipes can, of course, be arranged more compactly (back and forth, on top of each other, in a spiral/snail, also vertically - in addition, flowing from top to bottom), according to claim 19. The energy expenditure will certainly be higher.

When using electrical methods for deionization, regular polarity reversal is useful, as shown in claim 20, to reduce deposits. Without ion deposition and without using special electrodes, less maintenance is required.

The pipes can be made of plastic, metal, other materials, or combinations thereof (according to claim 21).

Deionization occurs in the pipeline system at low temperatures - i.e., ambient temperature - and low pressure (apart from the pressure conditions created by the pumps), as shown in claim 22.

Since the above invention itself does not use membranes, the problem of contamination and necessary cleaning is less than with other seawater desalination methods. Of course, grates, filters, methods for sterilization, and the removal of algae (ozone, UV light, etc.) installed in front of the actual deionization are necessary, as shown in claim 23. This is especially important if the freshwater is used as drinking water and is not only intended for land and agriculture.

An automatic cleaning of the pipeline (walls, partitions, etc.) is also possible with a type of movable "cleaning pads" or similar, which are moved, for example, from the outside using magnets, as shown in claim 24. Deposits can form, especially on the partitions. Thus, a rotating disc 14, which cleans itself, may be useful directly on the partitions, i.e., as a partition itself (according to claim 25, Fig. 5). The rotating disc can be driven by protrusions/paddles in the liquid flow and electrically from the inside (electric motor) or from the outside (with magnets).

A major advantage is that, as with other deionization methods, except for pump parts, there are no moving parts that require regular maintenance or can fail.

The pumps and deionization devices can receive the necessary or supportive power from a photovoltaic system/solar cells on the pipeline, as shown in claim 26.

When using magnetic fields, permanent magnets (also from used magnets from old wind turbines) or electromagnets can be used, according to claim 27.

The inflow and outflow of the seawater desalination plant can consist of two large pipelines whose outlets must be so far apart that the inflow does not mix with the higher salt concentration of the outflow, as shown in claim 28. This can be easily achieved, for example, if the pipeline outlets are also at different heights. Moreover, it is important for the environment to ensure that the higher salt concentration of the outflow does not cause damage to the underwater world. In the event of coastal contamination of the sea and as a transitional solution, tankers or other means of transport can be used, for example.

Reference List

(1) Pipeline with forward-flowing salt solution
(2) Return pipeline with low salt content
(3) Return pipeline with high salt content
(4) Desalination unit using electricity (electric fields, applied [high] voltage, electrochemical separation, including electroosmosis, electrodialysis, electrophoresis) and/or magnetic fields
(5) Insulation between pipe sections
(6) Insulation on the outside of the pipeline
(7) Mechanism for opening the pipeline
(8) Joint for the mechanism for opening the pipeline
(9) Vertical partition in round pipeline
(10) Horizontal partition in round pipeline
(11) Central pipe for forward-flowing salt solution
(12) Vertical partition in square pipeline
(13) Horizontal partition in square pipeline
(14) Rotating disc as partition.

Claims

1. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields,

characterized by

a return piping system alongside the forward-flowing liquid, which is increasingly desalinated by electricity and/or magnetic fields.

2. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to claim 1,

characterized by

the actual desalination is carried out by electricity (electric fields, applied [high] voltage, electrochemical separation, including electroosmosis, electrodialysis, electrophoresis) and/or magnetic fields.

3. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

the corresponding connections through pipelines of different diameters allow consistent recirculation of more ionized water.

4. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

the desalinating pipeline running as straight as possible (apart from measures due to thermal expansion) partially or predominantly consists of a desalinating reaction surface inside.

5. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

after ion separation, the more concentrated salt solution in a return pipeline flows back into a point of the forward pipeline with a comparable ion concentration.

6. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

the return pipelines are installed above, below, and/or left and right of the forward pipeline.

7. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

one, two, or more pipelines with backward-flowing, higher-concentration ions branch off from a pipeline with forward-flowing saltwater per deionization section.

8. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

the backward-flowing liquids with a higher concentration of positive or negative ions flow in at the edge of the pipe, i.e., near the corresponding electrode or the electric or magnetic field.

9. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

(longitudinal) webs/flow aids are installed in the pipelines.

10. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

the pipeline system consists of round, oval, and square pipes and their combinations.

11. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

when the pipeline is energized and functions as an electrode, additional insulation is present between the pipe sections and on the outside.

12. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

additional insulation is present between entire pipe sections when the pipeline is energized and functions as an electrode.

13. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

cleaning robots are introduced into the pipes to clean the pipeline.

14. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

a mechanism for opening the pipes is installed.

15. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

the differently concentrated solution components are separated with vertical or horizontal partitions, but also slanted partitions. Direct branching of the backward-flowing pipelines without using special partitions is also an option.

16. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

the (longitudinal) webs/flow aids act as additional electrodes in the pipeline (differently polarized depending on the position).

17. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

in the round pipeline, a central, round, forward-flowing pipe is installed at the end of a deionization section, and the more concentrated ions solution flowing around it is returned.

18. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

two partitions are installed at the end of a deionization section in square pipes.

19. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

the pipeline system is arranged more compactly (back and forth, on top of each other, in a spiral/snail, also vertically - in addition, flowing from top to bottom).

20. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

in electrical deionization processes, regular polarity reversal occurs.

21. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

the pipes are made of plastic, metal, other materials, or combinations thereof.

22. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

deionization in the pipeline system occurs at low temperatures - i.e., ambient temperature - and low pressure.

23. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

grates, filters, methods for sterilization, and the removal of algae (ozone, UV light, etc.) are installed in front of the actual deionization.

24. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

cleaning of the pipeline is carried out by moving "cleaning pads" or similar from the outside, for example, wirelessly by magnets.

25. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

a rotating disc acts as a partition and cleans itself. The disc is rotated by protrusions or paddles in the liquid flow or electrically from the inside (with an electric motor) or from the outside (via a magnetic drive).

26. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

the pumps and deionization devices receive the necessary or supportive power from a photovoltaic system/solar cells on the pipeline.

27. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

when using magnetic fields, permanent magnets and/or electromagnets are used.

28. Seawater desalination or deionization of water on an industrial scale using piping systems through electricity and/or magnetic fields, according to one of the preceding claims,

characterized by

the inflow and outflow of the seawater desalination plant consist of two pipelines that open far apart.

Fig. 1

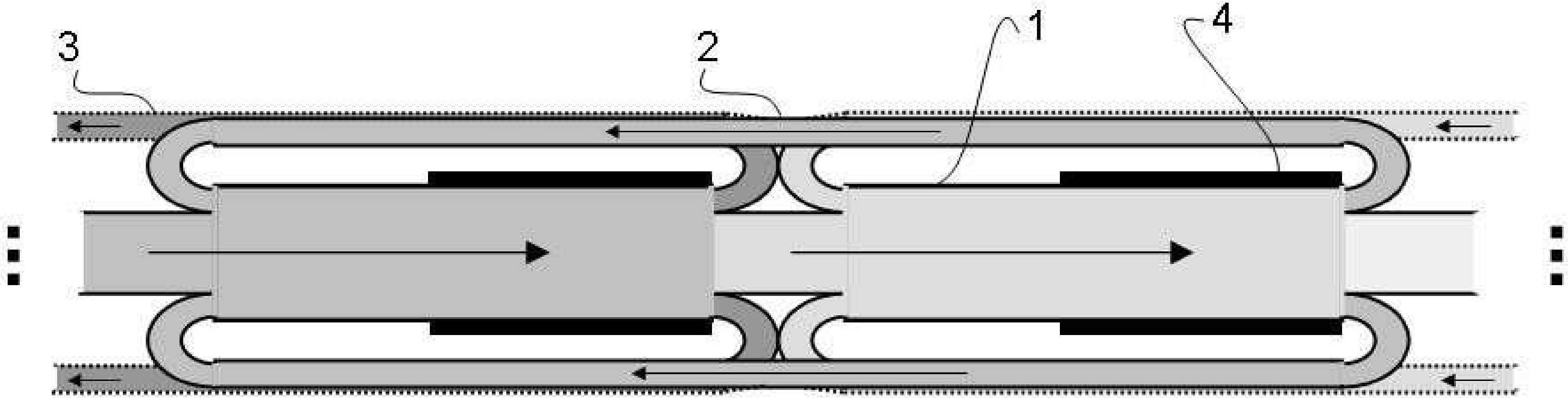

Fig. 2

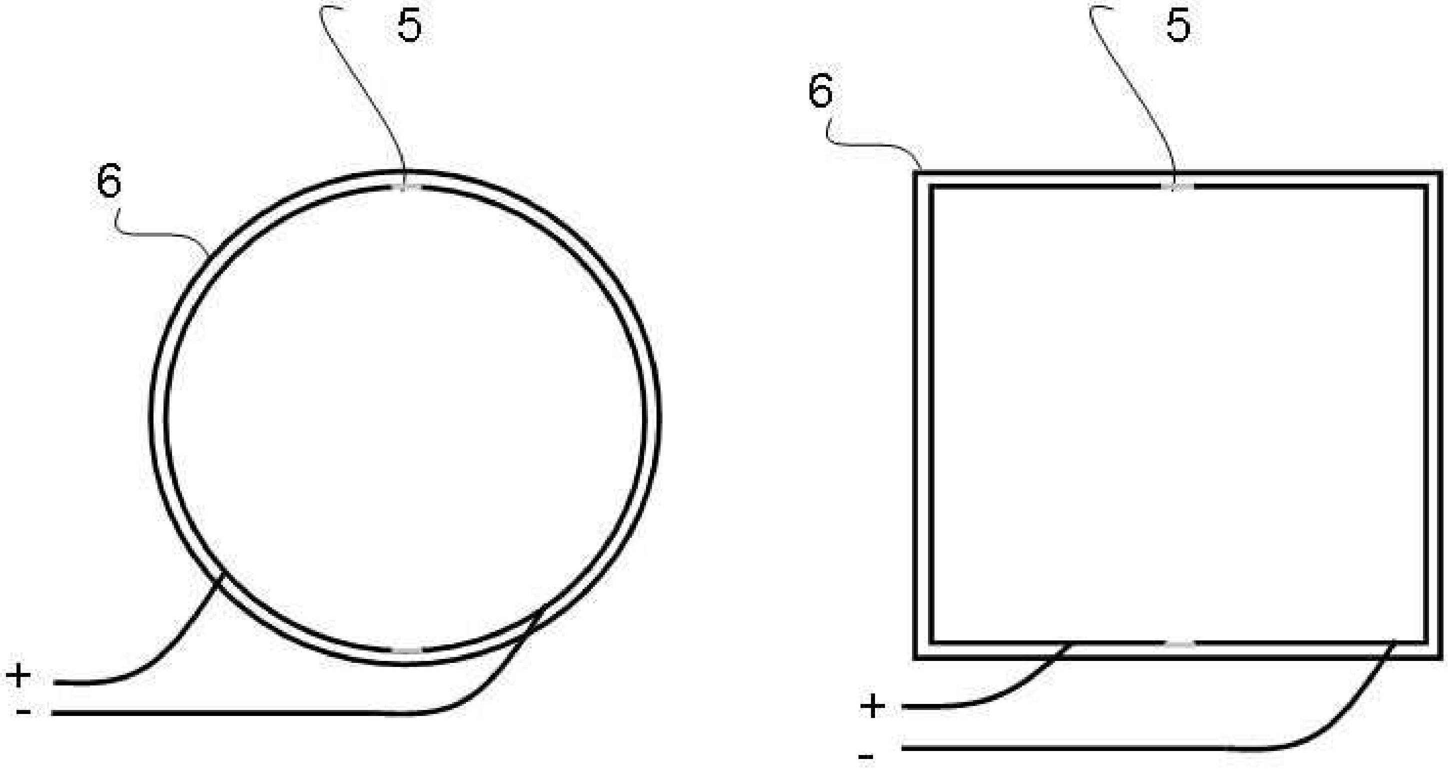

Fig. 3

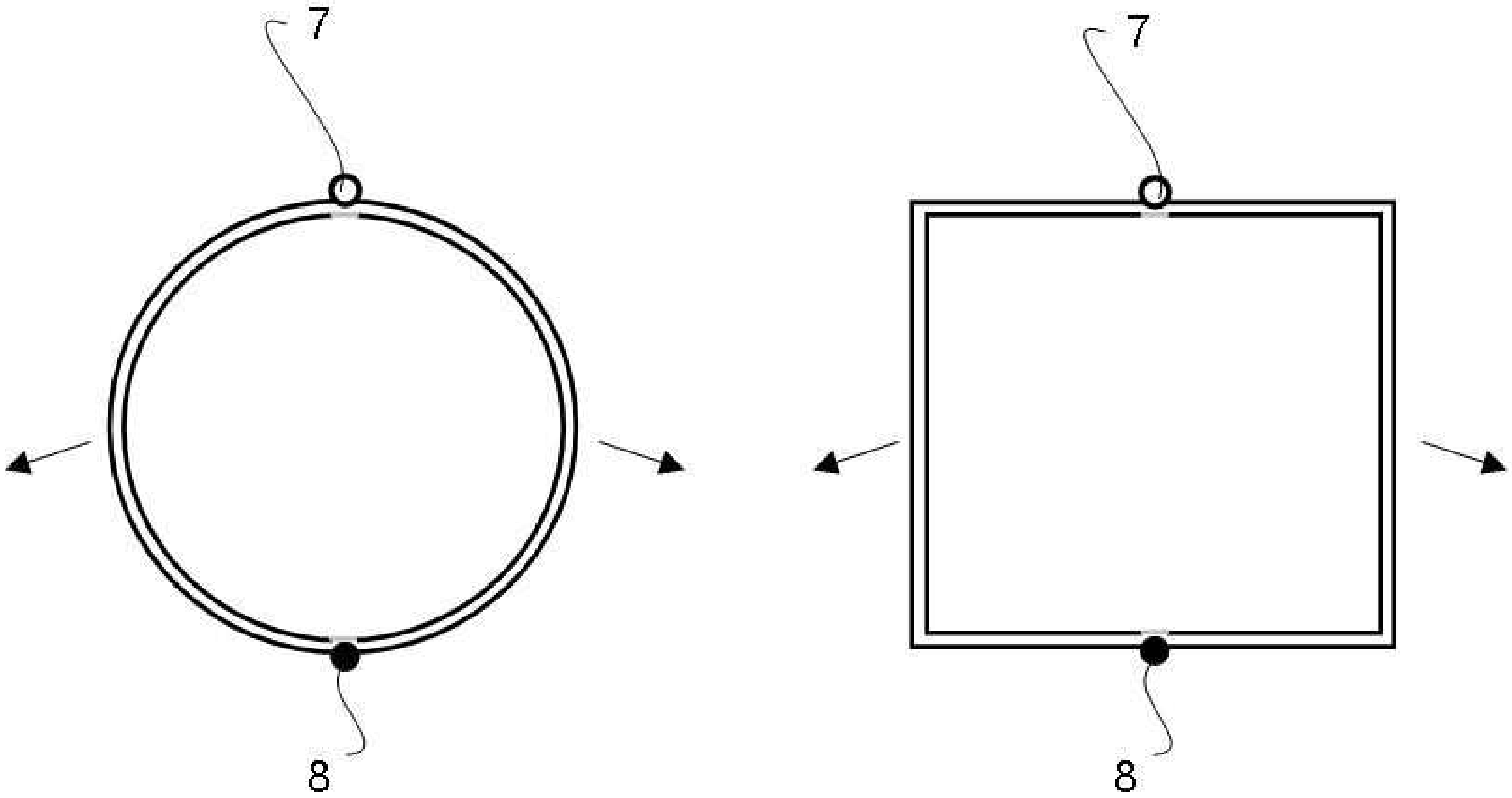

Fig. 4

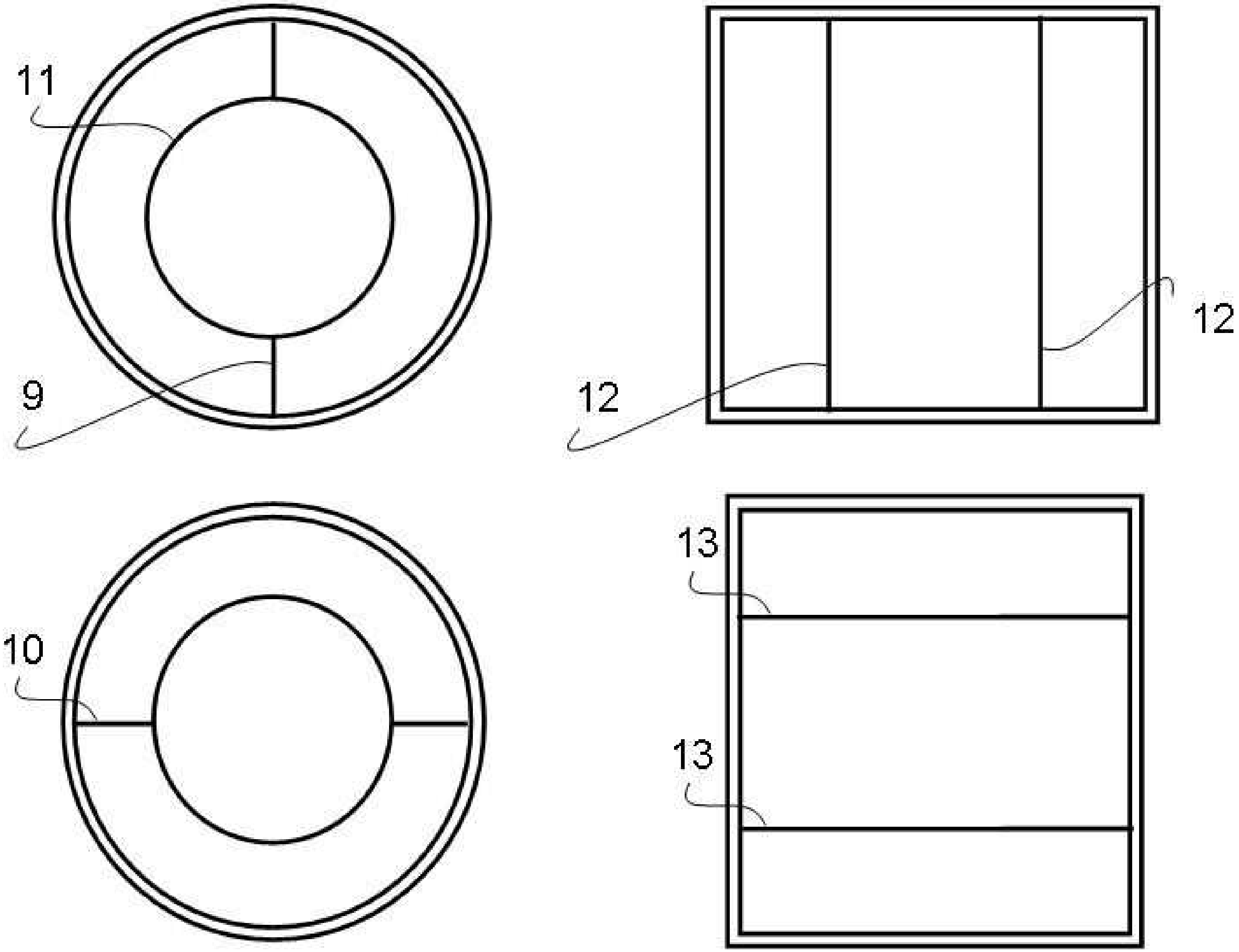

Fig. 5