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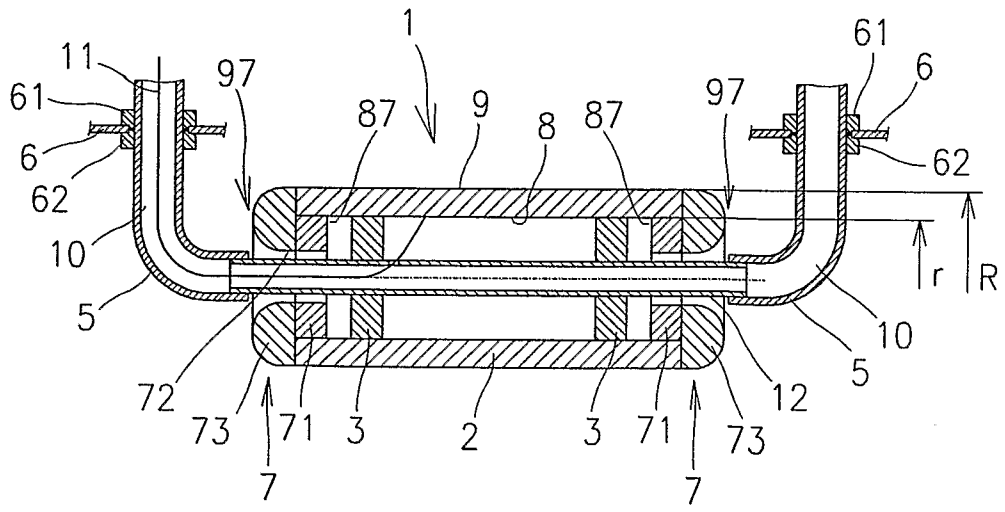
(54) **Title:** COLLECTING ELECTRODE OF THE DEVICE FOR PRODUCTION OF NANOFIBRES THROUGH ELECTROSTATIC SPINNING OF POLYMER SOLUTIONS



(57) **Abstract:** The collecting electrode (1) of the device for production of nanofibres through electrostatic spinning of polymer solutions, which contains a conductive thin-walled body (2) of electrode (1), in which there is performed at least one opening (4), on whose circumference there is arranged the border (7), while in the inner space of the body (2) of electrode (1) there is mounted at least one holder (3) of electrode (1) connected with at least one brace (5) fastened in the spinning chamber, while the holder (3) of electrode (1) is arranged behind border (7) of the opening (4).

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Collecting electrode of the device for production of nanofibres through electrostatic spinning of polymer solutions

Technical field

The invention relates to the collecting electrode of a device for production of nanofibres through electrostatic spinning of polymer solutions.

Background art

Collecting electrodes used at present for creation of electrostatic field applicable for production of nanofibres from polymer solutions are designed mostly as sheet metal, metallic plates. Nevertheless their main disadvantage is that after the high voltage is brought to such collecting electrode, in the vicinity of its sharp edges or peaks, but also in vicinity of contact of a conductive body of electrode with non-conductive elements, on which the body of electrode is mounted in the spinning chamber, there is created a corona, which is the streamer electrical discharge, that has a negative impact on electrostatic field being created between the collecting electrode and against it positioned spinning electrode – destabilizes it and reduces its intensity, thus also the output of the whole device for electrostatic spinning.

The goal of this invention is to remove the disadvantages of present state of the art and to create such collecting electrode of the device for electrostatic spinning, during its application there are no corona discharges on its surface with undesirable affect on an electrostatic field.

The principle of invention

The goal of the invention has been reached by a collecting electrode, whose principle consists in that, it contains a conductive thin-walled body of electrode, in which there is performed at least one opening, on whose circumference there is arranged the border, while in the inner space of the body of electrode there is mounted at least one holder of electrode connected with at

least one brace fastened in the spinning chamber, while the holder of electrode is arranged behind border of the opening. The advantage of such structure of collecting electrode is that the triple point – i.e. contact of non-conductive holder of electrode, conductive body of electrode and the surrounding air, possibly of another gas depending on technology, is hidden in the inner space of body of electrode, and so if a corona is created in this point, it will not influence an electrostatic field in any way.

In most applications, for which the collecting electrode is designated, it is connected with a source of high voltage, nevertheless in some applications with respect to the technology of production process of nanofibres it may be more advantageous, if the body of the spinning electrode is grounded.

To make the separation of corona created in an inner space of the body of electrode from electrostatic field as ideal as possible, and to prevent creation of corona in other point of body surface, all openings in body of electrode are on their circumference provided with a border with rounded edges, which is in the structurally most advantageous solution according to the claim 4 performed by an addition of material on the inner surface of body of electrode.

In another embodiments the border of openings is performed by bending of a portion of a wall of body of electrode to its inner surface, nevertheless the most advantageous solution guaranteeing a permanent access into an inner space of body of electrode is performing of a border of an opening as an independent removable part of annular shape, whose shape copies the shape of opening in the body of electrode. In this case it is advantageous from the point of view of assembly and disassembly of the border, if the border is to the body of electrode attached by means of a thread.

Under presumption of a low frequency of disassembly of collecting electrode, the connection between the border and body of electrode may be realised by means of a friction forces, which is less economically demanding than the thread connection.

In applications when the body of electrode is connected with a source of high voltage it is advantageous, if the lead of high voltage is placed in cavity of a brace, which opens in an inner space of body of electrode, and thanks to the

opening in a wall of the brace it is connected in a conductive manner to the inner surface of body of electrode , as in this case the lead is not exposed to acting of electric field, either it itself does not influence the same. At the same time it prevents creation of corona in a contact point of high voltage lead and the body of electrode. In a more advantageous alternative the brace cavity is connected to the cavity of holder of electrode and the lead of high voltage passes through these both cavities and it is in a conductive manner connected with inner surface of body of electrode in the space behind the holder of electrode.

At all applications of electrode it is undesirable, that on its outer surface the coronas are created, due to this it is necessary, that the outer surface does not contain any sharp edges or peaks, so that the transitions between the neighbouring walls of body of electrode are performed by rounding. The most advantageous shape of body of electrode is then a cylinder.

Holders of electrode mounted in an inner space of body of electrode may be with the corresponding braces connected directly, but from the point of view of supposed installation and certain cycles of assembly and disassembly it is advantageous especially in a case when the body of electrode is formed by a oblong formation, if the holders of electrode are connected by a supporting tube, whose length is greater than the length of body of electrode, and which protrudes from the body of electrode through openings on its opposite walls to outside. The protruding ends of supporting tube are after then in some of known manners in a demountable manner connected with braces attached in a spinning chamber of the device for production of nanofibres.

Especially in cases when the borders of openings are formed by separate detachable parts it is advantageous if the supporting tube is formed from several mutually detachable parts, out of which some may be used for securing the border against an undesirable movement.

Due to the fact that to the body of electrode in most cases the high voltage is supplied, from the point of view of stability of electric field created between the collecting electrode and the spinning electrode, and from the point

of view of safety and economy of the device for production of nanofibres it is advantageous if in vicinity of the collecting electrode there are no electrically conductive parts, so that the holders of electrode, braces and eventually also the supporting tube are made of electrically non-conductive material, mostly plastic.

Description of the drawing

Example of embodiment of collecting electrode of the device for production of nanofibres through electrostatic spinning of polymer solutions is schematically shown on the enclosed drawing, where the Fig. 1 shows a longitudinal section through the collecting electrode in one of the possible embodiments, the Fig. 2 a section of the collecting electrode in another of possible embodiments, and the Fig. 3 shows a section of alternative way of hanging of the collecting electrode.

Examples of embodiment

The collecting electrode of the device for production of nanofibres through electrostatic spinning of polymer solutions will be clarified on an example of embodiment schematically shown in the Fig. 1, where is shown the collecting electrode 1, which comprises the body 2 of electrode 1 formed by a thin-walled cylinder from electrically conductive material, e.g. steel, in whose inner space are mounted two non-conductive cylindric holders 3 of electrode 1, whose outer diameter is close to inner diameter r of the body 2 of electrode 1.

In each base of the body 2 of electrode 1 there is performed a circular opening 4, by means of which into the inner space of the body 2 extends the brace 5, which in the inner space of the body 2 is connected with the holder 3 of electrode 1. Diameter of opening 4 is close to the outer diameter of the brace 5. Opposite end of the brace 5 by means of the thread on its outer surface, of the upper button die 61 and the lower button die 62 is attached to the ceiling 6 of spinning chamber of the device for production of nanofibres, while sections of braces 5 extend above the ceiling 6 of spinning chamber and in connection with the manner of attachment they enable, in dependence on

technology and conditions of nanofibres production, to adjust an optimum distance between the body 2 of electrode 1 and the not represented spinning electrode, which is mounted in spinning chamber under the collecting electrode 1.

Undesired sharp edges of opening 4 are covered by a border 7, which is performed by an addition of material from the side of inner surface 8 of the body 2, arranged along the whole circumference of the opening 4, while inner transition 87 between the inner surface 8 of the body 2 and the border 7 in the represented example of embodiment is formed by a sharp edge, while the outer transition 97 between the outer surface 9 of the body 2 and the inner surface 72 of the border 7, which is a part of the border 7 closest to the brace 5, is formed by a rounding.

Both braces 5 are along its length provided with a cavity 10, while in the cavity 10 of one of the braces 5 there is placed a lead 11 of high voltage, which in the inner space of the body 2 of electrode 1 passes through the opening in the wall of the brace 5 and in a conducting manner ends on inner surface 8 of the body 2 before holder 3 of electrode 1. In another example of embodiment it is advantageous if the cavity 10 of the brace 5 merges into the cavity of the holder 3 of electrode 1 and the lead 11 of high voltage passes through the cavity 10 of the brace 5 and through cavity of the holder 3 of electrode 1, and in a conducting manner ends on inner surface 8 of the body 2, in the space behind the holder 3 of electrode 1.

Further not represented examples of embodiment from the example shown in the Fig. 1 differ e.g. in that the border 7 of opening 4 is performed by bending of a section of the wall of body 2 of electrode 1 in direction to the inner surface 8 of the body 2 by an angle, which guarantees parallel alignment of at least one section of the bending wall section with longitudinal axis of the body 2 of electrode 1.

In example of embodiment in the Fig. 2 the body 2 of electrode 1 is made of thin-walled tube of electrically conductive material. In the inner space of the body 2 of electrode 1 there are mounted two holders 3 of electrode 1 made of a non-conductive material, which are connected by means of the supporting tube 12 of a non-conductive material, whose length is greater than the length of the

body 2 of electrode 1, so that the supporting tube 12 protrudes on both sides from the body 2 of electrode 1, and each of its ends is inserted into and connected with the hollow brace 5, which is attached in the spinning chamber of the device for production of nanofibres in the same way as in example of embodiment shown in the Fig. 1. In the wall of the supporting tube 12, in inner space of the body 2 of electrode 1, there is performed an opening for lead 11 of high voltage, which passes through the cavity 10 of one of the braces 5 and through the inner space of the supporting tube 11 and in a conductive manner ends on the inner surface 8 of the body 2 of electrode 1 between the holders 3 of electrode 1.

The border 7 of the opening 4 in this example of embodiment is performed as an independent removable part of electrically conductive material, formed by an inner collar 71 with rectangular cross section, whose outer diameter is identical with inner diameter r of body 2 of electrode 1, and which concentrically continues in the outer collar 73, whose outer diameter is identical with outer diameter R of the body 2 of electrode 1, while the inner diameter of inner collar 71 and of the outer collar 73 is close to diameter of supporting tube 12 and it creates a continual cylindrical surface. Cross section of the outer collar 73 is formed by a rectangle, whose edges, which are opposite towards the inner collar 71 are rounded, and at mounting the inner collar 71 in inner space of the body 2 of electrode 1 it forms a rounded outer transition 97 between the outer surface 9 of the body 2 and inner surface 72 of the border 7.

In example of embodiment shown in the Fig. 3 the electrode 1 is performed in the same way as in the above described example shown in the Fig. 2, while the braces 5 are not attached to the ceiling of the spinning chamber, but their ends are bent above the collecting electrode 1 parallel with its longitudinal axis, so that the shape of braces 5 resembles the letter C. Ends of braces 5 are interconnected by means of a strut 13, made of electrically non-conductive tube, which is arranged parallel with longitudinal axis of the collecting electrode 1. To the strut 13, approximately in its centre, there is connected the bearer 14, formed by a tube from electrically non-conductive material, whose inner space is with inner space of the strut 13 connected through a hole in a wall of the strut 13. In an inner space of the bearer 14 and

in the section of inner space of the strut **13** there is placed the lead **11** of high voltage which is further through a cavity **10** of one of the braces **5** brought into an inner space of electrode **1**. The bearer **14** is by means of a thread on its outer surface and the upper button die **61** and the lower button die **62** attached to ceiling **6** of the spinning chamber of the device for production of nanofibres. A section of the bearer **14** protrudes in a space above the ceiling **6** of the spinning chamber and enables thus, in connection with a manner of attachment, to adjust an optimum distance between the collecting electrode **1** and the not represented spinning electrode, which is in the spinning chamber arranged under the collecting electrode **1**, in dependence on technology of nanofibres production.

In further not represented variants of example in the Fig. 3 the strut **13** is not parallel with longitudinal axis of the collecting electrode **1**, but it makes with it an acute angle, whose size depends, same as mutual arrangement of the strut **13** and bearer **14**, especially on the structure of device for production of nanofibres and on space arrangement of its parts.

In another not represented variant of solution shown in the Fig. 3 the braces **5** and/or strut **13** and/or bearer **14** divided into several demountably connected segments, through which placing of the lead **11** of high voltage upon installation of the collecting electrode **1** is simplified considerably.

At further not represented variant of example of embodiment according to the Fig. 3 the body of electrode is performed according to an example represented in the Fig. 1.

In described examples of embodiment the body **2** of electrode **1** is made by an thin-walled cylinder, nevertheless in another examples of embodiment it is possible to create it substantially as any thin-walled body, whose outer edges and peaks are rounded and do not cause creation of corona after bringing the high voltage.

In other examples of embodiment the supporting tube **12** is divided into several parts, which are mutually interconnected e.g. by means of a threaded coupling, while some of these parts of the supporting tube **12** are used for securing the border **7** (for example by means of a flange created on the border

7 and/or the given part of the supporting tube 12) formed by an independent removable part against an undesired motion.

Further examples of embodiment may from the described and represented examples differ e.g. by that the mounting of inner collar 71 in inner space of the body 2 of electrode 1 and/or mounting of holders 3 of electrode 1 in inner space of the body 2 of electrode 1 may be performed as a clearance fit. Further variations may e.g. relate to the shape of holders 3 of electrode 1, which may be performed in various manners.

Also the suspension of collecting electrode 1 in the spinning chamber may be performed in different ways and means than in the above described manner, while with respect to usability of collecting electrode 1 it is advantageous if this joint is demountable and if it enables to adjust the distance between the collecting electrode 1 and under it positioned spinning electrode.

Further constructional modifications, which are nevertheless for a correct function of the collecting electrode 1 negligible, may occur e.g. in such cases, when the cavity 10 is provided only in that brace 5, in which the lead 11 of high voltage is placed, or when the shaping of braces 5 and possibly also of the struts 13 and bearer 14 substantially differs from the described examples of embodiment shown in the Fig. 1 to 3, or in cases, when connection between the braces 5 and the supporting tube 12, possibly between the braces 5 and the strut 13 is performed differently than by inserting.

In other examples of embodiment, with respect to the structure of the device for production of nanofibres, it may be advantageous, if the collecting electrode by means of braces 5 or by means of the bearer 14 is attached to the frame of this device or to other wall of the spinning chamber than to the ceiling 6.

However, the substantial aspect for all solutions is that the connection between the conductive body 2 of electrode 1 and the non-conductive holder 3 of electrode 1, which together with surrounding air creates so called triple point, is positioned in an inner space of the body 2 of electrode 1, so that corona, possibly coronas, which originate in this point after a high voltage is brought to the body 2 of electrode 1 are hidden, which minimises their negative affecting of

an electric field created between the collecting electrode 1 and the spinning electrode.

Another substantial feature of all solutions of the collecting electrode 1 according to the invention is that on an outer surface of electrode 1 there are no sharp edges or curvatures with a small diameter, on which another possible coronas may originate.

List of referential markings

1	collecting electrode
2	body of electrode
3	holder of electrode
4	opening
5	brace
6	ceiling of spinning chamber
61	upper button die
62	lower button die
7	border
71	inner collar
72	inner surface of border
73	outer collar
8	inner surface
87	inner transition
9	outer surface
97	outer transition
10	cavity
11	lead of high voltage
12	supporting tube
13	strut
14	bearer
R	outer diameter of body of electroder inner diameter of body of electrode

CLAIMS

1. The collecting electrode of the device for production of nanofibres through electrostatic spinning of polymer solutions, **characterised by that** it contains a conductive thin-walled body (2) of electrode (1), in which there is performed at least one opening (4), on whose circumference there is arranged the border (7), while in the inner space of the body (2) of electrode (1) there is mounted at least one holder (3) of electrode (1) connected with at least one brace (5) fastened in the spinning chamber, while the holder (3) of electrode (1) is arranged behind border (7) of the opening (4).

2. The collecting electrode according to the claim 1, **characterised by that** the body (2) of electrode (1) is connected with a source of high voltage.

3. The collecting electrode according to the claim 1, **characterised by that** the body (2) of electrode (1) is grounded.

4. The collecting electrode according to the claim 1, **characterised by that** the border (7) of opening (4) is formed by a bending of a portion of a wall of the body (2) of electrode (1).

5. The collecting electrode according to the claim 1, **characterised by that** the border (7) of opening (4) is formed by an addition of material.

6. The collecting electrode according to the claim 1, **characterised by that** the border (7) of opening (4) is formed by an independent removable part.

7. The collecting electrode according to the claim 6, **characterised by that** the connection between the border (7) of opening (4) formed by an independent removable part and the body (2) of electrode (1) is secured by a thread.

8. The collecting electrode according to the claim 6, **characterised by that the** connection between the border (7) of opening (4) formed by an independent removable part and the body (2) of electrode (1) is secured by friction forces.

9. The collecting electrode according to any of the claims 1, 2 and 4 to 8, **characterised by that** at least one brace (5) is provided by a cavity (10), in which there is placed the lead (11) of high voltage.

10. The collecting electrode according to the claim 9, **characterised by that** at least one holder (3) of electrode (1) is provided with a cavity, in which there is positioned the lead (11) of high voltage.

11. The collecting electrode according to any of the previous claims, **characterised by that** the transition between the neighbouring walls of the body (2) of electrode (1) is on an outer surface (9) performed by rounding.

12. The collecting electrode according to any of the previous claims, **characterised by that** the body (2) of electrode (1) is formed by a hollow cylinder.

13. The collecting electrode according to any of the previous claims, **characterised by that** the brace (5) is with holder (3) of electrode (1) connected directly.

14. The collecting electrode according to any of the claims 1 to 8, **characterised by that** the brace (5) is with holder (3) of electrode (1) connected by means of the supporting tube (12).

15. The collecting electrode according to the claim 13, **characterised by that** the length of the supporting tube (12) is greater than the length of the body (2) of electrode (1) including borders (7) of openings (4) positioned in direction of the supporting tube (12), while the supporting tube (12) is in the wall provided with an opening for passage of the lead (11) of high voltage.

16. The collecting electrode according to the claims 14 or 15, **characterised by that** the supporting tube (12) is electrically non-conducting.

17. The collecting electrode according to any of the previous claims, **characterised by that** the holder (3) of electrode (1) is electrically non-conducting.

18. The collecting electrode according to any of the previous claims, **characterised by that** the brace (5) is electrically non-conducting.

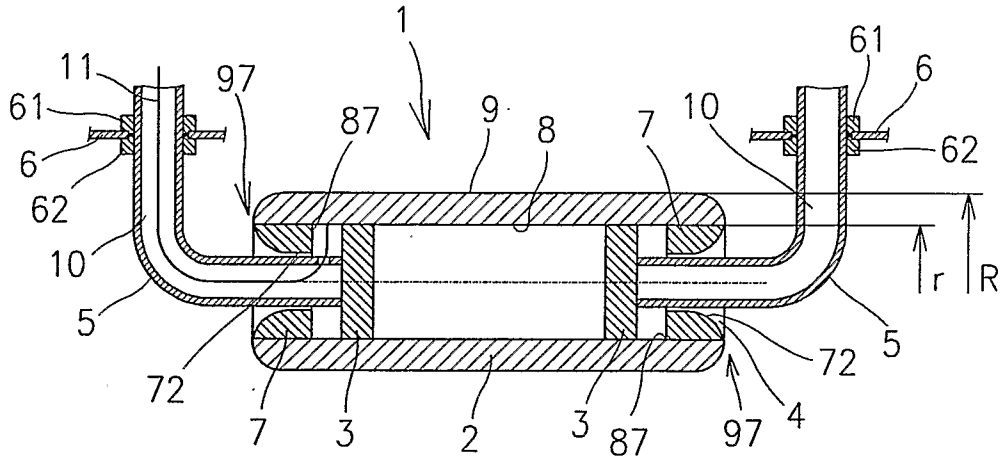
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Fig. 1

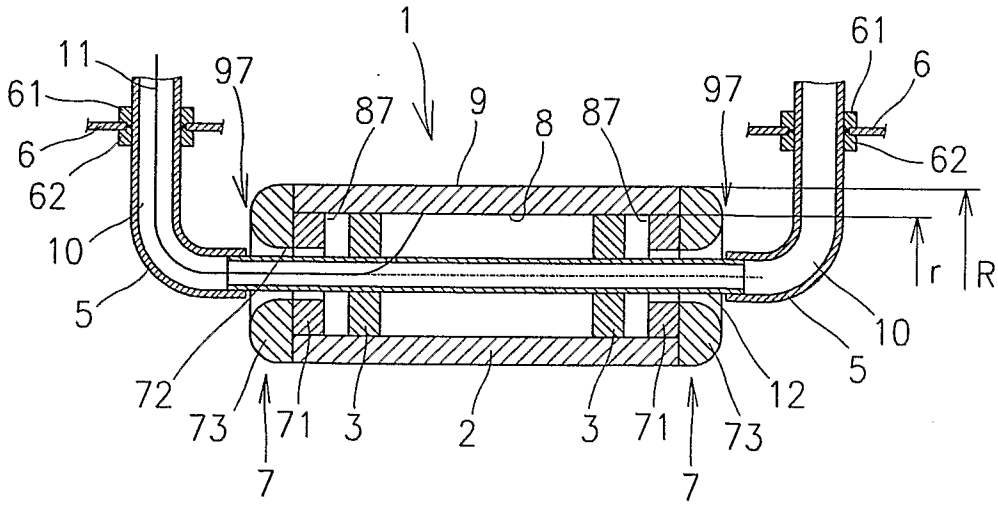
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Fig. 2

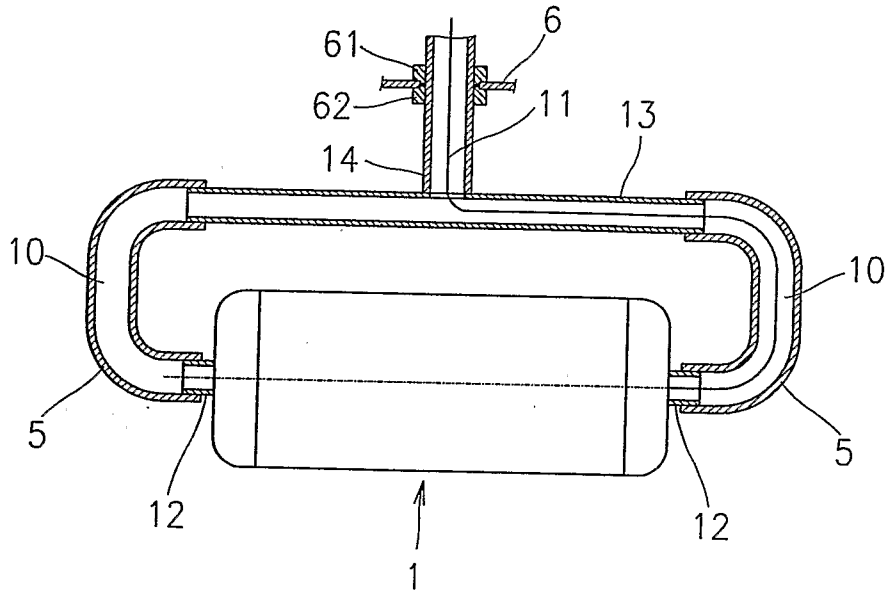

Fig. 3