



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
18.04.2018 Bulletin 2018/16

(51) Int Cl.:
B03C 3/49 (2006.01) **B03C 3/40** (2006.01)
B03C 3/41 (2006.01) **F01N 3/01** (2006.01)

(21) Application number: **16807359.1**

(86) International application number:
PCT/JP2016/066293

(22) Date of filing: **01.06.2016**

(87) International publication number:
WO 2016/199652 (15.12.2016 Gazette 2016/50)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(72) Inventors:
• **FURUGEN, Munekatsu**
Nishinomiya-shi
Hyogo 662-0875 (JP)
• **MAKINO, Tadashi**
Takatsuki-shi
Osaka 569-1020 (JP)
• **TAKIKAWA, Kazunori**
Numazu-shi
Shizuoka 410-0037 (JP)

(30) Priority: **09.06.2015 JP 2015117042**

(71) Applicant: **Usui Co., Ltd.**
Sunto-gun
Shizuoka 411-8610 (JP)

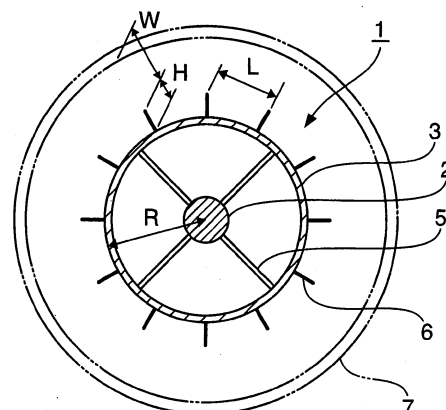
(74) Representative: **Hoppe, Lars**
VKK Patentanwälte
Edisonstraße 2
87437 Kempten (DE)

(54) **DISCHARGE ELECTRODE OF ELECTROSTATIC PRECIPITATOR FOR TREATING DIESEL ENGINE EXHAUST GAS**

(57) Provided is a discharge electrode capable of appropriately setting the arrangement of electrode needles with respect to a main electrode at a desired density even if the outer diameter of a collecting pipe of a tubular collecting part of an electrostatic precipitator for treating diesel engine exhaust gas is increased, reducing the weight and maintaining the shape of the electrode needles, and also being effective also for measures against high temperatures. The discharge electrode of the diesel engine exhaust gas treatment apparatus having a tubular collecting part with a predetermined length composed of the discharge electrode for charging particulate matter contained in the exhaust gas and a precipitation electrode for collecting the particulate matter charged, the discharge electrode being composed of a main electrode disposed in the tubular collecting part in a pipe axial direction and electrodes disposed on the main electrode to radially protrude, tubular collecting modules short in an axial direction with varied diameters arranged at a plurality of stages in the tubular collecting part is configured by radially arranging short discharge electrode needles or low-height saw-blade-shaped discharge electrode plates on the outer periphery of a cylindrical discharge electrode support barrel attached to the outer pe-

riphery of the main electrode.

Fig.1



Description

Technical Field

[0001] The present invention relates to electrical exhaust gas treatment technology using corona discharge in a diesel engine such as an engine for marine, for electric power generation, for general industry, or the like and, in particular, to a discharge electrode of an electrostatic precipitator for treating exhaust gas of a diesel engine which discharges exhaust gas at high temperatures using a fuel lower in quality than fuel oil.

Background Art

[0002] As a motive power source for various marines, electric power generators, large construction equipment, and furthermore, various automobiles and so forth, a diesel engine has been widely adopted. PM (particulate matter) included in exhaust gas discharged from the diesel engine not only causes air pollution, as well known, but also is a substance extremely poisonous to the human body. Thus, purification of that exhaust gas is extremely important. Therefore, numerous suggestions have already been made, such as an improvement of diesel engine combustion schemes, adoption of various exhaust gas filters, and methods of electrical treatment using corona discharge, and have been partially put into practice.

[0003] Among these, as a technique of electrical treatment using corona discharge, for example, an apparatus described in PTL 1 has been suggested.

[0004] A diesel engine exhaust gas treatment apparatus using a fuel lower in quality than fuel oil described in PTL 1 is, as in Figure 10 depicting its example of structure, of a multistage type exemplarily depicted, which is configured by combining a plurality of tubular collecting modules short in an axial direction with varied diameters in a tubular collecting part 91 formed of a discharge electrode and a precipitation electrode. Specifically, the tubular collecting module is formed as a three-stage type including a small-diameter collecting part 91-1A, an intermediate-diameter collecting part 91-1B, and a large-diameter collecting part 91-1C from an upstream side of the tubular collecting part.

[0005] That is, the diesel engine exhaust gas treatment apparatus with this tubular collecting part as a multistage type includes: the small-diameter collecting part 91-1A as a small-diameter tubular collecting module at the first stage on the uppermost stream side, with radial first-stage discharge electrodes 91-1A-2 retained inside a small-diameter collecting pipe 91-1A-1 fixed to a collecting pipe 91-1 being fixed and incorporated in a common main electrode 91-2a; the intermediate-diameter collecting part 91-1B as an intermediate-diameter tubular collecting module at the second stage, with radial second-stage discharge electrodes 91-1B-2 retained inside an intermediate-diameter collecting pipe 91-1B-1 being fixed and incorporated in the common main electrode

91-2a; and the large-diameter collecting part 91-1C as a largest-diameter tubular collecting module at the third stage on the lowermost stream side, with radial third-stage discharge electrodes 91-1C-2 retained inside a large-diameter collecting pipe 91-1C-1 common to the collecting pipe 91-1 being fixed and incorporated in the common main electrode 91-2a. Each of the discharge electrodes 91-1A-2, 91-1B-2, and 91-1C-2 of the small-diameter collecting part 91-1A, the intermediate-diameter collecting part 91-1B, and the large-diameter collecting part 91-1C in the diesel engine exhaust gas treatment apparatus having these three-stage-type tubular collecting modules are configured of the main electrode (electrode rod) 91-2a extending over an approximately full length near an axial center of the collecting pipe 91-1 configuring a precipitation electrode and a group of electrode needles 91-2b radially protruding and disposed with a desired space S' in a longitudinal direction of the main electrode 91-2a, as depicted in Figure 11A, Figure 11B, and Figure 12 in an enlarged manner. As this discharge electrode 91-2, specifically as depicted in Figure 12, for example, adopted is one configured by providing a saw-blade-shaped discharge electrode plate 91-2d integrally provided together with the main electrode 91-2a via a substrate part 91-2f with saw-blade-shaped discharge plate parts (mountain parts) 91-2e extending in an axial direction of the main electrode 91-2a so that the electrode plates protrude on the main electrode 91-2a via the substrate part 91-2f. In thus configured discharge electrode 91-2, both ends of the main electrode 91-2a are supported via support bodies 93 vertically provided to a seal air introduction pipe part 91-1c provided on an exhaust gas introduction port 91-1a side of the collecting pipe 91-1 and a seal air introduction pipe part 91-1c provided at an inlet portion of a PM-low-concentration exhaust gas delivery pipe 92.

[0006] Separation/collecting means 94 of a cyclone type provided between a downstream side and an upstream side of the tubular collecting part 91 is configured of a cyclone collecting part 94-1 and a recirculation piping 94-2 from the cyclone collecting part 94-1. This cyclone collecting part 94-1 is configured of a tangential cyclone 94-3 connected via the recirculation piping 94-2 to a PM-high-concentration exhaust gas piping 95 provided to a PM-high-concentration exhaust gas delivery part 91-1b provided near an inner circumferential surface on a downstream side of the collecting pipe 91-1 of the tubular collecting part 91. Furthermore, disposed between the tangential cyclone 94-3 and the exhaust gas introduction pipe 91-1a is the recirculation piping 94-2 for merging purified gas after passage of the tangential cyclone 94-3 with exhaust gas flowing in the exhaust gas introduction pipe 91-1a. 96 denotes a blower, and 97 denotes a flow rate control damper.

Citation List

Patent Literature

[0007] PTL 1: Japanese Patent Application Laid-Open No. 2014-238086

Summary of Invention

Technical Problem

[0008] However, the discharge electrode 91-2 in the conventional diesel engine exhaust gas purification apparatus (multistage type) described above for electrically treating PM in exhaust gas by using corona discharge or the like has the following problems.

[0009] That is, for example, in the case of a discharge electrode 91-2 depicted in Figure 11A, Figure 11B, and Figure 12, the discharge electrode is configured by providing the saw-blade-shaped discharge electrode plate 91-2d integrally provided together with the main electrode 91-2a via the substrate part 91-2f with the saw-blade-shaped discharge plate parts (mountain parts) 91-2e extending in the axial direction of the main electrode 91-2a so that the electrode plates protrude on the main electrode 91-2a via the substrate part 91-2f. Thus, if the outer diameter of the collecting pipe 91-1 of the tubular collecting part 91 is increased, a length H' of the corresponding electrode needle 91-2b in a radial direction is increased in order to keep a space W' between the tips of the electrode needles 91-2b (saw-blade-shaped discharge electrode plates 91-2d) and a collecting wall surface 91-1k at a desired dimension, thereby decreasing stiffness. If the stiffness is ensured, the weight becomes heavy. Not only that, but an electrode needle is normally manufactured by using an extremely thin plate with a thickness on the order of 0.5 mm. Thus, if the size is increased, it also becomes difficult to maintain the shape. In particular, when the electrode needle is exposed to high temperatures, problems such as an occurrence of thermal deformation arise. Moreover, to eliminate dead spots with a weak electric field and maintain a predetermined discharge current density in this precipitation part, it is required to keep a space L' between the tips of the electrode needles 91-2b in the circumferential direction approximately constantly at a desired dimension. As a result, if the outer diameter of the collecting pipe 91-1 of the tubular collecting part 91 is increased, the number of electrode needles (sheets) 91-2b has to be increased. However, if the number of electrode needles (sheets) 91-2b required is increased, a mount area on the main electrode 91-2a for one electrode needle (sheet) is inevitably decreased, thereby making it difficult to mount while ensuring the strength to the main electrode 91-2a.

[0010] Moreover, in the case of the conventional long (long-needle) electrode needle 91-2b (saw-blade-shaped discharge electrode plate 91-2d), the electric field

at the tip of the electrode needle is strong, but the electric field on the surface of the collecting wall is weak, and the electric field on the entire PM collecting space (space between the tips of the electrode needles and the collecting wall) is weak, and thus dead spots are prone to occur. The Coulomb force acting on PM is weak, and the collecting ratio cannot be improved. Not only that, but there is a drawback that a jumping phenomenon (a phenomenon of repeated deposition and exfoliation of PM) of PM exfoliated from the collecting wall is less prone to appear on the collecting wall surface.

[0011] The present invention was made to overcome the above-described problems in the conventional technology and, in particular, is to provide a discharge electrode in a multistage-type diesel engine exhaust gas treatment apparatus configured by combining in an axial direction a plurality of tubular collecting modules having a tubular collecting part formed of the discharge electrode and a precipitation electrode and made short in the axial direction and having different diameters, the discharge electrode enhancing an electric field and the Coulomb force in a PM collecting space to improve a PM collecting ratio, capable of appropriately setting the arrangement of electrode needles with respect to a main electrode at a desired density even if the outer diameter of a collecting pipe of the tubular collecting part is increased, maintaining the stiffness of the electrode needles, reducing the weight thereof, maintaining the shape thereof, and further being effective also for measures against high temperatures.

Solution to Problems

[0012] A discharge electrode of an electrostatic precipitator for treating diesel engine exhaust gas according to the present invention is a discharge electrode of a diesel engine exhaust gas treatment apparatus, including an electrostatic precipitating means having a tubular collecting part with a predetermined length composed of the discharge electrode for charging particulate matter contained in exhaust gas from a diesel engine using fuel oil and a precipitation electrode for collecting the particulate matter charged, the discharge electrode being composed of a main electrode disposed in the tubular collecting part in a pipe axial direction and electrodes disposed on the main electrode to radially protrude, wherein tubular collecting modules short in the pipe axial direction and having different diameters are arranged at a plurality of stages in the tubular collecting part formed of a main collecting pipe with a single diameter and a predetermined length, which corresponds to the discharge electrode and the precipitation electrode; the discharge electrode of at least one tubular collecting module of the tubular collecting modules arranged at the plurality of stages is configured of a cylindrical discharge electrode support barrel attached to an outer periphery of the main electrode via a stay concentrically with the main electrode and short discharge electrode needles or low-height saw-

blade-shaped discharge electrode plates radially arranged with a desired space in a circumferential direction and the pipe axial direction on a surface of the discharge electrode support barrel; a length of the short discharge electrode needles or the low-height saw-blade-shaped discharge electrode plates in a radial direction is set at 10 mm to 30 mm, and a space between tips of the short discharge electrode needles or the low-height saw-blade-shaped discharge electrode plates and a collecting wall surface is set at 30 mm to 70 mm; and an upstream side opening end of the discharge electrode support barrel of the tubular collecting module on an uppermost stream of the tubular collecting part is closed.

[0013] Also, an another discharge electrode of an electrostatic precipitator for treating diesel engine exhaust gas according to the present invention is a discharge electrode of a diesel engine exhaust gas treatment apparatus, including an electrostatic precipitating means having a tubular collecting part with a predetermined length composed of the discharge electrode for charging particulate matter contained in exhaust gas from a diesel engine using fuel oil and a precipitation electrode for collecting the particulate matter charged, the discharge electrode being composed of a main electrode disposed in the tubular collecting part in a pipe axial direction and electrodes disposed on the main electrode to radially protrude, wherein tubular collecting modules short in the pipe axial direction and having different diameters are arranged in the tubular collecting part formed of a main collecting with pipe a single diameter and a predetermined length, which corresponds to the discharge electrode and the precipitation electrode, at three stages as a small-diameter collecting part, an intermediate-diameter collecting part, and a large-diameter collecting part from an upstream side of the tubular collecting part; the discharge electrode of the tubular collecting modules arranged at the three stages is configured of a cylindrical discharge electrode support barrel attached to an outer periphery of the main electrode via a stay concentrically with the main electrode and short discharge electrode needles or low-height saw-blade-shaped discharge electrode plates radially arranged with a desired space in a circumferential direction and the pipe axial direction on a surface of the discharge electrode support barrel; a length of the short discharge electrode needles or the low-height saw-blade-shaped discharge electrode plates in a radial direction is set at 10 mm to 30 mm, and a space between tips of the short discharge electrode needles or the low-height saw-blade-shaped discharge electrode plates and a collecting wall surface is set at 30 mm to 70 mm; and an upstream side opening end of the discharge electrode support barrel of the tubular collecting module on an uppermost stream of the tubular collecting part is closed.

[0014] As a preferable mode, at least one tubular collecting module of the tubular collecting modules arranged at the plurality of stages or at the three stages in the electrostatic precipitator for treating diesel engine ex-

haust gas of the above present invention is configured of the discharge electrode and the precipitation electrode formed of the main collecting pipe.

[0015] Furthermore, as a preferable mode, the short discharge electrode needles or the low-height saw-blade-shaped discharge electrode plates radially provided on an outer periphery of the discharge electrode support barrel are each composed of a discharge electrode needle or saw-blade-shaped discharge electrode plate having an apex angle on the order of 20 degrees and assuming a substantially isosceles triangular shape or a cone-edge-ring-shaped discharge electrode plate or a cylindrically-shaped edge ring. In this regard, a space between tips of adjacent discharge electrode needles or saw-blade-shaped discharge electrode plates is preferably 10 mm to 50 mm.

Advantageous Effects of Invention

[0016] In the discharge electrode of the electrostatic precipitator for treating diesel engine exhaust gas according to the present invention, the discharge electrode of at least one tubular collecting module of the electrostatic precipitator with a multistage-type precipitation wall structure configured by combining in an axial direction a plurality of tubular collecting modules having a tubular collecting part formed of the discharge electrode and a precipitation electrode and made short in the axial direction and having different diameters is configured by attaching short discharge electrode needles or low-height saw-blade-shaped discharge electrode plates to a cylindrical discharge electrode support barrel attached to the outer periphery of a main electrode concentrically with the main electrode. Also, the length of the discharge electrode needle or the saw-blade-shaped discharge electrode is made appropriate, that is, the conventional long length is changed to a short length. Thus, the electric field between the tips of the electrode needles or electrode plates and the collecting wall is increased, and the amount of discharge of corona electrons occurring from the tips of the discharge electrodes is increased, thereby decreasing dead spots, making the Coulomb force strong, and improving the collecting ratio. Not only that, but a jumping phenomenon of PM exfoliated from the collecting wall occurs on the collecting wall surface, and PM is made coarse, thereby allowing cyclone collecting via a branch channel.

[0017] Also, in the case of these short discharge electrode needles or saw-blade-shaped discharge electrode plates, even if the diameter of the collecting pipe of the tubular collecting part is increased, the discharge electrode support barrel having an appropriate size corresponding to the diameter is used. With this, without an increase of the length of the discharge electrode needles or the discharge electrode plates in the axial direction, the space between the tips of the discharge electrode needles or discharge electrode plates and the inner wall of the collecting pipe can be set at a desired appropriate

dimension, the stiffness of the electrode needles is maintained, and the weight can be reduced. Not only that, but even if the electrode needles or electrode plates are exposed to high temperatures, a large thermal deformation does not occur, and thus the shape can also be maintained. Furthermore, the arrangement of the electrode needles or electrode plates on the main electrode can be appropriately set with a predetermined density, and the electrode needles or electrode plates can also be easily attached to the main electrode. Also, the discharge electrode support barrel interrupts a traffic of a gas flow flowing inside and outside the barrel body if without through holes, an operation of preventing a swirl or turbulent flow not preferable for dust collection can also be provided, contributing also to an improvement of a collecting ratio.

Brief Description of Drawings

[0018]

Figure 1 is a schematic longitudinal sectional end view depicting a basic structure of a discharge electrode of an electrostatic precipitator for treating diesel engine exhaust gas according to the present invention.

Figure 2 is a schematic longitudinal sectional side view of the discharge electrode depicted in Figure 1. Figure 3 is a diagram depicting one example of a discharge electrode plate of the discharge electrode depicted in Figure 1, (a) being a front view of a cone-edge-ring-shaped discharge electrode plate and (b) being a longitudinal sectional side view on an a-a line in (a).

Figure 4 is a diagram depicting another example of the cone-edge-ring-shaped discharge electrode plate depicted in Figure 3, (a) being a front view and (b) being a longitudinal sectional side view on a b-b line in (a).

Figure 5 is a diagram depicting a modification example of the cone-edge-ring-shaped discharge electrode plate depicted in Figure 4, (a) being a front view and (b) being a longitudinal sectional side view on a c-c line in (a).

Figure 6 is a longitudinal sectional side view depicting another example of the discharge electrode plate of the discharge electrode depicted in Figure 1.

Figure 7 is a schematic longitudinal sectional end view of main parts depicting a first embodiment (multistage-type precipitation wall structure) of the discharge electrode of the electrostatic precipitator for treating diesel engine exhaust gas according to the present invention.

Figure 8 is a schematic longitudinal sectional end face view of main parts depicting a second embodiment (multistage-type precipitation wall structure) of the discharge electrode of the electrostatic precipitator for treating diesel engine exhaust gas ac-

cording to the present invention.

Figure 9 is a schematic longitudinal sectional end face view of main parts depicting a third embodiment (multistage-type precipitation wall structure) of the discharge electrode of the electrostatic precipitator for treating diesel engine exhaust gas according to the present invention.

Figure 10 is a schematic longitudinal sectional view depicting one example of a conventional diesel engine exhaust gas treatment apparatus in a multistage-type precipitation wall structure.

Figure 11A is a schematic longitudinal sectional end view depicting, in an enlarged manner, a discharge electrode of the diesel engine exhaust gas treatment apparatus depicted in Figure 10.

Figure 11B is a schematic longitudinal sectional side view depicting, in an enlarged manner, the discharge electrode of the diesel engine exhaust gas treatment apparatus depicted in Figure 10.

Figure 12 is a schematic perspective view depicting, in an enlarged manner, the discharge electrode of the diesel engine exhaust gas treatment apparatus depicted in Figure 10.

25 Description of Embodiments

[0019] A discharge electrode 1 of a tubular collecting module of the present invention depicted in Figure 1 and Figure 2 is configured of a main electrode (electrode rod) 2 and a discharge electrode support barrel 3 having short discharge electrode needles 6 radially arranged with a desired space in a circumferential direction and a pipe axial direction on the outer perimeter on the main electrode 2. The discharge electrode support barrel 3 is configured to be attached concentrically with the main electrode 2 via a plurality of stays 5. Here, regarding a size (diameter) of the discharge electrode support barrel 3, an appropriate size is set in accordance with the diameter of the main electrode (electrode rod) 2 or the inner diameter of a collecting pipe 7 in consideration of the length of the discharge electrode needles 6 and a distance W from the tips of the discharge electrode needles 6 to a collecting wall surface. In this regard, as attaching means of the discharge electrode support barrel 3 to the main electrode 2, it is not restricted to a way of direct attachment via the plurality of stays 5 radially provided to the main electrode 2 and, for example, a way of attachment using a support ring (omitted in the drawings) fitting to the main electrode 2 and the stays 5 may be adopted. Also, as the stays 5, plate-shaped or rod-shaped ones can be used. When plate-shaped stays are used, they are attached on the outer circumferential surface of the main electrode 2 with a space in a pipe axial direction. When rod-shaped ones are used, they are attached with a desired space in the circumferential direction and the pipe axial direction of the main electrode 2.

[0020] As the short discharge electrode needles 6 provided to radially protrude on the outer periphery of the

discharge electrode support barrel 3, plate-shaped members each having an apex angle on the order of 20 degrees and assuming a substantially isosceles triangular shape can be used. A length H of this discharge electrode needle 6 (a length protruding from the outer circumferential surface of the discharge electrode support barrel 3) is set at 10 mm to 30 mm. The reason for this is as follows. If the length is shorter than 10 mm, a peak electric field for corona discharge at the tip of the discharge electrode needle 6 is weak, the Coulomb force cannot be enhanced, and it is difficult to increase attachment to the collecting wall surface. On the other hand, if the length exceeds 30 mm, while the peak electric field at the tip of the discharge electrode needle 6 is enhanced, an average electric field is decreased, and it is difficult to enhance the Coulomb force to increase attachment to the collecting wall surface.

[0021] This short discharge electrode needles 6 are provided to radially protrude on the outer periphery of the discharge electrode support barrel 3 with a desired tip space S in an axial center direction of the main electrode 2 and with a desired space L in a circumferential direction. Also, as the space S between the tips of adjacent discharge electrode needles 6 in the axial center direction, 10 mm to 50 mm is normally preferable, although not particularly restrictive. The reason for this is as follows. If the space is shorter than 10 mm, the electric field is decreased, the Coulomb force cannot be enhanced, and it is difficult to increase attachment to the collecting wall surface. On the other hand, if the space exceeds 50 mm, dead points with a weak electric field are increased, an average electric field is decreased, and it is difficult to enhance the Coulomb force to increase attachment to the collecting wall surface.

[0022] Also, the distance W from the tips of the discharge electrode needles 6 to the collecting wall surface (inner wall surface) of the collecting pipe 7 is set at 30 mm to 70 mm. The reason for this is as follows. If the distance is shorter than 30 mm, there is a concern that the tips of the discharge electrode needles 6 may contact or interfere with the collecting wall surface (inner wall surface) of the collecting pipe 7 at the time of assembling. During operation, due to a ship body's swing and engine vibrations, the tips of the discharge electrode needles 6 easily contact or interfere with the collecting wall surface (inner wall surface) of the collecting pipe 7. On the other hand, if the distance exceeds 70 mm, a discharge space is wide, and thus a high-voltage, high-output power source is required to maintain a high electric field and acquire a large Coulomb force. Also, due to high voltage, high insulation capability is required for each part, which makes the apparatus expensive and also requires an enormous number of processes for maintenance and management.

[0023] Note that the radius R of the discharge electrode support barrel 3, the length H of the discharge electrode needle 6, the space L between the discharge electrode needles 6 in the circumferential direction, and the dis-

tance W from the tips of the discharge electrode needles 6 to the collecting wall surface (inner wall surface) of the collecting pipe 7 are assumed to be defined as appropriate in accordance with the size of the diesel engine exhaust gas treatment apparatus, the arrangement position of the tubular collecting module, the size (diameter) of the collecting pipe 7 configuring a precipitation electrode, and so forth. In particular, the length H of the discharge electrode needle 6 is set in consideration of a relation with the collecting wall surface electric field of the collecting pipe 7.

[0024] Also, as the discharge electrode in the present invention, in place of the discharge electrode needles 6 depicted in Figure 1 and Figure 2 described above, for example, cone-edge-ring-shaped discharge electrodes 16, 26, and 36 depicted in Figure 3, Figure 4, and Figure 5 or a cylindrical-edge-ring-shaped discharge electrode plate 46 depicted in Figure 6 can be used. The cone-edge-ring-shaped discharge electrode 16 depicted in Figure 3 is formed of a ring having a cone-and-ring-shaped edge 16-1 on the outer periphery. The cone-edge-ring-shaped discharge electrode 26 depicted in Figure 4 is formed of a ring having, on a circumferential wall part of a cone-and-ring-shaped edge 26-1, leak holes 26-2 for decreasing flowing resistance of exhaust gas at the edge part, and a plurality of rings are combined, with phases of the leak holes 26-2 at positions in the circumferential direction being varied. The cone-edge-ring-shaped discharge electrode 36 depicted in Figure 5 is formed of a ring having leak holes 36-2 larger than the leak holes 26-2 on a circumferential wall part of a cone-shaped ring-shaped edge 36-1, and is combined with the cone-edge-ring-shaped discharge electrode 16 and/or the cone-edge-ring-shaped discharge electrode 26. And, a desired number of these cone-edge-ring-shaped discharge electrodes 16, 26, and 36 are combined as required with a desired space to be each externally coupled and fixed to the discharge electrode support barrel 3, thereby allowing the cone-and-ring-shaped edges 16-1, 26-1, and 36-1 to be provided to radially protrude on the outer periphery of the discharge electrode support barrel 3. In this regard, in the case of these cone-edge-ring-shaped discharge electrodes 16, 26, and 36, the length of each of the cone-shaped edges 16-1, 26-1, and 36-1 of the discharge electrode support barrel 3 corresponds to and is equal to the length H of the discharge electrode needle 6 depicted in Figure 1 and Figure 2 described above, and the space between the edges 16-1, 26-1, 36-1 of adjacent cone-edge-ring-shaped discharge electrodes 16, 26, 36 corresponds to and is equal to the space S between the tips of the discharge electrode needles 6. **[0025]** Also, in a cylindrical-edge-ring-shaped discharge electrode 46 depicted in Figure 6, a cone-shaped edge ring 46-2 are formed at one end of a cylindrical body part 46-1 in a circumferential direction by folding the end of the cylindrical body part preferably at an acute angle, and its circumferential edge is taken as a ring-shaped edge 46-3. The discharge electrode can be manufac-

tured from a thin plate or tubing having a thickness on the order of 0.5 mm. In the case of this cylindrical-edge-ring-shaped discharge electrode 46, the cylindrical body part 46-1 is externally coupled and fixed to the discharge electrode support barrel 3 so as to make contact with each other, thereby causing the edge rings 46-2 to be provided to radially protrude on the outer periphery of the discharge electrode support barrel 3. In the case of this cylindrical-edge-ring-shaped discharge electrode 46, the length of the edge ring 46-2 corresponds to and is equal to the length H of the discharge electrode needle 6 depicted in Figure 1 and Figure 2 described above and the space between the edge rings 46-2 of adjacent cylindrical-edge-ring-shaped discharge electrodes 46 corresponds to and is equal to the space S between the tips of the discharge electrode needles 6. Note that while the cylindrical-edge-ring-shaped discharge electrode formed by combining a plurality of single cylindrically-shaped electrode plates is described herein, a cylindrical-edge-ring-shaped discharge electrode may be formed by winding a band-shaped plate having the edge rings 46-2 around the discharge electrode support barrel 3 in a spiral manner (omitted in the drawings).

[0026] In the case of the above-structured discharge electrode of the present invention, the discharge electrode is configured of the short discharge electrode needles 6, the cone-edge ring-shaped discharge electrodes 16, 26, 36, or the cylindrically-shaped edge ring discharge electrode 46 on the cylindrical discharge electrode support barrel 3 attached to the outer periphery of the main electrode 2 concentrically with the main electrode 2. Thus, even if the size (diameter) of the collecting pipe 7 of the tubular collecting module is increased, the discharge electrode support barrel 3 having a size corresponding thereto is used. With this, the stiffness of the electrode needles and electrode plates is significantly increased to increase resistance to deformation strength with respect to vibrations or the like and ensure durability. Not only that, but even if the electrode needles or electrode plates are exposed to high temperatures, a large thermal deformation does not occur, and the shape can also be maintained. With the ring-shaped edge parts continuing in the circumferential direction, dead points with a weak electric field are less prone to occur, the discharge current can be made as a large current, and effective electric field intensity is also increased. Particles are reliably charged to acquire the Coulomb force and are collected. Also, the space W between the tips of the short discharge electrode needles 6, the cone-edge-ring-shaped discharge electrodes 16, 26, 36, or the cylindrical-edge-ring-shaped discharge electrodes 46 and the inner wall of the collecting pipe 7 can be set at a desired appropriate dimension. Thus, high stiffness of the discharge electrode needles or discharge electrode plates can be maintained, and the weight can be reduced. Furthermore, the arrangement of the electrode needles 6, the cone-edge-ring-shaped discharge electrodes 16, 26, 36, or the cylindrical-edge-ring-shaped discharge elec-

trodes 46 on the main electrode 2, that is, the length H of the short discharge electrode needle 6, the cone-edge-ring-shaped discharge electrode 16, 26, 36, or the cylindrical-edge-ring-shaped discharge electrode 46 and the space S in the axial center direction and the space L in the circumferential direction between the tips of the discharge electrode needles 6, the cone-edge-ring-shaped discharge electrodes 16, 26, 36, or the cylindrically-shaped edge ring discharge electrodes 46, can be appropriately set with a predetermined density, thereby allowing prevention of an occurrence of dead points with a weak electric field. Also, the short discharge electrode needles 6, the cone-edge-ring-shaped discharge electrodes 16, 26, 36, or the cylindrically-shaped edge ring discharge electrodes 46 can be easily attached to the main electrode 2. Furthermore, the discharge electrode support barrel 3 interrupts a traffic of a gas flow flowing inside and outside the barrel body if without through holes, an operation of preventing a swirl or turbulent flow not preferable for dust collection can also be provided, contributing also to an improvement of a collecting ratio.

[0027] Next, the discharge electrode of the present invention applied to an electrostatic precipitator for treating diesel engine exhaust gas having a multistage-type precipitation wall is described based on Figure 7 to Figure 9.

[0028] An electrostatic precipitator for treating diesel engine exhaust gas depicted in Figure 7 as a first embodiment (multistage-type precipitation wall structure) is configured, in a diesel engine exhaust gas treatment apparatus with a tubular collecting module arranged inside a main collecting pipe 51 formed as a three-stage type including a small-diameter collecting part 51-1, an intermediate-diameter collecting part 51-2, and a large-diameter collecting part 51-3 from an upstream side of a tubular collecting part, so that discharge electrodes 51-2A-1 and 51-3A-1 each configured of a short discharge electrode needle or low-height saw-blade-shaped discharge electrode plate similar to the above are arranged in the intermediate-diameter collecting part 51-2 and the large-diameter collecting part 51-3 except the small-diameter collecting part 51-1.

[0029] The discharge electrode 51-2A-1 arranged in an intermediate-diameter collecting pipe 51-2A of the intermediate-diameter collecting part 51-2 is formed of a discharge electrode support barrel 51-2A-1d having a radius R of 300 mm and having short discharge electrode needles 51-2A-1c having a length H of 10 mm to 30 mm radially arranged with a desired space in a circumferential direction and a pipe axial direction on the outer periphery of a main electrode (electrode rod) 52. The discharge electrode support barrel 51-2A-1d is configured to be attached concentrically with the main electrode 52 via a plurality of stays 51-2A-1e. A distance W from the tips of the discharge electrode needles 51-2A-1c to a collecting wall surface (inner wall surface) of the intermediate-diameter collecting pipe 51-2A is 30 mm to 70 mm.

[0030] Also, the discharge electrode 51-3A-1 arranged in a large-diameter collecting pipe part 51-3A of the large-

diameter collecting part 51-3 common to the main collecting pipe 51 is formed of, as with the discharge electrode support barrel 51-2A-1d of the discharge electrode 51-2A-1 arranged in the intermediate-diameter collecting part 51-2, a discharge electrode support barrel 51-3A-1d having a radius R of 400 mm and having short discharge electrode needles 51-3A-1c having a length H of 10 mm to 30 mm radially arranged with a desired space in the circumferential direction and the pipe axial direction on the outer periphery of the main electrode (electrode rod) 52. This discharge electrode support barrel 51-3A-1d is also configured to be attached concentrically with the main electrode 52 via a plurality of stays 51-3A-1e. A distance W from the tips of the discharge electrode needles 51-3A-1c to a collecting wall surface (inner wall surface) of the large-diameter collecting pipe part 51-3A common to the main collecting pipe 51 is 30 mm to 70 mm, similarly to the above.

[0031] The discharge electrode 51-1A-1 arranged in the small-diameter collecting pipe 51-1A of the small-diameter collecting part 51-1 is configured of short discharge electrode needles 51-1A-1c radially arranged with a desired space on the outer periphery of the main electrode (electrode rod) 52.

[0032] In the drawing, 51-4 denotes a main electrode support body, 51-5 denotes a PM-low-concentration exhaust gas delivery pipe, and 51-6 denotes a PM-high-concentration exhaust gas delivery part.

[0033] An electrostatic precipitator for treating diesel engine exhaust gas depicted in Figure 8 as a second embodiment (multistage-type precipitation wall structure) is configured, in a diesel engine exhaust gas treatment apparatus with a tubular collecting module arranged inside a main collecting pipe 61 formed as a three-stage type including a small-diameter collecting part 61-1, an intermediate-diameter collecting part 61-2, and a large-diameter collecting part 61-3 from an upstream side of a tubular collecting part, so that discharge electrodes 61-1A-1, 61-2A-1, 61-3A-1 each configured of a short discharge electrode needle or low-height saw-blade-shaped discharge electrode plate similar to the above are arranged in the small-diameter collecting part 61-1, the intermediate-diameter collecting part 61-2, and the large-diameter collecting part 61-3. Here, the discharge electrode 61-1A-1 arranged in a small-diameter collecting pipe 61-1A of the small-diameter collecting part 61-1 is formed of, as with the discharge electrode having a structure similar to the above, a discharge electrode support barrel 61-1A-1d having a radius R of 200 mm and having short discharge electrode needles 61-1A-1c having a length H of 10 mm to 30 mm radially arranged with a desired space in a circumferential direction and a pipe axial direction on the outer periphery of a main electrode (electrode rod) 62. Also, the discharge electrode support barrel 61-1A-1d has formed at an upstream side opening end a conical lid part 61-1A-1d' for inhibiting an inflow of exhaust gas into the discharge electrode support barrel to close the end and is configured to be attached

concentrically with the main electrode 62 via a plurality of stays 61-1A-1e. A distance W from the tips of the discharge electrode needles 61-2A-1c to a collecting wall surface (inner wall surface) of the small-diameter collecting pipe 61-1A is 30 mm to 70 mm. In this regard, the closed part is configured of a conical lid part to make the flow of exhaust gas in the collecting pipe 61 smooth without resistance.

[0034] Also, the discharge electrode 61-2A-1 arranged in an intermediate-diameter collecting pipe 61-2A of the intermediate-diameter collecting part 61-2 is formed of a discharge electrode support barrel 61-2A-1d having short discharge electrode needles 61-2A-1c radially arranged with a desired space in the circumferential direction and the pipe axial direction on the outer periphery of the main electrode (electrode rod) 62. The discharge electrode support barrel 61-2A-1d has formed at an upstream side end a truncated conical part 61-2A-1d' and is configured to be attached concentrically with the main electrode 62 via a plurality of stays 61-2A-1e.

[0035] Furthermore, the discharge electrode 61-3A-1 arranged in a large-diameter collecting pipe part 61-3A of the large-diameter collecting part 61-3 is formed of, as with the discharge electrode support barrel 61-2A-1d of the discharge electrode 61-2A-1 arranged in the intermediate-diameter collecting part 61-2, a discharge electrode support barrel 61-3A-1d having short discharge electrode needles 61-3A-1c radially arranged with a desired space in the circumferential direction and the pipe axial direction on the outer periphery of the main electrode (electrode rod) 62. This discharge electrode support barrel 61-3A-1d has also formed at an upstream side end a truncated conical part 61-3A-1d', as with the discharge electrode support barrel 61-2A-1d of the intermediate-diameter collecting part 61-2, and is configured to be attached concentrically with the main electrode 62 via a plurality of stays 61-3A-1e.

[0036] In the drawing, 61-4 denotes a main electrode support body, 61-5 denotes a PM-low-concentration exhaust gas delivery pipe, and 61-6 denotes a PM-high-concentration exhaust gas delivery part.

[0037] An electrostatic precipitator for treating diesel engine exhaust gas depicted in Figure 9 as a third embodiment (multistage-type precipitation wall structure) is an electrostatic precipitator for treating diesel engine exhaust gas having a structure similar to that of the second embodiment except that a discharge electrode support barrel 71-4A-1d having discharge electrodes 71-4A-1 each formed of a short discharge electrode needle or low-height saw-blade-shaped discharge electrode plate on both inner and outer surfaces is further provided to the small-diameter collecting part 61-1 of the electrostatic precipitator for treating diesel engine exhaust gas of the second embodiment depicted in Figure 8 described above between a small-diameter collecting pipe 71-1A and a main collecting pipe 71.

[0038] That is, this apparatus is configured, in a diesel engine exhaust gas treatment apparatus with a tubular

collecting module arranged inside the main collecting pipe 71 formed as a three-stage type including a small-diameter collecting part 71-1, an intermediate-diameter collecting part 71-2, and a large-diameter collecting part 71-3 from an upstream side of a tubular collecting part, so that discharge electrodes 71-1A-1, 71-2A-1, and 71-3A-1 each configured of a short discharge electrode needle or low-height saw-blade-shaped discharge electrode plate similar to the above are arranged in the small-diameter collecting part 71-1, the intermediate-diameter collecting part 71-2, and the large-diameter collecting part 71-3. Here, the discharge electrode 71-1A-1 arranged in the small-diameter collecting pipe 71-1A of the small-diameter collecting part 71-1 is formed of, as with the discharge electrode having a structure similar to the above, a discharge electrode support barrel 71-1A-1d having a radius R of 200 mm and having short discharge electrode needles 71-1A-1c having a length H of 10 mm to 30 mm radially arranged with a desired space in a circumferential direction and a pipe axial direction on the outer periphery of a main electrode (electrode rod) 72. Also, the discharge electrode support barrel 71-1A-1d has formed at an upstream side opening end a conical lid part 71-1A-1d' for inhibiting an inflow of exhaust gas into the discharge electrode support barrel to close the end and is configured to be attached concentrically with the main electrode 72 via a plurality of stays 71-1A-1e. A distance W from the tips of the discharge electrode needles 71-1A-1c to a collecting wall surface (inner wall surface) of the small-diameter collecting pipe 71-1A is 30 mm to 70 mm. And, furthermore, in the present apparatus, the discharge electrode support barrel 71-4A-1d having the discharge electrodes 71-4A-1 each formed of a short discharge electrode needle or low-height saw-blade-shaped discharge electrode plate on both inner and outer surfaces is attached between the small-diameter collecting pipe 71-1A and the main collecting pipe 71 concentrically with the main electrode 72 via stays 71-4A-1e. Note that this discharge electrode support barrel 71-4A-1d is provided between the small-diameter collecting pipe 71-1A and the main collecting pipe 71 to further promote PM agglomeration, concentration, and separation by repeating charging and collecting of an exhaust gas flow outside the small-diameter collecting pipe 71-1A at least twice in total in the small-diameter collecting part 71-1 and the intermediate-diameter collecting part 71-2 and/or the large-diameter collecting part 71-3 (three times for the flow passing between the small-diameter collecting pipe 71-1A and the discharge electrode support barrel 71-4A-1d and also passing through the inner-diameter collecting pipe 71-2A).

[0039] Also, the discharge electrode 71-2A-1 arranged in an intermediate-diameter collecting pipe 71-2A of the intermediate-diameter collecting part 71-2 is formed of a discharge electrode support barrel 71-2A-1d having a radius R of 300 mm and having short discharge electrode needles 71-2A-1c having a length H of 10 mm to 30 mm radially arranged with a desired space in the circumfer-

ential direction and the pipe axial direction on the outer periphery of the main electrode (electrode rod) 72. The discharge electrode support barrel 71-2A-1d has a truncated conical part 71-2A-1d' at an upstream side end and is configured to be attached concentrically with the main electrode 72 via a plurality of stays 71-2A-1e.

[0040] Furthermore, the discharge electrode 71-3A-1 arranged in a large-diameter collecting pipe part 71-3A of the large-diameter collecting part 71-3 is formed of, as with the discharge electrode support barrel 71-2A-1d of the discharge electrode 71-2A-1 arranged in the intermediate-diameter collecting part 71-2, a discharge electrode support barrel 71-3A-1d having a radius R of 400 mm and having short discharge electrode needles 71-3A-1c having a length H of 10 mm to 30 mm radially arranged with a desired space in the circumferential direction and the pipe axial direction on the outer periphery of the main electrode (electrode rod) 72. As with the discharge electrode support barrel 71-2A-1d of the intermediate-diameter collecting part 71-2, this discharge electrode support barrel 71-3A-1d also has a truncated conical part 71-3A-1d' at an upstream side end and is configured to be attached concentrically with the main electrode 72 via a plurality of stays 71-3A-1e.

[0041] In the drawing, 71-4 denotes a main electrode support body, 71-5 denotes a PM-low-concentration exhaust gas delivery pipe, and 71-6 denotes a PM-high-concentration exhaust gas delivery part.

[0042] Note that it goes without saying that the discharge electrode of the multistage-type electrostatic precipitator for treating diesel engine exhaust gas having short tubular collecting modules short in the pipe axial direction with varied diameters arranged at a plurality of stages, of the present invention described above, that is, the discharge electrode configured of a cylindrical discharge electrode support barrel attached via a stay on the outer periphery of a main electrode and short discharge electrode needles or low-height saw-blade-shaped discharge electrode plates radially arranged with a desired space in a circumferential direction and a pipe axial direction on a surface of the discharge electrode support barrel, is manufactured by selecting a sectional shape, size, and so forth of its discharge electrode support barrel, discharge electrode needles, or low-height saw-blade-shaped discharge electrode plates in accordance with the size of the electrostatic precipitator for treating diesel engine exhaust gas, the size of the main collecting pipe (such as a tubular diameter), the sectional shape and diameter of the main electrode, or the like.

Reference Signs List

[0043]

- 1, 51-1A-1, 51-2A-1, 51-3A-1, 61-1A-1, 61-2A-1, 61-3A-1, 71-1A-1, 71-2A-1, 71-3A-1, 71-4A-1...discharge electrode
2, 52, 62, 72...main electrode (electrode rod)

3, 51-2A-1d, 51-3A-1d, 61-1A-1d, 61-2A-1d, 61-3A-1d, 71-1A-1d, 71-2A-1d, 71-3A-1d, 71-4A-1d...cylindrical discharge electrode support barrel

5, 51-2A-1e, 51-3A-1e, 61-1A-1e, 61-2A-1e, 61-3A-1e, 71-2A-1e, 71-3A-1e, 71-4A-1e...stay 5

6, 51-1A-1c, 51-2A-1c, 51-3A-1c, 61-1A-1c, 61-2A-1c, 61-3A-1c, 71-1A-1c, 71-2A-1c, 71-3A-1c...discharge electrode needle

7...collecting pipe

16...cone-edge-ring-shaped discharge electrode 10

16-1...ring-shaped edge

26...cone-edge-ring-shaped discharge electrode

26-1...ring-shaped edge

26-2...leak hole

36...cone-edge-ring-shaped discharge electrode 15

36-1...ring-shaped edge

36-2...leak hole

46...cylindrical-edge-ring-shaped discharge electrode

46-1...cylindrical body part 20

46-2...edge ring

46-3...ring-shaped edge

51, 61, 71...main collecting pipe

51-1, 61-1, 71-1... small-diameter collecting part

51-1A, 61-1A, 71-1A...small-diameter collecting pipe 25

51-2, 61-2, 71-2...intermediate-diameter collecting part

51-2A, 61-2A, 71-2A...intermediate-diameter collecting pipe 30

51-3, 61-3, 71-3...large-diameter collecting part

51-3A, 61-3A, 71-3A...large-diameter collecting pipe part

51-4, 61-4, 71-4...main electrode support body

51-5, 61-5, 71-5...PM-low-concentration exhaust gas delivery pipe 35

51-6, 61-6, 71-6...PM-high-concentration exhaust gas delivery part

61-1A-1d', 71-1A-1d'...conical lid part

61-2A-1d', 61-3A-1d', 71-2A-1d', 71-3A-1d'...truncated conical part 40

S...space between tips of discharge electrode needles in an axial center direction

L...space between tips of discharge electrode needles in a circumferential direction 45

H...length of a discharge electrode needle

W...distance from the tips of the discharge electrode needles to a collecting wall surface

R...radius of the discharge electrode support barrel 50

Claims

1. A discharge electrode of an electrostatic precipitator for treating diesel engine exhaust gas, being a discharge electrode of the diesel engine exhaust gas treatment apparatus, comprising an electrostatic precipitating means having a tubular collecting part 55

with a predetermined length composed of the discharge electrode for charging particulate matter contained in exhaust gas from a diesel engine using fuel oil and a precipitation electrode for collecting the particulate matter charged, the discharge electrode being composed of a main electrode disposed in the tubular collecting part in a pipe axial direction and electrodes disposed on the main electrode to radially protrude, wherein tubular collecting modules short in the pipe axial direction and having different diameters are arranged at a plurality of stages in the tubular collecting part formed of a main collecting pipe with a single diameter and a predetermined length, which corresponds to the discharge electrode and the precipitation electrode,

wherein the discharge electrode of at least one tubular collecting module of the tubular collecting modules arranged at the plurality of stages is configured of a cylindrical discharge electrode support barrel attached to an outer periphery of the main electrode via a stay concentrically with the main electrode and short discharge electrode needles or low-height saw-blade-shaped discharge electrode plates radially arranged with a desired space in a circumferential direction and the pipe axial direction on a surface of the discharge electrode support barrel,

a length of the short discharge electrode needles or the low-height saw-blade-shaped discharge electrode plates in a radial direction is set at 10 mm to 30 mm, and a space between tips of the short discharge electrode needles or the low-height saw-blade-shaped discharge electrode plates and a collecting wall surface is set at 30 mm to 70 mm, and an upstream side opening end of the discharge electrode support barrel of the tubular collecting module on an uppermost stream of the tubular collecting part is closed.

2. A discharge electrode of an electrostatic precipitator for treating diesel engine exhaust gas, being a discharge electrode of the diesel engine exhaust gas treatment apparatus, comprising an electrostatic precipitating means having a tubular collecting part with a predetermined length composed of the discharge electrode for charging particulate matter contained in exhaust gas from a diesel engine using fuel oil and a precipitation electrode for collecting the particulate matter charged, the discharge electrode being composed of a main electrode disposed in the tubular collecting part in a pipe axial direction and electrodes disposed on the main electrode to radially protrude, wherein tubular collecting modules short in the pipe axial direction and having different diameters are arranged in the tubular collecting part formed of a main collecting with pipe a single diameter and a predetermined length, which corresponds to the discharge electrode and the precipitation electrode, at three stages as a small-diameter collecting

part, an intermediate-diameter collecting part, and a large-diameter collecting part from an upstream side of the tubular collecting part,
 wherein the discharge electrode of the tubular collecting modules arranged at the three stages is configured of a cylindrical discharge electrode support barrel attached to an outer periphery of the main electrode via a stay concentrically with the main electrode and short discharge electrode needles or low-height saw-blade-shaped discharge electrode plates radially arranged with a desired space in a circumferential direction and the pipe axial direction on a surface of the discharge electrode support barrel,
 a length of the short discharge electrode needles or the low-height saw-blade-shaped discharge electrode plates in a radial direction is set at 10 mm to 30 mm, and a space between tips of the short discharge electrode needles or the low-height saw-blade-shaped discharge electrode plates and a collecting wall surface is set at 30 mm to 70 mm, and an upstream side opening end of the discharge electrode support barrel of the tubular collecting module on an uppermost stream of the tubular collecting part is closed.

3. The discharge electrode of the electrostatic precipitator for treating diesel engine exhaust gas according to claim 1 or 2, wherein at least one tubular collecting module of the tubular collecting modules arranged at the plurality of stages or at the three stages is configured of the discharge electrode and the precipitation electrode formed of the main collecting pipe.
4. The discharge electrode of the electrostatic precipitator for treating diesel engine exhaust gas according to any one of claims 1 to 3, wherein the short discharge electrode needles or the low-height saw-blade-shaped discharge electrode plates radially provided on the outer periphery of the discharge electrode support barrel are each composed of a cone edge ring or a cylindrical edge ring.

Fig.1

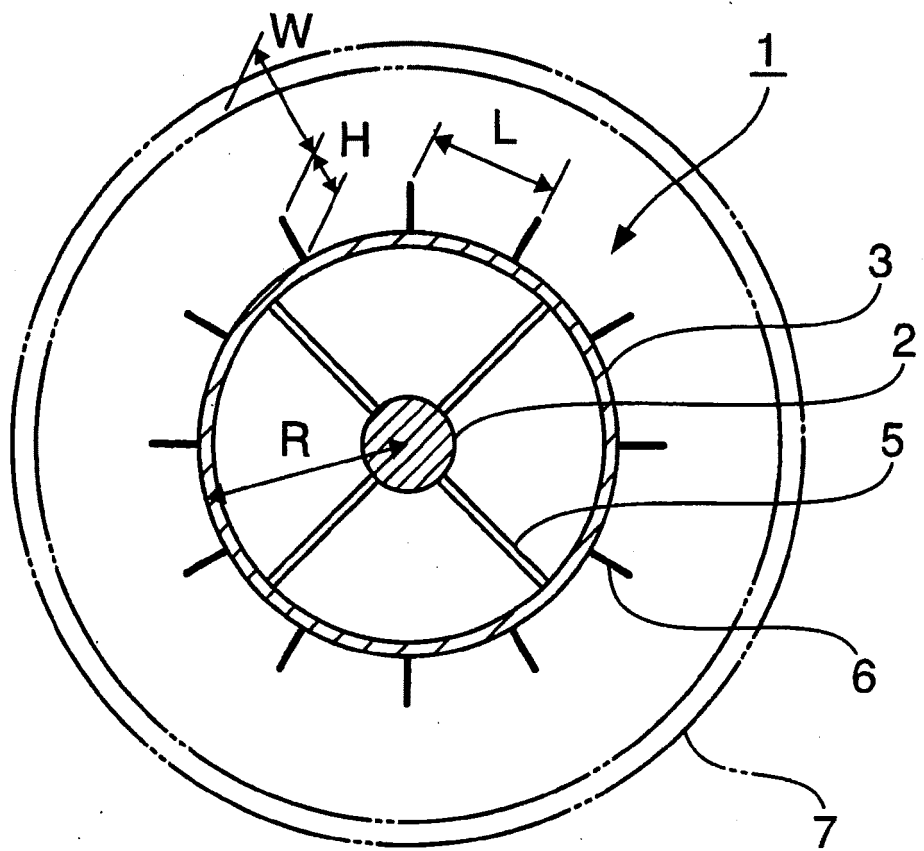


Fig.2

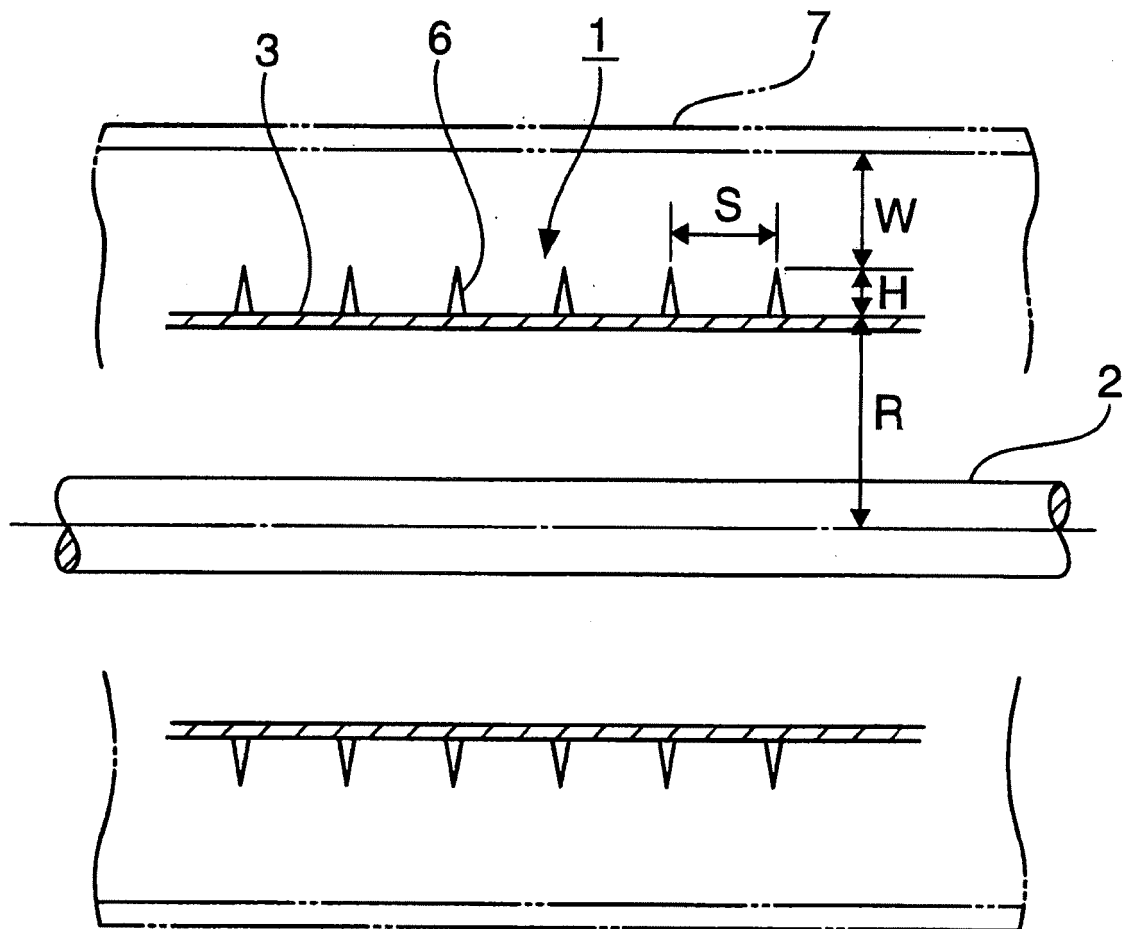


Fig.3

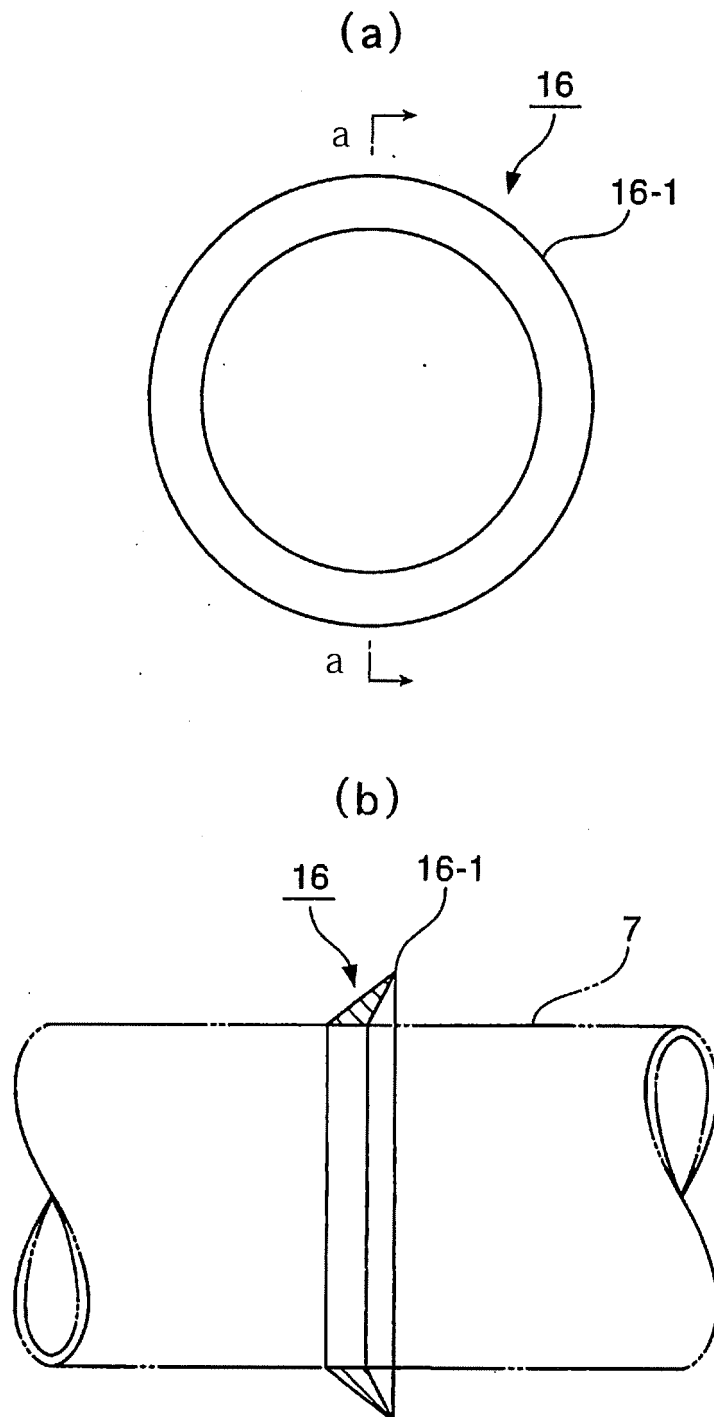


Fig.4

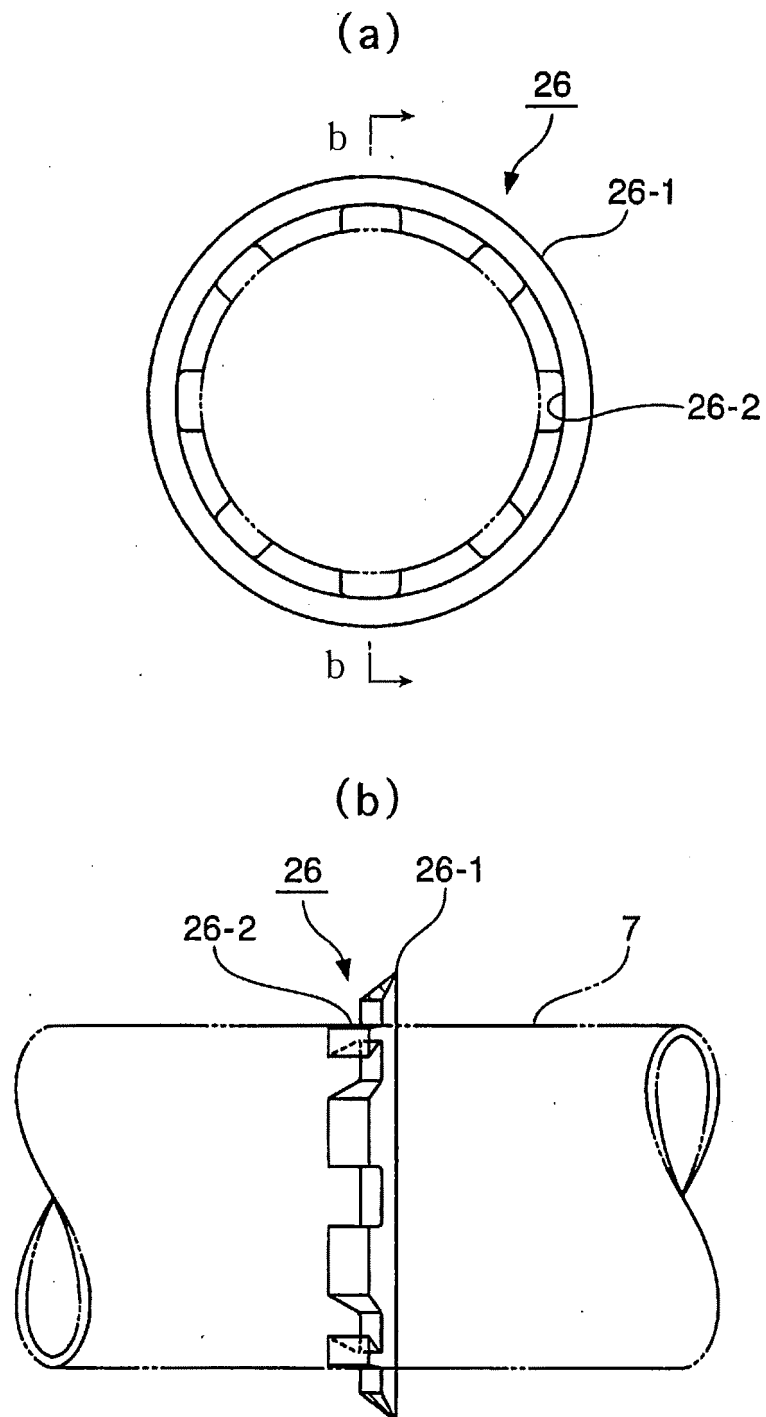


Fig.5

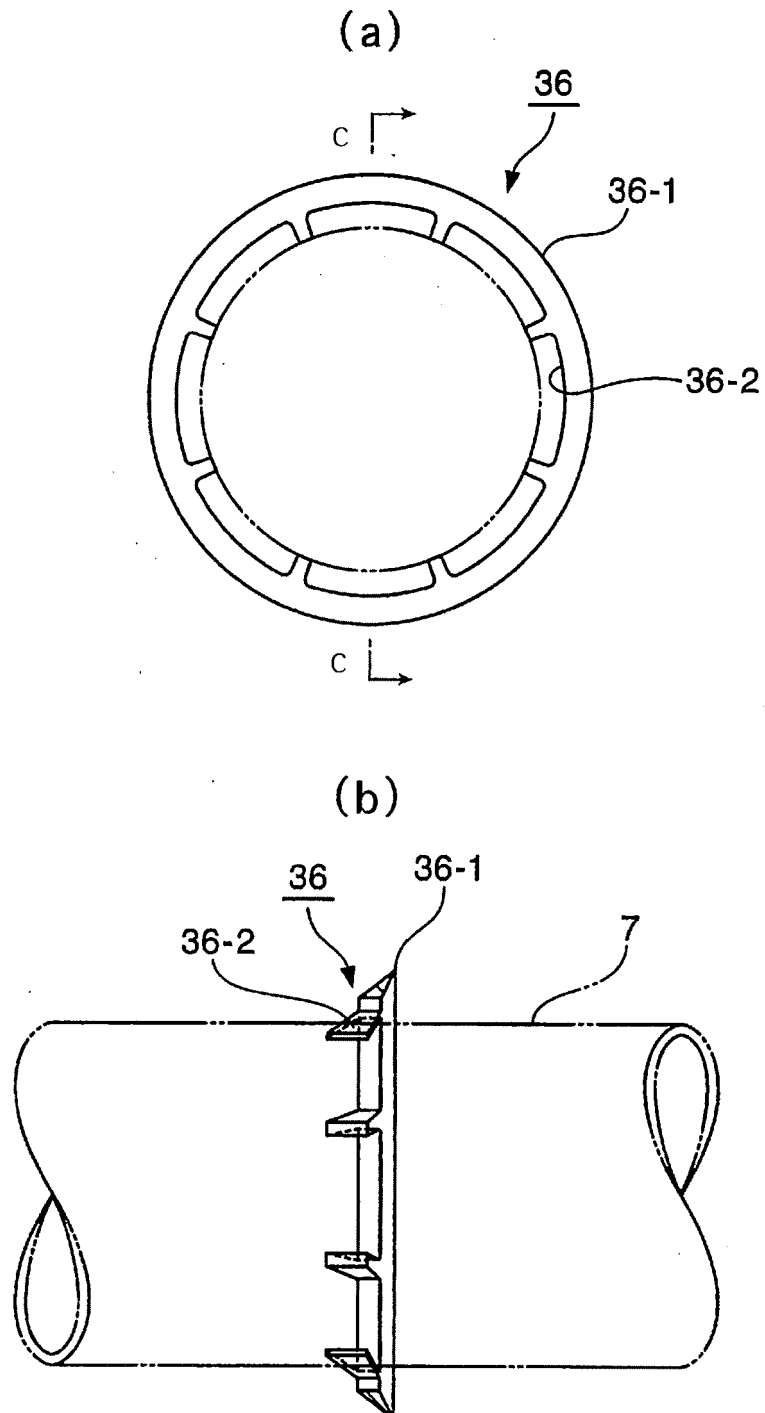


Fig.6

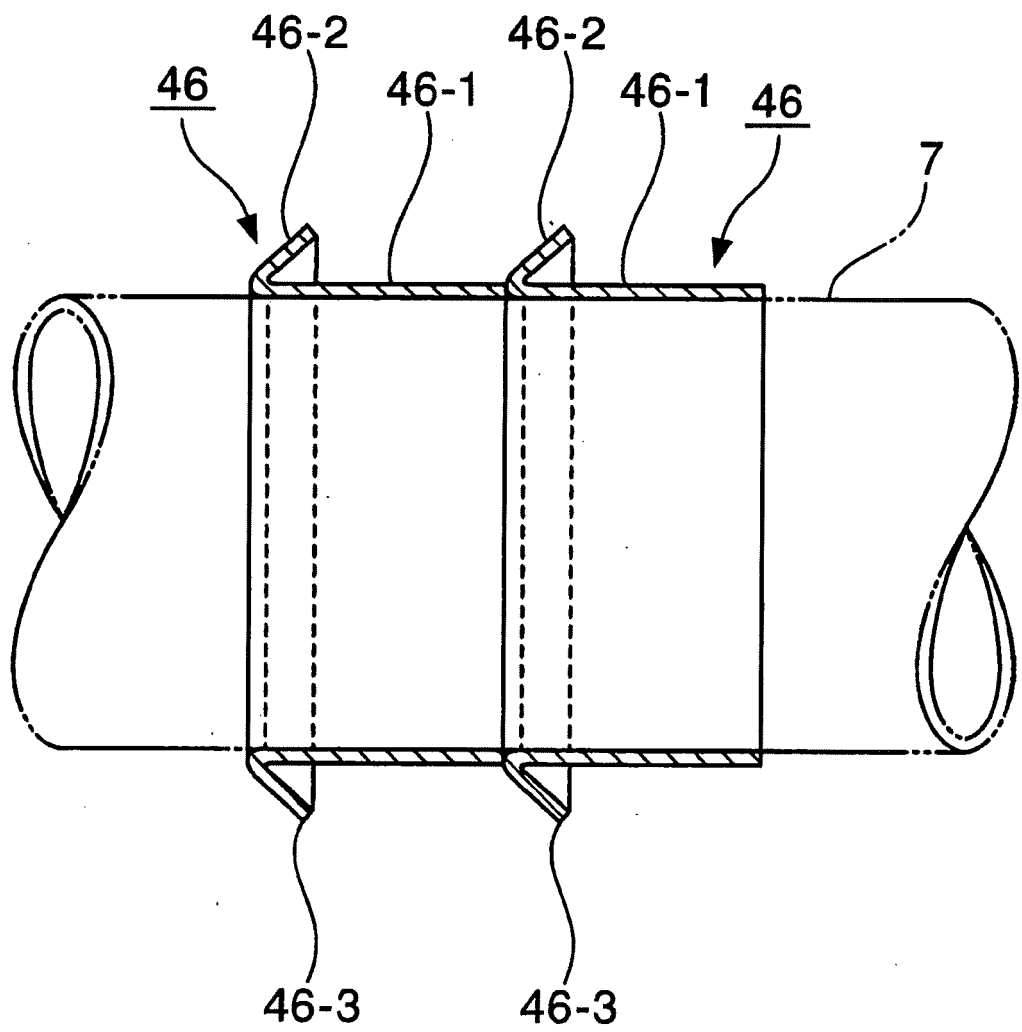


Fig.7

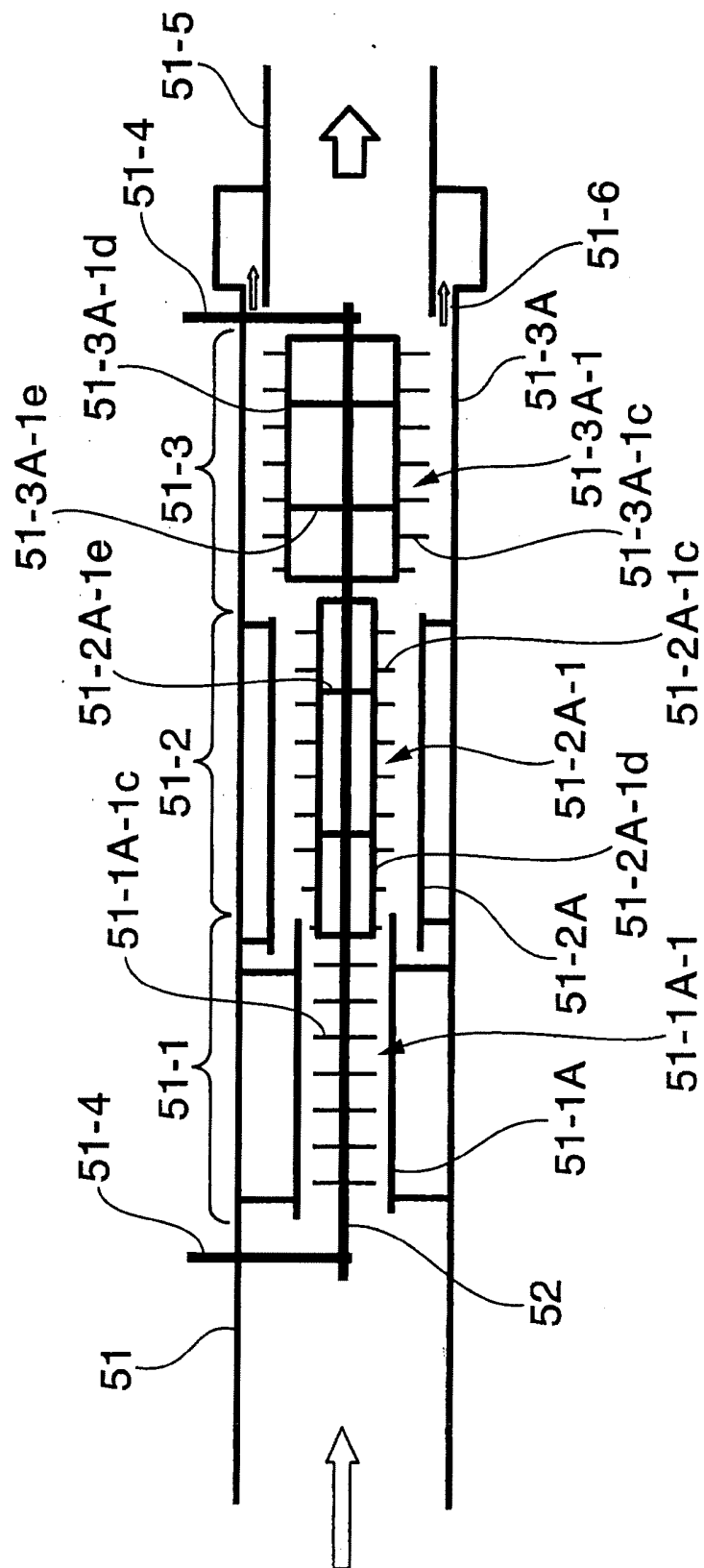


Fig.8

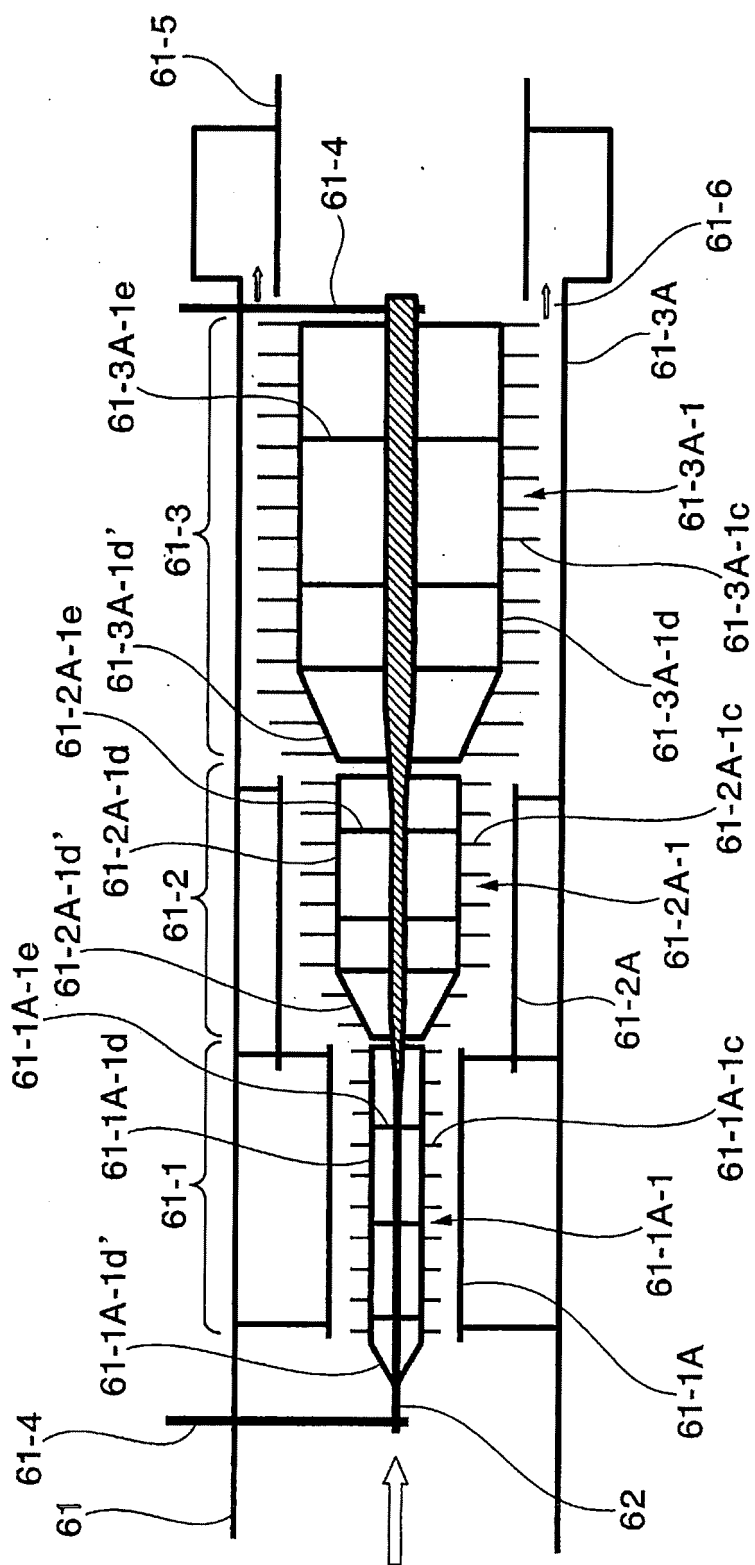


Fig.9

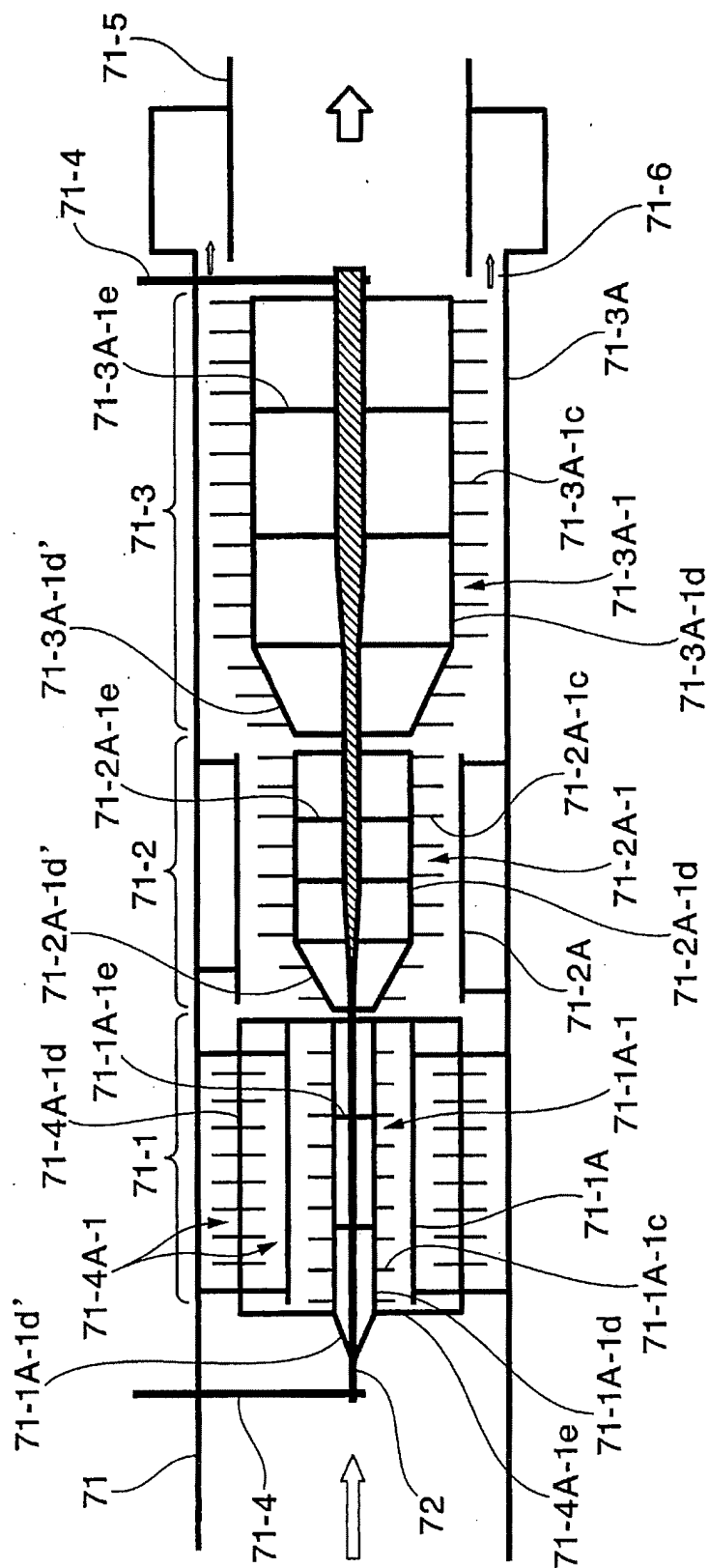


Fig.10

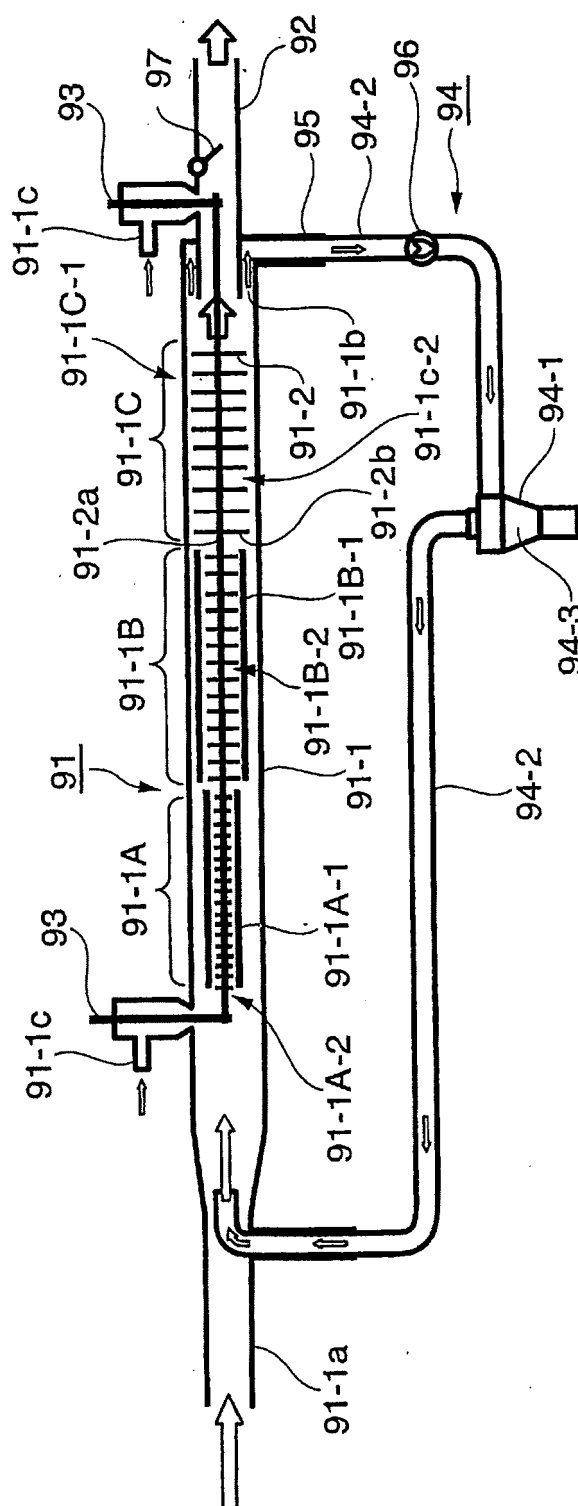


Fig.11A

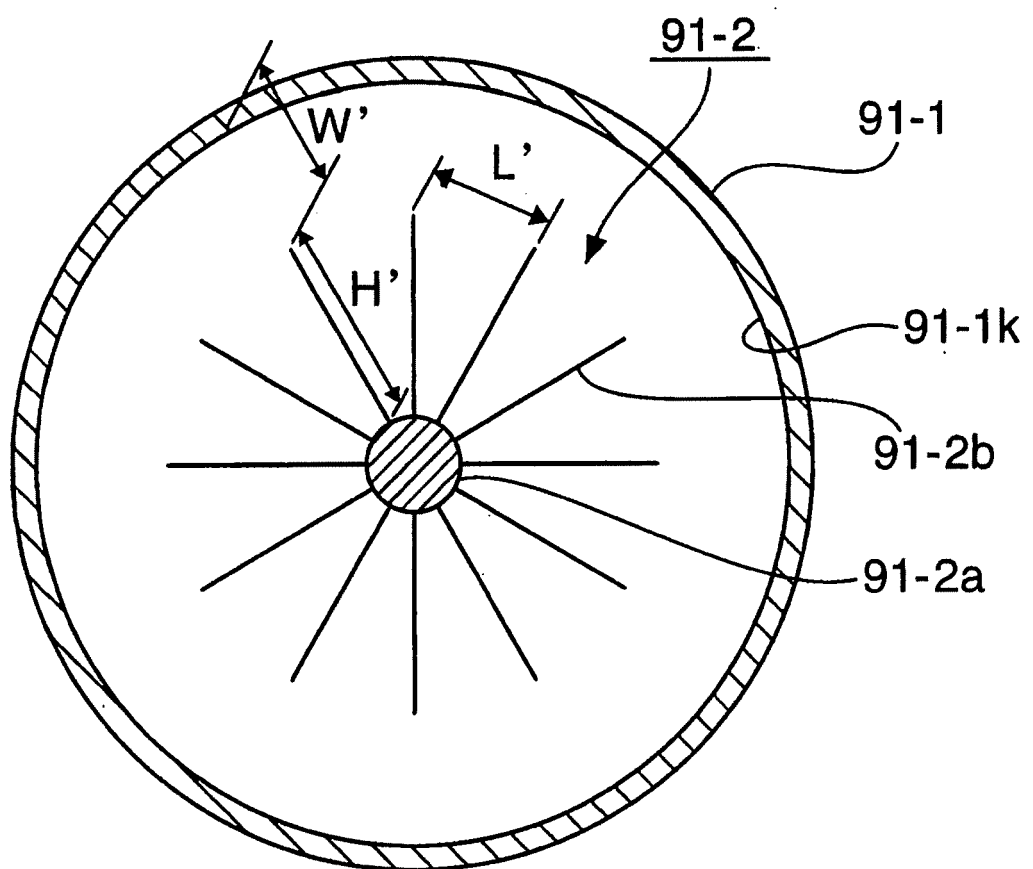


Fig.11B

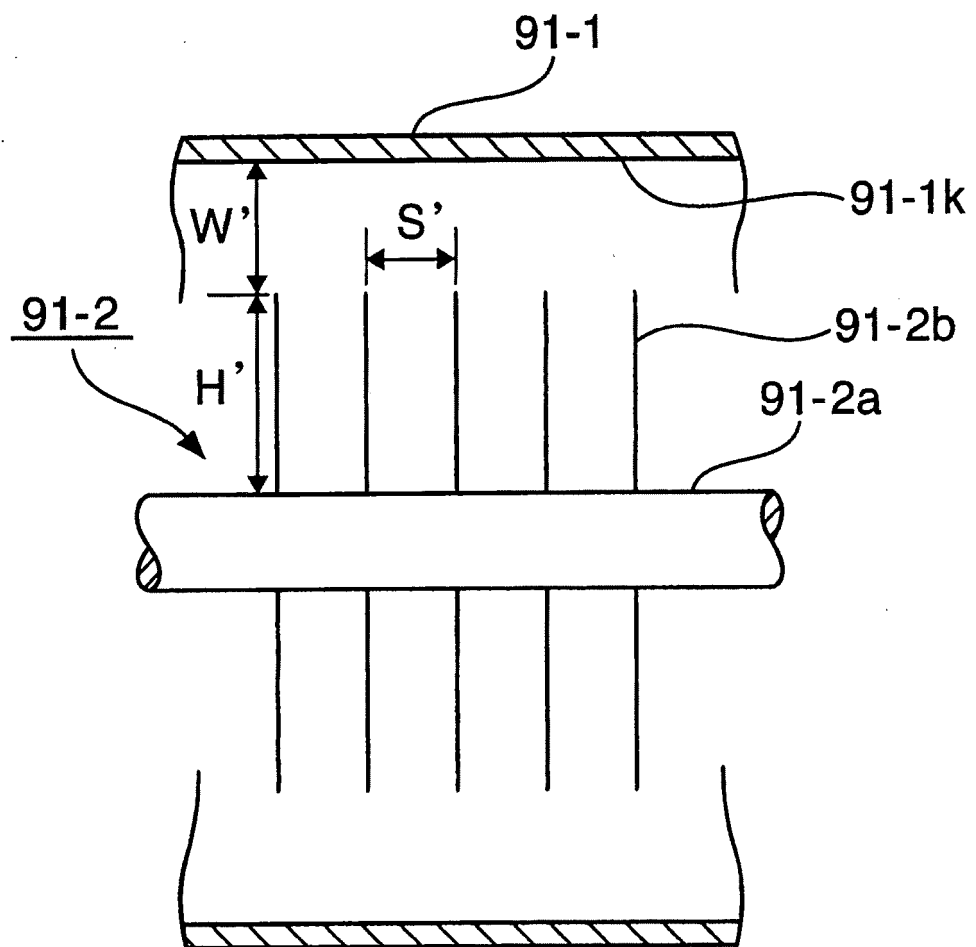
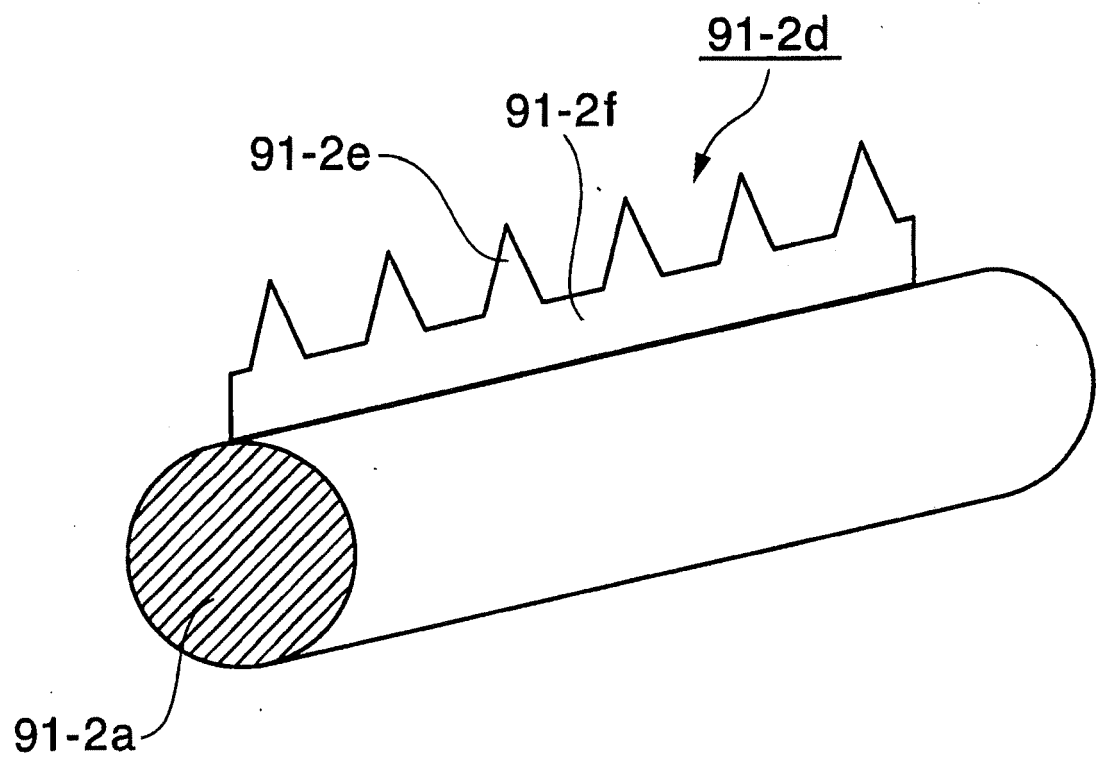


Fig.12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/066293

A. CLASSIFICATION OF SUBJECT MATTER

B03C3/49(2006.01)i, B03C3/40(2006.01)i, B03C3/41(2006.01)i, F01N3/01(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B03C3/49, B03C3/40, B03C3/41, F01N3/01

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2016
 Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 51-118167 A (The Japan Steel Works, Ltd.), 16 October 1976 (16.10.1976), claims; page 2, upper left column, line 15 to page 3, upper left column, line 13; fig. 1 to 8 (Family: none)	1-4
A	JP 2012-107556 A (Usui Kokusai Sangyo Kaisha, Ltd.), 07 June 2012 (07.06.2012), claims; paragraph [0035]; fig. 5 to 6 & WO 2012/066825 A1 & EP 2642095 A1 claims; paragraph [0035]; fig. 5 to 6 & CN 103261596 A & KR 10-2013-0087566 A	1-4

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
24 August 2016 (24.08.16)Date of mailing of the international search report
06 September 2016 (06.09.16)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/066293

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2014-238086 A (Usui Kokusai Sangyo Kaisha, Ltd.), 18 December 2014 (18.12.2014), claims; fig. 1 to 31 & WO 2014/181717 A1 & EP 2998528 A1 claims; fig. 1 to 31 & CN 105229269 A & KR 10-2016-0006742 A	1-4
A	US 2004/0025497 A1 (TRUCE, Rodney John), 12 February 2004 (12.02.2004), paragraphs [0034], [0064] to [0066]; fig. 4 & WO 2002/042003 A1 & EP 1343590 A1 & AU PR160500 D & AU 1806402 A & CN 1476354 A & AU 2002218064 B & AU PR160500 D0	1-4

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2014238086 A [0007]