(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 642 095 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
14.02.2018 Bulletin 2018/07

(21) Application number: **11842356.5**

(22) Date of filing: **28.07.2011**

(51) Int Cl.:
B03C 3/15 *(2006.01)* ***B03C 3/36*** *(2006.01)*
F01N 3/01 *(2006.01)* ***F01N 3/037*** *(2006.01)*
F01N 3/027 *(2006.01)* ***B04C 9/00*** *(2006.01)*
B03C 3/41 *(2006.01)* *B03C 3/49* *(2006.01)*
B03C 3/86 *(2006.01)* *B04C 5/04* *(2006.01)*

(86) International application number:
PCT/JP2011/067318

(87) International publication number:
WO 2012/066825 (24.05.2012 Gazette 2012/21)

(54) EXHAUST GAS PROCESSING DEVICE FOR DIESEL ENGINE

ABGASVERARBEITUNGSVORRICHTUNG FÜR EINEN DIESELMOTOR

DISPOSITIF DE TRAITEMENT DES GAZ D'ÉCHAPPEMENT POUR MOTEUR DIESEL

(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

(30) Priority: **16.11.2010 JP 2010256160**

(43) Date of publication of application:
25.09.2013 Bulletin 2013/39

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EP 2 642 095 B1

Description

Technical Field

[0001] The present invention relates to an exhaust gas treatment technique for large-displacement diesel engines using particularly a low-grade fuel equal to or less than fuel oil, such as for watercrafts, for power generation, or for industrial purposes, for eliminating particulate matter (called below "PM") mainly composed of carbon, or harmful gas, contained in exhaust gas of a diesel engine to purify the exhaust gas, and, in particular, relates to an exhaust gas treatment equipment using corona discharge in the large-displacement diesel engine exhausting high-temperature exhaust gas.

Background Art

[0002] Diesel engines are widely adopted as power sources for various watercrafts, power generators, large construction machines, and further, various automobiles, but since the PM contained in exhaust gas exhausted from the diesel engines, as is well known, not only causes air pollution, but also is extremely harmful to human bodies, purification of the exhaust gas is extremely important. Therefore, many suggestions have already been made, such as improvement of combustion systems of diesel engines, adoption of various types of exhaust gas filters, or electrical treatment methods using corona discharge, and some of such suggestions have been in practical use.

[0003] Here, the components of the PM (particulate matter) in the exhaust gas of the diesel engine can be classified into two components: soluble organic fractions (called below "SOF"); and insoluble organic fractions (called below "ISF"), and the SOF of the two components is mainly composed of unburnt combustion components of fuel or lubricant oil, and including harmful matter such as carcinogenic polycyclic aromatics. On the other hand, the ISF is mainly composed of low electrical resistive carbon (soot) and sulfate components, and the exhaust gas is desired to have as small an amount of SOF and ISF as possible, because of the effects of the SOF and ISF on human bodies and the environment. In particular, it is also said that the degree of the harmful effect of the PM on human bodies is problematic especially when the particulate size becomes nanometer size.

[0004] As the electrical treatment method using corona discharge, for example, the methods and equipments (patent literatures 1 to 5) described below have been suggested.

[0005] That is, as shown briefly in FIG. 12, the patent literature 1 suggests an electrical treatment method and equipment for exhaust gas of a diesel engine, the method and equipment having a system in which a discharging and charging part 22 comprising a corona discharging part 22-1 and a charging part 22-2 is so provided as to communicate with an exhaust gas passage 21, PM 28 mainly composed of carbon in exhaust gas G1 is charged with corona-discharged electrons 29, and the charged PM 28 is collected by a collection plate 23 disposed in the exhaust gas passage 21, the method and equipment having a configuration in which the length of an electrode needle 24 in the discharging and charging part 22 is short in a flowing direction of an exhaust gas stream, and the collection plate 23 is disposed so as to be perpendicular to the flowing direction of the exhaust gas stream. In FIG. 12, the reference numeral 25 denotes a seal gas pipe, 26 high-voltage power supply apparatus, and 27 an exhaust gas guide pipe.

[0006] In addition, as shown briefly in FIG. 13, the patent literature 2 suggests diesel-engine exhaust gas PM collector comprising a needle electrode 31 for causing corona discharge 35 around a needle tip 31-1 to charge PM 33 in exhaust gas, a collecting electrode 32 for collecting the charged PM 33, and a high-voltage DC power supply 34 for applying a predetermined DC high voltage to between the needle electrode 31 and the collecting electrode 32. In FIG. 13, the reference numeral 36 denotes a deflection electrode.

[0007] Further, as shown briefly in FIG. 14, the patent literature 3 suggests an exhaust gas purification equipment comprising a stationary cylindrical body 41 constituting one of a pair of collection electrodes for collecting PM provided in an exhaust gas route, an electrode bar 42 being extended axially in the center of the stationary cylindrical body 41 and constituting the other of the pair of the collection electrodes, a high-voltage power source part 43 forming an electrostatic field between the pair of collection electrodes and accumulating the PM in the exhaust gas on an inner face of the stationary cylindrical body 41, and a scraping-off part 44 making rotational movement relative to the stationary cylindrical body along the inner face of the stationary cylindrical body 41 and scraping off the PM accumulated on the inner face of the stationary cylindrical body. In FIG. 14, the reference numeral 45 denotes a discharge pipe, and 46 a rotary cylindrical part.

[0008] On the other hand, the patent literature 4 suggests a diesel-engine exhaust gas purification equipment comprising an electrical precipitation means having a discharge electrode charging PM contained in exhaust gas of a diesel engine and a precipitation electrode collecting the charged PM, a means for detaching the PM collected and retained on the precipitation electrode from the particulate electrode, and a cyclone-system segregating and collecting means for segregating and collecting the PM detached from the precipitation electrode.

[0009] This equipment, as shown by way of example in FIG. 15, is configured to treat the exhaust gas while causing the exhaust gas to flow laterally, and comprises an electrical precipitation part 51 for collecting the PM, and a cyclone 52 serving as a segregating and collecting part, where the electrical precipitation part 51 comprises: a precipitation electrode 54 composed of a tubular metal body 57 attached to an inner peripheral face of a tubular housing 56 and an uneven part 58 formed on an inner

peripheral face of the tubular metal body; and a discharge electrode 55 composed of a main electrode 59 extending along the axial line of the precipitation electrode 54 and a group of radially-projecting electrode needles 60 disposed at predetermined intervals in a longitudinal direction of the main electrode 59, and the cyclone 52 is configured downstream from a guide vane 61 converting a gas stream 53 which has passed through the electrical precipitation part 51 into a swirling flow, and an exhaust pipe 62 for discharging gas in the cyclone and a hopper 63 collecting the PM separated by centrifugation are provided downstream from the cyclone 52. The reference numeral 64 denotes a detaching mechanism detaching the PM collected and retained on the precipitation electrode 54 from the precipitation electrode, and composed of an eccentric motor 65 generating vibration due to eccentricity, for example. The reference numeral 66 denotes a gas-extraction pipe for returning the exhaust gas in the exhaust pipe 62 to an upper space of the hopper 63.

[0010] In other words, the exhaust gas purification equipment thus configured has an arrangement in which the PM in the exhaust gas which has flowed into the electrical precipitation part 51 is charged by discharge between the precipitation electrode 54 and the discharge electrode 55 to be collected on the precipitation electrode 54 by coulomb force, then the collected PM flows into the guide vane 61 with the gas stream, then the PM is centrifugally separated by the cyclone 52 configured downstream from the guide vane 61, and then the centrifugally-separated PM falls down to the hopper 63 and is collected, while the purified exhaust gas is released outside via the exhaust pipe 62.

[0011] In addition, the patent literature 5 suggests a gas treatment equipment comprising a charging and agglomerating part for charging and agglomerating, by corona discharge, target components to be collected in exhaust gas of a diesel engine mounted on an automobile, and a filter part for collecting the agglomerated components, the gas treatment equipment. As shown in FIGS. 16 and 17, this gas treatment equipment has a configuration in which the charging and agglomerating part 70 is disposed upstream, and the filter part 80 is disposed downstream, a gas passage wall of the charging and agglomerating part 70 is formed of tubular bodies 71, 71a, etc., a precipitation electrode, which is a low-voltage electrode, is formed of a conductive tubular body 71f disposed in the vicinity of the surface of the gas passage wall, corona electrodes are formed of wire-like high-voltage electrodes disposed inside these tubular bodies, and the tubular body of the gas passage wall is formed as a gas cooling part where natural convection and heat radiation cool gas naturally, and further a turbulence promoting means 71e for promoting disturbance of a gas stream passing in the vicinity of an inner surface of the tubular body of the gas passage wall or the conductive tubular body is provided on the surface of the tubular body or in the vicinity of the surface thereof. In FIGS. 16 and 17, the reference numeral 71c denotes a gas intake chamber, 71b a corona electrode, and 71d a gas outlet chamber. Document JP 5 222915 discloses an exhaust gas purification for an internal combustion engine that comprises two collectors of cyclone type at upstream and downstream stages in conjunction. The upstream collector includes a discharge electrode for corona discharge in an inner tube thereof and the downstream collector includes an air purging pipe connected to a discharge pipe of the downstream collector so as to cause cleaned gas to be blown to an insulator for supporting the discharge electrode, and thereby to prevent particulate collection ability from decreasing with decreasing applied voltage due to leak occurred between the electrode bar and the upstream collector, and accordingly to achieve prevention of decreasing purification efficiency. The downstream particulate separator which is a vertical collector of cyclone type where particles fall in the bottom of the collector receives from an outer tube tangentially, all of the gas flown from the upstream electric particulate agglomerator at a high velocity. The separator discharges the gas in a vertical discharge pipe, while the separator discharges particulate from the bottom of a tapered part to deliver the particulate to a particulate collector to burn the collected particulate at regular time intervals. The flow in the second collector is not controlled.

Citation List

Patent Literature

[0012]

PTL 1: WO2006/064805B
PTL 2: Japanese Patent Application Laid-Open No. H09-112246
PTL 3: Japanese Patent Application Laid-Open No. H06-173637
PTL 4: Japanese Patent Application Laid-Open No. 2006-136766
PTL 5: Japanese Patent No. 4529013

Summary of Invention

Technical Problem

[0013] However, the above-described conventional diesel-engine exhaust gas purification equipments have the following drawbacks.

[0014] That is, the electrical treatment method and equipment for exhaust gas of a diesel engine described in the patent literature 1 has problems as follows: high flow resistance (pressure loss) due to the configuration in which the length of the electrode needle 24 in the discharging and charging part 22 is short in the flowing direction of the exhaust gas stream and the collection plate 23 is so disposed as to be perpendicular to the flowing direction of the exhaust gas stream, and in which the exhaust gas stream directly hits the collection plate 23;

a possibility that since the collection plate 23 is thin and short in length in the flowing direction of the exhaust gas stream, the PM might pass through the collection plate 23 and the PM collection efficiency thus could not sufficiently be increased; and a worry that once the PM passes through the collection plate 23, the PM may not be charged by corona discharge or collected again, and may be exhausted as it is.

[0015] It should be noted that the patent literature 1 neither discloses nor suggests the technical idea that the collection plate has a tubular shape which is long in the flowing direction of the exhaust gas stream, the electrode needle is disposed in an axial direction of the tubular collecting part, a jumping phenomenon of depositing and detaching repeatedly the PM particles flowing in the flowing direction of the exhaust gas stream is caused so that the PM is grown, this growth phenomenon causes the size of the PM in the exhaust gas stream in the vicinity of an inner face of the tubular collecting part to increase so that a cyclone can easily collect the PM, and causes the PM concentration to increase, and this exhaust gas stream having the large-size PM and the high PM concentration is selectively extracted and then the PM is collected by the cyclone.

[0016] In addition, the exhaust gas PM collecting apparatus described in the patent literature 2 and the exhaust gas purification equipment described in the patent literature 3 have drawbacks as follows: a difficulty in setting both the discharge voltage and the collecting deflection voltage at their respective appropriate conditions due to the fact that the voltages are the same potential; a requirement that a large space must be left between the deflection electrode and the collecting electrode in order to prevent a spark from occurring therebetween; a reduction in collection efficiency due to an increase in the amount of PM passing through a collecting section without being collected due to the above requirement; and further, an inevitable increase in equipment size, which is inappropriate as a marine component that is desired to be small in size and light in weight, due to a requirement that the volume of the collecting part must be large in order to raise the collection efficiency.

[0017] Besides, the patent literature 2 states that the collecting electrode 32 is formed as a tunnel-like electrode through which the exhaust gas passes, that a combined-electrode body composed of the needle electrodes 31 and the deflection electrodes 36 is disposed in the tunnel of the collecting electrode 32 substantially coaxially with the tunnel, and that the combined-electrode body, which is thick and long, is disposed in the tubular collecting part over substantially the entire length thereof and arranged in a grid-like pattern. And also in the patent literature 3, a tubular collecting part is formed according to the following statements: "...an electrode bar 42 constituting one of the discharge electrode pair and one of the collection electrode is hung along the axis of the stationary cylindrical body 41, ...a wide gas outlet is provided in a lower side face of the stationary cylindrical body 41, and the gas outlet is fitted with a downstream exhaust pipe 45..." in paragraph [0033] in Example 6; "the rotary cylindrical part 46 has the shape of an inverted truncated cone, ...a long bar (scraping part) 44 extends upward on an inner face of the rotary cylindrical part 46, and an outer edge of the bar 44 is in contact with an inner face of a wide portion of the stationary cylindrical body 41." in paragraph [0035]; "...diesel particulates... by corona discharge between the electrode bar 42 and...the stationary cylindrical part 41 in the discharge space... The charged diesel particulates are attracted by an electrostatic field and deposited on the inner face of the wide part of the stationary cylindrical body 41." in paragraph [0036]; and further, "According to the rotation of the rotary cylindrical part 46, the bar 44 rotates at low speed in contact with the inner face of the wide part of the stationary cylindrical body 41, and drops a diesel-particulate layer deposited on the inner face of the wide part... The diesel-particulates are collected in a collection box... can be eliminated" in paragraph [0037]. But the technique described in the patent literature 3 is such a technique that the collecting electrode is provided as a stationary cylindrical portion (tubular) which is long in the flowing direction of the exhaust gas stream, the electrode needle is disposed with a space in the axial direction of the tubular collecting part, the PM is deposited flowing in the flowing direction of the exhaust gas stream, and the deposited PM particles are scraped off with the bar, and such technique is a technique which is very likely to discharge some of the PM particles, which fly when the PM particles are scraped off, from the downstream exhaust pipe fitted in the wide gas outlet port provided upstream from the collection box.

[0018] Therefore, both techniques described in the patent literatures 2 and 3, like the technique described in the patent literature 1, neither disclose nor suggest the technical idea that the collection plate has a tubular shape which is long in the flowing direction of the exhaust gas stream, the electrode needle is disposed in the axial direction of the tubular collecting part, a jumping phenomenon of depositing and detaching repeatedly the PM particles flowing in the flowing direction of the exhaust gas stream is caused so that the PM particles are grown, this growth phenomenon causes the size of the PM in the exhaust gas stream in the vicinity of an inner face of the tubular collecting part to increase so that a cyclone can easily collect the PM, and causes the PM concentration to increase, and the exhaust gas stream having the large-size PM and the high PM concentration is selectively extracted and the PM is efficiently collected by the cyclone.

[0019] On the other hand, the diesel-engine exhaust gas purification equipment described in the patent literature 4 has a system in which the PM particles collected on the precipitation electrode 54 or the inner peripheral wall (collecting pipe wall) of the tubular housing 56 of the electrical precipitation part 51 are agglomerated into large masses, then the PM masses are naturally detached or released from the precipitation electrode 54 or the collecting pipe wall by a mechanical detachment

mechanism and to be mixed in the tubular housing 56, and then the released and mixed PM masses are separated by centrifugation from the exhaust gas in the cyclone 52 to be collected again in the hopper 63. But this system has the drawbacks as follows: a high facility cost and running cost due to the necessity of the large cyclone 52 with the large guide vane 61 that is inevitably caused by the centrifugation of PM from the whole amount of the exhaust gas flowing into the cyclone 52 by the guide vane 61 disposed in the tubular housing 56 and involving mixing of the whole exhaust gas amount; the incapability of responding to a significant increase or decrease in exhaust gas flow rate involved in an increase or decrease in the number of operating engines or a large variation in engine load ratio due to the structural incapability of installing a plurality of cyclones 52; and the incapability of maintaining a high PM collection efficiency and solving such a problem as a deterioration in fuel economy due to an excessive pressure loss in the cyclone due to the lack of a means for controlling the exhaust gas flow velocity at the cyclone inlet portion appropriately.

[0020] In the patent literature 4, the collection plate has a tubular shape which is long in the flowing direction of the exhaust gas stream, the electrode needle is disposed in an axial direction of the tubular collecting part, and the PM particles flowing in the flowing direction of the exhaust gas stream are deposited in the vicinity of an inner face of the tubular collecting part, and collected by the cyclone, but the technique described in the patent literature 4, like the techniques described in the patent literatures 1 to 3, neither discloses nor suggests the technical idea that the particle size of the PM in the exhaust gas is coarsened so that the cyclone can easily collect the PM, and the PM concentration of the exhaust gas stream in the vicinity of the inner face of the tubular collecting part is increased, and further only this stream of the exhaust gas in the vicinity of the inner face of the tubular collecting part, which has the PM with the enlarged particle diameters and the high PM concentration, is selectively extracted and collected by the cyclone in a focused manner.

[0021] Furthermore, the gas treatment equipment described in the patent literature 5 is a vehicle-mounted small-sized gas treatment equipment, and is directed to a technique relating to an equipment in which the charging and agglomerating part 70 is configured to be disposed upstream, and the filter part 80 is disposed downstream, the charging and agglomerating part 70 is provided with the gas intake chamber 71c branching the exhaust gas into many streams, the gas passage wall is formed of the tubular body 71f, the tubular body 71f is exposed to ambient air and the tubular body 71f, which is the gas passage wall, is formed as a gas cooling part cooling the gas by natural heat loss due to natural convection and heat radiation, and the branched exhaust gas streams are then mixed again in the gas outlet chamber 71d. Such technique is different from a technique (the present invention described later) where an exhaust gas stream flowing from the tubular collecting part is not mixed again before the step of collecting PM particles. The gas treatment equipment described in the patent literature 5 has the drawback that since the means 71e for promoting disturbance of the gas stream is provided on the inner surface of the tubular body 71f or in the vicinity of the inner surface thereof, the disturbance of the gas is promoted particularly in the vicinity of the surface of the tubular body, which results in an increased agitating effect in the cross-sectional direction of the flow passage.

[0022] In the equipment described in the patent literature 5, the collecting wall is formed in a tubular shape which is long in the flowing direction of the exhaust gas stream, the electrode needle is disposed in an axial direction of the tubular collecting part, and the PM particles are deposited in the vicinity of an inner face of the tubular collecting part and collected by the cyclone, while being caused to flow in the flowing direction of the exhaust gas stream. But the technique described in the patent literature 5, like the techniques described in the patent literatures 1 to 4, neither discloses nor suggests the technical idea that the particle size of the PM in the exhaust gas is coarsened so that the cyclone disposed downstream can easily collect the PM and the PM concentration of the exhaust gas stream in the vicinity of the inner face of the tubular collecting part is increased, and further only this stream of the exhaust gas in the vicinity of the inner face of the tubular collecting part, which has the PM with the large particle diameters and the high PM concentration, is selectively extracted and collected by the cyclone in a focused manner.

[0023] The present invention has been made in order to solve the drawbacks of the conventional techniques described above, and it is intended to provide an exhaust gas purification equipment for a diesel-engine where, in particular, in place of the system of the diesel-engine exhaust gas purification equipment described in the patent literature 4 wherein the cyclone is constituted by providing a guide vane in the passage through which the entire amount of the exhaust gas flows, a system is adopted in which a segregating and collecting means of a cyclone system is disposed not within the tubular collecting part but on the downstream side of the tubular collecting part, and in which the cyclone collecting means is composed of a plurality of tangential cyclones, so that it is possible to reduce the size of the cyclone, and it is also possible to select appropriately and use the cyclone according to a significant increase or decrease in exhaust gas flow rate due to a change in operating condition or a large variation in engine load ratio involved in parallel operation or individual operation of a main engine and an auxiliary engine in a marine engine, and wherein a means for controlling appropriately the exhaust gas flow rate at a cyclone inlet portion is further provided, so that it is possible to maintain a high PM collection efficiency and solve such a problem as a deterioration in fuel economy due to an excessive pressure loss in the gas purification equipment.

Solution to Problems

[0024] The invention is set out in the appended set of claims.

Advantageous Effects of Invention

[0025] According to the present invention, since the exhaust gas purification equipment for a diesel engine adopts a system in which the PM is separated by centrifugation outside the tubular collecting part, a phenomenon occurs where PM in exhaust gas is collected on the tubular collecting wall and grown into a mass and this PM mass gradually increases in PM concentration in the vicinity of the tubular collecting wall while repeating attachment and detachment to the tubular collecting wall so that an exhaust gas stream containing PM in high concentration flows downstream, and the exhaust gas is separated in the tubular collecting part into high PM concentration of exhaust gas and low PM concentration of exhaust gas having only a low PM concentration due to gradual decrease in PM concentration in the vicinity of the axial center of the tubular collecting part, and then the high PM concentration of exhaust gas flows in the vicinity of the tubular collecting wall and the low PM concentration of exhaust gas flows in the vicinity of the axial center portion of the tubular collecting part, which makes it possible to introduce only the high PM concentration of exhaust gas having a high PM concentration from the vicinity of the tubular collecting wall to the cyclone collecting means. That is, according to the equipment of the present invention, only high PM concentration of exhaust gas, which is a part of the entire exhaust gas amount, can be introduced into the cyclone, and therefore the size of the cyclone can be reduced. On the other hand, the low PM concentration of exhaust gas having the decreased PM concentration (or purified exhaust gas) is released outside through the exhaust gas outlet pipe for low PM concentration provided in a communicating manner in the vicinity of the axial center on the downstream side of the tubular collecting part.

[0026] In addition, according to the equipment of the present invention, since a system is adopted in which the cyclone collecting means is composed of a plurality of tangential cyclones so that high PM concentration of exhaust gas discharged through the exhaust gas portion for high PM concentration is selectively introduced into the tangential cyclones according to the flow rate of the high PM concentration of exhaust gas, it becomes possible to select an appropriate treatment capacity and the appropriate number of tangential cyclones according to a significant increase or decrease in the exhaust gas flow rate due to a change in operating conditions or a large variation in engine load ratio involved in parallel operation or individual operation of a main engine and an auxiliary engine in a marine engine, in addition to the functional effect, "the higher the tangential velocity of a fluid flowing in is, the higher the collection efficiency becomes", of a tangential cyclone which has a better collection performance than the axial cyclone of the diesel-engine exhaust gas treatment equipment described in the patent literature 4 where the guide vane is provided, so that it is possible to ensure a high PM collection efficiency in response to a change in the exhaust gas flow rate. Further, since the velocity (tangential velocity) of the exhaust gas flowing into the tangential cyclone can be appropriately controlled by controlling the opening position of the damper provided in the exhaust gas outlet pipe for low PM concentration, it is possible to maintain a high PM collection efficiency and also solve such a problem as a deterioration in fuel economy due to an excessive pressure loss in the exhaust gas purification equipment.

[0027] Besides, since the exhaust gas purification equipment for a diesel engine according to the present invention is provided with a radially-expanding tubular portion having a gradually-increasing diameter or a large-diameter tubular portion communicating with the radially-expanding tubular portion on the downstream side of the tubular collecting part, the high PM concentration of exhaust gas stream is gradually slowed down due to the radially-expanding tubular portion, so that it is possible to introduce the PM reliably into the exhaust gas outlet portion for high PM concentration provided in a communicating manner in the inner peripheral face of the large-diameter tubular portion. Further, since a configuration is adopted in which the discharge electrode is provided so as to extend to the vicinity of the inner peripheral face in the area of the radially-expanding tubular portion and the large-diameter tubular portion communicating with the radially-expanding tubular portion in the tubular collecting part, it is possible to collect the PM more effectively, so that the exhaust gas can be further purified.

[0028] Further, according to the equipment of the present invention, the cyclone collecting means is composed of a plurality of tangential cyclones having different treatment capacities, for example, the following three types of cyclones: a tangential cyclone having a low treatment capacity; a tangential cyclone having an intermediate treatment capacity; and a tangential cyclone having a high treatment capacity, and a flow-rate control damper is provided at an inlet of each tangential cyclone, as a result, not only does it become possible to select and use more appropriately an tangential cyclone according to a significant increase or decrease in the exhaust gas flow rate due to a change in operating conditions or a large variation in engine load ratio involved in parallel operation or individual operation of a main engine and an auxiliary engine in a marine engine, but it also becomes possible to control the flow-rate control damper provided for each tangential cyclone in combination with the damper provided in the exhaust gas outlet pipe for low PM concentration, thereby controlling the velocity of the exhaust gas flowing into each tangential cyclone more appropriately. In addition, a configuration is adopted in which a discharge pipe for causing purified gas that has passed through the tangential cyclone to flow into the low PM

concentration of exhaust gas is provided between the tangential cyclone and the exhaust gas outlet pipe for low PM concentration, and an air nozzle or a motor-driven fan is disposed in the discharge pipe, as a result, a purified gas stream which has passed through the tangential cyclone is accelerated and sucked, so that a pressure loss in the exhaust gas purification equipment is further improved, which contributes to improvement in fuel economy.

[0029] Moreover, according to the invention, the following advantages can be obtained: when the tubular collecting part is disposed substantially horizontally, the workability at a maintenance time of the collecting pipe, the discharge electrode, and the like becomes excellent since the tubular collecting part is maintained at a horizontally substantially constant height from a floor surface of an engine room in which an engine is placed; when the tubular collecting part is disposed substantially vertically upward, space saving can be achieved since the tubular collecting part can be double as a pipe of an exhaust pipe to a funnel; and when the tubular collecting part is disposed substantially vertically downward, not only it becomes easy to collect the PM falling down, but also it becomes easy to collect liquefied components because of falling down the surface of the collecting wall when SOF or sulfate attached to the surface of the collecting wall is liquefied, , and further it becomes easy to collect even heavy oxidized scales corroded by sulfate or the like when the scales are detached and fall down from the surface of the wall.

Brief Description of Drawings

[0030]

Figure 1 is a schematic longitudinal sectional view showing an entire configuration of a first embodiment equipment of the present invention;

Figure 2 is a schematic longitudinal sectional view showing an entire configuration of a second embodiment equipment of the present invention;

Figure 3 is a schematic longitudinal sectional view showing in an enlarging manner an essential portion of a third embodiment equipment of the present invention;

Figure 4 is a schematic longitudinal sectional view showing in an enlarging manner an essential portion of a modification of the third embodiment equipment of the present invention;

Figure 5 is a schematic longitudinal sectional view showing in an enlarging manner an essential portion of a fourth embodiment equipment of the present invention;

Figure 6 is an enlarged sectional view taken along the line a-a in FIG. 5;

Figure 7 is a schematic longitudinal sectional view showing in a partially-omitting manner an entire configuration of a fifth embodiment equipment of the present invention;

Figure 8 is a descriptive view showing schematically another embodiment of a cyclone collecting means in the present invention equipment;

Figures 9(a) and 9(b) are descriptive views showing schematically in an enlarging manner speed-increasing sucking parts of purified gas which has passed through a tangential cyclone: 9(a) showing an air-nozzle type; and 9(b) showing a motor-driven fan type, according to in the present invention equipment;

Figure 10 is a schematic view showing an example of disposing a tubular collecting part in the present invention equipment substantially vertically downward;

Figure 11 is a schematic view showing an example of disposing the tubular collecting part in the present invention equipment substantially vertically upward;

Figure 12 is a schematic longitudinal sectional view showing an example of conventional diesel-engine exhaust gas treatment equipment;

Figure 13 is a schematic longitudinal sectional view showing another example of conventional diesel-engine exhaust gas treatment equipment;

Figure 14 is a schematic longitudinal sectional view showing yet another example of conventional diesel-engine exhaust gas treatment equipment;

Figure 15 is a schematic longitudinal sectional view showing yet another example of conventional diesel-engine exhaust gas treatment equipment;

Figure 16 is a schematic longitudinal sectional view showing yet another example of conventional diesel-engine exhaust gas treatment equipment in a partially-breaking manner; and

Figure 17 is a partially-enlarged sectional view of the diesel-engine exhaust gas treatment equipment shown in FIG. 16.

Description of Embodiments

[0031] An exhaust gas treatment equipment for a diesel engine shown as a first embodiment equipment of the present invention in FIG. 1 is composed of a tubular collecting part 1 constituting an electrical precipitation means and a segregating and collecting part 2 constituting a segregating and collecting means, which are roughly sectioned, and the tubular collecting part 1, which is provided in order to collect PM particles, is provided with a collecting pipe 1-1 constituting a precipitation electrode, having a predetermined length and having a collecting wall 1-1k, and with a discharge electrode 1-2 charging PM contained in exhaust gas. The collecting pipe 1-1 constituting a precipitation electrode has an exhaust gas inlet 1-1a at an end on an upstream side (diesel engine side) thereof, and a low PM concentration exhaust gas outlet pipe 3 and a high PM concentration exhaust gas outlet portion 1-1b are provided in a communicating manner in the vicinity of an axial center of an end on a down-

stream side thereof and in the vicinity of an inner peripheral face of the end on the downstream side, respectively. The discharge electrode 1-2 is composed of a main electrode 1-2a extending in the vicinity of the collecting pipe 1-1 constituting a precipitation electrode and over a substantially entire length thereof, and a group of electrode needles 1-2b projecting radially and disposed at desired intervals in a longitudinal direction of the main electrode 1-2a. In the discharge electrode 1-2 thus configured is supported at both ends of the main electrode 1-2a by supports 4 hung in a seal air intake pipe portion 1-1c disposed on the exhaust gas inlet 1-1a side of the collecting pipe 1-1 and in a seal air intake pipe portion 3-1 provided at an inlet of the low-PM-concentration exhaust gas outlet pipe 3. It should be noted that, though not shown in the figures, the discharge electrode 1-2 is supported by insulated stays at desired intervals inside the collecting pipe 1-1, if necessary. In addition, the discharge electrode 1-2 is wired to high-voltage power supply apparatus (not shown) installed outside, and supplied with controlled high-voltage power.

[0032] The segregating and collecting part 2 provided on the downstream side of the tubular collecting part 1 in a flowing direction of the exhaust gas is composed of a cyclone collecting means 2-1 serving as a segregating means. This cyclone collecting means 2-1 is composed of one tangential cyclone 2-1a connected via a communicating pipe 5-1 to the high-PM-concentration exhaust gas outlet portion 1-1b of the collecting pipe 1-1, and further a discharge pipe 6-1 for causing purified gas which has passed through the tangential cyclone 2-1a to mix into low PM concentration of exhaust gas flowing in the low-PM-concentration exhaust gas outlet pipe 3 is provided between the tangential cyclone 2-1a and the low-concentration exhaust gas outlet pipe 3. In addition, the low-PM-concentration exhaust gas outlet pipe 3 is provided with a flow-rate control damper 7 for regulating the inflow rate and inflow velocity of the high-concentration exhaust gas to the tangential cyclone 2-1a and the discharge rate of the low-concentration exhaust gas.

[0033] It should be noted that the dashed line in FIG. 1 shows an example of a combination of a main engine 12 and an auxiliary engine 13 in a marine diesel engine. In the case of this marine diesel engine, the modes of engine operation include parallel operation of the main engine 12 and the auxiliary engine 13 and individual operation thereof, where the load of each engine also significantly varies, and therefore the total flow rate of exhaust gas significantly varies. In addition, in the case of a large-displacement engine, a plurality of the collecting pipes 1-1 may be provided in parallel (not shown).

[0034] An exhaust gas treatment equipment for a diesel engine shown as a second embodiment equipment of the present invention in FIG. 2 has the same configuration as the first embodiment equipment, except that the cyclone collecting means 2-1 is composed of two tangential cyclones 2-1a. That is, the cyclone collecting means 2-1 is configured such that the two tangential cyclones 2-1a are parallel-connected via communicating pipes 5-1, 5-2 to the high-PM-concentration exhaust gas outlet portion 1-1b of the collecting pipe 1-1, and, also in this case, discharge pipes 6-1, 6-2 are provided for causing purified gas which have passed through each of the tangential cyclones 2-1a to mix into the low PM concentration of exhaust gas flowing in the low-PM-concentration exhaust gas outlet pipe 3.

[0035] In the above exhaust gas treatment equipments for a diesel engine shown in FIGS. 1 and 2, the PM in the exhaust gas flowing into the collecting pipe 1-1 from the exhaust gas inlet 1-1a is charged by discharge between the collecting wall 1-1k which is an inner wall of the collecting pipe 1-1 constituting the precipitation electrode and the discharge electrode 1-2, the charged PM particles are collected on the collecting wall 1-1k by coulomb force. An exhaust gas stream including PM in high concentration is created such that PM particles collected from an exhaust gas stream in the vicinity of the axial center are further deposited on the PM particles collected on the collecting wall 1-1k of the collecting pipe 1-1 and gradually grown into masses over time, and the PM masses flow while being concentrated in the vicinity of the collecting wall by repeating detachment due to the exhaust flow and reattachment to the tubular collecting wall 1-1k due to the coulomb force involved in the discharge (charge), and, as the same time, the PM in the exhaust gas flowing in the vicinity of the axial center of the collecting pipe 1-1 is gradually diluted by collecting the PM on the collecting wall 1-1k, so that the exhaust gas flows downstream as a stream having only a low PM concentration. That is, the exhaust gas which has flowed into the collecting pipe 1-1 from the exhaust gas inlet 1-1a is separated into a high PM concentration of exhaust gas stream and a low PM concentration of exhaust gas stream in the course of flowing down in the tubular collecting part 1, and the high-PM-concentration exhaust gas stream flows downstream in the vicinity of the collecting wall 1-1k of the inner wall of the collecting pipe 1-1, and the low PM concentration of exhaust gas stream in the vicinity of the axial center of the collecting pipe 1-1. Then, in the case of the exhaust gas treatment equipment for a diesel engine shown in FIG. 1, in the downstream side of the collecting pipe 1-1, the high PM concentration of exhaust gas stream which has flowed in the vicinity of the collecting wall 1-1k of the inner wall of the collecting pipe 1-1 is introduced into the tangential cyclone 2-1a from the high-PM-concentration exhaust gas outlet portion 1-1b of the collecting pipe 1-1 via the communicating pipe 5-1 and the PM is separated by centrifugation. While, in the case of the diesel-engine exhaust gas treatment equipment shown in FIG. 2, the high PM concentration of exhaust gas stream which has flowed in the vicinity of the collecting wall 1-1k of the inner wall of the collecting pipe 1-1 is introduced into the two tangential cyclones 2-1a from the high-PM-concentration exhaust gas outlet portion 1-1b of the collecting pipe 1-1 via the communicating pipes 5-1, 5-2 and the PM is separated by centrif-

ugation. On the other hand, the low PM concentration of exhaust gas stream flowing in the vicinity of the axial center portion of the collecting pipe 1-1 is discharged outside through the low-PM-concentration exhaust gas outlet pipe 3 provided in the vicinity of the axial center portion of the collecting pipe 1-1, in both the cases of the exhaust gas treatment equipments for a diesel engine in FIGS. 1 and 2. In addition, the exhaust gas streams purified by the tangential cyclones 2-1a are caused to mixed into the low PM concentration of exhaust gas stream flowing in the low-PM-concentration exhaust gas outlet pipe 3 via the discharge pipes 6-1, 6-1, and 6-2, respectively.

[0036] It should be noted that, in the case of the exhaust gas treatment equipment for a diesel engine shown in FIG. 2 where the cyclone collecting means 2-1 is composed of the two tangential cyclones 2-1a, the number of tangential cyclones can be determined according to the flow rate of high PM concentration of exhaust gas exhausted from the high-concentration exhaust gas outlet portion 1-1b, and the two tangential cyclones 2-1a can be used alternately.

[0037] As described above, in the cases of the exhaust gas treatment equipments for a diesel engine of the present invention shown in FIGS. 1 and 2, since only high PM concentration of exhaust gas (part of the entire exhaust gas amount) can be introduced into a cyclone, PM can be collected/segregated and collected efficiently by a small-sized cyclone.

[0038] Next, an exhaust gas treatment equipment for a diesel engine shown as a third embodiment equipment in FIG. 3 has the same configuration as the diesel-engine exhaust gas treatment equipment shown in FIGS. 1 or 2, except that a radially-expanding tubular portion 1-1d having a gradually-increasing diameter and a large-diameter tubular portion 1-1e communicating with the radially-expanding tubular portion 1-1e are formed at the end on the downstream side of the collecting pipe 1-1 constituting the precipitation electrode of the tubular collecting part 1, and that the low-PM-concentration exhaust gas outlet pipe 3 is provided in a communicating manner in the vicinity of an axial center of the large-diameter tubular portion 1-1e, and the high-PM-concentration exhaust gas outlet portion 1-1b in the vicinity of an inner peripheral face thereof. In the case of the diesel-engine exhaust gas treatment equipment for a diesel engine thus configured, at the end on the downstream side of the collecting pipe 1-1, the high PM concentration of exhaust gas stream is gradually slowed down by the radially-expanding tubular portion 1-1d, so that the PM can reliably be introduced into the high-PM-concentration exhaust gas outlet portion 1-1b provided in a communicating manner in the vicinity of the inner peripheral face of the large-diameter tubular portion 1-1e. It should be noted that it is further preferred that the electrode needles 1-2b of the discharge electrode 1-2 be continuously provided to the radially-expanding tubular portion 1-1b at the end on the downstream side of the collecting pipe 1-1.

[0039] In addition, in the exhaust gas treatment equipment for a diesel engine shown in FIG. 3, when the collecting pipe 1-1 is disposed vertically downward, as shown in FIG. 4, a bottom wall face 1-1e' of the large-diameter tubular portion 1-1e is inclined downward to the communicating pipe 5-1, as shown in FIG. 4. Such means is taken to make it easy to collect liquid components, such as dropped SOF or sulfate, by causing the liquid components to flow down to the cyclone side, and to make it easy to collect oxidized scales (metal-oxide scales or the like) detached from the collecting wall 1-1k when the oxidized scales are generated by corrosion of the collecting wall 1-1k of the inner face of the collecting pipe 1-1 caused by the PM, sulfate, or the like.

[0040] In addition, an exhaust gas treatment equipment for a diesel engine shown as fourth embodiment equipment in FIGS. 5 and 6 has the same configuration as the exhaust gas treatment equipment for a diesel engine shown in FIG. 1 or 2, except that a radially-expanding tubular portion 1-1d having a gradually-increasing diameter and a large-diameter tubular portion 1-1e communicating with the radially-expanding tubular portion 1-1e are formed at the end on the downstream side of the collecting pipe 1-1 constituting the precipitation electrode of the tubular collecting part 1, that the low-PM-concentration exhaust gas outlet pipe 3 is provided in a communicating manner in the vicinity of an axial center of the large-diameter tubular portion 1-1e, and the high-PM-concentration exhaust gas outlet portion 1-1b in the vicinity of an inner peripheral face thereof, and further that the discharge electrode 1-2 and the electrode needles 1-2b are extended to the area of the radially-expanding tubular portion 1-1d and the large-diameter tubular portion 1-1e communicating with the radially-expanding tubular portion. Incidentally, the reference numeral 1-2c denotes a support ring supporting each of a plurality of branches of the discharge electrode 1-2.

[0041] In the case of the exhaust gas treatment equipment for a diesel engine thus configured, in the end on the downstream side of the collecting pipe 1-1, not only is it possible to collect the PM more effectively since the high PM concentration of exhaust gas stream is gradually slowed down by the radially-expanding tubular portion 1-1d, but it is also possible to increase the collection efficiency in the cyclone collecting means 2-1 further since the PM masses grow even after the PM has flowed into the wide tubular portion 1-1e, so that the exhaust gas can be further purified.

[0042] Further, an exhaust gas treatment equipment for a diesel engine shown as a fifth embodiment equipment in FIG. 7 is configured such that an exhaust gas intake chamber 1-1f is disposed upstream from the collecting pipe 1-1, a narrowing portion 1-1f and a radially-expanding portion 1-1h are disposed between the exhaust gas intake chamber 1-1f and the collecting pipe 1-1, the narrowing portion 1-1g and the radially-expanding portion 1-1h are also provided with the electrode needles 1-2b, and the exhaust gas inlet 1-1a to the exhaust gas intake chamber 1-1f and a seal air inlet 1-1j to a seal

air intake chamber 1-1i are disposed so as to face each other.

[0043] In the exhaust gas treatment equipment for a diesel engine thus configured, when the length of the collecting pipe 1-1 is represented by L, and the inner diameter of the collecting pipe 1-1 is represented by D, it is preferred that the condition of $3D \leq L \leq 15D$, more preferably, $5D \leq L \leq 10D$, be satisfied. This is because, if L is less than 3D, the exhaust gas stream cannot sufficiently be rectified and the disturbance cannot completely be settled down, so that the increase in the PM concentration on the collecting wall 1-1k is promoted, and, on the other hand, if L is more than 15D, there is no difference in the degree of increase in the PM concentration, but the size of the equipment increases and the spatial efficiency thus deteriorates. In addition, the reason why the condition of $5D \leq L \leq 10D$ is preferred is because, if L is equal to or more than 5D, the stream is particularly well rectified and the increase in the PM concentration in the vicinity of the collecting wall 1-1k becomes stable, and the difference in the degree of increase in the PM concentration becomes small within 10D and a practical advantageous effect can then be obtained, so that the increase in the size of the equipment can be suppressed. Additionally, as specific examples of the dimensions of each part, the length L of the collecting pipe 1-1 is 3 m, the inner diameter of the collecting pipe 1-1 is ø 400 mm, the length of the narrowing portion 1-1g is 375 mm, the inner diameter of the narrowing portion 1-1g is ø 220 mm, and the expansion angle θ of the radially-expanding portion 1-1h is 30 degrees.

[0044] Further, the exhaust gas which has flowed from the exhaust gas inlet 1-1a into the exhaust gas intake chamber 1-1f passes through the narrowing portion 1-1g by which the disturbance of the exhaust gas stream after the radially-expanding portion 1-1h is suppressed and the gas stream is immediately stabilized and the increase in the PM concentration on the collecting wall 1-1k of the collecting pipe inner wall and the dilution in the PM concentration in the vicinity of the collecting pipe axial center are promoted. Besides, in the narrowing portion 1-1g, since a distance between the electrodes and the particulates is short, all the particles can reliably be charged and the particles are attached to the collecting wall 1-1k of the collecting pipe inner wall and the collection performance can be improved. Here, the reason why the exhaust gas is caused to flow into the exhaust gas intake chamber 1-1f from the opposite sides is because, by causing the exhaust gas to flow symmetrically into the collecting pipe 1-1, the exhaust gas stream flows in a well-balanced manner and the exhaust gas stream is less disturbed and immediately rectified, so that the exhaust gas stream, which is also an axially-short stream, can be well-rectified, which is preferred. In addition, it is also preferred that the seal air to the electrode be caused to flow into the seal air intake chamber 1-1i from the opposite sides.

[0045] Next, a cyclone collecting means shown in FIG. 8 is composed of a plurality of tangential cyclones having different treatment capacities, for example, the following three types of cyclones: a low-treatment-capacity tangential cyclone 2-1b; an intermediate-treatment-capacity tangential cyclone 2-1c; and a high-treatment-capacity tangential cyclone 2-1d, and the cyclone collecting means is configured such that the respective tangential cyclones 2-1b, 2-1c, 2-1d are connected via communicating pipes 8-1, 8-2, 8-3 connected radially to the high-PM-concentration exhaust gas outlet portion 1-1b of the collecting pipel-1, and flow-rate control dampers 9-1, 9-2, 9-3 are provided at the respective high-PM-concentration exhaust gas inlets of the communicating pipes 8-1, 8-2, 8-3.

[0046] When the cyclone collecting means is thus composed of tangential cyclones having different treatment capacities, not only does it become possible to select more appropriately each tangential cyclone according to the exhaust gas flow rate that changes according to a change in operating conditions or the engine load ratio involved in the parallel operation or individual operation of the main engine and the auxiliary engine in a marine engine, but it also becomes possible to control more appropriately the tangential velocity of exhaust gas flowing in each tangential cyclone by controlling the respective flow-rate control dampers 9-1, 9-2, 9-3 provided for the tangential cyclones in combination with the damper provided in the low-PM-concentration exhaust gas outlet pipe 3, so that a high collection efficiency can be ensured and maintained over a wide range of engine load ratios, or the like.

[0047] In addition, as shown in FIGS. 9(a) and 9(b), when the discharge pipe 6-1 provided to cause the purified gas which has passed through the tangential cyclone to mix into the low PM concentration of exhaust gas is provided with an air nozzle 10 or a fan 11 driven by a motor 11-1 for accelerating and sucking the purified gas which has passed through the tangential cyclone, the purified gas stream which has passed through the tangential cyclone is given kinetic energy and then accelerated and sucked, and the pressure loss in the exhaust gas purification equipment is improved so as to be lower, so that the fuel economy can be improved.

[0048] Further, FIGS. 10 and 11 each illustrate the case where the tubular collecting part 1 in the present invention equipment, for example, the tubular collecting part 1 having the radially-expanding portion 1-1e at the end on the downstream side of the collecting pipe 1-1, is disposed substantially vertically to an engine room floor surface, FIG. 10 showing an example of disposing the tubular collecting part 1 substantially vertically and downward, and FIG. 11 showing an example of disposing the tubular collecting part 1 substantially vertically and upward. Here, in the case where the tubular collecting part 1 is disposed substantially vertically and downward, as shown in FIG. 10, there is a space-saving advantage since the tubular collecting part 1 can double as a pipe of an exhaust pipe to a funnel (not shown) . On the other

hand, in the case where the tubular collecting part 1 is disposed substantially vertically and upward, as shown in FIG. 11, there is not only the advantage that it becomes easy to collect the falling PM, but also the advantage that, when SOF, sulfate, or the like, attached to the collecting wall face is liquefied, it becomes easy to collect the liquefied components because of falling down the surface of the collecting wall, and further the advantage it becomes easy to collect even heavy oxidized scales corroded by sulfate or the like detaching and falling from the surface of the wall. Besides, in a case where the tubular collecting part 1 is disposed substantially horizontally, there is the advantage that workability at a maintenance time of the collecting pipe, the discharge electrode, and the like becomes excellent since the tubular collecting part 1 is maintained at a horizontally substantially constant height from the floor surface of the engine room in which the engine is placed.

Industrial Applicability

[0049] Since the exhaust gas purification equipment for a diesel engine according to the present invention has a system in which the exhaust gas is purified by introducing a stream of part of the entire exhaust gas amount which has been concentrated up to a high PM concentration by condensing PM in advance into the cyclone and thereby the size of the cyclone can be reduced, and besides, when the system is such that the cyclone collecting means is composed of a plurality of tangential cyclones so that the high PM concentration of exhaust gas stream discharged through the high-PM-concentration exhaust gas outlet portion is selectively introduced into the tangential cyclones according to the flow rate of the exhaust gas, it becomes possible to select an appropriate treatment capacity and the appropriate number of the tangential cyclones in a well-balanced manner according to a significant increase or decrease in the exhaust gas flow rate (flow velocity) involved in a change in operating conditions or a fluctuation in engine load ratio caused by parallel operation or individual operation of the main engine and the auxiliary engine in a marine engine, in addition to the function effect of the tangential cyclone having a better collection capacity than an axial cyclone, so that a high PM collection efficiency can be ensured and maintained by responding to every change in the exhaust gas flow rate. In addition, since the tangential velocity of the exhaust gas flowing into the tangential cyclone can be appropriately controlled by controlling the opening position of the damper provided in the low-PM-concentration exhaust gas outlet pipe, a high PM collection efficiency can be ensured and maintained and such a problem as a deterioration in fuel economy due to an excessive pressure loss in the exhaust gas purification equipment can be solved. Achieving many advantageous effects such as these, the diesel-engine exhaust gas purification equipment according to the present invention makes a great consideration to exhaust gas purification treatment for a diesel engine for various applications, such as for watercrafts, for automobiles, or for industrial purposes, using a low-grade fuel equal to or less than fuel oil.

Reference Signs List

[0050]

1...tubular collecting part,
1-1...collecting pipe,
1-1a...exhaust gas inlet,
1-1b...high-PM-concentration exhaust gas outlet portion,
1-1c...seal air intake pipe portion,
1-1d...radially-expanding tubular portion,
1-1e...large-diameter tubular portion,
1-1f...exhaust gas intake chamber,
1-1g...narrowing portion,
1-1h...radially-expanding portion,
1-1i...seal air intake chamber,
1-1j...seal air inlet,
1-1k...collecting wall,
1-2...discharge electrode,
1-2a...main electrode,
1-2b...electrode needle,
1-2c...support ring,
2...segregating and collecting part,
2-1...cyclone collecting means,
2-1a...tangential cyclone,
2-1b...low-treatment-capacity tangential cyclone,
2-1c...intermediate-treatment-capacity tangential cyclone,
2-1d...high-treatment-capacity tangential cyclone,
3...low-PM-concentration exhaust gas outlet pipe,
3-1...seal air intake pipe portion,
4...support,
5-1... communicating pipe,
5-2... communicating pipe,
8-1 ... communicating pipe,
8-2... communicating pipe,
8-3... communicating pipe,
6-1...discharge pipe
6-2...discharge pipe,
7...flow-rate control damper,
9-1...flow-rate control damper,
9-2...flow-rate control damper,
9-3...flow-rate control damper,
10...air nozzle,
11...fan,
11-1...motor,
12...main engine,
13...auxiliary engine.

Claims

1. An exhaust gas treatment equipment for a diesel en-

gine comprising: an electrical precipitation means having a discharge electrode (1-2) for charging particulate matter contained in exhaust gas of a diesel engine using a low-grade fuel equal to or less than fuel oil, and a tubular collecting part (1) having a predetermined length and comprising a precipitation electrode for collecting the particulate matter charged, the discharge electrode (1-2) being composed of a main electrode (1-2a) disposed in an axial direction in the tubular collecting part (1-1) and a plurality of electrode needles (1-2b) disposed at intervals on the main electrode and projecting radially; and a segregating and collecting means (2) of a cyclone system for segregating and collecting the particulate matter which has been detached from the tubular collecting part, the exhaust gas treatment equipment having an arrangement in which an exhaust gas outlet pipe (3) for low PM concentration is provided in the vicinity of an axial center on a downstream side of the tubular collecting part and an exhaust gas outlet portion (1-1b) for high PM concentration is provided in the vicinity of an inner peripheral face on the downstream side of the tubular collecting part, a cyclone collecting means (2-1) for collecting the particulate matter is provided so as to communicate with the exhaust gas outlet portion for high PM concentration, the cyclone collecting means comprising a tangential cyclone (2-1a), and a damper (7) provided in the exhaust gas outlet pipe (3) for low PM concentration and means adapted to control the velocity of exhaust gas flowing into the tangential cyclone (2-1a) by controlling an opening position of the damper (7).

2. The exhaust gas treatment equipment for a diesel engine according to claim 1, wherein the cyclone collecting means (2-1a) comprises a plurality of tangential cyclones (2-1b, 2-1c, 2-1d) so that high PM concentration of exhaust gas discharged through the exhaust gas outlet portion (1-1b) for high PM concentration is selectively introduced into the tangential cyclones according to the flow rate of the high PM concentration of exhaust gas.

3. The exhaust gas treatment equipment for a diesel engine according to claim 1 or 2, wherein the tubular collecting part has a radially-expanding tubular portion having a gradually-increasing diameter (1-1d) and a large-diameter (1-1e) tubular portion communicating with the radially-expanding tubular portion (1-1d) at an end on the downstream side of the tubular collecting part, and the exhaust gas outlet pipe (3) for low PM concentration and the exhaust gas outlet (1-1b) portion for high PM concentration are provided, in a communicating manner, in the vicinity of an axial center of the large-diameter tubular portion (1-le) and in the vicinity of an inner peripheral face of the large-diameter tubular portion (1-1e), respectively.

4. The exhaust gas treatment equipment for a diesel engine according to claim 3, wherein the discharge electrode (1-2a) is provided so as to extend to the area of the radially-expanding tubular portion (1-1d) or the large-diameter tubular portion (1-1e) communicating with the radially-expanding tubular portion, in the tubular collecting part (1-1).

5. The exhaust gas treatment equipment for a diesel engine according to any one of claims 1 to 4, wherein the tubular collecting part (1-1) is substantially horizontally disposed.

6. The exhaust gas treatment equipment for a diesel engine according to any one of claims 1 to 4, wherein the tubular collecting part (1-1) is disposed substantially vertically with the downstream side upward.

7. The exhaust gas treatment equipment for a diesel engine according to any one of claims 1 to 4, wherein the tubular collecting part (1-1) is disposed substantially vertically with the downstream side downward.

8. The exhaust gas treatment equipment for a diesel engine according to any one of claims 1 to 7, wherein the cyclone collecting means (2-1a) comprises a plurality of tangential cyclones (2-1b, 2-1c, 2-1d) having different treatment capacities, and a flow-rate control damper (9-1, 9-2, 9-3) is provided at an inlet of each tangential cyclone.

9. The exhaust gas treatment equipment for a diesel engine according to any one of claims 1 to 8, wherein a discharge pipe (6-2) for causing purified gas that has passed through the tangential cyclone (2-1a) to mix into the low PM concentration of exhaust gas is provided between the tangential cyclone and the exhaust gas outlet pipe (3) for low PM concentration, and an air nozzle (10) or a motor-driven fan (11) is disposed in the discharge pipe (6-2).

Patentansprüche

1. Abgasverarbeitungsvorrichtung für einen Dieselmotor, umfassend: ein elektrisches Ausfällungsmittel mit einer Entladungselektrode (1-2) zum Laden von Schwebstoffen (PM), die in Abgas eines Dieselmotors enthalten sind, der einen geringwertigen Treibstoff verwendet, der Schweröl entspricht oder geringwertiger ist, und ein rohrförmiges Sammelteil (1) mit einer vorbestimmten Länge, und das eine Ausfällungselektrode zum Sammeln der geladenen Schwebstoffe umfasst, wobei die Entladungselektrode (1-2) aus einer Hauptelektrode (1-2a), die in einer axialen Richtung des rohrförmigen Sammel-

teils (1-1) angeordnet ist, und einer Vielzahl von Elektrodennadeln (1-2b) zusammengesetzt ist, die in Intervallen auf der Hauptelektrode angeordnet sind und radial vorstehen; und ein Absonderungs und Sammelmittel (2) eines Zyklonsystems zum Absondern und Sammeln der Schwebstoffe, die sich von dem rohrförmigen Sammelteil abgelöst haben, wobei die Abgasbehandlungsvorrichtung eine Anordnung aufweist, in der eine Abgasauslassleitung (3) für niedrige PM-Konzentration in der Nähe eines axialen Zentrums auf einer stromabwärtigen Seite des rohrförmigen Sammelteils und ein Abgasauslassabschnitt (1-1b) für hohe PM-Konzentration in der Nähe einer Innenumfangseite auf der stromabwärtigen Seite des rohrförmigen Sammelteils bereitgestellt werden, ein Zyklonsammelmittel (2-1) zum Sammeln der Schwebstoffe so bereitgestellt wird, dass es mit dem Abgasauslassabschnitt für hohe PM-Konzentration kommuniziert, wobei das Zyklonsammelmittel einen Tangential-Zyklon (2-1a), und eine Abgasklappe (7), die in der Abgasauslassleitung (3) für niedrige PM-Konzentration bereitgestellt wird, und Mittel umfasst, die zur Steuerung der Geschwindigkeit des in den Tangential-Zyklon (2-1a) fließenden Abgases vorgesehen sind, indem eine Öffnungsposition der Abgasklappe (7) gesteuert wird.

2. Abgasbehandlungsvorrichtung für einen Dieselmotor nach Anspruch 1, wobei das Zyklonsammelmittel (2-1a) eine Vielzahl von Tangential-Zyklonen (2-1b, 2-1c, 2-1d) umfasst, so dass Abgas mit hoher PM-Konzentration, das durch den Abgasauslassabschnitt (1-1b) für hohe PM-Konzentration abfließt, selektiv gemäß der Flussrate des Abgases mit hoher PM-Konzentration in die Tangential-Zyklone eingebracht wird.

3. Abgasbehandlungsvorrichtung für einen Dieselmotor nach Anspruch 1 oder 2, wobei das rohrförmige Sammelteil einen sich radial aufweitenden rohrförmigen Abschnitt mit einem allmählich zunehmenden Durchmesser (1-1d) und einen rohrförmigen Abschnitt (1-1e) mit großem Durchmesser aufweist, der mit dem sich radial aufweitenden rohrförmigen Abschnitt (1-1d) an einem Ende der stromabwärtigen Seite des rohrförmigen Sammelteils kommuniziert, und wobei die Abgasauslassleitung (3) für niedrige PM-Konzentration und der Abgasauslassabschnitt (1-1b) für hohe PM-Konzentration in kommunizierender Weise in der Nähe eines axialen Zentrums des rohrförmigen Abschnitts (1-1e) mit großem Durchmesser beziehungsweise in der Nähe einer Innenumfangseite des rohrförmigen Abschnitts (1-1e) mit großem Durchmesser bereitgestellt werden.

4. Abgasbehandlungsvorrichtung für einen Dieselmotor nach Anspruch 3, wobei die Entladungselektrode (1-2a) so bereitgestellt wird, dass sie sich in den Bereich des sich radial aufweitenden rohrförmigen Abschnitts (1-1d) oder des rohrförmigen Abschnitts (1-1e) mit großem Durchmesser, der mit dem sich radial aufweitenden rohrförmigen Abschnitt kommuniziert, in dem rohrförmigen Sammelteil (1-1) erstreckt.

5. Abgasbehandlungsvorrichtung für einen Dieselmotor nach einem der Ansprüche 1 bis 4, wobei das rohrförmige Sammelteil (1-1) im Wesentlichen horizontal angeordnet ist.

6. Abgasbehandlungsvorrichtung für einen Dieselmotor nach einem der Ansprüche 1 bis 4, wobei das rohrförmige Sammelteil (1-1) im Wesentlichen vertikal mit der stromabwärtigen Seite nach oben angeordnet ist.

7. Abgasbehandlungsvorrichtung für einen Dieselmotor nach einem der Ansprüche 1 bis 4, wobei das rohrförmige Sammelteil (1-1) im Wesentlichen vertikal mit der stromabwärtigen Seite nach unten angeordnet ist.

8. Abgasbehandlungsvorrichtung für einen Dieselmotor nach einem der Ansprüche 1 bis 7, wobei das Zyklonsammelmittel (2-1a) eine Vielzahl von Tangential-Zyklonen (2-1b, 2-1c, 2-1d) mit unterschiedlichen Behandlungskapazitäten umfasst und eine Abgasklappe (9-1, 9-2, 9-3) zur Steuerung der Durchflussrate an einem Einlass von jedem Tangential-Zyklon bereitgestellt wird.

9. Abgasbehandlungsvorrichtung für einen Dieselmotor nach einem der Ansprüche 1 bis 8, wobei eine Abflussleitung (6-2) zwischen dem Tangential-Zyklon und der Abgasauslassleitung (3) für niedrige PM-Konzentration bereitgestellt wird, um herbeizuführen, dass gereinigtes Gas, welches den Tangential-Zyklon (2-1a) passiert hat, sich in das Abgas mit niedriger PM-Konzentration mischt, und eine Luftdüse (10) oder ein motorgetriebenes Gebläse (11) in der Abflussleitung (6-2) angeordnet ist.

Revendications

1. Équipement de traitement des gaz d'échappement pour un moteur diesel, comprenant : un moyen de précipitation électrique ayant une électrode de décharge (1-2) pour charger la matière particulaire contenue dans les gaz d'échappement d'un moteur diesel qui utilise un carburant de qualité inférieure qui est égal ou inférieur au mazout, et une partie de collecte tubulaire (1) ayant une longueur prédéterminée et comprenant une électrode de précipitation pour collecter la matière particulaire chargée, l'électrode

de décharge (1-2) étant composée d'une électrode principale (1-2a) disposée dans une direction axiale dans la partie de collecte tubulaire (1-1) et d'une pluralité d'aiguilles d'électrode (1-2b) disposées à intervalles sur l'électrode principale et faisant saillie radialement ; et un moyen de séparation et de collecte (2) d'un système cyclonique, pour séparer et collecter la matière particulaire qui s'est détachée de la partie de collecte tubulaire,

l'équipement de traitement des gaz d'échappement ayant un agencement dans lequel un tuyau de sortie des gaz d'échappement (3) pour une faible concentration de matière particulaire (PM) est disposé à proximité d'un centre axial du côté aval de la partie de collecte tubulaire et une partie de sortie des gaz d'échappement (1-1b) pour une concentration élevée de matière particulaire est disposée à proximité d'une face périphérique interne du côté aval de la partie de collecte tubulaire, un moyen de collecte à cyclone (2-1) pour collecter la matière particulaire est disposé de sorte à communiquer avec la partie de sortie des gaz d'échappement pour une concentration élevée de matière particulaire, le moyen de collecte à cyclone comprenant un cyclone tangentiel (2-1a) et un amortisseur (7) disposé dans le tuyau de sortie des gaz d'échappement (3) pour une faible concentration de matière particulaire et un moyen conçu pour réguler la vitesse des gaz d'échappement circulant dans le cyclone tangentiel (2-1a) en régulant une position d'ouverture de l'amortisseur (7).

2. Équipement de traitement des gaz d'échappement pour un moteur diesel selon la revendication 1, dans lequel le moyen de collecte à cyclone (2-1a) comprend une pluralité de cyclones tangentiels (2-1b, 2-1c, 2-1d) de telle sorte que la concentration élevée de matière particulaire des gaz d'échappement évacués au moyen de la partie de sortie des gaz d'échappement (1-1b) pour une concentration élevée de matière particulaire soit introduite de façon sélective dans les cyclones tangentiels selon le débit de la concentration élevée de matière particulaire des gaz d'échappement.

3. Équipement de traitement des gaz d'échappement pour un moteur diesel selon la revendication 1 ou 2, dans lequel la partie de collecte tubulaire comporte une partie tubulaire s'étendant radialement ayant un diamètre augmentant petit à petit (1-1d) et une partie tubulaire à diamètre important (1-1e) communiquant avec la partie tubulaire s'étendant radialement (1-1d) au niveau d'une extrémité du côté aval de la partie de collecte tubulaire, et le tuyau de sortie des gaz d'échappement (3) pour une faible concentration de matière particulaire et la partie de sortie des gaz d'échappement (1-1b) pour une concentration élevée de matière particulaire sont disposées, de manière communiquant, à proximité d'un centre axial de la partie tubulaire à diamètre important (1-1e) et à proximité d'une face périphérique interne de la partie tubulaire à diamètre important (1-1e), respectivement.

4. Équipement de traitement des gaz d'échappement pour un moteur diesel selon la revendication 3, dans lequel l'électrode de décharge (1-2a) est disposée de sorte à s'étendre jusqu'à la zone de la partie tubulaire s'étendant radialement (1-1d) ou jusqu'à la partie tubulaire à diamètre important (1-1e) communiquant avec la partie tubulaire s'étendant radialement, dans la partie de collecte tubulaire (1-1) .

5. Équipement de traitement des gaz d'échappement pour un moteur diesel selon l'une quelconque des revendications 1 à 4, dans lequel la partie de collecte tubulaire (1-1) est disposée sensiblement horizontalement.

6. Équipement de traitement des gaz d'échappement pour un moteur diesel selon l'une quelconque des revendications 1 à 4, dans lequel la partie de collecte tubulaire (1-1) est disposée sensiblement verticalement avec le côté aval vers le haut.

7. Équipement de traitement des gaz d'échappement pour un moteur diesel selon l'une quelconque des revendications 1 à 4, dans lequel la partie de collecte tubulaire (1-1) est disposée sensiblement verticalement avec le côté aval vers le bas.

8. Équipement de traitement des gaz d'échappement pour un moteur diesel selon l'une quelconque des revendications 1 à 7, dans lequel le moyen de collecte à cyclone (2-1a) comprend une pluralité de cyclones tangentiels (2-1b, 2-1c, 2-1d) ayant des capacités de traitement différentes et un amortisseur de régulation de débit (9-1, 9-2, 9-3) est disposé au niveau d'un orifice d'entrée de chaque cyclone tangentiel.

9. Équipement de traitement des gaz d'échappement pour un moteur diesel selon l'une quelconque des revendications 1 à 8, dans lequel un tuyau d'évacuation (6-2) pour contraindre les gaz purifiés qui ont traversé le cyclone tangentiel (2-1a) à se mélanger dans la faible concentration de matière particulaire des gaz d'échappement est disposé entre le cyclone tangentiel et le tuyau de sortie des gaz d'échappement (3) pour une faible concentration de matière particulaire et une buse d'air (10) est disposée, ou un ventilateur entraîné par un moteur (11) est disposé, dans le tuyau d'évacuation (6-2).

Fig. 1

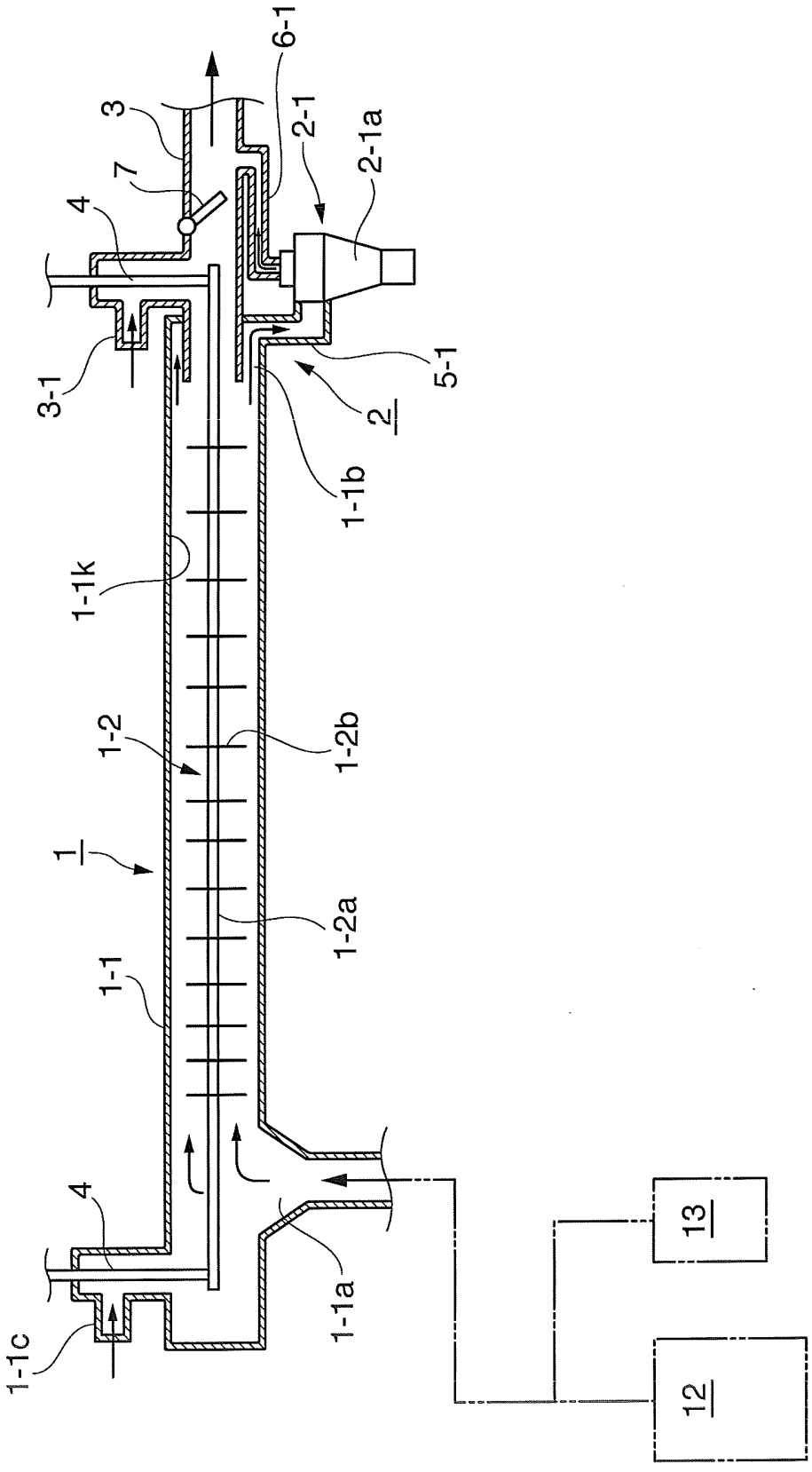


Fig. 2

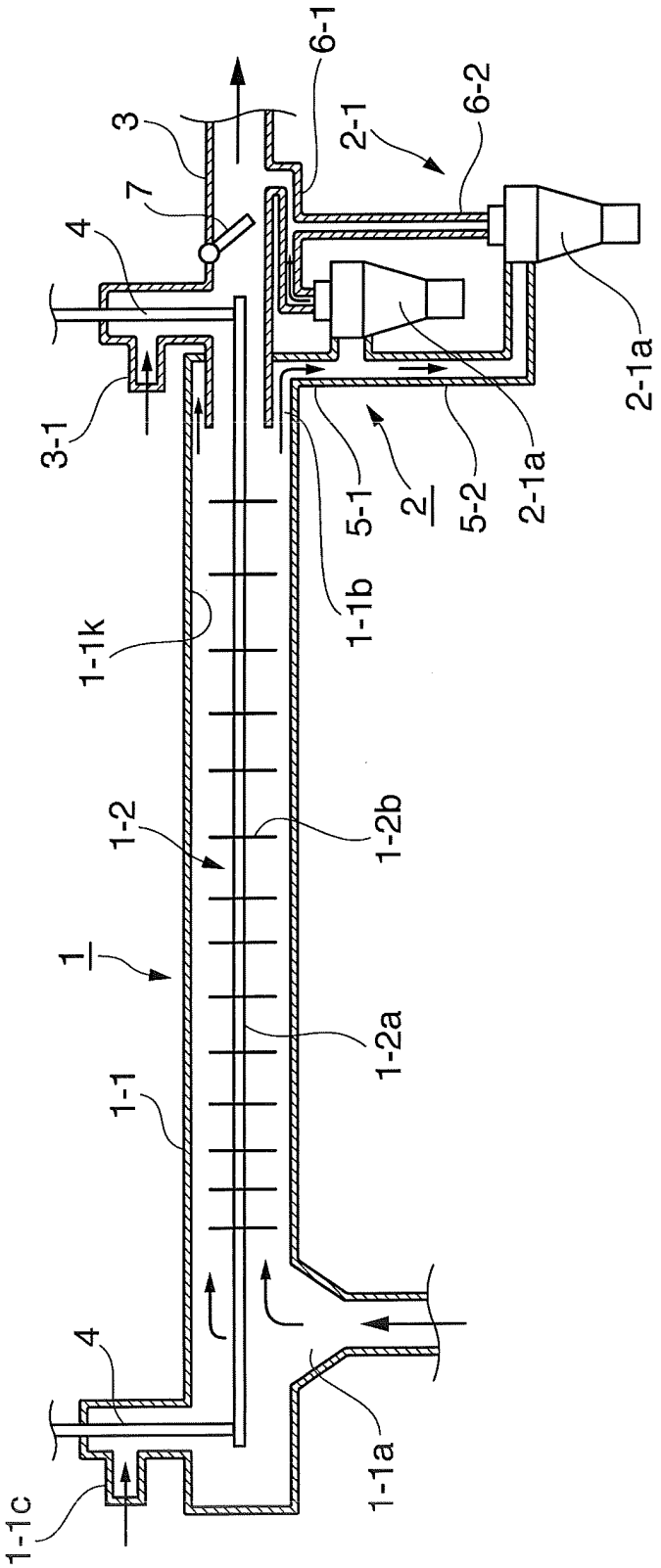


Fig. 3

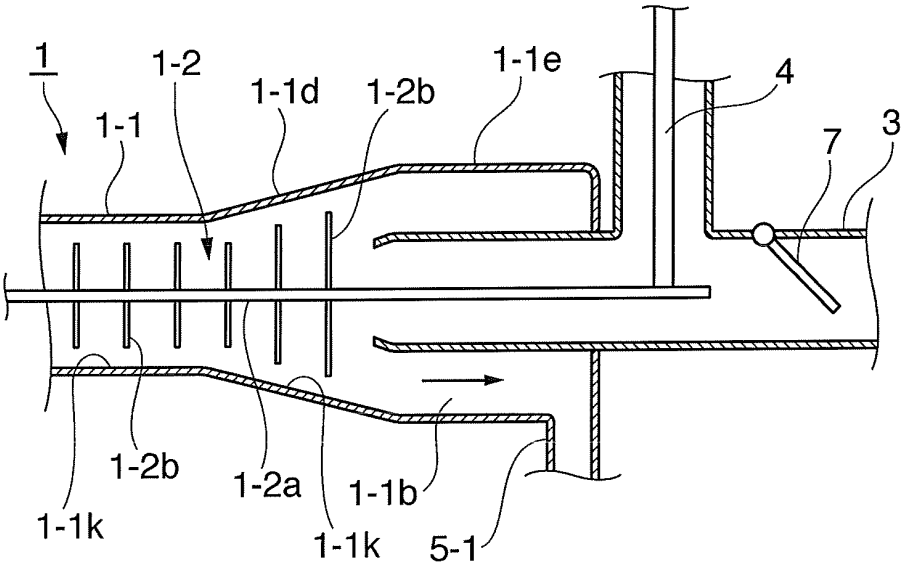

1
1-2
1-1d
1-2b
1-1e
4
1-1
7
3
1-2b
1-2a
1-1b
1-1k
1-1k
5-1

Fig. 4

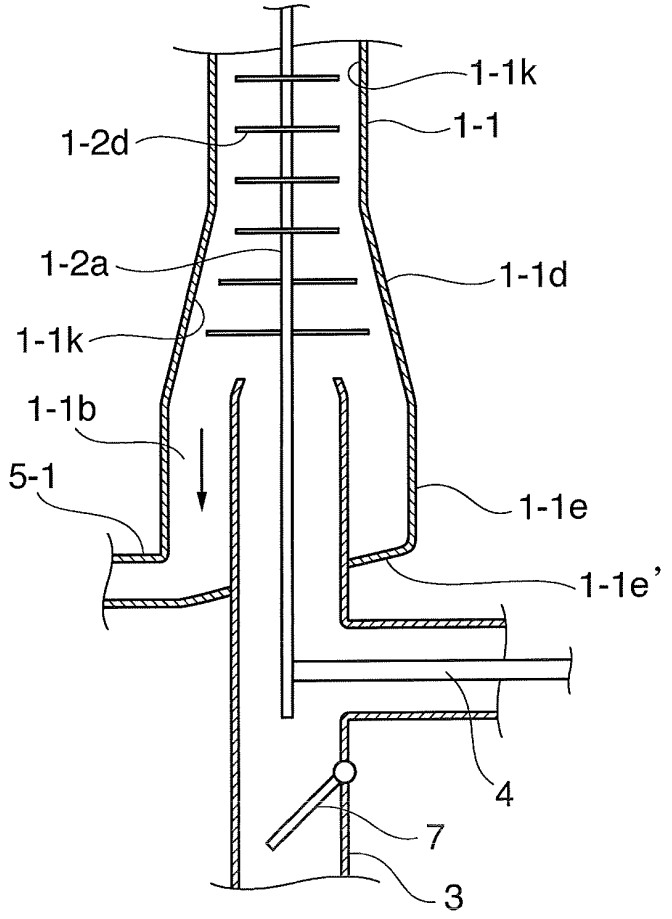

1-1k
1-1
1-2d
1-2a
1-1d
1-1k
1-1b
5-1
1-1e
1-1e'
4
7
3

Fig. 5

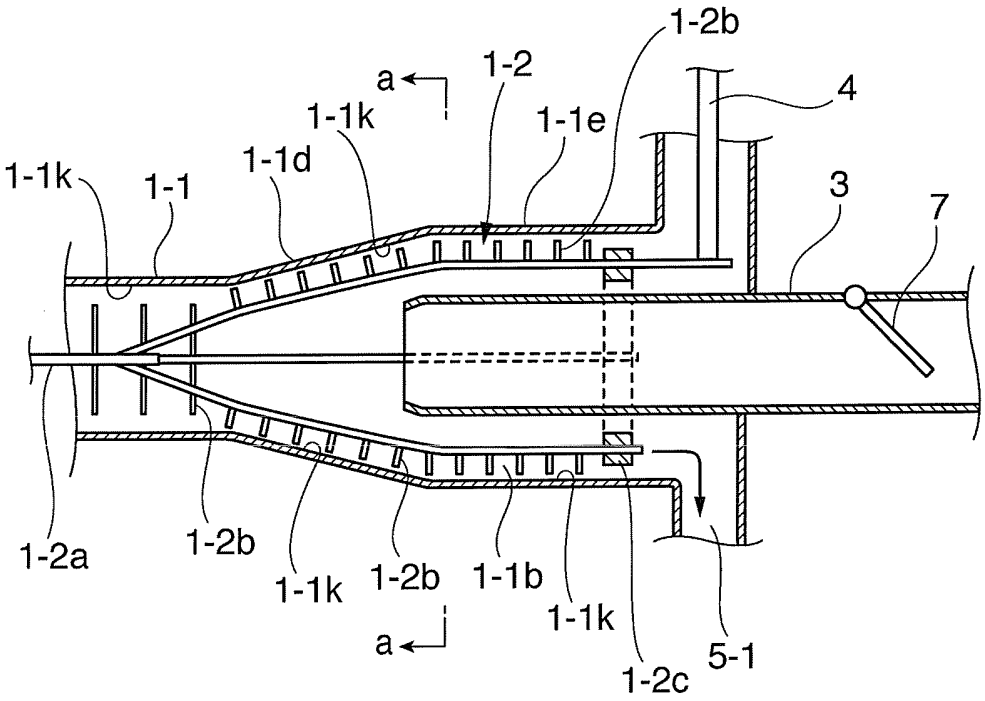

1-2b
a
1-2
4
1-1k
1-1e
1-1d
1-1k
1-1
3
7
1-2a
1-2b
1-1k
1-2b
1-1b
1-1k
a
1-2c
5-1

Fig. 6

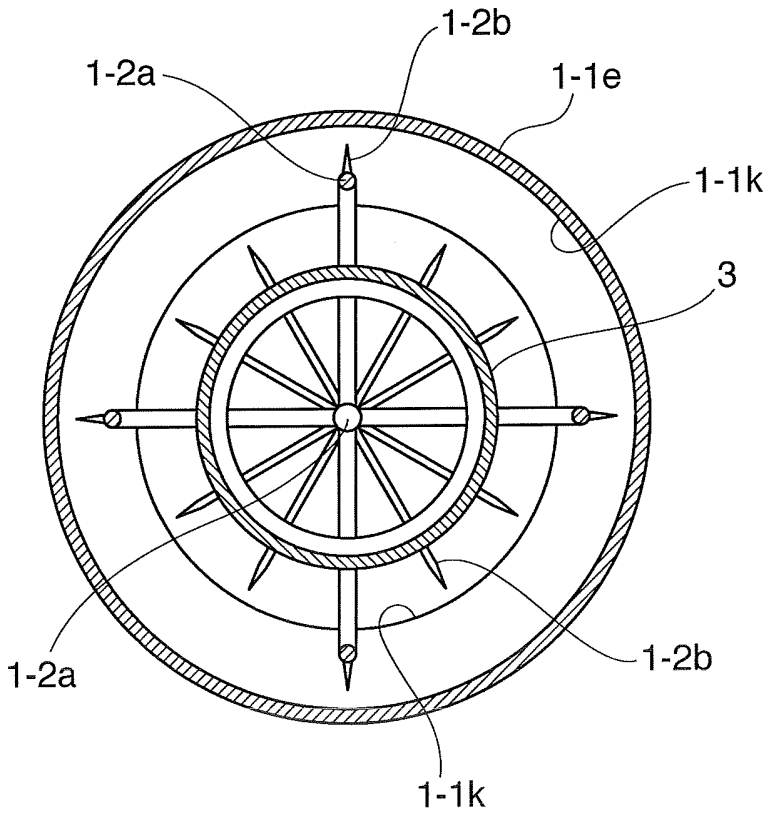

1-2b
1-2a
1-1e
1-1k
3
1-2a
1-2b
1-1k

Fig. 7

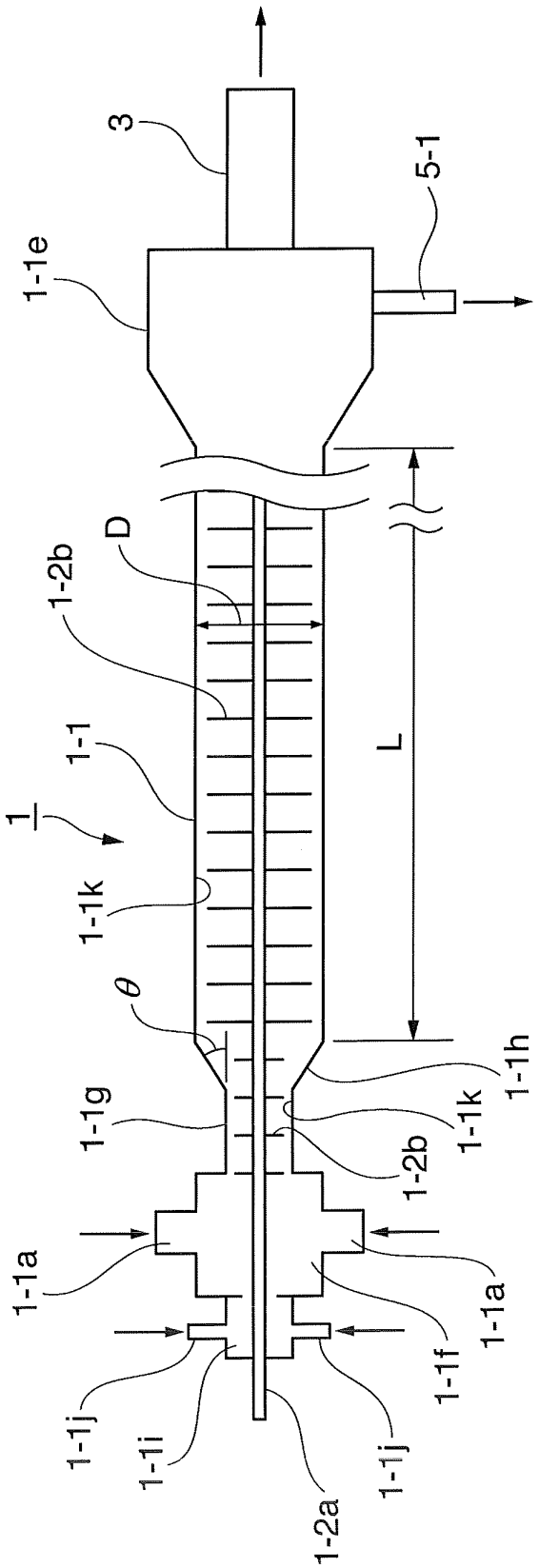

3
5-1
1-1e
D
1-2b
1-1
1
L
1-1k
θ
1-1h
1-1g
1-1k
1-2b
1-1a
1-1a
1-1f
1-1j
1-1i
1-1j
1-2a

Fig. 8

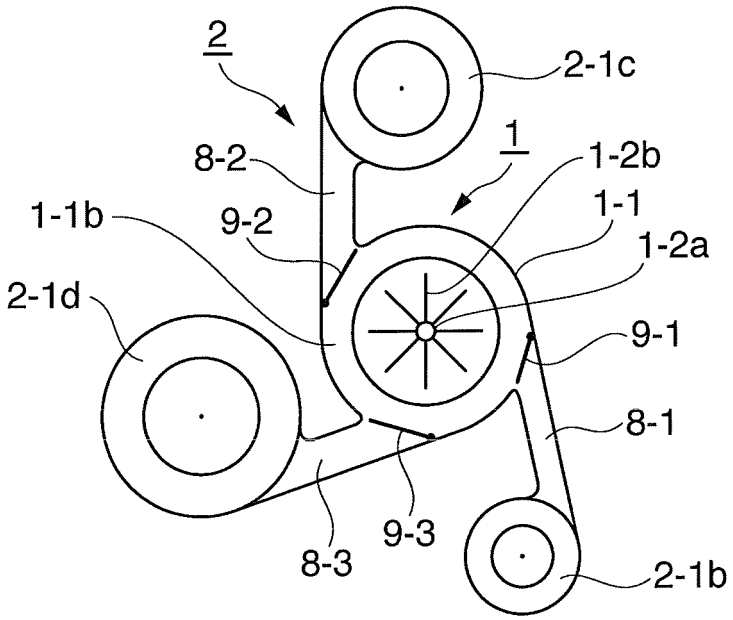

2
2-1c
1
8-2
1-2b
1-1b
9-2
1-1
1-2a
2-1d
9-1
8-1
9-3
8-3
2-1b

Fig. 9

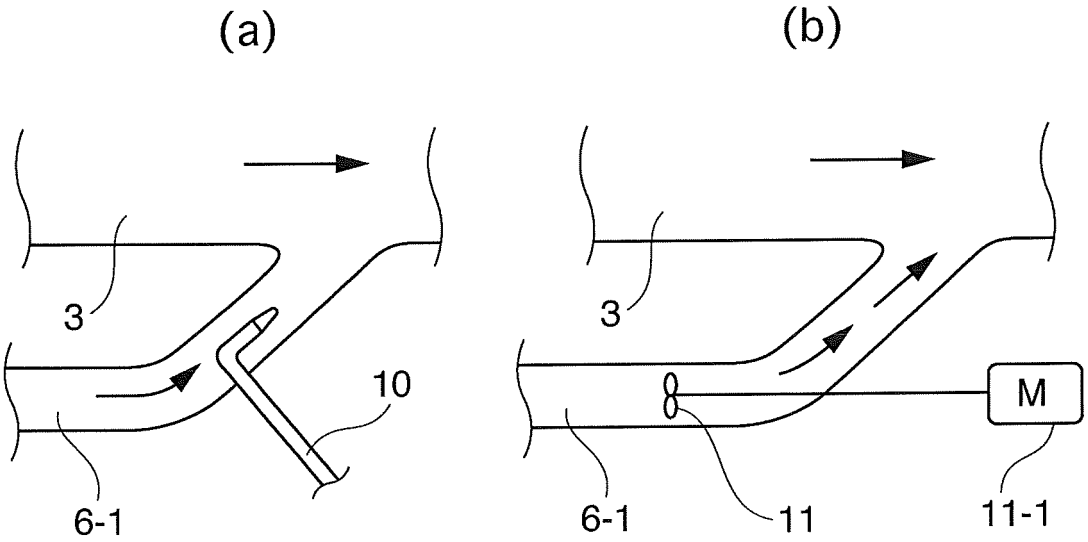

(a)
(b)
3
10
6-1
3
M
6-1
11
11-1

Fig. 10

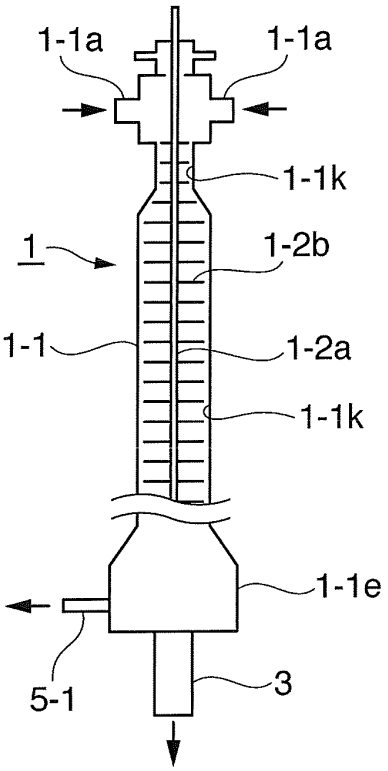

1-1a
1-1a
1-1k
1
1-2b
1-1
1-2a
1-1k
1-1e
5-1
3

Fig. 11

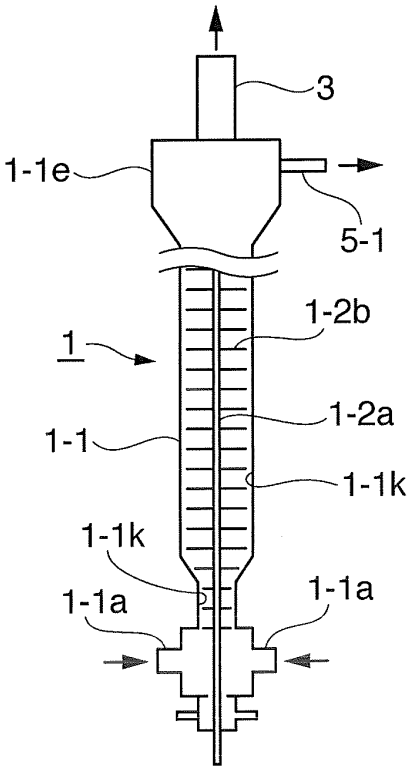

3
1-1e
5-1
1-2b
1
1-2a
1-1
1-1k
1-1k
1-1a
1-1a

Fig. 12

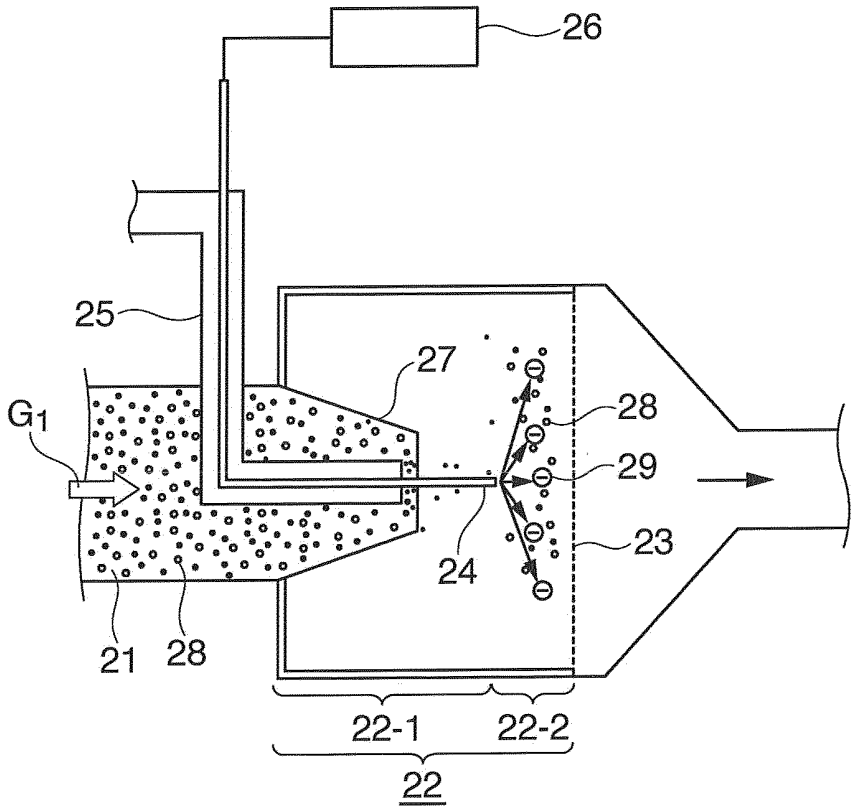


Fig. 13

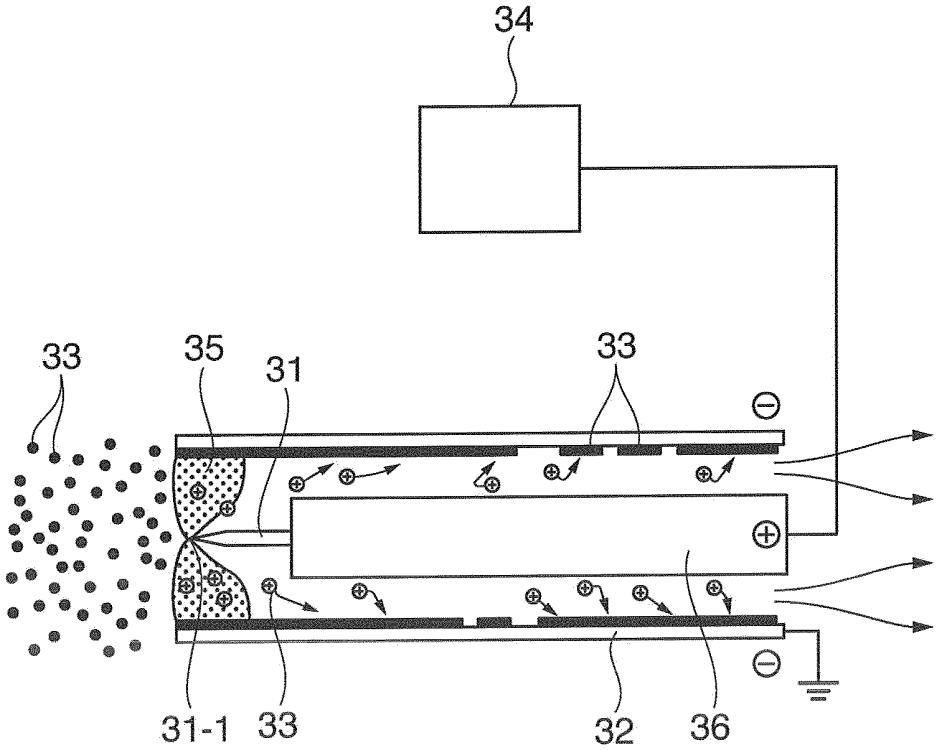


Fig. 14

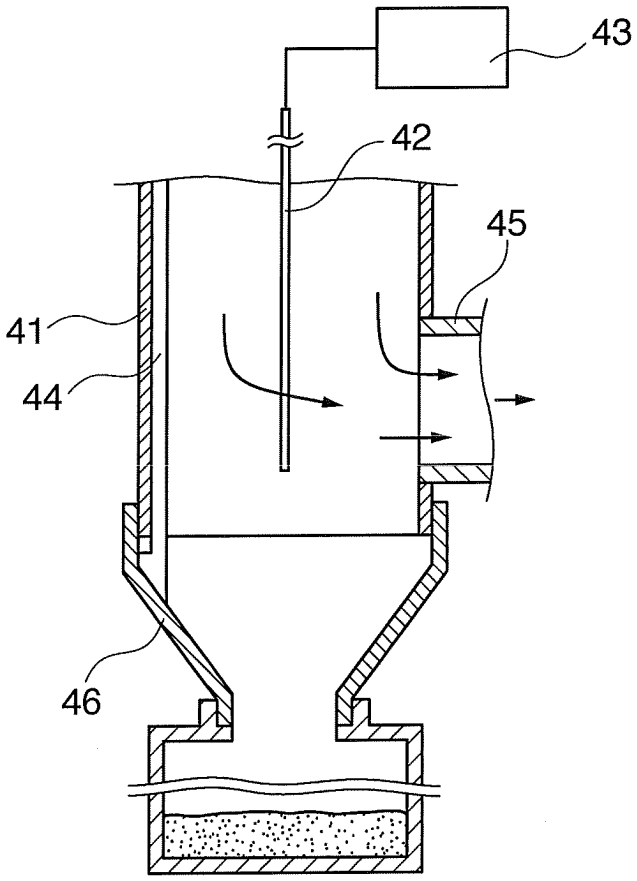


Fig. 15

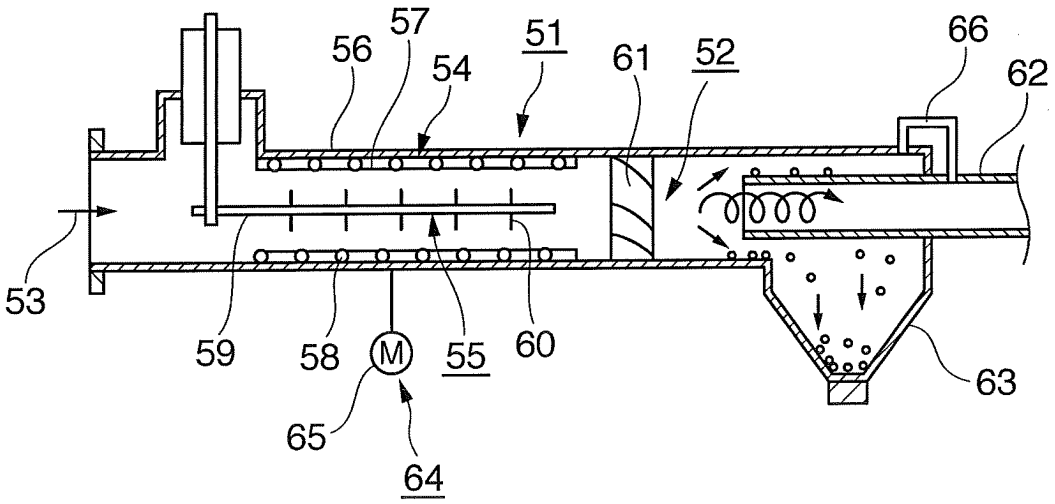


Fig. 16

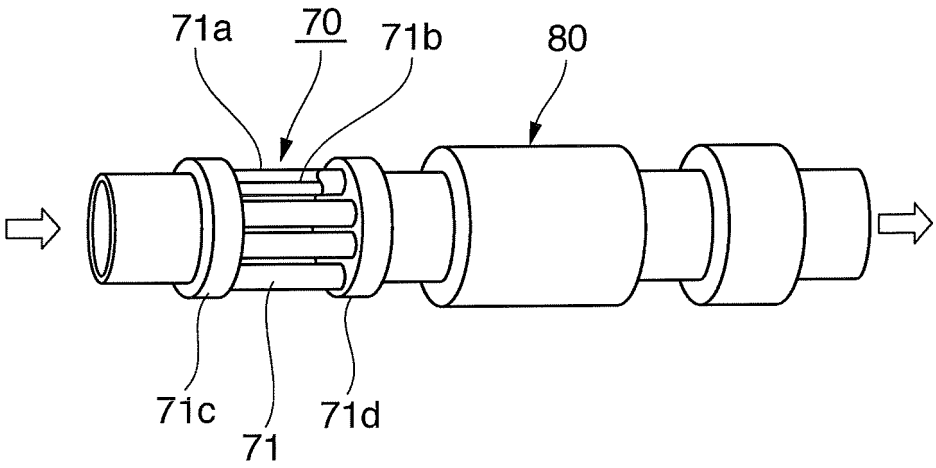
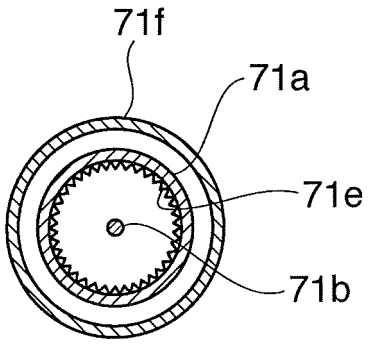


Fig. 17



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