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

(11) EP 1 126 138 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
22.08.2001 Bulletin 2001/34

(51) Int Cl.[7]: **F01N 3/022**, F01N 3/033, F01N 3/08

(21) Application number: **00301208.5**

(22) Date of filing: **16.02.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

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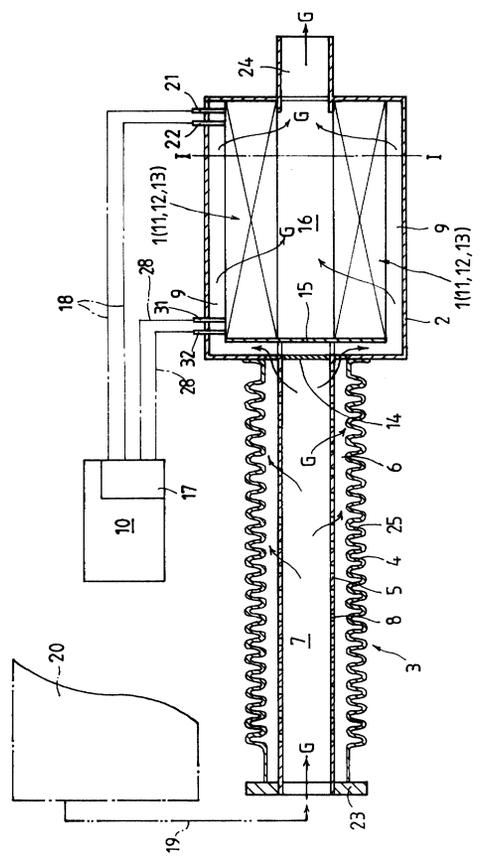
(54) Particulate filter system for diesel engine

(57) A particulate filter system for a diesel engine is disclosed in which particulate matter suspended in the exhaust gases is first charged negatively at an upstream metal screen(12) and then trapped on a downstream metal screen(13). Cooling means(3) is located within an exhaust tract(19) through which the exhaust gases from the engine pass. Filter means(1) is arranged immediately downstream of the cooling means(3). The filter means(1) is comprised of a filter medium(11) arranged in a casing(2) to trap the particulate matter contained in the exhaust gases, an upstream metal screen(12) arranged upstream of the filter medium(11) and biased negatively to charge negatively the particulate matter, and a downstream metal screen(13) arranged downstream of the filter medium(11) and biased positively to attract the particulate matter that has been charged negatively.

FIG. 1



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Description

[0001] The present invention relates to a particulate filter system for cleaning exhaust gas from a diesel engine, in which particulate matter or solid particle content in the exhaust gases are trapped or extracted and further burned out.

[0002] The major types of the conventional emission-control systems for the exhaust gas from the engine have a filter formed to provide a passage surface made so large as to filter out much particulate matter of the exhaust gas, which flows through the passage surface. The particulate matter, mainly in the form of carbon is trapped and accumulated on the filter. An electric heater is connected to the filter to burn away the accumulated particulate matter to thereby regenerate the filter.

[0003] Disclosed, for instance, in Japanese Utility Model Laid-Open No. 144427/1989 is a particulate trap for diesel engines, in which the exhaust gas from the engine passes through the filter medium, where solid particle content of the exhaust products, mainly in the form of carbon, smoke and others is trapped on the filter medium. The filter medium clogged with the particulate matter accumulated on the filter is isolated from the exhaust gas, which is thus allowed to flow through another filter medium arranged in parallel with the former filter medium. The former filter medium clogged with the particulates is heated to burn away the trapped particulates with air blown into from the downstream of the filter.

[0004] By-products of the operation of the engine include solid particle content or particulate matter of carbon, smoke, hydrocarbons, sulfur oxides (S0x) or the like. The particulate matter is mainly in the form of carbon and partially burned hydrocarbons suspended in the exhaust gas. While the particulates range widely in the particle size from about 40 μm to 0.1 μm, the most majority is about 0.20 μm. Especially, the fine particulate matter of less than 0.25 μm may raise an environmental problem or air pollution of irritating the respiratory tract of human beings, causing violent coughing or the like.

[0005] Nevertheless, it is very hard to trap the fine particulate matter on the filter medium because it is too small in particle size to deposit on the filter medium. In recent years much attention has been thus given to the problem of how the fine particulate matter may be trapped to cope with the air pollution resulting from the internal combustion engines.

[0006] In the meantime the particulate matter contained in the exhaust gases from the engine has such characteristics that it may be electrostatically charged while passing through the exhaust tract from the engine to the atmosphere. The charged particles in the particulate matter, in the higher temperature atmosphere of the exhaust gas, are constantly in violent particle motion, while emitting charged electrons, and thus they tend to move independently, colliding with each other and bouncing back and forth.

[0007] In contrast, decreasing the temperature of the exhaust gas leads to such phenomenon that the charged particles begin to aggregate, becoming particles larger in size. The large-sized particulate matter, when charged, may be considered attracted easily to any member charged oppositely in polarity to the particulate matter.

[0008] Moreover, the particulate matter trapped on the filter medium may be simply burned away by heating it to the temperature of about 600 °C in the atmosphere containing oxygen. Most diesel particulate filters should be regenerated inevitably by burning away the particulate matter accumulated on the filter medium, which is thus reactivated for next filtration. Thus, an improved particulate filter system may be imagined in which metal screens in the filter medium are energized with electric current while flowing the exhaust gas through the filter medium, to heat the filter medium up to the temperature, where the trapped particulate matter burns out to regenerate the filter medium.

[0009] With the filter medium made of ceramic fibers, the particulate matter trapped among the ceramic fibers, when heated up to the temperature above about 600 °C, initiates firing and burns out. Since the particulate matter trapped among the ceramic fibers is held in three-dimensional structure, pores or clearances are apt to be left among the trapped particulates so that the exhaust gas of high temperature is allowed to flow into the pores, where the particulates catch fire and burn out easily by the reaction with air contained in the exhaust gas.

[0010] A primary aim of the present invention is to overcome the problems on the prior art as having been described above, and to provide an improved particulate filter system for a diesel engine, which is developed on the basis of such characteristics that the particulates are apt to be charged negatively at low temperatures. More particularly, the present invention has as its principal object the provision of a novel particulate filter system in which exhaust gases from the engine are cooled down to a low temperature and a filter medium of a material such as ceramic fibers is interposed between metal screens serving as heaters arranged opposite to each other along a flowing stream of the low-temperature exhaust gases, the metal screen upstream of the filter medium being charged negatively while the downstream metal screen being charged positively, whereby fine particles of particulate matter in the exhaust gases are charged negatively when passing through the upstream metal screen and the particulates failed to be extracted from the exhaust at the filter medium are trapped on the downstream metal screen that is charged positively.

[0011] The present invention is concerned with a particulate filter system for a diesel engine, comprising an exhaust tract through which exhaust gases from the engine flow, cooling means located within the exhaust tract to cool down the exhaust gases, a casing connected to the cooling means, a filter medium arranged in the casing to trap particulate matter contained in the exhaust gases flowing from the cooling means, charging means

arranged upstream of the filter medium and biased negatively to charge negatively the particulate matter, and a metal screen arranged downstream of the filter medium and biased positively to attract the particulate matter that has been charged negatively.

[0012] In one aspect of the present invention a particulate filter system for a diesel engine is provided, wherein the cooling means is composed of an inner pipe connected with the exhaust tract in a fluid communication and provided with perforations, and an outer pipe arranged surrounding around the inner pipe and made with corrugations to provide fins for dissipation of heat, whereby the exhaust gases in the inner pipe are allowed to flow through the perforations to thereby collide against an inner surface of the outer pipe and further pass through a cooling passage defined between the inner and outer pipes into the filter medium.

[0013] In another aspect of the present invention a particulate filter system for a diesel engine is provided, wherein the filter medium is made in the form of hollow cylinder with pleats and the exhaust gases are allowed to pass radially inwardly across the filter medium. Moreover, the filter medium is made of nonwoven fabrics of ceramic fibers.

[0014] In another aspect of the present invention a particulate filter system for a diesel engine is provided, wherein the charging means comprises a charger of latticework type made of lattice electrodes arranged extending between the adjoining pleats at the upstream surface of the filter medium. As an alternative, the charging means comprises a charger of network type made of upstream and downstream metal screens arranged over the filter medium.

[0015] In a further another aspect of the present invention a particulate filter system for a diesel engine is provided, wherein the controller unit operates to make any one of the upstream and downstream metal screens conductive electrically when the particulate matter trapped on the filter medium reaches a preselected amount, whereby the selected metal screen is heated up to a high temperature, where the particulate matter trapped on the filter medium is burned away to regenerate the filter medium.

[0016] In accordance with the particulate filter system for the diesel engine constructed as described just above, the exhaust gases from the diesel engine pass through the cooling means located within the exhaust tract. The exhaust gases are cooled down at the cooling means to a low temperature where the particulate matter suspended in the exhaust gases aggregates to particles larger in particle size, which may be extracted or trapped easily on the filter medium. Moreover, the particulate matter is charged negatively while flowing over the metal screen biased negatively. On the other hand, the remaining fine particle content in the filtered exhaust gases is kept charged negatively and, therefore, attracted to the downstream metal screen 13 that has been charged positively. Thus, the particulate filter system of the present invention works to help ensure the cleaned exhaust gases, which are emitted from the tailpipe into the atmosphere. In addition, the filter medium may be regenerated or reactivated by heating electrically any one of the upstream and downstream metal screens to thereby burn away the particulate matter trapped on the filter medium.

[0017] Consequently, the present invention provides a particulate filter system for the diesel engine improved in removing the particulate matter, especially, fine particulates less than 0.25 μm in particle size, which cause the major environmental problem of irritating the respiratory tract.

[0018] Other aims and features of the present invention will be more apparent to those skilled in the art on consideration of the accompanying drawings and following specification wherein are disclosed preferred embodiments of the invention with the understanding that such variations, modifications and elimination of parts may be made therein as fall within the scope of the appended claims without departing from the scope of the invention.

[0019] Embodiments of the present invention will now be described by way of example only, with reference to the accompanying drawings, in which:-

FIG. 1 is a schematic sectional illustration showing a preferred embodiment of a diesel particulate filter system according to the present invention:

FIG. 2 is a schematic cross section showing an embodiment of electrostatic charging means connected with heaters, the view being taken along the line I — I of FIG. 1:

FIG. 3 is a fragmentary schematic sectional view illustrating an embodied combination of a filter medium with metal screens, employed in the diesel particulate filter system in FIG. 1: and

FIG. 4 is a schematic cross section taken substantially on the line I — I of FIG. 1 but showing another embodiment of electrostatic charging means.

[0020] Described below in detail with reference to the accompanying drawings will be a first preferred embodiment of a diesel particulate filter system according to the present invention.

[0021] The diesel particulate filter system is located within an exhaust tract 19. Exhaust gases from a combustion chamber 20 are passed through the particulate filter system, where particulate matter of the exhaust is trapped or extracted and the particulate matter trapped is burned away by heating to thereby clean the exhaust gases. The particulate filter system is comprised of cooling means 3 located in the exhaust tract 19, and filter means 1 arranged immediately downstream of the cooling means 3 along an exhaust gas flow G. The filter means 1 is housed within a casing 2 and made of a material such as ceramic fibers, which has a heat-resistant property and an ability of extracting the particulate mat-

ter of the exhaust, in the form of carbon, smoke, hydrocarbons (HC), sulfur oxides (SOx) or the like.

[0022] The diesel particulate filter system of the present invention mainly includes the exhaust tract 19 conveying the exhaust gases away from the combustion chamber 20 to the atmosphere, the cooling means 3 located in the exhaust tract 19 to cool down the exhaust gases, the casing 2 enclosing the filter means 1 communicated with the cooling means 3. The filter means 1 is comprised of a filter medium 11 for extracting or removing suspended particulate matter from the exhaust gases, an upstream metal screen 12 arranged upstream of the filter medium 11 on the exhaust flow G and biased negatively across electric lines 18 to charge negatively the particulate matter, and a downstream metal screen 13 arranged downstream of the filter medium 11 on the exhaust flow G and biased positively across electric lines 28 to charge positively the particulate matter.

[0023] Moreover, a controller unit 10 is to apply any electric potential of a d-c source 17 to charging means of network or latticework type, upon the exhaust gases passing through the filter means 11.

[0024] Illustrated in FIGS. 2 and 3 is the charging means of network type, which has the upstream metal screen 12 applied with the negative potential across terminals 21 connected to the lines 18, and the downstream metal screen 13 applied with the positive potential across terminals 22 connected to the lines 28.

[0025] As an alternative, the charging means of latticework type shown in FIG. 4 may be employed, in which a latticed electrode 27 applied with the negative potential across terminals 21 connected to the lines 18, and the downstream metal screen 13 applied with the positive potential across terminals 22 connected to the lines 28.

[0026] The cooling means 3 comprises a corrugated tube 4 provided at lengthwise opposing ends thereof with a flanged plate 23 and the filter means 1, each to each end, and an inner pipe 5 arranged in the corrugated tube 4 so as to define a radially-outer exhaust passage 6 and a radially-inner exhaust passage 7.

[0027] The inner pipe 5 having the inner exhaust passage 7 therein is arranged concentrically in the corrugated tube 4 to define the outer exhaust passage 6 between them. The corrugated tube 4 has fins 25 for the dissipation of heat and the inner pipe 5 is provided with perforations 8 through which the exhaust gases are allowed to flow from the inner exhaust passage 7 to the outer exhaust passage 6, where they are cooled down through fins.

[0028] The outer exhaust passage 6 formed between the corrugated tube 4 and the inner pipe 5 is closed at one end thereof with the flanged plate 23, but opened at the lengthwise opposing end thereof to an exhaust ingress 9 of the casing 2. The inner exhaust passage 7 in the inner pipe 5 is communicated at its one end with the exhaust tract 19 and blocked with a closure plate 14 at its lengthwise opposing end facing to the filter means 1. It will be thus understood that the exhaust gases flowing into the cooling means 3 from the exhaust tract 9 is allowed to pass from the inner exhaust passage 7 in the inner pipe 5 through the perforations 8 to the outer exhaust passage 6, where they further flow into the exhaust ingress 9 of the filter means 1. The exhaust gases are cooled down at the cooling means 3 to a low temperature where the suspended particulates aggregate to particles larger in particle size.

[0029] The filter means 1 is formed hollow inside and closed at one lengthwise end facing the exhaust ingress thereof, but opened at the lengthwise opposing end to an exhaust egress 16. The filter means 1 is composed of the filter medium 11, and the upstream and downstream metal screens 12, 13 confronting each other to sandwich the filter medium 11 between them.

[0030] The upstream metal screen 12 is arranged facing the upstream surface of the filter medium 11 and biased negatively across the terminals 21 connected through lines 18 to the d-c electric source 17 such as a batteries, which is under the controller unit 10. On the other hand, the downstream metal screen 13 is arranged facing the downstream surface of the filter medium 11 and biased positively across the terminals 22 connected through lines 28 to the d-c electric source 17 such as a batteries, which is under the controller unit 10.

[0031] For regenerating or reactivating the filter medium 11 that has extracted or trapped a preselected amount of particulate matter, any either one of the upstream and downstream metal screens 12 and 13 is electrically energized to act as the heating means, where the trapped particulate matter on the filter medium 11 is burned away.

[0032] To prepare the filter means 1, for example, the filter medium 11 is first provided by felting ceramic fibers piled up to a desired thickness. The filter means 1 is finished by laying the metal screens 12, 13 of heat-resistant property containing Ni, Cr or the like on the opposing surfaces of the filter medium 11, each screen to each surface, and pressing the filter medium 11 together with the metal screens 12, 13 to a desired dimension and configuration. In the accompanying drawings, the filter medium 11 of ceramic fibers in the filter means 1 is shown in the form of a hollow cylinder with lengthwise pleats 30, which are arranged around the periphery of the cylinder to extend the entire surface area coming into contact with the exhaust gases. It will be obvious, however, that filter medium 11 may be formed in any other design such as simple hollow cylinder, flat plate, corrugation and others. The filter medium 11 is made of a material such as nonwoven fabrics of ceramic fibers superior in heat-resistance. For example, the filter medium 11 may be of nonwoven fabrics that are made of a fibrous layer having randomly laid or oriented ceramic fibers of Si_3N_4 coated with SiC and/or SiC(Si-C-0, Si-Ti-C-0, Si-C). The ceramic fibers used are, for example, of about from 5 μm to 15 μm in width and about from 30mm to 150mm in length. Moreover, the matted felt of the ce-

ramic fibers has the thickness of about from 3mm to 5mm.

[0033] Upon the amount of the particulate matter trapped on the filter medium 11 reaching the preselected amount, the controller unit 10 operates to make any one of the upstream and downstream metal screens 12 and 13 conductive electrically to heat the selected metal screen up to the temperature, where the particulate matter trapped on the filter medium 11 is burned away to regenerate or reactivate the filter medium 11. The amount of the particulate matter accumulated on the filter medium 11 may be monitored by means of any suitable sensor such as an exhaust pressure sensor, a flow-resistance sensor in the filter means and the others.

[0034] The following will explain the operation of the diesel particulate filter system constructed as described just above.

[0035] The exhaust gases flow through the exhaust tract 9 into the inner pipe 7 in the cooling means 3, where the exhaust gases are allowed to pass through perforations 8 from the inner exhaust passage 7 into the outer exhaust passage 6. While flowing to the exhaust ingress 9 of the filter means 1, the exhaust gases pass lengthwise the outer exhaust passage 6 with keeping contact with the fins 25, thus cooling down to the temperature where the suspended particulates in the exhaust gases aggregate to particles larger in particle size. Then, the exhaust gases in the exhaust ingress 9 defined between the casing 2 and the filter means 1 flow across the filter means 1 to the exhaust egress 16. While the exhaust gases pass across the filter means 1, the particulate matter of the exhaust is trapped or extracted on the filter medium 11 and the downstream metal screen 13, so that only the cleaned exhaust gases free from the suspended particulate matter is allowed to flow into the exhaust line 24 from the exhaust egress 16.

[0036] As shown in FIG. 2, the controller unit 10 operates such that the upstream metal screen 12 is biased negatively across the terminals 21 connected to the dc source 17 through the lines 18 and also the downstream metal screen 13 is biased positively across the terminals 22 connected to the lines 28. Thus, the particulate matter suspended in the cooled exhaust gases, while passing across the filter means 1, is charged negatively at upstream metal screen 12. While the particulates larger in particle size may be trapped on the filter medium 11, the remaining particulate matter in the filtered exhaust gases is kept charged negatively and, therefore, attracted to the downstream metal screen 13 that has been charged positively.

[0037] In response to the amount of the particulate matter trapped on the filter medium 11 reaching the preselected amount, the controller unit 10 operates to make any one of the upstream and downstream metal screens 12, 13 conductive electrically to heat the selected metal screen up to the temperature, where the particulate matter trapped on the filter medium 11 is burned away to regenerate or reactivate the filter medium 11.

[0038] As will be seen from FIG. 4, the charging means to charge the particulate matter may be designed in the form of latticework type, which is comprised of a ring line 26 arranged around the filter medium 11, and lattice electrodes 27 connected to the ring line 26 and extended between any adjoining lengthwise pleats 30, 30 of the filter medium 11. The lattice electrodes 27 are each made in the form of a wire mesh extending along a valley between any adjoining pleats 30, 30. The particulate matter may be charged at the lattice electrodes 27. It will be understood that the charging means of latticework type are identical in function with the upstream and downstream metal screen 12, 13 of network type.

[0039] It should be understood that the foregoing relates to only preferred embodiments of the present invention, and that is intended to cover all changes and modifications of the examples of the invention herein chosen for the purposes of the disclosure, which do not constitute departure from the scope of the invention.

Claims

1. A particulate filter system for a diesel engine, comprising an'exhaust tract(19) through which exhaust gases from the engine flow, cooling means(3) located within the exhaust tract(19) to cool down the exhaust gases, a casing(2) connected to the cooling means(3), a filter medium(11) arranged in the casing(2) to trap particulate matter contained in the exhaust gases flowing from the cooling means(3), charging means arranged upstream of the filter medium(11) and biased negatively to charge negatively the particulate matter, and a metal screen(13) arranged downstream of the filter medium(11) and biased positively to attract the particulate matter that has been charged negatively.

2. A particulate filter system for a diesel engine constructed as defined in claim 1, wherein the cooling means(3) is composed of an inner pipe(5) connected with the exhaust tract(19) in a fluid communication and made with perforations(8), and an outer pipe(4) arranged surrounding around the inner pipe (5) and made with corrugations to provide fins(25) for dissipation of heat, whereby the exhaust gases in the inner pipe(5) are allowed to flow through the perforations(8) to thereby collide against an inner surface of the outer pipe(4) and further pass through a cooling passage(6) between the inner and outer pipes(5,4) into the filter medium(11).

3. A particulate filter system for a diesel engine constructed as defined in claim 1, wherein the filter medium(11) is made in the form of hollow cylinder with pleats(30) and the exhaust gases is allowed to pass radially inwardly across the filter medium(11).

4. A particulate filter system for a diesel engine constructed as defined in claim 3, wherein the charging means comprises a charger of latticework type made of lattice electrodes(27) arranged between the adjoining pleats(30) at the upstream surface of the filter medium (11).

5. A particulate filter system for a diesel engine constructed as defined in claim 1, wherein the charging means comprises a charger of network type made of upstream and downstream metal screens(12,13) arranged over the filter medium(11).

6. A particulate filter system for a diesel engine constructed as defined in claim 1, wherein the filter medium(11) is made of nonwoven fabrics of ceramic fibers.

7. A particulate filter system for a diesel engine constructed as defined in claim 1, wherein the controller unit operates to make any one of the upstream and downstream metal screens(12,12) conductive electrically when the particulate matter trapped on the filter medium(11) reaches a preselected amount, whereby the selected metal screen is heated up to a high temperature, where the particulate matter trapped on the filter medium(11) is burned away to regenerate the filter medium(11).

8. A particulate filter system for a diesel engine constructed as defined in claim 1, wherein the exhaust gases are cooled down at the cooling means(3) to a low temperature where the particulate matter aggregates to particles larger in particle size.

FIG. 1

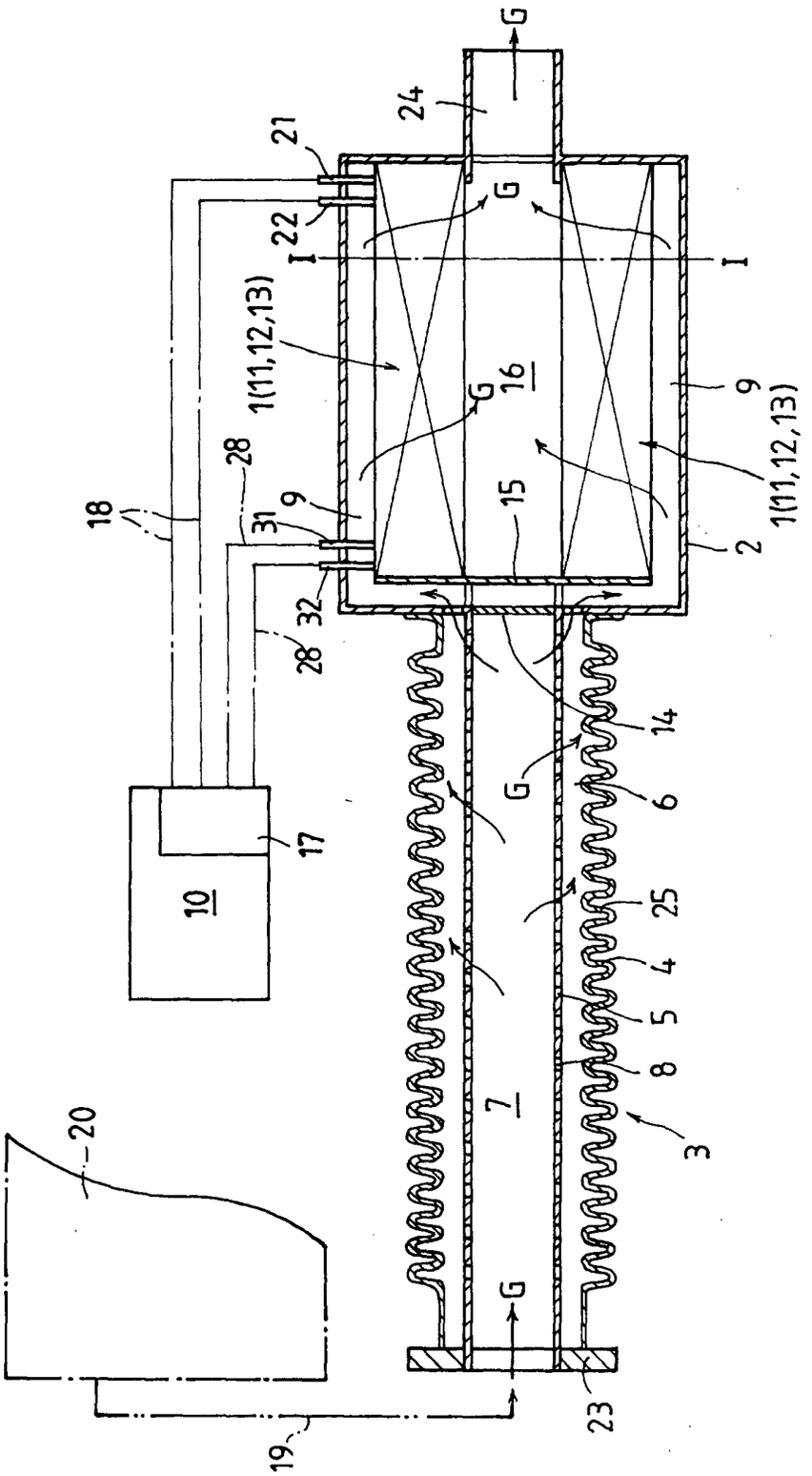
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FIG. 2

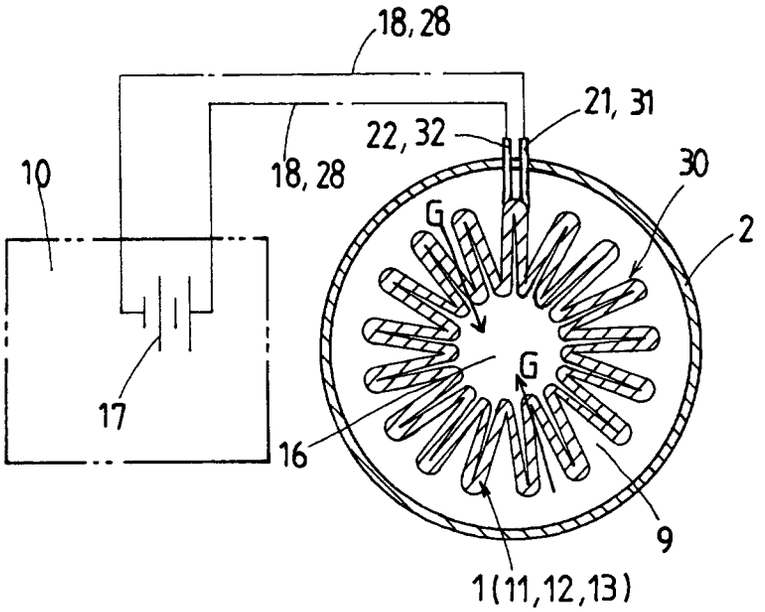
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FIG. 3

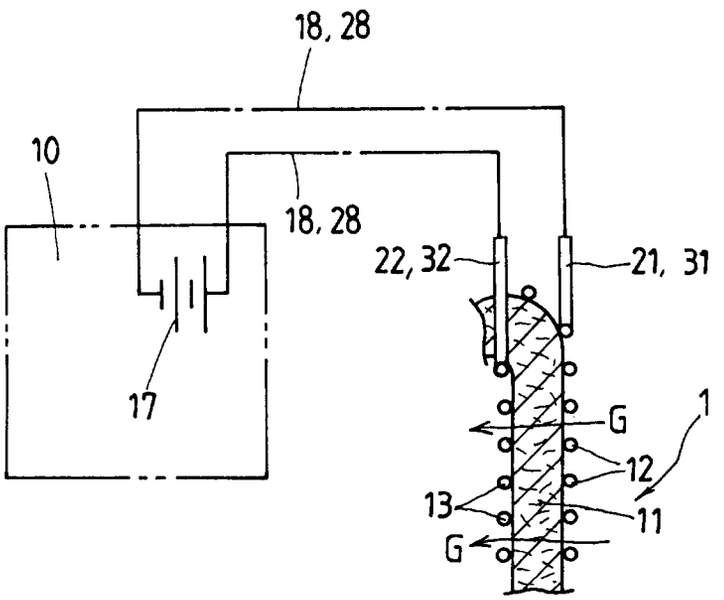
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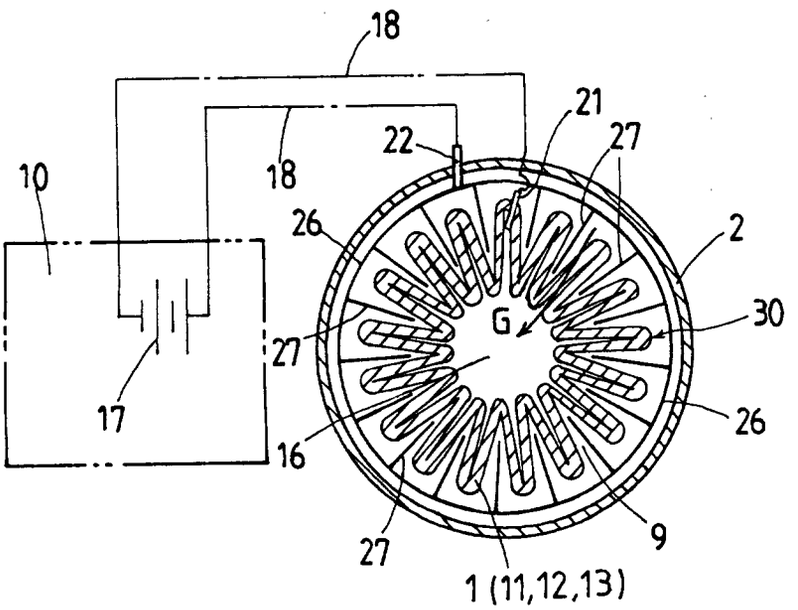
FIG. 4



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EUROPEAN SEARCH REPORT

Application Number
EP 00 30 1208

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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