



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) **EP 1 541 819 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
15.06.2005 Bulletin 2005/24

(51) Int Cl.7: **F01N 3/028**, H05B 6/64,
B01D 46/30

(21) Application number: **03078946.5**

(22) Date of filing: **12.12.2003**

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

(72) Inventors:
• **Strijbos, Johannes Hubertus Maria**
2252 GK Voorschoten (NL)
• **van Helden, Marinus**
3131 NG Vlaardingen (NL)

(71) Applicant: **Nederlandse Organisatie voor
toegepast-natuurwetenschappelijk Onderzoek
TNO**
2628 VK Delft (NL)

(74) Representative:
Prins, Adrianus Willem, Mr. Ir. et al
Vereenigde,
Nieuwe Parklaan 97
2587 BN Den Haag (NL)

(54) **Microwave regenerated diesel particulate trap**

(57) A self-burncleaning sootfilter for a diesel engine comprises a sootfilter element (2; 32A, 32B) for filtering soot from an exhaust gas of the diesel engine, and a heating system arranged for increasing the temperature in at least a part of the sootfilter (1; 31). The

heating system comprises a microwave generator (6; 36) for generating microwaves. The sootfilter element (2; 32A, 32B) is substantially transparent for the microwaves generated by the microwave generator (6; 36) and the microwave radiation can be absorbed by soot.

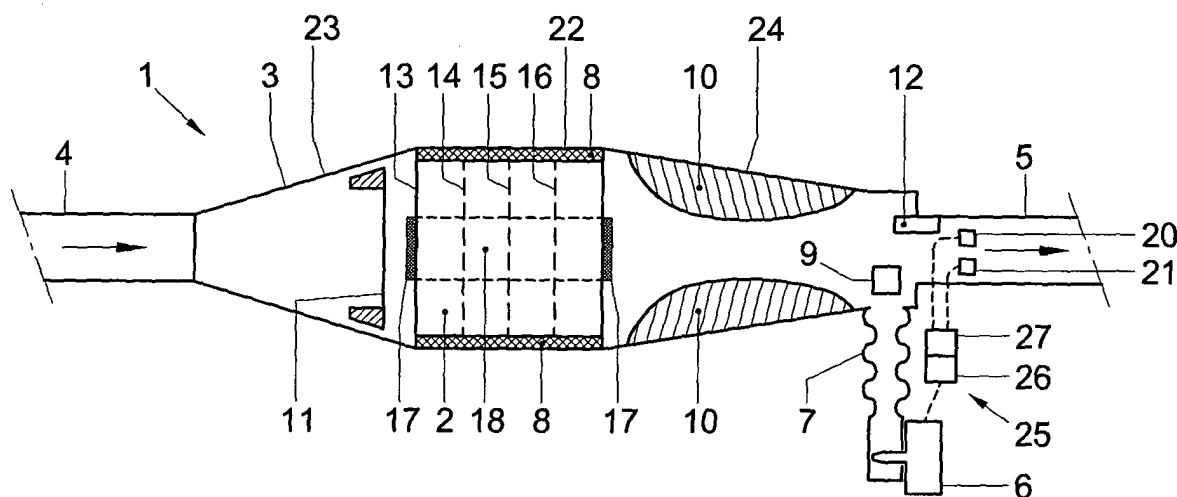


Fig. 1

Description

[0001] The invention relates to a self-burncleaning sootfilter for a diesel engine, comprising a sootfilter element for filtering soot from an exhaust gas of the diesel engine, and a heating system arranged for increasing the temperature in at least a part of the sootfilter, said heating system comprising a microwave generator for generating microwaves. The invention also relates to an exhaust gas system for a diesel engine, comprising such a self-burncleaning sootfilter, to a diesel engine provided with such an exhaust gas system, as well as to a vehicle comprising such an exhaust gas system. The invention furthermore relates to a method for cleaning a sootfilter for a diesel engine.

[0002] Sootfilters are used in, for example, vehicles with diesel engines to clean the exhaust gases by removing soot particles from the exhaust gases. More generally, sootfilters are used in apparatuses in which combustion takes place and soot-containing exhaust gas is released. However, in use, the sootfilter becomes saturated with soot, which affects the sootfilter operation. The saturated sootfilter has to be replaced with a new filter or the soot has to be removed from the saturated filter. Sootfilters are known in which the soot can be removed by burning the soot together with the fuel and lubrication oil remainders adhered to the soot, thereby cleaning the sootfilter. A contaminated filter can fully or almost fully be cleaned by means of such after-burning. However, the ignition temperature required to initiate after-burning is over 500 °C. In a modern diesel engine such high temperature is not reached under normal operating conditions. Therefore, self-burncleaning sootfilters require additional means for preheating a contaminated sootfilter element prior to soot combustion. One category of such known sootfilters is based upon preheating of a contaminated sootfilter element by means of microwaves.

[0003] The known microwave-based self-cleaning sootfilters comprise a filter housing and a lossy filter element therein. Microwaves generated by a microwave generator are injected into the filter element in order to heat the filter element prior to soot combustion. The filter housing together with the filter element constitute a microwave cavity and the lossy sootfilter element acts as an absorber for the microwaves. In order to enhance the absorption of microwaves by the filter element, special filter elements have been developed. For instance, cordierite filter elements are known which are provided with a layer which absorbs microwave radiation.

[0004] However, the known sootfilters suffer from a number of drawbacks. For example, the heating of the sootfilter element is nonuniform. This may lead to incomplete filter regeneration. Besides, due to local overheating, parts of the sootfilter element may melt. This frequently happens for filter elements comprising cordierite, but can also happen for silicon carbide elements. Furthermore, due to thermal stress induced by

the microwave heating of the filter element, cracks can occur in the filter element. Another drawback is, that high power and/or long preheating time of the microwave generator is required in order to heat the filter element. This results into a low efficiency of the filter regeneration process. A further drawback is, that special measures taken in order to enhance the microwave absorption by the filter element, sometimes have a negative influence upon the efficiency and reliability of soot-filtering. For example, applying microwave absorbing coatings to a filter element can lead to unwanted penetration of such coatings into the filtering pores, thereby affecting the filtering characteristics of the filter element.

[0005] It is a goal of the present invention to provide an improved self-cleaning sootfilter which is efficient.

[0006] The invention seeks to achieve said goal by providing a self-burncleaning sootfilter for a diesel engine, comprising a sootfilter element for filtering soot from an exhaust gas of the diesel engine, and a heating system arranged for increasing the temperature in at least a part of the sootfilter, said heating system comprising a microwave generator for generating microwaves, wherein the sootfilter element is substantially transparent for the microwaves generated by the microwave generator and the microwave radiation can be absorbed by soot.

[0007] Because of said transparency of the sootfilter element for microwaves and because the microwave radiation can be absorbed by soot, the soot in a sootfilter according to the invention can undergo a substantially direct heating. That is, unlike known sootfilters, no preheating of the filter element is required prior to heating of the soot. Since preheating of the filter element normally requires more power than direct heating of the soot, an improved sootfilter is obtained with efficient self-cleaning properties.

[0008] Specific embodiments of the invention are set forth in the dependent claims.

[0009] Further details, aspects and embodiments of the present invention will now be described by way of example with reference to the figures in the accompanying drawing, in which:

Figure 1 schematically shows a longitudinal sectional view of an example of a first embodiment of a sootfilter according to the invention;

Figure 2 schematically shows a longitudinal sectional view of an example of a part of a second embodiment of a sootfilter according to the invention;

Figure 3 schematically shows an arrangement of a third example of an embodiment of a sootfilter according to the invention.

[0010] Reference is first made to Figure 1, which shows an example of a sootfilter 1 according to the invention. The sootfilter 1 comprises a filter housing 3 which has an inlet 4 for providing exhaust gas to be filtered to the inside of the housing 3 and an outlet 5 for

discharging filtered exhaust gas. A sootfilter element 2 is housed in a cylindrical part 22 of the filter housing 3, which cylindrical part 22 lies between the inlet 4 and the outlet 5. The filter 1 further comprises a microwave generator 6 which can inject microwave radiation into the inside of the housing 3. In this application microwave radiation at least comprises electromagnetic radiation with a frequency in the range of 2400 - 2600 MHz. More particular, the microwave radiation can be injected into the sootfilter element 2, as will be explained below in more detail.

[0011] The sootfilter element 2 is substantially transparent for microwaves generated by the microwave generator 6. Thereby, the microwave wave radiation can heat up soot present in the sootfilter element 2, without significant loss of heating energy in the sootfilter element 2. The sootfilter element 2 may for example be a cordierite wall-flow filter element, which is a normal commercially available element. However, any high temperature ceramic filter element can be used instead, provided the element itself presents low loss to the microwaves.

[0012] Between the sootfilter element 2 and the housing 3 there is a layer 8, made up of material suitable for gas seal and thermal isolation. The housing 3 has conical sections 23, 24 connected to both sides of the cylindrical part 22. The conical section 23 is connected to the inlet 4 and the conical section 24 is connected to the outlet 5. The microwave generator 6 is connected to the filter housing 3 via a waveguide 7. The waveguide 7 preferably is flexible. The flexibility protects the microwave generator 6 against vibrations, for example against vibrations occurring in a vehicle in which the sootfilter 1 is applied.

[0013] The microwave generator 6 can for example be a 2450 MHz magnetron, which has a high efficiency. Microwave generators for 2450 MHz radiation are generally known from other fields of technology, such as microwave oven technology. These generators are produced in large amounts and are therefore available at low cost. However, other microwave generators can be applied as well.

[0014] The microwave generator 6 is located in the exhaust gas flow downstream of the sootfilter element 2. This is advantageous compared with an upstream location, because downstream the exhaust gas is already cleaned and has smaller temperature gradients, which is favourable with respect to the life span of the microwave generator 6.

[0015] The waveguide 7 in this example has a rectangular cross-section. As is generally known in the art, transverse electric ("TE") microwaves that correspond to such rectangular shaped waveguide 7 are of the so-called TE₀₁-mode type. The filter 1 comprises an ortho-mode coupler 9 which can be of a known type and which is located inside the housing 3 at the transition zone between the waveguide 7 and the housing 3. The ortho-mode coupler 9 converts the TE₀₁-waves into

TE₁₁-waves corresponding to the circular shaped cross-section of the housing 3.

[0016] The filter 1 further comprises a circular polarizer 10 located inside the housing 3 between the ortho-mode coupler 9 and the filter element 2. The circular polarizer 10 converts the TE₁₁-wave into a circular polarized TE₁₁-wave. Circular polarization is advantageous since it contributes to the uniformness of the heating of the soot in the sootfilter element 2, especially in the tangential direction of the sootfilter. The circular polarizer 10 in this example comprises two metallic fins 10. The fins may be, instead of a metal, also of a low loss dielectric material. The fins 10 are connected to the inner side of the filter housing 3 along which they extend in longitudinal direction. The two fins 10 furthermore extend radially inward with respect to the filter 1 and are located diametrically opposite with respect to one another. The realization of the circular polarizer 10 by means of these simple add-on fins is favourable because of ease of production.

[0017] Inside the filter housing 3 and upstream of the filter element 2, the sootfilter 1 comprises a microwave reflection grid 11. The reflection grid 11 has an adjustable position with respect to the sootfilter element 2 and is substantially disk shaped with a disk surface perpendicular to the longitudinal axis of the filter 1. The presence of the reflection grid 11 influences positions of antinodal planes of the microwaves, that is planes in which transverse microwaves have maximum amplitude and in which therefore maximum heating power is available. It is also possible to use other types of reflection grids or to use no reflection grid at all. In the last case the wall of the conical section 23 of the housing 3 can serve as reflection wall for microwaves, although this might be less preferable in some cases since a less favourable configuration of antinodal surfaces might result.

[0018] The sootfilter 1 further comprises a tuner 12 inside the housing 3 at or nearby an axial range of the filter 1 where the waveguide 7 is connected to the housing 3. The tuner 12 is for impedance matching of microwaves in the sootfilter 1 to the microwave generator 6. By the above described means it is possible to maintain a high electric field antinode on an endplane 13 of the sootfilter element 2 that faces towards the inlet 4. In this way microwave heating of the deposited soot will be more pronounced in that endplane 13, so filter regeneration may start there. Optionally, additional antinodal planes may be present at several equidistant positions in axial direction of the filter 1. By way of example in Figure 1 there are shown three antinodal planes 14, 15 and 16 through the filter element 2. In the antinodal planes 14, 15 and 16 the heating will be more intense, that is regeneration could start there too.

[0019] A further measure to contribute to the uniformness of the heating of the soot in the sootfilter element 2 is to inactivate for sootfiltering a central section of the sootfilter element 2. In the example of Figure 1 this is achieved by partially covering each of the two axial end-

planes of the sootfilter element 2 concentrically by a disk shaped blocking lid 17. The two identical lids 17 prevent deposit of soot in a central section 18 of the sootfilter element 2 between the two lids 17. This prevents the occurrence of too high temperatures in the central section 18 during microwave filter regeneration. In fact the central section 18 can thus serve as a central cooling region during filter regeneration, which contributes to the uniformness of heating and after-burning of the soot in the sootfilter element 2. Alternatively, a sootfilter element 2 can be applied in which a core similar to the central section 18 of Figure 1 is without filter material, while exhaust gas flow through the core is prevented for instance by application of a closed pipe. Figure 2 shows an example of such a pipe 19 applied in a sootfilter according to the invention. Preferably the pipe 19 is made of a metal or a low loss dielectric material.

[0020] The housing 3 is constructed of a full metallic enclosure. Thereby, leakage of microwave radiation is suppressed, since the enclosure reflects the radiation. Furthermore, the diameters of the inletpipe 4 and the outletpipe 5 are small enough to guarantee that the microwaves cannot propagate through these pipes. For example with standard diameters of 5 cm or smaller, microwave leakage at 2450 MHz is effectively blocked because the pipes are below "cut-off" for the dominant TE₁₁ mode of operation. Alternatively or additionally, the microwaves travelling towards the inlet 4 or outlet 5 can be reflected back into the inside of the housing 3 by means of reflection grids, for instance a reflection grid at the transition to the outlet 5. Moreover, the waveguide 7 and the microwave generator 6 can be integral parts of the sootfilter 1, which also contributes to the suppression of microwave leakage.

[0021] The sootfilter 1 comprises means for estimating the degree of sootloading. With such means it can be determined when the sootfilter needs regeneration. For conventional sootfilters often use is made of pressure drop measurements over the filter elements in order to estimate sootloading. This type of sootloading estimation can also be applied for the sootfilter according to the invention. However, it is remarked that for a sootfilter according to the invention also microwave technology can be applied for estimating the amount of soot contained in the sootfilter element. Thereto a microwave generator, for example the microwave generator 6, in combination with a known standing wave detector located in the waveguide 7 can be used for a short period of time.

[0022] Some further aspects in relation to the control of sootfilters according to the invention will now be described. Optionally, a sootfilter according to the invention may comprise a suitable sootfilter control structure 25 for controlling the operation of the sootfilter.

[0023] Upon a signal of the sootfilter control structure 25, filter regeneration is initiated by microwave-heating soot particles in the filter element 2 by means of the microwave generator 6 and optional further components.

Thereto for example a control unit 26 of the sootfilter control structure 25 may be communicatively connected to for example a sootloading sensor and to the microwave generator 6. After heating up the soot particles for a certain period of time, combustion will start at a certain moment in a number of antinodal planes 13-16 in axial direction. Then the microwave energy input can be stopped by the sootfilter control structure 25. As a stop-criterion several indicators marking the start of the self-burning process can be used. Such indicator can for example be an increase of the amount of carbon oxide gas, such as carbon monoxide or carbon dioxide, in the outlet pipe 5, which increase can be detected for example by a suitable sensor in the outlet pipe 5.

[0024] The generated heat from the particle combustion will be transferred from the hot antinodal planes 13-16 to the soot particles between the hot planes 13-16, in such way that these soot particles will be burnt as well. Thus, several flame fronts can propagate through the filter element 2. The oxygen required for the combustion may come from additional oxygen supply by for instance an air pump or a compressed air system. It may also come from the exhaust gases, since (diesel) exhaust gases do contain oxygen.

[0025] It is remarked that the sootfilter 1 may be implemented in different other ways. For example it is possible, among others by suitably implementing the sootfilter control structure 25, to let soot combustion take place during different consecutive time intervals, wherein in each different time interval a different part of the sootfilter element 2 is regenerated. That is, the microwave energy input is intermittently initiated and stopped several times. During a thus obtained regeneration interval of such stepwise process, those parts of the sootfilter element 2 that have already been regenerated, will not absorb microwaves anymore, whereas a yet unregenerated part of the sootfilter element 2 will be regenerated then. Thus in a number of steps the complete sootfilter element 2 may be regenerated, while the risk of local overheating the sootfilter element 2 is further decreased.

[0026] It is preferable that the oxygen supply is accurate. That is, if for example the oxygen-containing supply gases are colder than the combustion zone, the combustion will be cooled down which may lead to flame extinction. And, if for example oxygen supply is too high, uncontrolled fast combustion may arise, which might lead to unacceptably high temperatures. On the other hand, a too low oxygen supply causes poor combustion. For such reasons the sootfilter control structure 25 may optionally comprise a control unit 27 for accurately controlling the oxygen supply. The control unit 27 may be arranged among others to provide an effective ratio between oxygen and organic material in the sootfilter during regeneration. Thereto the control unit 27 may for example be communicatively connected to an oxygen sensor for determining the concentration of oxygen in the exhaust gas and/or to a temperature sensor for deter-

mining exhaust gas temperature, as well as to means for controlling the oxygen supply in dependence of signals from the oxygen sensor and/or the temperature sensor. Figure 1 shows such oxygen sensor 20 and such temperature sensor 21, both located downstream of the sootfilter element 2. In Figure 1 the sensors 20 and 21 are located in the outletpipe 5. An advantage of this location is, that in the outletpipe 5 there are no propagating microwaves that might disturb the operation of these sensors 20 and 21.

[0027] In a sootfilter the exhaust gas flow of the engine, even at idle, can be too high for maintaining propagating flame fronts and accordingly cleaning the filter. To prevent this, the filter may be implemented such that regeneration only takes place at engine stand-still. In this case the oxygen required for the combustion can not come from the exhaust gases, but may instead be supplied by for instance an air pump or a compressed air system.

[0028] Another way of dealing with the problem of a too high exhaust gas flow for maintaining propagating flame fronts, can be to apply a multiple branch system, which enables filter regeneration while the engine is running. An example of a sootfilter according to such an optional system comprises at least two branches for flow of the exhaust gas, wherein each flow branch comprises a sootfilter element and a valve for controlling the exhaust gas flow. During engine running the exhaust gas may for instance flow through a clean filter element, while at least one other filter element can be regenerated.

[0029] Figure 3 shows, in a highly schematical way, an example of such a sootfilter 31. The sootfilter 31 has two flow branches A and B. The branches A and B are branched off from an inletpipe 34 for exhaust gas to be filtered. They join again at an outletpipe 35 for filtered exhaust gas. The flow branches A and B can each comprise diverse sootfilter parts, for example those of the embodiments of Figure 1 and 2. For reasons of simplicity most of such parts are not shown in Figure 3.

[0030] Flow branch A comprises a sootfilter element 32A and a valve 40A for controlling the exhaust gas flow. Flow branch B similarly comprises a sootfilter element 32B and a valve 40B. In order to avoid fouling by the exhaust gases, the valves 40A and 40B, respectively, are preferably located downstream of the sootfilter elements 32A and 32B, respectively. However, upstream locations of the valves can also be applied.

[0031] In this example the sootfilter 31 comprises one single microwave generator 36 which via a waveguide 37A is connected to branch A and via a waveguide 37B to branch B. Hence the microwave generator 36 can generate microwaves for both branch A and B. The sootfilter 31 further comprises a microwave valve structure for controlling microwave propagation from the microwave generator 36 to the different branches A and B. In this example the microwave valve structure comprises a microwave valve 41A incorporated in waveguide 37A

and a microwave valve 41B incorporated in waveguide 37B.

[0032] For the sootfilter 31 an example is now described of a manner in which regeneration can take place during engine running. It is remarked that, as mentioned above, the sootfilter control structure 25 controls the operation of the sootfilter. This comprises the operation of the exhaust gas valves 40A, 40B and of the microwave valves 41A and 41B. In this example it is assumed that the filter element 32A has to be regenerated. During regeneration the exhaust gases mainly flow through branch B, that is the valve 40B in branch B is in open position then.

[0033] As a preferable, optional, initial step the filter element 32A is preheated by forcing exhaust gas through it. That is, the valve 40A in branch A is in open position then. After the filter element 32A has been warmed up to for example the actual exhaust gas temperature, the valve 40A is closed. At about that time, the microwave valve 41A, if not yet open, is opened and the microwave valve 41B, if not yet closed, is closed. Furthermore, operation of the microwave generator 36 is started then, in order to heat the soot particles in the sootfilter element 32A to their ignition temperature. The advantage of the initial step of pre-heating the filter element 32A by the exhaust gases is that less energy from the microwave generator 36 is required to heat the soot to ignition temperature. When combustion has started the microwave generator 36 is switched off. After switching off the microwave generator 36, the supply of oxygen for the soot combustion can be controlled by a control unit, for instance as described above with reference to Figures 1 and 2 or otherwise.

[0034] Preferably such control unit is, for each flow branch downstream of the sootfilter element, communicatively connected to an oxygen sensor for determining the concentration of oxygen in the exhaust gas and/or to a temperature sensor for determining exhaust gas temperature. In case exhaust gas is used as oxygen supplier, the valves 40A and 40B are adequately controlled by the control unit and possibly by other parts of the sootfilter control structure.

[0035] Having described the invention, however, many modifications thereto will become apparent to those skilled within the art without deviation from the invention as defined by the scope of the appended claims.

[0036] For instance, in the abovementioned example of Figure 3, the filter element 32A was regenerated. Regeneration of the filter element 32B can be performed in a similar way. Furthermore, instead of a two-branch system, a system with more branches can be more or less likewise applied for regeneration of one or more sootfilter elements during engine running. Also more than one microwave generator can be applied in a single sootfilter.

Claims

1. A self-burncleaning sootfilter for a diesel engine, comprising a sootfilter element (2; 32A, 32B) for filtering soot from an exhaust gas of the diesel engine, and a heating system arranged for increasing the temperature in at least a part of the sootfilter (1; 31), said heating system comprising a microwave generator (6; 36) for generating microwaves, wherein the sootfilter element (2; 32A, 32B) is substantially transparent for the microwaves generated by the microwave generator (6; 36) and the microwave radiation can be absorbed by soot.
2. A sootfilter according to claim 1, wherein the microwave generator (6; 36) is arranged for generating electro-magnetic radiation with a frequency in the range of 2400 - 2600 MHz, such as 2450 MHz.
3. A sootfilter according to claim 1 or 2, wherein the microwave generator (6; 36) is located in the exhaust gas flow downstream of the sootfilter element (2; 32A, 32B).
4. A sootfilter according to any one of the preceding claims, comprising a circular polarizer (10) for converting the generated microwaves into circular polarized microwaves.
5. A sootfilter according to claim 4, wherein the circular polarizer comprises two fins (10) of a metal or a low loss dielectric material.
6. A sootfilter according to any one of the preceding claims, wherein the sootfilter element (2; 32A, 32B) has a central section (18) which is inactive for retaining soot.
7. A sootfilter according to any one of the preceding claims, **characterized by** a tuner (12) for impedance matching of microwaves in the sootfilter (1; 31) to the microwave generator (6; 36).
8. A sootfilter according to any one of the preceding claims, **characterized by** a microwave reflection grid (11) with adjustable position for influencing positions of antinodal planes (13-16) of the microwaves.
9. A sootfilter according to any one of the preceding claims, **characterized by** a sootfilter housing (3) constructed of a full metallic enclosure.
10. A sootfilter according to any one of the preceding claims, **characterized by** a flexible waveguide (7) connecting the microwave generator (6; 36) to a housing (3) of the sootfilter (1; 31).
11. A sootfilter according to any one of the preceding claims, **characterized by** a control unit (27) for controlling oxygen supply.
12. A sootfilter according to claim 11, wherein the control unit (27) is communicatively connected to an oxygen sensor (20) for determining the concentration of oxygen in the exhaust gas and/or to a temperature sensor (21) for determining exhaust gas temperature, as well as to means for controlling the oxygen supply in dependence of signals from the oxygen sensor (20) and/or the temperature sensor (21).
13. A sootfilter according to any one of the preceding claims, comprising at least two branches (A, B) for flow of the exhaust gas, wherein each flow branch (A, B) comprises a sootfilter element (32A, 32B) and a valve (40A, 40B) for controlling the exhaust gas flow.
14. A sootfilter according to claim 13, wherein for at least one branch (A, B) the valve (40A, 40B) for controlling the exhaust gas flow is located downstream of the sootfilter element (32A, 32B).
15. A sootfilter according to claim 13 or 14, wherein at least two branches (A, B) are connected to the same microwave generator (36).
16. A sootfilter according to claim 15, **characterized by** a valve structure (41A, 41B) for controlling microwave propagation from the microwave generator (36) to the different branches (A, B).
17. An exhaust gas system for a diesel engine, comprising a self-burncleaning sootfilter (1; 31) according to any one of the preceding claims.
18. Diesel engine provided with an exhaust gas system according to claim 17.
19. Vehicle comprising an exhaust gas system according to claim 17.
20. Method for cleaning a sootfilter (1; 31) for a diesel engine, wherein microwaves are generated by a microwave generator (6; 36); the microwaves are injected into a sootfilter element (2; 32A, 32B) of the sootfilter (1; 31), which sootfilter element (2; 32A, 32B) is substantially transparent for the microwaves; at least part of the soot contained in the sootfilter (1; 31) is preheated by the microwaves until ignition temperature; and at least part of the soot contained in the sootfilter (1; 31) is burned.
21. Method according to claim 20, wherein microwave power is intermittently applied.

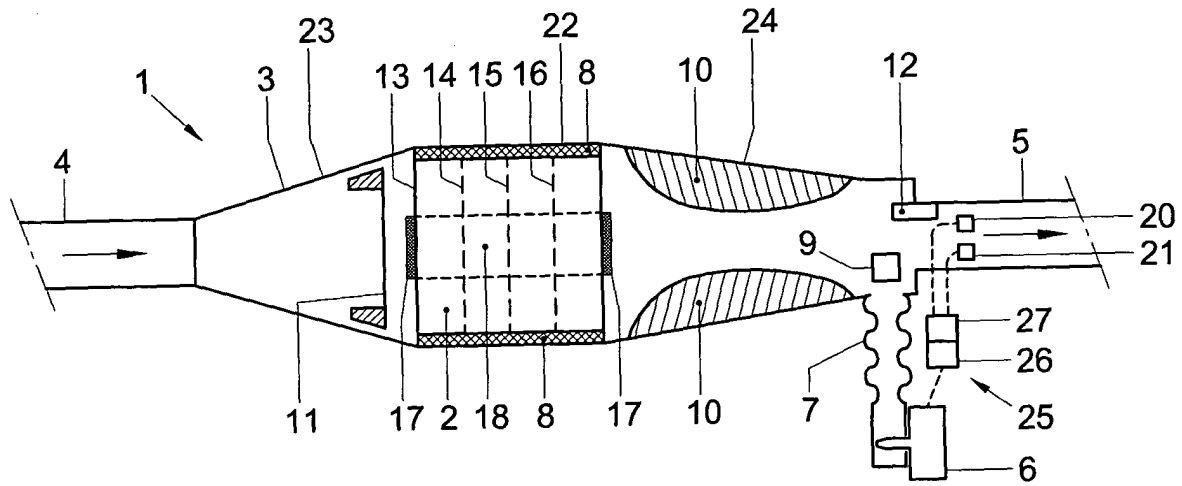


Fig. 1

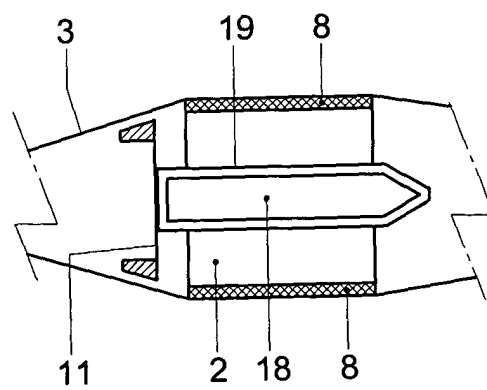


Fig. 2

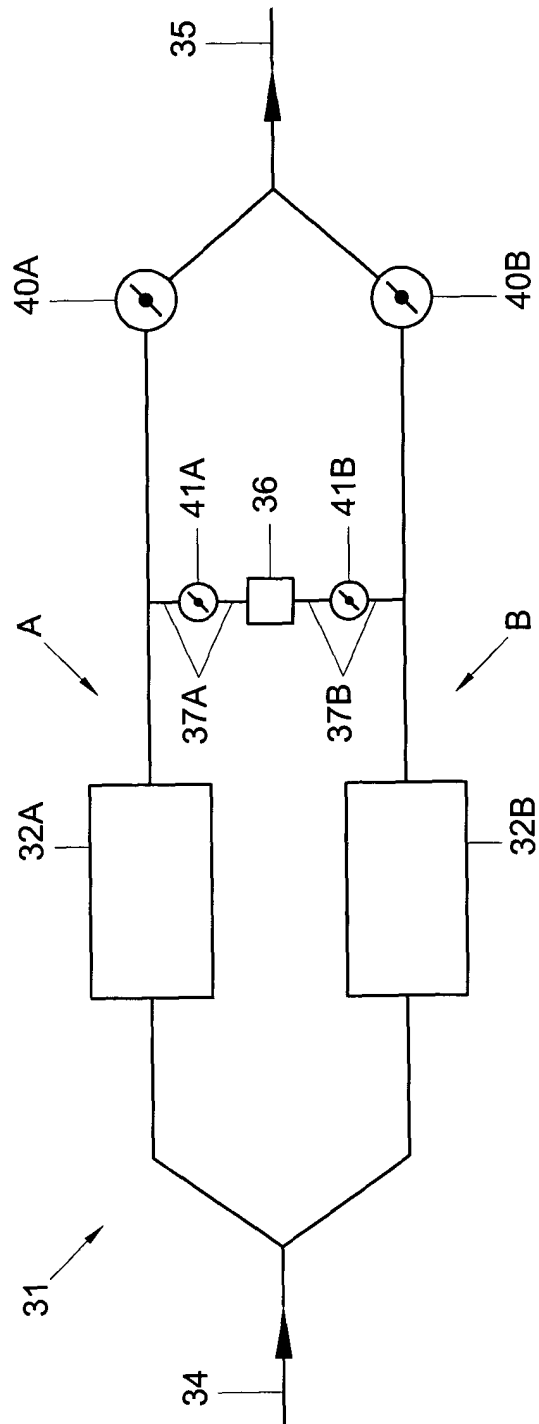


Fig. 3



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 07 8946

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	FR 2 701 514 A (RENAULT) 19 August 1994 (1994-08-19) * page 1, line 12 - page 11, line 25; figure 1 *	1,3,11, 13,15-20	F01N3/028 H05B6/64 B01D46/30
X	DE 40 14 153 A (STROMERZEUGUNG GMBH & CO ANLAG) 19 December 1991 (1991-12-19) * column 2, line 24 - column 3, line 4; claims 1-3,10; figure 1 * * column 3, line 62 - column 4, line 51 *	1-3, 17-21	
X	EP 0 356 040 A (LOUGHBOROUGH CONSULT LTD) 28 February 1990 (1990-02-28) * column 1, line 1 - column 1, line 11; figure 1 * * column 7, line 8 - column 7, line 33 * * column 8, line 50 - column 9, line 6 * * column 12, line 12 - column 12, line 21 *	1,2,11, 17-20	
X	EP 0 635 625 A (DORNIER GMBH) 25 January 1995 (1995-01-25) * page 2, line 53 - page 3, line 8; claims 1-3 *	1,2,11, 17-20	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A	US 5 453 116 A (SANOCKI STEPHEN M ET AL) 26 September 1995 (1995-09-26) * column 1, line 55 - column 2, line 6 * * column 6, line 56 - column 7, line 6 *	1	F01N H05B B01D
A	US 2002/092422 A1 (GONZE EUGENE VICTOR ET AL) 18 July 2002 (2002-07-18) * paragraph [0019] - paragraph [0021]; figure 1 *	1	
A	EP 0 412 019 A (RENAULT) 6 February 1991 (1991-02-06) * abstract; figure 1 *	1,13	
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 21 April 2004	Examiner Tatus, W
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

1
EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 03 07 8946

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

21-04-2004

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
FR 2701514	A	19-08-1994	FR	2701514 A1	19-08-1994
DE 4014153	A	19-12-1991	DE	4014153 A1	19-12-1991
EP 0356040	A	28-02-1990	AU	4067089 A	05-03-1990
			CN	1040075 A	28-02-1990
			EP	0356040 A2	28-02-1990
			EP	0429511 A1	05-06-1991
			WO	9001618 A1	22-02-1990
			GB	2239408 A	03-07-1991
EP 0635625	A	25-01-1995	DE	4321363 A1	05-01-1995
			EP	0635625 A1	25-01-1995
US 5453116	A	26-09-1995	DE	69508121 D1	08-04-1999
			EP	0834004 A1	08-04-1998
			JP	10501176 T	03-02-1998
			WO	9534748 A1	21-12-1995
US 2002092422	A1	18-07-2002	DE	10161055 A1	01-08-2002
			JP	2002339732 A	27-11-2002
EP 0412019	A	06-02-1991	FR	2650627 A1	08-02-1991
			DE	69018727 D1	24-05-1995
			DE	69018727 T2	23-11-1995
			EP	0412019 A1	06-02-1991
			ES	2071056 T3	16-06-1995