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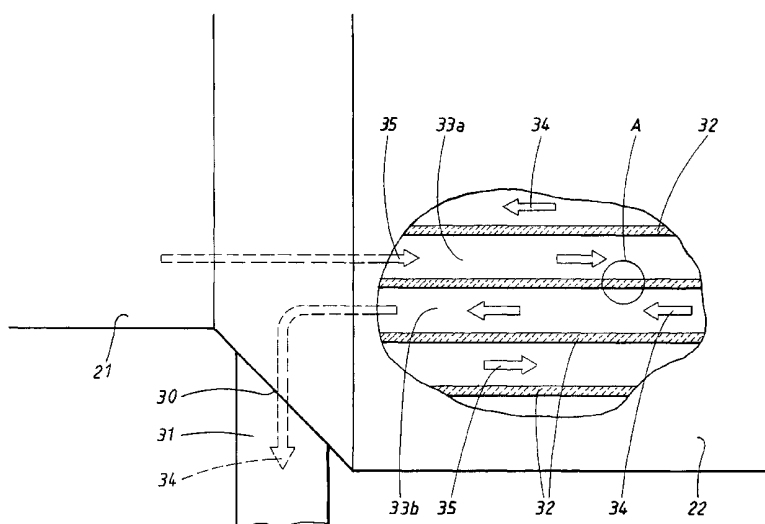
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(54) Title: DEVICE AND METHOD FOR REDUCTION OF A GAS COMPONENT IN AN EXHAUST GAS FLOW OF A COMBUSTION ENGINE



(57) Abstract: The invention relates to a device for reduction of a gas component in an exhaust gas flow of a combustion engine (1) which is adapted for operation by a lean air/fuel mixture, comprising an exhaust pipe (21) for transport of said exhaust gas flow from the engine (1). The invention is characterized in that it comprises a separation unit (22) which is arranged along the exhaust pipe (21), which separation unit (22) comprises a wall structure (32) of a material which provides separation of said gas component from said exhaust gas flow by means of a selective passage of said gas component before other gas components in the exhaust gas flow. The invention also relates to a method for such a reduction and a separation unit which is intended to be utilized during such a reduction. By means of the invention, an improved reduction of in particular NO_x compounds from a so-called "lean-burn" engine is provided.



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TITLE:

Device and method for reduction of a gas component in an exhaust gas flow of a combustion engine.

5 TECHNICAL FIELD:

The present invention relates to a device for reduction of a gas component in an exhaust gas flow of a combustion engine. Said engine is adapted for operation by a lean air/fuel mixture and comprises an exhaust pipe for transport of said exhaust gas flow from the engine. The invention is particularly intended for reduction of harmful emissions in said exhaust gas flow. The invention also relates to a method for such a reduction of a gas component, and a separation unit which is intended to be utilized during such a reduction.

15 BACKGROUND OF THE INVENTION:

In the field of vehicles which are operated by combustion engines, there is a general demand for low emissions of harmful substances in the exhaust gases from the engine. Said substances are primarily constituted by pollutants in the form of oxides of nitrogen (NO_x), hydrocarbon compounds (HC), and carbon monoxide (CO). As regards conventional petrol engines, the exhaust gases are purified by means of an exhaust catalyst which forms part of the exhaust system and through which the exhaust gases are guided. In a so-called three-way catalyst, which is previously known, the major part of the above-mentioned harmful compounds is eliminated by means of known catalytic reactions. In order to optimize the function of the catalyst so that it provides an optimal degree of purification for NO_x, HC, and CO, the engine is in most operating conditions operated by a stoichiometric air/fuel mixture, i.e. a mixture where $\lambda=1$.

30 Furthermore, in the field of today's vehicles, there is a general demand for reducing the fuel consumption of the engine to the highest possible degree. To this end, during the last few years, engines with new types of combustion

chambers in the engine's cylinders have been developed, in particular in order to be able to operate the engine by increasingly lean fuel mixtures, i.e. where $\lambda=1$. In such an engine, which normally is called "lean-burn" engine (alternatively "DI engine"), i.e. a direct-injected Otto cycle engine, the
5 respective combustion chamber in the engine is arranged in such manner that the supplied fuel to a great degree can be concentrated at the respective ignition plug. This mode of operation is generally termed "stratified" operation and during continuous driving at a low or a medium-high torque and engine speed of the engine, it provides an operation by a very lean air/fuel mixture,
10 more precisely up to approximately $\lambda=3$. In this manner, a substantial saving in the fuel consumption is obtained in this type of engine. The engine can also be operated in an additional, "homogeneous" mode of operation, with an essentially stoichiometric mixture ($\lambda=1$) or a comparatively rich mixture ($\lambda<1$). This latter mode of operation normally prevails during driving situations with
15 comparatively high torques and engine speeds of the engine.

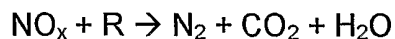
During stratified operation, a lean exhaust gas mixture will flow through the three-way catalyst. This corresponds to an exhaust gas mixture with a surplus of oxygen in relation to what is the case during $\lambda=1$. This results in
20 that the three-way catalyst cannot be utilized for reduction of the NO_x compounds in the exhaust gases (due to the fact that it is constructed for an optimal purification capacity during stoichiometric mixture). In this case, a demand therefore occurs of other devices and methods for reduction of the NO_x compounds. This demand also occurs in connection with other types of
25 engines which are operated by a surplus of oxygen and where NO_x compounds are generated during operation, which for example is the case as regards diesel engines.

In order to provide a reduction of NO_x compounds from a "lean-burn engine",
30 said engine can be provided with a nitrogen oxide adsorbent (also-called NO_x adsorbent, or " NO_x trap"), which is a per se previously known device for

absorption of NO_x compounds in the exhaust gases from a combustion engine. The NO_x adsorbent can be utilized as a complement to a conventional three-way catalyst, either as a separate unit upstream of the three-way catalyst or as an integral part of the three-way catalyst, i.e. together with the catalytic material of the three-way catalyst.

The NO_x adsorbent is constructed in such manner that it takes up (adsorbs) NO_x compounds in the exhaust gases if the engine is operated by a lean air/fuel mixture and gives off (desorbs) the NO_x compounds if the engine is operated by a rich air/fuel mixture during a certain time period. Furthermore, the NO_x adsorbent has the property of being able only to adsorb NO_x compounds up to a certain limit, i.e. it is eventually "filled" and thus reaches a limit for the adsorption. In this situation, the NO_x adsorbent must be regenerated, i.e. it must be influenced to desorb and thus to release the accumulated NO_x compounds. If a conventional three-way catalyst in this case is provided downstream of a NO_x adsorbent, or if alternatively a three-way catalyst is formed as an integral part of a NO_x adsorbent, the desorbed NO_x compounds can be eliminated by means of the three-way catalyst, provided that the latter has reached its ignition temperature.

According to the prior art, a NO_x adsorbent can be regenerated by means of the fact that the exhaust gas mixture which flows through the NO_x adsorbent is made comparatively rich during a certain time period, approximately a few seconds. In practice, this is achieved by means of the fact that the engine during this time period is operated in the above-mentioned homogeneous mode of operation, wherein the engine thus is operated by a comparatively rich air/fuel mixture. By means of this "rich pulse", a surplus of CO and H₂ molecules is generated which functions as a reduction agent which in turn reacts with NO_x compounds according to the following:



where R schematically indicates the relevant reduction agent. In this manner, a large part of the NO_x compounds in the exhaust gas flow can be eliminated by means of transformation into molecular nitrogen, carbon dioxide and water. Then, the engine once again can be reset to lean operation, by means of which the NO_x adsorbent absorbs NO_x compounds during a certain time period which lasts until a new regeneration becomes necessary.

Thus, according to what has been described above, the NO_x compounds are reduced by means of a reduction agent which is taken from the engine's own fuel, i.e. it is generated in the engine during the short time period during which the engine is operated during rich conditions. Furthermore, according to prior art, a control unit is utilized with a suitable strategy for switching the combustion engine between homogeneous and stratified operation depending on whether a NO_x regeneration is necessary and depending on the engine's mode of operation in other respects, e.g. depending on the relevant degree of throttle application and the engine speed.

Although the above-mentioned course of events for regeneration of a NO_x adsorbent in principle functions satisfactorily, it suffers from certain drawbacks. For example, it can be noted that the fact that it is necessary to operate the engine by a rich exhaust gas mixture for regeneration of the NO_x adsorbent requires an accurate control of the engine's mode of operation, particularly for switching between rich and lean operation, respectively. Moreover, the regeneration results in that a surplus of fuel is supplied to the engine during the rich pulse. This in turn results in that the engine's fuel consumption is influenced in a negative way.

An additional drawback as regards the prior art for regeneration of a NO_x adsorbent by means of supply of a reduction agent is that a large part of the reduction agent reacts with the oxygen molecules which are present in the exhaust gas flow. Thus, the HC, H₂ or CO molecules in the exhaust gas flow which could react with NO_x compounds in the exhaust gases and form

harmless N_2 instead to a great extent react with oxygen molecules in the exhaust gases. This impairs the efficiency of the process.

5 Another known manner of reducing NO_x compounds is to supply a reduction agent in the form of ammonia/urea (so-called SCR technique) to the relevant gas flow. A drawback as regards this method is that it requires special arrangements for storage and supply of ammonia/urea, and that a NO_x reduction by means of this technique only is allowed within a certain temperature interval, more precisely approximately 300-500° C.

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An additionally known manner of reducing NO_x compounds in engine exhaust gases is to utilize a so-called EGR system (Exhaust Gas Recirculation), wherein a certain amount of the exhaust gases from the engine is returned to the inlet of the engine.

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An additionally known manner of reducing NO_x compounds in engine exhaust gases is to utilize zeolite structures with pores of two different sizes (so-called "dual pore size" technique). In that case, for example NO molecules in a gas flow which passes the zeolite structure will be transformed into NO_2 molecules in the pores of the smaller size, whereupon said NO_2 molecules react with a reduction agent, e.g. a HC compound, in the pores of the larger size. In this case, by means of the last-mentioned reaction, N_2 , CO_2 and H_2O are formed.

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25 Other HC-based systems can also be utilized for NO_x reduction, e.g. a system which is based on an oxide of aluminium (Al_2O_3) to which silver atoms have been supplied. In such a structure, a HC compound can be supplied at the same time as a gas flow containing NO_x compounds is allowed to pass said structure. This results in a decrease of the NO_x compounds in the gas flow.

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SUMMARY OF THE INVENTION:

One object of the present invention is to provide an improved reduction of a gas component, in particular a NO_x compound, in an exhaust gas flow of a combustion engine, by means of which the above-mentioned problems and drawbacks are eliminated. Said object is accomplished by means of a device, the characterizing features of which will be apparent from appended claim 1, and a device, the characterizing features of which will be apparent from appended claim 11. Said object is also accomplished by means of a separation unit, the characterizing features of which will be apparent from appended claim 21. Said object is also accomplished by means of a method, the characterizing features of which will be apparent from appended claim 22, and a method, the characterizing features of which will be apparent from appended claim 34.

According to a first embodiment, the invention relates to a device for reduction of a gas component in an exhaust gas flow of a combustion engine which is adapted for operation by a lean air/fuel mixture, comprising an exhaust pipe for transport of said exhaust gas flow from the engine. The device comprises a separation unit which is arranged along the exhaust pipe, which separation unit comprises a wall structure of a material which provides separation of said gas component from said exhaust gas flow by means of a selective passage of said gas component from the exhaust gas flow before other gas components in the exhaust gas flow.

According to said first embodiment of the invention, a reduction agent is preferably supplied for catalytic reduction of the relevant gas component, e.g. a NO_x compound. Said wall structure provides a selective passage of the relevant gas component from the exhaust gas flow before other gas components in the exhaust gas flow. In this case, the gas component reacts in a catalytic manner with the reduction agent after (or during) its passage through the wall structure. In this manner, several advantages are attained. Primarily, it can be noted that it allows that the car's own fuel is used as

reduction agent at the same time as the reduction of NO_x compounds can take place continuously during lean operation of the engine in question.

5 Moreover, in connection with the above-mentioned wall structure, a catalytic reaction is provided for the above-mentioned reduction. This implies that the reduction agent will react primarily with NO_x molecules in the exhaust gas flow (instead of being wasted by reacting with oxygen molecules). In this manner, the reaction with oxygen is suppressed, which is an advantage.

10 One particular advantage of said embodiment relates to the fact that reduction agent which has not reacted with any gas component in the exhaust gas flow can be guided back into the engine. To this end, the separation unit comprises an outlet which is connected with the inlet of the engine. This affects the fuel consumption – i.e. the consumption of reduction
15 agent for the reduction of NO_x compounds – in a positive way.

A certain amount of NO_x compounds which pass through said wall structure without reacting with the reduction agent can also be returned to the intake side of the engine.

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According to a second embodiment of the invention, no reduction agent is supplied to the separation unit. Instead, the invention is in this case utilized for return of said gas component to the inlet of the engine after separation in the separation unit. In this manner, the returned gas component is prevented
25 from being released out into the surrounding atmosphere.

According to a third embodiment, the invention relates to a device for reduction of a first gas component in an exhaust gas flow of a combustion engine which is adapted for operation by a lean air/fuel mixture, comprising
30 an exhaust pipe for transport of said exhaust gas flow from the engine. The device comprises a separation unit which is arranged along the exhaust pipe, which separation unit comprises a wall structure of a material which provides

separation of a second gas component from said exhaust gas flow by means of a selective passage of said second gas component before other gas components in the exhaust gas flow, and that the separation unit comprises an outlet which is connected with the inlet of the engine via a conduit, for
5 return of said second gas component to the inlet after separation from said exhaust gas flow.

According to said third embodiment of the invention, a component in the form of water can be separated from the exhaust gas flow and be returned to the
10 intake side of the engine. This contributes to a decrease of the amount of NO_x compounds which are formed in the engine. In this manner, the invention provides a "selective EGR function" with return of water which is separated from the exhaust gases in said wall structure. One advantage as regards this arrangement is that no extra water needs to be supplied to the
15 engine for decrease of NO_x compounds, but that instead the amount of water that is present in the exhaust gas flow out from the engine is utilized.

According to a fourth embodiment of the invention, it can be utilized in connection with a combustion engine of the type which comprises a turbo-
20 aggregate. By means of the fact that in particular water (which has been separated from the exhaust gases by means of the above-mentioned separation unit) is returned to a point upstream of a compressor forming part of the turbo-aggregate and that said water is cooled by means of an intercooler, the discharge of NO_x compounds from the engine can be
25 reduced additionally.

BRIEF DESCRIPTION OF THE DRAWINGS:

The invention will be further described in the following with reference to a preferred embodiment and to the annexed drawings, in which
30

Fig. 1 is a principal diagram which shows an arrangement in which the present invention can be utilized, according to a first embodiment,

Fig. 2 is an enlarged detail view of a separation unit according to the invention,

- 5 Fig. 3 is an additionally enlarged detail view of a part of the separation unit according to the invention,

Fig. 4 is principal diagram which essentially corresponds to Fig. 1 but which shows an arrangement according to a second embodiment of the invention,
10 and

Fig. 5 shows an arrangement according to a fourth embodiment of the invention.

15 **PREFERRED EMBODIMENTS:**

Fig. 1 shows a schematic view of an arrangement according to the present invention. According to a preferred embodiment, the invention is arranged in connection with a combustion engine 1 of the "lean-burn" type (also called DI engine), i.e. an engine of the direct-injected Otto cycle engine type, where
20 the injection of fuel to the engine 1 is adapted for at least two modes of operation with different air and fuel supply to the engine 1 and varying periods of time for injection of fuel and for the ignition of the air/fuel mixture. More precisely, the engine 1 is preferably adapted to be able to be set in a "stratified" mode of operation, wherein the supplied fuel is concentrated in the
25 respective combustion chamber of the engine so that the engine during certain predetermined operating cases can be operated by a very lean air/fuel mixture, approximately $\lambda=3$. The stratified mode of operation is based on the fact that fuel is injected into the engine 1 so that it is mixed partially (i.e. non-homogeneously) with air, wherein a small "cloud" of mixed fuel and
30 air is formed. Around this partial mixture there is essentially clean air. In this manner, ignition of a very lean mixture, approximately $\lambda=3$, can occur.

Compared with the case where $\lambda=1$, three times as much air is in this case supplied with the same amount of fuel. By means of such an engine, considerable fuel savings are provided compared with engines which are operated by a stoichiometric mixture, i.e. where $\lambda=1$. Furthermore, the engine
5 1 can preferably be set in a "homogeneous" mode of operation during certain operating cases at comparatively high torques and engine speeds of the engine 1, wherein a stoichiometric or a comparatively rich mixture is supplied to the engine 1. In this case, this mixture – in contrast to what is the case during the stratified mode of operation – is essentially uniformly distributed in
10 the combustion chamber.

The invention is not limited for utilization in connection with merely "lean-burn" engines, but it may also be applied in other connections, e.g. in connection with diesel engines and other types of engines which can be
15 operated by a surplus of oxygen in relation to the stoichiometric mixture and where there is a demand for reduction of NO_x compounds. In the following, however, the invention will be described with reference to a "lean-burn" engine which is intended to be driven by petrol.

20 The engine 1 is in a conventional manner fed with inflowing air via an air inlet 2. Furthermore, the engine 1 is provided with a number of (e.g. four) cylinders 3 and a corresponding number of fuel injectors 4. The respective injector 4 is connected to a central control unit 5 via an electrical connection
6. The control unit 5 is preferably computer-based and is adapted to control
25 the fuel supply to each injector 4 with fuel from a fuel tank 7 in a known manner, so that an air/fuel mixture which is adapted in every given moment is fed to the engine 1. The fuel is fed from the fuel tank 7 via conduits 8 to the respective injector 4. Moreover, for feeding of the fuel to the respective injector 4, a fuel pump 9 is provided in connection with the fuel tank 7. The
30 fuel pump 9 is controllable by means of the control unit 5, which to this end is connected to the fuel pump 9 via an additional electrical connection 10. The

engine 1 according to the embodiment is formed in accordance with the "multi-point" injection type, where the correct amount of fuel to the engine 1 in a known manner can be supplied individually to the respective injector 4 by means of control by the control unit 5.

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The engine 1 that is shown in the drawing is of a four-cylinder type. However, it shall be noted that Fig. 1 only shows the principal design of an engine system according to the invention, which can be utilized in engines having various numbers of cylinders and various cylinder configurations.

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During operation of the engine 1, the control unit 5 is generally adapted in order to control the air/fuel mixture to the engine 1 so that it in every given moment is adjusted to the prevailing mode of operation. The control of the engine 1 takes place in an essentially known manner depending on various parameters which reflect the mode of operation of the engine 1 and the vehicle in question. For example, the control of the engine can take place depending on the relevant degree of throttle application, the engine speed, the amount of injected air to the engine and the oxygen concentration in the exhaust gases. To this end, the engine 1 is provided with, for example, a position indicator 11 for the vehicle's accelerator pedal (not shown), an engine speed indicator 12 for detection of the engine speed of the engine 1 and an air flow meter 13 for detection of the amount of supplied air to the engine 1, all of which are connected to the control unit 5 via corresponding electrical connections 14, 15 and 16, respectively. Furthermore, the system comprises a gas throttle 17, which preferably is electrically controllable and, for this reason, is provided with a controllable shifting motor 18, by means of which the gas throttle 17 can be set in a certain desired position so that a suitable amount of air is fed into the engine 1 depending on the relevant mode of operation. Thus, the shifting motor 18 is connected to the control unit 5 via an additional connection 19.

30

During operation of the engine 1, its exhaust gases are guided out from the cylinders 3 via a branch pipe 20 and further on to an exhaust pipe 21 which is connected to the branch pipe 20. A special separation unit 22 is provided further downstream along the exhaust pipe 21. According to what will be described in detail below, the separation unit 22 is adapted to be utilized during reduction of NO_x compounds in the exhaust gas flow which is guided from the engine 1, through the exhaust pipe 21 and the separation unit 22, and then further out into the atmosphere.

Furthermore, the arrangement according to the invention comprises a sensor 23 for detection of the oxygen concentration in the exhaust gases. Preferably, the sensor 23 is of the linear lambda probe type (but may alternatively be constituted by a binary probe) and is connected to the control unit 5 via an electrical connection 24. Preferably, the sensor 23 is provided in the exhaust pipe 21, upstream of the separation unit 22. In a manner which is per se previously known, the sensor 23 is utilized for generation of a signal which corresponds to the oxygen concentration in the exhaust gases. Said signal is fed to the control unit 5 via the connection 24 and is utilized for controlling the air/fuel mixture to the engine 1.

Moreover, according to the embodiment, a NO_x sensor 25 is provided, i.e. an indicator which is utilized in order to determine the concentration of NO_x compounds in the exhaust gas flow. To this end, the NO_x sensor 25 is provided in the exhaust pipe 21, downstream of the separation unit 22, and is connected to the control unit 5 via an additional electrical connection 26. According to what will be described in detail below, by means of a continuous detection of the concentration of NO_x compounds in the exhaust gases, a possibility is provided to control the amount of reduction agent in the control unit 5, i.e. a possibility to continuously control the degree of reduction of NO_x compounds. Furthermore, by means of the NO_x sensor 25, a possibility is provided to diagnose the function regarding the NO_x reduction and to control

the function of the parts forming part of the system. This will also be described more in detail below.

As an alternative to what is shown in Fig. 1, the NO_x sensor can be provided
5 upstream of the separation unit 22. Also in this case, it can be utilized for
controlling the amount of reduction agent which is to be supplied to the inlet
27. According to an additional alternative, two NO_x sensors can be utilized,
which in this case are arranged in front of and after the separation unit 22. In
this manner, an excellent opportunity is provided for determination of the
10 degree of transformation in the separation unit 22 as well as for functional
control of the separation unit 22.

The structure and the function of the invention will now be described in detail.
During stratified operation of the engine 1, a lean exhaust gas mixture (i.e.
15 $\lambda=1$) is generated which flows through the exhaust pipe 21 and reaches the
separation unit 22. This corresponds to a large surplus of oxygen in the
exhaust gases, and according to what has been described initially, this
results in that the NO_x compounds which are generated by the engine 1
would not be able to be eliminated by means of a conventional three-way
20 catalyst. Instead, for reduction of NO_x compounds in the exhaust gases from
the engine 1, the separation unit 22 according to the invention is provided
with an inlet 27 through which a reduction agent can be fed into the
separation unit 22. According to the embodiment, this reduction agent is
supplied separately from the exhaust gas flow which is emitted from the
25 engine 1. More precisely, the reduction agent is taken from the vehicle's own
fuel and is in this case constituted by, for example, various HC compounds.
To this end, the inlet 27 is connected with a conduit 28 for feeding of fuel
from the fuel tank 7. Furthermore, along the conduit 28, a special
transformation unit 29 is provided which is adapted for treatment of the fuel,
30 which is fed via the conduit 28, into a form which is suitable as reduction
agent in the separation unit 22. More precisely, the transformation unit 29
can comprise a vaporizing device for transformation of fuel from liquid form to

gas form. This gaseous fuel is subsequently supplied to the separation unit 22 in the form of a reduction agent. Alternatively, the transformation unit 29 can comprise a reformer, for catalytic reformation of fuel into a suitable reduction agent in the separation unit 22. Furthermore, the transformation
5 unit can suitably comprise additional (not shown) components, e.g. in the form of a pump for adjustment of the pressure of the reduction agent which is fed to the separation unit and a valve for control of the flow of reduction agent to the separation unit 22. In this case, such additional components are suitably controllable via (not shown) connections to the above-mentioned
10 control unit 5.

Due to the fact that the engine 1 according to the embodiment is a "lean-burn" engine, the fuel is constituted by petrol. However, the invention is not limited to this type of fuel, but it may also be utilized in, for example, diesel
15 engines. Furthermore, the reduction agent can be constituted by other substances as well, e.g. alcohols, methanol, hydrogen gas, ethanol or pure hydrocarbons (according to the formula C_xH_y). In such cases, the reduction agent is supplied to the separation unit 22 from a separate tank (not shown in Fig. 1) which is particularly intended for the reduction agent in question.

20 According to what will be described hereinafter, the invention is arranged in such a way that the reduction agent reacts with the exhaust gas flow in the separation unit 22, wherein NO_x compounds in the exhaust gas flow can be eliminated. The amount of reduction agent which has not reacted is guided
25 back to the fuel tank 7 via an outlet 30 in the separation unit 22 and an additional conduit 31 which connects the separation unit 22 with the inlet 2 of the engine 1. In this manner, an advantage is attained by means of the invention in so far as any possible remaining and unutilized reduction agent is returned to the engine 1 instead of being lost. The reaction between the
30 reduction agent and the exhaust gas flow in which NO_x compounds are reduced is apparent in detail from Fig. 2, which is an enlarged and partly broken view of a section of the inside of the separation unit 22. Said unit is

provided with a number of inner walls 32 which are separated from each other and are arranged with such an extension that the exhaust gas flow is allowed to pass through the separation unit 22 and out into the atmosphere. Preferably, the walls 32 are arranged with an extension which essentially is in the longitudinal direction of the separation unit 22. Said walls 32 define a number of separated, longitudinal ducts 33a, 33b. The ducts 33a, 33b are provided in such a way that the reduction agent in question is guided along every other duct 33b and that the exhaust gas flow is guided along ducts 33a which are arranged between the ducts 33b through which the reduction agent is guided. In this regard, the reduction agent and the exhaust gas flow are guided in essentially the opposite direction in relation to each other.

In order to additionally facilitate the transport of fuel from the tank 7 to the inlet 27 of the separation unit 22, a carrier gas can be supplied to the transformation unit 29, alternatively directly to the conduit 28. Such a connection from the surrounding atmosphere to the transformation unit 29 is shown with broken lines and with the reference numeral 28b in Fig. 1. Alternatively, said connection can connect directly to the conduit 28 which leads to the separation unit 22. Due to the fact that the separation unit 22 according to the embodiment is connected to the inlet 2 of the engine 1 via the conduit 31, there is a pressure difference between the inlet 2 and the separation unit 22, which in turn contributes to a sufficient operating pressure which in an effective manner brings the carrier gas to the separation unit 22 together with the fuel.

According to an additional alternative of the invention, the outlet 30 can be excluded. In such a case, it is controlled that only the amount of reduction agent which is estimated to be consumed during the reaction with the NO_x compounds is supplied to the separation unit 22.

Thus, according to what is indicated by means of arrows 34 in Fig. 2, the relevant reduction agent is guided along every other duct in the separation

unit 22. In this case, as is indicated by means of additional arrows 35, the exhaust gases are guided from the engine 1 along the intermediate ducts. Thus, according to the invention, the exhaust gases and the reduction agent are guided into the separation unit 22 along separated ducts.

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According to what is apparent from the drawings, the reduction agent is suitably guided into the separation unit 22 counter-current in relation to the exhaust gas flow. However, the invention is not limited to this. Alternatively, the reduction agent can be guided into the separation unit along essentially
10 the same direction as the exhaust gases, i.e. with the current, or crosswise in relation to the flowing direction of the exhaust gases. Preferably, the reduction agent is guided into the separation unit 22 in a counter-current manner, seeing that a minimum concentration of NO_x compounds in this case is met by a maximum concentration of the reduction agent.

15

According to the preferred embodiment, the walls 32 are arranged as essentially plane and parallel plates with an extension in the longitudinal direction of the separation unit 22. However, the invention is not limited to such a design, but the walls may e.g. be defined by a number of concentric
20 pipes, between which pipes intervals are defined which correspond to the above-mentioned ducts. An additional alternative is to design the separation unit in the form of an extruded monolith with honeycomb structure where the exhaust gas flow and the reduction agent are fed into every other duct. A fourth alternative is to design the separation unit as a disc which, when seen
25 in a cross-sectional view, is folded essentially as an "S".

Independently of which alternative is selected for realizing this first embodiment, it can be said that it is based on the fact that exhaust gases and reduction agent are fed into the separation unit 22 along the ducts 33a, 33b,
30 which are separated from each other and which are situated on both sides of a number of walls 32 which together constitute a wall structure. The walls 32 are designed in order to control the exhaust gas flow from the engine 1 in an

optimal and correct manner as regards the flow, and so that the reduction agent and the exhaust gas flow, respectively, can be guided into one side each of the respective wall 32.

- 5 According to the invention, the walls 32 are constructed of a material which has a selective adsorption capacity as regards diffusion (i.e. penetration) into the walls 32 of various gas components which are guided along the respective duct 33a, 33b. Preferably, the walls 32 are constructed of a zeolite material, which is a per se previously known type of material which has the
- 10 property that it comprises a molecular structure which can be utilized in order to separate various gas components in e.g. a gas mixture depending on differences as regards molecular size and molecular form in these gas components. More precisely, zeolites comprise a crystal structure in which "pores" or "ducts" are formed which are of such dimensions that the above-
- 15 mentioned selective function is provided.

According to the invention, a suitable zeolite material can be utilized in order to allow passage of NO_x compounds in the exhaust gas flow through the respective wall 32, while passage of oxygen is prevented considerably. The

20 zeolite material also allows passage of the reduction agent through the respective wall 32. According to the preferred embodiment, such zeolite material is utilized whose molecular structure has a duct diameter which is of such a size, approximately 5 angstrom (1 angstrom = 10⁻¹⁰ m), that oxides of nitrogen are allowed to pass with a comparatively high rate of diffusion while

25 other gas components, e.g. oxygen, are allowed to pass with a comparatively low rate of diffusion. One example of such a zeolite material is ZSM-5. However, the invention is not limited to this material. Thus, according to the embodiment, a separation of molecules depending on the size is provided. The transport through the wall structure is maintained by means of a partial

30 pressure difference, wherein a carrier gas suitably can be utilized in order to transport the molecules which have passed through the wall structure.

Zeolites are merely one example of a material which can be utilized in order to separate molecules of various size and form in accordance with the invention. Another example of a suitable material is so-called SAPO (silicon, aluminium, phosphorus and oxygen).

5

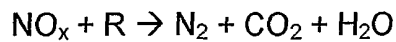
With reference to Fig. 2, it can be noted that the invention provides that reduction agent is fed from the inlet of the separation unit 22 (not apparent from Fig. 2) and along one of the sides of the respective wall 32, while exhaust gases are fed from the exhaust pipe 21 and along the other side of the corresponding wall 32. In this case, the walls 32 constitute a membrane structure which, by means of its material properties, is adapted to allow passage of gas components in the exhaust gas flow with a high rate of diffusion in the direction of the ducts 33a where the reduction agent is guided. In a corresponding manner, the walls 32 allow passage of reduction agent with a high rate of diffusion in the direction of the ducts 33b where the exhaust gas flow is guided. On the other hand, a considerably restricted diffusion of oxygen from the exhaust gas flow and through the respective wall 32 occurs, which corresponds to a comparatively low rate of diffusion for oxygen. This delay of the passage of the oxygen through the respective wall 32 is in turn provided by means of the fact that the walls 32 consist of said zeolite material, wherein the gas transport from the duct 33a with the reduction agent as well as the duct 33b with the exhaust gas flow is forced to go through the pore structure of the zeolite. According to the invention, the diffusion capacity can be affected considerably by means of the fact that the polarity of the wall structure 32 is modified in order to provide a slow transport speed for non-polar gas components such as N_2 and O_2 , while polar gas components are provided with a high transport speed. For example, the polarity can be affected by exchanging aluminium (Al) for silicon (Si) in the structure of the zeolite. Silicon is quadrivalent and aluminium is trivalent. In this case, silicon needs a counter-ion, for example Na^+ or H^+ . Alternatively, the counter-ion can be constituted by silver (Ag^+). Moreover, the relation Si/Al in the zeolite can be varied. Furthermore, a zeolite with

small pores is suitably used, with a pore structure where the pores are approximately 5 angstrom or smaller.

Thus, the membrane structure which is defined by the walls 32 provides an improved selectivity for the reaction between the NO_x compounds and the reduction agent, compared with the competing reaction between oxygen and the reduction agent. In this manner, an advantage is attained in so far as the reduction agent is not wasted unnecessarily by reacting with oxygen molecules in the exhaust gas flow.

10

The reactions which take place in the wall structure 32 are indicated more in detail in Fig. 3, which is an additionally enlarged view of a section A which also is indicated in Fig. 2. Accordingly, in Fig. 3, the reduction of NO_x compounds in the respective wall 32 is shown in a diagrammatical manner. A basic principle of the invention is that the walls 32 also serve as a catalyst for the reaction between NO_x compounds in the exhaust gas flow and the reduction agent. In this case, the catalytic reaction essentially takes place in connection with the surface layer of the respective wall 32, i.e. in the surface layer of the respective wall 32 which is directed inwards to the corresponding duct 33b for reduction agent. Said surface layer is indicated in Fig. 3 with the reference numeral 32b. The NO_x compounds which are guided through the respective wall 32 will be adsorbed on the surface layer 32b, as well as the reduction agent which is guided along the respective duct 33b. Due to the fact that the material is selected in the above-mentioned manner so that oxygen in the respective exhaust gas duct 33a has a low transport speed through the wall 32, a selective penetration of NO_x compounds before (e.g.) oxygen takes place. In this manner, oxygen will not take part in the reaction in the surface layer 32b. Due to the fact that the reduction agent too has a low transport speed through the wall 32, it will diffuse inwards a very short distance 32 and react with the NO_x compounds in the surface layer 32b. The reaction which is utilized in the membrane follows the relation



where R is the reduction agent in question, which e.g. is constituted by HC compounds in the engine's 1 fuel. Other examples of suitable reduction agents are hydrogen gas (H₂), carbon monoxide (CO) and ammonia (NH₃). Thus, it can be established that the NO_x compounds react with the reduction agent and form harmless molecular nitrogen, carbon dioxide and water.

As an alternative to what has been described above, wherein a catalytic reaction occurs in the surface layer of a wall structure with a catalytic function, the catalytic function can be provided by means of a separate catalyst coating which is placed on the wall structure. Accordingly, in this alternative solution (which is not shown in the drawings), a separate surface layer is utilized for this function.

With reference once again to Fig. 1, it is shown that any possible remaining reduction agent, i.e. reduction agent which has not reacted with any gas component in the exhaust gas flow, is guided back to the intake side of the engine via the conduit 31, wherein it is transported by means of the negative pressure which prevails in the inlet 2 in relation to what prevails in the separation unit 22. This process is facilitated if the above-mentioned carrier gas conduit 28b is utilized. Alternatively, a (not shown) pump device can be used in order to suck through the reduction agent and then feed it in into the car's cylinders together with the remaining air and fuel.

According to one possible solution, the remaining reduction agent can also be guided out directly into the atmosphere, i.e. without being returned to the engine 1.

The control unit 5 can be utilized for a control of the amount of reduction agent which is fed to the separation unit 22 by means of the signal from the NO_x sensor 25 or by supplying the control unit 5 with stored tables which

describe how the prevailing operating condition – as regards the engine's 1 relevant load, engine speed and temperature – produces NO_x compounds. In this latter case, no separate NO_x sensor is required.

5 Furthermore, the control unit 5 is suitably adapted for calculation of how effective the NO_x reduction is in connection with a particular flow of reduction agent, suitably by utilizing the NO_x sensor 25 in order to detect the amount of NO_x compounds in the exhaust gas flow after the separation unit 22, for the respective flow of reduction agent. Suitably, the amount of supplied reduction
10 agent can in this case be adjusted to the prevailing NO_x reduction. Accordingly, by utilizing the control unit 5 for a continuous detection of the concentration of NO_x compounds in the exhaust gases, a possibility to adjust the amount of supplied reduction agent is provided.

15 Furthermore, by means of the NO_x sensor 25, a possibility to diagnose the function regarding the NO_x reduction is provided. In this case, this takes place by utilizing the control unit 5 for measuring the relevant concentration of NO_x compounds and for comparing certain predetermined limit values during various operating conditions of the engine 1. In those cases where the
20 limit values are not fulfilled, it can be established that there is some kind of error as regards one of the integral components. In such a case, the control unit 5 can also be utilized in order to generate some form of indication, e.g. in the form of a warning lamp, which warns the vehicle's driver that the NO_x reduction does not function normally.

25 Calculations have shown that the relevant engine 1 with essentially continuous lean operation provides a decrease of the fuel consumption with approximately 10-15 % in relation to conventional petrol engines. From this profit in fuel consumption, approximately one percentage unit disappears
30 which is required for providing the above-mentioned reduction agent. Thus, a clear profit of 9-14 % in fuel consumption is provided in relation to previously known engine arrangements. Furthermore, it has been established that in the

case when the invention is utilized in connection with a diesel engine, a fuel saving is provided which is approximately 30 % lower than what is the case as regards conventional petrol engines.

- 5 Incidentally, the invention is particularly suitable to be utilized in diesel engines, which is due to the fact that the temperature of the exhaust gases from a diesel engine normally is lower than the exhaust gas temperature in a petrol engine and that the method according to the invention for reduction of NO_x compounds has proven to be particularly effective during comparatively
10 low exhaust gas temperatures.

In the following, a second embodiment of the invention will be described with reference to the Fig. 4, which essentially corresponds to Fig. 1 but which not comprises any supply of a reduction agent. Moreover, it can be noted that the
15 same reference numerals are used in Fig. 4 for the components which also are apparent from Fig. 1.

According to what is apparent from Fig. 4, the separation unit 22 is connected with the inlet 2 of the engine 1 in a manner which corresponds to
20 the above-mentioned embodiment, i.e. via a conduit 31. However, unlike the embodiment according to Fig. 1 – in which the conduit 31 is utilized for return of any possible unutilized reduction agent to the engine 1 – the conduit 31 in the embodiment according to Fig. 4 is utilized for return of NO_x compounds which have been separated from the engine exhaust gases by means of the
25 separation unit 22. In this case, the separation of NO_x compounds takes place in a manner which corresponds to what has been explained above with reference to Figs. 2 and 3, in so far as the separation unit 22 comprises a wall structure of a material which provides a selective passage of NO_x compounds before other gas components in the exhaust gases. Accordingly,
30 in the embodiment according to Fig. 4, no reduction agent is supplied, but NO_x compounds in the exhaust gases will be separated from the exhaust

gases in the separation unit 22 and be returned to the engine 1 via the conduit 31 instead of being released out into the surrounding atmosphere.

5 Furthermore, a conduit 28b is preferably utilized for a carrier gas, preferably air from the surrounding atmosphere, which in this case is fed into the separation unit 22. Said carrier gas will in this case guide the NO_x compounds which have been separated by the separation unit 22 back to the engine 1, via the return conduit 31.

10 According to a third embodiment of the invention, an arrangement is utilized which essentially corresponds to what is shown in Fig. 4. Nor in this third embodiment is any supply of reduction agent utilized. Furthermore, the separation unit according to this third embodiment is provided with a wall structure of a material which provides a selective passage of water in the exhaust gases which flow out from the engine and through the separation
15 unit 22. To this end, the material in the wall structure may suitably be constituted by ZSM-5, but other materials are also possible.

It is per se previously known that a supply of water to a combustion engine
20 decreases the generation of NO_x compounds in the engine. This principle is utilized in this third embodiment in so far as that a certain amount of water is separated from the exhaust gas flow in the separation unit and is subsequently returned to the air inlet 2 of the engine 1, via a return conduit 31 which is intended for return of water.

25 A fourth embodiment of the invention is shown in Fig. 5. Fig. 5 is a slightly simplified principal diagram of an engine system which essentially corresponds to what has been described above but which is intended for an engine 1 which is provided with a per se previously known turbo-aggregate
30 36, which in turn comprises an exhaust gas operated turbine 37 and a compressor 38 by means of which inflowing air is compressed. To this end, the turbine 37 and the compressor 38 are arranged on a common axle 39 in

a known manner, wherein the compressor 38 is operated by the turbine 37, which in turn is operated by the exhaust gases which flow from the engine 1. Moreover, said system comprises a so-called "intercooler" 40, by means of which the air, which has been fed through the compressor 38 and to the engine 1, can be cooled.

According to what is apparent from Fig. 5, the engine 1, via its exhaust pipe 21, is connected with a separation unit 22 of the corresponding type which has been described above. The exhaust gases from the engine 1 are fed through the exhaust gas turbine 37 and further through the separation unit 22. In a manner which has been described above, the separation unit 22 is adapted to separate a certain exhaust gas component – in this case water – from the flowing exhaust gases. According to the embodiment, this return of water takes place to a point upstream of the compressor 38 of the turbo-aggregate 36, via a conduit 31 which connects the separation unit 22 with the inlet 2 of the engine 1. In this manner, water can be separated from the exhaust gases and be returned to the intake side of the engine 1. This is conducive to decreasing the amount of NO_x compounds which are formed in the engine. Alternatively, the return of water can also take place to a point downstream of the compressor 38.

Accordingly, in contrast to conventional EGR systems, a "selective EGR function" is provided by means of the invention, where no extra water needs to be added. Instead, the amount of water which is present in the exhaust gases is utilized.

The water which is returned from the exhaust gas flow can either be gaseous or liquid. In the latter case, an improved function is provided by means of the above-mentioned cooling device 40, which in this case is utilized for cooling the water which then is returned to the engine 1. It can be established that the generation of NO_x compounds in the engine 1 in principle decreases, the larger the amount of water is which is returned to the inlet 2. In can in

particular be established that after saturation of the water, a decrease of the NO_x generation is provided which is higher in proportion to the case where there is no saturation.

- 5 The invention is not limited to the embodiment which is described above and shown in the drawings, but may be varied within the scope of the appended claims. For example, the invention can be utilized in both petrol and diesel engines, or in other applications where there is desirable with a reduction of NO_x compounds in an engine which is operated by a surplus of oxygen in the
10 exhaust gases. In principle, the invention can also be applicated in other connections where a reduction of a certain gas component, e.g. carbon monoxide, CO, in a gas flow is desirable.

By means of the invention, a NO_x adsorbent of known type can be replaced,
15 which results in advantages, not least since it no longer becomes necessary with a periodically rich operation (for regeneration of the NO_x adsorbent).

According to an alternative of the embodiments which have been described above with reference to Fig. 4, the invention can be utilized for a combined
20 return of NO_x compounds as well as water to the inlet of the engine. This can be provided by utilizing a separation unit with a wall structure of essentially the same type that has been described above, but which is designed in such manner that a selective passage of both NO_x compounds and water is provided. This can be realized by means of suitably selected material
25 properties in the wall structure, e.g. as regards its material and pore size. For example, a material of the ZSM-5 type with different pore sizes in different walls can be utilized for this simultaneous selective separation of NO_x compounds and water. In this case, by means of such a separation and subsequent return of NO_x compounds and water to the engine's inlet, a
30 decrease of the generation of NO_x compounds in the engine is provided.

Furthermore, the separation unit 22 according to the invention can be combined with a separate three-way catalyst. Alternatively, the separation unit 22 can be combined with e.g. a particle filter, an oxidation catalyst or a urea based after-treatment unit.

5

Furthermore, the invention can be supplemented with some form of compressor device, which e.g. is situated along the carrier gas conduit 28b (cf. Figs. 1 and 4), in order to increase the pressure of the carrier gas that is utilized for return of the separated exhaust gas component. This can be
10 suitable for adjusting the invention to utilization in various engine types.

Moreover, the invention can be supplemented with some form of regulating device for the supplied carrier gas. This can for example be realized by means of a per se previously known regulating valve which in this case can
15 be situated along the carrier gas conduit 28b. In this case, such a valve is suitably electrically connected to and controllable by means of the control unit 5 (cf. Figs. 1 and 4).

CLAIMS:

1. Device for reduction of a gas component in an exhaust gas flow of a combustion engine (1) which is adapted for operation by a lean air/fuel mixture, comprising an exhaust pipe (21) for transport of said exhaust gas flow from the engine (1),
5 characterized in that it comprises a separation unit (22) which is arranged along the exhaust pipe (21), which separation unit (22) comprises a wall structure (32) of a material which provides separation of said gas component from said exhaust gas flow by means of a selective passage of
10 said gas component before other gas components in the exhaust gas flow.
2. Device according to claim 1,
characterized in that the separation unit (22) comprises an inlet (27)
15 for supply of a reduction agent, which is separated from the incoming exhaust gas flow by means of said wall structure (32), wherein the separation unit (22) provides catalytic reduction of said gas component by means of supply of the reduction agent.
- 20 3. Device according to claim 2,
characterized in that the inlet (27) of the separation unit (22), via a conduit (28), is connected to a tank (7) forming part of the engine (1) and being intended for the regular fuel of the engine (1), wherein said reduction agent is taken from said fuel.
- 25 4. Device according to claim 2,
characterized in that the inlet (27) of the separation unit (22), via a conduit, is connected to a separate tank for said reduction agent.
- 30 5. Device according to any one of claims 2-4,
characterized in that the separation unit (22) is adapted for feeding in said reduction agent counter-current in relation to said exhaust gas flow.

6. Device according to any one of claims 2-5,
c h a r a c t e r i z e d i n that the separation unit (22) comprises an outlet
(30) which is connected with the inlet (2) of the engine (1) via a conduit (31),
5 for feeding any reduction agent which has not reacted with said gas
component out from the separation unit (22) and back to the inlet (2).
7. Device according to claim 6,
c h a r a c t e r i z e d i n that said inlet (27) is connected with an additional
10 conduit (28b) for feeding in fresh air as carrier gas for said reduction agent.
8. Device according to claim 1,
c h a r a c t e r i z e d i n that the separation unit (22) comprises an outlet
(30) which is connected with the inlet (2) of the engine (1) via a conduit (31),
15 for returning said gas component to the inlet (2) after separation from said
exhaust gas flow.
9. Device according to claim 8,
c h a r a c t e r i z e d i n that said inlet (27) is connected with an additional
20 conduit (28b) for feeding in fresh air as carrier gas for said gas component.
10. Device according to any one of the preceding claims,
c h a r a c t e r i z e d i n that said gas component is constituted by an oxide
of nitrogen (NO_x compound) in the exhaust gas flow.
25
11. Device for reduction of a first gas component from a combustion engine
(1) which is adapted for operation by a lean air/fuel mixture, comprising an
exhaust pipe (21) for transport of said exhaust gas flow from the engine (1),
c h a r a c t e r i z e d i n that it comprises a separation unit (22) which is
30 arranged along the exhaust pipe (21), which separation unit (22) comprises a
wall structure (32) of a material which provides separation of a second gas
component from said exhaust gas flow by means of a selective passage of

5 said second gas component before other gas components in the exhaust gas flow, and that the separation unit (22) comprises an outlet (30) which is connected with the inlet (2) of the engine (1) via a conduit (31), for return of said second gas component to the inlet (2) after separation from said exhaust gas flow.

12. Device according to claim 11,
c h a r a c t e r i z e d i n that said second gas component is constituted by water.

10

13. Device according to any one of claims 11 or 12,
c h a r a c t e r i z e d i n that said first gas component is constituted by an oxide of nitrogen (NO_x compound) in the exhaust gas flow.

15 14. Device according to any one of claims 11-13, wherein said engine (1) is provided in connection with a turbo-aggregate (36) with an exhaust gas operated turbine (37) and a compressor (38) for compression of air which has been fed into the engine (1),
c h a r a c t e r i z e d i n that said conduit (31) is connected to a point
20 upstream of said compressor (38).

15. Device according to any one of the preceding claims, wherein the function of the engine (1) is controllable by means of a control unit (5),
c h a r a c t e r i z e d i n that the control unit (5) is adapted for supply of said
25 reduction agent essentially continuously during lean operation of the engine (1).

16. Device according to claim 15,
c h a r a c t e r i z e d i n that a NO_x sensor (25) is connected to the control
30 unit (5) for detection of the amount of NO_x compounds in said exhaust gas flow.

17. Device according to claim 16,
c h a r a c t e r i z e d i n that the control unit (5) is adapted for supply of said
reduction agent depending on the amount of said NO_x compound.
- 5 18. Device according to claim 16 or 17,
c h a r a c t e r i z e d i n that said NO_x sensor (25) is utilized during
diagnosis of the function regarding reduction of said NO_x compound.
19. Device according to any one of the preceding claims,
10 c h a r a c t e r i z e d i n that the engine (1) is of the "lean-burn" type.
20. Device according to any one of claims 1-18,
c h a r a c t e r i z e d i n that the engine is of the diesel engine type.
- 15 21. Separation unit (22) for reduction of a gas component in a gas flow,
c h a r a c t e r i z e d i n that it comprises a wall structure (32) which
comprises material which provides a selective passage of said gas
component from the gas flow before other gas components in the gas flow.
- 20 22. Method for reduction of a gas component in an exhaust gas flow of a
combustion engine (1) which is adapted for operation by a lean air/fuel
mixture, comprising feeding of said exhaust gas flow from the engine (1) to a
separation unit (22),
c h a r a c t e r i z e d i n that it comprises separation of said gas
25 component from said exhaust gas flow in a wall structure (32) comprising
material which provides a selective passage of said gas component before
other gas components in the exhaust gas flow.
23. Method according to claim 22,
30 c h a r a c t e r i z e d i n that it comprises
supply of a reduction agent to an inlet (27) of the separation unit (22),
wherein

supplied reduction agent is separated from said exhaust gas flow by means of said wall structure (32), and

 catalytic reduction of said gas component by means of said reduction agent.

5

24. Method according to claim 23,

 c h a r a c t e r i z e d i n that the supply of the reduction agent takes place from a tank (7) forming part of the engine (1) and being intended for the regular fuel of the engine (1), wherein said reduction agent is taken from said

10 fuel.

25. Method according to claim 23 or 24,

 c h a r a c t e r i z e d i n that said reduction agent is fed through the separation unit (22) essentially counter-current in relation to said exhaust gas

15 flow.

26. Method according to any one of claims 23-25,

 c h a r a c t e r i z e d i n that reduction agent which has not reacted with said gas component is fed out from the separation unit (22) and returned to the inlet (2) of the engine (1).

20

27. Method according to claim 26,

 c h a r a c t e r i z e d i n that it comprises feeding in fresh air as carrier gas for said reduction agent.

25

28. Method according to any one of claims 23-27,

 c h a r a c t e r i z e d i n that said reduction agent is supplied to the separation unit (22) essentially continuously during lean operation of the engine (1).

30

29. Method according to claim 22,

characterized in that it comprises return of said gas component to the inlet (2) via a conduit (31).

30. Method according to claim 29,

5 characterized in that it comprises feeding in fresh air as carrier gas for said gas component.

31. Method according to any one of claims 23-30, wherein said gas component is constituted by an oxide of nitrogen (NO_x compound) in the exhaust gas flow,

10 characterized in that it comprises detection of the amount of said NO_x compound in said exhaust gas flow.

32. Method according to claim 31,

15 characterized in that the supply of said reduction agent takes place depending on the detected amount of NO_x compounds.

33. Method according to claim 31 or 32,

20 characterized in that it comprises a diagnosis of the function regarding reduction of said NO_x compound.

34. Method for reduction of a first gas component from a combustion engine (1) which is adapted for operation by a lean air/fuel mixture, comprising feeding of said exhaust gas flow from the engine (1) to a separation unit (22),

25 characterized in that it comprises

separation of a second gas component from said exhaust gas flow in a wall structure (32) comprising material which provides a selective passage of said second gas component before other gas components in the exhaust gas flow, and

30 return of said second gas component to the inlet (2) of the engine (1).

35. Method according to claim 34,

characterized in that it comprises

- separation of said first gas component and said second gas component in said wall structure, which comprises material which provides a selective passage of said first gas component and said second gas component before
- 5 other gas components in the exhaust gas flow, and
- return of said first gas component and said second gas component to the inlet of the engine.

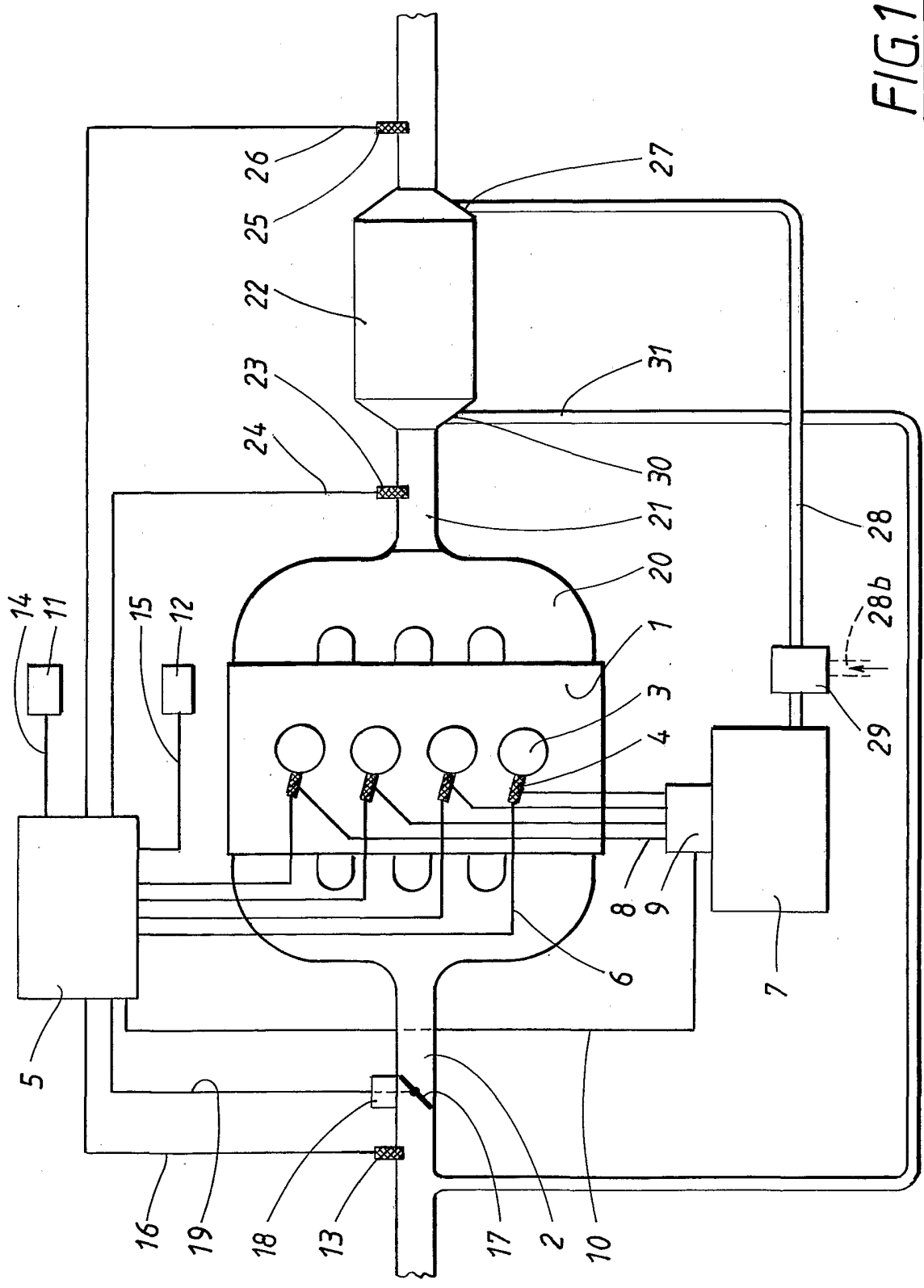


FIG. 1

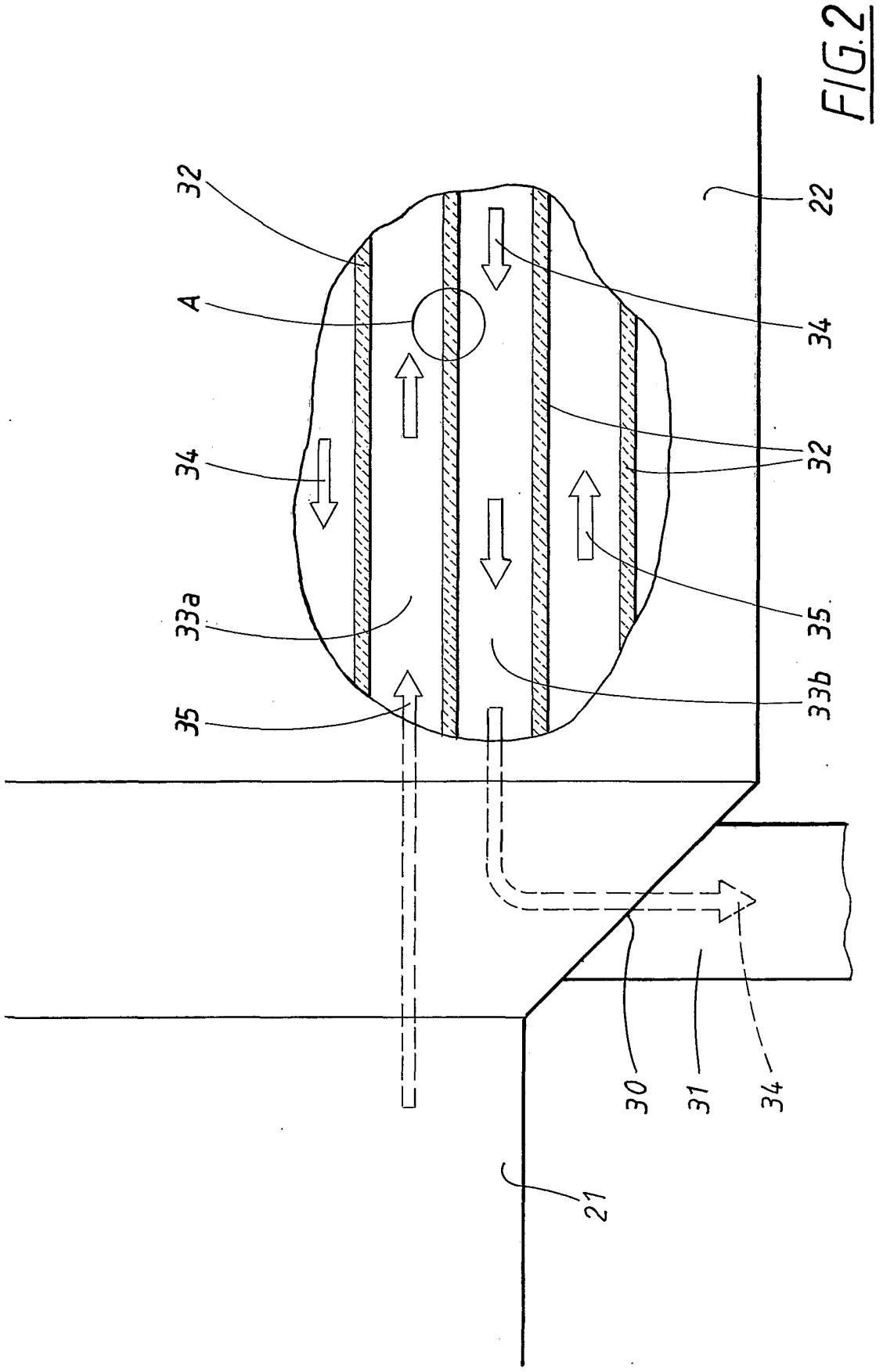


FIG. 2

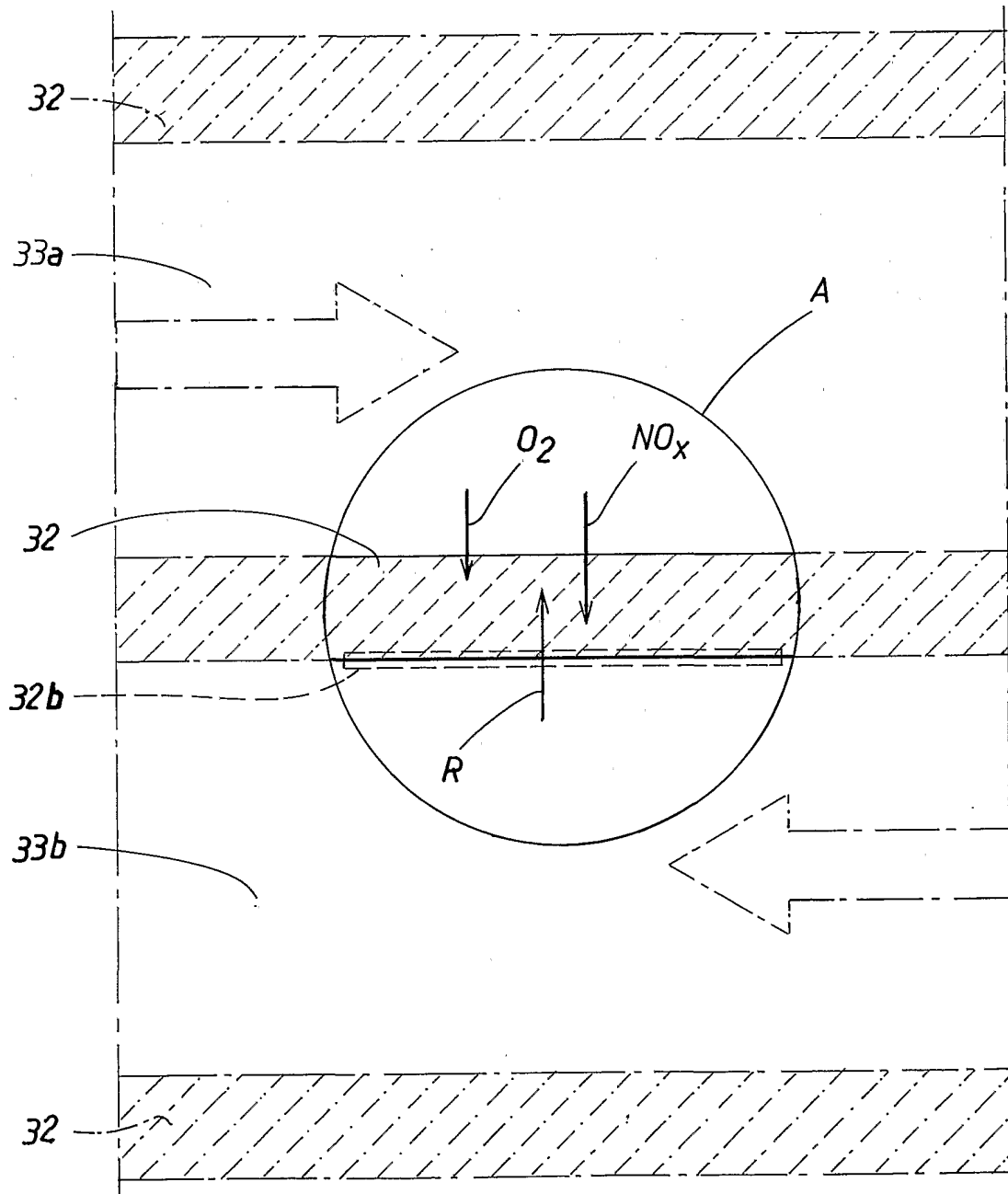


FIG. 3

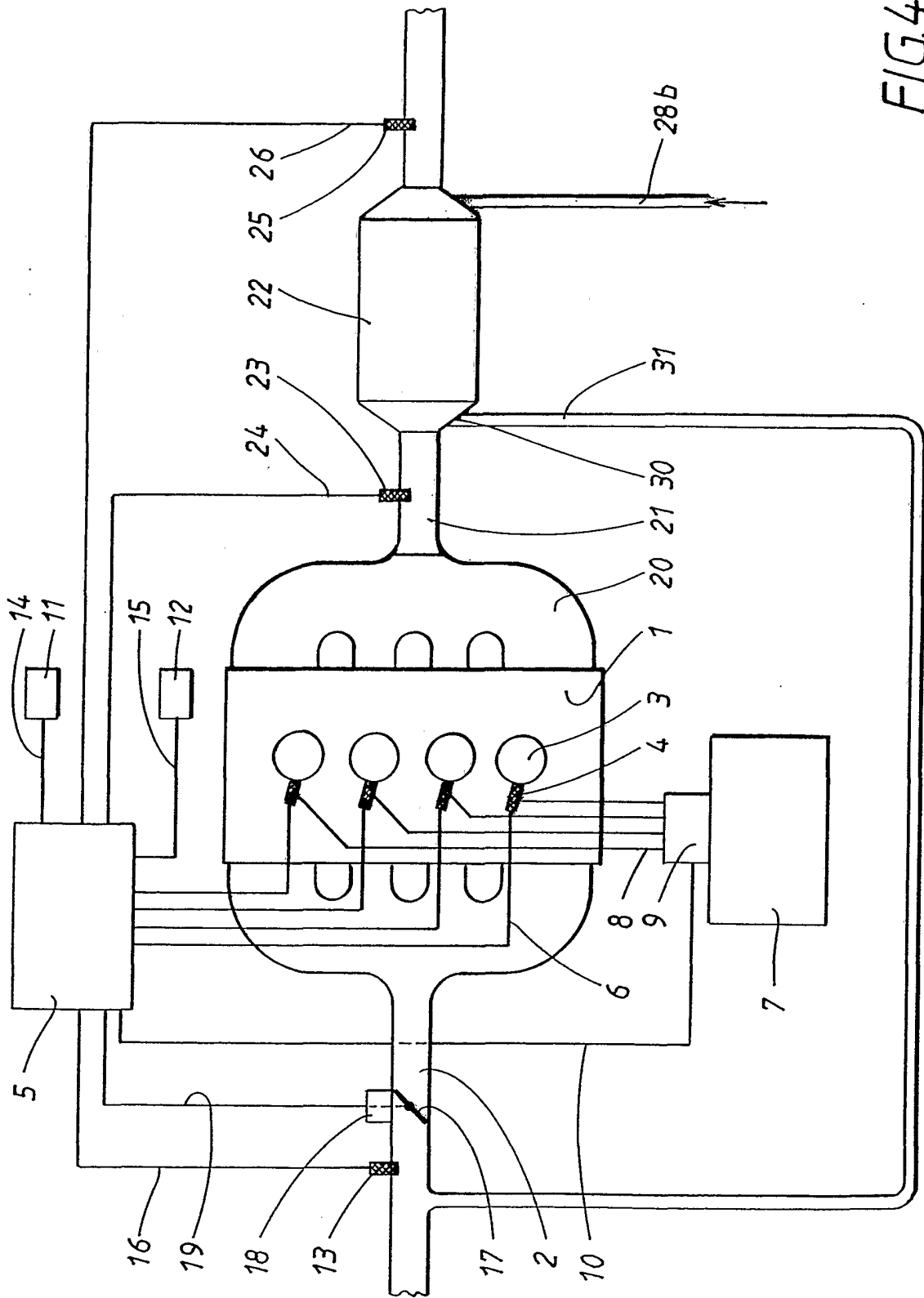


FIG. 4

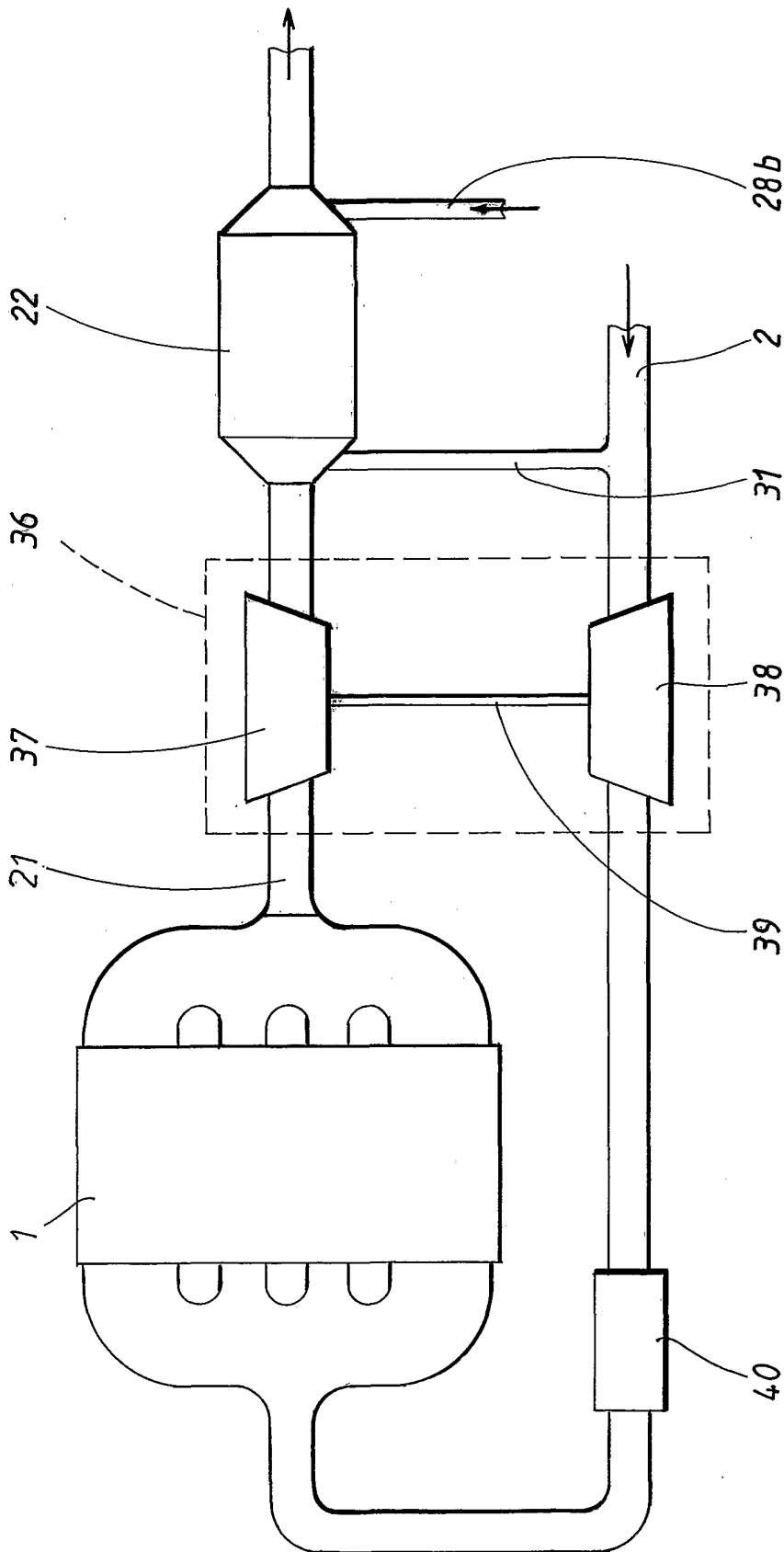


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 01/00934

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B01D 53/56, B01D 53/92, F01N 3/22, B01D 53/22
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B01D, F01N

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

SE,DK,FI,NO classes as above

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

WPI, PAJ, EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 19713633 C1 (DORNIER GMBH), 28 January 1999 (28.01.99) --	1-4,8-11, 13-24,28-35
X	DE 19654977 A1 (DAIMLER-BENZ AKTIENGESELLSCHAFT), 10 June 1998 (10.06.98), column 3, line 45 - column 4, line 10, figure 1, abstract --	1,8-9,11-12, 14-22,29-30, 34-35
A	DE 19837505 C1 (DORNIER GMBH), 30 December 1999 (30.12.99), column 2, line 67 - column 3, line 47, claim 8 --	10,13

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

* Special categories of cited documents:

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

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

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

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

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

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Date of the actual completion of the international search

27 July 2001

Date of mailing of the international search report

31 -07- 2001

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 01/00934

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 4342297 A1 (DAIMLER-BENZ AKTIENGESELLSCHAFT), 22 June 1995 (22.06.95), figures 1-4, abstract --	1-9,11-12, 14-35
A	WO 9425642 A1 (CERAMATEC, INC.), 10 November 1994 (10.11.94), abstract --	1-35
A	File WPI, Derwent accession no. 2001-027457, KYOCERA CORP: "Gas separation filter suitable for selectively separating acidic gases such as carbon dioxide and nitrogen oxides"; & JP,A,2000279773, 20001010 --	10,13
A	DE 4331508 C1 (MTU MOTOREN-UND TURBINEN-UNION FRIEDRICHSHAFEN GMBH), 20 October 1994 (20.10.94), figures 1-2, claims 1,4, abstract --	1-9,11-12, 14-35
P,X	GB 2345866 A (ROVER GROUP LIMITED), 26 July 2000 (26.07.00), whole document -----	1,8-9,11-12, 14-22,29-30, 34-35

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE01/00934

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet.

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest.
 No protest accompanied the payment of additional search fees.

Considering the background art in this technical field, i.e. it is known to separate a component of a gas selectively by the use of a membrane, the independent claims 1, 11, 21, 22 and 34 do not have any special technical feature within the meaning of PK 16 S. Hence, there is no special technical feature in common linking following 7 groups of inventions regarding:

- I construction of a separation/reduction device (claim 2-7, 23-28 and 31-33)
- II membrane separation of NO_x (claim 10 and 13)
- III recirculation of the separated gas component to the engine (claim 8-9 and 29-30)
- IV membrane separation of water (claim 12)
- V incorporation of a turbo charger in the system (claim 14)
- VI injection and controlling of reducing agent (claim 15-18)
- VII the engine (19-20)

INTERNATIONAL SEARCH REPORT
Information on patent family members

02/07/01

International application No.

PCT/SE 01/00934

Patent document cited in search report			Publication date	Patent family member(s)		Publication date
DE	19713633	C1	28/01/99	EP	0868938 A	07/10/98
				US	6015483 A	18/01/00
DE	19654977	A1	10/06/98	DE	19648219 C	12/11/98
DE	19837505	C1	30/12/99	NONE		
DE	4342297	A1	22/06/95	NONE		
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DE	4331508	C1	20/10/94	NONE		
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				GB	9928626 D	00/00/00