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## (54) Gas mixing device particularly for internal-combustion engines equipped with exhaust gas recirculation system

(57) The present invention relates to a device for mixing exhaust gases with intake fresh air of an internal-combustion engine equipped with exhaust gas recirculation system (EGR).

The device according to this invention allows the fragmentation of the flow of the recirculated exhaust gases, in order to optimize the mixing. The device here claimed solves the problem of the optimization of the two flows with a compact system and in a easy and efficient way; moreover, the device according to this invention is modular, and is easily adaptable to different types of internal-combustion engines.

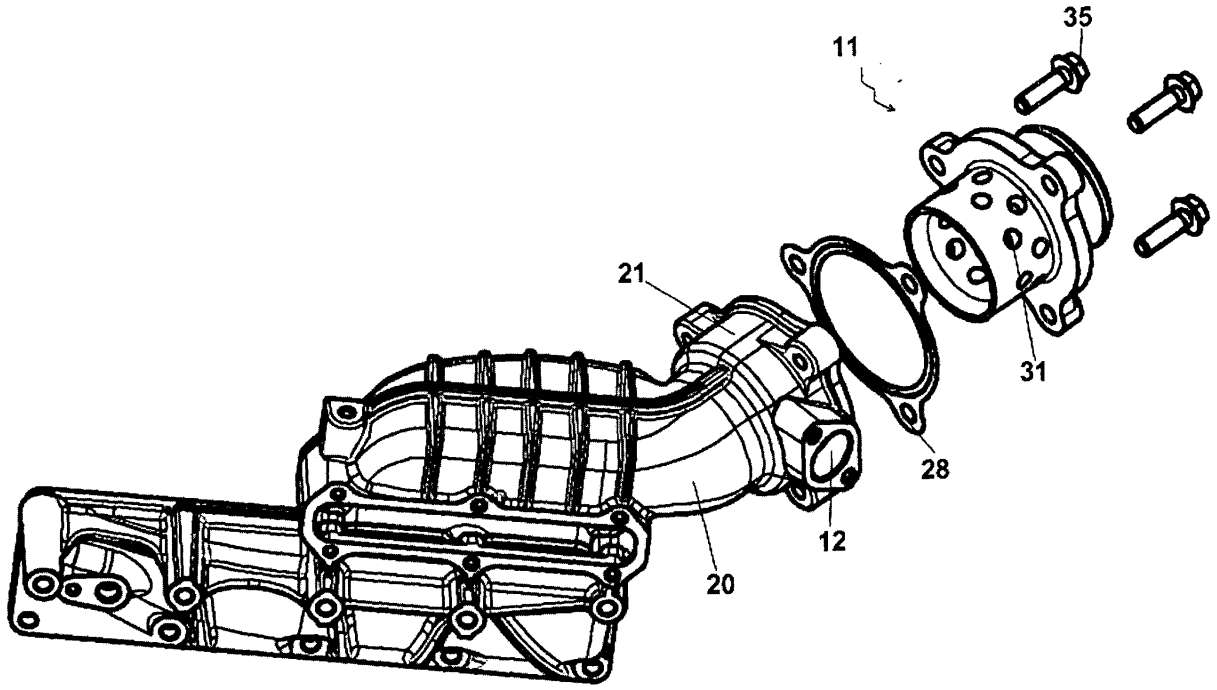


FIG. 1

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## Description

### Application field of the invention

**[0001]** The present invention relates to a device for mixing exhaust gases with intake fresh air of an internal-combustion engine equipped with exhaust gas recirculation system (EGR).

### Description of the prior art

**[0002]** As known in the prior art, in the internal-combustion engines the recirculation of the exhaust gases is necessary for lowering the combustion temperature in a controlled way, in order to obtain the abatement of the pollutant emissions, in particular of the nitrogen oxide.

**[0003]** The exhaust gas recirculation is known in the field with its acronym EGR.

**[0004]** At present, two different architectures are known for the exhaust gas recirculation systems: in the first technology the exhaust gases are withdrawn upstream of the turbine (high pressure loop). In the second technology the exhaust gases are withdrawn downstream of the turbine and are recirculated upstream of the compressor (low pressure loop).

**[0005]** In the first case, the problem is mixing two gases having different pressure and temperature values in the limited mixing length available.

**[0006]** First the exhaust gases to be recirculated are cooled by a heat exchanger, then they are mixed with compressed air and after that they are cooled in a different heat exchanger; the typical temperatures of the two flows are 130-180°C for the gases coming from the exhaust downstream of the exchanger and about 50°C for the gases coming from the compressor downstream of the aftercooler.

**[0007]** Therefore two gases with different composition, temperature and pressure, have to be mixed starting from a determined section of the intake circuit, in order to obtain a mixture as homogeneous as possible.

**[0008]** The pipe which brings the recirculated exhaust gases may be grafted on the intake pipe, so that the speeds of the two flows are perpendicular or parallel and in opposite direction; the mixing of the two flows takes place in the segment of pipe following this graft. The longer is the segment of intake pipe downstream of the graft, the better is the mixing.

**[0009]** In order to have a balanced combustion, the ratio of recirculated gases in the cylinders has to be as uniform as possible; this is obtained by guaranteeing a complete mixing before the introduction in every intake pipe of each cylinder, for this reason, it is necessary to complete the mixing of the gas in the first segment of the intake pipe.

**[0010]** The length of the pipes available for the mixing is usually limited, because of the typical dimensions of the engines.

**[0011]** Mixing devices of exhaust gases with intake fresh air for internal-combustion engines equipped with EGR system are known in the art.

**[0012]** For example US2003/0226552-A1 shows a device for mixing the exhaust gases which comprises a main body having an inlet for the recirculated exhaust gases and an inlet for the intake fresh air, and which is shaped as to split the flow of the recirculated exhaust gases coming into the device, in order to obtain the mixing of the intake fresh air flow with a plurality of distinct recirculated exhaust gas flows. The two fluids, the recirculated exhaust gases and the intake fresh air, have a substantially perpendicular direction, and the mixer has a substantially cylindrical shape with two segments having different internal diameter, and has a plurality of holes which put into communication an hollow space where the gases are conveyed with the axial pipe where the intake fresh air moves. Through these holes, the recirculated gases are put into communication with the intake air flow in radial direction. The described solution causes an excessive counterpressure when discharging which increases the fuel consumption.

**[0013]** DE-4420247-A1 shows a mixer ring for mixing the exhaust gases with the intake air of an engine, using a Venturi tube placed immediately downstream of the throttle valve integrated in the mixer ring segment. This solution, however, causes the slowing down and the vorticity of the airflow upstream of the mixing point, with a consequent drop of the intake pressure and increase of fuel consumption.

**[0014]** These systems of the type known carrying out gas mixing in EGR systems may be improved in terms of gas mixing efficiency in the short segment of intake pipe available. In particular, in the EGR engines for automobiles or for heavy vehicles intended to transport goods and/or passengers, the engine is of reduced dimensions, therefore the segment of the intake pipe wherein the mixing of the recirculated exhaust gases may take place is very short, which results in a nonuniform gas mixing at the inlet of the cylinders.

### Summary of the invention

**[0015]** The primary task of this invention is to provide a gas mixing device of improved efficacy.

**[0016]** A further purpose of the present invention is to provide a compact mixing device, as to engage a short segment of the intake pipe and to keep the dimensions of the engine reduced, which is also modular and easily usable in the geometries of the intake pipes.

**[0017]** This task and these and other purposes that are explained below are achieved by a mixing device particularly for mixing the recirculated exhaust gases with the intake air in an EGR system of an internal-combustion engine, comprising: a main body having an inlet for said recirculated exhaust gases substantially perpendicular to an inlet for the intake fresh air; means suitable to split the flow of the recirculated exhaust gases coming into the device as to obtain the mixing of the intake fresh air

with a plurality of distinct recirculated exhaust gas flows; **characterized in that** it comprises an internal shape suitable to realize an inverted Venturi tube, provided with two internal segments with different slope, the segment with the lower slope placed in the direction of said inlet for fresh air, and the segment with higher slope placed in the direction of the output of said mixing.

**[0018]** The present invention relates in particular to a mixing device of exhaust gases with intake fresh air of an internal-combustion engine equipped with exhaust gas recirculation system, as described more fully in the claims, which are an integral part of the present description.

Brief description of the Figures

**[0019]** Further characteristics and advantages of this invention will become clear from the following detailed description, that is merely illustrative and not limitative and is shown in the figures that are attached hereto, in which:

figure 1 shows an axonometric exploded view of the mixing device according to the present invention, associated to a generic intake pipe of an internal-combustion engine;
figure 2 shows a longitudinal section of the device according to the present invention, assembled and connected to an intake pipe, wherein the directions of the flows of fresh air and recirculated gas are indicated;
figure 3 shows a cross section A-A of the device according to the present invention, wherein the direction of the recirculated gas is indicated by arrows.

Detailed description of preferred embodiments of the invention

**[0020]** According to a preferred embodiment of the present invention shown in the figures, the mixing device of recirculated gases with intake fresh air coming from outside comprises a main body 11 suitable for being firmly connected to a flange 21 of an intake pipe 20, which may be shaped in any way.

**[0021]** The mixing device is preferably embodied having a main body made of metal cast in a single piece, and is provided with through holes 31 on its circumference, with an internal surface suitable for generating a Venturi effect, therefore comprising a constriction area 13a on the intake air side, followed by an expansion area 13b on the output side of the mixture air/exhaust gas, at the inlet of the intake pipe 20.

**[0022]** There is an intake manifold 12 of the recirculated gas (GAS arrow), which opens on an internal chamber shaped as an enveloping ring 15 on the external part of the mixing device.

**[0023]** The holes are placed in the area approximately corresponding to the minimum section of the mixing device, in order to facilitate the passing of the exhaust gases through the holes. Preferably the holes 31 are such that they create a perforated surface which is approximately equal to the surface of the intake manifold 12 in order to obtain a large enough area for the passing of the gas.

**[0024]** Therefore the Venturi effect increases the speed in the segment downstream of the holes, where the pressure decreases, and it generates a depression, which facilitates the gas intake.

**[0025]** Moreover, a vorticity is generated downstream, favouring the mixing. This effect is particularly and effectively due to the fact the Venturi tube is inverted, namely with the longer side having lower slope 13a upstream, on the air intake side 14, while the shorter side with higher slope 13b is downstream, on the intake manifold input side 20.

**[0026]** The higher taper downstream increases the turbulence effect in the most appropriate point, where the exhaust gases have to mix with air, increasing the efficacy of the mixing. Upstream, on the contrary, the lower taper facilitates the increase of the air speed, hindering as less as possible its intake and therefore reducing the counterpressure upstream. In a non limitative example, the taper ratio may be equal to about 3.

**[0027]** Taking as a reference the direction of the intake air flow indicated by the arrow AIR in figure 2, the air coming into the device 10 first passes through the segment with the lower taper 13a, and then through the second segment with the higher taper 13b.

**[0028]** In the central part of the mixing device there is a flange enlargement 25 suitable to beat against the flange 21 of the intake pipe itself, and to be fixed there, for example with screws 35, possibly with a seal 28 placed in-between. The mixing device enters, at least in part, the flange 21.

**[0029]** The mixing device according to the present invention has an hollow space 15 in the area of the holes 31, between the external surface of the central segment of the main body 11 and the internal surface of the flange 21.

**[0030]** The inlet 12 for the recirculated exhaust gases may be duly made up of a substantially cylindrical pipe, according to figures 2 and 3, the axis of said cylindrical pipe 12 being substantially perpendicular to the longitudinal axis of the mixing device.

**[0031]** Also with reference to figure 2, the recirculated exhaust gases reach the mixing device 10 through the exhaust gas intake pipe 12 following the direction indicated by the arrow GAS in the figure.

**[0032]** According to this invention, the mixing device functions as follows.

**[0033]** When the device is assembled, it is placed upstream of the intake manifold 20 and receives the intake fresh air flow from outside according to the direction shown by the arrow AIR in figure 2, namely according to a direction parallel to the longitudinal axis of the device, which therefore corresponds to the axial direction of the cylindrical pipes segments of the device. The intake air

axially enters the device passing through the first cylindrical segment 13a of the device 10 and goes on towards the intake manifold 20.

**[0034]** The recirculated gases enter the device in correspondence of the inlet 12, with a flow direction substantially perpendicular to the axial direction, that is with a radial direction, according to what is indicated by the arrow GAS of figure 2. The incoming recirculated gas flow runs into the wall of the cylindrical ring 31 which deviates it along a direction tangent to said external wall, according to what shown in figure 3. Therefore the recirculated gas flow entering the device from the intake pipe 12 splits up as shown in figure 3 following the direction tangent to the external wall, clockwise and counter clockwise in a symmetrical way, as a consequence of the symmetry of the device. The recirculated gas are sucked through the holes 31 by the depression created by the intake fresh air, therefore the gases pass through the hollow space 15 to the cylindrical pipe 14 and mix with the intake fresh air.

**[0035]** The plurality of passages 31 guarantees a more uniform mixing compared to a single inlet. The mixture obtained this way goes out from the device 10 and enters the intake manifold 20.

**[0036]** Therefore it has been shown that the mixing device according to this invention achieves the purpose and the objects proposed.

**[0037]** In particular, it has been shown that the device according to this invention allows an optimization of the mixing of exhaust gases with fresh air going into the intake pipes.

**[0038]** More in detail, the device according to the present invention allows the fragmentation of the flow of the recirculated exhaust gases, obtaining a turbulence that enhances the mixing. Moreover, this solution allows to reduce the counterpressure necessary to the discharge and also the drop of the intake pressure, solving the drawbacks affecting the solutions known in the art described above.

**[0039]** Also, the mixing device according to this invention achieves the purpose of providing a very compact and modular device, suitable for being used on various types of engine, thanks to its easy connection with the intake manifold. Therefore the device allows to solve in an extremely easy way the problem of the mixing of the recirculated gases engaging a very short segment of pipe.

**[0040]** It will be apparent to the person skilled in the art that various modifications can be conceived and reduced to practice without departing from the scope of the invention.

**[0041]** Therefore, the scope of the claims is not limited to the illustrations or the preferred embodiments shown in the description as an example, but rather the claims include all the patentable novelties deriving from the present invention, including all the equivalent embodiments for a person skilled in the art.

## Claims

1. Mixing device particularly for mixing recirculated exhaust gases with intake air in an EGR system of an internal-combustion engine, comprising:

   a main body (11) having an inlet (12) for said recirculated exhaust gases substantially perpendicular to an inlet (14) for intake fresh air;
   means suitable to split the flow of the recirculated exhaust gases incoming in said device, in order to obtain the mixing of the intake fresh air flow with a plurality of distinct recirculated exhaust gas flows;

   **characterized in that** it comprises an internal configuration suitable to realize an inverted Venturi tube, provided with two internal segments with different slope, with a segment having lower slope (13a) in the direction of said inlet (14) for fresh air, and a segment having higher slope (13b) in the direction of the output of said mixing.

2. Mixing device according to claim 1, wherein the junction of said segments with higher and lower slope creates an area with minimal internal diameter, where there is a plurality of holes (31) suitable to put into communication said inlet (12) for said exhaust gas with the internal part of the mixing device, in order to allow the intake and the mixing of said exhaust gases.

3. Mixing device according to claim 2, wherein said main body (11) is suitable for being firmly connected to a flange (21) of an intake pipe (20) of an engine, said main body entering at least in part said flange, as to form a ring chamber (15).

4. Mixing device according to claim 3, wherein said inlet (12) for said exhaust gases opens on said enveloping ring chamber (15) in the external part of the mixing device, in correspondence of the minimal internal diameter.

5. Mixing device according to claim 2, wherein said holes (31) are such that they create an overall perforated surface equal to approximately the surface of the intake manifold (12) for said exhaust gases.

6. Mixing device according to any of the previous claims, whose main body is made of metal cast in a single piece.

7. Internal-combustion engine provided with a circuit for the exhaust gas recirculation, comprising a mixing device according to one or more of the previous claims.

**8.** Vehicle comprising an internal-combustion engine provided with circuit for the exhaust gas recirculation according to the previous claim.

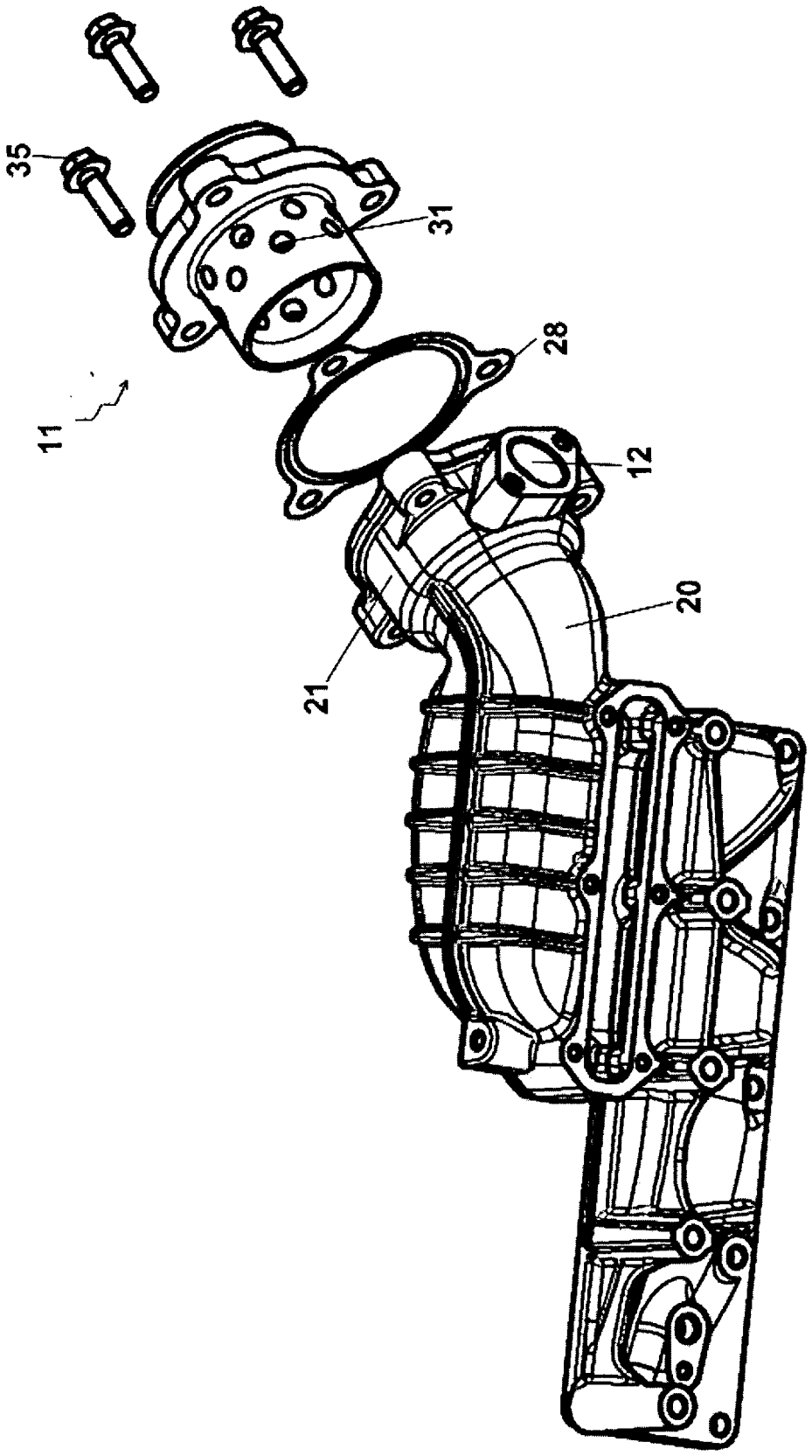


FIG. 1

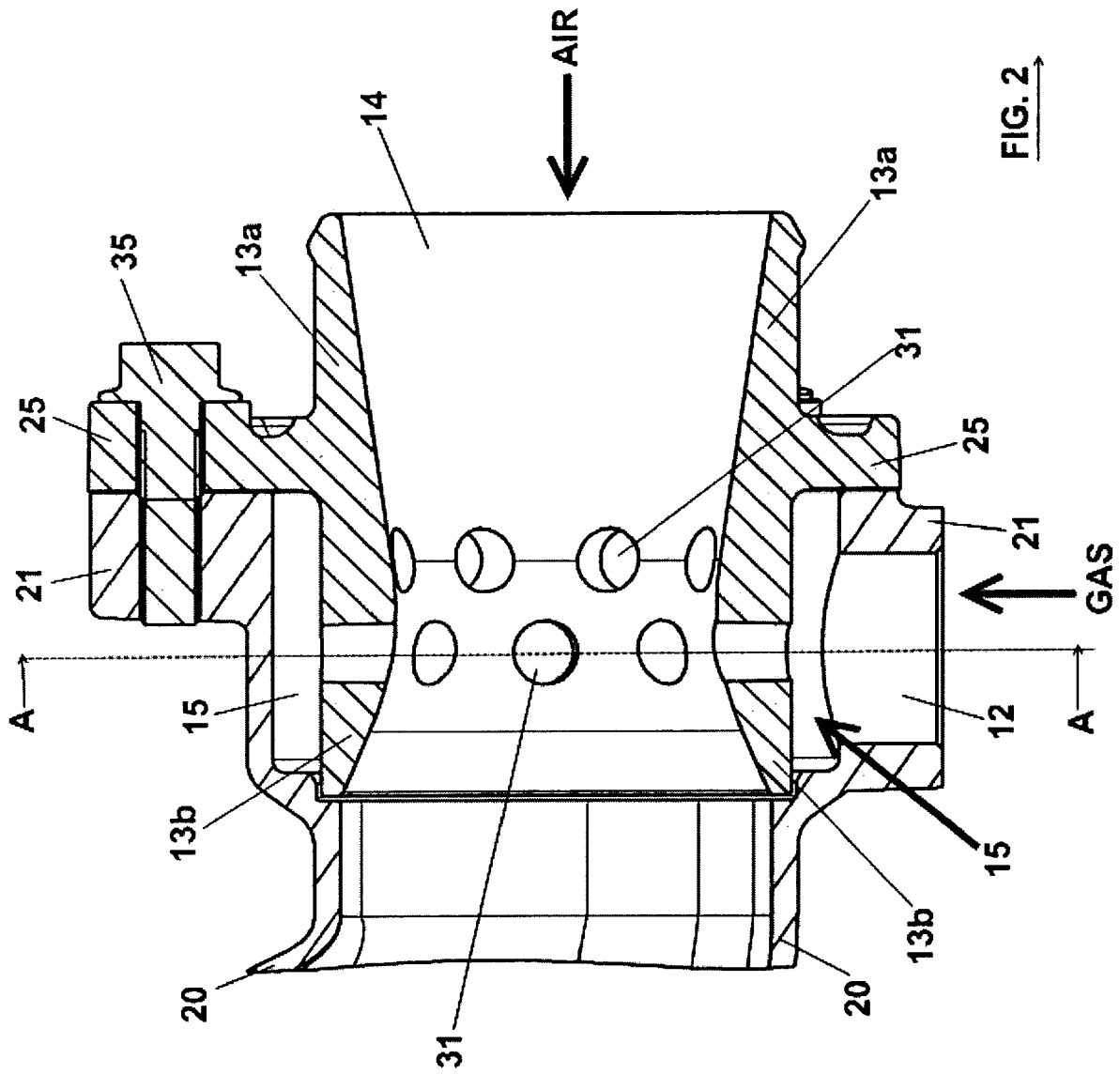


FIG. 2

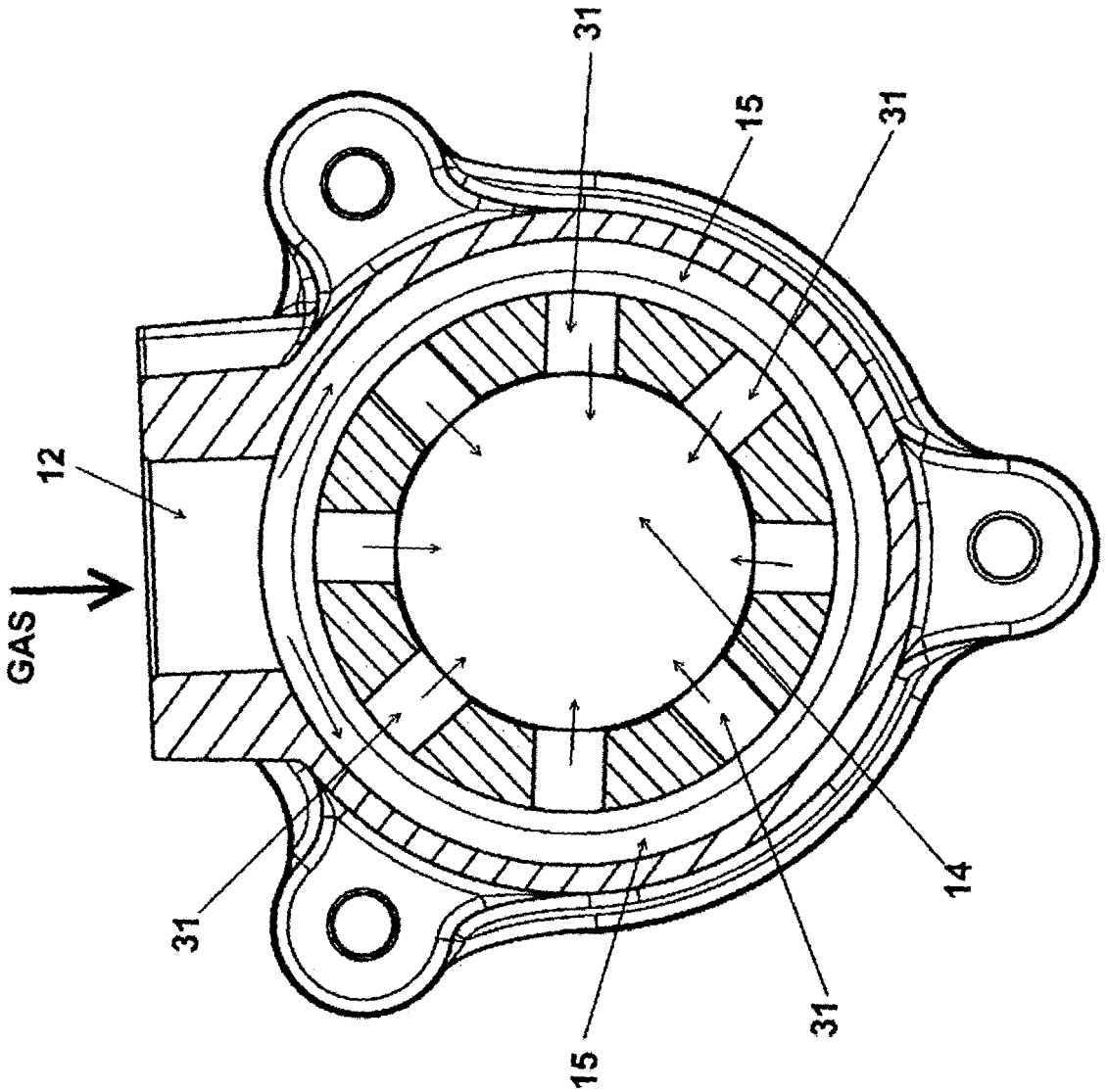


FIG. 3

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# EUROPEAN SEARCH REPORT

Application Number
EP 09 42 5125

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
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The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 8 September 2009 | Marsano, Flavio |

CATEGORY OF CITED DOCUMENTS

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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 42 5125

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## REFERENCES CITED IN THE DESCRIPTION

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