Title: GAS TREATMENT APPARATUS

(57) Abstract: The invention relates to a gas treatment apparatus (1) for treating a gas stream. The gas treatment apparatus (1) comprising addition means (14) for adding a reducing agent (12) to a gas stream passing through the apparatus (1), a guide chamber (8), a mixing conduit (18) and a catalytic treatment chamber (16) containing a catalytic treatment element (20). The apparatus (1) is arranged such that gas must pass through the mixing conduit (18) to pass from the guide chamber (8) to the catalytic treatment chamber (16). The mixing conduit (18) includes an outer wall (22) surrounding a mixing axis (20) within the guide chamber (8). The outer wall (22) including at least one apertures (30) through which gas can enter the mixing conduit (18) from the guide chamber (8). The at least one aperture includes guide means (32) associated therewith for causing at least some of a gas passing through the at least one aperture (30) to flow circumferentially about the mixing axis (20) within the mixing conduit (18) before entering the catalytic treatment chamber (16).
Published:

- with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
Gas Treatment Apparatus

The present invention relates to gas treatment apparatus and, in particular, to gas treatment apparatus for treating the exhaust gases from a diesel engine of a vehicle. The invention extends to a vehicle equipped with such gas treatment apparatus.

Diesel engine exhaust gases contain a number of noxious gases, such as nitrogen oxides, sulphur oxides and carbon oxides, as well as un-burnt hydrocarbons, carbon and other particles. Some of these compounds can be treated so as to render them less obnoxious.

It is therefore common practice to pass the exhaust gases through one or more treatment elements such as catalytic converters and filters. The exhaust gases can be subjected to reduction of nitrogen oxides to nitrogen by injecting a reducing agent, typically urea dissolved in water, into the gas stream and then passing it through a catalytic treatment element to convert residual ammonia from the urea to nitrogen and water, which are acceptable exhaust emissions. This process is known as Selective Catalytic Reduction (SCR). In practice, the efficiency of the process is partly dependent upon the quality of the mixing of the reducing agent and gas before the mixture enters the catalyst.

Such a technology may also be combined with other technologies such as catalysed Diesel Particulate Filters, CRT™ (Continuously Regenerating Trap) technology or other treatment methods to further reduce undesirable emissions from diesel engines.
To ensure acceptable mixing of the reducing agent and gas stream a mixing region of the gas treatment apparatus can be large and therefore have a long residence time during which mixing and chemical breakdown of the urea-water solution can occur.

It is an object of the present invention to address some of the above issues.

According to the present invention there is provided a gas treatment apparatus for treating a gas stream, the gas treatment apparatus comprising addition means for adding a reducing agent to a gas stream passing through the apparatus, a guide chamber having an end wall, a mixing conduit within which the addition means are located and a catalytic treatment chamber containing a catalytic treatment element, wherein:

the mixing conduit has a smaller cross sectional area for gas flow than the catalytic treatment chamber and guide chamber such that, in use, gas flows faster within the mixing conduit than in the catalytic treatment chamber and guide chamber, the mixing conduit extends through the end wall from the guide chamber to the catalytic treatment chamber and the apparatus is arranged such that gas must pass through the mixing conduit to pass from the guide chamber to the catalytic treatment chamber;

the mixing conduit extends into the guide chamber and includes an outer wall surrounding a mixing axis therein;

the outer wall includes at least one aperture through which a gas can enter the mixing conduit from the guide chamber, the at least one aperture including guide means
associated therewith for causing at least some of a gas passing through the at least one aperture to flow circumferentially about the mixing axis within the mixing conduit;

the gas treatment apparatus being arranged such that, in use, gas flowing through the apparatus passes from the guide chamber into the mixing conduit and it is caused to accelerate and to flow circumferentially around the mixing axis is mixed with reducing agent as the rotating gas flow passes along the mixing conduit and the rotating mixed gas flow leaving the mixing conduit expands radially and slows as the cross sectional area for gas flow increases.

Positioning at least a portion of the mixing conduit within the guide chamber and including at least one aperture in the outer wall of the mixing conduit within the guide chamber causes gas to enter the mixing conduit substantially radially. In this case, the term ‘radially’ means that the gas must have a component of its flow velocity towards the mixing axis. It should be understood that the flow velocity could also include radial or axial components with respect to the mixing axis as the gas enters the gas treatment apparatus. The radial entry of the gas into the mixing conduit allows simple guide means to cause at least some of the gas to flow substantially circumferentially. The term ‘circumferentially’ means that the gas has a component of its flow velocity circumferentially around the mixing axis. It should be understood that the gas may still include an axial component to its motion so that the gas moves through the mixing conduit. Simple guide means are easy to construct and may have a low resistance to gas flow which enables a reduction in the pressure drop across the gas treatment
apparatus caused as a gas stream flows through the apparatus. The reduction in pressure drop may increase the torque output of an engine to which the gas treatment apparatus is coupled. The circumferential flow, or swirl, of the gas within the mixing conduit increases turbulence within the gas which promotes mixing of the gas and reducing agent as the mixture passes along the mixing conduit.

By locating the addition means within the mixing conduit and having the rotating gas stream expand radially after leaving the mixing conduit the requirements for providing satisfactory mixing and satisfactory distribution of the mixture in downstream chambers are effectively de-coupled. This means that the mixing parameters or the flow distribution parameters can be altered substantially without affecting the other. This can be achieved because the rapidly rotating gas flow is turbulent and this promotes rapid mixing, but the turbulent flow through the mixing conduit has an overall flow pattern which is rotating about a mixing axis. This rotating overall flow pattern causes the gas exiting the mixing conduit to expand rapidly radially and therefore distribute the gas across the downstream chamber.

The guide chamber of the apparatus may be a conduit from an inlet into the apparatus, or from an upstream treatment chamber to the mixing conduit. In the guide region it is possible that no treatment is performed on a gas passing therethrough. The guide chamber may comprise means for removing particulates such as a filter, performing a catalytic treatment on a gas, or attenuating noise that may be generated as a gas flows through the apparatus, or transmitted by the gas flow. Gas may enter the guide chamber
a any angle, for example axially or radially.

The catalytic treatment chamber contains a catalytic treatment element that preferably catalyses a reaction between a gas stream passing through the apparatus and the reducing agent added such that NOx in the gas stream is converted to N2 and water. The preferred reducing agent is a urea in water solution and this is preferably added through an injector into the gas stream. The reducing agent is preferably injected so that at least some of the reducing agent reaches the rapidly swirling gas flow near the wall of the mixing conduit as this results in more efficient mixing. Such an arrangement can be achieved in many ways, for example using a central injector injecting radially, or one or more injectors arranged adjacent the wall of the mixing conduit injecting reducing agent substantially axially. It should be noted that the catalytic treatment element may any other catalytic treatment element, for example it may act as a hydrolysis catalyst.

Although it is preferred that the mixing conduit discharges directly into the catalytic treatment chamber it should be understood that the apparatus may include other chambers between the mixing conduit and the catalytic treatment chamber. Gas must still flow through the mixing conduit to pass from the guide chamber to the catalytic treatment chamber, but may additionally have to pass through other chambers. It should be understood that no further mixing is required in these chambers as the gas and reducing agent leaving the mixing conduit are substantially well mixed.

It is preferred that the mixing conduit, catalytic treatment
chamber, and guide chamber have substantially circular cross sections as this facilitates manufacture and reduces the likelihood of damage to the apparatus at weak spots that may occur at corners of the apparatus. It should be understood that the cross section of one or all of the sections mentioned above may not be circular, for example one or more may have elliptical cross sections, or other shapes depending upon the desired final use and location of the apparatus.

The outer wall of the mixing conduit preferably includes a plurality of apertures through which gas may flow, and each of which includes a guide means that causes at least some of the gas passing through the aperture to flow substantially circumferentially. All the guide means preferably cause the gas to flow circumferentially in the same direction about the mixing axis. It should be understood that there may be additional apertures through the outer wall of the mixing conduit which do not include guide means and, in this case, a circumferential flow of gas about the mixing axis would be created by the guide means provided.

If a plurality of apertures are provided through the outer wall of the mixing conduit, it is preferred that the apertures are substantially equally circumferentially spaced as this helps to maintain a substantially equal distribution of gas flow within the guide chamber and mixing conduit and this may help to avoid poor distribution of the reducing agent within the gas stream.

The guide means may be any size, shape or configuration but are preferably formed integrally with the outer wall rather than formed separately and then attached. A deflection wall
which is angled such that at least some of a gas passing substantially radially through the aperture is deflected by a surface of the deflection wall and caused to flow substantially circumferentially is preferred due to the simplicity in construction and low pressure drop of such a design.

The apertures are preferably substantially rectangular and are preferably arranged such that a long axis of the rectangular aperture is substantially parallel with the mixing axis.

The apertures and guide means can be formed in a plurality of different ways. An embodiment of the aperture and guide means is a “louver” design which comprises a substantially rectangular aperture with a substantially rectangular deflection wall attached to a long edge of the aperture. A mixing conduit having such an embodiment can be readily fabricated using sheet metal, the sheet metal being stamped such that three of the sides that will define the rectangular aperture are cut (in a preferred example, two short sides and one long side) and the resulting flap of metal is bent so that the aperture is opened, the folded edge of the flap defines the aperture together with the three cut sides and the flap is arranged to form a deflection wall. A plurality of such apertures and deflection walls are formed in the sheet and the sheet is then rolled to form the outer wall of the mixing conduit. The seam where two ends of the sheet meet may then be welded to form the mixing conduit.

Other examples of aperture and guide means include a “twisted ribbon” design and an “out of plane” design. In the “twisted
ribbon” design two slits are made through the wall of the mixing conduit. The slits are preferably made such that they are substantially parallel with the mixing axis and have a substantially equal length. The two slits define two sides of a ‘ribbon’ of material which is attached to the wall of the mixing conduit at each end. To create the guide means and aperture the ribbon is twisted by forcing a first side of the ‘ribbon’ into the mixing conduit and a second side of the ribbon out of the conduit, simultaneously opening an aperture through the wall and creating guide means.

The “out of plane” design is based on the “louver” design. Two adjacent sets of cuts through the wall of the mixing conduit are formed such that the resulting deflection walls are attached to adjacent long edges of the two apertures. One deflection wall is bent into the mixing conduit and one out of the mixing conduit.

The deflection walls can be curved or otherwise shaped to aid in the deflection of gas in the required direction. It should be understood that the deflection walls and apertures can be formed in a variety of other ways, which may include, for example, separate fabrication of deflection walls and subsequent attachment to the mixing conduit wall. It should be understood that the apertures may have any suitable shape.

The guide chamber and catalytic treatment chambers may be separate chambers, joined by an elongate mixing conduit, or the two chambers may have a common outer wall and a gas be prevented from passing from the guide chamber to the catalytic treatment chamber by a wall through which the mixing conduit passes. Such a wall is preferably
substantially perpendicular to a chamber axis around which the common outer wall extends, but may be at any suitable angle.

5 The mixing conduit has a smaller cross sectional area for gas flow than the catalytic treatment chamber. This allows the swirling gas flow from within the mixing conduit to expand radially upon entry into the catalytic treatment chamber. This slows the rotation of the gas flow and since the cross sectional area for flow is increased, the axial speed of the gas flow is also reduced which allows a longer residence time within the apparatus. The catalytic treatment chamber may include an entry portion located between the mixing conduit and the catalytic treatment element. This allows gas leaving the mixing conduit to disperse across the entire cross section of the catalytic treatment chamber before entering the catalytic treatment element. This radial dispersal reduces the rotational velocity of the gas stream which reduces the pressure loses associated with a rapidly rotating gas flow entering a catalytic treatment element.

The mixing conduit has a smaller cross sectional area for gas flow than the guide chamber. This means that the average gas speed is increased as a gas stream flowing through the apparatus passes from the guide chamber to the mixing conduit. The increased gas speed is both axial and circumferential and this results in greater turbulence within the mixing region and therefore more efficient mixing.

30 In a particularly preferred embodiment the guide chamber, mixing conduit and catalytic treatment chamber have substantially circular cross sections and are therefore
substantially cylindrical in shape, with the mixing conduit have a smaller diameter than the guide chamber and catalytic treatment chamber. It is preferred that the portion of the mixing conduit within the guide chamber is substantially co-axial with guide chamber and that the exit from the mixing conduit is substantially co-axial with the downstream chamber into which the rotating gas flow passes. This facilitates control of the distribution of the mixed gas flow across the cross section of downstream chamber and catalytic treatment element.
The invention will now be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows a schematic view of a gas treatment apparatus;

Figure 2 shows a cross section through a portion of an embodiment of gas treatment apparatus according to the invention;

Figure 3 shows a detailed view of an aperture of Figure 2;

Figure 4 shows the cross section of Figure 2 including arrows indicating gas flows;

Figure 5 shows a cross section through a mixing conduit and illustrates the possible path of reducing agent;

Figures 6, 7, 8 and 9 show possible arrangements of gas treatment apparatus according to the invention; and

Figures 10, 11 and 12 show cross sections through possible guide wall and aperture arrangements.

Figure 1 shows a schematic representation of a gas treatment apparatus 1 having an inlet 2, an outlet 3 and a surrounding wall 4. It should be understood that, although the surrounding wall is shown as a single wall, it may be formed from two or more wall sections welded or coupled together. Arrows 6 show the direction of gas flow through the apparatus.
1. Gas enters the apparatus 1 through the inlet 2 and enters a guide chamber 8. The guide chamber 8 guides gas towards a mixing region 10 in which a reducing agent 12 is added to the gas stream using addition means 14 and in which the gas and reducing agent 12 are mixed. Upon leaving the mixing region 10, the gas enters a catalytic treatment chamber 16 comprising an entry portion 17 and a catalytic treatment element 20. The catalytic treatment element 20 includes a catalyst that catalyses a reaction between at least one chemical within the gas stream and the reducing agent 12. The gas leaving the catalytic treatment element 20 then exits the apparatus 1 through the outlet 3.

Although the inlet 2 and outlet 3 are shown in Figure 1 as having a smaller diameter than the surrounding wall 4 of the apparatus 1, it should be understood that the inlet 2 and outlet 3 may be any suitable size or shape. It should also be understood that the gas passing through the inlet 2 may already have undergone one or more gas treatments, for example filtration, a catalytic treatment, or other treatment.

Figure 2 shows a cross section through the gas treatment apparatus shown in Figure 1. This Figure shows the mixing region 10, an end of the guide chamber 8 and a start of the catalytic treatment chamber 16.

The mixing region 10 includes a mixing conduit 18 which includes an outer wall 22 that surrounds a mixing axis 20 and an endwall 24. The outer wall 22 extends into the guide chamber 8. The addition means 14 extends through the surrounding wall 4 and through the endwall 24 of the mixing
conduit 18 so that outlets 26 from the addition means 14 are arranged such that reducing agent 12 is injected into the gas stream substantially radially outwardly from the mixing axis 20. In this case there are ten outlets 26 substantially equally circumferentially distributed around an outlet end 20 of the addition means 14. It should be understood that any suitable number of injector outlets may be used and injection may occur in directions other than radially.

The mixing conduit 18 also includes apertures 30 through the outer wall 22 through which gas from the guide chamber 8 can enter the mixing conduit 18. In this example the endwall 24 includes no apertures, and prevents gas from entering the mixing conduit without passing through the apertures 30 in the outer wall 22. It should be understood that the endwall 24 may also include apertures.

Guide means 32 are associated with each of the apertures 30. The guide means 32 (in this case guide walls 34) cause at least some of the gas passing through the apertures 30 to flow circumferentially around the mixing axis 20. The guide means 32 and apertures are better shown in Figure 3.

The guide chamber 8 and catalytic treatment chamber 16 are separated by a wall 13 through which the mixing conduit 18 passes. The wall 13 is, in this case, both the end wall of the guide chamber 8 and the catalytic treatment chamber 16.

Figure 3 shows a detailed view of the apertures 30 of Figure 2. The aperture 30 is rectangular having long sides 36 and short sides 38. The long sides 36 are substantially parallel with the mixing axis 20. The guide means 32 is a deflection
wall 34 that extends from a long side 36 of the aperture 30 into the mixing conduit 18.

Gas passing from the guide chamber 8 into the mixing conduit 18 through the aperture 30 may contact the deflection wall 34 and be deflected so that it moves substantially circumferentially around the mixing axis 20. The deflected gas from the apertures 30 cause the gas flow within the mixing conduit 18 to swirl or rotate about the mixing axis 20 which increases turbulence and therefore promotes mixing.

The deflection wall 34 of Figure 3 is formed by cutting three sides of the aperture 30 and then bending the resulting flap into the mixing conduit to form the deflection wall 34 and the fourth side of the aperture 30.

Figure 4 shows the same view as Figure 3, but includes arrows 6 showing the direction of gas flow. In the guide chamber 8 the gas flow is substantially parallel with the surrounding wall 4. As the gas enters the mixing region 10, the gas is prevented from passing directly to the catalytic treatment chamber 10 by wall 13. The gas is therefore 'funneled' through the apertures 30 and into the mixing conduit 18. As the gas passes through the apertures 30 it contacts the guide means and the gas flow is therefore caused to rotate about the mixing axis 20. Into the rapidly swirling gas stream a reducing agent 12 is added by the addition means 14. The reducing agent 12 and the gas stream mix in the rapidly swirling gas and exit the mixing conduit 18 into the catalytic treatment chamber 16. As the gas leaves the mixing conduit and enters the catalytic treatment chamber 16 the gas slows and the flow expands radially as the diameter of the
catalytic treatment chamber 16 is bigger than that of the mixing conduit 18. The gas is still rotating within the catalytic treatment chamber 16, but slower. The rotation of the gas facilitates the radial expansion of the gas to fill the larger diameter flow path of the catalytic treatment chamber 16.

The deflection wall 34 helps to re-entrain droplets of reducing agent 12 that may form within the mixing conduit. Figure 5 shows a cross section through a mixing conduit 18 and shows reducing agent 12 being added from addition means 14, in this case an injector having 4 substantially radially directed outlets 26. Again, arrows 6 are used to show the direction of gas flow.

Figure 5 shows a droplet 40 of reducing agent on a face 42 of a deflection wall 34 facing an outlet 26. The rapidly swirling gas flow within the mixing conduit 18 moves the droplet 40 towards an edge 44 of the deflection wall 38. The droplet 40 is then entrained in the gas flow as shown by the path 46.

Figures 6 to 9 show different arrangement of gas treatment apparatus. In each case, the different parts of the apparatus that have the same function as in the apparatus 1 shown in Figure 2 will retain their reference numeral, but these will be incremented by 100,200,300 or 400 respectively.

Figure 6 shows a gas treatment apparatus 101 having a similar arrangement to that shown in Figure 1 in that the apparatus 101 is substantially enclosed by a substantially cylindrical surrounding wall 104, with all the chambers 108,116 and
regions 110 arranged in a substantially linear arrangement. In this case the guide chamber, mixing conduit and catalytic treatment chamber are all substantially co-axial with the mixing axis so that the mixing conduit is substantially central within the guide chamber and the outlet from the mixing conduit is substantially central with respect to the catalytic treatment chamber.

Figure 7 shows a gas treatment apparatus 201 having a arrangement to Figure 6, except that the mixing axis 220 along which a portion of the mixing region 218 extends is arranged substantially perpendicular to the surrounding wall 204 and a bend 50 in the mixing conduit 218 redirects the swirling gas flow towards the catalytic treatment chamber 216.

Figure 8 shows a gas treatment apparatus 301 having a twin tube arrangement. The guide chamber 308 and catalytic treatment chamber 316 are separate chambers linked by a transfer conduit 52 that extends from the mixing conduit 318 into the catalytic treatment chamber 316. The mixing axis 320 extends substantially perpendicular to a central axis of the guide chamber 308. In the gas treatment apparatus 301 the gas flows through the guide chamber 308 substantially parallel with the central axis of the guide chamber 308 and then enters the mixing conduit 318 and is caused to swirl.

The swirling gas flows through the mixing conduit 318 and then into the transfer conduit 52. The transfer conduit 52 directs the gas into the catalytic treatment chamber 320 where the gas decelerates before entering the catalytic treatment element 320. In this arrangement, the gas flow
through the catalytic treatment chamber 316 in a direction opposite to that in which the gas flows through the guide chamber 308. It should be understood that this need not be the case, the transfer conduit 52 could include bends to redirect the gas and/or the catalytic treatment chamber 316 could be orientated in a different direction.

Figure 9 shows a gas treatment apparatus 401 which has substantially the same arrangement as the gas treatment apparatus 301 in Figure 8. In this case, the transfer conduit 152 includes a bend 54 within the catalytic treatment chamber 416 to redirect the gas stream towards the catalytic treatment element 420. In this case, the outlet of the mixing conduit is substantially centrally located with respect to the catalytic treatment chamber.

Figure 10 shows a cross section through a guide wall and aperture 70 according to a “twisted ribbon” design. The cross section is taken so that only half the aperture and guide wall 70 is shown so that the structure can be more easily understood. The guide wall and aperture 70 is formed by two parallel slits 72 which define a ribbon 74 therebetween. The ribbon 74 is twisted and deformed such that a leading edge 76 is raised out of the mixing conduit and a trailing edge 78 is within the mixing conduit.

Figure 11 shows a cross section through a guide wall and aperture 170 according to an “out of plane” design. The cross section is taken so that only half the aperture and guide wall 170 is shown so that the structure can be more easily understood. The guide wall and aperture 170 in fact comprise two guide walls 78,80 which are formed in a similar way to
the wall 34 of the louver design shown in Figure 3. The wall 78 is bent so that it extends away from the mixing conduit and the wall 80 is bent so that it extends into the mixing conduit. In this case, both walls 78,80 are curved to direct gas flow. The long edges 136,236 of the walls 78,80 that remain attached to the mixing conduit wall 22 are adjacent.

Figure 12 shows a cross section through a guide wall and aperture 270 according to a “cheese grater” design. The cross section is taken so that only half the aperture and guide wall 270 is shown so that the structure can be more easily understood. The aperture and guide wall 270 is formed by a single slit 82 through the mixing conduit wall 22. A region 84 of the wall 22 adjacent the slit 82 is deformed to form a guide wall 86 that extends into the mixing conduit.

It should be understood that the invention has been described above by way of example only and that modifications in detail may be made without departing from the scope of the invention as described in the claims.
Claims

1. A gas treatment apparatus for treating a gas stream, the gas treatment apparatus comprising addition means for adding a reducing agent to a gas stream passing through the apparatus, a guide chamber having an end wall, a mixing conduit within which the addition means are located and a catalytic treatment chamber containing a catalytic treatment element, wherein:

   the mixing conduit has a smaller cross sectional area for gas flow than the catalytic treatment chamber and guide chamber such that, in use, gas flows faster within the mixing conduit than in the catalytic treatment chamber and guide chamber, the mixing conduit extends through the end wall from the guide chamber to the catalytic treatment chamber and the apparatus is arranged such that gas must pass through the mixing conduit to pass from the guide chamber to the catalytic treatment chamber;

   the mixing conduit extends into the guide chamber and includes an outer wall surrounding a mixing axis therein;

   the outer wall includes at least one aperture through which a gas can enter the mixing conduit from the guide chamber, the at least one aperture including guide means associated therewith for causing at least some of a gas passing through the at least one aperture to flow circumferentially about the mixing axis within the mixing conduit;

   the gas treatment apparatus being arranged such that, in use, gas flowing through the apparatus passes from the guide chamber into the mixing conduit and it is caused to accelerate and to flow circumferentially around the mixing axis is mixed with reducing agent as the rotating gas flow
passes along the mixing conduit and the rotating mixed gas flow leaving the mixing conduit expands radially and slows as the cross sectional area for gas flow increases.

2. A gas treatment apparatus as claimed in claim 1, in which there are a plurality of apertures through the outer wall of the mixing conduit and each aperture includes guide means for causing at least some of a gas passing through the aperture to flow circumferentially about the mixing axis within the mixing conduit.

3. A gas treatment apparatus as claimed in claim 1 or claim 2, in which the mixing conduit has a substantially circular cross section.

4. A gas treatment apparatus as claimed in any preceding claim, in which the catalytic treatment chamber has a substantially circular cross section.

5. A gas treatment apparatus as claimed any previous claim, in which the guide chamber has a substantially circular cross section.

6. A gas treatment apparatus as claimed in any of claims 2 to 5, in which the plurality of apertures are substantially equally circumferentially spaced around the outer wall of the mixing conduit.

7. A gas treatment apparatus as claimed in any preceding claim, in which the guide means comprise a deflection wall, the deflection wall being angled such that at least some of a gas passing substantially radially through the, or each,
aperture is deflected by the deflection wall to flow substantially circumferentially.

8. A gas treatment apparatus as claimed in any preceding claim, in which the, or each, aperture is substantially rectangular.

9. A gas treatment apparatus as claimed in claim 8, in which the, or each, aperture is arranged such that a long axis of the rectangular aperture is substantially parallel with the mixing axis.

10. A gas treatment apparatus as claimed in claim 8 or claim 9, in which the guide means associated with the, or each, aperture comprises a substantially rectangular deflection wall, the deflection wall extending from a side of the aperture into the mixing conduit.

11. A gas treatment apparatus as claimed in any of claims 1 to 6, in which the guide means and aperture in the wall of the mixing region are formed by forming a cut in the wall of the mixing chamber and then deforming a region of said wall adjacent to the cut into the mixing conduit such that an aperture is opened and a guide means formed.

12. A gas treatment apparatus as claimed in any preceding claim, in which the catalytic treatment chamber includes an entry portion located between the mixing conduit and the catalytic treatment element such that a gas leaving the mixing conduit can disperse across the entire cross section of the catalytic treatment chamber before entering the catalytic treatment element.
13. A vehicle having a diesel engine, the vehicle being equipped with a gas treatment apparatus as claimed in any preceding claim for treating the exhaust gas from the diesel engine.
## INTERNATIONAL SEARCH REPORT

**A. CLASSIFICATION OF SUBJECT MATTER**

<table>
<thead>
<tr>
<th>IPC</th>
<th>Classification</th>
<th>Code</th>
<th>Classification Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>F01N3/20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F01N5/04</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F01N3/08</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>IPC</th>
<th>F01N</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

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

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

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>EP 1 262 644 A (NELSON BURGESS LIMITED) 4 December 2002 (2002-12-04) paragraph '0015!' - paragraph '0028!'; figure 1</td>
<td>1-13</td>
</tr>
<tr>
<td>Y</td>
<td>EP 0 555 746 A (MAN NUTZFAHRZEUGE AG; MAN NUTZFAHRZEUGE AKTIENGESELLSCHAFT) 18 August 1993 (1993-08-18) page 6, line 31 - line 51; figures 6,7</td>
<td>1-13</td>
</tr>
<tr>
<td>A</td>
<td>WO 03/036054 A (EMINOX LIMITED; BALL, WILLIAM, FREDERICK; GAULT, ANTHONY, JOHN; HARROD) 1 May 2003 (2003-05-01) page 20, line 4 - page 22, line 24; figures 5-7</td>
<td>1</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of box C. Patent family members are listed in 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 document but published on or after the international filing date
* L* document which may throw doubts on priority claims or which is cited to establish the publication date of another citation or other special reason (as specified)
* O* document referring to an oral disclosure, use, exhibition or other means
* P* document published prior to the international filing date but later than the priority date claimed

**Date of the actual completion of the international search**

6 October 2005

**Date of mailing of the international search report**

13/10/2005

**Name and mailing address of the ISA**

European Patent Office, P.B. 5816 Patentcentrum 2 NL - 2280 HV Rijswijk
Tel: (+31-78) 340-2040, Tx: 31 651 epo nl Fax: (+31-78) 340-3016

**Authorized officer**

Zebst, M
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EP 1438492 A1</td>
<td>21-07-2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB 2381218 A</td>
<td>30-04-2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 03036056 A1</td>
<td>01-05-2003</td>
</tr>
</tbody>
</table>