Abstract: An exhaust diluting and diffusing apparatus includes a first pipe forming a vertically directed outlet for an exhaust conduit and a second diffuser pipe mounted to receive an exhaust gas flow from the outlet of the first pipe, the second pipe having a diameter greater than the diameter of the first pipe to define an ambient air inlet gap surrounding the outlet of the first pipe, and being sufficiently wide to allow the exhaust gas to expand and diffuse in the second pipe. The device further includes a dispersing outlet mounted at an end of the second pipe and configured to direct exhaust gas radially outward, an area defined by the diffuser outlet being greater than an area of the outlet of the first pipe.
Declaration under Rule 4.17:
— of inventorship (Rule 4.17(iv))
## Exhaust Diffuser for a Truck

**Background**

[002] Exhaust treatment devices in trucks require maintenance procedures that can create situations where exhaust temperatures are much higher than during normal use of the vehicle. For example, diesel particulate filters, which trap soot and other particulate matter in the exhaust stream, require a regeneration process to burn off the collected particulate matter. The process requires that the temperature of the exhaust entering the diesel particulate filter be in excess of 600° C. Normal operating exhaust temperature is about 425° C for a diesel engine in a truck.

[003] Exhausting the higher temperature stream to the environment can pose difficulties, particularly for trucks operating in close environments. A truck typically has an exhaust stack pipe rising from the chassis adjacent to the truck cab. High temperature exhaust can produce a hot spot on the truck cab or trailer, or direct hot gases to a building (such as at a loading dock) or an overhanging tree.

[004] What is needed is a device to reduce the exhaust temperature of an internal combustion engine.

**Summary of the invention**

[005] The invention includes an exhaust diffuser, a relatively short, relatively wide stack mounted on an exhaust pipe. The diffuser allows entering exhaust gas and its heat energy to diffuse over the larger volume. The stack induces a buoyancy induced flow that is created by the difference in density between the low density, high energy exhaust flow, and the higher density of the surrounding ambient air. This buoyancy induced flow, or "stack effect", induces a flow of ambient air into the exhaust diffuser, which mixes with hot exhaust gas and cools it.

[006] The invention further includes an outlet formed as axi-symetric louvers mounted at the top of the stack. The louvers include a central diverter to balance the flow distribution radially. The outlet louvers define a greater area than the outlet of the exhaust pipe so also to act as a diffuser. This decelerates the exhaust gas flow as it flows from the outlet which allows it to
readily mix with additional ambient air, which further cools the exhaust gas. The combination of the "stack effect" and "diffuser mixing effect" cool the exhaust gas by an amount that neither would be able to achieve on their own.

[007] The loss in stack effect due to reduced height is countered by the increasing the diameter so as to better utilize the flow energy.

[008] An exhaust diluting and diffusing apparatus in accordance with the invention includes a first pipe forming a vertically directed outlet for an exhaust conduit and a second diffuser pipe mounted to receive an exhaust gas flow from the outlet of the first pipe, the second pipe having a diameter greater than the diameter of the first pipe to define an ambient air inlet gap surrounding the outlet of the first pipe, and being sufficiently wide to allow the exhaust gas to expand and diffuse in the second pipe. The device further includes a dispersing outlet mounted at an end of the second pipe and configured to direct exhaust gas radially outward, an area defined by the diffuser outlet being greater than an area of the outlet of the first pipe.

Brief Description of the Drawings

[009] The invention will be better understood by reference to the following detailed description read in conjunction with the appended drawings, in which:

[010] Figure 1 illustrates an embodiment of an exhaust stack dilution and diffusion element in perspective view;

[011] Figure 2 is an exploded view of the exhaust stack dilution and diffusion element of Figure 1; and,

[012] Figure 3 is a schematic view of the exhaust stack dilution and diffusion element of the invention illustrating certain size relationships.

Detailed Description

[013] The invention relates to devices that are mounted on a truck exhaust system at the point where exhaust gas is released to the surrounding air. In particular, the invention is an apparatus mounted on an exhaust conduit downstream of a diesel particulate filter to diffuse the hot gases
exiting the diesel particulate filter over a wide area. According to another aspect of the invention, structure is provided to dilute exhaust gases with ambient air and diffuse the diluted exhaust gas over a wider area than a typical exhaust stack pipe to prevent hot spots and dissipate heat more quickly.

[014] Figure 1 shows a perspective view of a diluter/diffuser device in accordance with an embodiment of the invention. The device comprises a first pipe 10 that is mountable on an exhaust stack (not illustrated) of a heavy truck. The first pipe 10 may include a reduced diameter fitting 12 that can be inserted into the truck exhaust stack to facilitate mounting of the device. Heavy trucks use a standard 5 inch diameter exhaust pipe, and the invention is readily adapted to fit this standard pipe, but can be adapted to other size exhaust pipes as will be understood.

[015] The first pipe 10 has an exhaust or outlet (not shown in Figure 1; see, outlet 14 in Figure 3) that is disposed inside a second pipe 20 or diffuser. The second pipe 20 has a diameter greater than the diameter of the first pipe 10 to define an inlet gap 22 surrounding the first pipe. The inlet gap 22 allows ambient air to enter the second pipe 20 to mix with the exhaust gas entering the second pipe from the first pipe 10. Exhaust gas and ambient air mix in the second pipe 20 as the gases flow through.

[016] The diffuser 20 is made sufficiently wider than the exhaust outlet of the first pipe 10 so that the entering exhaust gas expands and decelerates in the interior volume of the diffuser.

[017] To cool the exhaust gas, the device in accordance with the invention relies on the buoyancy of the exhaust gas flowing through the second pipe 20 to induce a flow of ambient air into the second pipe. The buoyancy or stack effect is created by the hotter exhaust gases expanding in the second pipe 20 and developing a pressure gradient inducing ambient air into the second pipe. Accordingly, two features of the invention, which will be described further below, include the second pipe 20 being sufficiently wider than the first pipe to allow the exhaust gas exiting the first pipe to expand, and the first pipe 10 and at least a portion of the second pipe 20 being vertically oriented to allow the hot exhaust gas to entrain ambient air via buoyancy effects.

[018] The device of the invention further includes a disperser 50 mounted at the end of the second pipe 20, and configured to direct the mixed exhaust gas and ambient air radially outward. The disperser 50 includes an end cap or end plate 52 having a diverter 54 extending into the gas.
flow to direct the upward flowing gases outward. In the illustrated embodiment, the diverter 54 is a conically shaped protrusion extending from a lower surface of the end plate 52.

[019] An upper edge 24 of the second pipe 20 is flared outward and upward in a frusto-conical profile also to guide flowing gases in the radially outward exiting direction of the diffuser 20.

[020] Turning now to Figure 2, the invention is shown in exploded view to better show some of the details. In Figure 2, only an upper end portion of the first pipe 10 is shown, the rest being omitted for clarity of the illustration. The disperser 50 is shown removed from the second pipe 20. The end plate 52 is shown separated from the disperser 50, also for clarity.

[021] As mentioned, the disperser 50 directs the flow of mixed exhaust gas and ambient air radially outward. The end plate 52 forms a barrier at the axial end of the diffuser and the diverter 54 is provided to help turn the flow from the axial direction to the radial direction. A second diverter 56 is provided to divide the flow and direct a portion of the flow radially outward. In combination, the end plate 52 and second diverter 56 spread or diffuse the flow over a greater outlet area than either would alone. The second diverter 56 is formed as a plate having a central hole 58 to allow a portion of the exhaust and air flow to flow through toward the end plate 52. A lower surface 60 is concave to form a guide turning the flow outward. In the illustrated embodiment, the second diverter 56 has a frusto-conical cross section.

[022] The second diverter 56 is positioned between the upper edge 24 of the second pipe 20 and the end plate 52 of the disperser 50. Referring again to Figure 1, an outlet 62 of the disperser 50 is thus defined as the area between the upper edge 24 of the second pipe 20 and the end plate 52 of the diffuser.

[023] The disperser 50 further comprises a plurality of fins 64 which are vertically and radially oriented with respect to the axial direction of the device, and regularly spaced around the diffuser. The fins 64 extend radially inward from the outlet 62 of the disperser 50. The fins 64 help disperse and diffuse the exhaust flow over the outlet 62 area of the disperser 50. As illustrated, the fins 64 are mounted to and support the second diverter 56, and form a base to support the end plate 52. The fins 64 shown in Figure 2 extend downward through the second pipe 20 and are mounted at their lower ends 66 to an nipper end of the first pipe 10. Alternatively, the lower ends 66 of the fins 64 could be mounted to a collar (not shown), which would in turn be mounted to the upper end of the first pipe 10.
Alternatively, the fins 64 may be configured as shorter, extending between the end plate 52 and the upper edge 24 of the second pipe 20. Brace members (not illustrated) could be provided to mount the first pipe 10 at the inlet of the second pipe 20.

The flow characteristics of the diluter/diffuser of the invention will be described in connection with Figure 3, which shows a schematic view of the device. Figure 3 shows the first pipe 10, an outlet 14 of the first pipe, the second pipe 20 and the disperser 50.

As mentioned, the invention relies on two effects, diffusion of the hot exhaust gases and a buoyancy or stack effect to draw cooling ambient air into the diffuser 20. "Stack effect" is a buoyancy induced flow that is created by the difference in density between a higher temperature, lower density gas (in this case the exhaust gas) and a lower temperature, higher density gas (the ambient air).

The exhaust gas is allowed to expand in the second pipe 20 so as to reduce the heat flux of the gas. This spreads the thermal energy of the hot exhaust gas over a larger area (i.e., the outer surface areas of the diffuser), and decelerates the exhaust flow to a point were it can effectively mix with ambient air.

As is known, a higher temperature, lower density gas will form a plume as it rises through a lower temperature, higher density gas. In buoyant flow, the plume will expand at a constant 15°.

The broken lines 70 in Figure 3 begin at the outer margin of the outlet 14 of the first pipe 10 and are oriented at 15° from the vertical to show the space a buoyant plume forming from hot exhaust gas exiting the first pipe 10 would occupy in the second pipe 20.

Two considerations in specifying the dimensions of the second pipe relative to the outlet of the first pipe are to avoid creating a Venturi-like throat at the ambient air inlet 22, and to have sufficient space in the second pipe to allow the exhaust gas exiting the first pipe to expand to create the buoyancy effect.

The second pipe 20 is configured to be a buoyancy mixing conduit by dimensioning the second pipe to avoid constraining the plume development, so that the cross-sectional area of the exhaust plume is at least as great as the cross-sectional area of the second pipe to induce the ambient air flow. This relationship is illustrated by the relative position of the broken lines 70.
indicating a plume expansion and the outline of the second pipe in Figure 3. Stated in terms of
the diameters of the first pipe 10 and the width of the inlet gap 22, the diameter of the second
pipe 20 is equal to or greater than the diameter of the outlet 14 of the first pipe 10 plus twice the
inlet gap 22 width.

[032] To avoid creating a Venturi-like throat at the second pipe inlet 22, the cross-sectional
area of the second pipe inlet 22 is preferably established to be greater than or equal to the cross-
sectional area of the outlet 14 of the first pipe (taking the total area surrounding the first pipe
outlet 14). This means that the diameter of the second pipe 20 is at least twice the diameter of
the first pipe 10.

[033] Taking these relationships into account, the inventor determined that the second pipe 20
preferably has a height (measured between the inlet 22 and the upper edge 24) of at least 2.5
times the width of the inlet gap 22.

[034] As an upper limit, a height of not more than 15 times the diameter of the second pipe 20
is preferable. Keeping the height at not more than 15 times the diameter of the second pipe 20
ensures the flow has sufficient energy to disperse radially outward from the second pipe outlet
62.

[035] In addition, it was determined that the outlet 62 of the disperser 50 should allow for the
flow of mixed gas without creating backpressure. The area of the outlet 62 is preferably greater
than the area of the outlet 14 of the first pipe 10.

[036] The invention has been described in terms of preferred embodiments and structure;
however those skilled in the art will understand that substitutions and variations may be made
without departing from the scope of the invention as defined in the appended claims.
What is claimed is:

1. An apparatus for cooling exhaust gases from an engine exhaust, comprising:
   a first pipe forming a vertically directed outlet for an exhaust conduit;
   a second pipe mounted to receive an exhaust gas flow from the outlet of the first pipe, the second pipe having a diameter greater than the diameter of the first pipe to define an ambient air inlet gap surrounding the outlet of the first pipe, the second pipe having a height that is at least 2.5 times a width of the inlet gap; and,
   a dispersing outlet mounted at an end of the second pipe and configured to direct exhaust gas radially outward.

2. The apparatus of claim 1, wherein the second pipe has a height that is not more than 15 times the width of the inlet gap.

3. The apparatus of claim 1, wherein an area defined by the inlet gap is at least equal to an area of the outlet of the first pipe.

4. The apparatus of claim 1, wherein the dispersing outlet comprises an end plate having a conical protrusion formed thereon and directed into the exhaust flow, the plate being spaced from an end of the second pipe to define therebetween a radial outlet opening.

5. The apparatus of claim 4, further comprising an annular deflector plate mounted between the end of the second pipe and the end plate, the deflector plate having a downward facing concave surface.

6. The apparatus of claim 5, wherein the annular deflector plate has a frusto-conical cross section.

7. The apparatus of claim 5, further comprising a plurality of vertically and radially disposed fins mounted to the second pipe and supporting the end plate and deflector plate.
8. The apparatus of claim 1, wherein an area defined by the dispersing outlet is greater than an area of the outlet of the first pipe.

9. The apparatus of claim 1, wherein the second pipe has an outwardly curving lip at an end leading to the diffuser outlet.

10. An apparatus for cooling exhaust gases from an engine exhaust, comprising:
    a first pipe forming a vertically directed outlet for an exhaust conduit;
    a second pipe mounted to receive an exhaust gas flow from the outlet of the first pipe, the second pipe having a diameter greater than the diameter of the first pipe to define an ambient air inlet gap surrounding the outlet of the first pipe, an area defined by the inlet gap is at least equal to an area of the outlet of the first pipe, the second pipe having a height that is at least 2.5 times a width of the inlet gap; and,
    a dispersing outlet mounted at an end of the second pipe and configured to direct exhaust gas radially outward, an area defined by the diffuser outlet being greater than an area of the outlet of the first pipe.
AMENDED CLAIMS

1. An apparatus for cooling exhaust gases from an engine exhaust, comprising:
a first pipe forming a vertically directed outlet for an exhaust conduit;
a second pipe mounted to receive an exhaust gas flow from the outlet of the first pipe, the second pipe having a diameter at least twice a diameter of the first pipe to define an ambient air inlet gap surrounding the outlet of the first pipe, the second pipe having a height that is at least 2.5 times a width of the inlet gap; and,
a dispersing outlet mounted at an end of the second pipe and configured to direct exhaust gas radially outward.

2. The apparatus of claim 1, wherein the second pipe has a height that is not more than 15 times the width of the inlet gap.

3. The apparatus of claim 1, wherein an area defined by the inlet gap is at least equal to an area of the outlet of the first pipe.

4. The apparatus of claim 1, wherein the dispersing outlet comprises an end plate having a conical protrusion formed there on and directed into the exhaust flow, the plate being spaced from an end of the second pipe to define therebetween a radial outlet opening.

5. The apparatus of claim 4, further comprising an annular deflector plate mounted between the end of the second pipe and the end plate, the deflector plate having a downward facing concave surface.

6. The apparatus of claim 5, wherein the annular deflector plate has a frusto-conical cross section and a centrally located hole to allow exhaust gas to pass therethrough.

7. The apparatus of claim 5, further comprising a plurality of vertically and radially disposed fins mounted to the second pipe and supporting the end plate and deflector plate.

8. The apparatus of claim 1, wherein an area defined by the dispersing outlet is greater than an area of the outlet of the first pipe.
9. The apparatus of claim 1, wherein the second pipe has an outwardly curving lip at a α end leading to the diffuser outlet,

10. An apparatus for cooling exhaust gases from an engine exhaust, comprising:
    a first pipe forming a vertically directed outlet for an exhaust conduit;
    a second pipe mounted to receive an exhaust gas flow from the outlet of the first pipe, the second pipe having a diameter greater than the diameter of the first pipe to define an ambient air inlet gap surrounding the outlet of the first pipe, an area defined by the inlet gap is at least equal to an area of the outlet of the first pipe, the second pipe having a height that is at least 2.5 times a width of the inlet gap;
    a dispersing outlet mounted at an end of the second pipe and configured to direct exhaust gas radially outward, an area defined by the diffuser outlet being greater than an area of the outlet of the first pipe, the dispersing outlet comprising an end plate having a conical protrusion formed thereon and directed into the exhaust flow, the plate being spaced from an end of the second pipe to define therebetween a radial outlet opening; and,
    an annular deflector plate mounted between the end of the second pipe and the end plate, the deflector plate having a frusto-conical cross section with a downward facing concave surface and a centrally located hole to allow exhaust gas to pass therethrough.
Dear Sir:

This Statement Under Article 19(1) accompanies an amendment under Article 19 filed on even date.

Claim 1 has been amended to define the diameter of the second pipe to be at least twice the diameter of the first pipe.

Claim 6 has been amended to define a centrally located hole in the annular deflector plate.

Claim 10 has been amended to include the subject matter of claims 4, 5, and 6, to define an end plate having an conical protrusion spaced from the end of the second pipe to define the outlet opening, an annular deflector plate mounted between the end of the second pipe and the end plate, the annular deflector plate having a frusto-conical cross section and downward facing concave surface and having a centrally located hole.

The art cited in the International Search and Written Opinion does not show or suggest the features of the claimed invention.

In regard to claim 1, the cited art, FR 509 107 (Nootens) shows a stack exhaust pipe with a first pipe 2 having an outlet disposed in a second pipe 1. However, Nootens does not show or describe the second pipe having a diameter at least twice a diameter of the first pipe to define an ambient air inlet gap surrounding the outlet of the first pipe, the second pipe having a height that is at least 2.5 times a width of the inlet gap. As explained in the specification, this allows the second pipe to operate on the buoyancy principle, rather than creating a Venturi at the inlet gap between the first pipe and second pipe.
Claim 3 recites an area defined by the inlet gap being at least equal to an area of the outlet of the first pipe. The Written Opinion considers this to be an obvious modification of Nootens, merely the finding of an optimum range. The reasoning is flawed, however. The Nootens device appears to rely on the Venturi principle to induce flow into the second pipe from the radial inlet 3 because of the relatively narrow inlet 3. The device of the invention, on the other hand, is directed to using the buoyancy effect in the exhaust flow, a different flow principle, which is not a mere optimization of the Venturi principle. Thus, it would not have been obvious to modify the relative size of the Nootens components.

Claim 6 defines the annular deflector plate has a frusto-conical cross section and a centrally located hole to allow exhaust gas to pass therethrough, which is not present in the Nootens device. This allows exhaust gas to directly enter the space between the deflector plate and the end plate, which is not possible in the Nootens apparatus.

Claim 7 recites a plurality of vertically and radially disposed fins mounted to the second pipe and supporting the end plate and deflector plate. These fins help guide the air and exhaust flow toward the outlet. The Written Opinion cites the "pattes" or legs 7, 10 of the Nootens apparatus as disclosing fins. The legs are not fins, neither by shape, orientation or intent. These are merely structural members to support the deflectors 6 and 9, and the cap 10 relative to the first and second pipes.

Claim 8 recites an area defined by the dispersing outlet being greater than an area of the outlet of the first pipe. The Nootens specification does not describe the relative size of the first and second pipe, and the drawings do not suggest the claimed subject matter. To the extent that measurement of the figure can be relied on, the Nootens document shows the opposite relationship, the area of the inlet 3 appears to be greater than the outlet (the area between deflector 8 and the top edge 8 of the cylinder 1) by 25% to 30%.

Claim 10 includes subject matter of claim 6, and is patentable for at least the reasons stated in connection with claim 6.

Please contact the undersigned if there are any questions about this submission.

Respectfully submitted,

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/026019

A CLASSIFICATION OF SUBJECT MATTER

| IPC(8) | F01 D 25/00 (2008.04) |

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)

| IPC(8) | F01D 25/00, 25/30, F02C 7/00 (2008 04) |

USPC - 454/37

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

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>
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</thead>
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<tr>
<td>X</td>
<td>BE 509,107 (NOOTENS) 29 February 1952 (29 02 1952) entire document</td>
<td>1-8, 10</td>
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<tr>
<td>Y</td>
<td>US 4,069,668 A (OLDBERG) 24 January 1978 (24 01 1978) entire document</td>
<td>9</td>
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<td>A</td>
<td>US 2,547,448 A (DEMUTH) 20 February 1946 (20 02 1946) entire document</td>
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Further documents are listed in the continuation of Box C

- Special categories of cited documents
- "A" - document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search
16 July 2008

Date of mailing of the international search report
23 JUL 2008

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