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(54) **SYSTEM AND METHOD TO REMOVE DEBRIS FROM A CHAMBER**

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(57) **ABSTRACT**

A system to remove debris from a chamber includes a debris chamber, an exhaust pipe, a debris conduit, and a tab. The exhaust pipe may direct a flow of gas into an air outlet, and include an exhaust pipe interior. The debris conduit connects the chamber with at least one of the exhaust pipe interior and the air outlet, and includes a debris conduit end disposed in at least one of the exhaust pipe interior and the air outlet. The tab includes at least three outer edges forming at least two corners, and an adjacent edge. The adjacent edge is adjacent to the debris conduit end.

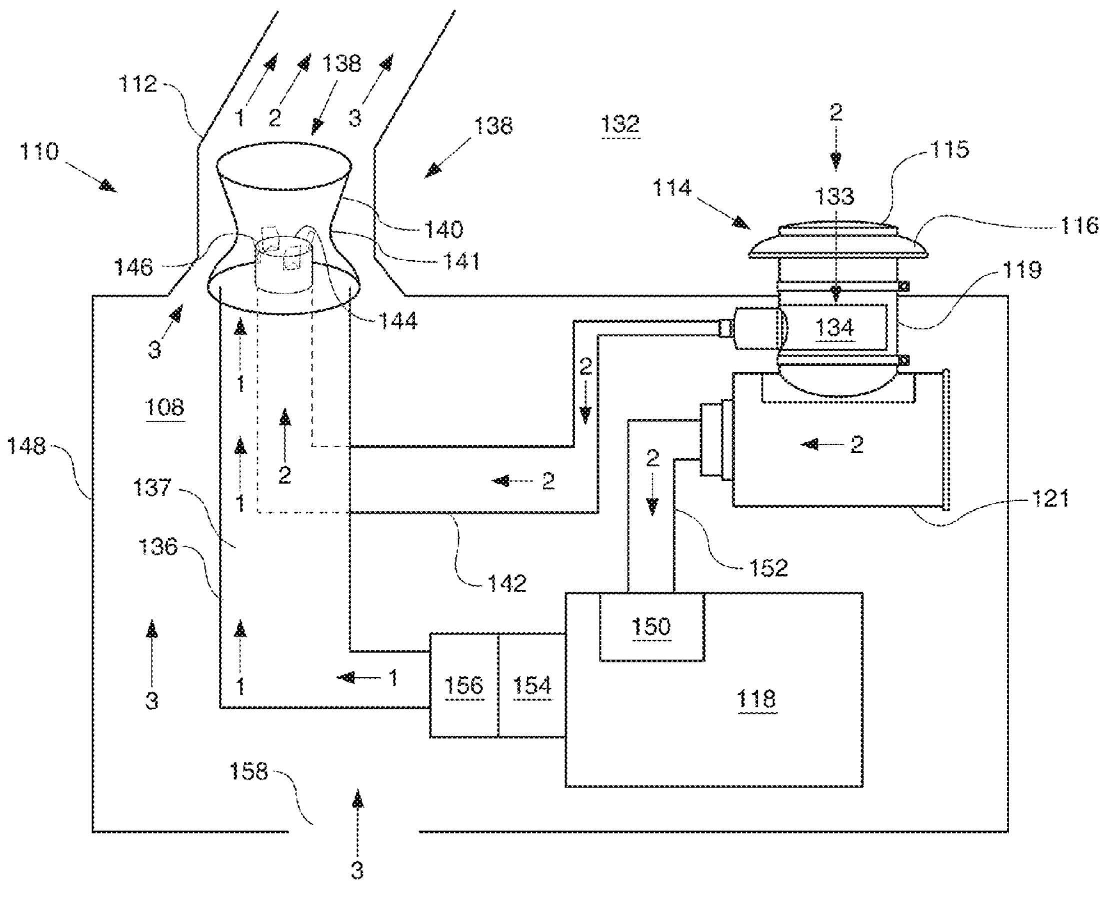
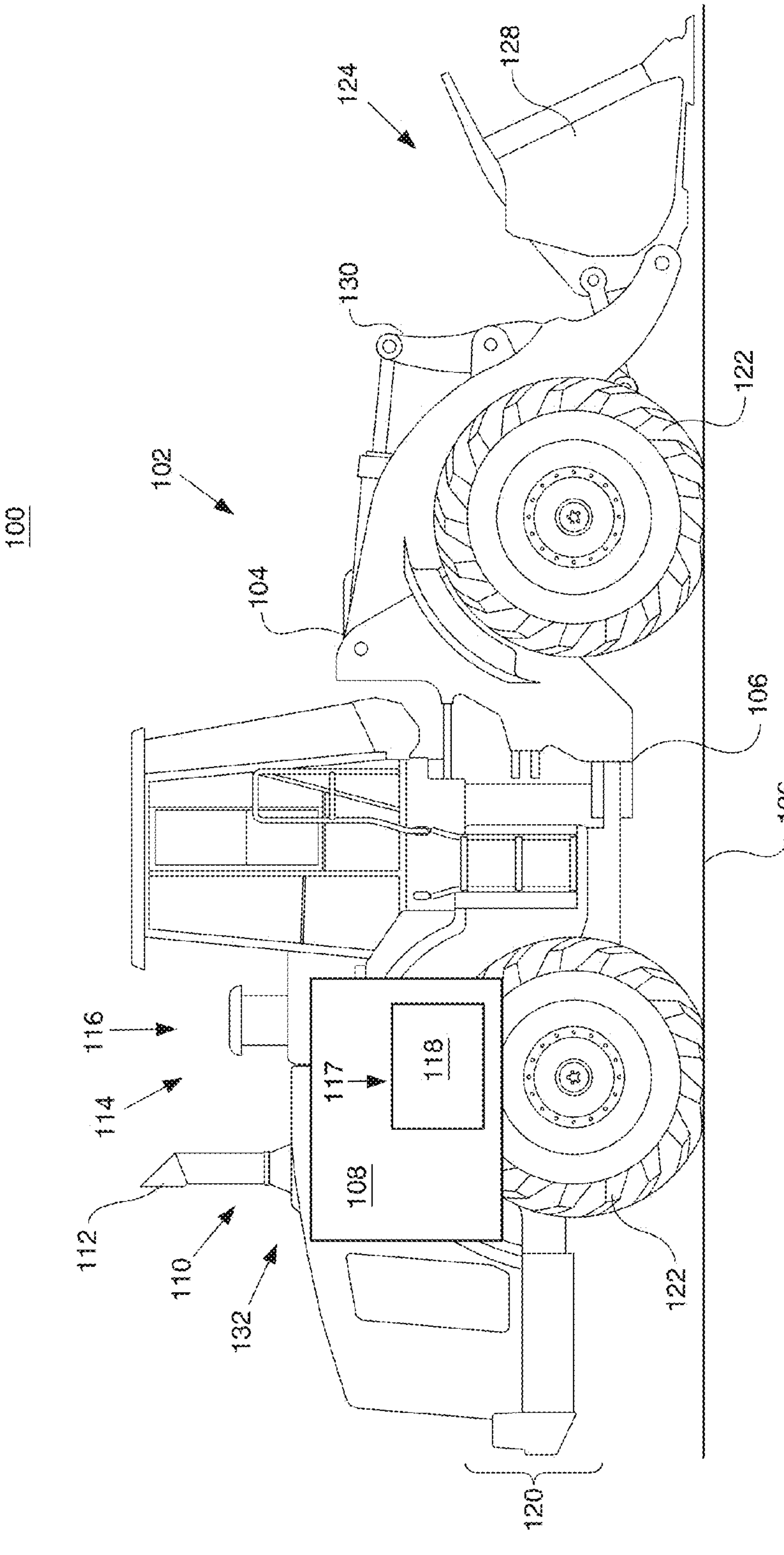


FIG. 1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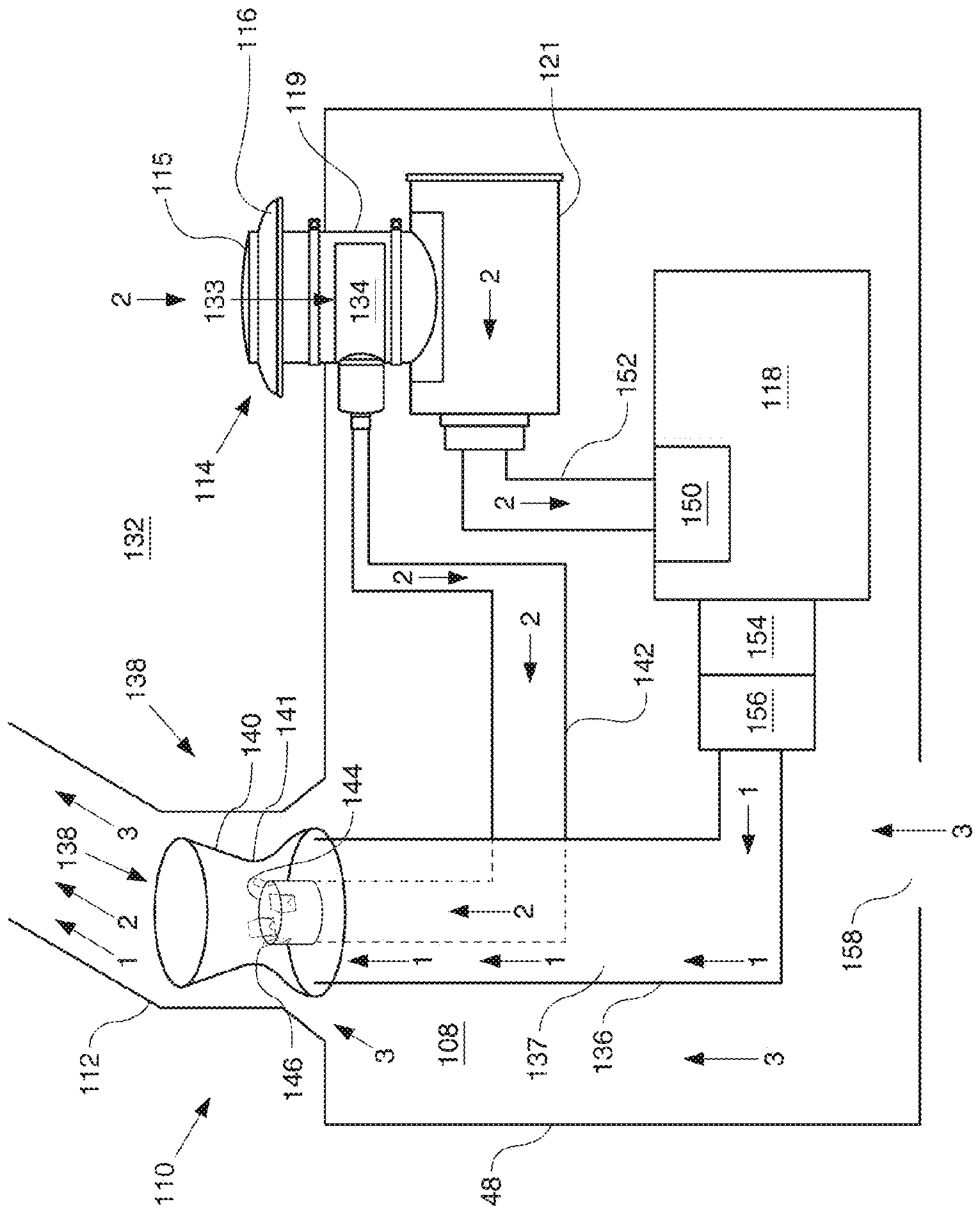

116
115
119
121
114
133
134
118
150
152
132
142
154
156
138
140
141
144
158
112
146
108
137
136
148
110

FIG. 2

FIG. 4

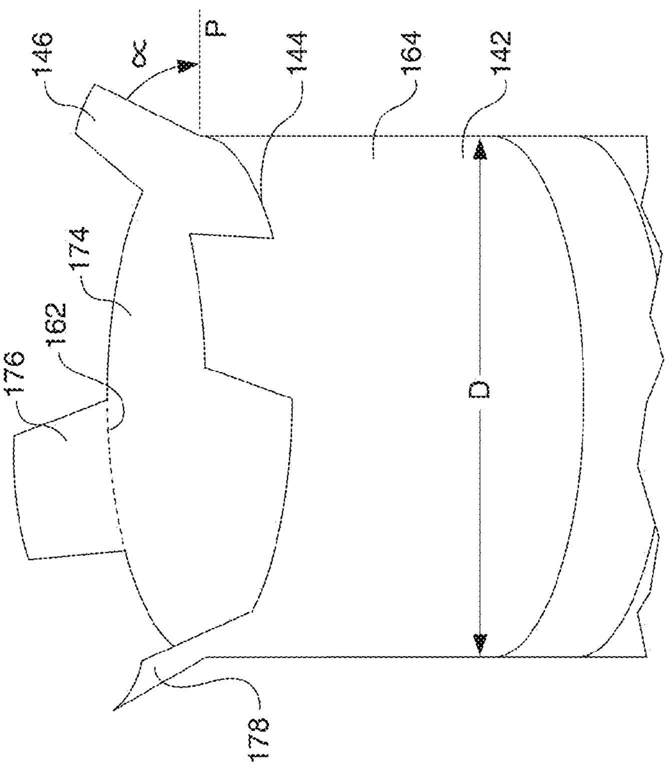

146
∝
P
144
164
142
174
162
176
D
178

FIG. 3

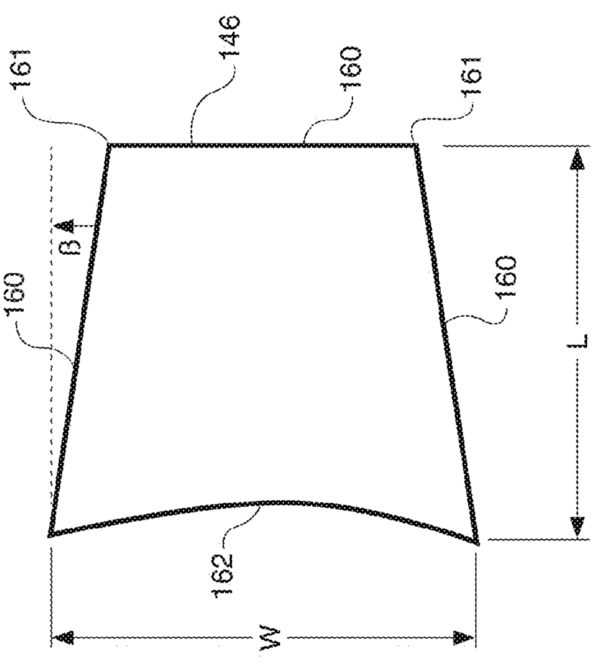

161
146
160
161
B
160
160
L
162
W

FIG. 7

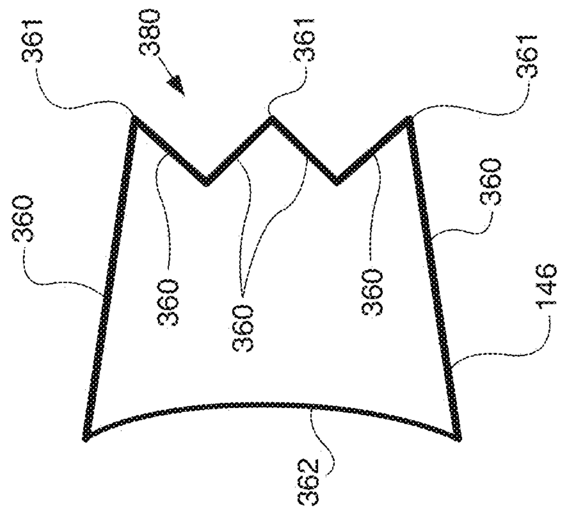


FIG. 6

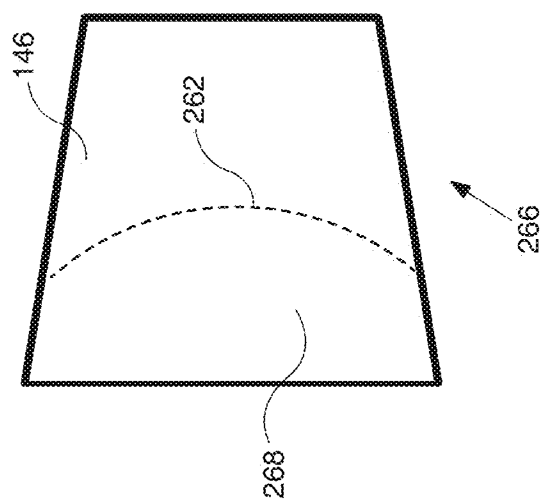


FIG. 5

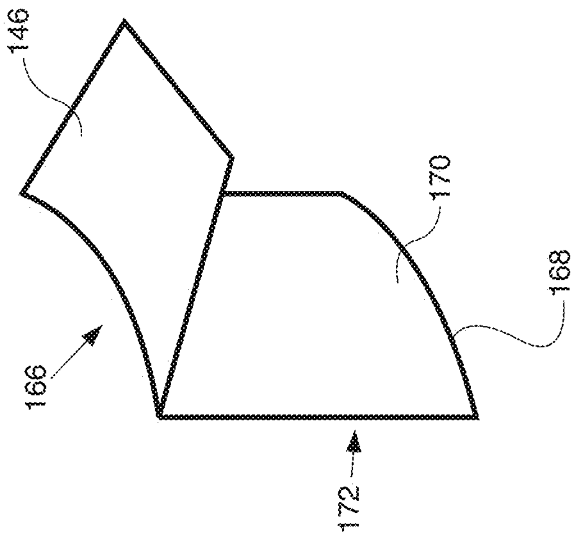


FIG. 8

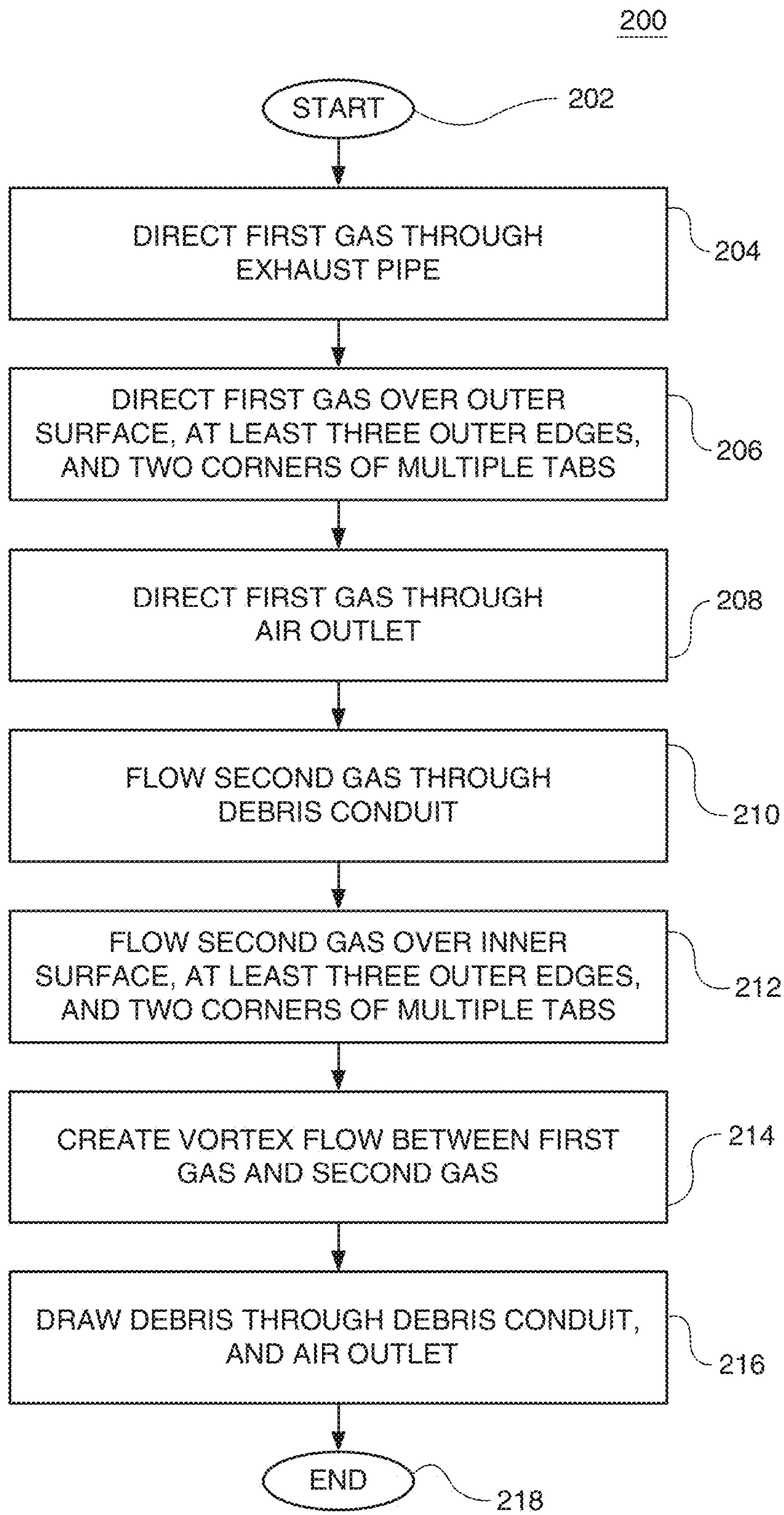
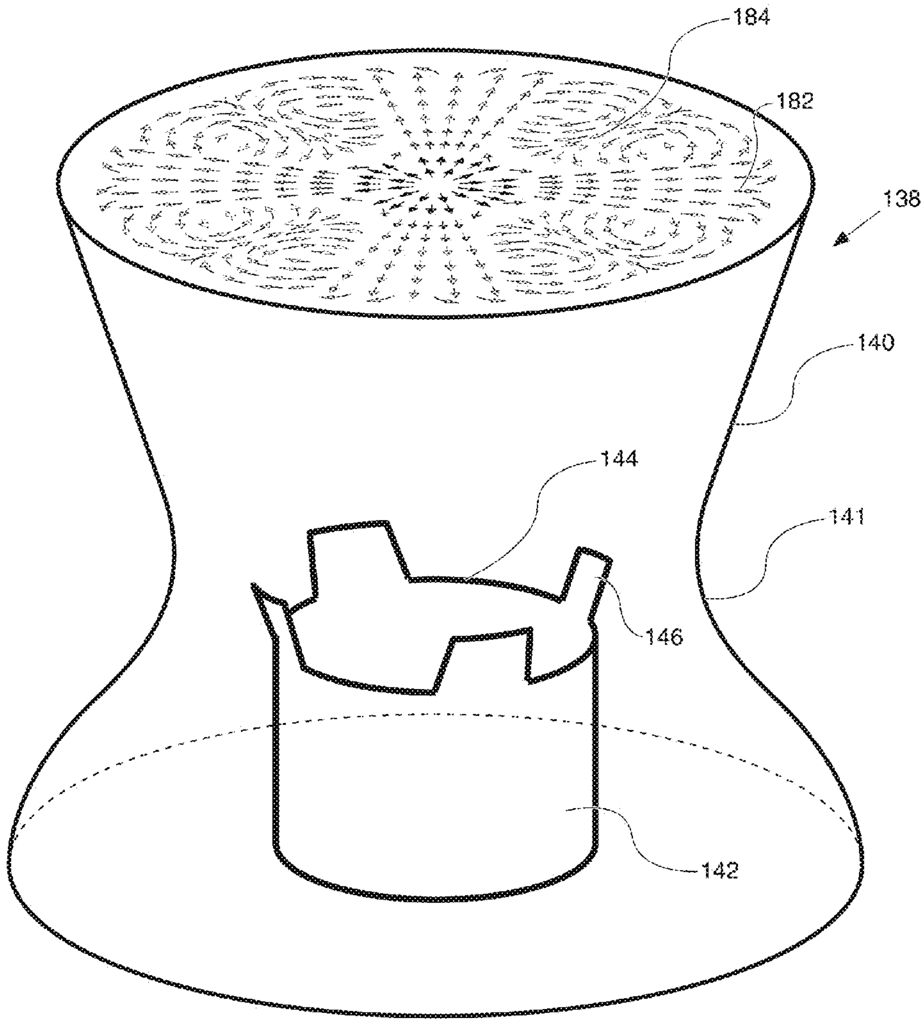

200
START
202
DIRECT FIRST GAS THROUGH EXHAUST PIPE
204
DIRECT FIRST GAS OVER OUTER SURFACE, AT LEAST THREE OUTER EDGES, AND TWO CORNERS OF MULTIPLE TABS
206
DIRECT FIRST GAS THROUGH AIR OUTLET
208
FLOW SECOND GAS THROUGH DEBRIS CONDUIT
210
FLOW SECOND GAS OVER INNER SURFACE, AT LEAST THREE OUTER EDGES, AND TWO CORNERS OF MULTIPLE TABS
212
CREATE VORTEX FLOW BETWEEN FIRST GAS AND SECOND GAS
214
DRAW DEBRIS THROUGH DEBRIS CONDUIT, AND AIR OUTLET
216
END
218

FIG. 9



SYSTEM AND METHOD TO REMOVE DEBRIS FROM A CHAMBER

TECHNICAL FIELD

[0001] The present disclosure relates generally to debris removal systems. Specifically, an embodiment of the present invention relates to a debris removal system for removing debris from a chamber.

BACKGROUND

[0002] Some components of machines can be damaged if dust or debris come in contact with or enter the component. For example, if dust enters an intake manifold of an engine, it may damage the combustion cylinders. Often machines working in dusty, or debris filled environments are equipped with air filtration systems. The air filtration systems protect sensitive components by removing dust and/or debris from air entering or having contact with the components.

[0003] Some filtration systems trap larger debris in a debris chamber and then filter the remaining air. The chamber may be fluidly connected with an air outlet through an exhaust pipe which may draw the debris out of the chamber and expel it through the air outlet into the air surrounding the machine. U.S. Pat. No. 7,004,987 issued to Pikesh et al., discloses a pre-cleaner for an air induction system of an internal combustion engine including a housing enclosing an upper chamber and an aspirator port chamber. The upper chamber contains a plurality of particulate separator tubes arranged in a predetermined array. Each of the tubes includes a particulate outlet through which particles removed from air flowing through the tube en route to the engine are discharged. The aspirator port chamber is located beneath, and is upwardly open to, the particulate outlets and includes an upwardly facing particle collecting surface located directly beneath the particulate outlets. Particles can fall from the tubes into the aspirator port chamber and onto the upwardly facing particle collecting surface. The housing includes a generally horizontally facing aspirator port in the aspirator port chamber adjacent to and facing the particle collecting surface. The housing also includes an element disposed for connecting the aspirator port to an exhaust tract of the internal combustion engine such that the exhaust flow through the exhaust tract will generate a suction condition in the aspirator port when the engine is operated. The particle collecting surface is positioned and oriented such that the suction generated by the exhaust flow during the operation of the engine will draw a flow of air from the upper chamber across the particle collecting surface such that particles collected on the surface will be drawn in an at least generally horizontal direction into the aspirator port.

[0004] In some operating conditions, airflow created through a pre-cleaner by a flow of gas through an exhaust pipe and an air outlet, to draw debris out of a debris chamber, through a debris conduit, and through the air outlet may not be sufficient to remove enough debris from the chamber.

SUMMARY OF THE INVENTION

[0005] Disclosed is a system to remove debris from a chamber including a debris chamber, an exhaust pipe, a debris conduit, an air outlet, and a tab. The exhaust pipe directs a flow of gas into the air outlet and includes an exhaust pipe interior. The debris conduit connects the chamber with at least one of the exhaust pipe interior and the air outlet and includes a debris conduit end disposed in at least one of the exhaust pipe interior and the air outlet. The tab has at least three outer edges forming at least two outer corners, and an adjacent edge, the adjacent edge adjacent to the debris conduit end.

[0006] In another aspect, disclosed is a machine including a body, an air filtration system, an exhaust pipe, an engine, a debris conduit, and a tab. The body defines a compartment with an air inlet and an air outlet. The air filtration system includes a pre-cleaner with a debris collection area disposed, the pre-cleaner configured to filter and trap debris in the debris collection area. The air filtration system is disposed in the air inlet. An air outlet stack is disposed in the air outlet. The exhaust pipe directs exhaust gas into and out of the air outlet, and includes an interior and an exhaust pipe end having a venturi portion. The engine is disposed in the compartment and is configured to exhaust gases through the exhaust pipe. The engine includes an intake manifold fluidly connected to the air inlet through the air filtration system. The debris conduit connects the debris collection area with at least one of the interior of the exhaust pipe and the air outlet, and includes a debris conduit end. The debris conduit end is disposed in at least one of the interior of the exhaust pipe and the air outlet. The debris conduit is configured for directing debris from the debris chamber through and out of at least one of the exhaust pipe and the air outlet. The tab, with at least three outer edges forming at least two outer corners and an adjacent edge, is adjacent to the debris conduit end.

[0007] In another aspect disclosed is a method for removing debris from a debris chamber. The method includes directing a first gas through an exhaust pipe; over an outer surface, and around at least three outer edges, and two corners formed by the at least three outer edges of a tab; and through an air outlet. The method further includes flowing a second gas through the debris chamber and a debris conduit; and over an inner surface, and around the at least three outer edges, and two corners formed by the three outer edges of the tab. Additionally, the method includes creating vortex flow between the first gas and the second gas, and drawing debris out of the debris chamber, through the debris conduit, and through the air outlet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** depicts an exemplary machine including an embodiment of a debris removal system.

[0009] FIG. **2** schematically depicts an exemplary debris removal system.

[0010] FIG. **3** depicts a portion of an exemplary tab.

[0011] FIG. **4** depicts a portion of an exemplary debris conduit from a perspective.

[0012] FIG. **5** depicts an embodiment of an exemplary tab assembly.

[0013] FIG. **6** depicts another embodiment of an exemplary tab assembly.

[0014] FIG. **7** depicts another embodiment of a tab.

[0015] FIG. **8** is a flow chart of an exemplary debris removal method.

[0016] FIG. **9** schematically depicts an embodiment of a portion of a debris conduit disposed in the interior of an exhaust pipe with a cross section depicting vortex flow.

DETAILED DESCRIPTION

[0017] Reference will now be made in detail to specific embodiments or features, examples of which are illustrated in the accompanying drawings. Generally, corresponding or similar reference numbers will be used, when possible, throughout the drawings to refer to the same or corresponding parts. Elements in schematics, included in the drawings, and described herein, may not be drawn with dimensions or in relation to other elements to any realistic scale. But, may rather be drawn to illustrate different aspects of the disclosure.

[0018] Referring now to FIG. **1**, an exemplary machine **100** is illustrated. In the embodiment depicted, the machine **100** is a vehicle **102**, and in particular a wheel loader **104**. The vehicle **102** may perform a type of operation associated with a particular industry such as mining, construction, farming, transportation, etc. and operates between or within work environments (e.g. construction site, mine site, power plants, on-highway applications, marine applications, etc.). Non-limiting examples of vehicle **104** include cranes, earthmoving vehicles, mining vehicles, backhoes, excavators, material handling equipment, dredgers, and farming equipment. In other embodiments, machine **100** may include a stationary machine, such as an electric power generator or a pumping station for oil or gas (not shown).

[0019] The wheel loader **104** includes a body **106** which defines a compartment **108** including an air outlet **110**, and an air inlet **114**. The air outlet includes an air outlet stack **112**. The air inlet **114** includes an air filtration system **116**, with a debris chamber **133** (shown in relation to FIG. **2**). The air filtration system may also include a rain cap **115**, pre-cleaner **119**, and air filter **121** (shown in relation to FIG. **2**). The pre-cleaner **119** may include the debris chamber **133** in the form of a debris collection area **134** (shown in relation to FIG. **2**).

[0020] The wheel loader **104** includes a power source **117**. In the illustrated embodiment, the power source **117** includes an engine **118** disposed in the compartment **108**. The engine **118** may include an internal combustion engine. The wheel loader **104** is equipped with systems that facilitate the operation of the wheel loader **104** at a worksite **126**. In the illustrated embodiment, these systems include a work implement system **124**, and a drive system **120**, both of which are powered by the engine **118**. The drive system **120** propels the wheel loader **104** on ground engaging devices **122** (depicted as wheels) to move the wheel loader **104** from one location to another. The work implement system **124** includes a bucket **128** and actuators and linkages **130** to move the bucket **128** to perform work at the worksite **126**. Wheel loader **104** includes an embodiment of a debris removal system **132**, depicted in FIG. **2**.

[0021] Referring now to FIG. **2**, a debris removal system **132** is depicted. The debris removal system **132** includes a debris chamber **133**, an exhaust pipe **136**, a debris conduit **142**, and a tab **146**. In the embodiment illustrated, exhaust pipe **136** directs the flow of a first gas into an air outlet **110** and includes an exhaust pipe interior **137**. A flow of the first gas is illustrated in FIG. **2** with the arrows labeled "1". The debris conduit **142** connects the debris chamber **133** with at least one of the exhaust pipe interior **137** and the air outlet **110**, and includes a debris conduit end **144** disposed in at least one of the exhaust pipe interior **137** and the air outlet **110**. The debris conduit **142** is configured to direct debris from the debris chamber **133** into at least one of the exhaust pipe **136** and the air outlet **110**. A tab **146** is adjacent the debris conduit end **144**.

[0022] In the illustrated embodiment, the system **132** includes a housing **148** which defines the compartment **108**, the air outlet **110**, and an air inlet **114**. The debris chamber **133**, debris conduit **142**, and at least a portion of the exhaust pipe **136** may be substantially enclosed by the housing **148**. The debris chamber **133** may include any substantially enclosed space or cavity for collecting dust and/or debris. The debris may include tiny pieces of rock, mud, seeds, chaff, ash, or other substances which may become airborne. In the illustrated embodiment, the debris chamber **133** includes a debris collection area **134** which is contained in, and is an element of, the precleaner **119**. A flow of a second gas is illustrated in FIG. **2** with the arrows labeled "2". Larger pieces of debris and dust, airborne in the second gas flowing through the air filtration system **116**, are trapped in the collection area **134** of the pre-cleaner **119**. The second gas, devoid of these larger pieces of debris, is then passed through the air filter **121**. A non-limiting example of an embodiment of air filtration system **116** includes the Donaldson STB Strata™ Air Cleaner including the Donaspin™ Pre-Cleaner. The second gas may include air from outside the compartment. For example, in the embodiment illustrated in FIG. **1**, the second gas may include air from the worksite **126** surrounding the machine **100**. Although shown as an element of the air filtration system **116**, the debris chamber **133** may include embodiments where additional filtering elements are not necessary, or embodiments in which the debris chamber **133** is not a component of the air filtration system **116**.

[0023] In the embodiment illustrated, the engine **118** includes an air intake manifold **150** fluidly connecting the engine **118** to the outside of the compartment **108** through the air filtration system **116**. A portion of the second gas flowing through the air inlet **114** may flow through the pre-cleaner **119** and the air filter **121** and into the intake manifold **150**. The pre-cleaner **119** may remove larger pieces of debris from the second gas by trapping them in the collection area **134**, and then remove additional dust and smaller debris particles through the air filter **121**, before the second gas is allowed to flow into the intake manifold **150**. Another portion of the second gas flowing through the inlet **114** may flow through the collection area **134** of the pre-cleaner **119** and then into the debris conduit **142**.

[0024] The flow of the first gas from the exhaust pipe **136** may include a flow of heated gas, for example, a flow of heated exhaust gas from the engine **118**. In the illustrated embodiment, the exhaust pipe **136** fluidly connects the engine **118**, with the air outlet **110** to expel exhaust gas. The exhaust gas from the engine **118** may flow through one or more aftertreatment devices **154**, and through one or more sound suppression devices **156**, before flowing into the exhaust pipe **136** and then through the air outlet **110**. Although engine **118** is depicted disposed in the compartment **108**, in other embodiments, engine **118** may be located outside or only partially disposed in the compartment **108**. Although engine **118** exhausts the flow of the first gas in the illustrated embodiment, in other embodiments the flow of the first gas may originate and be directed through the exhaust pipe **136** by other devices or processes known in the art. For example, a turbine may exhaust the flow of the first gas into the exhaust pipe **136**, or a manufacturing process may create heat and a series of fans, air conduits, and/or valves may direct the flow of the first gas through the exhaust pipe **136**.

[0025] In the depicted embodiment, the exhaust pipe **136** includes an exhaust pipe end **138** including a venturi portion

140. The venturi portion **140** includes a neck portion **141** providing a restriction such that the velocity of the flow of the first gas is increased upon exiting the neck portion **141**, as is known in the art.

[0026] In the depicted embodiment, the debris conduit **142** connects the debris chamber **133** to the exhaust pipe interior **137**. In one embodiment, a portion of the debris conduit **142** including the debris conduit end **144** may be inserted into the exhaust pipe interior **137** through an aperture in the wall of the exhaust pipe **136**. In other embodiments the debris conduit **142** or a portion of the debris conduit **142**, and the exhaust pipe **136** or a portion of the exhaust pipe **136** may be manufactured as a single component. The debris conduit **142** and the debris conduit end **144** are positioned in relation to the exhaust pipe **136**, such that debris from the debris chamber **133** is directed into at least one of the exhaust pipe **136** and the air outlet **110**. In the depicted embodiment, the air outlet **110** includes the air outlet stack **112**. The exhaust pipe end **138** and debris conduit end **144** are positioned in the air outlet stack **112** such that the flow of the first gas from the exhaust pipe **136** into the air outlet stack **112** creates a low pressure area proximate the debris conduit end **144**. In the depicted embodiment, the low pressure area may be created above the debris conduit end **144**. The second gas from outside the compartment **108**, entering the compartment **108** through the air filtration system **116**, may be at a higher pressure than the low pressure area created proximate the debris conduit end **144**. The second gas may flow from the higher pressure area outside the compartment, through the collection area **134**, and through the debris conduit **142**. The second gas may carry dust and/or debris from the collection area **134**, through the debris conduit **142**, through the outlet stack **112**, and out of the compartment **108**.

[0027] In the embodiment illustrated, the housing **148** defines an aperture **158** fluidly connecting the compartment **108** with air outside the housing **148**. A flow of a third gas is illustrated in FIG. **2** with the arrows labeled "3". The third gas may flow in the aperture **158**, through the compartment **108**, and out the air outlet **110**. Heat energy may transfer from the engine **118**, aftertreatment devices **154**, sound suppression devices **156**, and/or other components in the compartment **108** to the third gas to cool these components. The flow of the first gas through the exhaust pipe **136** and out the air outlet **110** may increase the velocity of the flow of the third gas through the compartment **108**, as is known in the art. The increased velocity of the third gas may provide improved cooling of the components in the compartment **108**. Although one aperture **158** is shown in the embodiment of FIG. **2**, many embodiments of compartments **108**, such as those defined by a machine body **106**, may have multiple apertures **158**. The apertures **158** may include vents, cracks, or an open side of the compartment **108**. The third gas is drawn through these apertures **158**, through the compartment **108**, and through the air outlet **110**.

[0028] Referring now to FIGS. **3** and **4**, a perspective view of a portion of an exemplary embodiment of the debris conduit **142**, including debris conduit end **144**, having multiple tabs **146**; and a view of an exemplary tab **146** are illustrated. Debris conduit **142** includes debris conduit end **144**. Although the debris conduit end **144** is illustrated with four tabs, it is contemplated that there may be embodiments with one, two, three, or more than four tabs **146**. In the embodiment illustrated, debris conduit end **144** includes a circle shape with a diameter marked as "D" in FIG. **4**. In other embodiments the debris conduit end **144** may include other shapes, for example an ellipse, an octagon, a square, or any other shape known in the art.

[0029] In the illustrated embodiment, the debris conduit **142** includes an exterior wall **164** and an interior wall **174**. In the illustrated embodiment, debris conduit **142** is substantially cylindrical. In alternative embodiments, the debris conduit **142** may be any elongated tube type shape known in the art to be operable to fluidly connect the debris chamber **133** with one of the interior of the exhaust stack **136** and the air outlet **110**. Non-limiting examples include a tube like structure with cross sections in the shapes of ellipses or polygons such as octagons, or rectangles. In some embodiments, the debris conduit **142** may include cross sections which differ in shape and size at different points. The debris conduit **142** may, for example, include a venturi type shape.

[0030] Multiple tabs **146** are attached to, and spaced around the debris conduit end **144**. In the illustrated embodiment, the tabs **146** are angled out from the exterior wall **164** and circumferentially spaced around the circular debris conduit end **142**. Each tab **146** includes an adjacent edge **162** adjacent the debris conduit end **144**, and at least three outer edges **160** angled out from the exterior wall **164** of the debris conduit **142**. The outer edges **160** form at least two corners **161**.

[0031] In the illustrated embodiment four tabs **146** are circumferentially evenly spaced around the debris conduit end **144**. In alternative embodiments, different numbers of tabs **146** may be evenly, or unevenly, spaced around the debris conduit end **144**. There may be, for example, as few as one tab **146**, or as many as eight tabs **146**. The number of tabs **146**, the shape of tabs **146**, the size of tabs **146**, and the orientation of the tabs in relation to the debris conduit **142** may be determined as a function of a number of factors. Non-limiting examples of factors to be considered include estimates of the range of velocities and temperatures, the velocity profile, and the range of other characteristics of the flow of the first gas. Other examples may include the geometry of the debris conduit **142**, the debris conduit end **144**, the debris chamber **133**, the air inlet **114**, and the filter **116**; the possible characteristics of the second gas; and the size and configuration of the air outlet stack **112**.

[0032] The tabs **146** include an inner surface **176** and an outer surface **178**. The tabs may be held stationery such that the first gas flows over the outer surface **178** and around the outer edges **160** and corners **162**; and the second gas flows over the inner surface **176** and around the outer edges **160** and corners **162**; in any manner known in the art.

[0033] In the illustrated embodiment, the tabs **146** are fixedly attached to the debris conduit end **144** such that the adjacent edge **162** is adjacent the debris conduit end **144**. The tabs **146** may, for example, be welded onto the exterior wall **164** or interior wall **174** of the debris conduit **142** with attachment portions **168** as shown and explained in relation to FIGS. **5** and **6**. In other embodiments the tabs **146** may be formed integral to the debris conduit **142**. In still other embodiments, the tabs **146** may be fixedly attached to the debris conduit end **144** with a one or more bolts (not shown), snap ring (not shown), clamp arrangement (not shown), and/or adhesives. The tabs **146** may be fixedly attached to the debris conduit **142** such that the adjacent edge **162** is adjacent the debris conduit end **144** in any way known in the art. It is also contemplated that in some embodiments, the tabs **146** may be fixedly attached to another component(s) different than the debris conduit **142**, and held stationary against the debris conduit **142**, such that the adjacent edges **162** are adjacent the debris conduit end **144**. For example, the aftertreatment **118**, muffler **119**, exhaust pipe **136**, and/or debris conduit **142** may be at least partially enclosed by a housing (not shown). The tabs **146** may be fixedly attached to the housing by, for example, brackets, such that the adjacent edges **162** are adjacent the debris conduit end **144**. In still other embodiments, it is contemplated that the tabs **146** may be fixedly attached to another component(s) different than the debris conduit **142**, but not adjacent the debris conduit end **144**, such that the first gas flows over the outer surface **178** and around the outer edges **160** and corners **162**, and the second gas flows over the inner surface **176** and around the outer edges **160** and corners **162**.

[0034] In the illustrated embodiment, each tab **146** is substantially flat. The adjacent edge **162** and outer edges **160** form the outline of the inner surface **176** and the outer surface **178**. Both the inner surface **176** and the outer surface **178** are generally planar. In alternative embodiments, the tabs **146** may be curved as opposed to flat.

[0035] In the embodiment illustrated, each tab **146** is a generally a trapezoidal shape with a semi-circular adjacent edge **162**, and three outer edges **160**. As depicted in FIGS. **4** and **5**, the debris conduit end **144** includes a diameter (indicated by "D"). Each tab **146** includes a tab width (indicated by "W"), a tab length (indicated by "L"), and a trapezoid angle (indicated by "β"). In some embodiments the tab width (W) is approximately three tenths (0.3) of the debris conduit end **144** diameter, (D), the tab length (L) is between eight tenths (0.8) to one and two tenths (1.2) the tab width (W), and the trapezoidal angle (β) is between eight (8) and twelve (12) degrees. In the illustrated embodiment of FIG. **4**, a plane perpendicular to the exterior wall **164** of the debris conduit **142** (indicated by "P") and the tab **146** define a conduit-tab angle (indicated by "α"). In some embodiments, the conduit-tab angle (α) is between twenty and eighty degrees (20°-80°).

[0036] In the embodiment illustrated, each tab **146** is generally the same size and shape, and adjacent the debris conduit end **144** at the same conduit-tab angle (α). In alternative embodiments, the tabs **146** may be different shapes and sizes, and adjacent the debris conduit end **144** at different conduit-tab angles (α).

[0037] Referring now to FIGS. **5** and **6**, each figure illustrates an exemplary embodiment of a tab assembly **166**, **266**. The tab assembly **166**, **266** includes one of the tabs **146** and a tab attachment piece **168**, **268** for attaching the tab **146** to the debris conduit **142**. The tab attachment piece **168**, **268** includes a first side **170** and a second side **172** (not shown on FIG. **6**). In one embodiment, the tab **146** may be attached to the debris conduit end **144** by attaching the first side **170** to the debris conduit interior wall **174** such that the adjacent edge **162** of the tab is adjacent to the debris conduit end **144**. In another embodiment, the tab **146** may be attached to the debris conduit end **144** by attaching the second side **172** to the debris conduit exterior wall **164** such that the adjacent edge **162** of the tab is adjacent to the debris conduit end **144**. The tab assembly **166**, **266** may be fixedly attached to the debris conduit **142** through welding, adhesive, clamps, snap rings, bolts, or any other means known in the art.

[0038] In one embodiment of the tab assembly **166**, **266**; the tab **146** and the tab attachment piece **268** may be formed as one integral piece through molding or from bending and shaping sheet metal. In other embodiments, the tab **146** and the tab attachment piece **168**, **268** may be welded together, riveted together, bolted together or fixedly attached together by any means known in the art.

[0039] FIG. **5** illustrates a tab assembly **166** formed to be attached to the debris conduit **142**. FIG. **6** illustrates an embodiment of a tab assembly **266** including a generally flat piece of metal. This embodiment may be bent and shaped to attach to debris conduit **142**.

[0040] FIG. **7** illustrates another exemplary embodiment of a tab **146**. The tab **146** in FIG. **7** is similar to the embodiments of the tab **146** illustrated and described in relation to FIGS. **3** and **4**, except tab **146** in this embodiment includes a sawtooth end **380**. With the sawtooth end, instead of three outer edges **160** (as shown in relation to FIGS. **3** and **4**), tab **146** includes six outer edges **360**; and instead of two corners **161** (as shown in relation to FIGS. **3** and **4**), tab **146** includes five corners **361**.

INDUSTRIAL APPLICABILITY

[0041] Air filtration systems to remove debris and dust from air entering or having contact with components of a machine may include a debris chamber to trap larger pieces of debris. The debris chamber may be fluidly connected, through a debris conduit, to a flow of gas from an exhaust pipe, to create a low pressure area and a flow of air through the debris conduit from a higher pressure area, to draw the debris out of the chamber, and expel it outside the machine. In some operating conditions, the flow created may not be sufficient to remove enough debris from the chamber. Tabs at the end of the debris conduit may create vortex flow between the gas being drawn through the debris conduit and the gas flowing from the exhaust pipe. This vortex flow may enhance the mixing of the two gases and increase the velocity of the gas flowing through the debris conduit, and increase the amount of debris removed from the chamber. Experimentation, modeling, and simulation have indicated that the tab can increase the vortex flow and thus the amount of debris removed from the debris chamber.

[0042] Referring now to FIG. **8**, a flow chart is shown depicting a method **200** for removing debris from a debris chamber. The method **200** includes directing the flow of the first gas through the exhaust pipe **136**; directing the flow of the first gas over the outer surface **178**, and around at least three outer edges **160**, and two corners **161** formed by the at least three outer edges **160**, of a tab **146**; and directing the flow of the first gas through an air outlet **110**. The method **200** further includes directing the flow of the second gas through the debris chamber **133** and the debris conduit **142**; and directing the flow of the second gas over the inner surface **176**, and around the at least three outer edges **160**, and two corners **161** formed by the three outer edges **160** of the tab **146**. Additionally the method **200** includes creating vortex flow between the first gas and the second gas; and drawing debris out of the debris chamber **133**, through the debris conduit **142**, and through the air outlet stack **112**.

[0043] The method **200** starts at step **202** and proceeds to step **204**. In step **204**, the flow of the first gas is directed through the exhaust pipe **136**. In the embodiment depicted in FIG. **2**, the flow of the first gas includes a heated gas, and more specifically exhaust gas from the engine **118**. The exhaust gas flows from the engine **118**, through one or more aftertreatment devices **154**, through one or more sound suppression devices **156**, through the exhaust pipe **136**, through the venturi portion **140**, out the exhaust pipe end **138**, into the air outlet stack **112**, and out the air outlet stack **112**. The flow of the first gas may narrow as it passes through the neck portion **141** of the venturi portion **140** and increase in velocity. As the flow of the first gas may widen as it exits the neck portion **141**. Although depicted as engine **118** exhaust gas, the first gas may include gas from other sources in other embodiments. The method **200** proceeds to step **206**.

[0044] In step **206**, the flow of the first gas is directed over the outer surface **178** of a tab **146**, and over at least three outer edges **160** and two corners **161** formed by the outer edges **160** of the tab **146**. In the embodiment depicted in FIG. **2**, multiple tabs **146** are attached to, and angled out from, the debris conduit end **144**. The debris conduit end **144** is disposed in the exhaust pipe interior **137**. As the exhaust gas from the engine **118** flows around the debris conduit, it flows over the outer surface **178** of the tabs **146**, and over and around the outer edges **160** and corners **161**. In other embodiments, the tabs **146** may be fixed in the flow of the first gas in other ways and locations. For example, a portion of the debris conduit **142** may extend through the exhaust pipe **136** and extend into the air outlet stack **112**, such that although the debris conduit end **144** is not disposed in the exhaust pipe interior **137**, the debris conduit end **144** is disposed in the flow of the first gas in the air outlet stack **112**. In still other embodiments, the multiple tabs **146** may not be fixedly attached to the debris conduit end **144**, but rather fixed in another manner in the flow of the first gas. The method **200** proceeds to step **208**.

[0045] In step **208**, the first gas is directed through the air outlet **110**. In the embodiment depicted in FIG. **2**, the air outlet **110** includes the air outlet stack **112**. The method proceeds to step **210**.

[0046] In step **210**, the flow of the second gas flows through the debris conduit **142**. In the embodiment depicted in FIG. **2**, the second gas includes air from outside the compartment **108**, a portion of which is filtered through the air filtration system **116** and directed into the intake manifold **150** of the engine **118**. Another portion of the second gas flows through the debris chamber **133**, and through the debris conduit **142**. In the illustrated embodiment, the air filtration system **116** includes a pre-cleaner **119**, and the debris chamber **133** includes a collection area **134** of the pre-cleaner. In other embodiments the debris chamber **133** may not be an element of the air filtration system **116**, and the debris may not have been filtered from the second gas. For example, the debris may be ash created as a result of some type of combustion in a chamber. Ducts and valves may be actuated to permit the flow of the second gas through the chamber with the ash and through the debris conduit **142**. The flow of the first gas around the debris conduit end may create a low pressure area proximate the debris conduit end. In the depicted embodiment, the low pressure area may be above the debris conduit end. The flow of the second gas outside the compartment **108** may be at a higher pressure than the low pressure area proximate the debris conduit end **144**. A flow of the second gas may be created by the pressure differential through the collection area **134**, and the debris conduit. The method **200** proceeds to step **212**.

[0047] In step **212**, the flow of the second gas passes over the inner surface **176** of the multiple tabs **146**, and over and around the outer edges **160** and corners **161**. In the embodiment depicted in FIG. **2**, the flow of the second gas disperses as it exits the debris conduit end **144**. Where a tab **146** is fixed, the flow of the second gas passes over the inner surface **176**, and around the outer edges **160** and corners **161**. The method **200** proceeds to step **214**.

[0048] In step **214**, vortex flow **184** is created between the first gas and the second gas. Referring now to FIG. **9**, a cross section **182** of gas flow at the end of the exhaust pipe **138** is depicted for the embodiment of FIG. **2**. As the two gases meet at the corners **161** of the tabs **146**, vortex flow **184** is created between the first gas and the second gas. When tabs **146** include more corners **160**, the vortex flow **184** may be increased. Vortex flow **184** may, in turn, increase the mixing of the first gas and the second gas, and thus the velocity of the flow of the second gas through the collection area **134** and the debris conduit **142**. Referring back now to FIG. **8**, the method **200** proceeds to step **216**.

[0049] In step **216**, debris is drawn through the debris conduit **142** and expelled out the air outlet **110**. When heated exhaust gas is directed through the exhaust pipe and in a flow path direction out the air outlet stack **112**, flow of air from outside the compartment **108** may be created through the collection area **134** and debris conduit **142**. This flow may be strong enough to draw debris from the collection area **134**, through the debris conduit **142**, and out the air outlet stack **112**. However, this flow may not be strong enough to draw all debris out of the collection area **134**. Creating vortex flow as the first gas and the second gas meet at the corners **161** of the tabs **146** increases the mixing of the first gas and the second gas and thus the velocity of the second gas. Increasing the velocity of the second gas may increase the amount of debris drawn out of the debris chamber **133**. The method **200** proceeds to step **218** and ends.

[0050] It will be appreciated that the foregoing description provides examples of the disclosed system and technique. However, it is contemplated that other implementations of the disclosure may differ in detail from the foregoing examples. All references to the disclosure or examples thereof are intended to reference the particular example being discussed at that point and are not intended to imply any limitation as to the scope of the disclosure more generally. All language of distinction and disparagement with respect to certain features is intended to indicate a lack of preference for those features, but not to exclude such from the scope of the disclosure entirely unless otherwise indicated.

What is claimed is:

1. A system to remove debris from a chamber, comprising:

a debris chamber,

an exhaust pipe for directing a flow of gas into an air outlet, the exhaust pipe including an exhaust pipe interior,

a debris conduit connecting the chamber with at least one of the exhaust pipe interior and the air outlet, the debris conduit including a debris conduit end disposed in at least one of the exhaust pipe interior and the air outlet, and

a tab with at least three outer edges forming at least two corners, and an adjacent edge, the adjacent edge adjacent to the debris conduit end.

2. The system of claim **1**, further including multiple tabs.

3. The system of claim **1**, wherein the tab has a trapezoid shape formed by three outer edges and a connecting edge.

4. The system of claim **3**, wherein the trapezoid shape includes a tapering angle of at least eight degrees.

5. The system of claim **3**, wherein the trapezoid shape includes a tapering angle of no more than twelve degrees.

6. The system of claim **1**, wherein at the tab includes an outer surface, the debris conduit includes an exterior wall, and a plane perpendicular to the exterior wall forms a conduit-tab angle with the outer surface of at least twenty degrees.

7. The system of claim **1**, wherein the tab includes an outer surface, the debris conduit includes an exterior wall, and a plane perpendicular to the exterior wall forms a conduit-tab angle with the outer surface of no more than eighty degrees.

8. The system of claim **1**, wherein the tab is fixedly attached to the debris conduit end.

9. The system of claim **8**, wherein the tab is integral to the debris conduit.

10. The system of claim **8**, wherein the tab is welded onto the debris conduit end.

11. The system of claim **8**, wherein the tab is bolted onto the debris conduit end.

12. The system of claim **1**, wherein the debris conduit end includes a debris conduit diameter, the tab includes a tab width, and the tab width is at least three tenths of the debris conduit diameter.

13. The system of claim **1**, wherein the tab includes a tab width and a tab length, and the tab length is at least eight tenths of the tab width.

14. The system of claim **1**, wherein the tab includes a tab width and a tab length, and the tab length is no more than one and two tenths of the tab width.

15. The system of claim **1**, wherein the debris conduit fluidly connects the debris chamber with the interior of the exhaust pipe.

16. The system of claim **1**, wherein the exhaust pipe includes an exhaust pipe end having a venturi portion with a neck portion, and the debris conduit end is disposed in the neck portion.

17. The system of claim **1**, further including a housing defining a compartment; the housing including an air inlet including an air filtration system configured to filter and trap debris in the debris chamber, and the air outlet having an air outlet stack.

18. The system of claim **17**, further including an engine disposed in the compartment with an intake manifold and configured to exhaust gases through the exhaust pipe, and wherein the air inlet is fluidly connected to the intake manifold through the air filtration system.

19. A machine, comprising

a body defining a compartment; and including an air inlet and an air outlet,

an air filtration system including a pre-cleaner with a debris collection area disposed in the air inlet, the pre-cleaner configured to filter and trap debris in the debris collection area,

an air outlet stack disposed in the air outlet,

an exhaust pipe for directing exhaust gas into and out of the air outlet, the exhaust pipe including an interior and an exhaust pipe end having a venturi portion,

an engine disposed in the compartment configured to exhaust gases through the exhaust pipe, and including an intake manifold fluidly connected to the air inlet through the air filtration system,

a debris conduit connecting the debris collection area with at least one of the interior of the exhaust pipe and the air outlet, the debris conduit including a debris conduit end disposed in at least one of the interior of the exhaust pipe and the air outlet, the debris conduit configured for directing debris from the debris collection area through and out of the exhaust pipe and the air outlet, and

a tab with at least three outer edges forming at least two corners, and an adjacent edge, the adjacent edge adjacent the debris conduit end.

20. A method for removing debris from a debris chamber, comprising:

directing a flow of a first gas through an exhaust pipe,

directing the flow of the first gas over an outer surface, and around at least three outer edges, and two corners formed by the at least three outer edges of a tab,

directing the flow of the first gas through an air outlet,

directing a flow of a second gas through the debris chamber and a debris conduit,

directing the flow of the second gas over an inner surface, and around the at least three outer edges, and two corners formed by the three outer edges of the tab,

creating vortex flow between the first gas and the second gas, and

drawing debris out of the debris chamber, through the debris conduit, and through the air outlet.

21. The method of claim **20**, wherein the tab is angled outward from the end of the debris conduit.

22. The method of claim **20**, further including narrowing and increasing the velocity of the flow of the first gas before directing the flow of the first gas over the outer surface of the tab.

23. The method of claim **20**, further including widening the flow of the first gas as or after the flow of the first gas is directed over the outer surface of the tab.

24. The method of claim **20**, further including creating a low pressure area over an end of the debris conduit.

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