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(54) A VACUUM EXCAVATOR

(57) A vacuum excavator comprising: a vacuum generator configured to draw a gas-particulate mixture into the vacuum excavator; and a chamber comprising: an inlet configured to receive at least some of the gas-particulate mixture; a filter configured to redirect the gas-particulate mixture received by the inlet and filter at least some of the particulate from the gas-particulate mixture by causing that particulate to separate from the gas-particulate mixture; and an exhaust, located below the inlet in a vertical dimension, configured to exhaust the filtered gas-particulate mixture.

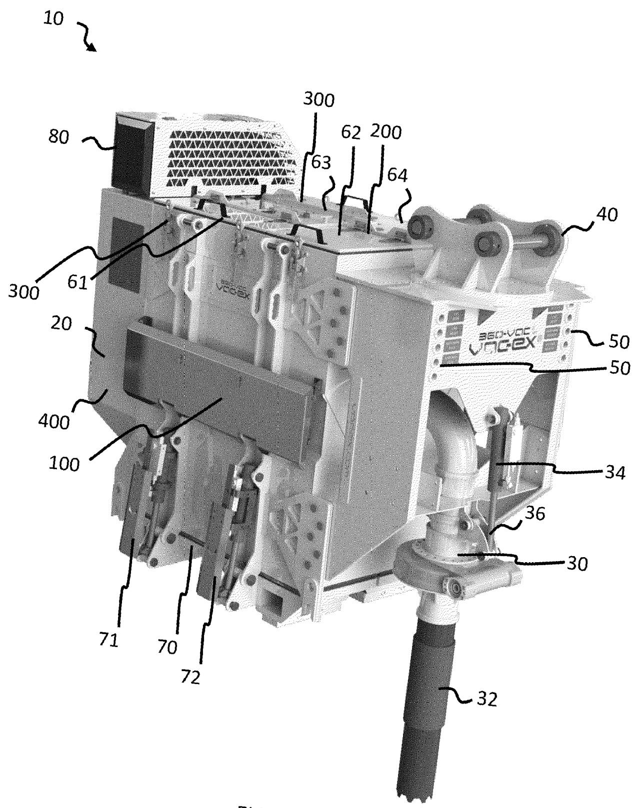

FIG. 1

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Description

TECHNOLOGICAL FIELD

[0001] Examples of the disclosure relate to a vacuum excavator. Some relate to a vacuum excavator for attaching to construction equipment.

BACKGROUND

[0002] Vacuum excavators are used for excavating. A vacuum excavator comprises a vacuum generator for generating at least a partial vacuum. A pressure differential caused by generation of the (partial) vacuum causes material to be urged through a conduit of the excavator into a collector.

BRIEF SUMMARY

[0003] According to various, but not necessarily all, examples there is provided a vacuum excavator comprising: a vacuum generator configured to draw a gas-particulate mixture into the vacuum excavator; and a chamber comprising: an inlet configured to receive at least some of the gas-particulate mixture; a filter configured to redirect the gas-particulate mixture received by the inlet and filter at least some of the particulate from the gas-particulate mixture by causing that particulate to separate from the gas-particulate mixture; and an exhaust, located below the inlet in a vertical dimension, configured to exhaust the filtered gas-particulate mixture.

[0004] The vacuum excavator may further comprise at least one textile filter, different from the filter, configured to receive and filter the exhausted gas-particulate mixture from the exhaust.

[0005] The filter may comprise at least one guide configured to redirect the gas-particulate mixture received by the inlet.

[0006] The guide may be configured to guide the gas-particulate mixture received from the inlet in a direction angled relative to a first dimension and angled relative to a second dimension that is orthogonal to the first dimension. The first dimension may be the vertical dimension.

[0007] The guide may have a surface that is angled relative to the vertical dimension and a horizontal dimension.

[0008] The guide may be formed at least partly from at least one metal.

[0009] The chamber may comprise a collector configured to collect the particulate separated by the filter.

[0010] The collector may be located below the inlet and the exhaust in the vertical dimension.

[0011] The chamber may be removable from the vacuum excavator.

[0012] The filter may be removable from the chamber.

[0013] The filter may comprise at least one connector configured to couple the filter to the chamber.

[0014] The filter may comprise at least one fastener configured to fasten the filter to the chamber.

[0015] The vacuum excavator may further comprise at least one further filter configured to filter the drawn gas-particulate mixture prior to being received at the inlet of the chamber.

[0016] The at least one further filter may comprise one or more gravity filters and one or more plenum filters.

[0017] The vacuum excavator may further comprise a connector configured to attach the vacuum excavator to construction equipment.

[0018] The filter may comprise a cyclone filter. The guide may be provided by a cone of the cyclone filter.

[0019] The vacuum excavator may further comprise a further chamber comprising: a further inlet configured to receive at least some of the gas-particulate mixture; a further cyclone filter configured to redirect the gas-particulate mixture received by the further inlet and filter at least some of the particulate from the gas-particulate mixture by causing that particulate to separate from the gas-particulate mixture; and a further exhaust, located below the further inlet in a vertical dimension, configured to exhaust the filtered gas-particulate mixture.

[0020] The filter may comprise a filtration device having at least one guide.

[0021] The at least one guide may be a slat.

[0022] The filtration device may comprise a plurality of slats having a plurality of guides.

[0023] Each of the plurality of slats are evenly spaced from one another in the vertical dimension.

[0024] Each slat may be spaced from one another such that each slat is greater than 20mm apart from one another.

[0025] According to various, but not necessarily all, examples there is provided a vacuum excavator comprising: a vacuum generator configured to draw a gas-particulate mixture into the vacuum excavator; and a chamber comprising: an inlet configured to receive at least some of the gas-particulate mixture; a filter, configured to receive the gas-particulate mixture from the inlet in a first dimension, comprising at least one guide that is configured to guide the gas-particulate mixture received from the inlet in a direction angled relative to the first dimension and a second dimension that is orthogonal with the first dimension; and an exhaust, located below the inlet in a vertical dimension and separated from the inlet by the at least one guide, configured to exhaust the filtered gas-particulate mixture.

[0026] While the above examples of the disclosure and optional features are described separately, it is to be understood that their provision in all possible combinations and permutations is contained within the disclosure. It is to be understood that various examples of the disclosure can comprise any or all of the features described in respect of other examples of the disclosure, and vice versa. Also, it is to be appreciated that any one or more or all of the features, in any combination, may be implemented by/comprised in/performable by an apparatus, a method, and/or computer program instructions as desired, and as appropriate.

BRIEF DESCRIPTION

[0027] Some examples will now be described with reference to the accompanying drawings in which:

FIG. 1 shows a perspective view of an example vacuum excavator;
FIG. 2 shows a schematic cross-sectional side view of the example vacuum excavator;
FIG. 3 shows a schematic cross-sectional plan view of the example vacuum excavator through section A-A of FIG.2;
FIG. 4 shows a schematic cross-sectional side view of the example vacuum excavator;
FIG. 5 shows a schematic cross-sectional side view of the example vacuum excavator;
FIG. 6 shows a schematic cross-sectional side view of the example vacuum excavator;
FIG. 7 shows a schematic cross-sectional plan view of the example vacuum excavator shown in FIG. 6; and
FIG. 8 shows a further schematic cross-sectional side view of the example vacuum excavator shown in FIG. 6 and FIG. 7.

[0028] The figures are not necessarily to scale. Certain features and views of the figures can be shown schematically or exaggerated in scale in the interest of clarity and conciseness. For example, the dimensions of some elements in the figures can be exaggerated relative to other elements to aid explication. Similar reference numerals are used in the figures to designate similar features. For clarity, all reference numerals are not necessarily displayed in all figures.

DETAILED DESCRIPTION

[0029] Material collected and subsequently exhausted by a vacuum excavator may comprise one or more substances (e.g., silica) that may be harmful to workers and other people around the vicinity of the vacuum excavator. A vacuum excavator may require one or more filters to prevent or mitigate the exhaustion of such substances.

[0030] FIG. 1 shows a perspective view of an example vacuum excavator 10. The vacuum excavator 10 comprises a vacuum generator 20 configured to draw a gas-particulate mixture into the vacuum excavator 10.

[0031] FIG.1 shows that the vacuum excavator 10 comprises a connector 40 configured to attach the vacuum excavator 10 to construction equipment (e.g., an excavator, a loader, a digger etc.). The construction equipment may have a weight greater than 10 tons.

[0032] The vacuum excavator 10 may comprise at least one power supply to supply power to components of the vacuum excavator 10 (e.g., the vacuum generator 20, the inlet actuator 34 etc.). One or more of the components of the vacuum excavator 10 may be supplied with power (e.g., electrical power or pneumatic power) by construction equipment (e.g., construction equipment to which the vacuum excavator 10 is to be attached via the connector 40). As shown in FIG.1, the vacuum excavator 10 may comprise one or more connectors 50 that are configured to transmit and/or receive power from construction equipment. In FIG.1, all of these connectors 50 have not been marked with a reference sign for clarity purposes.

[0033] As shown in FIG.1, the vacuum excavator 10 comprises an inlet 30 to which a conduit/pipe 32 may be attached. The conduit 32 and the inlet 30 enable matter to enter the vacuum excavator 10 and its various chambers, as discussed below. The vacuum excavator 10 may comprise an inlet actuator 34 that is configured to move the inlet 30 (and the conduit 32) relative to the vacuum excavator 10. For example, the inlet actuator 34 and linkage 36 may be configured to tilt the inlet 30. The inlet actuator 34 may be a hydraulic actuator.

[0034] When the vacuum generator 20 is supplied with power, it generates at least a partial vacuum. A pressure differential caused by generation of the (partial) vacuum causes gas (e.g., air) and material (e.g., silica dust) from around the vacuum excavator 10 and to be urged through the conduit 32 and into the vacuum excavator 10 via the inlet 30. As the gas and material are being urged into the vacuum excavator 10, the gas and material mix to form a gas-particulate mixture. The particulate may comprise one or more substances that are harmful to humans (e.g., silica), for example, if the vacuum generator 10 is used to remove debris (such as silica dust) from railways.

[0035] As shown in FIG.1, the vacuum excavator 10 may comprise one or more of a plurality of doors 61-64, an openable floor 70, one or more floor actuators 71, 72, a first chamber 100, a second chamber 200, a third chamber 300, a fourth chamber 400 and an exhaust fan 80 that will be described in further detail below.

[0036] The pressure differential may cause the gas-particulate mixture to be urged from the inlet 30 to the exhaust fan 80 (e.g., to be exhausted from the vacuum excavator 10) via one or more of the chambers 100, 200, 300, 400. A pressure differential (e.g., caused by the vacuum generator 20) may cause the gas-particulate mixture to move from the inlet 30 into the first chamber 100 via an inlet of the first chamber 100. A pressure differential (e.g., caused by the vacuum generator 20) may cause the gas-particulate mixture to move from an outlet of the first chamber 100 and into the second chamber 200 via an inlet of the second chamber 200. A pressure differential (e.g., caused by the vacuum generator 20) may cause the gas-particulate mixture to move from an outlet of the second chamber 200 and into the third chamber 300 via an inlet of the third chamber 300. A pressure differential (e.g., caused by the vacuum generator 20) may cause the gas-particulate mixture to move from an outlet of the third chamber 300 and into the fourth chamber 400 via an inlet of the fourth chamber 200. The gas-particulate mixture may be exhausted from the fourth chamber 400 to outside of the vacuum excavator 10 via the exhaust fan 80. Arrows are provided in FIGs 2 to 8 which indicate the flow of the gas-particulate mixture through the vacuum excavator 10. The flow of the gas-particulate mixture through the vacuum excavator 10 is discussed in further detail below.

[0037] FIG. 2 shows a schematic cross-sectional side view of the vacuum excavator 10. It should be understood that the schematic does not include certain components (e.g., components of the second chamber 200 for clarity purposes).

[0038] FIG. 2 shows that the first chamber 100 is connected to the inlet 30 via a connector 90. In some examples, the vacuum generator 20 may cause the gas-particulate mixture to be drawn from the inlet 30 and into the first chamber 100 via the connector 90. As mentioned above, the first chamber 100 may comprise an inlet 102 configured to allow the gas-particulate mixture received from the connector 90 to enter the first chamber 100.

[0039] The first chamber 100 may comprise a collector 104 configured to collect at least some of the particulate that separates from the gas-particulate mixture whilst the gas-particulate mixture is in the first chamber 100. The first chamber 100 may comprise one or more filters configured to cause at least some of the particulate may separate from the gas-particulate mixture. The one or more filters may comprise a gravity filter and/or a plenum filter. These are described in more detail below.

[0040] As shown in FIG.2, the inlet 102 may comprise a hood that has an opening facing towards the collector. The hood being faced in this manner ensures that more of the gas-particulate mixture is urged towards the collector 104 such that a greater amount of particulate is collected in the collector 90 than if the hood was not present.

[0041] In some examples such as the example shown in FIG. 2, the first chamber 100 may comprise a guide surface 106. The guide surface 106 is configured to face at least part of the collector 90. The guide surface 106 may be angled relative to a vertical dimension and a horizontal dimension. The guide surface 106 being orientated in this manner causes more of the gas-particulate mixture to be guided towards the collector 104 such that a greater amount of particulate is collected in the collector 90 than if the guide surface 106 were not present.

[0042] As mentioned above, the first chamber 100 may comprise a gravity filter. As shown in FIG. 2, the portion of the first chamber 100 that extends from the inlet 102 to the collector 104 may be a gravity filter. A gravity filter may be considered to be a portion of the vacuum excavator 10 that causes particulate to separate from the gas-particulate mixture due to gravity.

[0043] In use, after the gas-particulate mixture enters the first chamber 100 via the inlet 102, at least part of the gas-particulate mixture is drawn towards an outlet 108 of the first chamber 100 (by the vacuum generator 20), where it exits the first chamber 100 via the passageway 108. As the outlet 108 of the first chamber 100 is located above the inlet 102 of the first chamber 100, in order for the gas-particulate mixture to exit the first chamber 100, the gas-particulate mixture must travel in a direction that opposite to that of gravity. As the particulate is typically denser than the gas in the gas-particulate mixture, some of the particulate separates from the gas-particulate mixture and is collected in the collector 104.

[0044] Additionally, or alternatively to comprising one or more gravity filters, the vacuum excavator 10 may comprise one or more plenum filters. The first chamber 100 may comprise one or more plenum filters. The portion of the first chamber 100 above the inlet 102 to the first chamber 100 may be considered to be an upper portion of the first chamber 100. The upper portion of the first chamber 100 may be a plenum filter. The plenum filter is described in more detail below.

[0045] The collector 104 may be located above the openable floor 70. The openable floor 70 may be openable such that the particulate collected in the collector 104 can be removed from the vacuum excavator 10. For example, the particulate stored in the collector 104 may be removed from the collector 104 by gravity when the floor 70 is opened (i.e., the particulate falls out of the opening in the openable floor 70). As shown in FIGs 1 and 2, the openable floor 70 may be opened and closed by one or more floor actuators 71-74. The one or more floor actuators 71-74 may comprise a hydraulic actuator connected to the openable floor 70 via a linkage.

[0046] As shown in FIGs 1 and 2, the first chamber 100 may be accessed by one or more doors 61, 63. As shown best in FIG. 1, each of the doors may comprise a locking mechanism to ensure that each door 61, 63 does not open unintendedly during use. The periphery of each door 61, 63 may comprise a sealant configured to maintain the desired pressure in the first chamber 100 when the vacuum excavator 10 is being used. The one or more doors 61, 63 may provide access to a user of the vacuum excavator 10 to provide maintenance to the first chamber 100 (i.e., components of the first chamber 100).

[0047] FIG. 3 shows a schematic cross-sectional plan view of the example vacuum excavator 10 through section A-A of FIG. 2. It should be understood that the schematic does not include certain components (e.g., components of the second chamber 200 for clarity purposes).

[0048] FIG. 3 shows the passageway 110 that couples the upper portion to the lower portion of the first chamber 100. The gas-particulate mixture may be drawn into the upper portion of the first chamber 100 from the lower portion of first chamber 100 via the passageway 110.

[0049] The upper portion of the first chamber 100 may be a plenum filter in that the passageway 106 has a smaller volume (for allowing the gas-particulate mixture to pass through) than the upper portion of the first chamber 100. The smaller volume may be caused by the passageway having a smaller cross-sectional area than upper portion. As the gas-particulate mixture passes from the passageway 106 into the upper portion, the change in volume causes the velocity of the gas-particulate mixture to decrease. The decrease in velocity of the gas-particulate mixture causes at least some of the particulate in the gas-particulate mixture to separate. In this regard, the first chamber 100 may be shaped to form at least one plenum filter.

[0050] The separated particulate may contact one or more collection surfaces 112, 114. As shown best in FIG. 2, the collection surfaces 112, 114 are shaped such that the particulate that contact the collection surface 112, 114 is guided into the collector 104.

[0051] It should be understood that whilst this example plenum filter uses a change in volume to reduce the speed of the gas-particulate mixture, other methods of reducing the speed of the gas particulate mixture may be used.

[0052] As mentioned above, the gas-particulate mixture may be drawn out of the first chamber 100 by the vacuum generator 20 into a second chamber 200. FIG. 4 and FIG. 5 each show a schematic cross-sectional side view of the example vacuum excavator 10, showing the second chamber 200.

[0053] As shown in FIGs 4 and 5, the outlet 108 of the first chamber 100 may be the inlet 108 of the second chamber 200. The inlet 108 is configured to receive at least some of the gas-particulate mixture. At this stage, at least some of the particulate may have already been separated from the gas-particulate mixture in the first chamber 100 (e.g., by at least one of a gravity and plenum filter) in the manner described above.

[0054] The second chamber 200 may comprise a filter. The filter may be configured to redirect the gas-particulate mixture received by the inlet 108 and filter at least some of the particulate from the gas-particulate mixture by causing that particulate to separate from the gas-particulate mixture.

[0055] The filter may comprise a filtration device 210 (as shown in FIG. 4) and/or a cyclone filter 220 (as shown in FIG. 5). In use, the gas-particulate mixture may be drawn from the inlet 108 of the second chamber 200 to an exhaust 208 of the second chamber 200 via the filter 210, 220.

[0056] The filter 210, 220 may comprise at least one guide 211, 221 configured to redirect the gas-particulate mixture received by the inlet 108. As mentioned above, FIG. 4 shows an example second chamber 200 comprising a filtration device 210. The filtration device 210 comprises at least one guide 211. FIG. 4 shows that the at least one guide 211 of the filtration device 210 is provided by at least one slat.

[0057] The guide 211, 221 (e.g., the slat) may be configured to guide the gas-particulate mixture received from the inlet 108 in a direction angled relative to a first dimension (e.g., a vertical dimension) and angled relative to a second dimension (e.g., a horizontal dimension) that is orthogonal to the first dimension. For example, the guide 211, 221 may have a surface that is angled relative to the vertical dimension and the horizontal dimension. The guide 211, 221 may be formed at least in part of a corrosion resistant material such as metal (e.g., steel).

[0058] The guide 211 of the filtration device 210 may be configured to redirect the gas-particulate mixture. As shown in FIG. 4, the gas-particulate mixture may be directed downwards when travelling from the inlet 108 to the filtration device 210 via a passageway 206. As shown by the arrows in the filtration device 210 of FIG. 4, the guide(s) 211 of the filtration device 210 cause the gas-particulate mixture to be redirected such that the direction of the gas-particulate mixture has an upwards component.

[0059] As shown in FIG. 4, the filtration device 210 may comprise a plurality of slats 211. The slats 211 may be evenly spaced from one another in the vertical dimension. For example, the slats 211 may be spaced more than 20mm apart from one another in the vertical dimension. The slats 211 may be spaced 50mm from one another in the vertical dimension. The slats 211 may be formed from a corrosion resistant material. The corrosion resistant material may be a plastic or metal (e.g., steel).

[0060] As shown in FIGs 4 and 5, the second chamber 200 may comprise a collector 204, 304 that is configured to collect particulate that is separated from the gas-particulate mixture by the filter. The collector 204 may be located below the inlet 108 and the exhaust 208 in the vertical dimension.

[0061] In use, the gas-particulate mixture is drawn from the inlet 108 to the exhaust 208 via the passageway 206 and the filtration device 210. As shown by the arrows passing between the slats/guides 211 in FIG. 4, the at least one guide 211 causes the direction of the gas-particulate mixture to be redirected (e.g., rotated).

[0062] During testing, the inventor has found that the gas-particulate mixture being redirected (e.g., rotated) in this manner causes at least some of the particulate from the gas-particulate mixture to be separated from gas-particulate mixture. The separated particulate may be collected in the collector 204.

[0063] As shown in FIG. 4, the at least one guide 211 causes the gas-particulate mixture to rotate by more than 90 degrees. The at least one guide 211 may cause the gas-particulate mixture to rotate more than 120 degrees. The at least one guide 211 may cause the gas particulate mixture to rotate around 135 degrees.

[0064] During testing, the inventor has also found that the redirection of the gas-particulate mixture also causes more significant rotation (e.g., spinning) of the gas-particulate mixture in the volume between the filtration device 210 and the collector 204 (as illustrated by the arrows in FIG. 4). This rotation of the gas-particulate mixture may also cause at least some of the particulate from the gas-particulate mixture to be separated from gas-particulate mixture. The separated particulate may be collected in the collector 204.

[0065] During testing, the inventor has also found that as the gas-particulate mixture passes into the filtration device 210, at least some of the particulate in the gas-particulate mixture is separated from the gas-particulate mixture on the upper surfaces of each of the guides/slats 211. The separate particulate may fall down the guides 211 and be collected in the collector 204.

[0066] The second chamber 200 may comprise at least part of the openable floor 70. Particulate collected in the collector 204 may be removed from the second chamber 200 via the openable floor 70.

[0067] As mentioned above, FIG. 5 shows an example second chamber 200 comprising a cyclone filter 220. The cyclone filter 220 comprises at least one guide 221. The at least one guide 221 may be provided by a cone (e.g., a cone-shaped portion) of the cyclone filter 220.

[0068] The chamber 200 shown in FIG. 5 comprises a passageway 206 configured to guide the gas-particulate mixture from the inlet 108 into the cyclone filter 220. The passageway 206 may be provided by a conduit. The conduit may comprise one or more pipes. The conduit may be flexible.

[0069] The gas-particulate mixture received by the cyclone filter 220 via the passageway 206 is caused to rotate at least in part by the shape of the cone. The rotation of the gas-particulate mixture causes at least some of the particulate from the gas-particulate mixture to be separated from gas-particulate mixture. The separated particulate may be urged against the cone/guide 221. The separated particulate may fall down the cone 221 into the collector 204. The remainder of the gas-particulate mixture may be drawn to the exhaust 208 from the cyclone filter 220 via a conduit in the cyclone filter.

[0070] The inventor has found that incorporating the filtration device 210 and/or the cyclone filter 220 into a vacuum excavator 10 is effective such that exhausted gas-particulate mixture need not be sprayed with water to reduce the effects of the harmful substances. Large water tanks that are used to spray gas-particulate with water are, therefore, potentially no longer required by the vacuum excavator 10 thereby saving weight of the vacuum excavator 10 and also no longer requiring access to water that is not always readily available on construction sites (e.g., on railways).

[0071] During testing, the inventor has found that the filter of the second chamber 200 is effective such that textile filters can be used in the vacuum excavator 10 without being easily blocked or damaged by particulates (e.g., of greater than 10 microns in diameter) from the gas-particulate mixture.

[0072] As shown best in FIG. 3, the second chamber 200 of the vacuum excavator 10 may be split (e.g., substantially in half) to form two sub-chambers. Each of the sub-chambers may comprise a filtration device 210 or a cyclone filter 220 as described above.

[0073] In view of the restrictive volume and weight requirements for a vacuum excavator, the inventor has found that having two smaller cyclone filters 220 in the second chamber 200 rather than a single larger cyclone filter 220 provides improved filtration of the gas-particulate mixture.

[0074] The second chamber 200 may be user-removable from the vacuum excavator 10. For example, a vacuum excavator 10 may be configured such that a chamber comprising a cyclone filter 220 can be replaced by a chamber 200 comprising a filtration device 210. Additionally, or alternatively, the filter (e.g., the filtration device 210 and/or the cyclone filter 220) may be user-removable from the second chamber 200. Other components between the inlet 108 of the second chamber 200 and the outlet 208 of the second chamber 200 may be user-removable.

[0075] The filtration device 210 and/or cyclone filter 220 may comprise at least one connector for coupling the filtration device 210 and/or cyclone filter 220 to the second chamber 200. The connector may comprise at least one male or female portion for coupling (directly or indirectly) the filtration device 210 and/or cyclone filter 220 to the second chamber 200. The second chamber 200 may comprise the other of at least one corresponding male or female portion.

[0076] The filtration device 210 shown in FIG. 4 comprises a male portion 230 that is configured to couple the filtration device 210 to the second chamber 200. The second chamber 200 comprises a corresponding female portion (not shown) configured to receive the male portion 230. FIG. 5 shows that the cyclone filter 220 may comprise a male portion 230 as described above.

[0077] The filtration device 210 and/or the cyclone filter 220 may comprise a fastener to secure the filtration device 210 and/or the cyclone filter 220 to the second chamber 200 (e.g., such that a user cannot uncouple the filtration device 210 and/or cyclone filter 220 from the second chamber 200 without removing the fastener). FIG. 4 shows that the fastener 232 is a nut and a bolt. It should be understood that the fastener may be any suitable means for securing the filtration device 210 and/or cyclone filter 220 to the second chamber 200.

[0078] During assembly, the second chamber 200 might not yet comprise a filtration device 210 or a cyclone filter 220. A user may access the second chamber 200 (e.g., via the door 64). The user may couple the filtration device 210 to the second chamber 200. For example, the user may couple the male portion 230 of the filtration device 210 into a corresponding female portion of the second chamber 200. The user may then fasten the filtration device 210 to the second chamber 200 with the fastener 232.

[0079] Upon replacing the filtration device 210 with the cyclone filter 220, a user may unfasten the fastener 232 and then remove the filtration device 210 from the second chamber 200 (e.g., via the door 64). The user may couple the cyclone filter 220 to the second chamber 200. For example, the user may couple the male portion 230 of the cyclone filter 220 into a corresponding female portion of the second chamber 200. The user may then fasten the cyclone filter 220 to the second chamber 200 with the fastener (not shown in FIG. 5).

[0080] The removable and replaceable nature of the second chamber 200, filtration device 210 and/or cyclone filter 220 may be beneficial depending on the conditions in which the vacuum excavator 10 is operating in. For example, during testing, the inventor has found that when excavating in wet conditions a chamber 200 comprising at least one filtration device 210 provides better performance than a chamber 200 comprising at least one cyclone filter 220. It should be understood, however, that both the filtration device 210 and the cyclone filter 220 are suitable for use during wet conditions (e.g., when excavating wet material).

[0081] During testing, the inventor has found that the cyclone filter 220 and the filtration device 210 provide improved filtration versus gravity and plenum filter (assuming that the volume available for the filter is the same for each). In examples in which the vacuum excavator 10 is attached to construction equipment, the volume and weight of the vacuum excavator 10 are limited.

[0082] FIG. 6 shows a schematic cross-sectional side view of the example vacuum excavator 10. FIG. 7 shows a schematic cross-sectional plan view and FIG. 8 shows a further schematic cross-sectional side view of the example vacuum excavator 10.

[0083] As shown in FIGs 6 and 7, the vacuum excavator 10 may comprise a third chamber 300. The third chamber 300 may comprise an inlet 208. The inlet 208 may be the outlet 208 of the second chamber 200. The third chamber 300 may have one or more outlets/exhausts 308 as shown in FIG. 7. The third chamber 300 may have one or more textile filters 311-318 located between the inlet 208 and the outlet 308.

[0084] The vacuum excavator 10 may comprise at least one textile filter 311-318 configured to receive and filter the exhausted gas-particulate mixture from the exhaust 208 (e.g., of the second chamber 200). The size of the particulates filtered in the second chamber 200 (e.g., by the filtration device and/or the cyclone filter) may be greater than 10 microns in diameter. The at least one textile filter 311-318 may be different from the filters 210, 220 in the second chamber 200.

[0085] A textile filter 311-318 may be a filter having a permeable textile (e.g., any suitable woven, knitted, tufted, or knotted material) that is configured to separate fluids (such as air) from particulates (such as silica) in a fluid-particulate mixture.

[0086] In use, the vacuum generator 20 may draw the gas-particulate fluid from the inlet 208 to the outlet 308 via the one or more textile filters 311-318. The textile filters 311-318 may be configured such that the gas-particulate mixture has to pass through at least one textile filter 311-318 when travelling between the inlet 208 and the outlet 308 of the third chamber 308.

[0087] Each filter 311-318 may be configured to separate harmful substances (such as silica dust) from the gas-particulate mixture.

[0088] Once the gas-particulate mixture has been filtered by the vacuum excavator 10, the remaining gas-particulate mixture may be exhausted from the vacuum excavator 10. FIGs 7 and 8 show that the vacuum excavator 10 may comprise an exhaust fan 80 that is configured to draw the remaining gas-particulate mixture from the vacuum excavator 10 and to the outside of the vacuum excavator 10 (e.g., into the atmosphere).

[0089] FIGs 7 and 8 show that the exhaust fan 80 draws the filtered gas particulate mixture from the third chamber 300 into a fourth chamber 400 and then out of the fourth chamber 400. The size of the particulates filtered in the third chamber 300 (e.g., by the one or more textile filters 311-318) may be 5 to 10 microns in diameter.

[0090] The filtered gas-particulate mixture may be exhausted in a substantially vertical direction (e.g., substantially parallel to the vertical dimension), such as upwardly. Exhausting the filtered gas-particulate mixture in this manner ensures that a person operating the vacuum excavator 10 or other person on or near the construction site is less likely to inhale the exhausted gas-particulate mixture.

[0091] Whilst the figures show a vacuum excavator 10 having a plurality of chambers 100, 200, 300, 400 and filters 210, 220, 311-318, it should be understood that the vacuum excavator may comprise any number of chambers and filters. For example, the vacuum excavator 10 may comprise the chamber 200 that is described as the "second chamber" 200 above, without one or more of the chambers that are described as the first, third and fourth chambers 100, 300, 400 described above.

[0092] For example, a vacuum excavator 10 may comprise a vacuum generator 20 configured to draw a gas-particulate mixture into the vacuum excavator 10. In use, the vacuum generator 20 may draw a gas-particulate mixture from the outside of the vacuum excavator 10 into a chamber 200 corresponding to an example of the "second chamber" 200 described above. The chamber 200 may comprise an inlet 108 configured to receive at least some of the gas-particulate mixture; a filter 210, 220 configured to redirect the gas-particulate mixture received by the inlet and filter at least some of the particulate from the gas-particulate mixture by causing that particulate to separate from the gas-particulate mixture; and an exhaust 208, located below the inlet 108 in a vertical dimension, configured to exhaust the filtered gas-particulate mixture.

[0093] As described above, the chamber 200 may comprise a filter 210, 220, configured to receive the gas-particulate mixture from the inlet 108 in a first dimension, comprising at least one guide 211, 221 that is configured to guide the gas-particulate mixture received from the inlet 108 in a direction angled relative to the first dimension and a second dimension that is orthogonal with the first dimension.

[0094] The term 'comprise' is used in this document with an inclusive not an exclusive meaning. That is any reference to X comprising Y indicates that X may comprise only one Y or may comprise more than one Y. If it is intended to use 'comprise' with an exclusive meaning then it will be made clear in the context by referring to "comprising only one..." or by using "consisting".

[0095] In this description, the wording 'connect', 'couple' and 'communication' and their derivatives mean operationally connected/coupled/in communication. It should be appreciated that any number or combination of intervening components can exist (including no intervening components), i.e., so as to provide direct or indirect connection/coupling/communication. Any such intervening components can include hardware and/or software components.

[0096] As used herein, the term "determine/determining" (and grammatical variants thereof) can include, not least: calculating, computing, processing, deriving, measuring, investigating, identifying, looking up (for example, looking up in a table, a database or another data structure), ascertaining and the like. Also, "determining" can include receiving (for example, receiving information), accessing (for example, accessing data in a memory), obtaining and the like. Also, " determine/determining" can include resolving, selecting, choosing, establishing, and the like.

[0097] In this description, reference has been made to various examples. The description of features or functions in relation to an example indicates that those features or functions are present in that example. The use of the term 'example' or 'for example' or 'can' or 'may' in the text denotes, whether explicitly stated or not, that such features or functions are present in at least the described example, whether described as an example or not, and that they can be, but are not necessarily, present in some of or all other examples. Thus 'example', 'for example', 'can' or 'may' refers to a particular instance in a class of examples. A property of the instance can be a property of only that instance or a property of the class or a property of a sub-class of the class that includes some but not all of the instances in the class. It is therefore implicitly disclosed that a feature described with reference to one example but not with reference to another example, can where possible be used in that other example as part of a working combination but does not necessarily have to be used in that other example.

[0098] Although examples have been described in the preceding paragraphs with reference to various examples, it should be appreciated that modifications to the examples given can be made without departing from the scope of the claims.

[0099] Features described in the preceding description may be used in combinations other than the combinations explicitly described above.

[0100] Although functions have been described with reference to certain features, those functions may be performable by other features whether described or not.

[0101] Although features have been described with reference to certain examples, those features may also be present in other examples whether described or not.

[0102] The term 'a', 'an' or 'the' is used in this document with an inclusive not an exclusive meaning. That is any reference to X comprising a/an/the Y indicates that X may comprise only one Y or may comprise more than one Y unless the context clearly indicates the contrary. If it is intended to use 'a', 'an' or 'the' with an exclusive meaning then it will be made clear in the context. In some circumstances the use of 'at least one' or 'one or more' may be used to emphasis an inclusive meaning but the absence of these terms should not be taken to infer any exclusive meaning.

[0103] The presence of a feature (or combination of features) in a claim is a reference to that feature or (combination of features) itself and also to features that achieve substantially the same technical effect (equivalent features). The equivalent features include, for example, features that are variants and achieve substantially the same result in substantially the same way. The equivalent features include, for example, features that perform substantially the same function, in substantially the same way to achieve substantially the same result.

[0104] In this description, reference has been made to various examples using adjectives or adjectival phrases to describe characteristics of the examples. Such a description of a characteristic in relation to an example indicates that the characteristic is present in some examples exactly as described and is present in other examples substantially as described.

[0105] The above description describes some examples of the present disclosure however those of ordinary skill in the art will be aware of possible alternative structures and method features which offer equivalent functionality to the specific examples of such structures and features described herein above and which for the sake of brevity and clarity have been omitted from the above description. Nonetheless, the above description should be read as implicitly including reference to such alternative structures and method features which provide equivalent functionality unless such alternative structures or method features are explicitly excluded in the above description of the examples of the present disclosure.

[0106] Whilst endeavoring in the foregoing specification to draw attention to those features believed to be of importance it should be understood that the Applicant may seek protection via the claims in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not emphasis has been placed thereon.

Claims

1. A vacuum excavator comprising:

a vacuum generator configured to draw a gas-particulate mixture into the vacuum excavator; and

a chamber comprising:

an inlet configured to receive at least some of the gas-particulate mixture;

a filter configured to redirect the gas-particulate mixture received by the inlet and filter at least some of the particulate from the gas-particulate mixture by causing that particulate to separate from the gas-particulate mixture; and

an exhaust, located below the inlet in a vertical dimension, configured to exhaust the filtered gas-particulate mixture.

2. The vacuum excavator of claim 1, further comprising at least one textile filter, different from the filter, configured to receive and filter the exhausted gas-particulate mixture from the exhaust.

3. The vacuum excavator of claim 1 or 2, wherein the filter comprises at least one guide configured to redirect the gas-particulate mixture received by the inlet, and wherein, optionally, the guide is configured to guide the gas-particulate mixture received from the inlet in a direction angled relative to a first dimension and angled relative to a second dimension that is orthogonal to the first dimension, and wherein, optionally, the first dimension is the vertical dimension.

4. The vacuum excavator of claim 3, wherein the guide has a surface that is angled relative to the vertical dimension and a horizontal dimension.

5. The vacuum excavator of claim 4, wherein the guide is formed at least partly from at least one metal.

6. The vacuum excavator according to any of the preceding claims, wherein the chamber comprises a collector configured to collect the particulate separated by the filter, and wherein, optionally, the collector is located below the inlet and the exhaust in the vertical dimension.

7. The vacuum excavator according to any of the preceding claims, wherein the chamber is removable from the vacuum excavator.

8. The vacuum excavator according to any of the preceding claims, wherein the filter is removable from the chamber, and wherein, optionally, the filter comprises at least one connector configured to couple the filter to the chamber, and wherein, optionally, the filter comprises at least one fastener configured to fasten the filter to the chamber.

9. The vacuum excavator according to any of the preceding claims, further comprising at least one further filter configured to filter the drawn gas-particulate mixture prior to being received at the inlet of the chamber, and wherein, optionally, the at least one further filter comprises one or more gravity filters and one or more plenum filters.

10. The vacuum excavator according to any of the preceding claims, further comprising a connector configured to attach the vacuum excavator to construction equipment.

11. The vacuum excavator according to any of the preceding claims, wherein the filter comprises a cyclone filter.

12. The vacuum excavator according to claim 11 when dependent on claim 3 or 4, wherein the guide is provided by a cone of the cyclone filter.

13. The vacuum excavator according to claim 11 or 12, further comprising a further chamber comprising:

a further inlet configured to receive at least some of the gas-particulate mixture;

a further cyclone filter configured to redirect the gas-particulate mixture received by the further inlet and filter at least some of the particulate from the gas-particulate mixture by causing that particulate to separate from the gas-particulate mixture; and

a further exhaust, located below the further inlet in a vertical dimension, configured to exhaust the filtered gas-particulate mixture.

14. The vacuum excavator according to any of the preceding claims, wherein the filter comprises a filtration device, the filtration device having at least one guide according to dependent claim 3 or 4, and wherein, optionally, the at least one guide is a slat, and wherein, optionally, the filtration device comprises a plurality of slats having a plurality of guides, and wherein, optionally, each of the plurality of slats are evenly spaced from one another in the vertical dimension, and wherein, optionally, each slat is spaced from one another such that each slat is greater than 20mm apart from one another.

15. A vacuum excavator comprising:

a vacuum generator configured to draw a gas-particulate mixture into the vacuum excavator; and

a chamber comprising:

an inlet configured to receive at least some of the gas-particulate mixture;

a filter, configured to receive the gas-particulate mixture from the inlet in a first dimension, comprising at least one guide that is configured to guide the gas-particulate mixture received from the inlet in a direction angled relative to the first dimension and a second dimension that is orthogonal with the first dimension; and

an exhaust, located below the inlet in a vertical dimension and separated from the inlet by the at least one guide, configured to exhaust the filtered gas-particulate mixture.

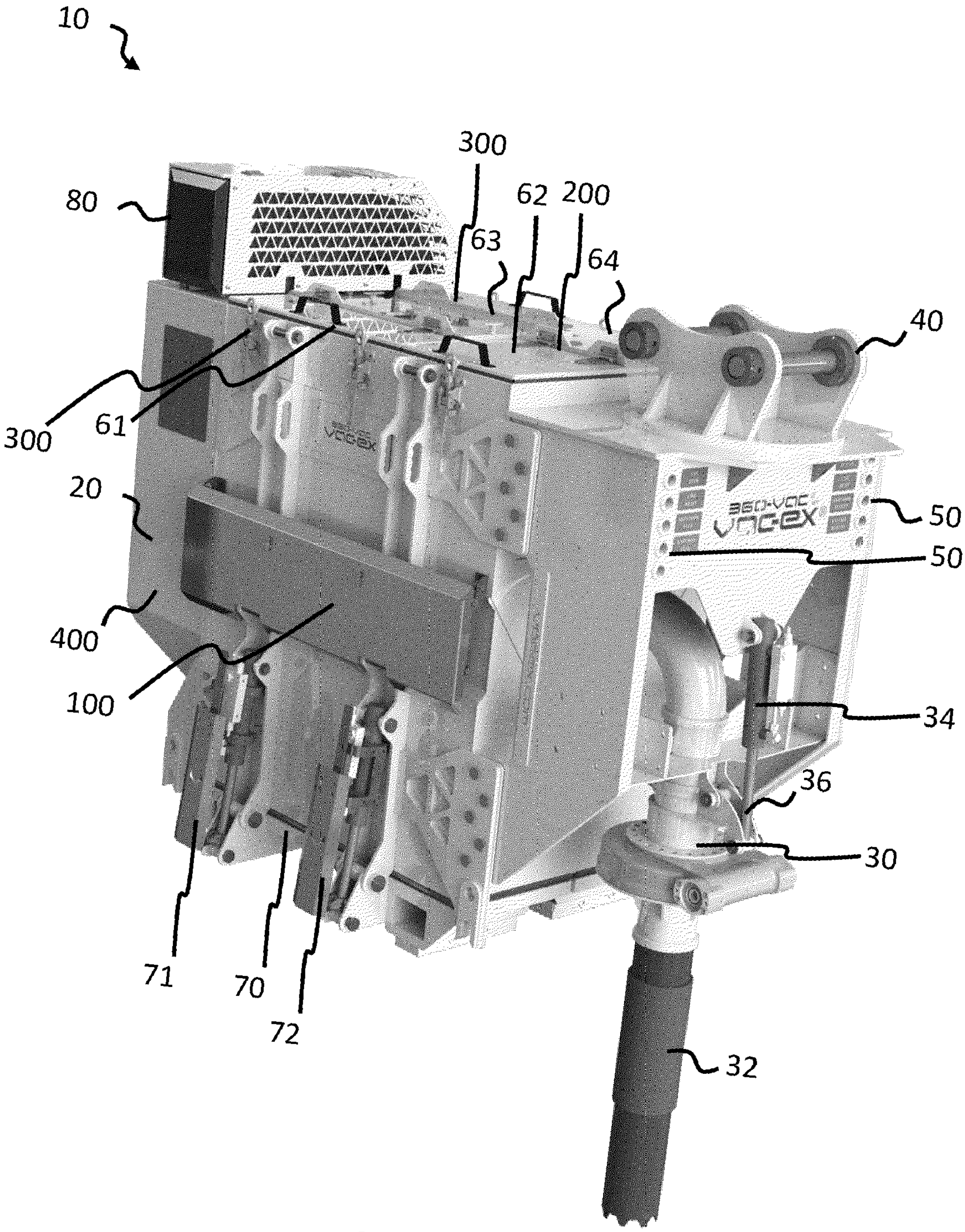

FIG. 1

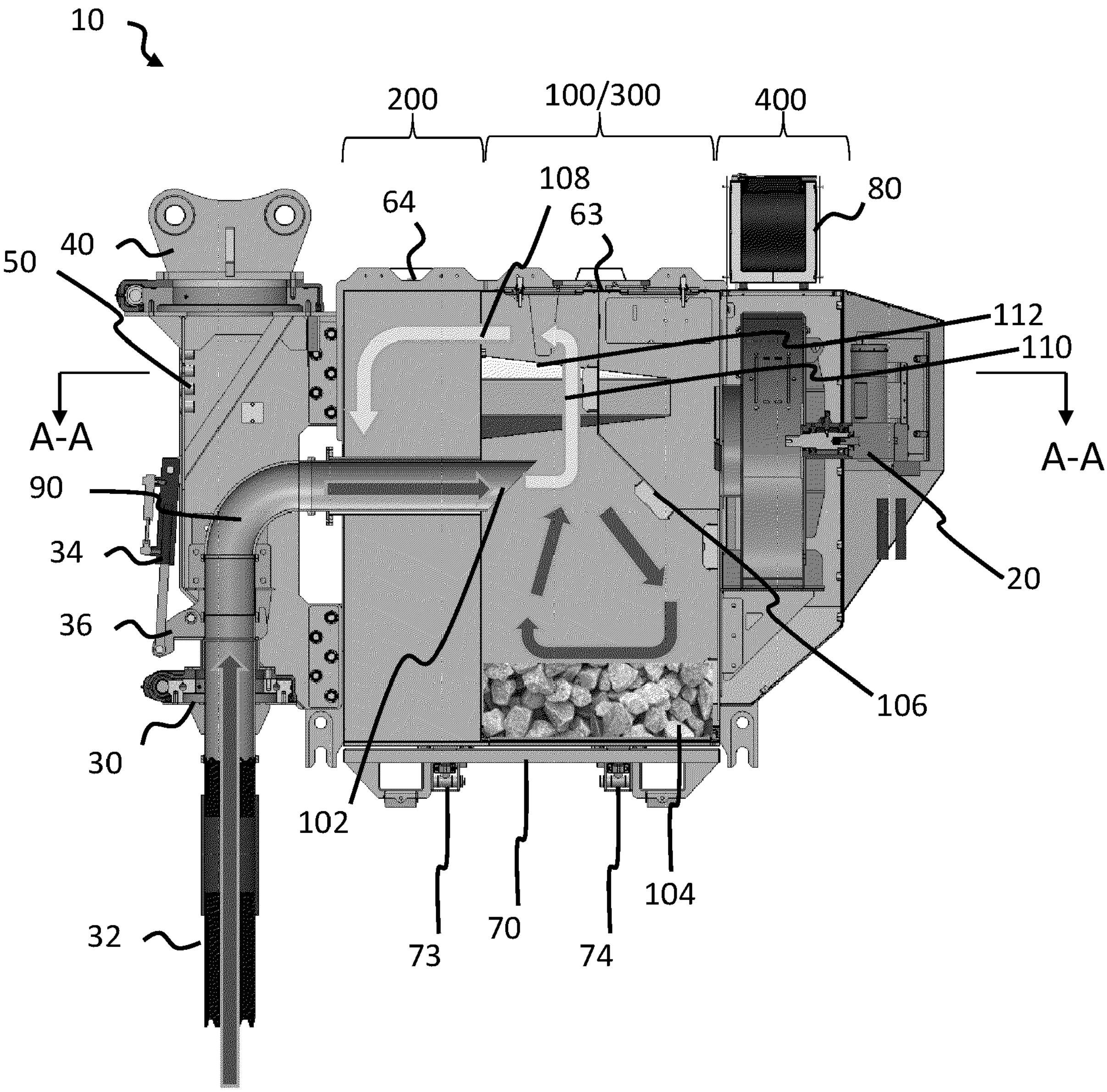
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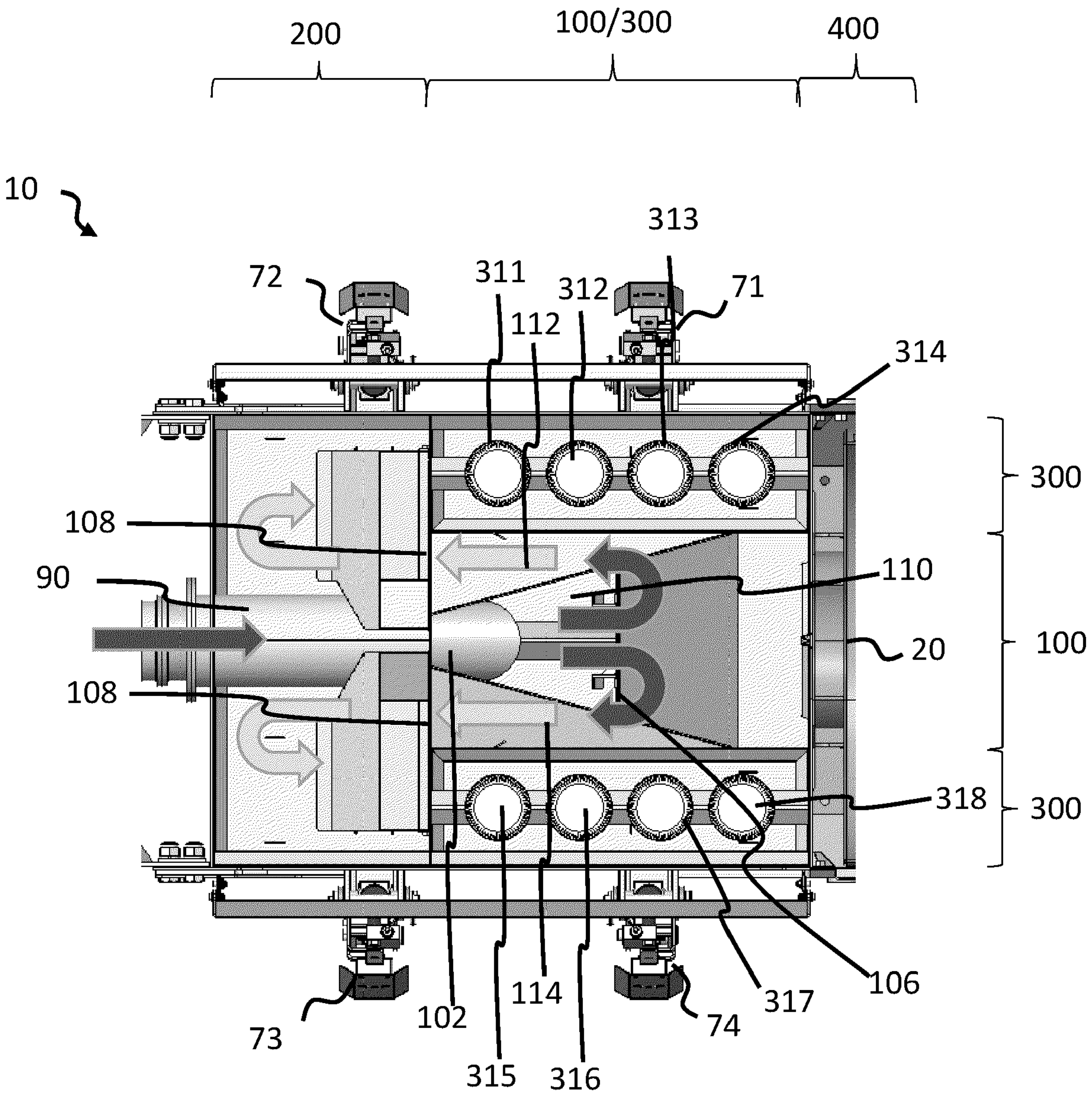
FIG. 2



Section A-A

FIG. 3

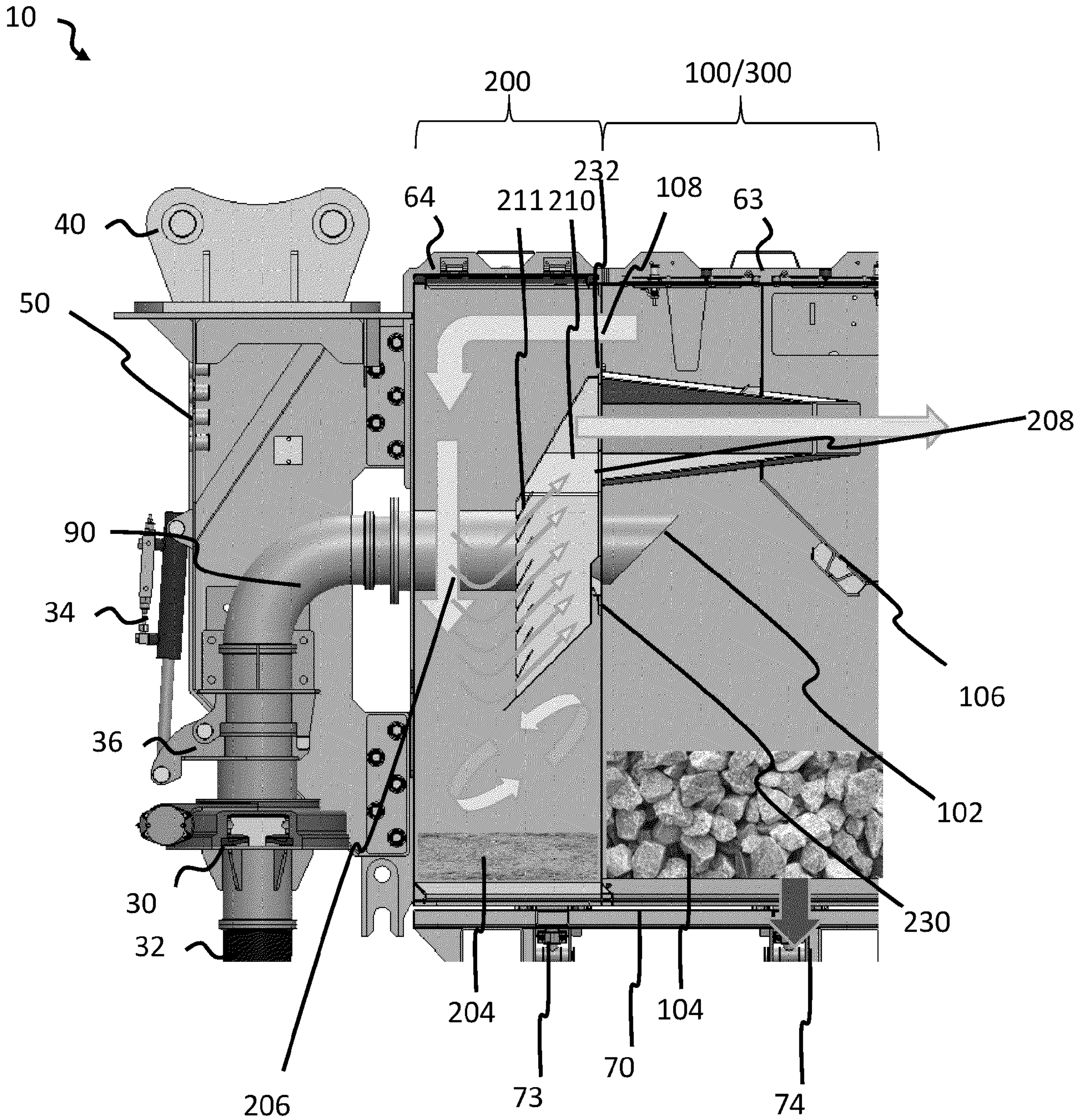

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FIG. 4

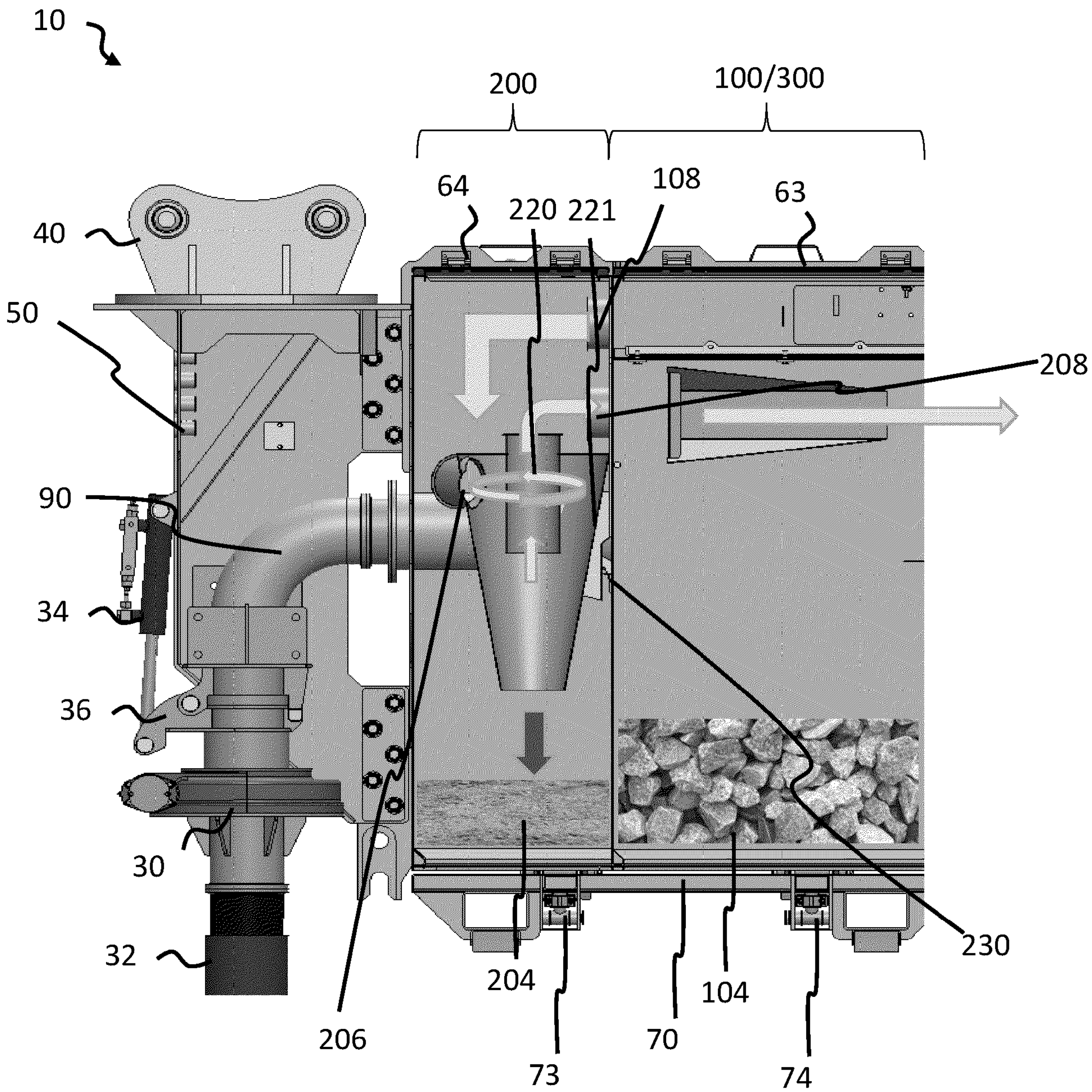
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FIG. 5

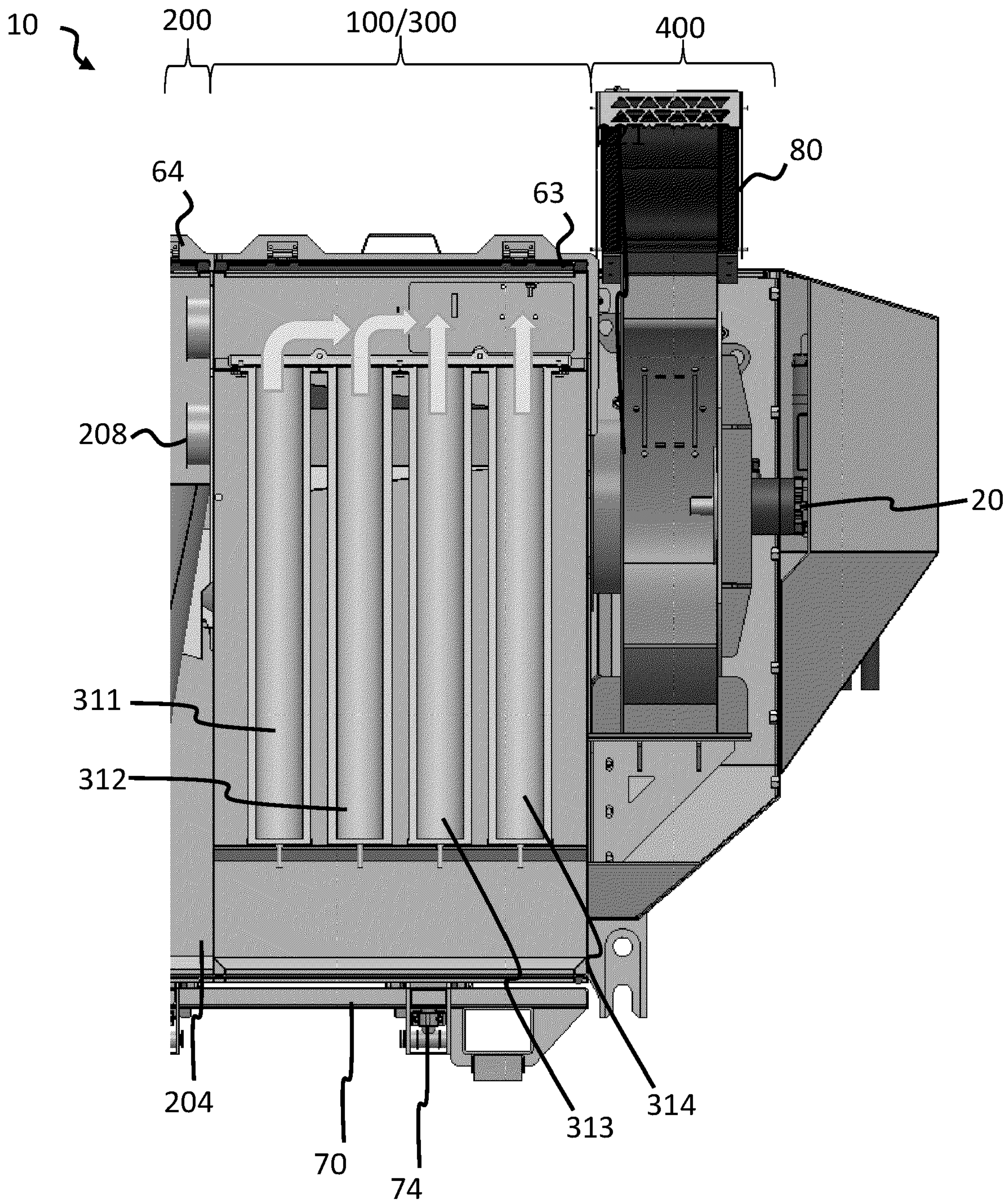

FIG. 6

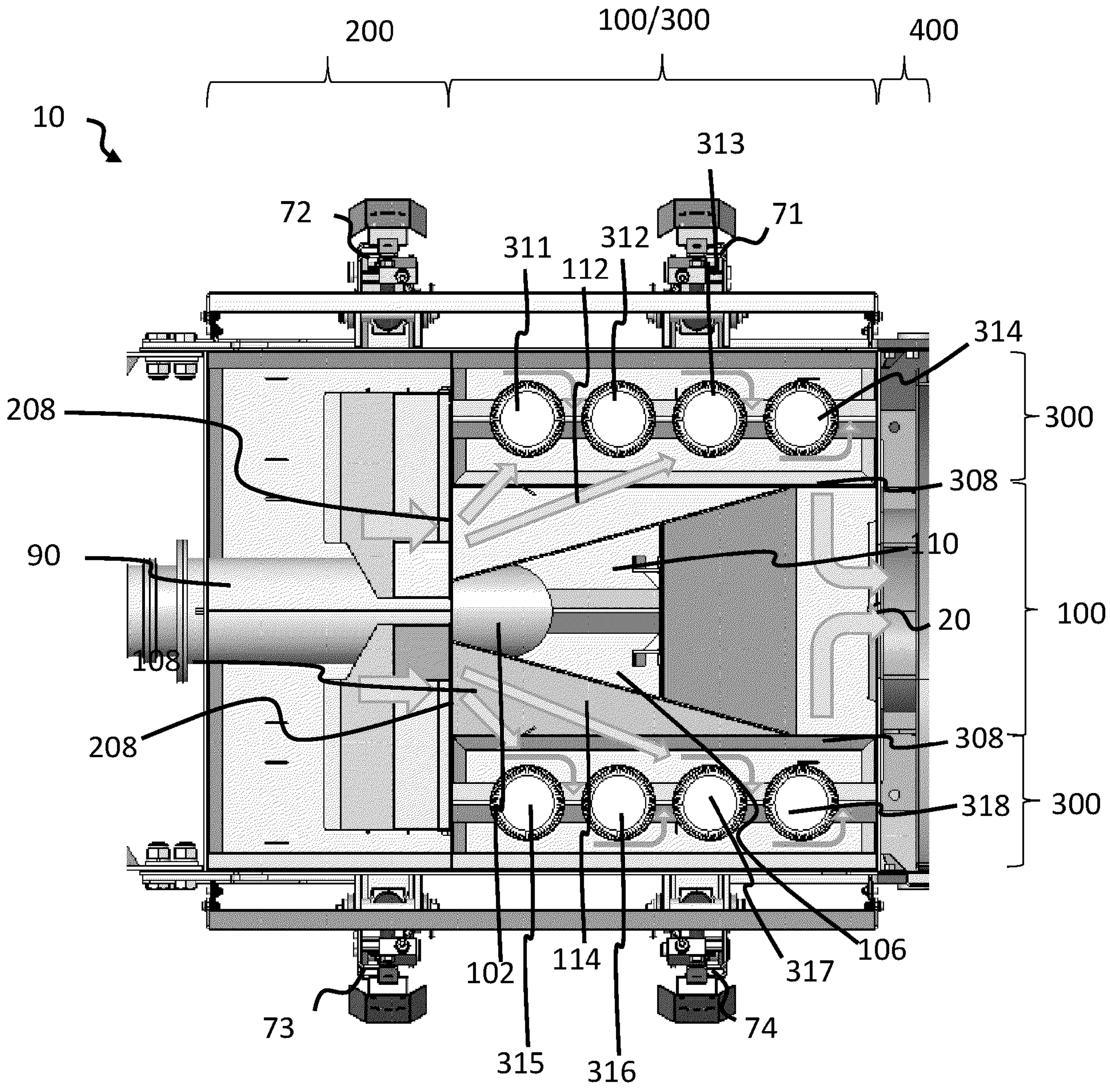
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FIG. 7

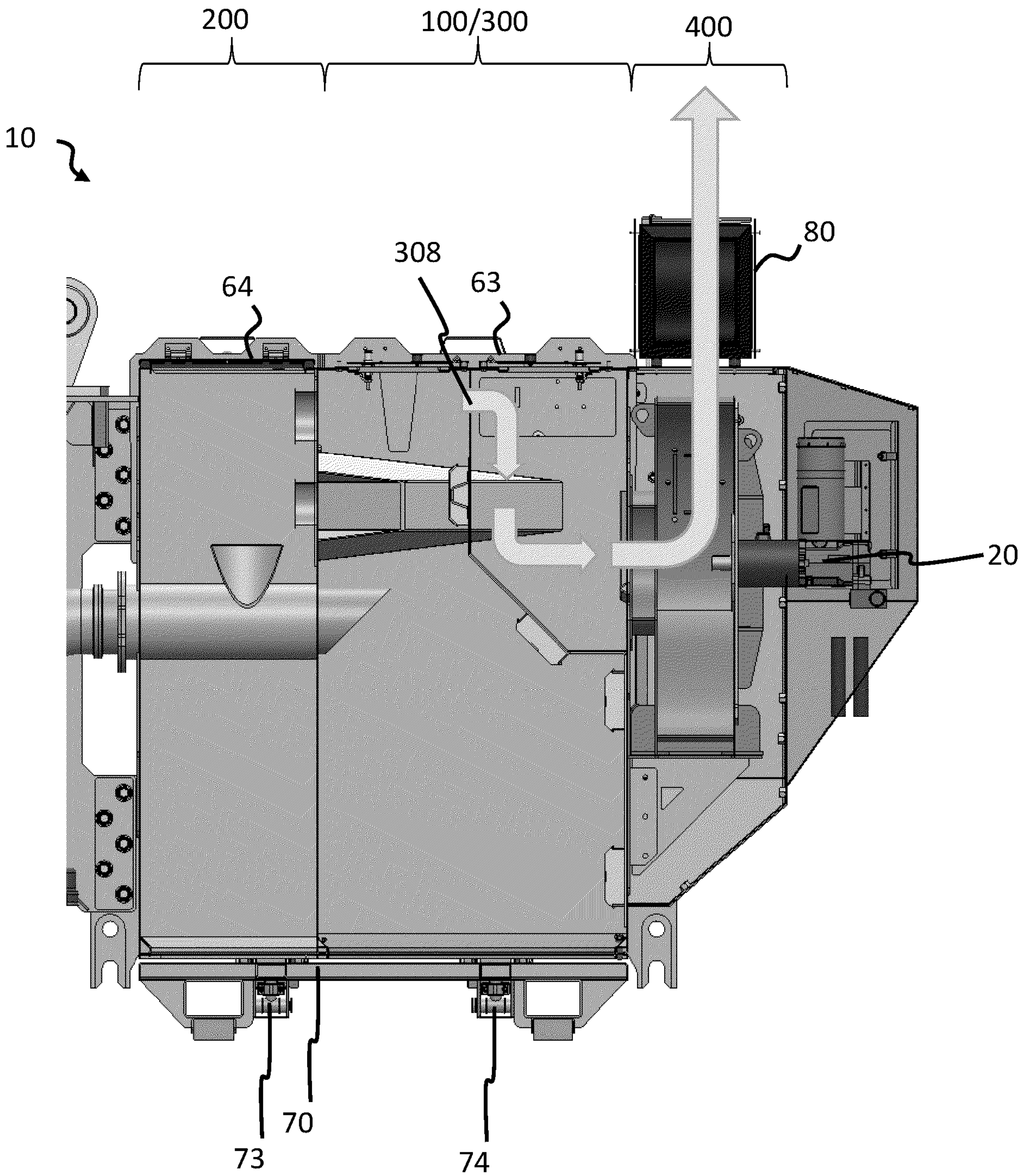

FIG. 8

EUROPEAN SEARCH REPORT

Application Number
EP 24 18 0602

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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E02F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	24 October 2024	Rocabruna Vilardell

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

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