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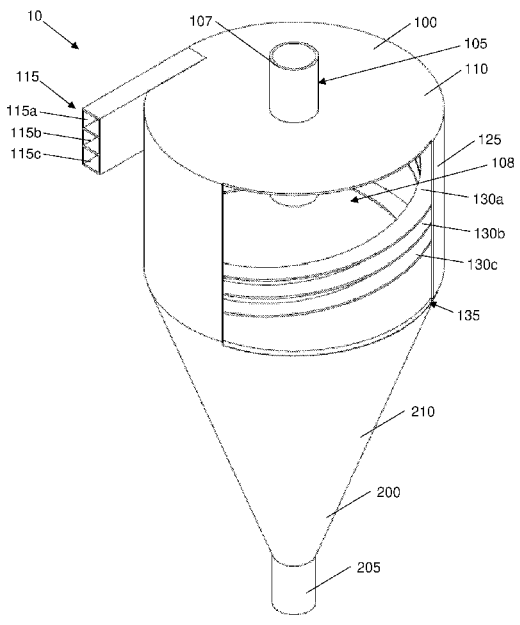

FIG. 1

(57) Abstract: A hydrocyclone including a substantially cylindrical chamber having at least one opening and a substantially conical chamber in open fluid communication with the cylindrical chamber. The hydrocyclone also includes a first outlet extending from the cylindrical chamber, a second outlet extending from the conical chamber and located opposite the first outlet, and two or more vertically arranged inlets connected to the opening of the cylindrical chamber.

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HYDROCYCLONE

FIELD OF THE INVENTION

[0001] The invention relates to a cyclonic separation system and, in particular, a hydrocyclone having two or more inlets.

BACKGROUND

[0002] Reference to background art herein is not to be construed as an admission that such art constitutes common general knowledge.

[0003] Cyclonic separators, such as hydrocyclones, are used to separate heavy/large particles from lighter/smaller particles

[0004] Hydrocyclones are useful in mining and quarrying applications and are typically of value in the coal cleaning industry where the heavy ash-rich particles of raw coal can be separated from the lighter low ash particles.

[0005] Using the fluid pressure from a slurry, the hydrocyclone creates internal rotational movement within a cylindrical chamber. Centrally located outlets, located at the top and bottom, allow the liquid moving around the chamber in a helical path to leave the hydrocyclone.

[0006] In operation, rotation of the aqueous slurry within the hydrocyclone is initiated by the tangential injection of the slurry into the chamber of the hydrocyclone. Due to the rotation, a heavy/large particle of the slurry moves outwardly toward one outlet and downwardly while another lighter/smaller particle of the slurry moves radially inwardly toward another outlet.

[0007] Typically, hydrocyclones use an aqueous slurry feed inlet stream introduced through a single feed conduit which is tangential to the cylindrical

surface of the cylindrical chamber of the hydrocyclone. However, this results in the stream of slurry travelling along the same path within the chamber during each use whereby the stream eventually wears away that particular portion of the lining of the chamber.

[0008] Hydrocyclones having two feed inlet openings to receive slurry into the chamber are described in US Patent No. 4,090,956 wherein two separate feed inlets are provided diametrically opposed to each other across a cylindrical section of a hydrocyclone.

[0009] A desired objective of the dual feed inlet hydrocyclone is to provide more uniform wear of the inner wall of the apex cone of the hydrocyclone. However, the dual feed inlet hydrocyclone of the prior art, having the separate feed conduits, presents serious installation, operating and maintenance problems.

[0010] A proposed solution to US Patent No. 4,090,956 lies in US Patent No. 4,652,363 which utilises a single stream input split across two different diametrically opposed openings into the hydrocyclone chamber. However, operationally, the dual streams provided into the chamber are unlikely to remain separate. Furthermore, the introduction of the second stream may disrupt the flow of the first stream thereby inhibiting the rotational forces within the hydrocyclone preventing effective separation of the particulates.

OBJECT OF THE INVENTION

[0011] It is an aim of this invention to provide a hydrocyclone which overcomes or ameliorates one or more of the disadvantages or problems described above, or which at least provides a useful commercial alternative.

[0012] Other preferred objects of the present invention will become apparent from the following description.

SUMMARY OF THE INVENTION

[0013] In one form, although it need not be the only or indeed the broadest form, there is provided a hydrocyclone comprising:

a substantially cylindrical chamber having at least one opening;

a substantially conical chamber in open fluid communication with the cylindrical chamber;

a first outlet extending from the cylindrical chamber;

a second outlet extending from the conical chamber and located opposite the first outlet; and

two or more vertically arranged inlets connected to the at least one opening of the cylindrical chamber.

[0014] In another form, the invention resides in a cylindrical chamber for a hydrocyclone comprising:

an outlet extending from the cylindrical chamber;

at least one opening; and

two or more vertically arranged inlets connected to the opening of the cylindrical chamber.

[0015] In another form, there is provided a hydrocyclone comprising:

a substantially cylindrical chamber having two or more vertically arranged openings;

a substantially conical chamber in open fluid communication with the cylindrical chamber;

a first outlet extending from the cylindrical chamber; and

a second outlet extending from the conical chamber and located opposite the first outlet.

[0016] In another form, the invention resides in a cylindrical chamber for a hydrocyclone comprising:

an outlet extending from the cylindrical chamber; and

two or more vertically arranged openings in fluid communication with the cylindrical chamber.

[0017] Preferably, a flow direction conduit extends from each inlet around a perimeter of the cylindrical chamber. Preferably, the flow direction conduits are parallel. Preferably, the flow direction conduits are sloped downwardly toward the conical chamber. Preferably, the flow direction conduits extend to a base of the cylindrical chamber. Preferably, the flow direction conduit comprises a sloping path extending from the inlet to the base of the cylindrical chamber.

[0018] Preferably, the cylindrical chamber is removably secured to the conical chamber. Alternatively, the cylindrical chamber is fixed to the conical chamber.

[0019] Preferably, the cylindrical chamber and the conical chamber are lined with an abrasion-resistant material. Preferably, the abrasion-resistant material comprises one or more of an elastomeric material, a hard metal and a ceramic material.

[0020] Preferably, the cylindrical chamber has two or more openings. Preferably, the openings are arranged vertically adjacent, wherein each opening is adjacent at least one other opening. Preferably, each inlet is connected to a corresponding opening.

[0021] Preferably, each inlet has a substantially rectangular cross-section.

[0022] In some embodiments, a first end of each inlet has a substantially circular cross-section and a second opposing end of each inlet has a substantially rectangular cross-section.

[0023] Preferably, the cylindrical chamber comprises a flange for engaging a corresponding flange of the conical chamber.

[0024] Preferably, the cylindrical chamber and the conical chamber are integrally formed.

[0025] Preferably, each inlet is directly adjacent another inlet.

[0026] Preferably, each opening is directly adjacent another opening.

[0027] Preferably, the inlets are connected tangentially to the openings of the cylindrical chamber.

[0028] Preferably, the conical chamber comprises a flange for engaging the corresponding flange of the cylindrical chamber.

[0029] Preferably, the hydrocyclone comprises three vertically arranged inlets and three corresponding vertically arranged openings.

[0030] In another form, the invention resides in an inlet unit having two or more vertically arranged passageways. Preferably, each inlet is adjacent at least one other inlet. More preferably, the inlet unit has three vertically arranged passageways.

[0031] Further features and advantages of the present invention will become apparent from the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] By way of example only, preferred embodiments of the invention will be described more fully hereinafter with reference to the accompanying figures, wherein:

[0033] FIG. 1 illustrates a hydrocyclone according to an embodiment of the present invention; and

[0034] FIG. 2 illustrates an internal view of the hydrocyclone of FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0035] FIG. 1 shows a hydrocyclone 10 having a cylindrical chamber 100 connected to a substantially conical chamber 200 made from or coated with an abrasion resistant material, such as an elastomer, a ceramic material or a hard metal. The base of the cylindrical chamber 100 is in fluid communication with the top (or circular base) of the conical chamber 200 to allow fluids to be transferred between the two chambers 100, 200.

[0036] The conical chamber 200 terminates at a first outlet known as the apex 205 of the conical chamber 200. The hydrocyclone 10 also includes a second outlet known as a vortex finder 105 located opposite the apex 205 in the top wall 110 of the cylindrical chamber 100. As can be seen in FIG. 2, the vortex finder 105 includes a pipe 107 which extends from outside the cylindrical chamber 100 through the top wall 110 to within the interior 108 of cylindrical chamber 100.

[0037] An inlet unit 115 comprising three vertically arranged directly adjacent inlet passageways 115a, 115b, 115c allows aqueous slurries to be delivered into the cylindrical chamber 100. As can be seen, a second of the inlet

passageways 115b is located between the other two inlet passageways 115a, 115c. This inlet unit 115 may be either permanently fixed (or integrally formed) with the cylindrical chamber 100, or, in some embodiments, may be a removable unit that can be connected to/disconnected from the cylindrical chamber 100. In this regard, the inlet unit 115 may be retrofitted to existing devices hydrocyclonic devices.

[0038] Turning to FIG. 2, it is shown that each inlet passageway 115a, 115b, 115c is connected to a corresponding opening 120a, 120b, 120c in the wall 125 of the cylindrical chamber 100 to allow the slurry to enter. It can be seen in the illustrated embodiment that the openings 120a, 120b, 120c are vertically arranged and directly adjacent one another. Thus, the typically singular stream of particles is divided into three distinct parallel or side-by-side streams that all enter the cylindrical chamber 100 in the same vertical plane.

[0039] While the presently illustrated embodiment has three inlet passageways and three corresponding openings, it will be appreciated that the invention could have as a few as two inlet passageways and openings, and more than three passageways and openings.

[0040] In some further embodiments, the invention may have a single opening that receives a slurry split into two or more streams by two or more respective inlet passageways.

[0041] In use, a source of pressurised slurry to be separated is coupled by suitable pipes to the three passageways 115a, 115b, 115c of the inlet unit 115 thereby creating three streams of slurry. The three illustrated inlet passageways 115a, 115b, 115c deliver each stream onto a respective sloping flow direction conduit 130a, 130b, 130c located around the periphery (or circumference) of

the wall 125 to the base 135 of the cylindrical chamber 110. Each stream initially travels along the sloping flow direction conduits 130a, 130b, 130c and is delivered to the conical chamber 200. It will be appreciated that the length of the conduits 130a, 130b, 130c can be lengthened or shortened as needed.

[0042] As the streams travel around the wall 125 of the cylindrical chamber 100, the heavy particles and the light particles of each stream separate. The heavy particles of each stream are pushed to the walls 125, 210 of the cylindrical and conical chambers 100, 200 and travel in a descending helix pattern or pathway toward the apex 205 of the conical chamber 200 where they are eventually dispelled as indicated by arrow 206. In contrast, the light particles accumulate in the centre of the hydrocyclone 10 and are thereby separated out.

[0043] The heavy particles generate internal pressure as they move towards the apex 205 which creates a vortex that extends all the way to the top of the cylindrical chamber 100, where the vortex finder 105 is located. This vortex captures the lighter particles, which have not been centrifugally displaced to the walls 125, 210 and draws them out through the vortex finder 105 located in the cylindrical chamber 100 as indicated by arrow 208. Due to the separate parallel streams, the abrasive wear on the lining of the inner walls 125, 210 of the cylindrical chamber 100 and the conical chamber 200 is dispersed more evenly about the lining and thereby avoids any localised wear caused by single path input streams. As a result, there is an increase in the useful life of the liner.

[0044] The inlet passageways 115a, 115b, 115c are linear and positioned tangentially to the cylindrical chamber 100 but could also be non-linearly positioned, e.g. arcuate about or contiguous with the wall 125 of the cylindrical chamber 100.

[0045] In some embodiments, the hydrocyclone 10 includes a flange (not shown) located about the outer circumference of the cylindrical chamber 100 for engaging a complementary flange (not shown) located on the conical chamber 200. This allows the cylindrical chamber to be removed from a hydrocyclone if any part becomes damaged thereby mitigating the need for the entire hydrocyclone to be replaced. Advantageously, this also allows existing hydrocyclones having single inlets to be retrofitted with the multiple inlet cylindrical chamber.

[0046] In some alternative embodiments, the cylindrical chamber and the conical chamber are integrally formed.

[0047] In some embodiments, there is provided a spool piece (not shown). The spool piece may act as a replacement for an individual inlet passageway (such as inlet passageway 115a) or as an attachment to an inlet passageway that acts as a transition piece to convert the normal circular cross-section piping which delivers slurry into the rectangular cross-section of the inlet feed of the cylindrical chamber. In some alternative embodiments, the spool piece may house an inlet unit.

[0048] It will therefore be realised that embodiments of the invention provide a hydrocyclone suitable for use in mining and quarrying applications which has reduced wear properties and the capability for effective separation of the heavy/larger particles and smaller/lighter particles.

[0049] In this specification, adjectives such as first and second, left and right, top and bottom, and the like may be used solely to distinguish one element or action from another element or action without necessarily requiring or implying any actual such relationship or order. Where the context permits, reference to

an integer or a component or step (or the like) is not to be interpreted as being limited to only one of that integer, component, or step, but rather could be one or more of that integer, component, or step etc.

[0050] The above description of various embodiments of the present invention is provided for purposes of description to one of ordinary skill in the related art. It is not intended to be exhaustive or to limit the invention to a single disclosed embodiment. As mentioned above, numerous alternatives and variations to the present invention will be apparent to those skilled in the art of the above teaching. Accordingly, while some alternative embodiments have been discussed specifically, other embodiments will be apparent or relatively easily developed by those of ordinary skill in the art. The invention is intended to embrace all alternatives, modifications, and variations of the present invention that have been discussed herein, and other embodiments that fall within the spirit and scope of the above described invention.

[0051] In this specification, the terms ‘comprises’, ‘comprising’, ‘includes’, ‘including’, or similar terms are intended to mean a non-exclusive inclusion, such that a method, system or apparatus that comprises a list of elements does not include those elements solely, but may well include other elements not listed.

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CLAIMS

1. A hydrocyclone comprising:

a substantially cylindrical chamber having at least one opening;

a substantially conical chamber in open fluid communication with the cylindrical chamber;

a first outlet extending from the cylindrical chamber;

a second outlet extending from the conical chamber and located opposite the first outlet;

two or more vertically arranged adjacent inlets connected to the at least one opening of the cylindrical chamber;

two or more flow direction conduits, each flow direction conduit extending from a corresponding inlet of the two or more vertically arranged adjacent inlets, wherein the flow direction conduits extend in parallel around a perimeter of a wall of the cylindrical chamber.

2. A hydrocyclone in accordance with claim 1, wherein the flow direction conduits are sloped downwardly toward the conical chamber and extend to a base of the cylindrical chamber.
3. A hydrocyclone in accordance with claim 1 or 2, wherein each flow direction conduit comprises a sloping path extending from the inlet to the base of the cylindrical chamber.
4. A hydrocyclone in accordance with any one of the preceding claims, wherein the cylindrical chamber is removably secured to the conical chamber.
5. A hydrocyclone in accordance with any one of claims 1-3, wherein the cylindrical chamber is fixed to the conical chamber.

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6. A hydrocyclone in accordance with any one of the preceding claims, wherein the cylindrical chamber and the conical chamber are lined with an abrasion-resistant material.
7. A hydrocyclone in accordance with any one of the preceding claims, wherein the cylindrical chamber has two or more openings.
8. A hydrocyclone in accordance with claim 7, wherein two or more openings are arranged vertically adjacent, wherein each opening is adjacent at least one other opening.
9. A hydrocyclone in accordance with claim 8, wherein each inlet is connected to a corresponding opening.
10. A hydrocyclone in accordance with any one of the preceding claims, wherein each inlet has a substantially rectangular cross-section.
11. A hydrocyclone in accordance with any one of claims 1-9, wherein a first end of each inlet has a substantially circular cross-section and a second opposing end of each inlet has a substantially rectangular cross-section.
12. A hydrocyclone in accordance with any one of claims 1-11, the cylindrical chamber comprises a flange connected to a corresponding flange of the conical chamber.
13. A hydrocyclone in accordance with any one of claims 1-12, wherein each inlet is connected tangentially to the opening of the cylindrical chamber.
14. A hydrocyclone in accordance with any one of claims 1-13, wherein the hydrocyclone comprises three vertically arranged inlets and three corresponding vertically arranged openings.
15. A cylindrical chamber for a hydrocyclone comprising:

an outlet extending from the cylindrical chamber;

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at least one opening;

two or more vertically arranged adjacent inlets connected to the opening of the cylindrical chamber; and

two or more flow direction conduits, each flow direction conduit extending from a corresponding inlet of the two or more vertically arranged adjacent inlets, wherein the flow direction conduits extend in parallel around a perimeter of a wall of the cylindrical chamber.

16. A hydrocyclone comprising:

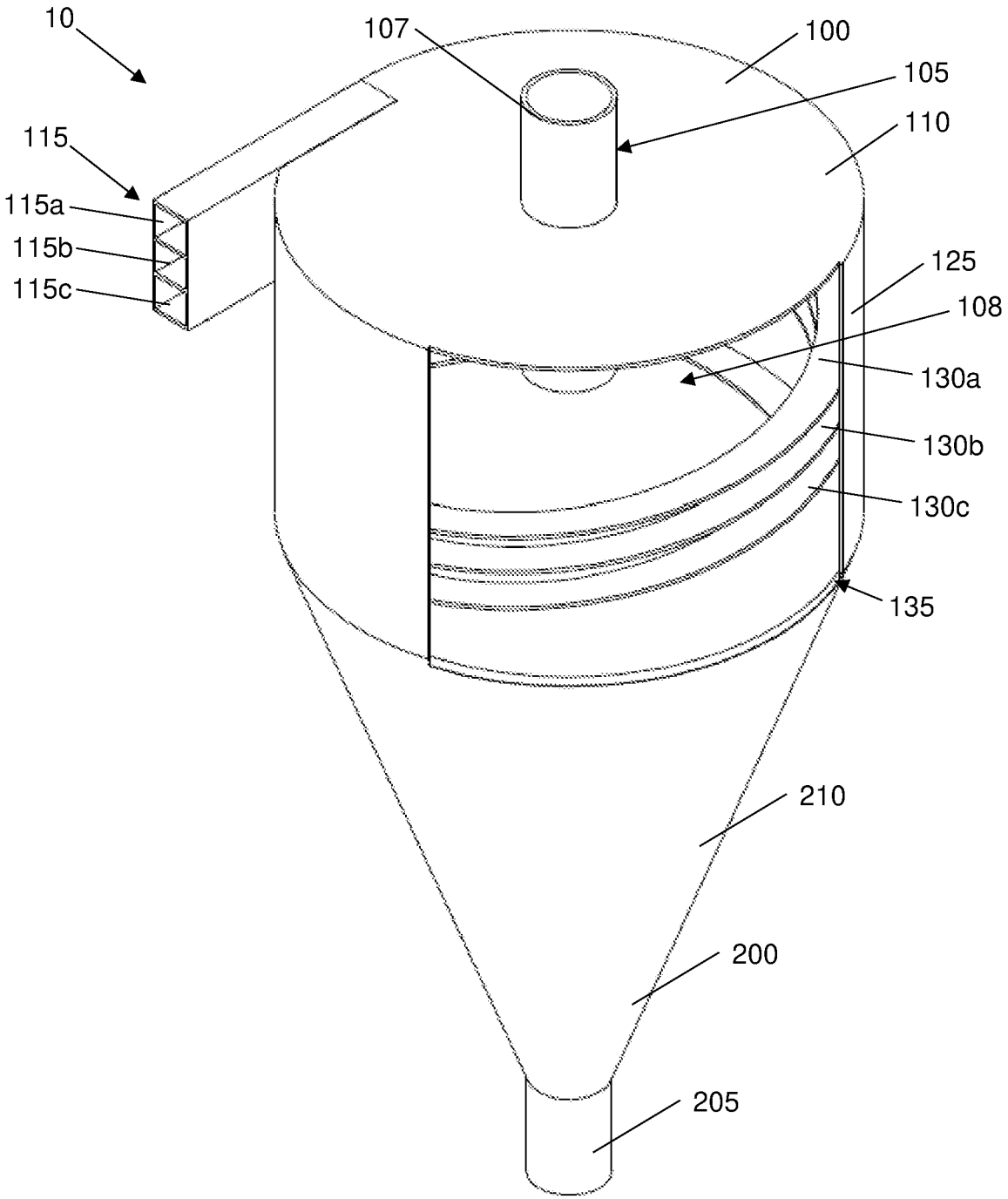
a substantially cylindrical chamber having two or more vertically arranged adjacent openings;

a substantially conical chamber in open fluid communication with the cylindrical chamber;

a first outlet extending from the cylindrical chamber;

a second outlet extending from the conical chamber and located opposite the first outlet' and

two or more flow direction conduits, each flow direction conduit extending from a corresponding opening of the two or more vertically arranged adjacent openinings, wherein the flow direction conduits extend in parallel around a perimeter of a wall of the cylindrical chamber.


10
107
100
105
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115
115a
115b
115c
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108
130a
130b
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205

FIG. 1

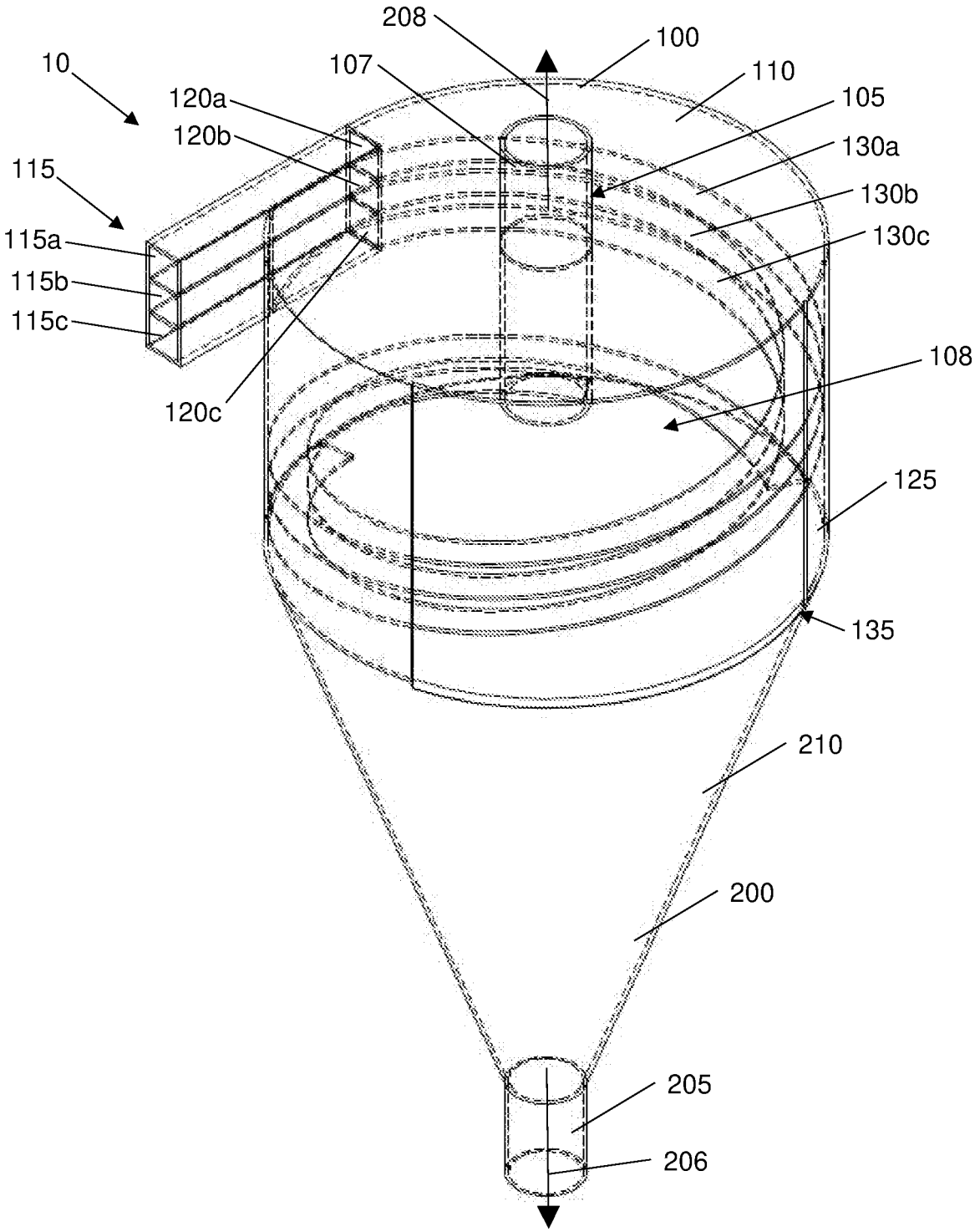
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FIG. 2