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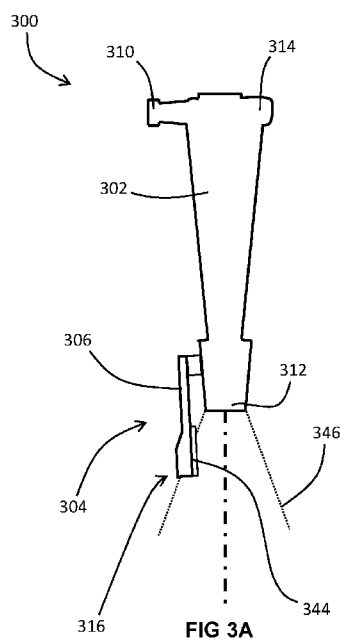
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(54) Title: HYDROCYCLONE SYSTEM



(57) Abstract: Disclosed is a hydrocyclone system comprising a hydrocyclone and a probe. The hydrocyclone comprises an outlet for discharging an underflow. The probe is for detecting a flow condition of the underflow and comprises an elongate body and a vibration sensor to detect vibration of the elongate body. Also disclosed is a method of operating a hydrocyclone by detecting a characteristic of the shape of the underflow of a hydrocyclone.



HYDROCYCLONE SYSTEM

TECHNICAL FIELD

5 This disclosure relates to a hydrocyclone system for detecting a flow condition of a hydrocyclone, a probe for use in the system, and to a method of detecting a flow condition. The disclosure has particular, but not exclusive, application for use in minerals processing operations and is herein described in that context.

BACKGROUND ART

10 Hydrocyclones are used to separate flowable material into two fractions, based on density or coarseness, by way of centrifugal forces. In general operation, a first (less dense or coarse) fraction is able to be carried by a central vortex within the hydrocyclone and exits via an overflow at the upper end of the hydrocyclone, and a second (denser and coarser) fraction, that is unable to be carried by the vortex, is discharged through an underflow at the lower end of the hydrocyclone.

15 Effective separation in a hydrocyclone may depend on the size of the underflow and overflow outlets, the flow rate of the fluid entering the hydrocyclone and the characteristics of the material being separated. Appropriate management of these factors, to ensure suitable operation of the hydrocyclone, can be challenging. Problems with the operation of a hydrocyclone are generally identified by sight
20 and such identification often requires the physical presence of an operator (often having many years' experience) to be in the vicinity of the hydrocyclone.

It is to be understood that, if any prior art is referred to herein, such reference does not constitute an admission that the prior art forms a part of the common general knowledge in the art, in Australia or any other country.

SUMMARY

Disclosed is a hydrocyclone system comprising a hydrocyclone and a probe. The hydrocyclone comprises an outlet for discharging an underflow. The probe is for detecting a flow condition of the underflow and comprises an elongate body and a
5 vibration sensor to detect vibration of the elongate body.

In operation, the underflow discharging from the hydrocyclone (e.g. at the outlet or apex of the hydrocyclone) causes the body to vibrate. The sensor senses or detects this vibration and the detected vibration may be used to determine a flow condition of the underflow. This flow condition may, for example, be used to
10 indicate whether or not the underflow is discharging at a particular angle or according to a particular profile. The detection of the flow condition may be made without the need for an operator to be physically present (or, in some cases, without any operator at all).

The use of a probe to detect the vibration is beneficial as the construction and
15 positioning of the probe can be optimised to achieve the desired result. For example the structural characteristics of the elongate body may be chosen to provide appropriate flexural qualities for vibration detection and adequate strength to remain serviceable in operation. The use of an elongate body means that the underflow discharging from the hydrocyclone may not be fully (or substantially)
20 enclosed or shrouded. Hence, the underflow may remain visible to e.g. an operator. This may allow visual confirmation of results provided by the system, which may be useful for troubleshooting or adjustment of the system.

In one embodiment the vibration sensor may be mounted to the elongate body. This may enable the vibration sensor to better detect the vibration of the elongate
25 body. In embodiments where the sensor is not mounted to the elongate body it may be mounted to the hydrocyclone or to a structure in physical contact with the hydrocyclone (such that the vibration of the elongate body may be indirectly detected by the sensor).

In one embodiment the elongate body may be arranged so as to extend into the underflow when discharging according to at least one flow condition. So, when discharging under the at least one flow condition, the elongate body will vibrate due to impact of the discharge, which is detected by the sensor.

- 5 In one embodiment the vibration of the body may be indicative of the discharge spray angle of the underflow.

In one embodiment under a first flow condition, the underflow may discharge at a first spray angle, and under a second flow condition the underflow may discharge at a second spray angle that is smaller than the first spray angle. The system may
10 be operative to distinguish between the first and second flow conditions. The system may distinguish between the first and second flow conditions using the sensed vibration of the elongate body caused by the discharging underflow.

In one embodiment the probe may be arranged so as to extend into the underflow when the underflow is discharging at the first and second spray angles. The
15 vibration of the body may be indicative of the discharge spray angle of the underflow. That is, the elongate body may extend into the underflow under both first and second flow conditions, and the differences in the vibration of the elongate body under these conditions may be used to distinguish between them.

In one embodiment, in operation, the elongate body may be impacted by the
20 underflow when discharging and the region on the body at which the body is impacted may be dependent on the discharge spray angle. In this way, the system may be operative to distinguish between a plurality of discharge spray angles.

In one embodiment the elongate body may be arranged so as to be spaced from the underflow when discharging according to the first flow condition. The
25 elongate body may also be arranged to extend into the underflow when discharging according to the second flow condition. The first flow condition may correspond to a roping condition of the hydrocyclone. The second flow condition may correspond to an ideal operating condition of the hydrocyclone.

The term 'roping', when used in reference to a hydrocyclone, generally refers to a condition whereby the underflow discharging from the outlet of the hydrocyclone is caused to discharge downwards in a thick constant diameter stream. This can be a consequence of increased pressure in the hydrocyclone (e.g. due to a blockage) and is generally indicative of the hydrocyclone operating poorly or inefficiently. In some cases it may be an indication that the hydrocyclone is not performing any separation of material. Where the first flow condition corresponds to a roping condition, the system may act as a roping detector. For example, when the underflow is discharging according to the second flow condition (e.g. at the second spray angle) it may impact the elongate body and the detected vibration of the elongate body may indicate that the hydrocyclone is operating under normal or ideal conditions. If the discharging underflow then deviates so as to discharge according to the first flow condition (e.g. at the first spray angle) then it may no longer impact the elongate body (e.g. because the underflow may be discharging downwardly and with a generally constant diameter) and vibrations of the elongate body will reduce, or will not be present. The lack of detection of vibration of the elongate body will then be an indication that the hydrocyclone is operating under a roping condition.

In one embodiment a free end of the elongate body may extend into the underflow when discharging according to the second flow condition. That is, the elongate body may be arranged such that the free end cantilevers from a structure, or the hydrocyclone (when mounted thereto). Because of the moments involved in such an arrangement, the impact of the discharging fluid on the free end may cause the free end to vibrate to a larger extent than if it were secured. So, the cantilevered nature of the elongate body can, in effect, act to amplify the vibration caused by the impacting underflow.

In one embodiment the position of the free end of the elongate body may be adjustable with respect to the hydrocyclone. This may allow the system to be adjusted to suit various hydrocyclones and various hydrocyclone operating conditions. For example, the spray angle that corresponds to various fluid

conditions may differ between hydrocyclones or may differ depending on the characteristics of the flowable material being processed (which may fluctuate during operation of the hydrocyclone). Hence, adjustment of the positioning of the elongate body may be required to ensure that it extends into the underflow
5 when discharging at the second (e.g. ideal or normal) spray angle, and is optionally spaced from the discharging underflow when discharging at the first (e.g. roping) spray angle.

In one embodiment the elongate body may be mounted to the hydrocyclone. The elongate body may be mounted proximate to the outlet of the hydrocyclone and
10 may extend downwardly, in use, away from the outlet.

In one embodiment the hydrocyclone may comprise a spigot housing releasably mounted at the outlet. The elongate body may be mounted to the spigot housing. This may provide adaptability and flexibility to the system. It may allow the exchange of one probe with another replacement probe without requiring
15 replacement of the entire hydrocyclone. Dampening may be provided between the spigot housing and the remainder of the hydrocyclone (i.e. hydrocyclone body) which may prevent or reduce vibrations of the hydrocyclone to the elongate body.

In one embodiment the system may further comprise a coupling to releasably
20 mount the elongate body to the hydrocyclone. For example, the elongate body may be releasably mounted to the hydrocyclone. This coupling may, for example, be enabled by screws, bolts, clips, tabs, etc. Allowing the elongate body to be released or detached from the hydrocyclone provides further adaptability and flexibility to the system. It means that the probe can be replaced (e.g. due to a
25 fault, wear, changing requirements of the sensor, changing hydrocyclone conditions, etc.) without the need to replace the entire hydrocyclone. It also means that the probe can be retrofitted to existing hydrocyclones with minimal difficulty.

In one embodiment the coupling may comprise a plurality of mounting regions spaced along at least a portion of the length of the elongate body. The elongate body may be mountable to the hydrocyclone at one or more of the mounting regions. The mounting regions may comprise one or more apertures for receipt of one or more fasteners. Alternatively, the mounting regions may comprise tabs, clips, etc. for mounting the elongate body to the hydrocyclone. The plurality of mounting regions facilitates the adjustability of the positioning of the elongate body with respect to the hydrocyclone. For example, mounting the elongate body to the hydrocyclone using different mounting regions may result in the free end of the elongate body being closer to, or further away from, the outlet. The position of the free end may be adjusted depending on the spray angles of various flow conditions of the hydrocyclone.

In one embodiment the coupling may further comprise a mounting element secured to the hydrocyclone, the elongate body being mounted to the hydrocyclone via the mounting element. The mounting element may facilitate releasable and adjustable mounting of the elongate body to the hydrocyclone. It may also facilitate retrofitting of the mounting body to the hydrocyclone by providing a standard mounting surface (e.g. comprising predetermined mounting regions corresponding to one or more forms of the elongate body) on the hydrocyclone for mounting of the elongate body.

In one embodiment the vibration sensor may be mounted at the free end of the elongate body. This may ensure that the vibration sensor is located at a position where the amplitude of vibration of the elongate body is at or near to its maximum (as a result of impact of the discharging fluid). This may result in easier detection the vibration. It may also make it easier to distinguish between vibration caused by the underflow impacting the elongate body and vibrations caused by external factors (e.g. vibration of the hydrocyclone or other nearby equipment).

In one embodiment the elongate body is in the form of a profiled section. The elongate body may be in the form of a generally U-shaped channel section. The

U-shaped channel section may be formed of a web (i.e. base) portion and two flanges extending from the web. Profiled structures may provide a high strength-to-weight ratio in regards to resistance to bending (i.e. caused by impact of the discharging fluid on the elongate body). When the sensor is positioned between the flanges, they may provide some lateral protection from the under flow discharging from the hydrocyclone. To provide further protection, the flanges may be widened at the portion (e.g. the free end) of the elongate body where the sensor is mounted.

In one embodiment the probe may further comprise a wear resistant surface to form at least a partial barrier between the elongate body and the underflow. The wear surface may be in the form of a wear component. The wear component may, for example, be in the form of a flat bar positioned on the web of the elongate body (when in the form of a U-shaped channel section). The wear surface may provide protection to the sensor and the elongate body, and may be formed of a material specifically chosen for this purpose (i.e. having wear-resistant properties).

Also disclosed is a probe for detecting a flow condition of the underflow of a hydrocyclone. The probe comprises an elongate body, and a vibration sensor to detect vibration of the body.

The probe may form part of a new hydrocyclone assembly, or may be retrofitted to an existing hydrocyclone.

In one embodiment the vibration sensor may be mounted to the elongate body. This may enhance the ability of the vibration sensor to detect vibration of the elongate body.

In one embodiment the elongate body comprises at least one mounting region for mounting the probe to the hydrocyclone. The mounting region may be in the form of an aperture, a clip arrangement, tabs, a surface for adhesive, etc.

In one embodiment the elongate body may comprise a free end extending from the mounting region. The free end may be able to extend into the underflow of the hydrocyclone when mounted thereto. That is, the elongate body may be arranged such that the free end cantilevers from a structure, or the hydrocyclone
5 (when mounted thereto). The moments involved in such an arrangement, mean that the impact of the discharging fluid on the free end may cause the free end to vibrate to a larger extent than if it were secured. As set forth above, this means that the cantilevered nature of the elongate body can, in effect, act to amplify the vibration caused by the impacting underflow.

10 In one embodiment the vibration sensor may be mounted at the free end of the elongate body. This will mean that the vibration sensor detects the ‘amplified’ (due to the cantilever arrangement) vibration of the elongate body.

In one embodiment the at least one mounting region may be configured for releasable mounting of the elongate body to the hydrocyclone. This may allow
15 the probe to be replaced if it becomes faulty or worn, or if a different type of probe is required.

In one embodiment the at least one mounting region may be configured to allow the position of the free end of the elongate body to be adjusted with respect to the hydrocyclone. As set forth above, this may allow the probe to be configured for
20 particular flow conditions and spray angles of the underflow (which may vary between hydrocyclones).

In one embodiment the elongate body may comprise a plurality of mounting regions spaced along at least a portion of its length, the elongate body mountable to the hydrocyclone at one or more of the mounting regions. The plurality of
25 mounting regions may provide the adjustability of the position of the free end of the elongate body.

In one embodiment the elongate body may be in the form of a profiled section. This may be a U-shaped channel section. The profiled section may be a standard section, or may be formed from a standard section.

5 In one embodiment the system may further comprise a wear surface to form at least a partial barrier between the elongate body and the underflow in use. This may protect the elongate body from the underflow, and may increase the durability of the probe. The wear surface may be provided on a wear component secured to the elongate body.

10 Also disclosed is a method of detecting a flow condition of the underflow of a hydrocyclone. The method comprises providing a probe comprising an elongate body and positioning the elongate body such that it is able to vibrate responsive to the discharge of the underflow. The method further comprises detecting the flow condition from the vibration of the elongate body.

15 In one embodiment the elongate body may be caused to vibrate by being positioned so as to extend into the underflow when discharging according to at least one flow condition.

In one embodiment the method may further comprise distinguishing between first and second flow conditions by changes in the vibration of the elongate body. The change may include a change from an absence of vibration to the presence of
20 vibration. The change may also be limited to a particular frequency of the vibration.

In one embodiment under the first flow condition, the underflow may discharge at a first spray angle, and under the second flow condition the underflow may discharge at a second spray angle that is smaller than the first spray angle.

25 In one embodiment the elongate body may extend into the underflow under the first and second flow conditions.

- In one embodiment the step of positioning the elongate body may comprises arranging the elongate body so as to be spaced from the underflow when discharging according to the first flow condition. This step may also comprise arranging the elongate body so as to extend into the underflow when discharging
- 5 according to the second flow condition. The first flow condition may correspond to a roping condition of the hydrocyclone. The second flow condition may correspond to an ideal operating condition of the hydrocyclone. In this way, the method may provide a way of detecting roping of the hydrocyclone (e.g. without the need for an operator to visually inspect the hydrocyclone).
- 10 In one embodiment the method may further comprises controlling the hydrocyclone (e.g. directly or indirectly) in response to the detected flow condition. This control may be performed automatically by a controller and may comprise, for example, adjusting an operating parameter of the hydrocyclone such as the feed flow rate (e.g. by adjusting the feed pump) or ceasing operation of the
- 15 hydrocyclone.

Also disclosed herein is a method of operating a hydrocyclone. The method comprises detecting a characteristic of the shape of the underflow of a hydrocyclone, and adjusting an operating parameter of the hydrocyclone to alter the characteristic of the shape of the underflow.

- 20 In one embodiment the characteristic may be the discharge spray angle.

- In one embodiment the adjustment of the operating parameter may be performed so as to alter the discharge spray angle to a desired discharge spray angle. For example, this may include altering an operating parameter that is known to correlate with discharge spray angle. The operating parameter may be a
- 25 parameter of the feed into the hydrocyclone. For example, the operating parameter may be a feed flow rate

In one embodiment, the desired discharge spray angle may be indicative of the hydrocyclone operating under a semi-roping condition

In one embodiment the method may further comprising maintaining a generally consistent cut size. This may be performed by adjusting various other operating parameters of the hydrocyclone. The cut size may be measured using known methods, such as using on-line cut size measuring systems.

5

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments will now be described by way of example only, with reference to the accompanying drawings in which:

Figure 1A is a perspective view of a hydrocyclone system;

Figure 1B and 1C are detailed views of a probe of the hydrocyclone system;

10 **Figure 1D** is an exploded detailed view showing the assembly of the probe and its mounting to the hydrocyclone;

Figure 2A, 2B and 2C are front views showing the probe mounted to the hydrocyclone in various positions;

15 **Figures 3A, 3B and 3C** are side views of a hydrocyclone system operating with various underflow shapes;

Figure 4 is a flow chart showing a method of monitoring a hydrocyclone; and

Figure 5 is a flow chart showing a method of operating a hydrocyclone.

DETAILED DESCRIPTION

20 In the following detailed description, reference is made to accompanying drawings which form a part of the detailed description. The illustrative embodiments described in the detailed description, depicted in the drawings and defined in the claims, are not intended to be limiting. Other embodiments may be utilised and other changes may be made without departing from the spirit or scope of the subject matter presented. It will be readily understood that the aspects of
25 the present disclosure, as generally described herein and illustrated in the drawings can be arranged, substituted, combined, separated and designed in a

wide variety of different configurations, all of which are contemplated in this disclosure.

Referring first to Figure 1, the hydrocyclone system 100 comprises a hydrocyclone 102, and a probe 104 comprising an elongate body 106 and a vibration sensor 108, which in the illustrated form, is mounted to the elongate body 106.

The hydrocyclone 102 comprises an inlet 110 for receipt of a flowable material (e.g. a slurry, solid mixture, etc.) and two outlets 112, 114 for discharge of two fractions (in the form of the underflow and the overflow) of the flowable material.

10 A first outlet 112 of the two outlets is for discharge of the underflow and is positioned at an in use lower end of the hydrocyclone 102 (i.e. at the apex). A second outlet 114 of the two outlets 112, 114 is for discharge of the overflow and is positioned at an in use upper end of the hydrocyclone 102. Hereafter, references to 'the outlet' are references to the first outlet, unless otherwise stated.

15 In use, flowable material enters the inlet 108 at the in use upper end of the hydrocyclone 102 and flows downwardly, generally guided by the conically shaped sidewalls of the hydrocyclone 102, along a helical path. The flowable material flows in this way from the inlet 110 towards the first outlet 112. The helical or spiralling nature of the flowable material, in combination with pressure

20 in the hydrocyclone 102, can result in a vortex extending generally centrally in the hydrocyclone 102 between the first 112 and second 114 outlets. Less dense or less coarse material can be carried by this vortex towards the second outlet 114 where it discharges from the hydrocyclone 102 as the overflow. Denser or coarser material is unable to be carried by this vortex and instead discharges from the

25 hydrocyclone 102 as the underflow at the first outlet 112. In this way, the flowable material may be separated by the hydrocyclone 102 into two fractions based on the density and/or coarseness of the material.

In normal operation, due to the reduced diameter of the first outlet 112 with respect to the remainder of the hydrocyclone 102, the underflow tends to be

generally conical in shape (i.e. the first outlet (or apex) acts like a nozzle). This is apparent from figures 2A, 2B and 2C. The elongate body 106 of the probe 104 is mounted to the hydrocyclone 102 and has a free end 116 that extends generally downwardly and away from the first outlet 112. In one possible arrangement, the
5 elongate body 106 may be arranged such that, in use, the free end 116 is spaced from the conical underflow when the underflow is discharging according to a particular (i.e. first) flow condition, and extends into the conical underflow when the underflow is discharging according to a particular (i.e. second) flow condition. For example, the second flow condition may correspond to an ideal or normal
10 operating condition of the hydrocyclone. In this respect, the elongate body 106 may be purposely mounted and oriented so as to extend into the underflow when the spray angle or profile of the underflow is such that it is indicative of the hydrocyclone 102 operating normally or ideally.

The first flow condition may, for example, correspond to a different (e.g. smaller)
15 spray angle or profile and may be indicative of a non-ideal or non-normal operating condition of the hydrocyclone 102. This is discussed in more detail below with reference to figures 2A, 2B and 2C.

The vibration sensor 108, which is in the form of an accelerometer, is mounted to the free end 114 of the elongate body 106 of the probe 104 so as to detect
20 vibration of the elongate body 106.

In operation (not shown in Figures 1A to 1D), when the underflow is discharging from the hydrocyclone 102 and impacts the elongate body 106 (e.g. when discharging according to the second flow condition), it causes the elongate body 106 to vibrate and this vibration is detected by the vibration sensor 108. On the
25 other hand, when the underflow discharges according to the first flow condition it doesn't impact the elongate body 106, because the elongate body 106 is positioned so as to be spaced from the underflow under this flow condition. Hence, under the first flow condition (described above), the elongate body 106 does not vibrate in response to discharge impact and the vibration (if any)

detected by the vibration sensor 108 is different to that detected under the second flow condition.

Figures 1B and 1C show the arrangement of the elongate body 106 and vibration sensor 108, according to one form, in more detail. As is apparent from Figure 1B in particular, the elongate body 106 is releasably mounted to a spigot housing 118 of the hydrocyclone 102, which in turn is releasably mounted to a body 120 of the hydrocyclone 102 via a clamping assembly 122. The elongate body 106 is mounted to the spigot housing 118 via a coupling 124, which comprises a mounting element in the form of a generally rectangular plate 126 (e.g. 40 mm x 8 flat bar). It should be apparent that the elongate body may be mounted in other ways (directly, or indirectly to the spigot housing 118 or hydrocyclone body 120). A portion of the outer surface of the spigot housing 118 is flattened to accommodate the mounting of the plate 126 thereto. In the illustrated form, the plate 126 comprises four countersunk holes 128 for receipt of corresponding countersunk self-tapping screws (not shown) to mount the plate 126 to the flat surface of the spigot housing 118. The plate 126 also comprises two centrally located tapped holes 130 to facilitate temporary mounting of the elongate body 106 thereto.

This mounting of the elongate body 106 to the releasable spigot housing 118 provides the system 100 with adaptability. For example, such an arrangement allows adjustment of the position of the elongate body 106 (and the sensor 108) by way of adjustment of the spigot housing 118. It also allows for convenient replacement of the probe 104 with a replacement probe. Such replacement may be necessary due to wear of the components, or may be performed in response to changing characteristics of the hydrocyclone 102 operation or of the material being processed by the hydrocyclone 102. For example, a replacement sensor may have a different sensitivity and/or a replacement elongate body 106 may be configured to extend at a different angle from the hydrocyclone 102 to accommodate one or more different underflow flow conditions.

The elongate body 106 of the probe 104 is in the form of a profiled section. More specifically, in the illustrated embodiment, the elongate body 106 is a U-shaped channel section comprising a web 132 (forming the base of the 'U') that extends between two parallel flanges 134 (forming the legs of the 'U'). In this case, the elongate body 106 is fabricated from a commonly available section, which may reduce the overall cost of manufacturing the probe 104. The elongate body 106 is mounted at one end to the hydrocyclone 102 (via the plate 126), and the opposing free end 116 of the elongate body 106 extends away from the outlet 112 of the hydrocyclone 102 so as to cantilever from the mounted end. The flanges 134 of elongate body 106 are fabricated so as to be wider at the free end 116. This strengthens the free end 116 which, in most cases, is the portion of the elongate body 106 that is impacted by the underflow (e.g. when discharging according to at least the first flow condition).

In the illustrated form, the coupling 124, mounting the elongate body 106 to the hydrocyclone 102, further comprises a plurality of mounting regions. These mounting regions are in the form of pairs of spaced apertures 136 that extend through the web 132, and that are spaced along a portion of the length of the elongate body 106. The spacing of the apertures 136 is such that each pair of apertures 136 can be used to temporarily or permanently mount the elongate body 106 to the plate 126 by way of two corresponding fasteners 138 (e.g. screws). This provides further adaptability to the system 100, because it allows for the position of the elongate body 106 with respect to the hydrocyclone 102 (and with respect to the underflow) to be adjusted.

Further mounting regions are also present at the free end of the elongate body 106. These are sensor mounting regions that are in the form of sensor mounting apertures 140 that extend through the web 132. Each of these sensor mounting apertures 140 is sized and shaped for receipt of a corresponding fastener to secure the sensor 108 to the elongate body 106. In the illustrated embodiment, there are three sensor mounting apertures 140 which correspond to three different sensor

positions on the elongate body 106. The sensor 108 may be mounted at any one of these positions depending on the requirements of the system 100.

The probe 104 may also comprises a wear resistant surface 142. This surface 142 may form part of a wear resistant element in the form of an elastomer plate 144, secured (e.g. by welding) to the web 132 of the elongate body 106 so as to form at least a partial barrier between the elongate body 106 and the underflow in use. This elastomer plate 144 also protects the sensor mounting apertures 140 in the web 132 of the elongate body 106, which could otherwise be damaged by the underflow upon impact. In the illustrated embodiment the wear resistant element is elastomer, but in other embodiments it may be formed of e.g. ceramic, steel, etc.

As set forth above, the free end 116 of the elongate body 106 is cantilevered from its mounting with the hydrocyclone 102. Because of this cantilever, the amplitude of vibration of the free end 116 is larger upon impact of the underflow (i.e. as opposed to if the free end 116 were secured). In other words, the cantilevered arrangement acts as an amplifier of the vibration caused by the impact. The sensor measures this ‘amplified’ vibration, due to its mounting at the free end 116 of the elongate body 106 (where the larger vibration occurs). These larger amplitudes of vibration may facilitate the ability to distinguish between (e.g. the first and second) flow conditions of the underflow. This ability to distinguish may also be enhanced by the positioning of the sensor 140 away from the hydrocyclone 102 where other vibrations (e.g. of the hydrocyclone or surrounding equipment) could make it difficult to distinguish relevant vibration data (e.g. useful for determining a condition of the hydrocyclone) from irrelevant vibration data.

Although not apparent from the figures, the vibration that is measured by the sensor 108 is able to be transmitted as vibration data for processing or storage. In some forms this transmission of data may be wireless and in other forms it may be via a wired connection. Where a wired connection is used, the wires may pass

along the elongate body 106 and be secured thereto by e.g. cable ties. The flanges 134 of the elongate body 106 are provided with holes 146 to accommodate e.g. cable ties (or another fastening means), when required.

Referring now to figures 2A, 2B and 2C, the ability to mount the elongate body 206 at different positions with respect to the hydrocyclone 202 is illustrated in more detail.

Figure 2A shows the underflow 246a discharging from the outlet 212 of the hydrocyclone 202 in a conical spray and at a spray angle of 30° (the angle taken between the outer limit of the conical spray and an axis extending centrally through the spray). In this configuration, the elongate body 206 is mounted to the hydrocyclone 202 using the two uppermost mounting apertures 236 such that the free end 216 of the elongate body 206 extends into the underflow 246a.

In Figure 2B, the spray angle of the underflow 246b is approximately 45° and the elongate body 206 is mounted to the hydrocyclone 202 at the third and fourth uppermost apertures 236, such that the free end 216 of the elongate body 206 is closer to the outlet of the hydrocyclone 202 (i.e. it has been moved upwards relative to the position shown in Figure 2A). This ensures that the elongate body 206 is impacted by the spray at the free end 216 rather than at a central portion of the elongate body 206.

In Figure 2C the mounting position of the elongate body 206 has again been adjusted such that its free end 216 is even closer to the outlet of the hydrocyclone 202 (than the arrangement shown in Figure 2B). The mounting is such that the free end 216 of the elongate body 206 extends into the underflow 246c which, in this case, has a spray angle of 60° .

As suggested above, different spray angles (corresponding to different underflow 246 flow conditions) may be indicative of various operating conditions of the hydrocyclone 202. Some spray angles may be indicative of ideal or desired operating performance, while others may be indicative of one or more issues with the operation of the hydrocyclone 202.

The ability of the present system to detect such spray angles is illustrated in Figures 3A, 3B and 3C. The embodiment of the hydrocyclone system 300 shown in these figures is similar to the arrangement 200 illustrated in Figures 1A to 2C and thus corresponding reference numerals have been used.

5 Figures 3A to 3C depict how a change in discharge spray angle of the hydrocyclone 302 may affect the signal produced by the sensor (not apparent from the figure, because it is blocked from view by the flanges of the elongate body 306). In Figure 3A the discharge spray angle of the underflow 346 may be such that the underflow 346 impacts an in use upper (i.e. proximate the hydrocyclone
10 302) end of the wear plate 344 of the probe 304. In practice, the probe 304 may be positioned, such that the underflow 346 only impacts this portion of the wear plate 344 when the discharge spray angle is at (or is close to) a maximum.

In Figure 3B, the discharge spray angle of the underflow 346 is smaller than that shown in Figure 3A. In this case, the underflow 346 impacts the wear plate 344
15 of the probe 304 at a region that is nearer to a distal end 316 of the probe 304 (i.e. distal from the hydrocyclone 302). It should be apparent that, between these two discharge spray angles, the underflow 346 will impact regions between the upper and lower in use ends of the wear plate 344. That is, the point or region at which the underflow 346 impacts the wear plate 344 is dependent on the discharge spray
20 angle of the underflow 344.

Because the probe 304 is cantilevered from its mounting to the hydrocyclone 302, it generally responds to force in a similar manner to a cantilever beam. Hence, the position at which the underflow 346 impacts the wear plate 344 (and thus the probe 304) affects the vibration response of the probe 304, which is detected by
25 the sensor (positioned on the distal end 316 of the probe, but not apparent in the figures). For example, impact of the underflow 346 at the distal (lower) end of the probe 304 may result in vibrations of larger amplitude than impact of the underflow 346 at the proximal (upper) end of the probe 304. In this way, the signal produced by the sensor may be used to determine where the underflow 346

is impacting the probe 304 which, in turn, can be used to determine the discharge spray angle of the underflow 346. As will be discussed further below, this information may be used to control operation of the hydrocyclone 302 (e.g. by adjusting the feed pump, water addition or number of cyclone valves open in the system). The information may also, for example, also be used to determine whether there is an issue with the operation of the hydrocyclone 302.

One such issue may be a condition that is referred to as ‘roping’. This generally occurs when the internal vortex within the hydrocyclone 302 collapses (e.g. due to a blockage or an increase in pressure in the hydrocyclone 302). When roping occurs, the underflow 346 discharges from the outlet 312 in a generally downwardly and vertical direction, and in a thick constant diameter stream (i.e. in the shape of a rope). This scenario is illustrated in Figure 3C. In most cases, when a hydrocyclone 302 is roping, it is not performing its function as a separator and is operating in an inefficient manner.

As is apparent from Figure 3C, the position of the probe 304 is such that, when the hydrocyclone 302 is operating according to a roping condition, the underflow 346 does not impact the probe 304. Hence, the probe 304 is not caused to vibrate by the underflow 346 (although it may vibrate due to external factors, such as its mounting to the hydrocyclone 302). Thus, a signal from the sensor that represents minimal vibration, may indicate that the hydrocyclone 302 is roping. In this way, the probe 304 may act as a roping detector.

Hence, the arrangement shown in Figures 3A to 3C can be used to determine both the discharge spray angle of the underflow 346 (i.e. across a generally continuous range), and whether a roping condition is occurring (i.e. a binary output). As will be described below with reference to Figures 4 and 5, these can both be used to control operation of the hydrocyclone 302 (e.g. by controlling the feed pump, water addition, etc).

The flow chart in Figure 4 depicts a process for detecting and handling a roping condition using the hydrocyclone system (such as those described above).

Although this process is described in regards to the detection of roping, it may be useful in detecting other operating conditions of a hydrocyclone.

In broad terms, the process comprises providing a probe having an elongate body, positioning the elongate body such that it is able to vibrate responsive to the discharge of the underflow, and detecting a flow condition from the vibration of the elongate body 448. The hydrocyclone may then be controlled (e.g. by adjusting an operating parameter of the feed pump) in response to the detected flow condition.

The vibration of the elongate body may be detected using a vibration sensor 448. The vibration sensor produces vibration data (e.g. transmitted in the form of a vibration signal) and this vibration data can be used to distinguish (at step 450) a flow condition of the underflow by whether or not the elongate body is being impacted by the underflow of the hydrocyclone, and/or the position of the impact and/or by some other characteristic of the vibration (such as amplitude or frequency)..

The detected vibration from the vibration sensor may be handled in various ways in order to distinguish the vibration. For example, the vibration data may be transformed to split the vibration signal into its separate basic frequencies (e.g. via an FFT operation). If the vibration data is transformed in this way a frequency, or range of frequencies, (e.g. that are indicative of the impact of the underflow) may be monitored.

The vibration data, whether transformed or not, can be monitored by a processor which is adapted to determine (at step 450), based on the vibration data it receives, whether or not the elongate body is vibrating in a manner that is indicative of a particular flow condition. As an example, the hydrocyclone may be set up such that the elongate body of the probe may or may not be impacted by the underflow. When it is being impacted, it is an indication that the hydrocyclone is operating under normal or ideal. As such, the processor simply continues to monitor the vibration data. The reason that impacting underflow

indicates such a condition is because the positioning of the elongate body is such that it extends into the underflow when the flow condition of the underflow corresponds to a normal or ideal operating condition of the hydrocyclone.

On the other hand, if the vibration data indicates that the underflow is not impacting the elongate body, then the processor may produce a signal or alert indicating that the hydrocyclone is operating in a roping condition. This is because, when the hydrocyclone is in a roping condition, the underflow is generally discharged downwardly and does not impact the elongate body. The alert may, for example, be in the form of a warning message on a display or may be an alert signal (e.g. transmitted to a controller).

In response to the alert, a processor or an operator may determine whether the issue (i.e. roping) can be resolved by adjusting an operating parameter of the hydrocyclone 452. This determination may be made based on historical data and/or other data indicative of the current operating condition of the hydrocyclone. If it is determined that the issue can be solved by adjusting an operating parameter, then an operator or controller may do so (step 454), and vibration of the elongate body will continue to be monitored. Should it be determined that the issue cannot be solved by adjusting an operating parameter of the hydrocyclone, an operator or controller may respond by ceasing operation of the hydrocyclone (step 456).

Figure 5 illustrates a further application of the systems described above and illustrated in Figures 1A to 3C. In particular, this figure depicts an exemplary feedback control loop for controlling a hydrocyclone (or feed pump for a hydrocyclone) using the described systems 100, 200, 300.

Generally speaking, the feedback control loop makes use of a signal 566 indicative of discharge spray angle to control aspects of the feed to the hydrocyclone. The signal 566 may, for example, be from a vibration sensor on a probe (i.e. as in the system described above). However, alternative arrangements could be used to obtain such a signal 566. For example, an arrangement

comprising a pivotable arm that rides an outer periphery of the underflow discharge spray, and an angular sensor, could be used to provide such a signal 566. Alternatively, an optical system (e.g. a laser-based sensor) could be used to determine the distance of the underflow from a fixed point, which could be used to provide a signal 566 indicative of discharge spray angle.

In operation, the feedback loop takes an input control signal 558 and passes it to a controller 560, which controls the feed pump 562 that feeds e.g. a slurry into the hydrocyclone 564. The control may be limited to one aspect of the feed – for example, the feed pump 562 speed (e.g. RPM) or flow rate. The sensor detects the discharge spray angle of the underflow of the hydrocyclone and transmits a signal 566 indicative of the discharge spray angle. The sensor signal 566 is combined with the input signal 558 (e.g. using a microprocessor or an electrical circuit) so as to provide a combined signal that is passed to the controller 560 (i.e. such that the sensor signal 566 affects how the pump is controlled, and how the hydrocyclone 564 functions).

In this way, the control loop can be used to maintain the discharge spray angle at a desired angle (e.g. that may be indicative of an efficiently operating hydrocyclone). That is, if the underflow discharge angle deviates from the desired angle, the sensor signal 566 results in a modification of the feed flow rate of the hydrocyclone 564 to return the underflow discharge spray angle back to the desired angle.

In some circumstances it is desirable to maintain the hydrocyclone 564 in a semi-roping condition (i.e. on the verge of entering a roping condition). The feedback control loop (in combination with the systems described above) can be used to achieve this. For example, the desired angle may be set at an angle that is indicative of the hydrocyclone 564 operating in a semi-roping state. In this way, the feedback control loop reverts the hydrocyclone 564 to operating in this condition if the sensed underflow discharge spray angle is indicative of it moving away from that condition.

When operating the hydrocyclone 564 in this way (i.e. maintain the hydrocyclone in a semi-roping condition using the above described feedback control loop) it can be desirable to maintain other operating parameters of the hydrocyclone 564 constant. One such parameter is the cut size of the hydrocyclone. This can be
5 maintained by manually measuring cut size, or by using known on-line cut size analyser systems.

Variations and modifications may be made to the parts previously described without departing from the spirit or ambit of the disclosure.

For example the system may comprise a plurality of probes (i.e. a plurality of
10 elongate bodies having vibration sensors). Each elongate body may be mounted so as to extend into the discharging fluid at different spray angles, such that multiple spray angles may be detected. Alternatively or additionally, the plurality of elongate bodies may be spaced about the underflow in case that the spray of discharging fluid doesn't have a circular profile (which could otherwise lead to a
15 false indication of roping or other issues).

The elongate body may not be mounted to the hydrocyclone. It may instead be mounted to externally to a support structure or separate piece of equipment. Similarly, the vibration sensor may not be mounted to the elongate body. It may, for example, mounted at a different position where it is still able to detect
20 vibration of the elongate body (e.g. on the hydrocyclone).

The elongate body may take other forms. For example, it may be in the form of a hollow circular section or a cylindrical projection. In some forms it may not be mounted adjacent the outlet of the hydrocyclone and may instead be mounted to a central or upper portion of the body of the hydrocyclone. The elongate body may
25 alternatively be mounted to a separate structure that is not fixed to, or is not directly in contact with, the hydrocyclone.

The elongate body described above is formed of steel section, but in other embodiments may be formed of other materials, such as plastic. Alternatively, it

may be formed of a combination of materials – for example, the steel section may comprise a wear-resistant coating.

In the described embodiment, the elongate body is adjustably mounted to the hydrocyclone by way of a plurality of mounting regions – more specifically, pairs
5 of apertures. This provides several discrete positions for mounting the elongate body to the hydrocyclone. In other embodiments, the elongate body may be adjusted in a continuous, rather than discrete, manner. For example, the elongate body may be slidably engaged with the hydrocyclone (or the mounting element). This may be facilitated by an elongate recess extending along the length of the
10 web of the elongate body. A fastener (e.g. bolt and nut arrangement) may pass through the elongate recess such that the elongate body can be moved along the axis of the recess and then locked into a chosen position by tightening of the fastener. In another embodiment the elongate body itself may be adjustable. So for example, it may comprise telescoping arrangement that allows the free end of
15 the elongate body to adjusted with respect to the underflow.

Although one feedback control loop is described, other control loops may be used to control the hydrocyclone based on the sensor signal. Similarly, rather than determining a discharge angle, a vibration signature may be used to control the hydrocyclone (e.g. via the feed pump). For example, a semi-roping condition may
20 have a particular vibration signature, and the control loop may act to maintain the vibration so as to be close to that vibration signature.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word “comprise” or variations such as “comprises” or
25 “comprising” is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

CLAIMS

1. A hydrocyclone system comprising:
a hydrocyclone comprising an outlet for discharging an underflow;
a probe for detecting a flow condition of the underflow comprising:
an elongate body; and
a vibration sensor to detect vibration of the body.
2. A system according to claim 1 wherein the vibration sensor is mounted to the elongate body.
3. A system according to claim 1 or 2 wherein the elongate body is arranged so as to extend into the underflow when discharging according to at least one flow condition.
4. A system according to claim 3 wherein vibration of the body is indicative of the discharge spray angle of the underflow.
5. A system according to claim 3 wherein:
under a first flow condition the underflow discharges at a first spray angle;
and
under a second flow condition the underflow discharges at a second spray angle that is smaller than the first spray angle; and
wherein the system is operative to distinguish between the first and second flow conditions.
6. A system according to claim 5 wherein the system distinguishes between the first and second flow conditions using the sensed vibration of the elongate body caused by the discharging underflow.
7. A system according to claim 6 wherein the elongate body is arranged so as to:

be spaced from the underflow when discharging according to the first flow condition; and

extend into the underflow when discharging according to the second flow condition.

8. A system according to claim 7 wherein the first flow condition corresponds to a roping condition of the hydrocyclone.
9. A system according to claim 8 wherein the position of the free end of the elongate body is adjustable with respect to the hydrocyclone.
10. A system according to claim 9 wherein the vibration sensor is mounted at the free end of the elongate body.
11. A probe for detecting a flow condition of the underflow of a hydrocyclone, the probe comprising:
 - an elongate body; and
 - a vibration sensor to detect vibration of the body.
12. A probe according to claim 11 that is as otherwise defined in any one of claims 1 to 10.
13. A method of detecting a flow condition of the underflow of a hydrocyclone, the method comprising:
 - providing a probe comprising an elongate body;
 - positioning the elongate body such that it is able to vibrate responsive to the discharge of the underflow; and
 - detecting the flow condition from the vibration of the elongate body.
14. A method according to claim 13 wherein the elongate body is caused to vibrate by being positioned so as to extend into the underflow when discharging according to at least one flow condition.

15. A method according to claim 14 wherein the method further comprises distinguishing between first and second flow conditions by changes in the vibration of the elongate body.
16. A method according to claim 15 wherein:
 - under the first flow condition, the underflow discharges at a first spray angle; and
 - under the second flow condition the underflow discharges at a second spray angle that is smaller than the first spray angle.
17. A method according to claim 16 wherein the elongate body extends into the underflow under the first and second flow conditions.
18. A method according to claim 16 wherein the step of positioning the elongate body comprises arranging the elongate body so as to:
 - be spaced from the underflow when discharging according to the first flow condition; and
 - extend into the underflow when discharging according to the second flow condition.
19. A method according to claim 18 wherein the first flow condition corresponds to a roping condition of the hydrocyclone.
20. A method according to any one of claims 13 to 19 further comprising controlling the hydrocyclone in response to the detected flow condition.
21. A method of operating a hydrocyclone, the method comprising:
 - detecting a characteristic of the shape of the underflow of a hydrocyclone;
 - adjusting an operating parameter of the hydrocyclone to alter the characteristic of the shape of the underflow.

22. A method according to claim 21 wherein the characteristic is the discharge spray angle.
23. A method according to claim 21 or 22, wherein the adjustment of the operating parameter is performed so as to alter the discharge spray angle to a desired discharge spray angle.
24. A method according to claim 23 wherein the desired discharge spray angle is indicative of the hydrocyclone operating under a semi-roping condition
25. A method according to any one of claims 21 to 24 further comprising maintaining a generally consistent cut size.

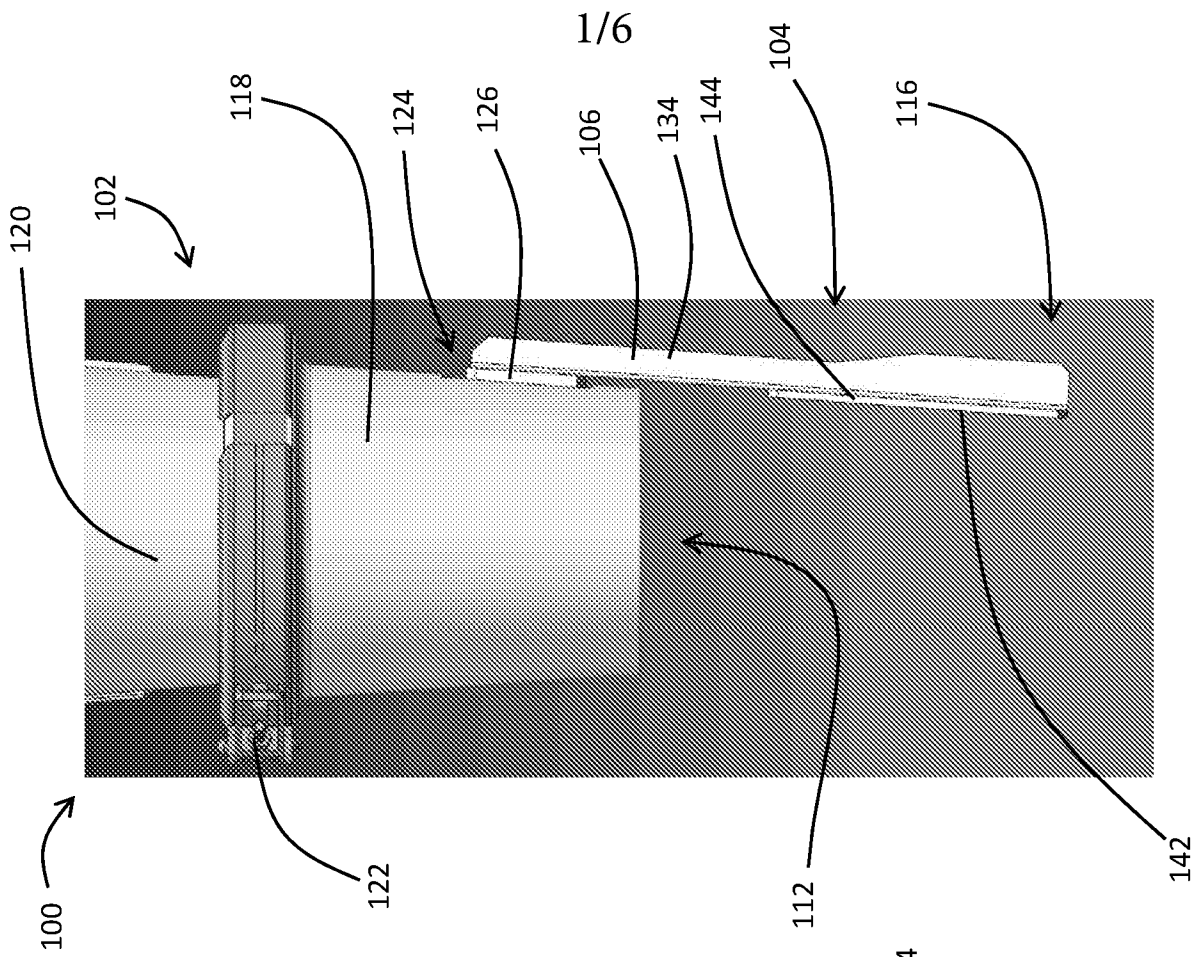


FIG 1B

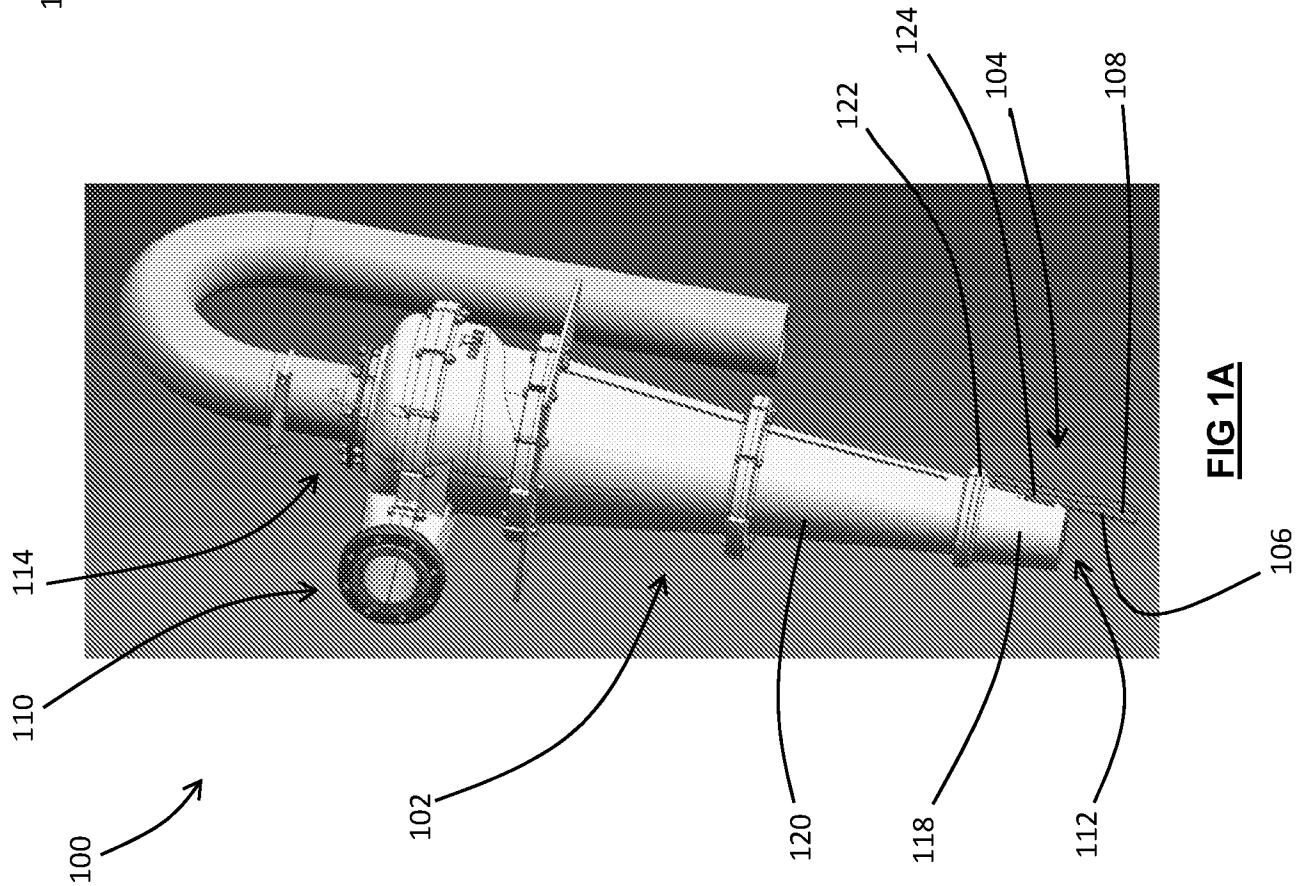
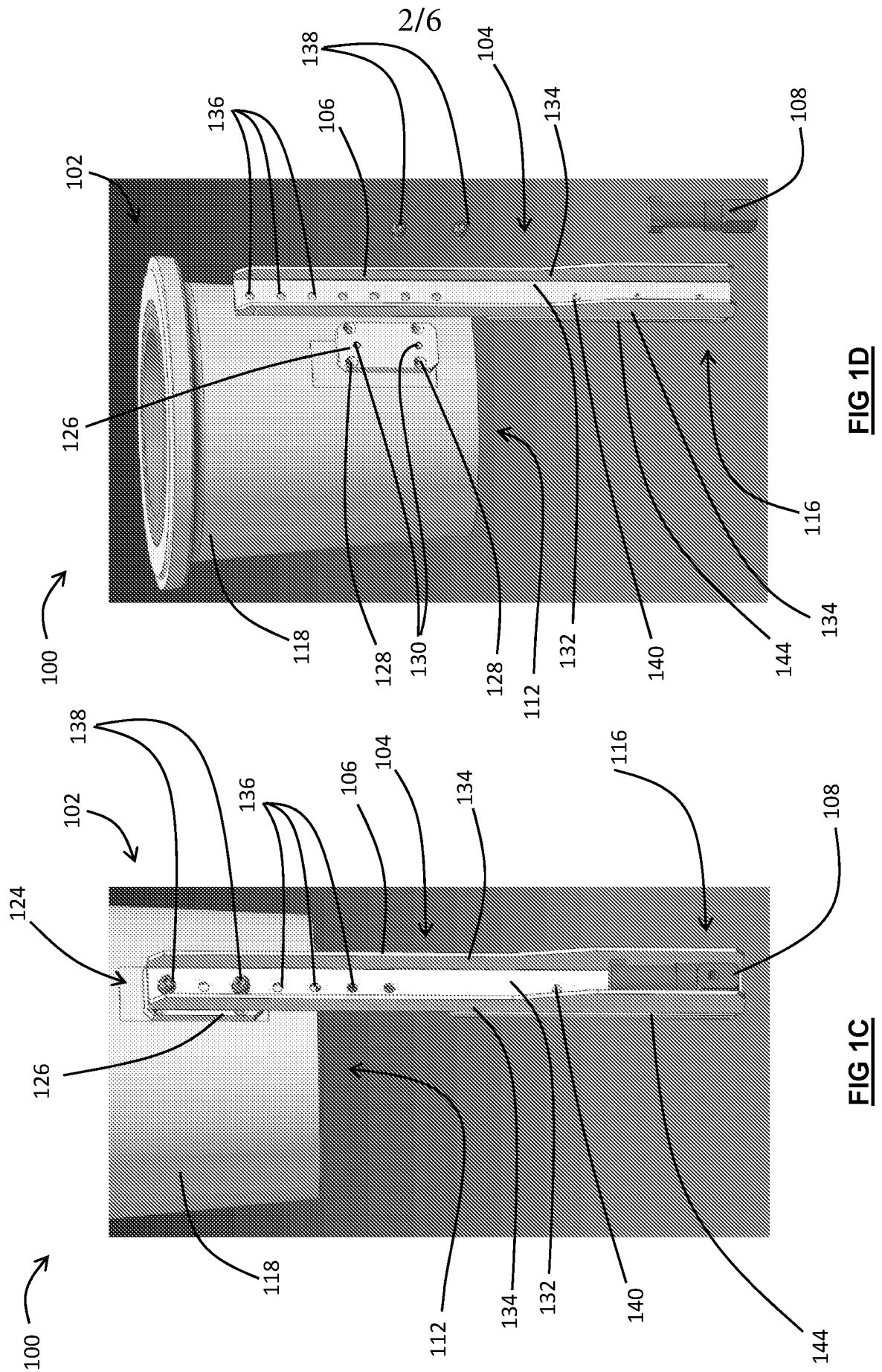
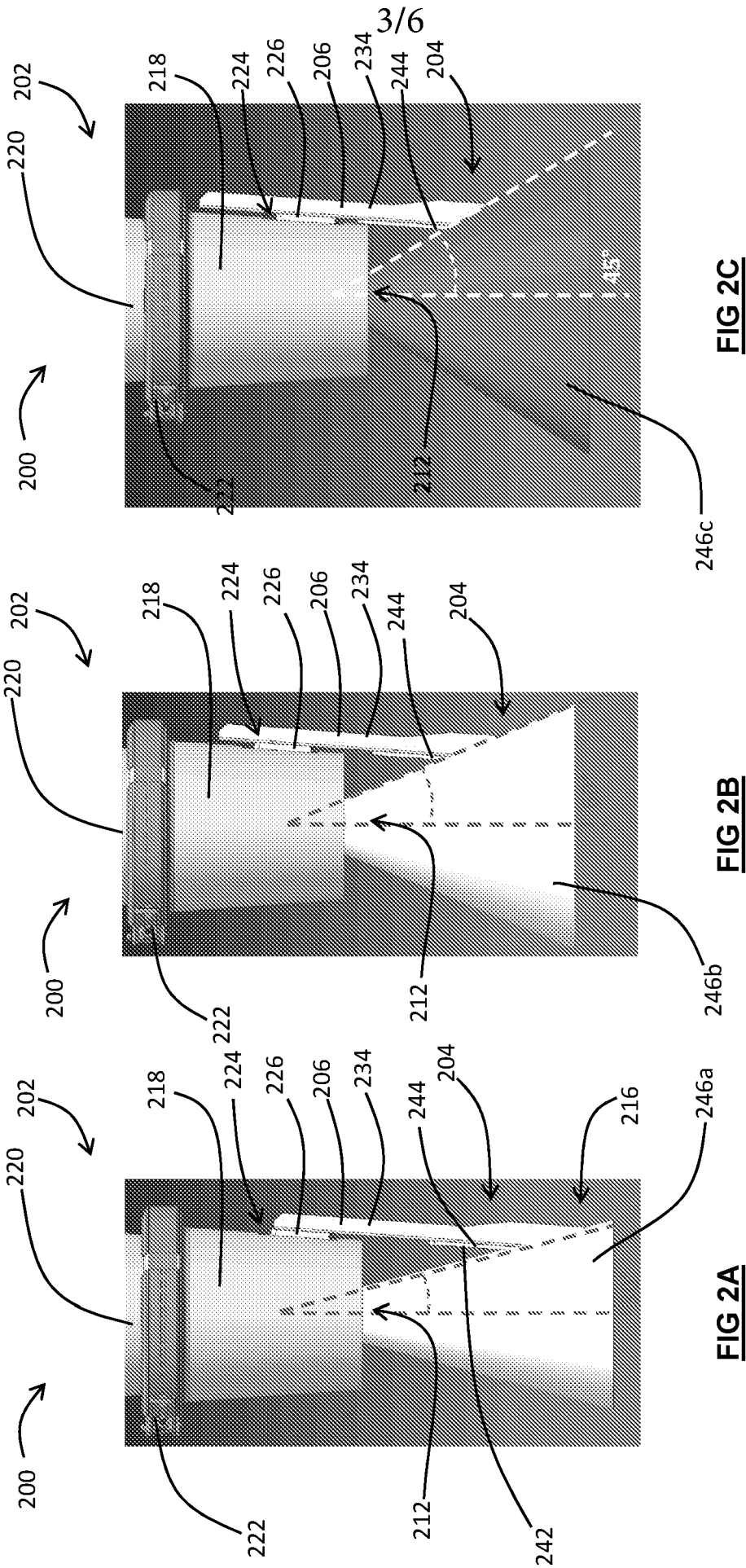
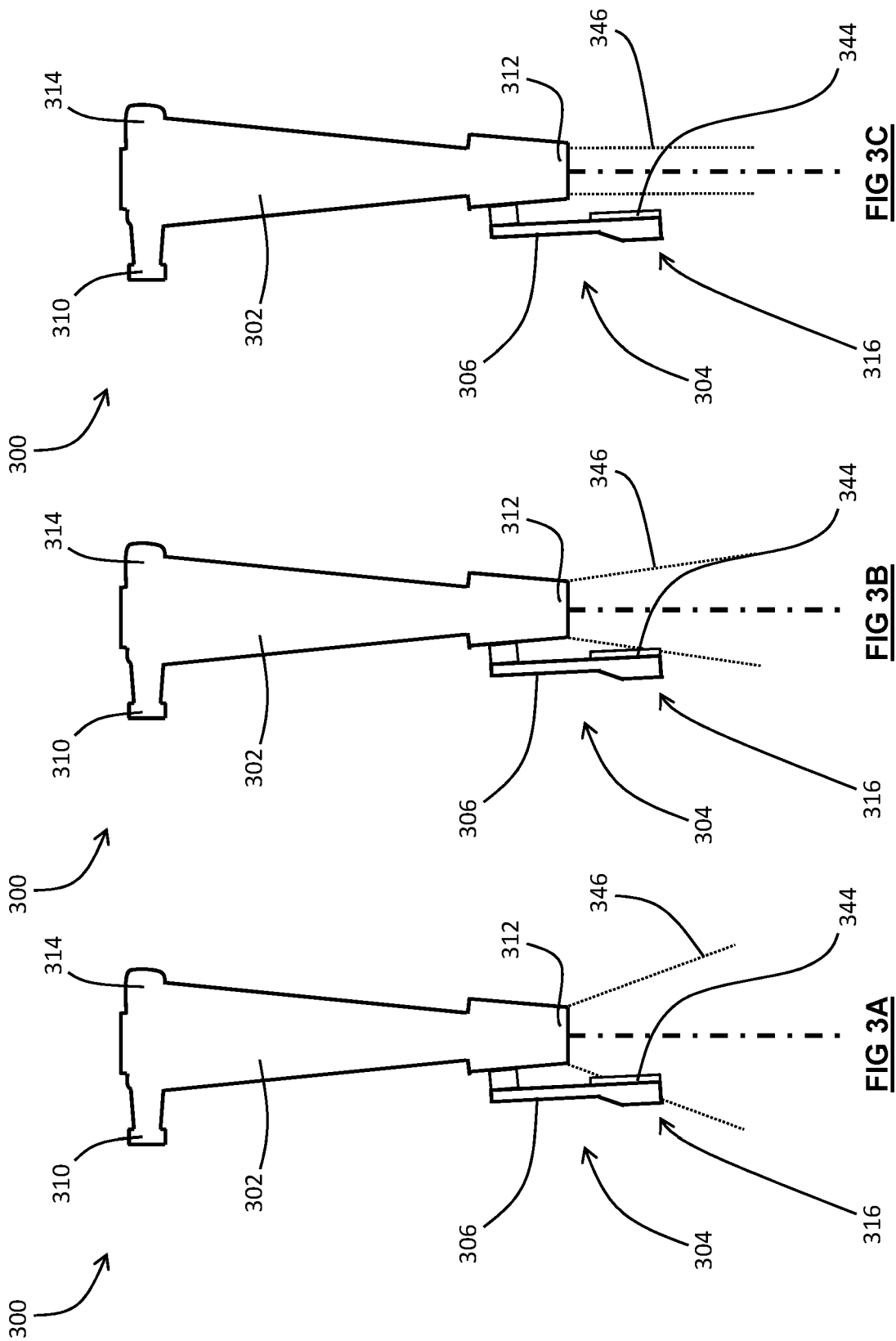


FIG 1A







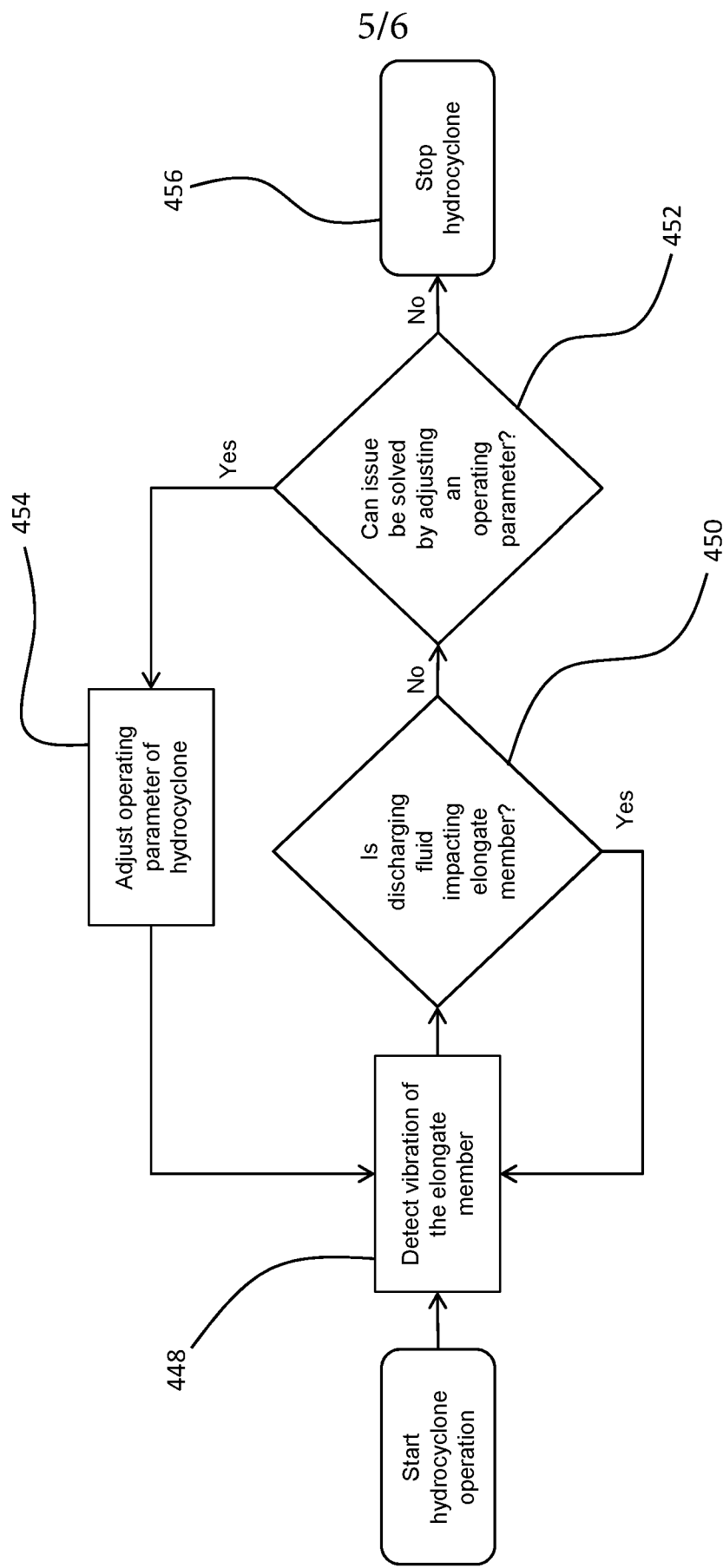


FIG 4

6/6

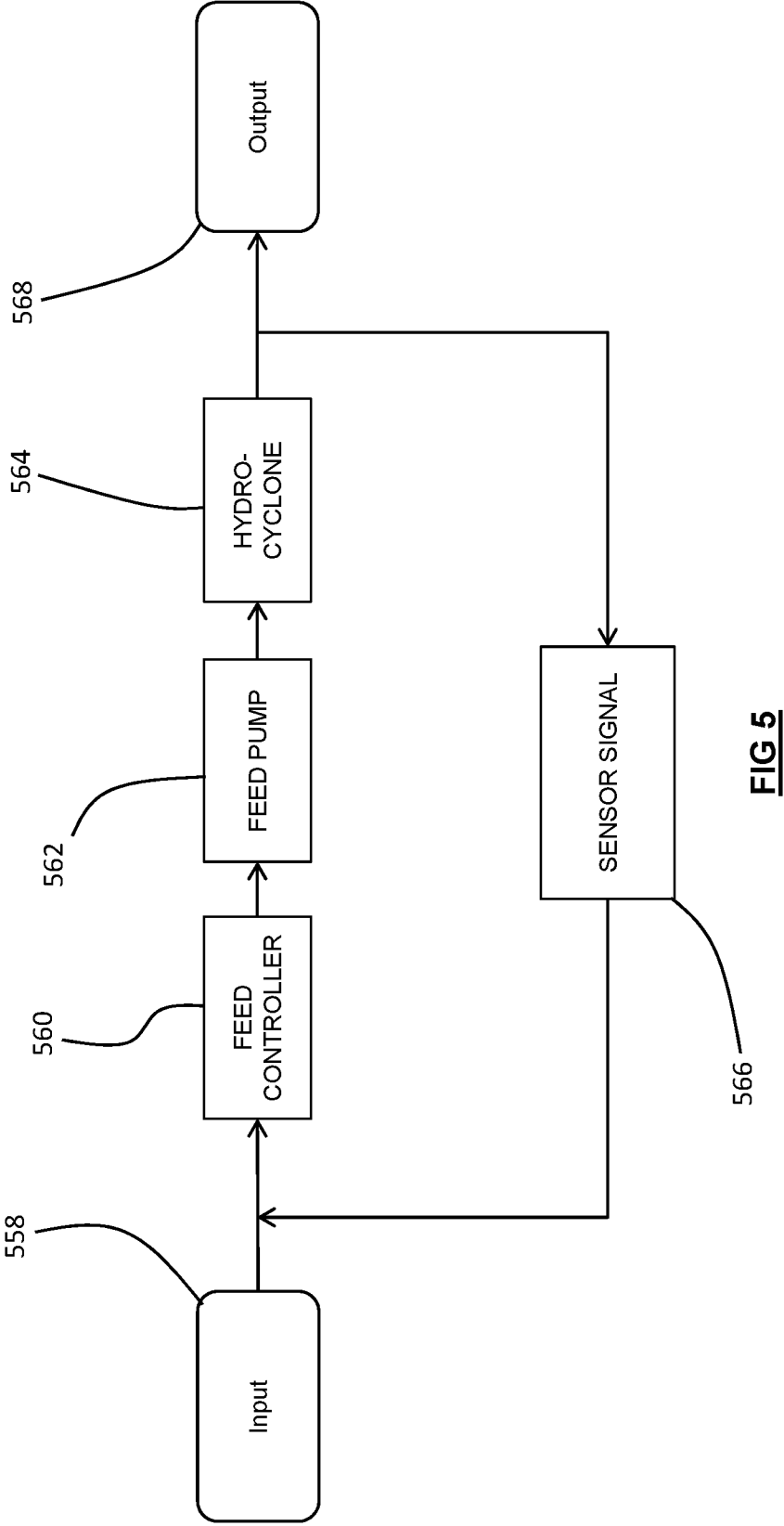


FIG 5

INTERNATIONAL SEARCH REPORT

 International application No.
PCT/AU2017/050451

A. CLASSIFICATION OF SUBJECT MATTER

B04C 11/00 (2006.01) G01H 1/12 (2006.01) G01H 3/00 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

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

PATENW: CPC/IPC (B01D21/267, B01D21/26, B01D17/0217, B01D17/02, B04C/LOW, B04C11/LOW, G01H1/12/LOW, G01F1/20/LOW, G01H3/LOW, G01P15/097/LOW, G01B, G01C, G01D, G01F, G01H, G01J, G01L, G01M, G01P, G01Q, G01R, G01S, G05B, G05D, G05F, G05G) and keywords (vibrate, tremor, shake, shudder, tremble, shiver, flutter, oscillate, acoustic, reverberate, resonate, sense, sensor, sensing, probe, detect, monitor, measure, alarm, signal, gauge, cyclone, hydrocyclone, roping, arm, armature, beam, staff, extension, elongate, shaft, batten, stick, limb, appendage, leg, pole, post, rod, tube, underflow, underpass, tailing, spray, apex, lower, free, bottom, outlet, flow, discharge, eject, angle, shape, cone, coning, direction, and like terms); Google, Google Patents and Espacenet: CPC/IPC for Espacenet (B04C, G01, G05) and keywords (cyclone, hydrocyclone, underflow, discharge, sensor, vibration, detect, probe, cone, angle, spray, width, pattern, roping, and like terms); Applicant(s)/inventor(s) searched in Espacenet and internal databases provided by IP Australia.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 30 August 2017	Date of mailing of the international search report 30 August 2017
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustalia.gov.au	Authorised officer Joannelle Bacus AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61262256174

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/AU2017/050451
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4246576 A (GRIEVE et al.) 20 January 1981 Abstract; column 3 line 30 to column 4 line 43, column 6 line 61 to column 7 line 40; Figs. 1-8	3-10, 14-19
X Y	US 2005/0016903 A1 (OLSON et al.) 27 January 2005 Abstract; paragraphs 0021-0027; Figs. 2-4 Abstract; paragraphs 0021-0026; Figs. 2-4	1-2, 11-13, 20 3-10, 14-19
X	WO 2016/051275 A2 (EMERSON ELECTRIC (US) HOLDING CORPORATION (CHILE) LIMITADA) 07 April 2016 Abstract; paragraphs 0005, 0039-0046, 0050-0055; Fig. 1, 6A-8D	21-25
X	US 5132024 A (HULBERT) 21 July 1992 Abstract; column 2 line 63 to column 4 line 41, column 5 lines 24-41; claims 1-7; Figs. 1-6B	21-25
X	WO 2010/089309 A1 (AKW APPARATE + VERFAHREN GMBH) 12 August 2010, English translation obtained from Espacenet Abstract; claims 1, 2 and 7; Fig. 1	1-2, 11-13, 20-25
X	DE 19963284 A1 (AKW APPARATE UND VERFAHREN GMBH & CO. KG) 28 June 2001, English translation obtained from Espacenet Abstract; Description; claim 1 and 3; Figs. 1 and 5	21-25
X	SU 543410 A1 (Gosudarstvennyj nauchno-isledovatel'skij & projektnij Institut po obogasheni rud cvetnykh metallov) 25 January 1977, Machine translation obtained from Espacenet Description; Figure	21-25
A	DE 102010027680 A1 (AKW APPARATE + VERFAHREN GMBH) 22 December 2011, Machine translation obtained from Espacenet Abstract; Figs. 1-2	

Supplemental Box**Continuation of: Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1-20 are directed to a hydrocyclone system, probe and method of detecting a flow condition of the underflow of a hydrocyclone. The feature of a probe (for detecting a flow condition of the underflow of a hydrocyclone) comprising an elongate body and a vibration sensor for detecting the vibration of the body is specific to this group of claims.
- Claims 21-25 are directed to a method of operating a hydrocyclone. The feature of detecting a characteristic of the shape of the underflow of a hydrocyclone and adjusting an operating parameter of the hydrocyclone to alter the characteristic of the shape of the underflow is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a priori*.

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/AU2017/050451	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
US 4246576 A	20 January 1981	US 4246576 A	20 Jan 1981
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