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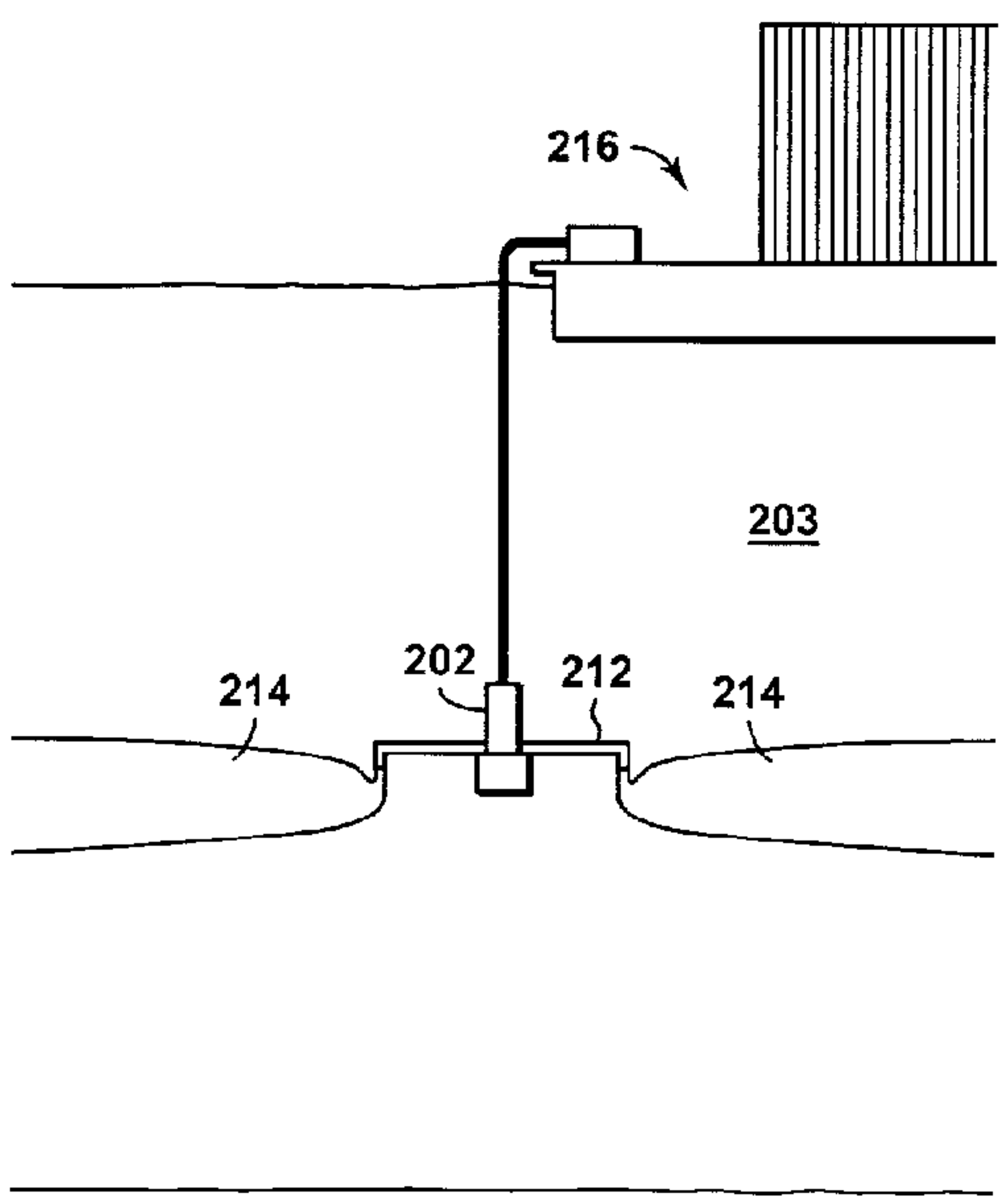


(57) Abrégé/Abstract:
A pump system for submersing into a slurry, the pump system including a pump body having an inlet for receiving the slurry; and a plate for mitigating coning, the plate being disposed adjacent the inlet and extending outwardly from the pump body. A method including submersing the pump system into a slurry; and pumping the slurry through the pump system. An apparatus for mitigating coning around a submersible pump, the submersible pump comprising a pump body having an inlet, the apparatus including a plate for mitigating coning around the submersible pump in use, the plate being for disposing adjacent the inlet and extending outwardly from the pump body; and a plate positioning structure for holding the plate in position.

ABSTRACT

A pump system for submersing into a slurry, the pump system including a pump body having an inlet for receiving the slurry; and a plate for mitigating coning, the plate being disposed adjacent the inlet and extending outwardly from the pump body. A method including submersing the pump system into a slurry; and pumping the slurry through the pump system. An apparatus for mitigating coning around a submersible pump, the submersible pump comprising a pump body having an inlet, the apparatus including a plate for mitigating coning around the submersible pump in use, the plate being for disposing adjacent the inlet and extending outwardly from the pump body; and a plate positioning structure for holding the plate in position.

SUBMERSIBLE PUMP SYSTEM FOR MITIGATING CONING

BACKGROUND

Field of Disclosure

[0001] The disclosure relates generally to the field of submersible pumps for pumping slurries, for instance oil sand tailings or mining tailings.

Description of Related Art

[0002] This section is intended to introduce various aspects of the art, which may be associated with the present disclosure. This discussion is believed to assist in providing a framework to facilitate a better understanding of particular aspects of the present disclosure. Accordingly, it should be understood that this section should be read in this light, and not necessarily as admissions of prior art.

[0003] Submersible pumps are pumps that may be submersed into a fluid or slurry for pumping a portion of the fluid or slurry to another location. Such pumps may be used, for instance, to pump oil sand tailings or mining tailings to another location.

[0004] When a submersible pump is deployed within a fluid or slurry, the velocities of the fluid or slurry entering a pump intake include velocity components in the vertical and horizontal directions. The vertical components can result in a "coning" effect at the pump's intake where fluid or slurry is pulled down and/or up to the pump's intake. The coning effect can negatively impact the ability to draw fluid or slurry into the pump's suction from a targeted depth.

[0005] Figure 1 illustrates this coning effect. A submersible pump (102) is disposed in a denser fluid such as water (104) beneath a less dense fluid such as oil (106). In an oil sand tailings pond, the interface may be muskeg (108). Upon pumping, the coning effecting (indicated by arrows 110) causes the unwanted oil and muskeg to be drawn down to an inlet of the pump (102).

[0006] In the oil sand industry, this coning effect of fine tailings suction pumps may result in at least two challenges: density control of the fine tailings being recovered and debris being drawn into the pump intake.

[0007] In the case of oil sand tailings treatment, it is desirable to remove fine tailings from the bottom of settling ponds. This is primarily tied to removing fine tailings from the ponds to support more rapid reclamation of the land. Depending on the specific facility, the desire to remove fine tailings from a pond may also be tied to improving process water containment as the volume taken up by the fine tailings in the pond may be desired for process water containment. In some cases, the desire to remove fine tailings from a tailings area may be tied to both reclamation and process water containment.

[0008] In settling ponds, fine tailings settle in a layer below the water level and above the soil in the settling pond. The layer of fine tailings is commonly referred to as the "mud" layer. The specific gravity of the tailings changes considerably within the "mud" layer, ranging from 1.0 at the fine tailings-to-water interface to 1.4 or more towards the bottom of the pond.

[0009] In order to recover and process the tailings, submersible pumps or dredges are commonly used to draw the fine tailings out of the settling pond. As noted above, the coning effect results in at least two challenges for the reliable and sustainable recovery of fine tailings: density control of the fine tailings being recovered and debris being drawn into the pump intake.

[0010] Density Control

[0011] Typical tailings processing technologies may require a relatively narrow density range for the fine tailings feed to the process unit (e.g. a specific gravity of 1.15 to 1.25). As noted above, the density of fine tailings changes considerably with changes in depth within the "mud" layer.

[0012] The coning effect exhibited by submerged intakes may result in operational challenges in recovering tailings that meet the target density for feed to the process unit. For example, if the pump is lowered to the elevation that has a specific gravity of 1.2, the coning effect may pull in tailings and water from higher elevations in the settling pond that result in a product stream with less than adequate specific gravity.

[0013] Debris (Muskeg)

[0014] Muskeg overgrowth is common in oil sand settling ponds. Muskeg starts at the bottom of the pond but tends to have a macro density slightly greater than water and slightly less than fine tailings. As such, floating muskeg tends to rest at the water/tailings interface.

[0015] The coning effect can draw muskeg, which is originally above the vertical position of the pumps, down into the pumps suction resulting in pump plugging and required cleaning. The frequent plugging of pump intakes may create operational and maintenance challenges, as the pumps may be frequently taken out of service to clean of the muskeg debris.

[0016] While the following background on oil sand tailings is provided, the disclosure is not limited to oil sand tailings.

[0017] Modern society is greatly dependent on the use of hydrocarbon resources for fuels and chemical feedstocks. Hydrocarbons are generally found in subsurface formations that can be termed "reservoirs". Removing hydrocarbons from the reservoirs depends on numerous physical properties of the subsurface formations, such as the permeability of the rock containing the hydrocarbons, the ability of the hydrocarbons to flow through the subsurface formations, and the proportion of hydrocarbons present, among other things. Easily harvested sources of hydrocarbons are dwindling, leaving less accessible sources to satisfy future energy needs. As the costs of hydrocarbons increase, the less accessible sources become more economically attractive.

[0018] Recently, the harvesting of oil sand to remove heavy oil has become more economical. Hydrocarbon removal from oil sand may be performed by several techniques. For example, a well can be drilled to an oil sand reservoir and steam, hot air, solvents, or a combination thereof, can be injected to release the hydrocarbons. The released hydrocarbons may be collected by wells and brought to the surface.

[0019] In another technique, strip or surface mining may be performed to access the oil sand, which can be treated with water, steam or solvents to extract the heavy oil.

[0020] Oil sand extraction processes are used to liberate and separate bitumen from oil sand so that the bitumen can be further processed to produce synthetic crude oil or mixed with diluent to form “dilbit” and be transported to a refinery plant. Numerous oil sand extraction processes have been developed and commercialized, many of which involve the use of water as a processing medium. Where the oil sand is treated with water, the technique may be referred to as water-based extraction (WBE). WBE is a commonly used process to extract bitumen from mined oil sand.

[0021] One WBE process is the Clark hot water extraction process (the “Clark Process”). This process typically requires that mined oil sand be conditioned for extraction by being crushed to a desired lump size and then combined with hot water and perhaps other agents to form a conditioned slurry of water and crushed oil sand. In the Clark Process, an amount of sodium hydroxide (caustic) may be added to the slurry to increase the slurry pH, which enhances the liberation and separation of bitumen from the oil sand. Other WBE processes may use other temperatures and may include other conditioning agents, which are added to the oil sand slurry, or may operate without conditioning agents. This slurry is first processed in a Primary Separation Cell (PSC), also known as a Primary Separation Vessel (PSV), to extract the bitumen from the slurry.

[0022] In one bitumen extraction process, a water and oil sand slurry is separated into three major streams in the PSC: bitumen froth, middlings, and a PSC underflow (also known as primary separation tailings or coarse sand tailings (CST)).

[0023] Regardless of the type of WBE process employed, the process will typically result in the production of a bitumen froth that requires treatment with a solvent. For example, in the Clark Process, a bitumen froth stream comprises bitumen, solids, and water. Certain processes use naphtha to dilute bitumen froth before separating the product bitumen by centrifugation. These processes are called naphtha froth treatment (NFT) processes. Other processes use a paraffinic solvent, and are called paraffinic froth treatment (PFT) processes, to produce pipelineable bitumen with low levels of solids and water. In the PFT process, a paraffinic solvent (for example, a mixture of iso-pentane and n-pentane) is used to dilute the froth before separating the product, diluted bitumen, by gravity. A portion of the asphaltenes in the bitumen is also rejected by design in the PFT process and this rejection is used to achieve reduced solids and water levels. In both the NFT and the PFT processes, the diluted tailings (comprising water, solids and some hydrocarbon) are separated from the diluted product bitumen.

[0024] Solvent is typically recovered from the diluted product bitumen component before the bitumen is delivered to a refining facility for further processing.

[0025] The PFT process may comprise at least three units: Froth Separation Unit (FSU), Solvent Recovery Unity (SRU) and Tailings SRU (TSRU). Mixing of the solvent with the feed bitumen froth may be carried out counter-currently in two stages in separate froth separation units. The bitumen froth comprises bitumen, water, and solids. A typical composition of bitumen froth is about 60 wt. % bitumen, 30 wt. % water, and 10 wt. % solids. The paraffinic solvent is used to dilute the froth before separating the product bitumen by gravity. The foregoing is only an example of a PFT process and the values are provided by way of example only. An example of a PFT process is described in Canadian Patent No. 2,587,166 to Sury.

[0026] From the PSC, the middlings, comprising bitumen and about 10-30 wt. % solids, or about 20-25 wt. % solids, based on the total wt. % of the middlings, is withdrawn and sent to the flotation cells to further recover bitumen. The middlings are processed by bubbling air through the slurry and creating a bitumen froth, which is recycled back to the PSC. Flotation tailings (FT) from the flotation cells, comprising mostly solids and water, are sent for further treatment or disposed in an external tailings area (ETA).

[0027] In ETA tailings ponds, a liquid suspension of oil sand fines in water with a solids content greater than 2 wt. %, but less than the solids content corresponding to the Liquid Limit are called Fluid Fine Tailings (FFT). FFT settle over time to produce Mature Fine Tailings (MFT), having above about 30 wt. % solids.

[0028] It would be desirable to provide a pump system or apparatus for submersing into a slurry for mitigating coning.

SUMMARY

[0029] It is an object of the present disclosure to provide a pump system or apparatus for submersing into a slurry for mitigating coning.

[0030] According to one aspect, there is provided a pump system for submersing into a slurry, the pump system including a pump body having an inlet for receiving the slurry; and a plate for mitigating coning, the plate being disposed adjacent the inlet and extending outwardly from the pump body.

[0031] According to another aspect, there is provided a method including submersing the pump system into a slurry; and pumping the slurry through the pump system.

[0032] According to another aspect, there is provided an apparatus for mitigating coning around a submersible pump, the submersible pump comprising a pump body having an inlet, the apparatus including a plate for mitigating coning around the submersible pump in use, the plate being for disposing adjacent the inlet and extending outwardly from the pump body; and a plate positioning structure for holding the plate in position.

[0033] The foregoing has broadly outlined the features of the present disclosure so that the detailed description that follows may be better understood. Additional features will also be described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] These and other features, aspects and advantages of the disclosure will become apparent from the following description, appending claims and the accompanying drawings, which are briefly described below.

[0035] Figure 1 is an illustration of a coning effect using a known submersible pump system.

[0036] Figure 2 is an illustration of a mitigated coning effect using an example of a pump system described herein.

[0037] It should be noted that the figures are merely examples and no limitations on the scope of the present disclosure are intended thereby. Further, the figures are generally not drawn to scale, but are drafted for purposes of convenience and clarity in illustrating various aspects of the disclosure.

DETAILED DESCRIPTION

[0038] For the purpose of promoting an understanding of the principles of the disclosure, reference will now be made to the features illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the disclosure is thereby intended. Any alterations and further modifications, and any further applications of the principles of the disclosure as described herein are contemplated as would normally occur to one skilled in the art to which the disclosure relates. It will be apparent to those skilled in the relevant art that some features that are not relevant to the present disclosure may not be shown in the drawings for the sake of clarity.

[0039] At the outset, for ease of reference, certain terms used in this application and their meaning as used in this context are set forth below. To the extent a term used herein is not defined below, it should be given the broadest definition persons in the pertinent art have given that term as reflected in at least one printed publication or issued patent. Further, the present processes are not limited by the usage of the terms shown below, as all equivalents, synonyms, new developments and terms or processes that serve the same or a similar purpose are considered to be within the scope of the present disclosure.

[0040] Throughout this disclosure, where a range is used, any number between or inclusive of the range is implied.

[0041] A "hydrocarbon" is an organic compound that primarily includes the elements of hydrogen and carbon, although nitrogen, sulfur, oxygen, metals, or any number of other elements may be present in small amounts. Hydrocarbons generally refer to components found in heavy oil or in oil sand. However, the techniques described are not limited to heavy oils but may also be used with any number of other reservoirs to improve gravity drainage of liquids. Hydrocarbon compounds may be aliphatic or aromatic, and may be straight chained, branched, or partially or fully cyclic.

[0042] "Bitumen" is a naturally occurring heavy oil material. Generally, it is the hydrocarbon component found in oil sand. Bitumen can vary in composition depending upon the degree of loss of more volatile components. It can vary from a very viscous, tar-like, semi-solid material to solid forms. The hydrocarbon types found in bitumen can include aliphatics, aromatics, resins, and asphaltenes. A typical bitumen might be composed of:

19 weight (wt.) % aliphatics (which can range from 5 wt. % - 30 wt. %, or higher);

19 wt. % asphaltenes (which can range from 5 wt. % - 30 wt. %, or higher);

30 wt. % aromatics (which can range from 15 wt. % - 50 wt. %, or higher);

32 wt. % resins (which can range from 15 wt. % - 50 wt. %, or higher); and

some amount of sulfur (which can range in excess of 7 wt. %), based on a weight of the bitumen.

In addition, bitumen can contain some water and nitrogen compounds ranging from less than 0.4 wt. % to in excess of 0.7 wt. %, based on a weight of the bitumen. The percentage of the hydrocarbon found in bitumen can vary. The term "heavy oil" includes bitumen as well as lighter materials that may be found in a sand or carbonate reservoir.

[0043] "Heavy oil" includes oils which are classified by the American Petroleum Institute ("API"), as heavy oils, extra heavy oils, or bitumens. The term "heavy oil" includes bitumen. Heavy oil may have a viscosity of about 1,000 centipoise (cP) or more, 10,000 cP or more, 100,000 cP or more, or 1,000,000 cP or more. In general, a heavy oil has an API gravity between 22.3° API (density of 920 kilograms per meter cubed (kg/m^3) or 0.920 grams per centimeter cubed (g/cm^3)) and 10.0° API (density of 1,000 kg/m^3 or 1 g/cm^3). An extra heavy oil, in general, has an API gravity of less than 10.0° API (density greater than 1,000 kg/m^3 or 1 g/cm^3). For example, a source of heavy oil includes oil sand or bituminous sand, which is a combination of clay, sand, water and bitumen. The recovery of heavy oils is based on the viscosity decrease of fluids with increasing temperature or solvent concentration. Once the viscosity is reduced, the mobilization of fluid by steam, hot water flooding, or gravity is possible. The reduced viscosity makes the drainage or dissolution quicker and therefore directly contributes to the recovery rate.

[0044] "Fine particles" are generally defined as those solids having a size of less than 44 microns (μm), that is, material that passes through a 325 mesh (44 micron).

[0045] "Coarse particles" are generally defined as those solids having a size of greater than 44 microns (μm).

[0046] A "bitumen extract" is generally defined as bitumen that has been extracted from oil sand.

[0047] A "bitumen product stream" or "bitumen product" is generally defined as a high grade bitumen product that may be suitable for transport within pipelines and processing within downstream refineries. A high grade bitumen product stream may have a solids content of less than 1 wt. %, or less than 0.1 wt. %, on a dry bitumen basis.

[0048] The term "solvent" as used in the present disclosure should be understood to mean either a single solvent, or a combination of solvents.

[0049] The terms "approximately," "about," "substantially," and similar terms are intended to have a broad meaning in harmony with the common and accepted usage by those of ordinary skill in the art to which the subject matter of this disclosure pertains. It should be understood by those of skill in the art who review this disclosure that these terms are intended to allow a description of certain features described and claimed without restricting the scope of these features to the precise numeral ranges provided. Accordingly, these terms should be interpreted as indicating that insubstantial or inconsequential modifications or alterations of the subject matter described and are considered to be within the scope of the disclosure.

[0050] The articles "the", "a" and "an" are not necessarily limited to mean only one, but rather are inclusive and open ended so as to include, optionally, multiple such elements.

[0051] "At least one," in reference to a list of one or more entities should be understood to mean at least one entity selected from any one or more of the entity in the list of entities, but not necessarily including at least one of each and every entity specifically listed within the list of entities and not excluding any combinations of entities in the list of entities. This definition also allows that entities may optionally be present other than the entities specifically identified within the list of entities to which the phrase "at least one" refers, whether related or unrelated to those entities specifically identified. Thus, as a non-limiting example, "at least one of A and B" (or, equivalently, "at least one of A or B," or, equivalently "at least one of A and/or B") may refer, to at least one, optionally including more than one, A, with no B present (and optionally including entities other than B); to at least one, optionally including more than one, B, with no

A present (and optionally including entities other than A); to at least one, optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other entities). In other words, the phrases "at least one," "one or more," and "and/or" are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions "at least one of A, B and C," "at least one of A, B, or C," "one or more of A, B, and C," "one or more of A, B, or C" and "A, B, and/or C" may mean A alone, B alone, C alone, A and B together, A and C together, B and C together, A, B and C together, and optionally any of the above in combination with at least one other entity.

[0052] A pump system for submersing into a slurry may comprise:

a) a pump body having an inlet for receiving the slurry; and

b) a plate for mitigating coning, the plate being disposed adjacent the inlet and extending outwardly from the pump body.

[0053] Figure 2 is an illustration of an example of a pump system described herein illustrating a mitigated coning effect. With reference to Figure 2, a submersible pump (202) is submersed into a slurry (203). A plate (212) for mitigating coning is disposed adjacent an inlet of the pump and extends outwardly from a pump body. Drawn slurry (214) to the pump (202) is sourced from a relatively thin layer because the plate (212) reduces the coning effect. The illustrated reduction in coning over Figure 1 is evident.

[0054] The pump (202) may be physically and/or flowably connected to an onshore facility, a platform, or as illustrated in Figure 2, a floating barge (216).

[0055] The slurry may be any suitable slurry. The slurry may comprise mining tailings. The mining tailings may be any suitable mining tailings. The slurry may comprise oil sand tailings. The slurry comprises oil sand fine tailings. The oil sand tailings may be any suitable oil sand tailings.

[0056] The pump body has an inlet for receiving the slurry as is known in the art. The plate is for mitigating coning for drawing in slurry from a targeted slurry depth or elevation.

[0057] The plate is disposed adjacent the inlet and extends outwardly from the pump body. For example, the plate may comprise a disc-shaped portion extending outwardly from the pump body.

[0058] The plate may be disposed downstream or upstream of the inlet.

[0059] The plate may form a plane within 30 degrees of perpendicular to a main longitudinal axis of the pump body. For instance, the plate may extend out substantially horizontally.

[0060] The plate may be attached to the pump body or may be separate from the pump body but integrated into the support structure and/or surrounding equipment.

[0061] The plate may be in the form of a large disk immediately above or below a submersible pump's suction intake with the intent of manipulating the vertical velocity vectors of the slurry entering the pump suction such that the fluid can be targeted for pump out at a specific elevation without drawing fluid from elevations above or below the suction intake.

[0062] The plate may involve installing an engineered disk, or hat, above and/or below the pump suction to effectively reduce the vertical vectors of the incoming fluid, thus reducing the coning effect and allowing the pump suction to target a specific elevation of the slurry being pumped.

[0063] The specific size and shape of the plate may depend on the specific application taking into account, for instance, slurry densities, flow rates, slurry characteristics, or a combination thereof.

[0064] A method may comprise:

a) submersing the pump system as described herein into a slurry; and

b) pumping the slurry through the pump system.

[0065] An apparatus may be provided for mitigating coning around a submersible pump, the submersible pump comprising a pump body having an inlet, the apparatus comprising:

a) a plate for mitigating coning around the submersible pump in use, the plate being for disposing adjacent the inlet and extending outwardly from the pump body; and

b) a plate positioning structure for holding the plate in position.

[0066] In the case of fine tailings recovery in the presence of muskeg, a primary use of the pump system may be to reduce the draw of muskeg into the pump suction by installing the plate above the pump elevation. Properly sizing and installing the plate above the pump suction may reduce downward velocity vectors of the incoming slurry, thus reducing the coning effect and reducing the downward pull of muskeg into the pump.

[0067] In the presence of muskeg, a potential benefit of the pump system may be reducing the chance of plugging the pump by muskeg being pulled down from higher elevations. In the absence of muskeg, the plate may be to support an effective targeting of a specific density, or specific gravity, of fine tailings.

[0068] The pump system may be used outside of the field of oil sand tailings. For example, the pump system may be used in fluid separation services where one of the fluids needs be removed without impacting the others. Oil/water separation/settling tanks may be able to be reduced in size such that the pump suction for the water may be closer to the elevation of the oil where the plate would be placed above the suction level. The efficiency of an oil pump out may be improved by reducing the amount of water drawn out with the oil where the tool would be placed below the suction level.

[0069] The scope of the claims should not be limited by particular embodiments set forth herein, but should be construed in a manner consistent with the specification as a whole.

CLAIMS:

1. A pump system for submersing into a slurry, the pump system comprising:
   a. a pump body having an inlet for receiving the slurry; and
   b. a plate for mitigating coning, the plate being disposed adjacent the inlet and extending outwardly from the pump body.

2. The pump system of claim 1, wherein the plate is disposed downstream of the inlet.

3. The pump system of claim 1, wherein the plate is disposed upstream of the inlet.

4. The pump system of any one of claims 1 to 3, wherein the plate forms a plane within 30 degrees of perpendicular to a main longitudinal axis of the pump body.

5. The pump system of any one of claims 1 to 4, wherein the plate comprises a disc-shaped portion extending outwardly from the pump body.

6. The pump system of any one of claims 1 to 5, wherein the plate is attached to the pump body.

7. The pump system of any one of claims 1 to 5, wherein the plate is separate from the pump body.

8. A method comprising:
   a. submersing the pump system of any one of claims 1 to 7 into a slurry; and
   b. pumping the slurry through the pump system.

9. The method of claim 8, wherein the slurry comprises mining tailings.

10. The method of claim 8, wherein the slurry comprises oil sand tailings.

11. The method of claim 8, wherein the slurry comprises oil sand fine tailings.

12. An apparatus for mitigating coning around a submersible pump, the submersible pump comprising a pump body having an inlet, the apparatus comprising:

a. a plate for mitigating coning around the submersible pump in use, the plate being for disposing adjacent the inlet and extending outwardly from the pump body; and

b. a plate positioning structure for holding the plate in position.

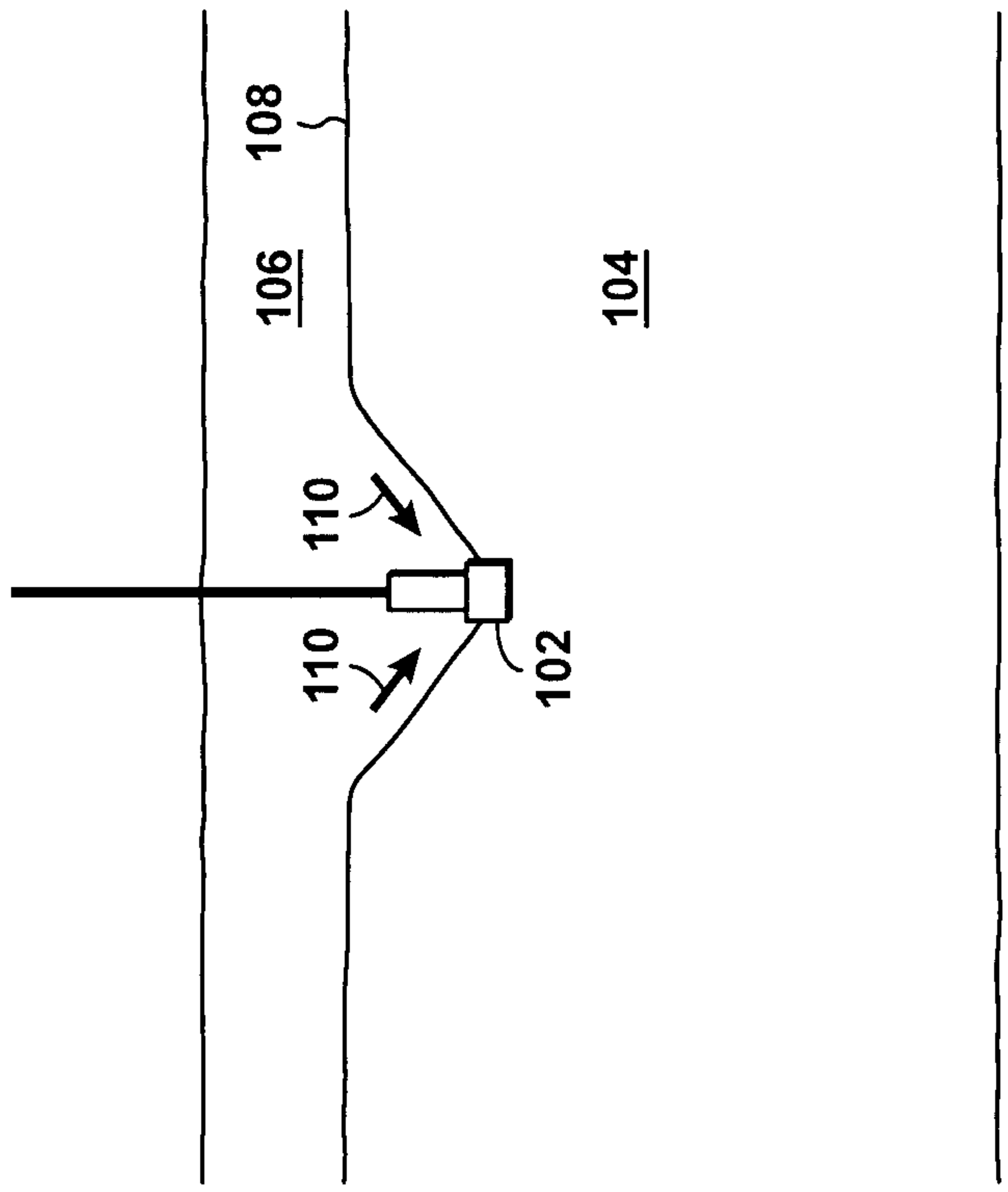


FIG. 1
(Prior Art)

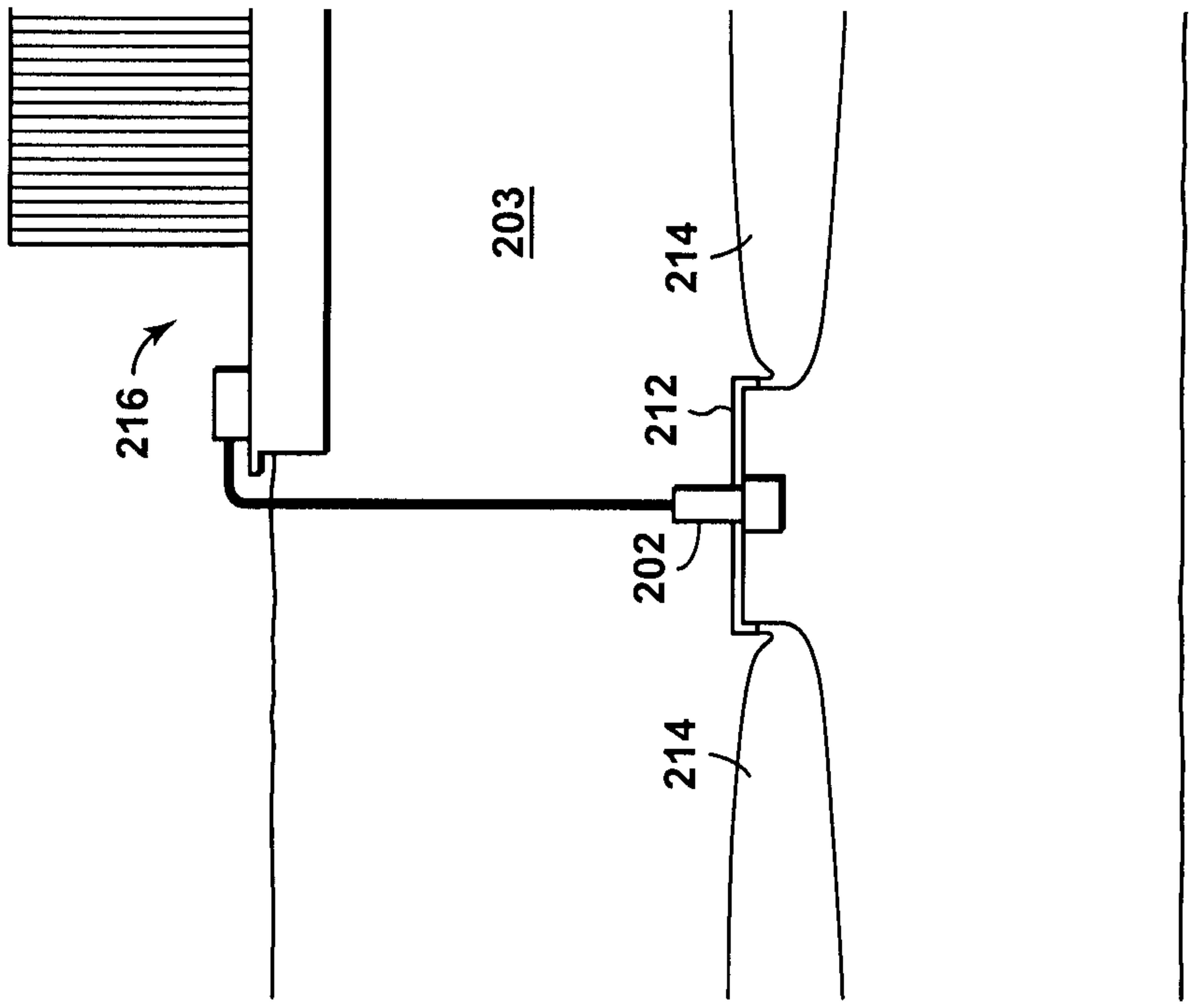
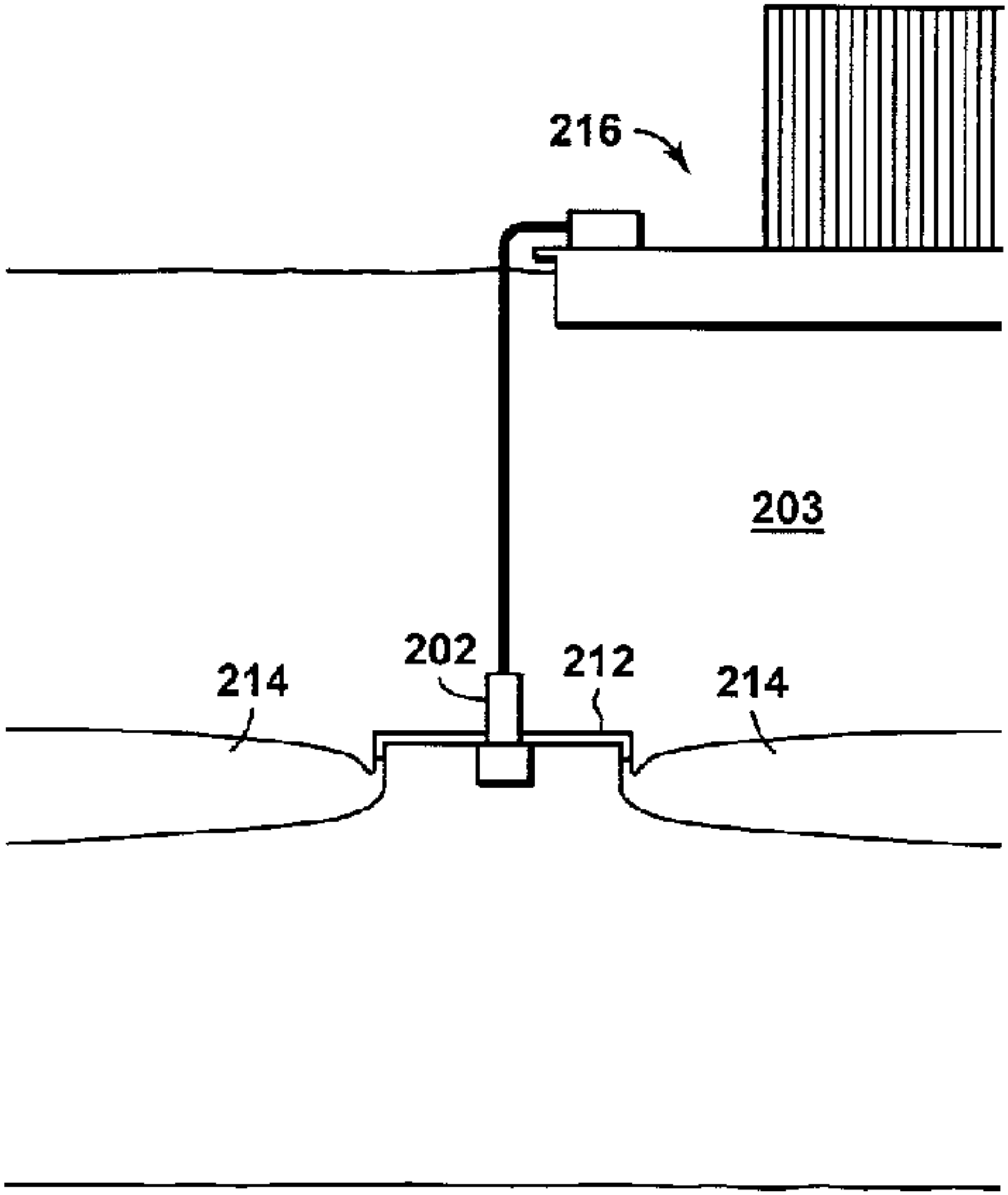


FIG. 2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