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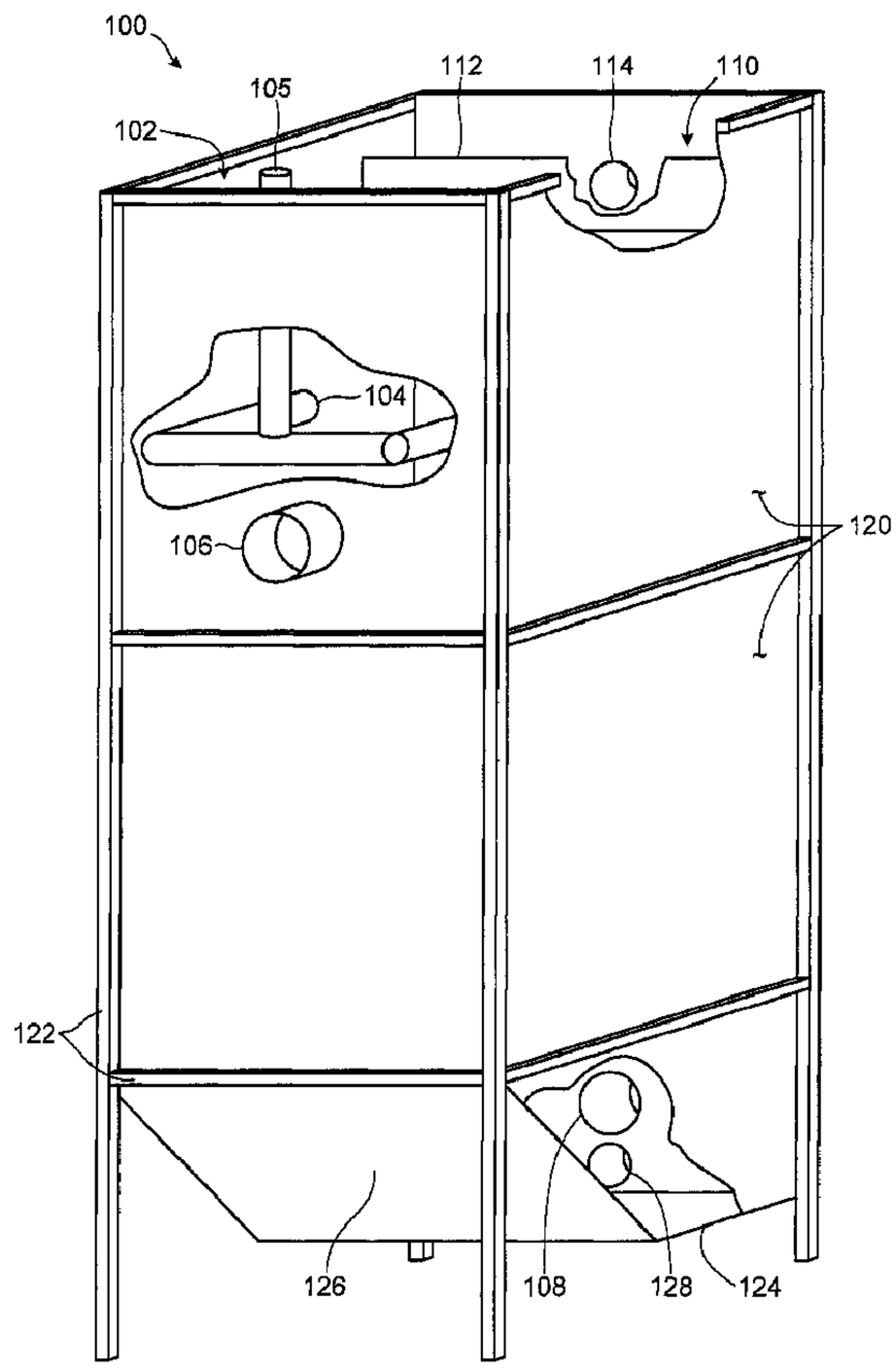

(57) Abrégé/Abstract:
A pumpbox apparatus includes a reservoir volume having a first inlet for receiving a feedstock stream and a second inlet for receiving a water stream, the reservoir volume being in communication with a discharge outlet disposed to discharge accumulated

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(57) Abrégé(suite)/Abstract(continued):
liquid from the reservoir volume. The reservoir volume is operable to accumulate the feedstock stream and the water stream to a first liquid level in the reservoir volume while withdrawing a discharge stream through the discharge outlet to cause a flow of liquid through the pumpbox. The first inlet is located above the second inlet and defines a first flow velocity region between the first inlet and the second inlet and a second flow velocity region between the second inlet and the discharge outlet. The first flow velocity is lower than the second flow velocity to facilitate flotation of a low specific gravity portion of the feedstock through the first region toward an upper surface of the liquid accumulated in the reservoir volume.

ABSTRACT

A pumpbox apparatus includes a reservoir volume having a first inlet for receiving a feedstock stream and a second inlet for receiving a water stream, the reservoir volume being in communication with a discharge outlet disposed to discharge accumulated liquid from the reservoir volume. The reservoir volume is operable to accumulate the feedstock stream and the water stream to a first liquid level in the reservoir volume while withdrawing a discharge stream through the discharge outlet to cause a flow of liquid through the pumpbox. The first inlet is located above the second inlet and defines a first flow velocity region between the first inlet and the second inlet and a second flow velocity region between the second inlet and the discharge outlet. The first flow velocity is lower than the second flow velocity to facilitate flotation of a low specific gravity portion of the feedstock through the first region toward an upper surface of the liquid accumulated in the reservoir volume.

APPARATUS AND METHOD FOR REGULATING FLOW THROUGH A PUMPBOX

BACKGROUND OF THE INVENTION

1. Field of Invention

This invention relates generally to processing of a feedstock and more particularly to a pumpbox for receiving a hydrocarbon feedstock.

2. Description of Related Art

Hydrocarbon feedstocks are generally viscous and may be entrained with other components such as rock, sand, clay and other minerals. As a result, such feedstocks require processing to separate useful hydrocarbon products from residue before transport and refining.

One example of a hydrocarbon ore deposit is the Northern Alberta oil sands, which comprises about **70** to about **90** percent by weight of mineral solids including sand and clay, about **1** to about **10** percent by weight of water, and a bitumen or oil film. The bitumen may be present in amounts ranging from a trace amount up to as much as **20** percent by weight. Due to the highly viscous nature of bitumen, when excavated some of the ore may remain as clumps of oversize ore that requires sizing to produce a sized ore feed suitable for processing. The ore may also be frozen due to the northerly geographic location of many oil sands deposits, making sizing of the ore more difficult. The sized ore feed is typically processed by adding water to form a slurry in a location proximate to the ore deposit, and the resulting slurry is hydro-transported through a pipeline to a processing plant, where the slurry forms the feedstock for a processing plant that separates hydrocarbon products from the sand and other minerals.

Low specific gravity hydrocarbons such as bitumen froth may be separated from sand and water, which generally have higher specific gravity, by various gravity separation processes. There remains a need for improved processes and apparatus for treating heavy hydrocarbon feedstocks.

SUMMARY OF THE INVENTION

In accordance with one aspect of the invention there is provided a pumpbox apparatus for processing a feedstock stream including. The apparatus includes a reservoir having a first inlet for receiving the feedstock stream and a second inlet for receiving a water stream, the reservoir being in communication with a discharge outlet disposed to discharge accumulated liquid from the reservoir, the reservoir being operable to accumulate the feedstock stream and the water stream to a first liquid level in the reservoir while withdrawing a discharge stream through the discharge outlet to cause a flow of liquid through the pumpbox. The first inlet is located above the second inlet and defines a first flow region of the reservoir between the first inlet and the second inlet. The second inlet is located above the discharge outlet and defines a second flow region of the reservoir between the second inlet and the discharge outlet. A first flow velocity in the first flow region is lower than a second flow velocity in the second flow region to facilitate flotation of a low specific gravity portion of the feedstock through the first flow region toward an upper surface of the liquid accumulated in the reservoir. The apparatus also includes a collector for collecting at least a portion of the low specific gravity portion from an upper surface of the accumulated volume when the first liquid level is above the first inlet.

The apparatus may include a controller for controlling a flow rate through the discharge outlet to maintain the first liquid level at a level between the first inlet and a high liquid level associated with a maximum operating level for the reservoir.

The collector may be operably configured to collect at least a portion of the low specific gravity portion from an upper surface of the accumulated volume when the first liquid level reaches a high liquid level.

The collector may include a launder having an inlet disposed in the reservoir at the high liquid level for receiving an overflow of the low specific gravity portion from the reservoir.

The reservoir may be selected to maintain a retention time of feedstock and water in the pumpbox of about 1 minute at an expected average flow rate of the feedstock stream and the water stream.

The apparatus may include a discharge pump in communication with the discharge outlet for withdrawing the discharge stream from the discharge outlet.

The discharge pump may be operably configured to discontinue operation when the liquid level reaches a low liquid level.

The apparatus may include a controller operably configured to control operation of the discharge pump in response to receiving a liquid level signal representing an accumulation level of liquid in the reservoir.

The feedstock stream may include an aerated bitumen froth having a density in the range of about 600 kg/m^3 to about 1000kg/m^3.

The feedstock stream may include water and solids.

The water stream may include a re-circulated water stream.

The re-circulated water stream may include residual bitumen and solids.

The second inlet may be disposed to cause solids that settle out of the accumulated liquid volume to be dispersed toward the discharge outlet for discharge in the discharge stream.

The second inlet may be oriented to direct the water stream received at the second inlet generally towards the discharge outlet.

The pumpbox may include a base having portion that may be inclined to direct solids that settle out of the accumulated liquid volume toward the discharge outlet for discharge in the discharge stream.

A density of the discharge stream may be between about 122×10^1 and about 128×10^1 kg/m3.

The flow velocity in the first flow region may be less than about 5×10^{-2} meters per second.

In accordance with another aspect of the invention there is provided a pumpbox apparatus for processing a feedstock stream. The apparatus includes a reservoir having a first inlet for receiving the feedstock stream and a second inlet for receiving a water stream, the reservoir being in communication with a discharge outlet disposed to discharge accumulated liquid from the reservoir, the reservoir being operable to accumulate the feedstock stream and the water stream to a first liquid level in the reservoir while withdrawing a discharge stream through the discharge outlet to cause a flow of liquid through the pumpbox. The first inlet is located above the second inlet and defines a first flow region of the reservoir between the first inlet and the second inlet. The second inlet is located above the discharge outlet and defines a second flow region of the reservoir between

the second inlet and the discharge outlet. A first flow velocity in the first flow region is lower than a second flow velocity in the second flow region to facilitate flotation of a low specific gravity portion of the feedstock through the first flow region toward an upper surface of the liquid accumulated in the reservoir. The apparatus also includes provisions for collecting at least a portion of the low specific gravity portion from an upper surface of the accumulated volume when the first liquid level is above the first inlet.

The apparatus may include provisions for controlling a flow rate through the discharge outlet to maintain the first liquid level at a level between the first inlet and a high liquid level associated with a maximum operating level for the pumpbox.

The provisions for collecting may include provisions for collecting at least a portion of the low specific gravity portion from an upper surface of the accumulated volume when the first liquid level reaches a high liquid level.

The provisions for controlling may include provisions for controlling a flow rate through the discharge outlet to maintain a retention time of the feedstock stream and water stream in the reservoir of about 1 minute.

The feedstock stream may include an aerated bitumen froth having a density in the range of about 600 kg/m^3 to about 1000kg/m^3.

The feedstock stream may further include water and solids.

The water stream may include a re-circulated water stream.

The re-circulated water stream may include at least one of residual bitumen and solids.

The apparatus may include provisions for causing solids that settle out of the accumulated liquid volume to be dispersed toward the discharge outlet for discharge in the discharge stream.

A density of the discharge stream may be between about 122×10^1 and about 128×10^1 kg/m3.

The first flow velocity may be less than about 5×10^{-2} meters per second.

In accordance with another aspect of the invention there is provided a method for regulating flow through a pumpbox having a reservoir in communication with a discharge outlet disposed to discharge accumulated liquid from the reservoir. The method involves receiving a feedstock stream at a first inlet of the reservoir, the feedstock. The method also involves receiving a water stream at a second inlet of the reservoir, and accumulating the feedstock stream and the water stream to a first liquid level in the reservoir while withdrawing a discharge stream through the discharge outlet to cause a flow of liquid through the pumpbox. The first inlet is located above the second inlet and defines a first flow region of the reservoir between the first inlet and the second inlet. The second inlet is located above the discharge outlet and defines a second flow region of the reservoir between the second inlet and the discharge outlet. A first flow velocity in the first flow region is lower than a second flow velocity in the second flow region to facilitate flotation of a low specific gravity portion of the feedstock through the first flow region toward an upper surface of the liquid accumulated in the reservoir. The method further involves collecting at least a portion of the low specific gravity portion from an upper surface of the accumulated volume when the first liquid level is above the first inlet.

The method may involve controlling a flow rate through the discharge outlet to maintain the first liquid level at a level between the first inlet and a high liquid level associated with a maximum operating level for the reservoir.

Collecting may involve collecting at least a portion of the low specific gravity portion from an upper surface of the accumulated volume when the first liquid level reaches the high liquid level.

Collecting may involve causing the low specific gravity portion to overflow into a launder having an inlet disposed in the reservoir at the high liquid level.

Withdrawing the discharge stream may involve operating a discharge pump in communication with the discharge outlet.

The method may involve discontinuing operation of the discharge pump when the liquid level reaches a low liquid level.

The method may involve controlling operation of the discharge pump in response to receiving a liquid level signal representing an accumulation level of liquid in the reservoir.

The feedstock stream may include an aerated bitumen froth having a density in the range of about 600 kg/m^3 to about 1000kg/m^3.

The feedstock stream may include water and solids.

Receiving the water stream may involve receiving a re-circulated water stream.

The re-circulated water stream may include residual bitumen and solids.

The method may involve causing solids that settle out of the accumulated liquid volume to be dispersed toward the discharge outlet for discharge in the discharge stream.

Causing solids that settle out of the accumulated liquid volume to be dispersed may involve directing the water stream received at the second inlet generally towards the discharge outlet.

A density of the discharge stream may be between about 122×10^1 and about 128×10^1 kg/m3.

The first flow velocity may be less than about 5×10^{-2} meters per second.

In accordance with another aspect of the invention there is provided a system for extracting bitumen from a feedstock. The system includes a pumpbox including a reservoir having a first inlet for receiving a feedstock stream. The pumpbox includes a second inlet for receiving a water stream, the reservoir being in communication with a discharge outlet disposed to discharge accumulated liquid from the reservoir. The reservoir is operable to accumulate the feedstock stream and the water stream to a first liquid level in the reservoir while withdrawing a discharge stream through the discharge outlet to cause a flow of liquid through the pumpbox. The first inlet is located above the second inlet and defines a first flow region of the reservoir between the first inlet and the second inlet. The second inlet is located above the discharge outlet and defines a second flow region of the reservoir between the second inlet and the discharge outlet. A first flow velocity in the first flow region is lower than a second flow velocity in the second flow region to facilitate flotation of a low

specific gravity portion of the feedstock through the first flow region toward an upper surface of the liquid accumulated in the reservoir. The system also includes a first hydrocyclone having a feed inlet, an overflow outlet for producing a first product stream, and an underflow outlet, the feed inlet of the first hydrocyclone being in communication with the discharge outlet of the pumpbox for receiving the discharge stream from the pumpbox. The system further includes a second hydrocyclone having a feed inlet, an overflow outlet, and an underflow outlet for producing a first tailings stream, the feed inlet of the second hydrocyclone being in communication with the underflow outlet of the first hydrocyclone, the overflow outlet of the second hydrocyclone being in communication with the second inlet of the pumpbox for providing the water stream to the pumpbox. The pumpbox further includes a collector for collecting at least a portion of the low specific gravity bitumen portion from an upper surface of the accumulated volume when the first liquid level is above the first inlet to produce a second product stream, the second product stream being combined with the first product stream to produce a system product stream.

The system may include a third hydrocyclone having a feed inlet, an overflow outlet, and an underflow outlet, the feed inlet of the third hydrocyclone being in communication with the underflow outlet of the second hydrocyclone for receiving the first tailings stream, the third hydrocyclone being operable to produce a second tailings stream at the underflow outlet of the second hydrocyclone, the overflow outlet of the third hydrocyclone being in communication with the feed inlet of the second hydrocyclone to provide an additional feed to the second hydrocyclone.

Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

In drawings which illustrate embodiments of the invention,

Figure **1** is a perspective partially cut-away view of a pumpbox apparatus in accordance with a first embodiment of the invention;

Figure **2** is a side schematic view of the pumpbox shown in Figure **1**; and

Figure **3** is a schematic flow diagram of a system for extracting bitumen employing the pumpbox shown in Figure **1**.

DETAILED DESCRIPTION

Referring to Figure **1**, a pumpbox apparatus according to a first embodiment of the invention is shown generally at **100**. The pumpbox apparatus **100**

includes a reservoir volume **102** having a first inlet **104** for receiving a feedstock stream and a second inlet **106** for receiving a water stream. The reservoir volume **102** is in communication with a discharge outlet **108** disposed to discharge accumulated liquid from the reservoir volume. The reservoir volume **102** is operable to accumulate the feedstock stream received at the first inlet **104** and the water stream received at the second inlet **106** to a first liquid level in the reservoir volume while withdrawing a discharge stream through the discharge outlet **108** to cause a flow of liquid through the pumpbox apparatus **100**. In one embodiment the density of the discharge stream may be between about 122 x 10^1 and about 128 x 10^1 kg/m3.

The first inlet **104** is located above the second inlet **106**. In this embodiment the first inlet **104** is in communication with a feed conduit **105**, which is receives the feedstock stream, and directs the stream to the first inlet **104**. The pumpbox apparatus **100** is shown in side schematic view in Figure **2**. Referring to Figure **2**, the feedstock stream received at the first inlet **104** and the water stream received at the second inlet **106** cause respective flows **142** and **143** in the reservoir volume **102**. A first flow velocity region **144** is defined between the first inlet **104** and the second inlet **106**. A second flow velocity region **146** is defined generally between the second inlet **106** and the discharge outlet **108**. A first flow velocity in the first region **144** is lower than a second flow velocity in the second region **144**, which facilitates flotation of a low specific gravity portion of the feedstock through the first region **144** toward an upper surface **148** of the liquid accumulated in the reservoir volume **102**.

The flow through the first and second flow velocity regions **144** and **146** is generally in a downwards direction and in one embodiment where the feedstock stream comprises bitumen, the first flow velocity is less than about **5** x $\mathbf{10^{-2}}$ meters per second, which permits a fast rising bitumen portion to float upwardly in the reservoir volume **102**. Referring back to Figure **1**, the

pumpbox apparatus **100** further includes a collector **110** for collecting at least a portion of the low specific gravity portion of the feedstock from the upper surface **148** when the first liquid level is above the first inlet **104**.

In the embodiment shown in Figure **2**, the pumpbox apparatus **100** further includes a discharge pump **160**. The discharge pump **160** includes an inlet **162** in communication with the discharge outlet **108** for withdrawing the discharge stream from the pumpbox. The pump **160** also has an outlet **164**, which may be coupled to a conduit for conveying the discharged stream for further processing. The pump **160** also includes the control input **166** for receiving a pump control signal for controlling operation of the pump.

In the embodiment shown in Figure **1** and Figure **2** the collector **110** is configured as a launder having an overflow inlet **112** and a product outlet **114** for producing a product stream. When the first liquid level in the reservoir volume **102** reaches the level of the inlet **112** the lower specific gravity portion which accumulates at the upper surface **148** overflows into the launder and is discharged through the product outlet **114**. Referring back to Figure **2**, the overflow inlet **112** thus defines a high liquid level (HLL) for the reservoir volume **102**.

In this embodiment, the apparatus **100** also includes a liquid level sensor **170** and an opening **172** in a sidewall **174** of the pumpbox, which permits sensing of the first liquid level in the reservoir volume **102**. The level sensor **170** includes an output **176** for producing a level signal representing a liquid level in the reservoir volume **102**. The apparatus **100** further includes a controller **180** having an input **182** for receiving the level signal from the output **176** of the level sensor **170**. The controller **180** also includes an output **184** for producing the pump control signal for controlling operation of the pump **160**. In one embodiment, the control signal received at the input **166** of the pump **160** may be an analog signal that controls a speed of the pump, and thus the

discharge flow rate through the discharge outlet **108**. In other embodiments, the control signal may be a signal having one of two states, including a first state for causing the pump **160** to operate, and a second state for causing the pump to discontinue operation.

Referring back to Figure **1**, in the illustrative embodiment the pumpbox apparatus includes a plurality of sidewalls **120** supported by a frame **122**, a base **124**, and a back plate **126**, which together define the reservoir volume **102**. The back plate **126** is inclined at an angle to the base **124** to cause solids that settle out from the accumulated liquid to be generally directed toward the discharge outlet **108**. The apparatus **100** may also include a drain outlet **128** located below the discharge outlet **108**. The drain outlet facilitates periodic or selective flushing of the pumpbox for inspection of the apparatus. Note that while the pumpbox apparatus may have a rectangular outline, curved surfaces may be used in connection with the apparatus in another variation to provide further structural strength.

The feedstock stream received at the first inlet **104** may be an oil sand slurry including mineral solids such as sand and clay, water, and a bitumen froth. Preferably, the feedstock stream includes a highly aerated bitumen froth. Highly aerated bitumen froth tends to float fast. Advantageously, in one aspect of the invention, the pumpbox apparatus is operative to selectively separate out such a fast floating aerated bitumen froth.

In one embodiment the upstream oil sand flow rate of an oil sand feed may be in the range of about **1000** and about **6000** tonnes per hour. The oil sand feed is diluted with water (e.g. process water) to produce a slurry having densities in the range of about **1400** kg/m3 to about **1650** kg/m3, which is received at the first inlet **104**. The water stream received at the second inlet **106** may be re-circulated process water, which may include dispersed solids and at least some residual bitumen.

During operation of the pumpbox apparatus **100**, the feedstock stream and the water stream accumulate in the reservoir volume **102** while the controller **180** monitors the liquid level signal produced by the level sensor **170**. When the first liquid level reaches the low liquid level (indicated as LLL in Figure **2**), the controller **180** responds by changing the state of the pump control signal produced at the output **184**, which in turn causes the discharge pump **160** to be activated to cause accumulated liquid in the reservoir volume **102** to be discharged through the discharge outlet **108**. As the first liquid level in the reservoir volume **102** continues to rise, the controller **180** may respond by increasing the speed of the discharge pump **160** to increase the discharge flow rate through the discharge outlet **108**. When the first liquid level reaches the level of the first inlet **104**, the first and second flow velocity regions **144** and **146** are established. Volumetric flow rates through the pumpbox apparatus **100** may be written as follows:

$$Q_D = Q_1 + Q_2 \qquad \text{Eqn } \mathbf{1}$$

where Q_D is the volumetric flow rate through the discharge outlet **108**, Q_1 is the volumetric flow rate in the first region **144**, and Q_2 is the volumetric flow rate through the second region **146**. Assuming a downwardly vertical flow, the volumetric flow rate in the first region **144** may be written as:

$$Q_1 = Av_1 \qquad \text{Eqn } \mathbf{2}$$

where A is the cross-sectional area of the reservoir volume **102**, v_1 is the flow velocity in the first region **144**. Rearranging and substituting Eqn **2** into Eqn **1** gives:

$$Q_2 = Q_D - Av_1 . \qquad \text{Eqn } \mathbf{3}$$

For example, at a discharge rate of **2000** m^3/hour through the discharge outlet **108** in a vessel having a cross-sectional area of **8**m^2, in order to maintain a velocity v_1 of **5** x **10**$^{-2}$ meters per second, the flow rate through the

second inlet **106** should be about **560** m^3/hour. Under these conditions a velocity v_2 in the second region **146** would be about **7** x $\mathbf{10^{-2}}$ meters per second. Advantageously, the reduced first flow velocity v_1 in the first region **144** facilitates flotation of the low specific gravity portion of the feedstock through the first region **144** to the upper surface **148**. Equations **1** – **3** above are derived under assumption of vertically downward flow. In practice, flow paths through the apparatus **100** will have portions that are not vertically downward. It should thus be appreciated that for accurate calculation the above analysis would need to be applied to actual flow paths through the apparatus.

In the embodiment shown, collection of the low specific gravity portion of the feedstock that floats to the upper surface **148** occurs when the first liquid level in the reservoir volume **102** reaches the level of the overflow inlet **112** of the collector **110**. The overflow inlet **112** therefore defines a high liquid level (HLL) for operation of the pumpbox apparatus **100**. Generally, while it may be desirable to always operate the pumpbox apparatus **100** at the HLL in order to facilitate continuous collection of the low specific gravity portion of the feedstock, in practice variations in flow rate of the feedstock stream through the first inlet **104** would necessarily result in deviations from HLL that would require periodic intervention by an operator to adjust the discharge flow rate Q_D and/or the flow rate Q_2 of the water stream. Practically, the operator would seek to maintain the first liquid level in the reservoir volume **102** between a normal liquid level (NLL) located at or above the first inlet **104** and the HLL. The NLL assumes liquid densities are about a nominal fluid density. Aerated bitumen froth, due to the air content, has a lower density hence a higher level than the nominal fluid. Aerated bitumen froth may have a density ranging from about **600** kg/m3 to about **1000** kg/m3.

While the first liquid level is maintained between NLL and HLL and the velocity v_1 is maintained below less than about **5** x $\mathbf{10^{-2}}$ meters per second,

favorable conditions for flotation of the low specific gravity portion of the feedstock exists and bitumen should accumulate at the upper surface. When the first liquid level is above NLL but below HLL, bitumen may accumulate, but would not be collected. Accumulated bitumen is collected when the various flows permit the first liquid level in the reservoir volume to rise to the HLL. In one embodiment the discharge pump **160** is operated to maintain the first liquid level at an average liquid level of about **75**% of the vertical distance between NLL and HLL above the NLL.

Referring to Figure **3**, a flow diagram of a system for extracting bitumen from a slurry of bitumen, solids, and water according to one embodiment of the invention is shown generally at **200**. The system **200** includes a plurality of generally conically shaped hydrocyclones, including a first hydrocyclone **202**, a second hydrocyclone **204**, and a third hydrocyclone **206**. The first hydrocyclone **202** includes a feed inlet **210**, an overflow outlet **212**, and an underflow outlet **214**. The second hydrocyclone **204** includes a feed inlet **216**, an overflow outlet **218**, and an underflow outlet **220**. The third hydrocyclone **206** includes a feed inlet **222**, an overflow outlet **224**, and an underflow outlet **226**.

In general, hydrocyclones operate by receiving a tangentially oriented flow at the feed inlet and a resulting circumferential flow transports heavier solid particles outwardly towards the walls of the hydrocyclone allowing lower specific gravity components and a portion of the water to be extracted as an overflow stream at the overflow outlet. The solids and a remaining portion of the water exit the hydrocyclone at the underflow outlet. Suitable hydrocyclones for the cyclone separation stages include those manufactured by FLSmidth Krebs of Tucson AZ, USA under the trademark gMAX®. Alternatively, Cavex hydrocyclones marketed by Warman International may be used.

The system **200** further includes the pumpbox apparatus **100** shown in Figure **1** and Figure **2**. The feedstock received at the first inlet **104** of the pumpbox apparatus **100** includes solids and/or minerals in a significant portion, by weight. For example, the feedstock may have a composition of about **5** wt% to about **15** wt% bitumen, about **40** wt% to about **70** wt% solids (including minerals), and about **30** wt% to about **75** wt% water. The pumpbox apparatus **100** generally operates as described above, and a portion of the low specific gravity bitumen in the feedstock that readily floats to the upper surface **148** of the accumulated liquid in the reservoir volume **102** overflows through the product outlet **114**, and forms a first product stream **228**. The remaining water, solids, and a portion of the bitumen is discharged through the discharge outlet **108** of the pumpbox apparatus **100** and forms the feed stream at the feed inlet **210** of the first hydrocyclone **202**.

The first hydrocyclone **202** separates the feed received at the inlet **210** and produces a second product stream **230** of low specific gravity bitumen, water, and some fine entrained solids at the overflow outlet **212** and an underflow stream including solids, water, and a bitumen portion at the underflow outlet **214**. The second product stream **230** is mixed with the first product stream **228** to produce a combined product stream **232** from the system **200**, which may be further processed to separate the low specific gravity bitumen components from the water. In general mixing of the second product stream **230** and the first product stream **228** would occur in a conventional pumpbox.

The underflow at the outlet **214** is fed to the feed inlet **216** of the second hydrocyclone **204**. The second hydrocyclone **204** further separates the feed into a low specific gravity overflow stream including mostly water, some bitumen, and some fine solids. The overflow outlet **218** of the second hydrocyclone **204** is fed to the second inlet **106** of the pumpbox apparatus **100**, and forms the water stream inlet for the pumpbox. The underflow stream produced by the second hydrocyclone **204** at the outlet **220** and a system

process water feed **208** are combined to make up the feed to the inlet **222** of the third hydrocyclone **206**. The combining of these streams may occur in a conventional pumpbox, for example.

The third hydrocyclone **206** further separates the feed into an overflow stream including mostly water, some bitumen, and some fine solids which is fed through the outlet **224** to the feed inlet **216** of the second hydrocyclone **204**. The underflow stream produced by the third hydrocyclone **206** at the outlet **226** forms a tailings stream **234** for the system **200**. The tailings stream **234** may be further processed or diverted to a tailings pond for treatment. The feedstock thus flows serially through the first, second, and third hydrocyclones **202**, **204**, and **206**, while the system process water feed **208** flows through the third hydrocyclone, to the second hydrocyclone, and through the pumpbox apparatus **100** to the first hydrocyclone. The system process water **208** is thus generally counter to the feedstock flow through the system **200**, which serves to improve recovery of bitumen from the feedstock.

The reservoir volume **102** of the pumpbox apparatus **100** provides a capacity for buffering the flow of feedstock to the first hydrocyclone **202**, thereby facilitating operation of the hydrocyclones at a desired steady-state flow rate. In one embodiment the cross sectional dimension of the reservoir volume **102** is about **7.3** meters by about **7.3** meters and the capacity of the pumpbox is selected to accommodate flows of between about **1400** kg/m3 to about **1650** kg/m3 with a residence time of about **30** seconds to about several minutes. For illustrative purposes, in one arrangement, the retention time is about **1** minute. Advantageously, the pumpbox apparatus **100** further facilitates collection of a bitumen portion, in the form of aerated bitumen froth, that readily floats to the surface of the accumulated liquid in the reservoir volume **102**. The first, second, and third hydrocyclones **202**, **204**, and **206** thus operate on feed streams having bitumen requiring more aggressive processing to separate low specific gravity bitumen from the solids.

Advantageously, in the event of a failure of a pump, such as the pump **160** shown in Figure **2**, the first liquid level in the reservoir volume **102** of the pumpbox apparatus **100** will rise and overflow at the inlet **112** of the collector **110**, facilitating diversion of the feedstock through the outlet **114** to a safe location. Under these conditions solids will accumulate in the reservoir volume, and the overflow at the inlet **112** will include water, bitumen and some solids.

In other embodiments, the configuration of the system **200** may be changed to suit a particular feedstock. For example, where it is desired to process a feedstock having a lower portion of solids, the third hydrocyclone **206** may be omitted, in which case the system process water may be provided to feed inlet **216** of the second hydrocyclone **204**, and the underflow **220** of the second hydrocyclone forms the tailings stream for the system **200**.

The pumpbox apparatus **100** may also be used in other applications that generally require blending of two or more streams having components of different specific gravity and where it is desired to collect a low specific gravity portion that readily floats upwardly within the accumulated liquid.

While specific embodiments of the invention have been described and illustrated, such embodiments should be considered illustrative of the invention only and not as limiting the invention as construed in accordance with the accompanying claims.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A pumpbox apparatus for processing a feedstock stream, the apparatus comprising:

a reservoir having a first inlet for receiving the feedstock stream and a second inlet for receiving a water stream, the reservoir being in communication with a discharge outlet disposed to discharge accumulated liquid from the reservoir, the reservoir being operable to accumulate the feedstock stream and the water stream to a first liquid level in the reservoir while withdrawing a discharge stream through the discharge outlet to cause a flow of liquid through the pumpbox, the first inlet being located above the second inlet and defining a first flow region of the reservoir between the first inlet and the second inlet, the second inlet being located above the discharge outlet and defining a second flow region of the reservoir between the second inlet and the discharge outlet, a first flow velocity in the first flow region being lower than a second flow velocity in the second flow region to facilitate flotation of a low specific gravity portion of the feedstock through the first flow region toward an upper surface of the liquid accumulated in the reservoir; and

a collector for collecting at least a portion of the low specific gravity portion from an upper surface of the accumulated volume when the first liquid level is above the first inlet.

2. The apparatus of claim **1** further comprising a controller for controlling a flow rate through the discharge outlet to maintain the first liquid level at a level between the first inlet and a high liquid level associated with a maximum operating level for the reservoir.

3. The apparatus of claim **2** wherein the collector is operably configured to collect at least a portion of the low specific gravity portion from an upper surface of the accumulated volume when the first liquid level reaches a high liquid level.

4. The apparatus of any one of claims **2** to **3** wherein the collector comprises a launder having an inlet disposed in the reservoir at the high liquid level for receiving an overflow of the low specific gravity portion from the reservoir.

5. The apparatus of any one of claims **2** to **4** wherein the reservoir is selected to maintain a retention time of feedstock and water in the pumpbox of about **1** minute at an expected average flow rate of the feedstock stream and the water stream.

6. The apparatus of any one of claims **1** to **5** further comprising a discharge pump in communication with the discharge outlet for withdrawing the discharge stream from the discharge outlet.

7. The apparatus of claim **6** wherein the discharge pump is operably configured to discontinue operation when the liquid level reaches a low liquid level.

8. The apparatus of claim **6** further comprising a controller operably configured to control operation of the discharge pump in response to

receiving a liquid level signal representing an accumulation level of liquid in the reservoir.

9. The apparatus of any one of claims **1** to **8** wherein the feedstock stream comprises an aerated bitumen froth having a density in the range of about **600** kg/m^3 to about **1000**kg/m^3.

10. The apparatus of claim **9** wherein the feedstock stream comprises water and solids.

11. The apparatus of any one of claims **1** to **10** wherein the water stream comprises a re-circulated water stream.

12. The apparatus of claim **11** wherein the re-circulated water stream comprises residual bitumen and solids.

13. The apparatus of any one of claims **1** to **11** wherein said second inlet is disposed to cause solids that settle out of the accumulated liquid volume to be dispersed toward the discharge outlet for discharge in the discharge stream.

14. The apparatus of claim **13** wherein said second inlet is oriented to direct the water stream received at the second inlet generally towards the discharge outlet.

15. The apparatus of claim **13** wherein the pumpbox comprises a base having portion that is inclined to direct solids that settle out of the accumulated liquid volume toward the discharge outlet for discharge in the discharge stream.

16. The apparatus of any one of claims **1** to **15** wherein a density of the discharge stream is between about **122** x 10^1 and about **128** x 10^1 kg/m^3.

17. The apparatus of any one of claims **1** to **16** wherein the flow velocity in the first flow region is less than about **5** x 10^{-2} meters per second.

18. A pumpbox apparatus for processing a feedstock stream, the apparatus comprising:

a reservoir having a first inlet for receiving the feedstock stream and a second inlet for receiving a water stream, the reservoir being in communication with a discharge outlet disposed to discharge accumulated liquid from the reservoir, the reservoir being operable to accumulate the feedstock stream and the water stream to a first liquid level in the reservoir while withdrawing a discharge stream through the discharge outlet to cause a flow of liquid through the pumpbox, the first inlet being located above the second inlet and defining a first flow region of the reservoir between the first inlet and the second inlet, the second inlet being located above the discharge outlet and defining a second flow region of the reservoir between the second inlet and the discharge outlet, a first flow velocity in the first flow region being lower than a second flow velocity in the second flow region to facilitate flotation of a low specific gravity portion of the feedstock through the first flow region toward an upper surface of the liquid accumulated in the reservoir; and

means for collecting at least a portion of the low specific gravity portion from an upper surface of the accumulated volume when the first liquid level is above the first inlet.

19. The apparatus of claim **18** further comprising means for controlling a flow rate through the discharge outlet to maintain the first liquid level at a level between the first inlet and a high liquid level associated with a maximum operating level for the pumpbox.

20. The apparatus of claim **19** wherein said means for collecting comprises means for collecting at least a portion of the low specific gravity portion from an upper surface of the accumulated volume when the first liquid level reaches a high liquid level.

21. The apparatus of any one of claims **19** to **20** wherein said means for controlling comprises means for controlling a flow rate through the discharge outlet to maintain a retention time of the feedstock stream and water stream in the reservoir of about **1** minute.

22. The apparatus of any one of claims **18** to **21** wherein the feedstock stream comprises an aerated bitumen froth having a density in the range of about **600** kg/m^3 to about **1000**kg/m^3.

23. The apparatus of claim **22** wherein the feedstock stream further comprises water and solids.

24. The apparatus of any one of claims **18** to **23** wherein the water stream comprises a re-circulated water stream.

25. The apparatus of claim **24** wherein the re-circulated water stream comprises at least one of residual bitumen and solids.

26. The apparatus of any one of claims **18** to **25** further comprising means for causing solids that settle out of the accumulated liquid volume to be

dispersed toward the discharge outlet for discharge in the discharge stream.

27. The apparatus of any one of claims **18** to **26** wherein a density of the discharge stream is between about **122** x 10^1 and about **128** x 10^1 kg/m^3.

28. The apparatus of any one of claims **18** to **27** wherein the first flow velocity is less than about **5** x 10^{-2} meters per second.

29. A method for regulating flow through a pumpbox having a reservoir in communication with a discharge outlet disposed to discharge accumulated liquid from the reservoir, the method comprising:

receiving a feedstock stream at a first inlet of the reservoir;

receiving a water stream at a second inlet of the reservoir;

accumulating the feedstock stream and the water stream to a first liquid level in the reservoir while withdrawing a discharge stream through the discharge outlet to cause a flow of liquid through the pumpbox, the first inlet being located above the second inlet and defining a first flow region of the reservoir between the first inlet and the second inlet, the second inlet being located above the discharge outlet and defining a second flow region of the reservoir between the second inlet and the discharge outlet, a first flow velocity in the first flow region being lower than a second flow velocity in the second flow region to facilitate flotation of a low specific gravity portion of the feedstock through the first flow region toward an upper surface of the liquid accumulated in the reservoir; and

collecting at least a portion of the low specific gravity portion from an upper surface of the accumulated volume when the first liquid level is above the first inlet.

30. The method of claim **29** further comprising controlling a flow rate through the discharge outlet to maintain the first liquid level at a level between the first inlet and a high liquid level associated with a maximum operating level for the reservoir.

31. The method of claim **30** wherein collecting comprises collecting at least a portion of the low specific gravity portion from an upper surface of the accumulated volume when the first liquid level reaches the high liquid level.

32. The method of any one of claims **30** to **31** wherein collecting comprises causing the low specific gravity portion to overflow into a launder having an inlet disposed in the reservoir at the high liquid level.

33. The method of any one of claims **29** to **32** wherein withdrawing the discharge stream comprises operating a discharge pump in communication with the discharge outlet.

34. The method of claim **33** further comprising discontinuing operation of the discharge pump when the liquid level reaches a low liquid level.

35. The method of claim **33** further comprising controlling operation of the discharge pump in response to receiving a liquid level signal representing an accumulation level of liquid in the reservoir.

36. The method of any one of claims **29** to **35** wherein the feedstock stream comprises an aerated bitumen froth having a density in the range of about **600** kg/m^3 to about **1000**kg/m^3.

37. The method of claim **36** wherein the feedstock stream comprises water and solids.

38. The method of any one of claims **29** to **37** wherein receiving the water stream comprises receiving a re-circulated water stream.

39. The method of claim **38** wherein the re-circulated water stream comprises residual bitumen and solids.

40. The method of any one of claims **29** to **38** further comprising causing solids that settle out of the accumulated liquid volume to be dispersed toward the discharge outlet for discharge in the discharge stream.

41. The method of claim **40** wherein causing solids that settle out of the accumulated liquid volume to be dispersed comprises directing the water stream received at the second inlet generally towards the discharge outlet.

42. The method of any one of claims **29** to **41** wherein a density of the discharge stream is between about **122** x $\mathbf{10^1}$ and about **128** x $\mathbf{10^1}$ kg/m^3.

43. The method of claim **29** wherein the first flow velocity is less than about **5** x $\mathbf{10^{-2}}$ meters per second.

44. A system for extracting bitumen from a feedstock, the system comprising:

a pumpbox comprising a reservoir having a first inlet for receiving a feedstock stream and a second inlet for receiving a water stream, the reservoir being in communication with a discharge outlet disposed to discharge accumulated liquid from the reservoir, the reservoir being operable to accumulate the feedstock stream and the water stream to a first liquid level in the reservoir while withdrawing a discharge stream through the discharge outlet to cause a flow of liquid through the pumpbox, the first inlet being located above the second inlet and defining a first flow region of the reservoir between the first inlet and the second inlet, the second inlet being located above the discharge outlet and defining a second flow region of the reservoir between the second inlet and the discharge outlet, a first flow velocity in the first flow region being lower than a second flow velocity in the second flow region to facilitate flotation of a low specific gravity portion of the feedstock through the first flow region toward an upper surface of the liquid accumulated in the reservoir;

a first hydrocyclone having a feed inlet, an overflow outlet for producing a first product stream, and an underflow outlet, the feed inlet of the first hydrocyclone being in communication with the discharge outlet of the pumpbox for receiving the discharge stream from the pumpbox;

a second hydrocyclone having a feed inlet, an overflow outlet, and an underflow outlet for producing a first tailings stream, the feed inlet of the second hydrocyclone being in communication with the underflow outlet of the first hydrocyclone, the overflow outlet of the

second hydrocyclone being in communication with the second inlet of the pumpbox for providing the water stream to the pumpbox; and

wherein the pumpbox further comprises a collector for collecting at least a portion of the low specific gravity bitumen portion from an upper surface of the accumulated volume when the first liquid level is above the first inlet to produce a second product stream, the second product stream being combined with the first product stream to produce a system product stream.

45. The system of claim **44** further comprising a third hydrocyclone having a feed inlet, an overflow outlet, and an underflow outlet, the feed inlet of the third hydrocyclone being in communication with the underflow outlet of the second hydrocyclone for receiving the first tailings stream, the third hydrocyclone being operable to produce a second tailings stream at the underflow outlet of the second hydrocyclone, the overflow outlet of the third hydrocyclone being in communication with the feed inlet of the second hydrocyclone to provide an additional feed to the second hydrocyclone.

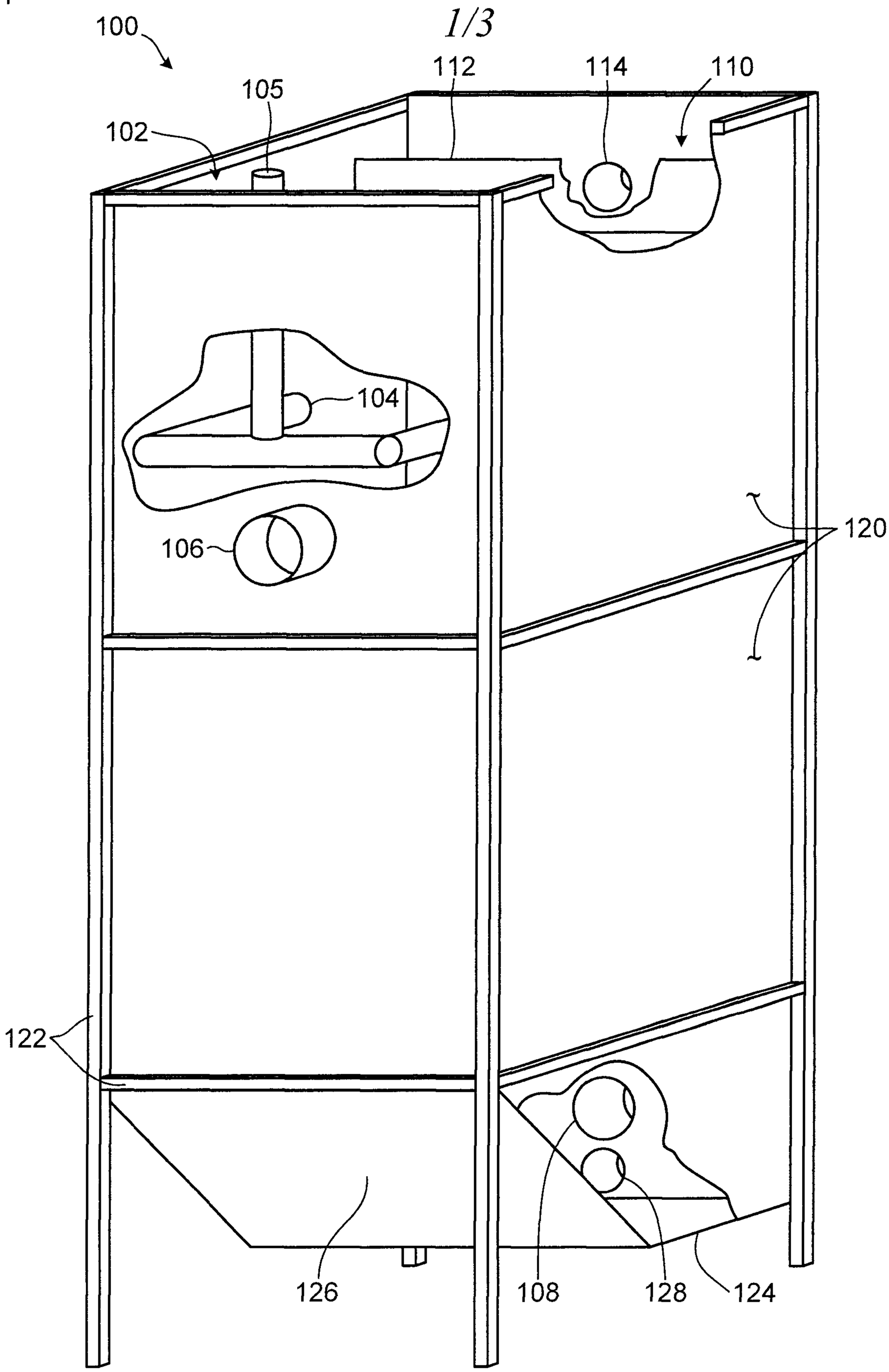

FIG. 1

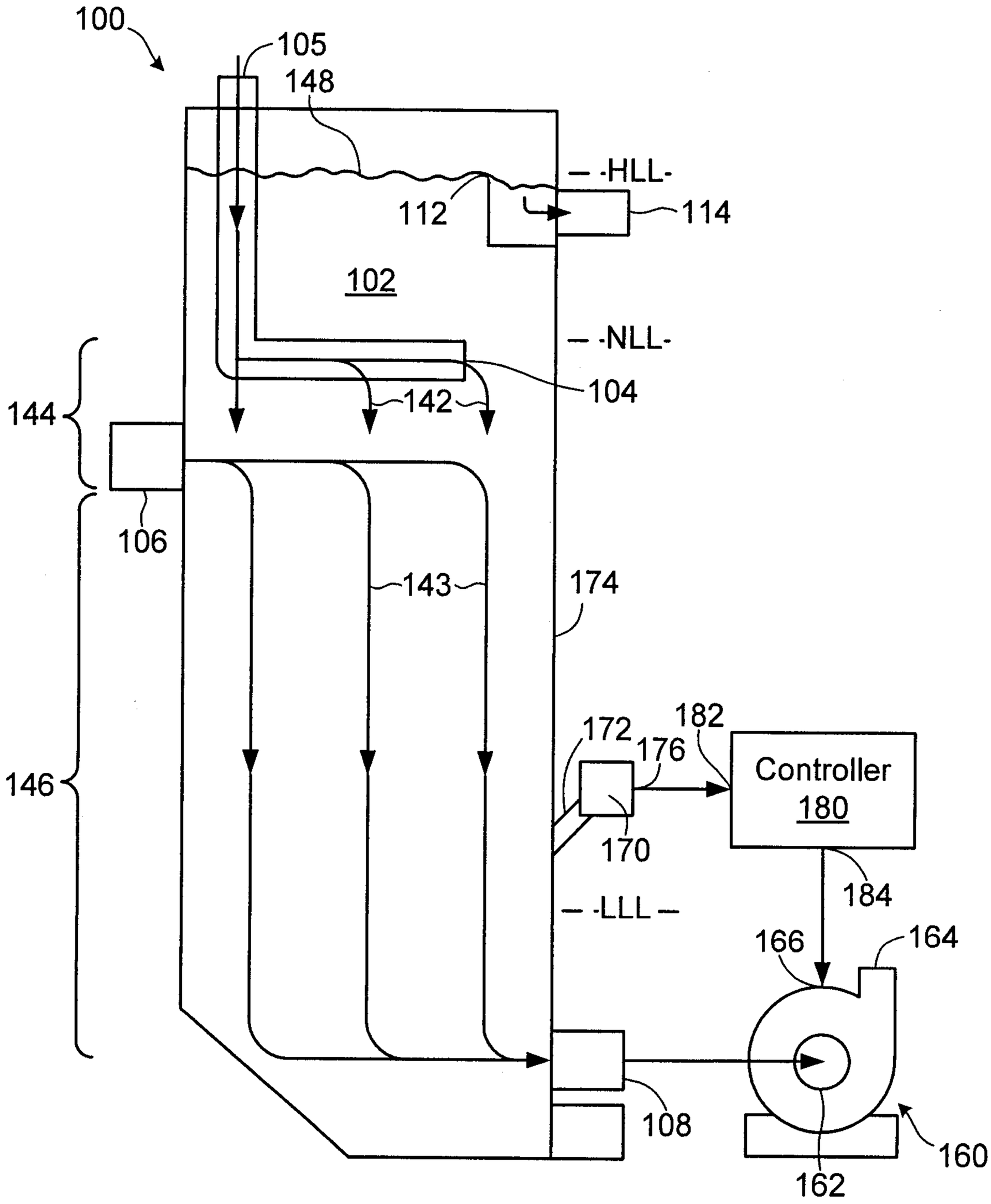
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FIG. 2

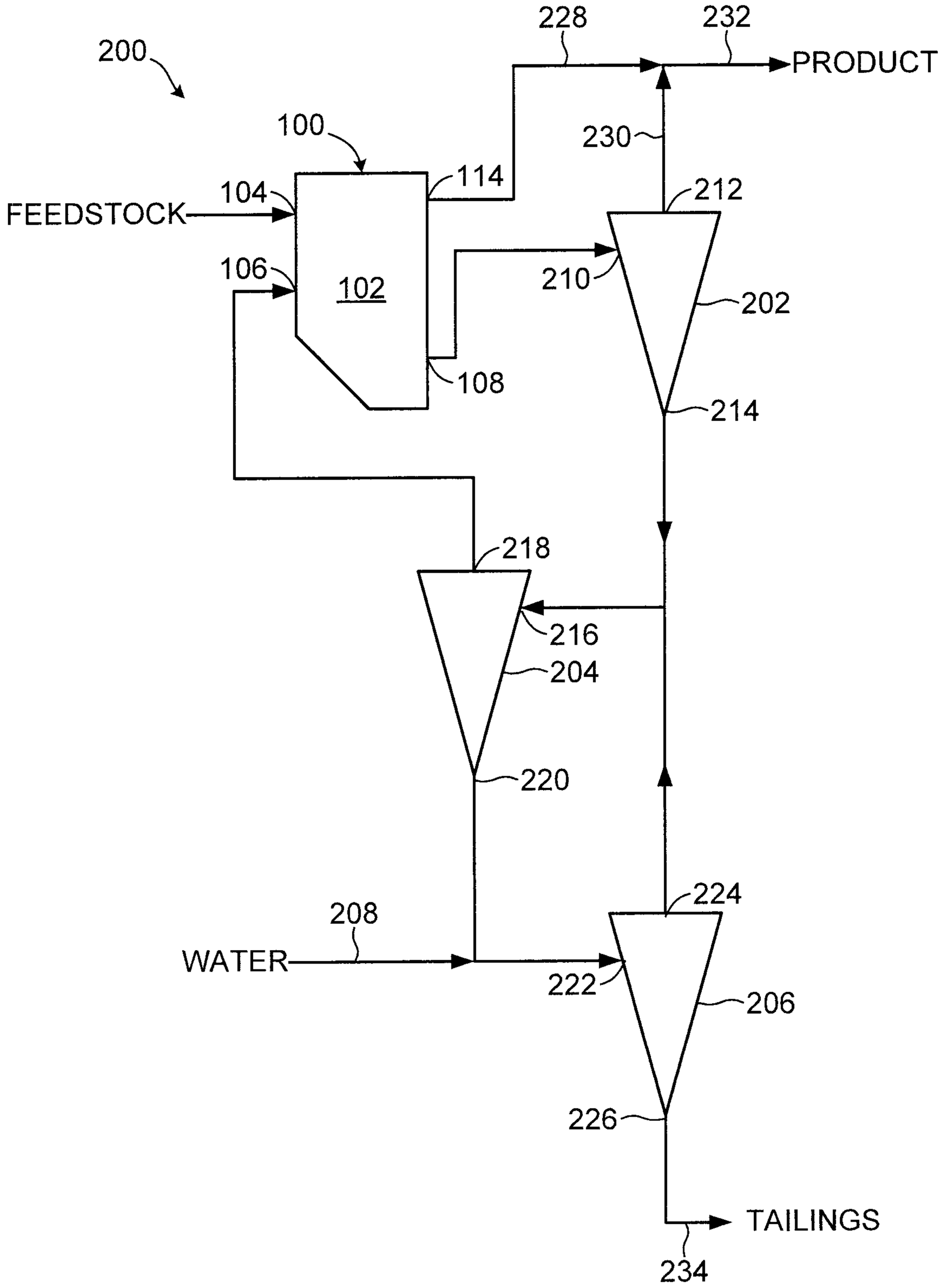
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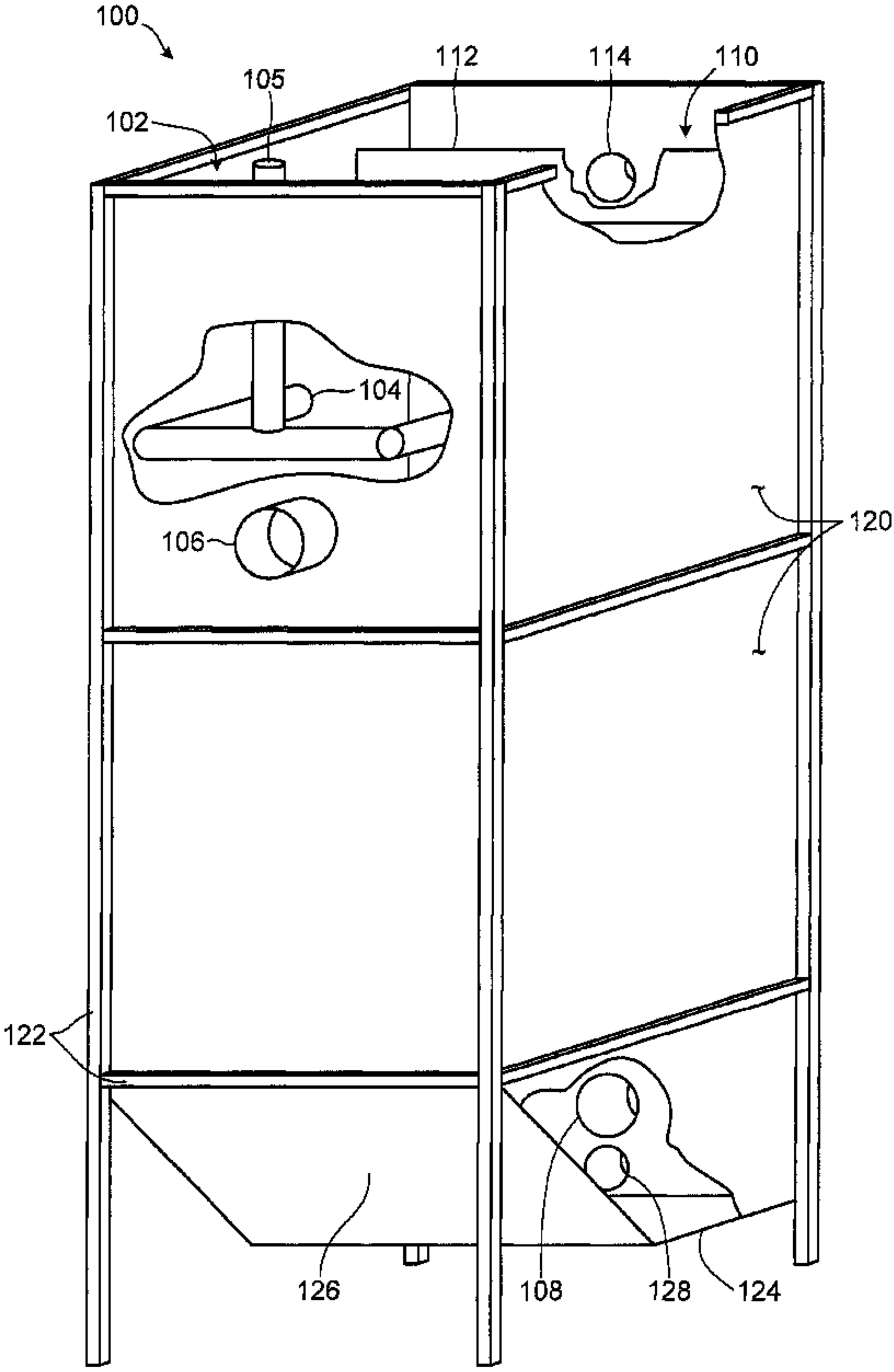
FIG. 3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