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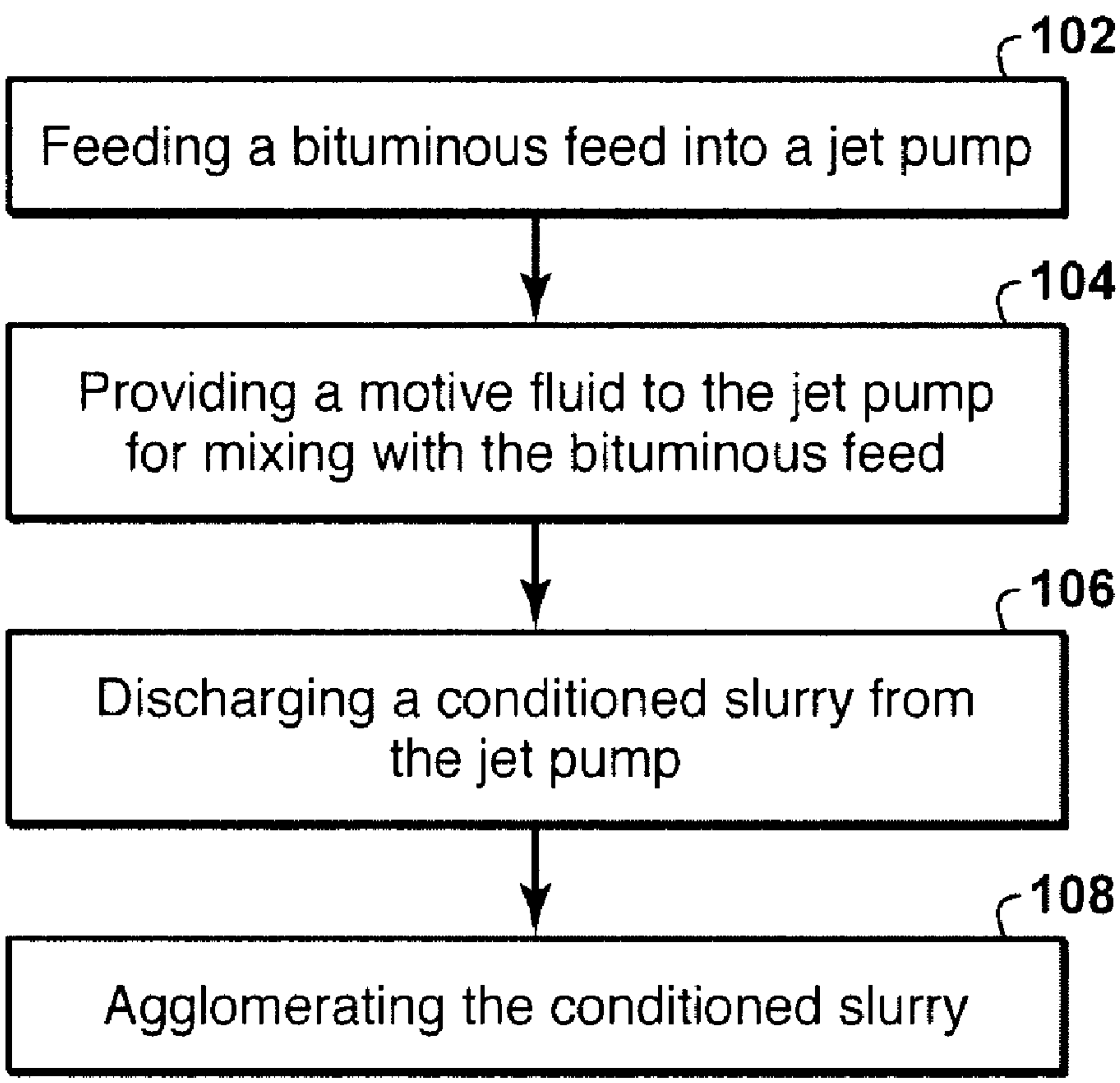
(54) **Titre : PROCEDE DE TRAITEMENT DE CHARGE D'ALIMENTATION DE BITUME**
(54) **Title: METHOD OF PROCESSING A BITUMINOUS FEED**



(57) **Abrégé/Abstract:**
A bituminous feed is fed into a jet pump. A motive fluid, comprising a solvent for extracting bitumen, is provided to the jet pump for mixing with the bituminous feed. A conditioned slurry is discharged from the jet pump. The conditioned slurry is agglomerated to create an agglomerated slurry.

ABSTRACT

A bituminous feed is fed into a jet pump. A motive fluid, comprising a solvent for extracting bitumen, is provided to the jet pump for mixing with the bituminous feed. A conditioned slurry is discharged from the jet pump. The conditioned slurry is agglomerated to create an agglomerated slurry.

METHOD OF PROCESSING A BITUMINOUS FEED

BACKGROUND

Field of Disclosure

[0001] The disclosure relates generally to the field of oil sands processing. More specifically, the present disclosure relates to methods of processing bituminous feeds.

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] 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.

[0004] Recently, the harvesting of oil sands to remove heavy oil has become more economical. Hydrocarbon removal from oil sands may be performed by several techniques. For example, a well can be drilled to an oil sand reservoir and steam, hot gas, 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. In another technique, strip or surface mining may be performed to access the oil sands, which can be treated with hot water, to extract the heavy oil. This other technique may be referred to as a water-based extraction process (WBE). The WBE is a commonly used process to extract bitumen from mined oil sands. In another technique, a non water-based extraction process can be used to treat the strip or surface mined oil sands. The non water-based extraction process may be referred to as a solvent based extraction process. The commercial application of a solvent based extraction process has, for various reasons, eluded the oil sands industry. A major challenge associated with the solvent based extraction process is the tendency of fine particles within the oil sands to hamper the separation of solids from the heavy oil (e.g., bitumen) extracted.

[0005] A solids agglomeration process has been proposed for use in the solvent based extraction process. The solid agglomeration process was coined Solvent Extraction Spherical Agglomeration (SESA). A description of the SESA process can be found in Sparks *et al.*, *Fuel* 1992(71); pp 1349-1353. Previously described methodologies for SESA have not been commercially adopted. In general, the SESA process involves mixing oil sands with a hydrocarbon solvent, adding a bridging liquid to the oil sands slurry, agitating the mixture in a slow and controlled manner to nucleate particles, and continuing such agitation so as to permit these nucleated particles to form larger multi-particle spherical agglomerates for removal. The bridging liquid may be water or an aqueous solution since the solids of oil sands are mostly hydrophilic and water is immiscible to hydrocarbon solvents. The bridging liquid preferentially wets the solids. With the right amount of the bridging liquid and suitable agitation of the slurry; the bridging liquid displaces the suspension liquid on the surface of the solids. As a result of interfacial forces among the three phases (i.e. the bridging liquid, the suspension liquid, and the solids), the fines solids consolidate into larger, compact agglomerates that are more readily separated from the suspension liquid.

[0006] The SESA process described by Meadus *et al.* in U.S. Patent No. 4,057,486 involves combining solvent extraction with solids agglomeration to achieve dry tailings suitable for direct mine refill. In the process, organic material is separated from oil sands by mixing the oil sands material with an organic solvent to form a slurry, after which an aqueous bridging liquid is added in an amount of 8 to 50 weight percent (wt.%) of the feed mixture. By using controlled agitation, solid particles from oil sands come into contact with the aqueous bridging liquid and adhere to each other to form macro-agglomerates with a mean diameter of 2 millimeters (mm) or greater. The formed agglomerates are more easily separated from the organic solvent compared to un-agglomerated solids. The formed agglomerates are referred to as macro-agglomerates because they result from the consolidation of both fine particles and coarse particles that make up the oil sands.

[0007] It is desirable to have an improved or alternative method of processing a bituminous feed.

SUMMARY

[0008] It is an object of the present disclosure to provide methods of processing bituminous feeds.

[0009] A bituminous feed is fed into a jet pump. A motive fluid, comprising a solvent for extracting bitumen, is provided to the jet pump for mixing with the bituminous feed. A conditioned slurry is discharged from the jet pump. The conditioned slurry is agglomerated to create an agglomerated slurry.

[0010] 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

[0011] 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.

[0012] Figure 1 is a flow chart illustrating a method of processing a bituminous feed.

[0013] Figure 2 is a flow diagram illustrating a method of processing a bituminous feed.

[0014] Figure 3 is a flow diagram illustrating a method of processing a bituminous feed.

[0015] Figure 4 is a flow diagram illustrating a method of processing a bituminous feed.

[0016] Figure 5 is a flow diagram illustrating a method of processing a bituminous feed.

[0017] 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

[0018] 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.

[0019] 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.

[0020] 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 sands. Hydrocarbon compounds may be aliphatic or aromatic, and may be straight chained, branched, or partially or fully cyclic.

[0021] "Bitumen" is a naturally occurring heavy oil material. Generally, it is the hydrocarbon component found in oil sands. Bitumen can vary in composition depending upon the degree of loss of more volatile components. It can vary from a very viscous, tarlike, 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.) percent (%) 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 total bitumen weight.

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 total bitumen weight. 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.

[0022] "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.

[0023] The term "bituminous feed" refers to a stream derived from oil sands that requires downstream processing in order to realize valuable bitumen products or fractions. The bituminous feed is one that comprises bitumen along with undesirable components, notably solids and water. Such a bituminous feed may be derived directly from oil sands, and may be, for example, raw oil sands ore. Further, the bituminous feed may be a feed that has already realized some initial processing but nevertheless requires further processing. Also, recycled streams that comprise bitumen in combination with other components for removal as described herein can be included in the bituminous feed. A bituminous feed need not be derived directly from oil sands, but may arise from other processes. For example, a waste product from other extraction processes which comprises bitumen that would otherwise not have been recovered may be used as a bituminous feed.

[0024] "Fines" or "fine particles" are generally defined as those solids having a size of less than 44 micrometer (μm). The aforementioned range includes any number within the range.

[0025] "Coarse particles" are generally defined as those solids having a size of 44 micrometers (μm) or more. The aforementioned range includes any number within the range.

[0026] 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.

[0027] 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.

[0028] "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.

[0029] The term "solvent" as used herein should be understood to mean either a single solvent, or a combination of solvents.

[0030] Prior to describing the use of a jet pump for mixing a bituminous feed with a solvent, solvent based extraction will be described in greater detail.

[0031] To extract bitumen from oil sands using a solvent based extraction process, a solvent based extraction process solvent may be combined with a bituminous feed. The solvent and bituminous feed may be combined in any suitable mechanism. For example, the solvent based extraction process solvent and bituminous feed may be combined in an extractor to form an oil sand slurry. Complete or partial bitumen dissolution into the solvent based extraction process solvent may occur in the extractor. The extractor may comprise at least one of a slurry system and an extraction vessel.

[0032] The solvent based extraction process solvent may be capable of dissolving the bitumen in the bituminous feed. Bitumen may be added to the bituminous feed along with the solvent based extraction process solvent, for instance in a range of between 10 and 70 wt. %, or between 10 and 50 wt. % based on a combined weight of bitumen and solvent that is added to the bituminous feed. The range of bitumen added may be any number within or bounded by the preceding range. Adding bitumen and solvent based extraction process solvent to the bituminous feed may reduce solvent inventory requirements. In cases where a non-aromatic hydrocarbon solvent is used as the solvent based extraction process solvent, the bitumen added with the solvent based extraction process solvent may increase the dissolution rate of the incoming bitumen. In cases where a non-aromatic hydrocarbon solvent is used, the bitumen added with the solvent may increase the solubility of the solvent/bitumen towards dissolving additional bitumen in the bituminous feed. In cases where a paraffinic solvent is used as the solvent based extraction process, the bitumen added with the solvent based extraction process solvent may avoid or limit precipitation of asphaltenes.

[0033] The solvent based extraction process solvent entering the extractor may be recycled to the extractor from one or more downstream steps. The solvent based extraction process solvent may comprise residual bitumen and residual solid fines.

[0034] The solvent based extraction process solvent may or may not include a low boiling point solvent. A low boiling point solvent may be any solvent having a boiling point less than 100° (degrees) C (Celsius). Examples of suitable low boiling point solvents include but are not limited to low boiling point cycloalkanes, or a mixture of such cycloalkanes, which substantially dissolve asphaltenes, or paraffinic solvents in which the solvent to bitumen ratio, the temperature, the pressure or a combination thereof are maintained at levels to avoid or limit precipitation of asphaltenes. The solvent based extraction process solvent may have a boiling point of 30°C to 90°C. Using a low boiling point solvent may provide an advantage in that solvent recovery through an evaporative or distillation process may proceed at lower temperatures and/or require a lower energy consumption than using a solvent that does not have a low boiling point.

[0035] The solvent based extraction process solvent may comprise an organic solvent or a mixture of organic solvents. For example, the solvent based extraction process solvent may comprise at least one of a paraffinic solvent, an open chain aliphatic hydrocarbon, and a cyclic aliphatic hydrocarbon. Should a paraffinic solvent be utilized, it may comprise an alkane, a natural gas condensate, a distillate from a fractionation unit (or diluent cut), or a combination of these containing more than 40% small chain paraffins of 5 to 10 carbon atoms. Should such a paraffinic solvent be used, it would be considered primarily a small chain (or short chain) paraffin mixture. Should an alkane be selected as the solvent based extraction process solvent, the alkane may comprise at least one of a normal alkane and an iso-alkane. The alkane may comprise at least one of heptane, iso-heptane, hexane, iso-hexane, pentane, and iso-pentane. Should a cyclic aliphatic hydrocarbon be selected as the solvent based extraction process solvent, it may comprise a cycloalkane of 4 to 9 carbon atoms (C_4-C_9). A mixture of C_4-C_9 cyclic and/or open chain aliphatic solvents would be appropriate. Exemplary cycloalkanes include at least one of cyclohexane and cyclopentane.

If the solvent based extraction process solvent is selected as the distillate from a fractionation unit, it may for example be one having a final boiling point of less than 180°C. An exemplary upper limit of the final boiling point of the distillate may be less than 100°C. The final boiling point may be any number within or bounded by the preceding ranges. The solvent based extraction process solvent may comprise a mixture of C_4-C_{10} cyclic and/or open chain aliphatic solvents. For example, the solvent based extraction process solvent may be a mixture of C_4-C_9 cyclic aliphatic hydrocarbons and paraffinic solvents where the percentage of the cyclic aliphatic hydrocarbons in the mixture is greater than 50%. Some of these listed solvents may or may not be low boiling point solvents.

[0036] The solvent based extraction process may be adjusted to render the ratio of the solvent to bitumen in the oil sand slurry at a level that avoids or limits precipitation of asphaltenes during the solvent based extraction process. Some amount of asphaltene precipitation may be unavoidable, but by adjusting the amount of solvent based extraction process solvent flowing into a system, with respect to the expected amount of bitumen in the bituminous feed, when taken together with the amount of bitumen that may be entrained in the solvent based extraction process solvent used, can permit the control of a ratio of solvent to bitumen in the extractor. When the solvent based extraction process solvent is assessed for a target ratio of solvent to bitumen during downstream agglomeration, the precipitation of asphaltenes may be minimized or avoided beyond an unavoidable amount; costs of the oil sands solvent based extraction process may be decreased due to reduced total solvent usage when having a target ratio.

[0037] An exemplary ratio of solvent to bitumen to be selected as a target ratio during agglomeration is less than or equal to 2:1. A ratio of 1.5:1 or less, and a ratio of 1:1 or less, for example, a ratio of 0.75:1, would also be considered acceptable target ratios for agglomeration. For clarity, ratios may be expressed herein using a colon between two values, such as "2:1", or may equally be expressed as a single number, such as "2", which carries the assumption that the denominator of the ratio is 1 and is expressed on a weight to weight basis.

[0038] The oil sand slurry may have a solid content in the range of 5 to 65 wt. %, 20 to 65 wt. %, or 40 to 65 wt. % based on the weight of the oil sand slurry. The oil sand slurry may have a solid content of greater than 65 wt. % based on the weight of the oil sand slurry.

[0039] The temperature of the oil sand slurry may be in the range of 20-80°C, inclusively. An elevated oil sand slurry temperature may be desired to increase the bitumen dissolution rate and reduce the viscosity of the slurry to promote more effective sand digestion and agglomerate formation. An elevated slurry temperature may be any temperature within or bounded by the range of 60-80°C, inclusively. An elevated slurry temperature may be desired to improve the solid-liquid separation process. An elevated oil sand slurry temperature may result in a reduced slurry viscosity, which in turn, may improve solid-liquid separation. Temperatures above 80°C may be avoided due to the complications resulting from high vapor pressures of low boiling point solvents.

[0040] With reference to Figure 1, a bituminous feed is fed (102) into a jet pump. A motive fluid, comprising a solvent for extracting bitumen, is provided (104) to the jet pump for mixing with the bituminous feed. A conditioned slurry is discharged (106) from the jet pump. The conditioned slurry is agglomerated (108) to create an agglomerated slurry.

[0041] With reference to Figure 2, bituminous ore (202) from a mine may be conditioned (204) for use, for instance, by crushing and/or screening to an appropriate maximum ore lump size. An appropriate maximum size may be less than a mixing chamber diameter of the downstream jet pump. For instance, at least 90 wt. % of the bituminous feed may have a maximum dimension of less than 150 mm. Conditioned ore (206) may be sent to a surge bin or stockpile (208) and may then be fed into an inerting system (210) where inert gas is added. The inerting system (210) may act as a boundary between general purpose and electrically classified zones. The inerting system (210) may have two main purposes: to remove sufficient oxygen through a venting stream to prevent flammable mixtures from occurring; and to admit ore into the extraction process while preventing solvent vapor from escaping to the atmosphere.

[0042] The inerted ore (also referred to herein as a bituminous feed) (212) may enter a hopper (214). A hopper wash solvent may be added to the hopper (214) to initiate bitumen dissolution. The hopper wash solvent may also assist solids flow to a jet pump suction and thaw or heat the bituminous feed. The hopper wash solvent may be provided to the hopper at a temperature above a bituminous feed temperature. The hopper wash solvent may also be used to fill void spaces in the bituminous feed by displacing the inerting gas which may otherwise affect jet pump performance. The hopper wash solvent may be a mixture of bitumen and lighter hydrocarbons, or may be lighter hydrocarbons alone. The hopper wash solvent may comprise fine particles along with the bitumen and lighter hydrocarbon. A combined bituminous feed (212) and hopper wash solvent level in the hopper (214) may be maintained at a height in the hopper (214) to provide a sufficient net positive suction head (NPSH) for the jet pump to limit cavitation as well as to provide sufficient residence time in the hopper for initial dissolution to occur. The hopper (214) may be vibrated to assist solids feeding. The hopper wash solvent may be added to the hopper (214) in any suitable manner, for instance as a central jet or a liquid along the hopper walls, or as part of a final feed sizing step. The level may be monitored by a level sensor or any other suitable device performing this function.

[0043] Bituminous feed (216) from the hopper (214) may be introduced into the jet pump (218). One or more pre-treatment steps may be present between the hopper (214) and the jet pump (218). The following background on jet pumps is provided. A motive fluid is pumped at a certain rate (Qn) through a nozzle at a high pressure (Pn). This high-pressure liquid passes through the nozzle, which converts the fluid from a low velocity, high static pressure flow to a high velocity, low static pressure flow (Ps). This lower static pressure (Ps) actually creates the suction for the material to be pumped to be fed into the system (via the hopper) at a certain flow rate (Qs) into a mixing chamber. The feed material in the suction can be a liquid, solid, slurry, or a combination thereof. An energy transfer occurs in a mixing chamber from the high energy to the low energy stream, resulting in a medium-high energy discharge stream (Qd, Pd). The volume of motive fluid used is primarily proportional to the size of the nozzle as well as the differential pressure (Pn - Ps). When the two streams (motive and suction) come into contact with each other, vigorous mixing occurs, which may cause ablation of the ore fed through the hopper in the suction chamber. "Ablation" refers to the breaking down of ore lumps. Overall, the hopper may comprise approximately 85 wt.% (or approximately 80 to 90 wt.%) solids, based on the weight of the hopper contents, so that the subsequent solids concentration in the discharge may be in the range of 30 wt.% to 70wt.% or 10 wt.% to 40wt.%, based on the total weight of the discharge, as described below. The following three references are mentioned, which describe jet pumps: Practical

Solids-Handling Jet Pumps, A.W. Wakefield, Symposium on Jet Pumps and Ejectors, London, November 1, 1982, Paper 12; Performance of Solids-Handling Jet Pumps at Low Reynolds's Numbers, A.W. Wakefield, 2nd Symposium on Jet Pumps & Ejectors and Gas Lift Techniques, March 24-26, 1975, Paper A3; and Slurry Handling Design of Solid Liquid Systems; Edited by Nigel P. Brown and Nigel I Heywood; ISBN 1-85166-645-1 (Chapter 18: Jet Pumps, A.W. Wakefield).

[0044] The jet pump (or pumps if configured in a multiple unit, parallel configuration) may be located and oriented in several ways. The jet pump may be positioned within the hopper, arranged vertically. Motive fluid may progress to a lower section of the hopper, make a U-turn, and enter the jet pump nozzle. This configuration may have the advantage of using the hopper as a secondary containment in the case of erosive wear through the jet pump body, but possibly at the cost of added complexity for maintenance.

[0045] Alternately, the jet pump may be mounted horizontally below the hopper, and configured with isolation valves at motive fluid connection, jet pump discharge, and suction connection to the hopper. This permits maintenance to be performed without withdrawing a submerged unit from an enclosed space of the sealed hopper.

[0046] Additional connections may be provided to drain the jet pump body, flush out remaining hydrocarbons and slurry to improve jet pump maintenance safety. The jet pump may be configured with a mixing and diffusing section contained within a secondary containment shell. An annular space between the jet pump and the containment may be monitored for the presence of pressure or liquid in order to detect leakage prior to any loss of containment to atmosphere.

[0047] The bituminous feed (216) may have a solids content of 60 to 85 wt. %, based on the total weight of the bituminous feed. A motive fluid (220) may be added to the jet pump (218). The motive fluid (220) comprises a solvent for extracting bitumen (also referred to as dissolution) as described above with reference to the solvent based extraction process. The motive fluid (220) may have viscosity of less than 20 cP, or less than 10 cP. The motive fluid (220) may have a viscosity of less than 300 cP to allow for an effective jet pump operation. The motive fluid (220) may be provided to the jet pump at any suitable pressure, for instance at a pressure of between 50 psig and 300 psig, or between 100 and 200 psig. A higher viscosity may serve as impediment to flow and subsequently, the jet pump action. The motive fluid (220) may be provided to the jet pump at any suitable temperature, for instance at a temperature above an atmospheric boiling point of the solvent, as long as the pressure is sufficiently maintained for safety considerations. The jet pump (218) may introduce shear which breaks down the ore lumps, increasing a surface area to volume ratio, enabling higher mass transfer and more rapid dissolution of the bitumen. Energy imparted to the bituminous feed (216) by the jet pump (218) may be used to transport the bituminous feed to the next process step. A jet pump discharge may enter a conventional slurry pump (219) for additional pressure boost. The slurry pump can act to reduce the backpressure on the jet pump exit enabling the jet pump performance to move along the characteristic M curve (ratio of bituminous feed to motive fluid) and so adjust the density of a slurry exiting the jet pump. The jet pump discharge may be operated at a temperature below the vapor point of the solvent to limit vapor bubbles in the discharge line. The jet pump may be operated at the point of cavitation at the motive fluid nozzle exit, or along the way into a mixing section to increase agitation of the bituminous feed. The jet pump may be operated at a temperature of less than 100°C. A conditioned slurry (222) may be discharged from the jet pump (218). The conditioned slurry (222) may have a solids content of 20 to 70 wt. %, or 10 to 40wt. % in the case of diluted slurries, based on the weight of the conditioned slurry. The conditioned slurry may be sent to a second jet pump hopper for further processing or to a pump box for additional capacitance, dissolution time, and density control.

[0048] The conditioned slurry (222) may be agglomerated (224) to create an agglomerated slurry (226). The agglomerated slurry (226) may have at least 50 wt. % of its solids weight between 0.1 mm and 1.0 mm, or at least 80 wt. % of its solids weight between 0.1 mm and 1.0 mm. A bitumen extract may be separated and recovered from the agglomerated slurry (226).

[0049] A bridging liquid may assist in agglomeration of solids with a mixing action during agglomeration to capture hydrophilic fines. Capturing the hydrophilic fines may assist separation of solids from bitumen and solvent.

[0050] Formed agglomerates within the agglomerated slurry (226) may be sized on the order of 0.1-1.0 mm, or on the order of 0.1-0.6 mm. At least 80 wt. % of the formed agglomerates may be 0.1-1.0 mm, or 0.1 to 0.6 mm in size. The rate of agglomeration may be controlled by a balance between intensity of agitation during agglomeration (224), shear during agglomeration (224) which can be adjusted, for example, by changing the shape or size of the agglomerator, fines content of the conditioned slurry (222), amount of bridging liquid addition, method of bridging liquid addition, and/or residence time of the agglomeration process. The size distribution of the agglomerates may be related to the particle size distribution of the bituminous feed (212) or the particle size distribution of the conditioned slurry (222), which may be screened, as detailed below. The agglomerated slurry (226) may have a solids content of 20 to 70 wt. %.

[0051] The bridging liquid may be an aqueous liquid with affinity for the solids particles in the bituminous feed. The bridging liquid may be immiscible in the solvent. Exemplary bridging liquids may be water that accompanies the bituminous feed and/or recycled water from other aspects or steps of oil sands processing. The bridging liquid may not be pure water, and may indeed be water containing one or more salts, a waste product from conventional aqueous oil sand extraction processes which may include additives, aqueous solution with a range of pH and/ or any other acceptable aqueous solution capable of adhering to solid particles in such a way that permits fines to adhere to each other. The ratio of bridging liquid plus connate water from the combined bituminous feed (216) to the solids in the bituminous feed may be in the range of 0.05-0.11. Therefore, if the connate water content in the incoming bituminous feed (216) is sufficiently high, no further bridging liquid may be required in the system. The bridging liquid may comprise fine particles suspended therein. The fine particles may serve as seed particles for the agglomeration process. The bridging liquid may comprise less than 40 wt. % solid fines, based on the weight of the bridging liquid, or have a solids content of 20 to 70 wt.%, based on the weight of the bridging liquid. The bridging liquid may be added in one or multiple locations in the agglomerator.

[0052] Agglomerating the conditioned slurry (222) by agitating the solids may include agitating by mixing, shaking, rolling, or another known suitable method. The agitation of the conditioned slurry (222) need only be severe enough and of sufficient duration to intimately contact the bridging liquid with solids in the conditioned slurry (222). Mixing may occur in a mixing type vessel. Rolling may occur in a rolling type vessel. Exemplary rolling type vessels include rod mills and tumblers. Exemplary mixing type vessels include mixing tanks, blenders, and attrition scrubbers. In the case of mixing type vessels, a substantial amount of agitation is needed to keep the formed agglomerates in suspension. In rolling type vessels, the solids content of the conditioned slurry (222) may be greater than 40 wt. %, based on the weight of the conditioned slurry, so that compaction forces assist agglomerate formation. The agitation of the conditioned slurry (222) has an impact on the growth of the agglomerates. In the case of mixing type vessels, the mixing power can be increased in order to limit the growth of agglomerates by attrition of the agglomerates. In the case of rolling type vessels, the fill volume and rotation rate of the vessel can be adjusted in order to vary the compaction forces on the agglomerates.

[0053] The agglomeration process may occur within a pipeline. The conditioned slurry (222) may be fed into a pipeline where additional bitumen extraction may occur. The conditioned slurry (222) may flow within the pipeline, and at one or more points along the pipeline, the bridging liquid may be added to the pipeline to assist in the agglomeration of the solids within the pipeline. Alternatively or additionally, bridging liquid may be added to the conditioned slurry (222) prior to the pipeline such as along with the solvent into the second jet pump, as described below. The bridging liquid itself may be added in the form of an emulsion with the mixture weight ratio ranging from 3:10 to 7:10 on a bridging liquid: total liquid emulsion mixturebasis. Some form of agitation is also used to assist agglomeration. The agitation may be provided by turbulent flow within the pipeline. The rate of agglomeration may be controlled by a balance between velocity within the pipeline (i.e. flow turbulence), fines content of the conditioned slurry (222), amount and method of bridging liquid addition, and residence time within the pipeline. The agglomerated slurry (226) from the pipeline, comprising agglomerates and bitumen extract, may be sent to the solid-liquid separation system to produce a bitumen extract stream and an agglomerated solids stream.

[0054] Additional features of an agglomeration process that may be used are described in Canadian Patent 2,740,670.

[0055] The agglomerated slurry (226) may be sent to a filter, such as sealed vacuum filter system, for instance as described in United States Provisional Patent Application No. 62/193,267, entitled “Method of Filtering an Oil Sand Slurry”, and filed on July 16, 2015.

[0056] Figure 3 illustrates the same features as Figure 2 and includes additional features between the jet pump and the agglomeration. Therefore, summarizing the features common to Figures 2 and 3, with reference to Figure 3, bituminous ore (302) from a mine may be conditioned (304) for use. Conditioned ore (306) may be sent to a surge bin or stockpile (308) and may then be fed into an inerting system (310) where inert gas is added. Bituminous feed (312) may enter a hopper (314). A hopper wash solvent may be added to the hopper (314). Bituminous feed (316) from the hopper (314) may be introduced into the jet pump (318). A motive fluid (320), comprising a solvent for extracting bitumen, may be added to the jet pump (318). The bituminous feed (316) spends a residence time with the hopper wash solvent in the hopper (314), where dissolution may occur. In addition, further dissolution and ablation occurs as the slurry is exposed to high shear and energy within the jet pump (318). A conditioned slurry (322) may be discharged from the jet pump (318). The conditioned slurry may be given a residence time in the pipe to ensure substantially complete dissolution of bitumen prior to an agglomeration step. The residence time could be between 0 and 5 minutes, or between 0.5 minutes and 2 minutes.

[0057] The conditioned slurry (322) may be sent to a screen (324) to remove oversized particles (326), such as clay lumps, undigested ore, rocks, or other debris (328), and produce a screened conditioned slurry (330). The screen size openings may be nominally in the 6-10 mm range, to limit bitumen loss during agglomeration and/or to assist post-agglomeration filtration, for instance in a vacuum filter system. The oversized particles may be sized greater than 5 mm, or greater than 25 mm, or greater than a value therebetween. The screen may be static, vibrating, or rotating. Oversized particles are those particles that have a size greater than the screen openings and hence, may not go through the screen. The screen may comprise a first screen with first openings and a second screen with second smaller openings. The first openings of the first screen may be 15-50 mm and the second openings of the second screen may be 4-15 mm.

[0058] The screened conditioned slurry (330) may be fed to a second hopper (332) for a residence time to allow for solids-liquid separation by gravity sedimentation. A supernatant (334) may be removed from the hopper (332) and fed to a second jet pump (336) as a second motive fluid. A second bridging liquid (338) may be mixed (340) with the supernatant (334) to become the motive fluid to the second jet pump (336). The second bridging liquid (338) may be added as an aqueous stream or as a combination of an aqueous stream and a separate hydrocarbon stream pre-processed to form an emulsion. The second motive fluid may comprise 30-70 wt. % bitumen based on a weight of the second motive fluid. The second motive fluid may also comprise 0-30 wt. % fines.

[0059] A bottom bituminous stream (342) from the second hopper (332) may also be introduced into the second jet pump (336). The second jet pump (336) mixes the bottom stream (342) and the supernatant (334) to produce a second conditioned slurry (344). The second conditioned slurry (344) may be passed through a slurry booster (346) to agglomeration (348) as described herein. Alternately, or in addition, a portion of the supernatant from the second jet pump (336) may be used as hopper wash for the first jet pump (318). A portion of the screened conditioned slurry may be passed back to the jet pump as additional motive fluid.

[0060] A hopper wash solvent volume may be adjusted according to a conditioned slurry volume, to control an overall density of the conditioned slurry.

[0061] With reference to Figure 4, bituminous feed (412) may enter a hopper (414), which may feed a jet pump (418). A motive fluid (420), comprising a solvent for extracting bitumen, may be added to the jet pump (418) via a motive fluid pump (421). The motive fluid pump (421) may also supply hopper wash solvent (490) to the hopper (414) as an upper hopper wash solvent (492) or a lower hopper wash solvent (494) in respective upper and lower regions of the hopper. Both upper and lower wash solvents may provide flow assurance of solids in the hopper, addition of heat, and dissolution of bitumen. The lower wash solvent may also provide a disintegration action to mitigate any bridging and packing to ensure flow into the jet pump. In addition, the upper and lower wash solvents may be added in single or multiple locations or ports.

[0062] A conditioned slurry (422) may be discharged from the jet pump (418) and passed through a slurry boost pump (423) to a screen (425) to remove oversized particles (426), such as clay lumps, undigested ore, rocks, or other debris. The screen size openings may be nominally in the 6-10 mm range, to limit bitumen loss during agglomeration and/or to assist post-agglomeration filtration, for instance in a vacuum filter system.

[0063] The screened conditioned slurry (496) from the screen (425) may enter a pump box (427). A slurry (429) may progress from the pump box (427) to a slurry pump (474). A portion of the screened conditioned slurry (496) may be used for hopper wash service to support flow assurance in the hopper (414).

[0064] A portion of the conditioned slurry (422a) may be recirculated to the jet pump feed hopper (414) to increase the energy dissipated on the solids enhancing ablation of large lumps, thus reducing the amount of material that is rejected on the screen (425), and accelerating the dissolution of bitumen from the ore. In order to keep the density of the condition slurry (422) constant, since more liquid is returned into the hopper through the recirculated conditioned slurry (422a), the hopper wash (492) rate may be reduced.

[0065] Oversized particles (426) may be washed on the screen (425) by a wash fluid (431). The screen may comprise two or more screens with differently size openings. For instance, the first screen may have openings of 25 mm (or 15-30 mm), and the second screen may have openings of 10 mm (or 5-15 mm). The two oversize streams may be combined, or treated separately. Optionally, the particles screened by the second screen may be sent to an agglomerator or filtration (such as by a pan filter). The wash fluid (431) may comprise a washing solvent and, optionally, bitumen and fine particles. This wash fluid (431) may also assist in moving conditioned slurry (422) through the screen (425), minimizing the necessary screen size. The wash fluid (431) may comprise an aqueous or non-aqueous solvent. The wash fluid (431) may be sprayed at a pressure of between 50 psi and 3500 psi. In a case where the screen is a rotating trommel, heavy chains or other devices may be used to assist breaking up soft oversized particles.

[0066] Washed oversized particles (426) from the screen (425) may be sent to a scrubbing device (433) using second wash fluid (435) jets to remove bitumen or bitumen coated particulates that may have adhered to the components such as rock or clay lumps. An example of such a device is the Hydro-Clean (WS Tyler, Conyers, Georgia , US). The second wash fluid (435) may be aqueous or non-aqueous. Where the second wash fluid (435) is non-aqueous, it may comprise a non-aqueous solvent, and optionally bitumen and fine particles. Where the second wash fluid (435) comprises an aqueous fluid, the conditioned slurry may be used as the bridging liquid (481). When the second wash fluid (435) comprises a non-aqueous solvent, a recycle stream (451) may be used as part of combined slurry (453) or as hopper wash fluid (492). The second wash fluid may be sprayed at a pressure between 50 psi and 3500 psi.

[0067] Remaining oversized material (439) may be washed on a secondary screen (441) with clean solvent (also referred to as liquid wash) (443) to remove residual bitumen, and prepare the oversized particles for solvent removal.

[0068] If the high pressure liquid wash for the oversize materials is performed with a non-aqueous or hydrocarbon solvent, the liquid and liberated fines (437) may be drained from the scrubbing device, and co-mingled with the screened conditioned slurry in the pump box (427). Liquid and liberated fines may be sent back to the hopper (414) as hopper wash solvent, or as part of the motive fluid for the jet pump (418). Alternately, if the wash is performed with an aqueous solvent, the liquid stream (437) may be recycled as part of the bridging liquid for agglomeration.

[0069] Washed oversized particles (also referred to as a disposal stream) (445) may be sent for solvent removal (447) prior to disposal (498). Steam (449) may be added to the washed oversized particles (445) to evaporate the solvent.

[0070] Alternatively, the liquid wash (443) on the secondary screen (441) may be hot water. In this case, the heat of the water evaporates solvent, preparing the oversized material for direct disposal. Waste water from this step may be used as the bridging liquid for agglomeration as described herein.

[0071] Liquid recycle stream (451) may be co-mingled with slurry in the pump box (427), co-mingled with the higher density slurry (429) to form a combined slurry (453). The combined slurry (453) may be agglomerated as described herein. The combined slurry (453) may be used as motive fluid in the jet pump (418) if it is a dilute slurry and in all other cases, used as hopper wash solvent, or as other diluting, washing, or mixing service in the process. If the liquid wash (443) is water, liquid recycle stream (451) may be used in whole or in part as the bridging liquid (481).

[0072] The combined slurry (453) may be passed through a slurry pump (474). A bridging liquid (481) may be added to the combined slurry (453) to assist agglomeration. A static mixer (482) may be used to increase water dispersion of the combined slurry (453) to accelerate agglomeration, followed by filtration in a filter, for instance a pan filter (483), to and produce dry tailings (485), a lean extract (486), and a rich extract (487). Presence of a jet pump may eliminate or reduce the need for a static mixer for agglomeration, due to the high shear and energy therein.

[0073] A purpose of the jet pump and hopper wash solvent is to reduce the volume and cost of other systems required for ablation and dissolution. In the event that additional dissolution is required, a heated dissolution solvent (497) can be added into the pipeline prior to agglomeration. Due to the relatively higher pressure in the pipeline, the heated dissolution solvent can be added at a temperature above its atmospheric boiling point. This heated dissolution solvent, heat, and additional retention time may complete the dissolution to a desired extent. This heated dissolution solvent may be added in or prior to or post the pump box, i.e. before the agglomerator, as described above, and in or after the discharge from the jet pump. The dissolution solvent may comprise bitumen and a lighter hydrocarbon. The heated dissolution solvent may be added at a temperature of 30°C to 120°C.

[0074] In order to mitigate recycling solids to obtain appropriate slurry density for a downstream filter system, a section of the pipeline containing agglomerated slurry may have a screen section, arranged in a pipe-in- pipe fashion. The screen size may be chosen to retain solids, such as normally 100 to 200 microns. Liquid may be removed from the agglomerated slurry while still under pressure, and be measured and controlled to provide the agglomerated slurry in a higher solids concentration to the filter system. This hot, pressurized rich extract may be recycled to the prior steps as hopper wash or motive fluid for the jet pump. A potential benefit of the higher density to the filter system is a reduction in filter system requirements.

[0075] With reference to Figure 5, bituminous feed (512) may enter a hopper (514), which may feed a jet pump (518). A motive fluid (520), comprising a solvent for extracting bitumen, may be added to the jet pump (518) via a motive fluid pump (521). The motive fluid pump (521) may also supply hopper wash solvent (590) to the hopper (514) as an upper hopper wash solvent (592) or a lower hopper wash solvent (594). The hopper wash may alternatively be supplied in a different composition and temperature than the motive fluid.

[0076] A conditioned slurry (522) may be discharged from the jet pump (518) and pass through a slurry boost pump (523) to a screen (525) to remove oversized particles (526), such as clay lumps, undigested ore, rocks, or other debris.

[0077] The screened conditioned slurry (596) from the screen (525) screen may enter a second hopper (527) for solid-liquid separation. A higher density slurry (529) may progress from the second hopper (527) to a second jet pump (560) toward agglomeration.

[0078] Oversized particles (526) may be washed on the screen (525) by a wash fluid (531). The wash fluid (531) may be clean, or include a portion of bitumen and other materials, such as fine particles. This wash fluid (531) may also assist in moving conditioned slurry (522) through the screen (525), minimizing the screen size. The wash fluid (531) may comprise an aqueous or non-aqueous solvent. The wash fluid (531) may be sprayed at a pressure of between 50 psi and 3500 psi. In a case where the screen (525) is a rotating trommel, heavy chains or other devices may be used to assist breaking up soft oversized particles.

[0079] Washed oversized particles (526) from the screen (525) may be sent to a scrubbing device (533) using high-pressure liquid solvent (535) jets to remove bitumen or bitumen coated particulates that may have adhered to the non-ablatable components such as rock. An example of such a device is the Hydro-Clean (WS Tyler, Mentor, Ohio, US). Liquid and liberated fines (537) may be drained from the scrubbing device and added to the second hopper (527).

[0080] Remaining oversized material (539) may be washed on a second screen (541) with new solvent (543) to remove residual bitumen, and prepare the oversized particles for solvent removal.

[0081] Washed oversized particles (545) may be sent for solvent removal (547) and disposal (598). Steam (549) may be added to the washed oversized particles (545) to evaporate the solvent. Solvent based liquid (551) may be combined into the second hopper (527).

[0082] Alternatively, the liquid wash (543) on the second screen (541) may be hot water. In this case, the heat of the water evaporates solvent, preparing the oversized material for direct disposal. Waste water from this step may be used as the bridging liquid for agglomeration as described herein. Water based liquid (551) may be added to the pipeline as bridging liquid (581) or as bridging liquid (570) to the jet pump motive fluid (566).

[0083] Supernatant (566) may be passed through a motive fluid pump (568), combined with bridging liquid (570), and fed as motive fluid to the second jet pump (560). The intense mixing of the jet pump may effectively disperse the bridging liquid with the solids in the slurry (529). A second jet pump discharge (572), which may comprise about 20-60 wt. % solids, based on the weight of the discharge, may be passed to a slurry pump (574). A bridging liquid (581) may be added to assist agglomeration. A static mixer (582) may be used for increased water dispersion to aid agglomeration, followed by filtration in a filter, for instance a pan filter (583), to produce dry tailings (585), a lean extract (586), and a rich extract (587). In this configuration as well, the presence of jet pump may eliminate or reduce the need for a static mixer for agglomeration, due to the high shear and energy therein.

[0084] Supernatant (576) may be passed through a motive fluid recycle pump (578), heated (580), and recycled as motive fluid (520) for the jet pump (518), or as hopper wash solvent (590).

[0085] Wet crushing or sizing may be used in the hoppers (214, 314, 414, or 514) or to crush oversized particles (426 or 526). The addition of fluid to the bituminous feed can assist in throughput through sizing devices, reduce buildup of ore, and reduce frictional wear on grinding surfaces. Positioning the secondary screen (541) after the primary screen (525) may reduce the throughput of the combined slurry (453) which may reduce capital and/or operating expenses.

[0086] It should be understood that numerous changes, modifications, and alternatives to the preceding disclosure can be made without departing from the scope of the disclosure. The preceding description, therefore, is not meant to limit the scope of the disclosure. Rather, the scope of the disclosure is to be determined only by the appended claims and their equivalents. It is also contemplated that structures and features in the present examples can be altered, rearranged, substituted, deleted, duplicated, combined, or added to each other.

CLAIMS:

1. A solvent based extraction method using agglomeration, the method comprising:

a) feeding a bituminous feed into a jet pump;

b) providing a motive fluid to the jet pump for mixing with the bituminous feed, the motive fluid comprising a solvent for extracting bitumen;

c) discharging a conditioned slurry from the jet pump; and

d) agglomerating the conditioned slurry to create an agglomerated slurry.

2. The method of claim 1, further comprising, prior to a), reducing a particle size of the bituminous feed to achieve a bituminous feed with a maximum dimension less than a mixing chamber diameter of the jet pump.

3. The method of claim 1, further comprising, prior to a), reducing a particle size of the bituminous feed to achieve a bituminous feed with at least 90 wt. % of its total weight having a maximum dimension of less than 150 mm.

4. The method of any one of claims 1 to 3, wherein the motive fluid is provided to the jet pump at a pressure between 50 psig and 300 psig.

5. The method of any one of claims 1 to 3, wherein the motive fluid is provided to the jet pump at a pressure between 100 and 200 psig.

6. The method of any one of claims 1 to 5, wherein the motive fluid is provided to the jet pump at a temperature above an atmospheric boiling point of the solvent.

7. The method of any one of claims 1 to 6, wherein the bituminous feed is fed to the jet pump from a hopper.

8. The method of claim 7, wherein a hopper wash solvent is added to the hopper to initiate bitumen dissolution.

9. The method of claim 8, wherein the hopper wash solvent assists solids flow to a jet pump suction and thaws or heats the bituminous feed.

10. The method of claim 8 or 9, wherein the hopper wash solvent is provided to the hopper at a temperature above a bituminous feed temperature.

11. The method of any one of claims 8 to 10, wherein the hopper wash solvent is also used to fill void spaces in the bituminous feed.

12. The method of claim 11, wherein the hopper wash solvent displaces an inert gas from the void spaces.

13. The method of any one of claims 8 to 12, wherein the hopper wash solvent comprises a hydrocarbon liquid that is lighter than bitumen.

14. The method of any one of claims 8 to 12, wherein the hopper wash solvent comprises bitumen and a lighter hydrocarbon liquid.

15. The method of any one of claims 8 to 14, wherein a combined bituminous feed and hopper wash solvent level in the hopper is maintained at a height to provide a sufficient net positive suction head (NPSH) to limit cavitation in the jet pump.

16. The method of any one of claims 8 to 14, wherein the hopper wash solvent and the bituminous feed are kept in the hopper for a residence time sufficient to allow for initial dissolution to occur.

17. The method of any one of claims 8 to 16, wherein the hopper wash solvent is supplied from a motive fluid pump as an upper hopper wash or as a lower hopper wash, or both, in respective upper and lower regions of the hopper.

18. The method of any one of claims 1 to 17, further comprising screening the conditioned slurry to remove oversized particles using a primary screen and to produce a screened conditioned slurry.

19. The method of claim 18, wherein the primary screen comprises a first screen with first openings and a second screen with second smaller openings.

20. The method of claim 19, wherein the first openings are 15-50 mm and the second openings are 4-15 mm.

21. The method of any one of claims 18 to 20, wherein particles on the second screen are sent to a filtration step directly without progressing through an agglomeration stage.

22. The method of any one of claims 19 to 21, further comprising washing the oversized particles with a wash fluid.

23. The method of claim 22, wherein the wash fluid comprises a washing solvent, and optionally comprises bitumen and fine particles.

24. The method of claim 22 or 23, wherein the wash fluid assists in moving the conditioned slurry through the primary screen.

25. The method of any one of claims 19 to 24, wherein the primary screen is a rotating trommel with chains for breaking up soft oversized particles.

26. The method of claim 19 or 20, further comprising passing oversized particles screened by the second screen to an agglomerator.

27. The method of claim 19 or 20, further comprising passing oversized particles screened by the second screen to a pan filter.

28. The method of any one of claims 1 to 27, further comprising adding a heated dissolution solvent to the conditioned slurry prior to agglomeration to assist bitumen dissolution in the conditioned slurry.

29. The method of claim 28, wherein the dissolution solvent comprises bitumen and a lighter hydrocarbon.

30. The method of claim 28 or 29, wherein the heated dissolution solvent is at a temperature of 30°C to 120°C.

31. The method of any one of claims 1 to 30, further comprising operating the jet pump at a discharge pressure high enough to limit cavitation.

32. The method of any one of claims 1 to 31, wherein the conditioned slurry has a solids content between 20 and 70 wt. % based on a weight of the conditioned slurry.

33. The method of any one of claims 1 to 32, wherein the bituminous feed has a solids content between 60 and 85 wt.% based on a weight of the bituminous feed.

34. The method of any one of claims 1 to 33, wherein step d) is effected in a rolling type vessel, mixing type vessel or a pipeline.

35. The method of any one of claims 1 to 34, further comprising adding a bridging liquid to the conditioned slurry to assist with the agglomeration.

36. The method of claim 35, wherein the bridging liquid comprises an aqueous liquid or a mixture of aqueous and non-aqueous liquids as an emulsion.

37. The method of any one of claims 1 to 36, wherein the agglomerated slurry has at least 50 wt. % of its solids weight between 0.1 mm and 1.0 mm.

38. The method of any one of claims 1 to 36, wherein the agglomerated slurry has at least 80 wt. % of its solids weight between 0.1 mm and 1.0 mm.

39. The method of any one of claims 1 to 38, further comprising separating and recovering a bitumen extract from the agglomerated slurry.

40. The method of any one of claims 18 to 27, further comprising passing the screened conditioned slurry to a second jet pump along with a second motive fluid to produce a second conditioned slurry.

41. The method of claim 40, further comprising adding a second bridging liquid to the second jet pump as part of the second motive fluid, or to the second conditioned slurry to disperse an aqueous phase with solids, for agglomeration.

42. The method of claim 40, further comprising passing the screened conditioned slurry to a second hopper to allow solid-liquid separation during a residence time prior to introduction into the second jet pump.

43. The method of claim 42, further comprising removing a supernatant from the second hopper and recycling the supernatant to the second jet pump as additional second motive fluid.

44. The method of claim 43, wherein the second motive fluid comprises 30-70 wt. % bitumen based on a weight of the second motive fluid.

45. The method of any one of claims 18 to 27, further comprising passing a portion of the screened conditioned slurry back to the jet pump as additional motive fluid.

46. The method of any one of claims 7 to 17, further comprising passing a portion of the conditioned slurry back to the hopper.

47. The method of claim 46, wherein a hopper wash solvent volume is adjusted according to a conditioned slurry volume, to control an overall density of the conditioned slurry.

48. The method of any one of claims 18 to 27, further comprising spraying or washing the oversized particles that have been screened out from the conditioned slurry with a second wash fluid to form a recycle stream comprising smaller particles for recycling to the jet pump and a disposal stream comprising larger fluid wet particles for disposal.

49. The method of claim 48, wherein the second wash fluid comprises an aqueous or non-aqueous solvent.

50. The method of claim 48 or 49, wherein the second wash fluid is sprayed at a pressure between 50 psi and 3500 psi.

51. The method of claim 49, wherein the non-aqueous solvent comprises a washing non-aqueous solvent, and optionally bitumen and fine particles.

52. The method of claim 48, wherein the second wash fluid comprises an aqueous fluid, and wherein the conditioned slurry used as the bridging liquid.

53. The method of claim 48, wherein the second wash fluid comprises a non-aqueous solvent, and wherein the recycle stream is used as motive fluid or as a hopper wash solvent or is fed to a pump box.

54. The method of claim 48, further comprising washing the disposal stream on a disposal stream screen to produce a washed disposal stream.

55. The method of claim 54, further comprising evaporating solvent from the washed disposal stream using steam.

56. The method of claim 48, wherein the second screen comprises hot water for evaporating the solvent and for preparing the oversized particles for direct disposal.

57. The method of claim 55, further comprising recycling water condensed from the steam for use upstream as bridging liquid.

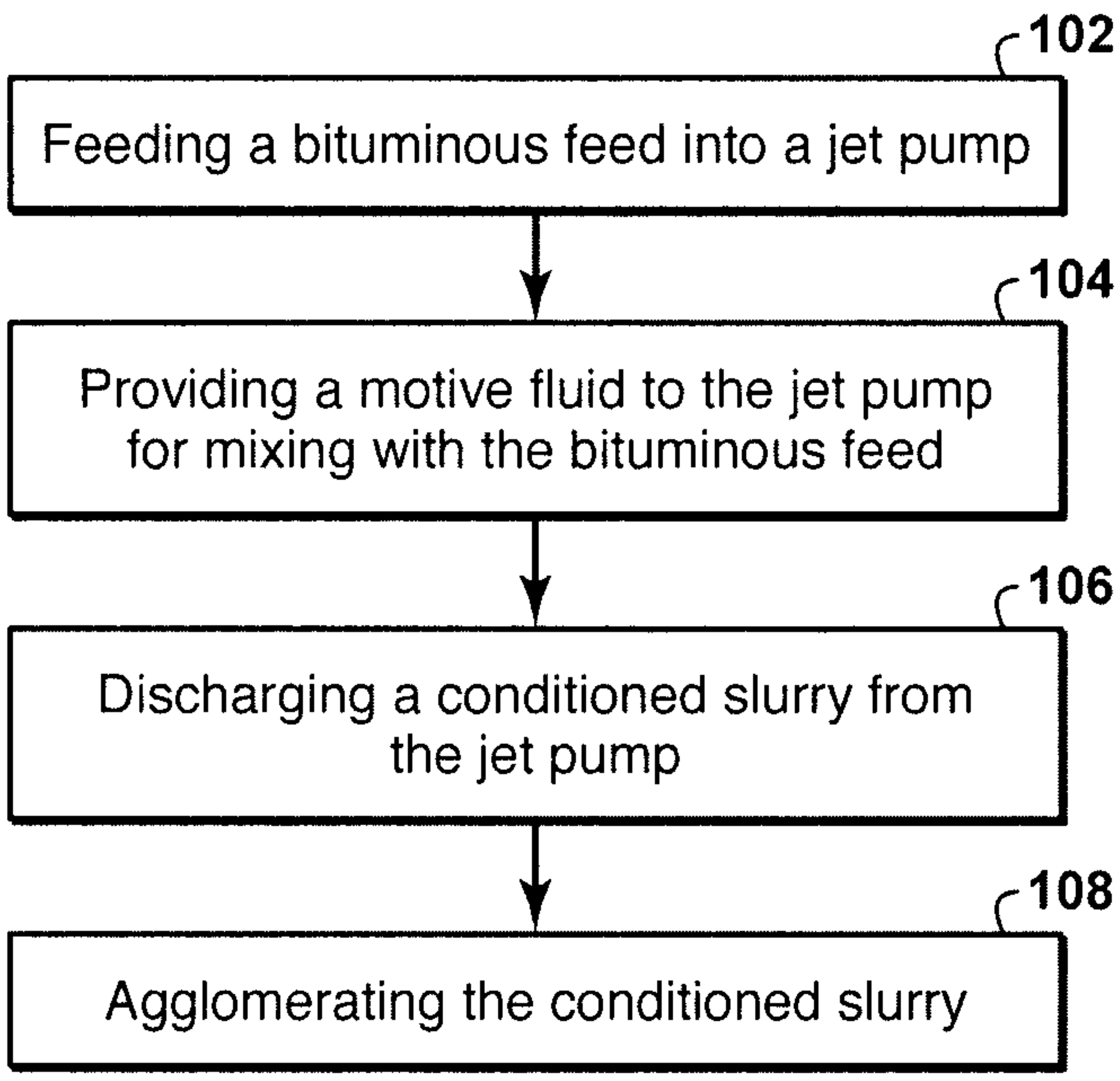
58. The method of any one of claims 1 to 57, wherein the jet pump is operated at a temperature of less than 100°C.

59. The method of any one of claims 1 to 58, wherein the motive fluid has a viscosity of less than 300 cP.

60. The method of any one of claims 1 to 58, wherein the motive fluid has a viscosity of less than 20 cP.

61. The method of any one of claims 1 to 58, wherein the motive fluid has a viscosity of less than 10 cP.

62. The method of any one of claims 1 to 61, wherein the bituminous feed is bituminous ore.


102
Feeding a bituminous feed into a jet pump
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Providing a motive fluid to the jet pump for mixing with the bituminous feed
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Discharging a conditioned slurry from the jet pump
108
Agglomerating the conditioned slurry

FIG. 1

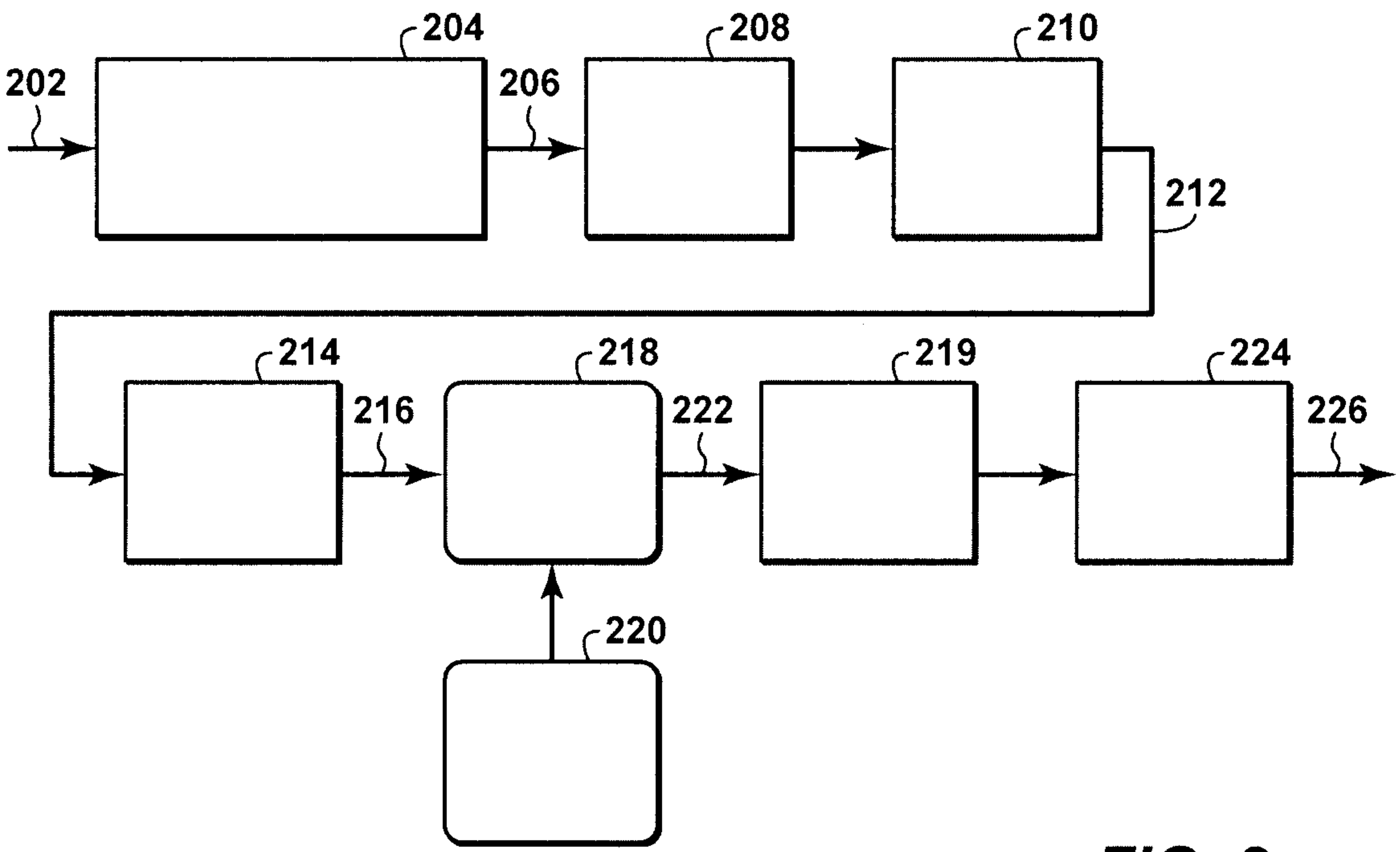
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FIG. 2

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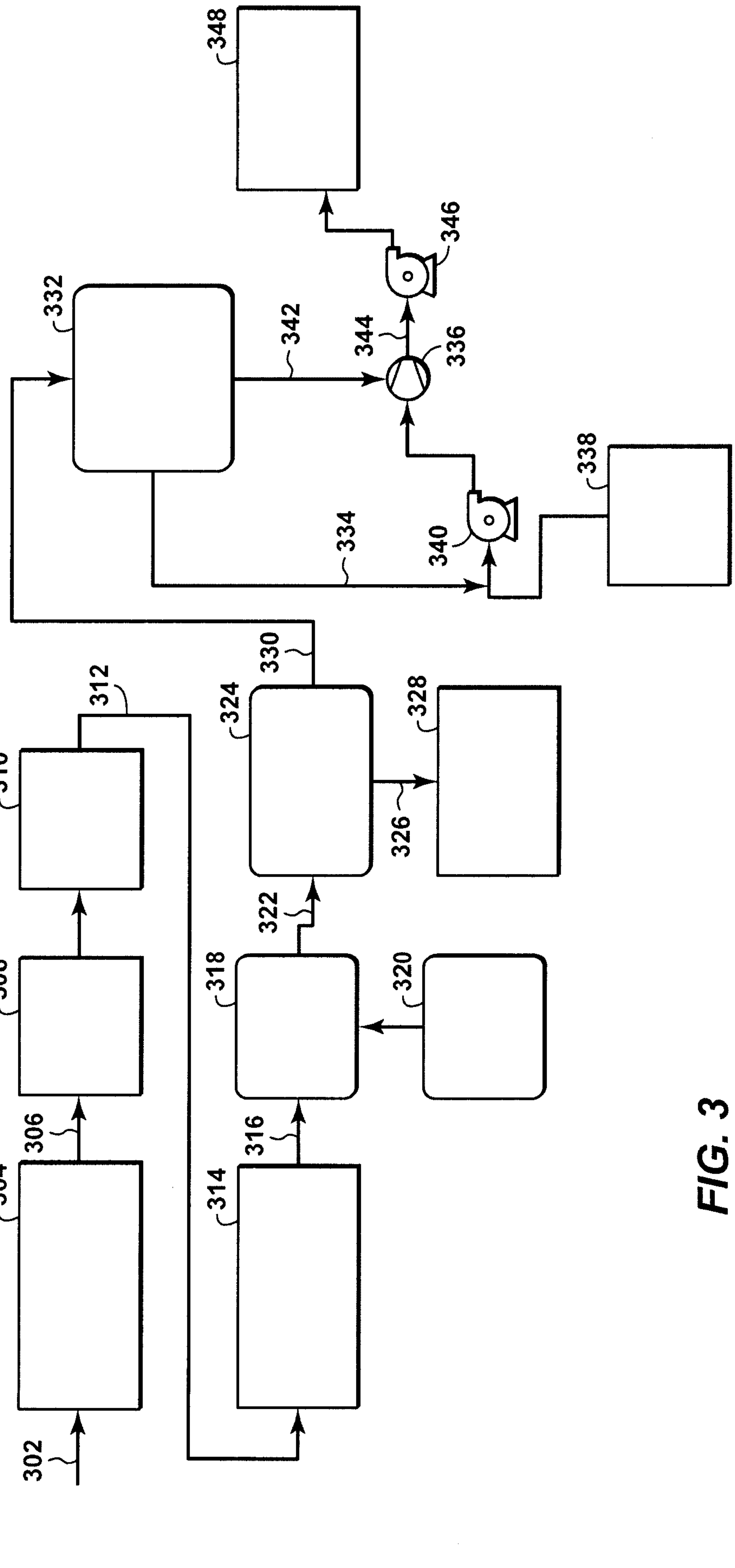
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FIG. 3

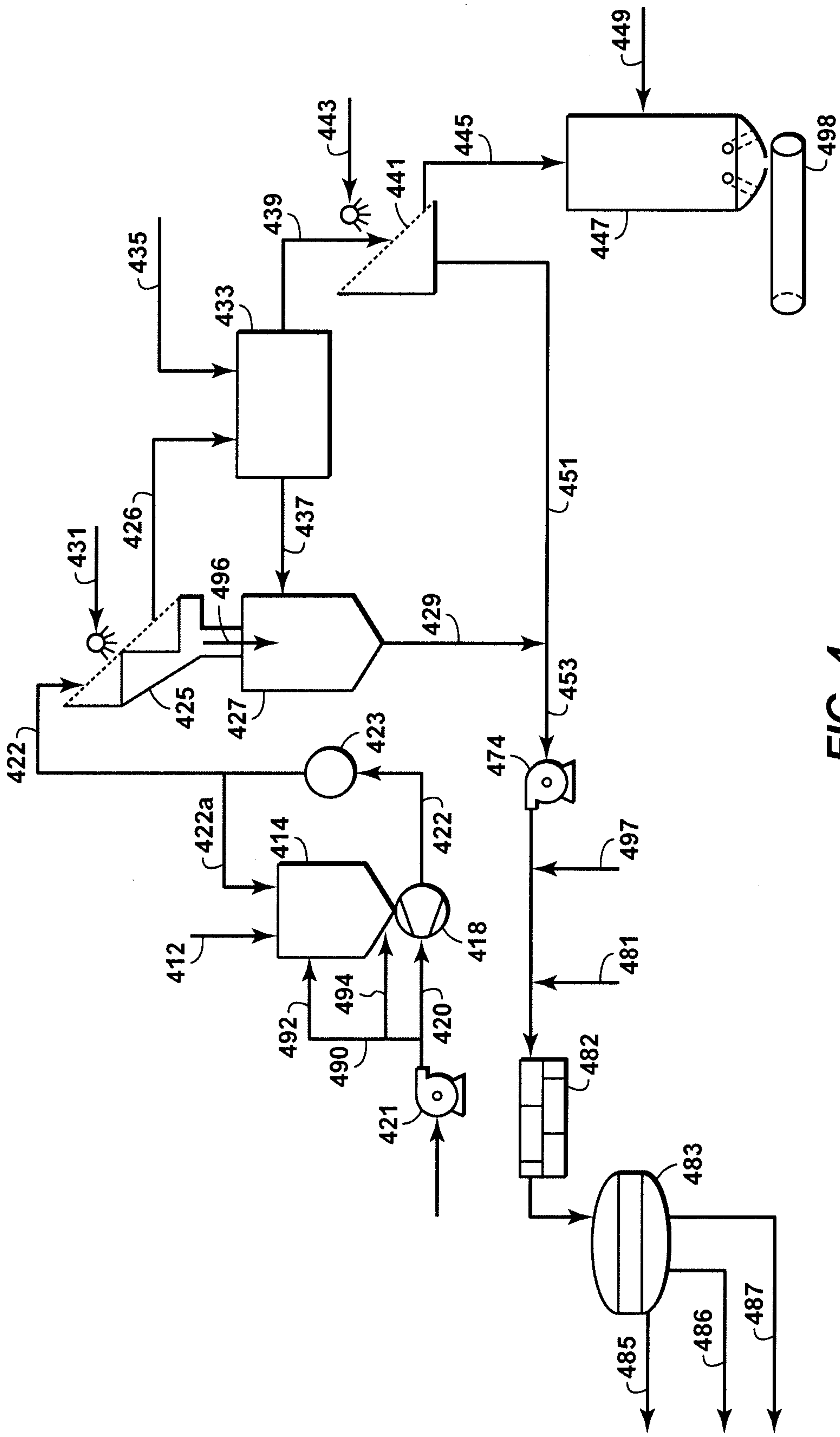
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FIG. 4

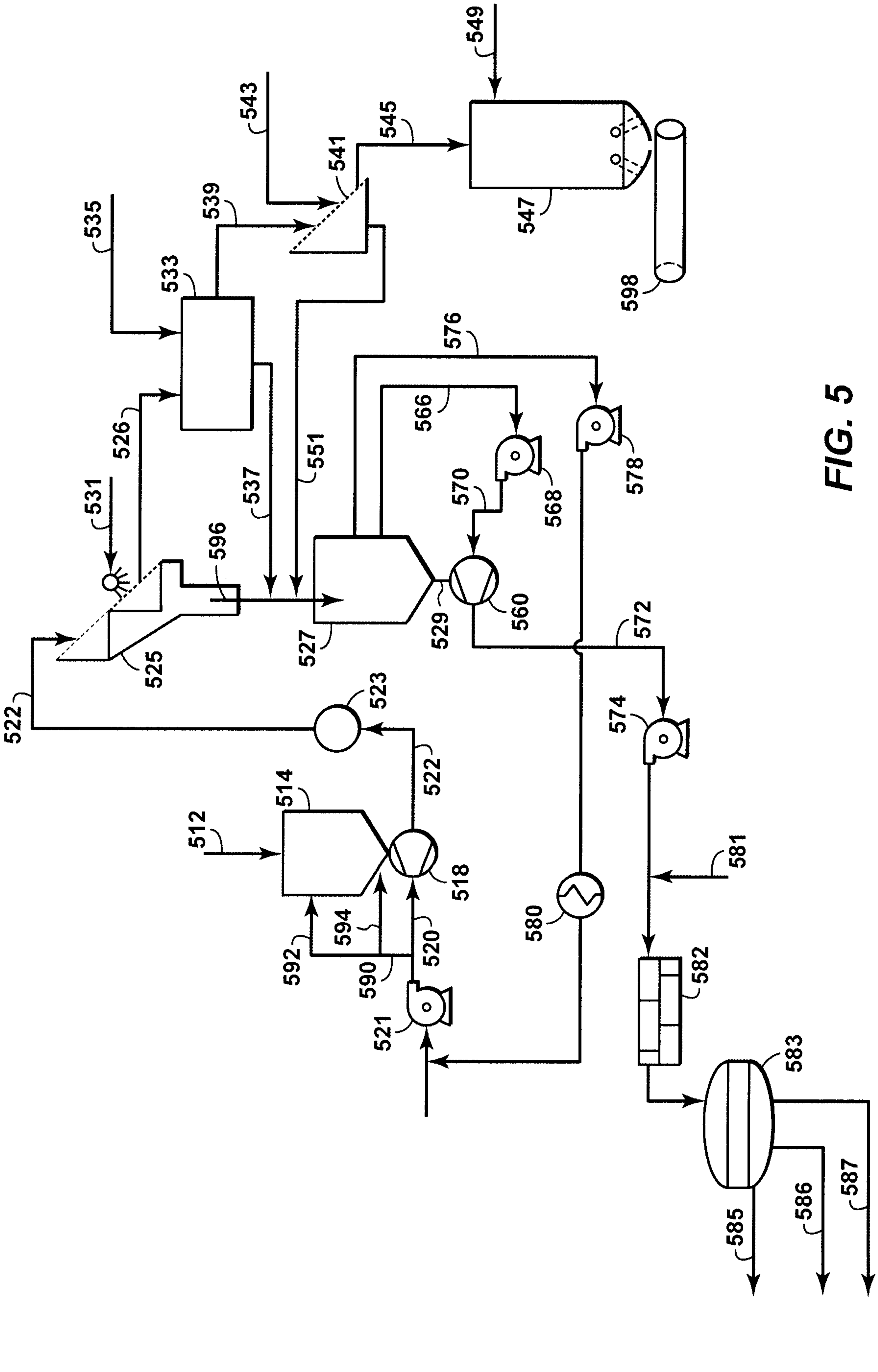

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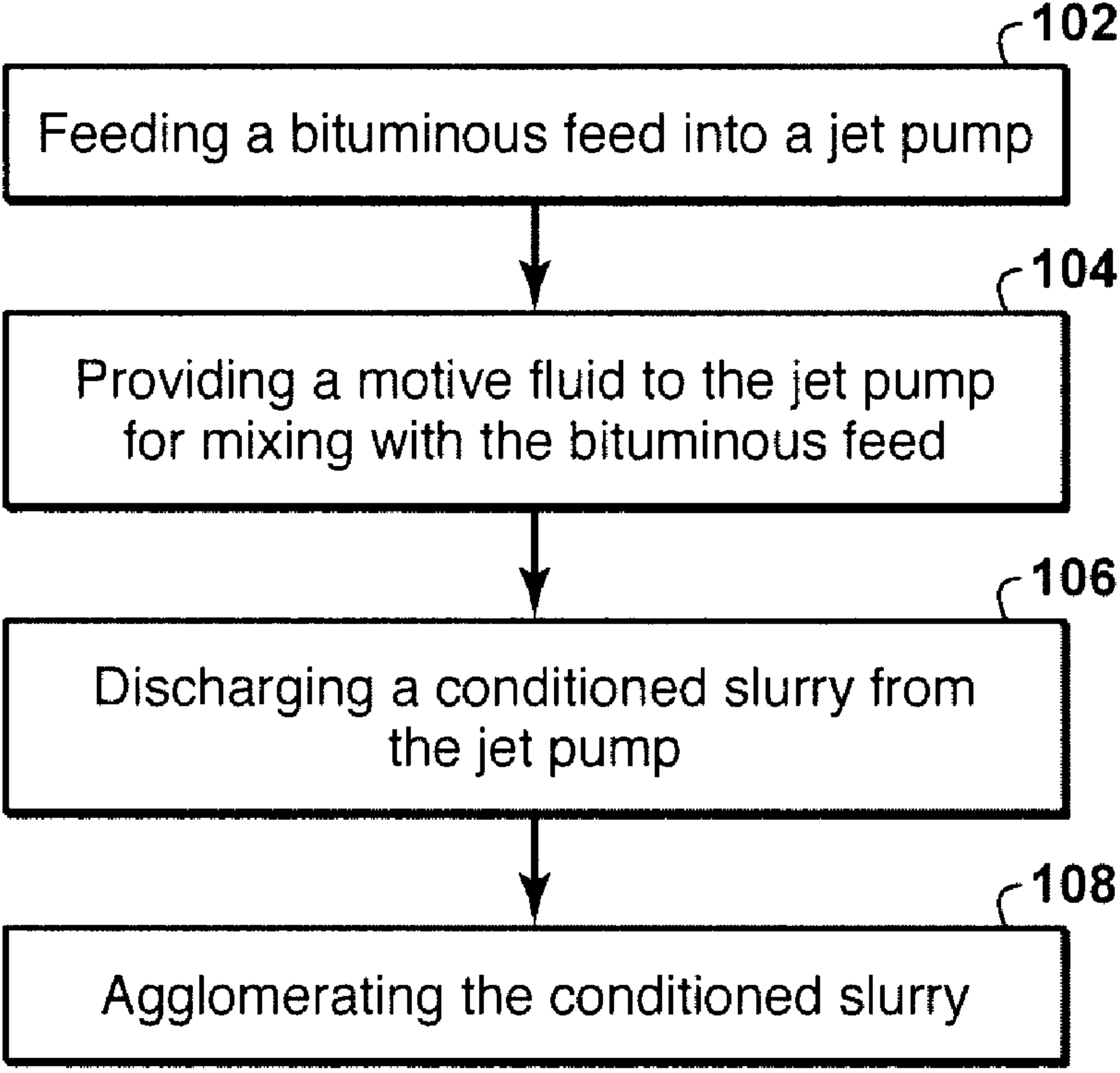
FIG. 5


102
Feeding a bituminous feed into a jet pump
104
Providing a motive fluid to the jet pump for mixing with the bituminous feed
106
Discharging a conditioned slurry from the jet pump
108
Agglomerating the conditioned slurry