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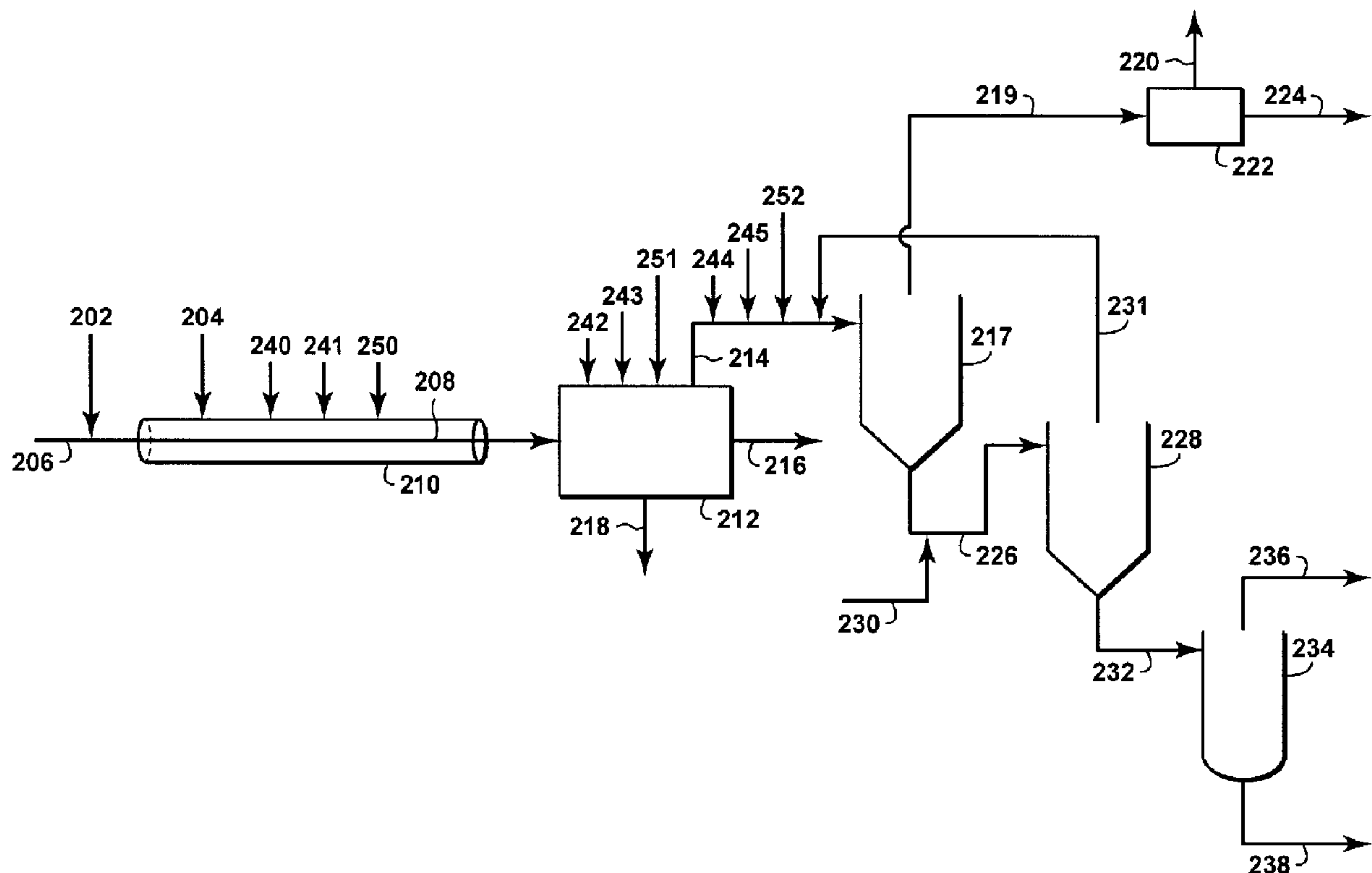
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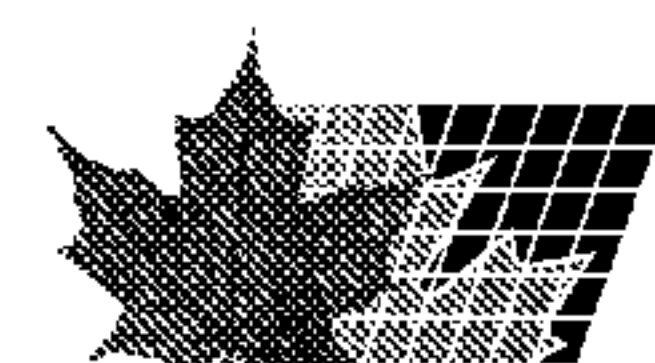
(54) **Titre :** TRAITEMENT DE FLUX DE SABLES BITUMINEUX PAR MICRO AGGLOMERATION INDUITE CHIMIQUEMENT

(54) **Title:** PROCESSING OF OIL SAND STREAMS VIA CHEMICALLY-INDUCED MICRO-AGGLOMERATION



(57) **Abrégé/Abstract:**

Disclosed is a method comprising providing an oil sand stream comprising bitumen, solids, and water; conditioning the oil sand stream with an aluminate to produce a conditioned stream; treating the conditioned stream with a silicate to produce a treated stream comprising chemically-induced micro-agglomerates to assist bitumen extraction or froth cleaning; and processing the treated stream to form a bitumen stream and a tailings stream.



ABSTRACT

Disclosed is a method comprising providing an oil sand stream comprising bitumen, solids, and water; conditioning the oil sand stream with an aluminate to produce a conditioned stream; treating the conditioned stream with a silicate to produce a treated stream comprising chemically-induced micro-agglomerates to assist bitumen extraction or froth cleaning; and processing the treated stream to form a bitumen stream and a tailings stream.

**PROCESSING OF OIL SAND STREAMS
VIA CHEMICALLY-INDUCED MICRO-AGGLOMERATION**

BACKGROUND

Field of Disclosure

[0001] The disclosure relates generally to the field of oil sand processing.

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.

[0004] Recently, the harvesting of oil sand to remove heavy oil has become more economical. Hydrocarbon removal from oil sand may be performed by several techniques. For example, a well can be drilled to an oil sand reservoir and steam, hot air, solvents, or a combination thereof, can be injected to release the hydrocarbons. The released hydrocarbons may be collected by wells and brought to the surface. In another technique, strip or surface mining may be performed to access the oil sand, which can be treated with water, steam or solvents to extract the heavy oil.

[0005] Oil sand extraction processes are used to liberate and separate bitumen from oil sand so that the bitumen can be further processed to produce synthetic crude oil or mixed with diluent to form “dilbit” and be transported to a refinery plant. Numerous oil sand extraction processes have been developed and commercialized, many of which involve the use of water as a processing medium. Where the oil sand is treated with water, the technique may be referred to as water-based extraction (WBE). WBE is a commonly used process to extract bitumen from mined oil sand. Other processes are non-aqueous solvent-based processes. An example of a solvent-based process is described in Canadian Patent Application No. 2,724,806 (Adeyinka *et al*, published June 30, 2011 and entitled “Process and Systems for Solvent Extraction of Bitumen from Oil Sands”). Solvent may be used in both aqueous and non-aqueous processes.

[0006] One WBE process is the Clark hot water extraction process (the “Clark Process”). This process typically requires that mined oil sand be conditioned for extraction by being crushed to a desired lump size and then combined with hot water and perhaps other agents to form a conditioned slurry of water and crushed oil sand. In the Clark Process, an amount of sodium hydroxide (caustic) may be added to the slurry to increase the slurry pH, which enhances the liberation and separation of bitumen from the oil sand. Other WBE processes may use other temperatures and may include other conditioning agents, which are added to the oil sand slurry, or may operate without conditioning agents. This slurry is first processed in a Primary Separation Cell (PSC), also known as a Primary Separation Vessel (PSV), to extract the bitumen from the slurry.

[0007] In one bitumen extraction process, a water and oil sand slurry is separated into three major streams in the PSC: bitumen froth, middlings, and a PSC underflow. As discussed further below, the bitumen froth may undergo froth treatment with a solvent.

[0008] From the PSC, the middlings, comprising bitumen and about 5-25 wt. % solids, based on the total wt. % of the middlings, is withdrawn and sent to the flotation cells to further recover bitumen. The middlings are processed by bubbling air through the slurry and creating a bitumen froth, which is recycled back to the PSC. Flotation tailings (FT) from the

flotation cells, comprising mostly solids and water, are sent for further treatment or disposed in an external tailings area (ETA).

[0009] In ETA tailings ponds, a liquid suspension of oil sand fines in water with a solids content greater than 2 wt. %, but less than the solids content corresponding to the Liquid Limit are called Fluid Fine Tailings (FFT). FFT settle over time to produce Mature Fine Tailings (MFT), having above about 30 wt. % solids.

[0010] Regardless of the type of WBE process employed, the process will typically result in the production of a bitumen froth that requires treatment with a solvent. For example, in the Clark Process, a bitumen froth comprises bitumen, solids, and water. Certain processes use naphtha to dilute bitumen froth before separating the product bitumen by centrifugation. These processes are called naphtha froth treatment (NFT) processes. Other processes use a paraffinic solvent, and are called paraffinic froth treatment (PFT) processes, to produce pipelineable bitumen with low levels of solids and water. In the PFT process, a paraffinic solvent (for example, a mixture of iso-pentane and n-pentane) is used to dilute the froth before separating the product, diluted bitumen, by gravity. A portion of the asphaltenes in the bitumen is also rejected by design in the PFT process and this rejection is used to achieve reduced solids and water levels. In both the NFT and the PFT processes, the diluted tailings (comprising water, solids and some hydrocarbon) are separated from the diluted product bitumen.

[0011] Solvent is typically recovered from the diluted product bitumen component before a resultant bitumen stream is delivered to a refining facility for further processing.

[0012] The PFT process may comprise at least three units: Froth Separation Unit (FSU), Solvent Recovery Unit (SRU) and Tailings Solvent Recovery Unit (TSRU). Mixing of the solvent with the feed bitumen froth may be carried out counter-currently in two stages in separate froth separation units. The bitumen froth comprises bitumen, water, and solids. A typical composition of bitumen froth is about 60 wt. % bitumen, 30 wt. % water, and 10 wt. % solids. The paraffinic solvent is used to dilute the froth before separating the product bitumen

by gravity. The foregoing is only an example of a PFT process and the values are provided by way of example only. An example of a PFT process is described in Canadian Patent No. 2,587,166 to Sury.

[0013] It would be desirable to have an alternative or improved method of processing an oil sand stream.

SUMMARY

[0014] It is an object of the present disclosure to provide a method of processing an oil sand stream.

[0015] Disclosed is a method comprising providing an oil sand stream comprising bitumen, solids, and water; conditioning the oil sand stream with an aluminate to produce a conditioned stream; treating the conditioned stream with a silicate to produce a treated stream comprising chemically-induced micro-agglomerates to assist bitumen extraction or froth cleaning; and processing the treated stream to form a bitumen stream and a tailings stream.

[0016] 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

[0017] 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.

[0018] Fig. 1 is a flow chart of a method of processing an oil sand stream.

[0019] Fig. 2 is a flow diagram of a method of processing an oil sand stream.

[0020] 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

[0021] 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.

[0022] 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.

[0023] Throughout this disclosure, where a range is used, any number between or inclusive of the range is implied.

[0024] A “hydrocarbon” is an organic compound that primarily includes the elements of hydrogen and carbon, although nitrogen, sulfur, oxygen, metals, or any number of other elements may be present in small amounts. Hydrocarbons generally refer to components found in heavy oil or in oil sand. However, the techniques described are not limited to heavy oils but may also be used with any number of other reservoirs to improve gravity drainage of

liquids. Hydrocarbon compounds may be aliphatic or aromatic, and may be straight chained, branched, or partially or fully cyclic.

[0025] “Bitumen” is a naturally occurring heavy oil material. Generally, it is the hydrocarbon component found in oil sand. Bitumen can vary in composition depending upon the degree of loss of more volatile components. It can vary from a very viscous, tar-like, semi-solid material to solid forms. The hydrocarbon types found in bitumen can include aliphatics, aromatics, resins, and asphaltenes. A typical bitumen might be composed of:

- 19 weight (wt.) % aliphatics (which can range from 5 wt. % - 30 wt. %, or higher);
- 19 wt. % asphaltenes (which can range from 5 wt. % - 30 wt. %, or higher);
- 30 wt. % aromatics (which can range from 15 wt. % - 50 wt. %, or higher);
- 32 wt. % resins (which can range from 15 wt. % - 50 wt. %, or higher); and
- some amount of sulfur (which can range in excess of 7 wt. %), the weight % based upon total weight of the bitumen.

In addition, bitumen can contain some water and nitrogen compounds ranging from less than 0.4 wt. % to in excess of 0.7 wt. %. 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.

[0026] “Heavy oil” includes oils which are classified by the American Petroleum Institute (“API”), as heavy oils, extra heavy oils, or bitumens. The term “heavy oil” includes bitumen. Heavy oil may have a viscosity of about 1,000 centipoise (cP) or more, 10,000 cP or more, 100,000 cP or more, or 1,000,000 cP or more. In general, a heavy oil has an API gravity between 22.3° API (density of 920 kilograms per meter cubed (kg/m^3) or 0.920 grams per centimeter cubed (g/cm^3)) and 10.0° API (density of 1,000 kg/m^3 or 1 g/cm^3). An extra heavy oil, in general, has an API gravity of less than 10.0° API (density greater than 1,000 kg/m^3 or 1 g/cm^3). For example, a source of heavy oil includes oil sand or bituminous sand, which is a combination of clay, sand, water and bitumen. The recovery of heavy oils is based on the viscosity decrease of fluids with increasing temperature or solvent concentration. Once the viscosity is reduced, the mobilization of fluid by steam, hot water flooding, or gravity is

possible. The reduced viscosity makes the drainage or dissolution quicker and therefore directly contributes to the recovery rate.

[0027] “Fine particles” or “fines” are generally defined as those solids having a size of less than 44 microns (μm), as determined by laser diffraction particle size measurement.

[0028] “Coarse particles” are generally defined as those solids having a size of greater than 44 microns (μm), as determined by laser diffraction particle size measurement.

[0029] The term “solvent” as used in the present disclosure should be understood to mean either a single solvent, or a combination of solvents.

[0030] 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.

[0031] 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.

[0032] The term “paraffinic solvent” as used herein means solvents comprising normal paraffins, isoparaffins or blends thereof in amounts greater than 50 wt. %. Presence of other components such as olefins, aromatics or naphthenes may counteract the function of the paraffinic solvent and hence may be present in an amount of only 1 to 20 wt. % combined, for instance no more than 3 wt. %. The paraffinic solvent may be a C_4 to C_{20} or C_4 to C_6 paraffinic hydrocarbon solvent or a combination of iso and normal components thereof. The paraffinic solvent may comprise pentane, iso-pentane, or a combination thereof. The

paraffinic solvent may comprise about 60 wt. % pentane and about 40 wt. % iso-pentane, with none or less than 20 wt. % of the counteracting components referred above.

[0033] The ease of separation of bitumen from solids is a function of bitumen and fines content. Generally, the higher the bitumen content and the lower the fines content, the easier it is to extract bitumen from the oil sand. Oil sand that is high in bitumen content and low in fines content are termed “good processing ores”. High fines, low bitumen ores typically yield low bitumen recoveries by conventional methods and are termed “poor processing ores”. The low bitumen recovery may at least partially be attributed to slimes coating the bitumen surfaces which inhibit bitumen-air attachment. Conventionally, caustic plays a role in the dispersion of fines from bitumen, thereby improving bitumen recovery and froth quality by promoting the release of natural surfactants from bitumen to the aqueous phase, precipitating divalent cations such as calcium and magnesium, and modifying the electrical surface potential of bitumen and solids, rendering the solids more hydrophilic. Despite the benefits of caustic, extraction of poor processing ores can be a challenge due to reduction in the bitumen-air attachment as a result of the surface of bitumen and air bubbles being covered by clay fines. Generally, the higher the fines content, the higher the caustic dosage required to disperse the fines. Because higher caustic addition may hinder settling of fines and tailings treatment and may also complicate froth treatment by emulsifying bitumen, reducing caustic addition may be desirable.

[0034] The present disclosure provides a method of processing an oil sand stream. The present disclosure provides a method in which chemically-induced micro-agglomerates (CIMA) are formed in an oil sand stream. With reference to Figure 1, the method may comprise providing (102) an oil sand stream comprising bitumen, solids, and water; conditioning (104) the oil sand stream with an aluminate to produce a conditioned stream; treating (106) the conditioned stream with a silicate to produce a treated stream comprising chemically-induced micro-agglomerates to assist bitumen extraction or froth cleaning; and processing (108) the treated stream to form a bitumen stream and a tailings stream.

[0035] Without being bound by theory or promise, by adding aluminate and silicate to the oil sand stream, the CIMA may be more easily agglomerated or flocculated, for instance using an agglomerating or flocculating polymer. With improved agglomeration, bitumen recovery may be improved by reducing slime coating while improving fines settling velocity. The use of caustic alone may fail to provide acceptable bitumen recovery and/or froth quality for high fines ores.

[0036] The following potential benefits may be realized by methods described herein.

[0037] The combined use of aluminate and silicate may yield micro-agglomerates of fines which scavenge fine silica and clays from bitumen surfaces, thereby reducing slime coating while increasing bitumen liberation and recovery.

[0038] The agglomerates may have higher settling velocities compared to dispersed fines, and flocculation of the micro-agglomerates may further increase fines separation.

[0039] The addition of an aluminate and caustic may have a synergistic effect, improving bitumen recovery and froth quality in poor processing ores and good ores due to increased fines dispersion by the caustic followed by charge neutralization by the reaction of the trivalent ions and the negatively charged fines.

[0040] The tailings generated from the flocculation of CIMA may have better settling, dewatering, and may tend to form higher strength deposits.

[0041] The “oil sand stream” is any suitable stream stemming from oil sand and comprising bitumen, solids, and water. For instance, the oil sand stream may be crushed oil sand with added water and/or one or more conditioning agents. As discussed herein, a water based extraction (WBE) followed by paraffinic froth treatment (PFT) may comprise conditioning, primary separation, and froth treatment in that order; the “oil sand stream” may be the bitumen-rich stream during these steps, prior to solvent addition in the froth treatment. The “oil sand stream” may be, for instance, within a hydrotransport pipeline (or mixing vessel), between a hydrotransport pipeline (or mixing vessel) and a primary separation

process, within the primary separation process, or a bitumen froth between a primary separation process and froth treatment. However, the “oil sand stream” is not a tailings stream. The oil sand stream may comprise at least 5 weight % bitumen, based on a total weight of the oil sand stream.

[0042] Figure 2 illustrates a method for processing an oil sand stream to yield a bitumen stream and a tailings stream. Hot water (202) and conditioning agents (204) are added to mined crushed oil sand (206) to form an oil sand stream (208). The oil sand stream (208) is flowed in a hydrotransport pipeline (210) to a primary separation cell (PSC) (212). The PSC (212) produces bitumen froth (214), middlings (216), and a PSC underflow (218) also known as coarse tailings. The bitumen froth (214) is treated in froth treatment. A known paraffinic froth treatment (PFT) is illustrated in Figure 2. As illustrated in Figure 2, froth treatment may include adding the bitumen froth (214) into a first froth settling unit (FSU-1) (217). FSU-1 overflow is a diluted bitumen product (219) from which solvent (220) is removed in a solvent recovery unit (SRU) (222) yielding a bitumen stream (224). FSU-1 underflow (226) is sent to a second FSU (FSU-2) (228) with a paraffinic solvent (230). FSU-2 overflow (231) is passed upstream to FSU-1 (217) with the bitumen froth (214). FSU-2 underflow (232) is passed to a tailings solvent recovery unit (TSRU) (234) to remove solvent (236) yielding a tailings stream (238).

[0043] The aluminate and silicate addition are illustrated in Figure 2 in three locations by way of example, namely within the hydrotransport pipeline (210) (aluminate addition (240) and silicate addition (241)), within the primary separation (aluminate addition (242) and silicate addition (243)), and to the bitumen froth (214) (aluminate addition (244) and silicate addition (245)) between the primary separation process and froth treatment. The number of aluminate and silicate addition points may be one or more than one. The aluminate may be added before, or concurrently, with the silicate. Some silicate may also be added before the aluminate to disperse ultrafines from the bitumen.

[0044] The aluminate and/or silicate may be added at the site of, in addition to or instead of, caustic addition, which may be added along with the water in the ore preparation as the oil sand stream enters hydrotransport.

[0045] The chemically-induced micro-agglomerates are predominately much less than 1 mm in diameter, with the weight majority between 2 and 100 microns, and they principally comprise fine particles of the oil sand.

[0046] The oil sand stream may be of poor quality, such as one having a fines content above 8 weight % or a bitumen content below 15 weight %, both based on a weight of the oil sand stream.

[0047] The aluminate used for conditioning the oil sand stream to produce a conditioned stream may comprise sodium aluminate or a similar species including, but not limited to, potassium aluminate, aluminum sulfate, aluminum oxide, aluminum chloride, polyaluminum chloride, polyaluminum sulfate, or a mixture thereof. In alkaline environments (e.g. oil sand streams), fine particles and clays carry a negative charge characterized by a negative zeta potential. Aluminate complexes can neutralize the negative charge and form a layer of coating around the fine particles and clays. When this occurs, natural coagulation begins due to van der Waals interactions. 1 to 500 ppmw of elemental Al in the form of aluminate may be added to the oil sand stream.

[0048] The silicate used for treating the conditioned stream to produce a treated stream comprising chemically-induced micro-agglomerates may be a polysilicate. The polysilicate may be sodium silicate, potassium silicate, or a mixture thereof. The silicate may comprise colloidal silica. The colloidal silica may comprise cationic silica, anionic silica, modified colloidal silica, ammonium silica, low sodium silicate, or a mixture thereof. The colloidal silica may be 7 to 50 nm, with a surface area between 60 and 400 m²/g SiO₂. The colloidal silica may be 7 nm with a surface area between 320 and 400 m²/g SiO₂, 12 nm with a surface area of between 198 and 258 m²/g SiO₂, 22 nm with a surface area between 110 and 150 m²/g SiO₂, 50 nm with a surface area between 60 and 90 m²/g SiO₂, or a combination

thereof. In the treating stage, a series of polycondensation reactions begin to occur as soluble silica reacts instantaneously or quickly with aluminate complexes to form a stable, chemical bond. The net effect of this in situ bonding is the rearrangement of the fine particles and clays into a chemically-induced micro-agglomerate (CIMA). 1 to 500 ppmw of elemental Si in the form of silicate may be added to the conditioned stream.

[0049] The aluminate may comprise sodium aluminate and the silicate may comprise colloidal silica.

[0050] An organic agglomerating polymer may be added to the treated steam to assist in agglomerating solids by forming macro-agglomerates. In Figure 2, the agglomerating polymer is shown by three addition streams (250, 251, and 252). The “macro-agglomerates” are generally greater than 500 microns, up to millimeters in size. These “macro-agglomerates” comprise both the fine particles and sand grains of the oil sand. The organic agglomerating polymer may comprise a flocculating polymer. The flocculating polymer may comprise a synthetic polymer. The synthetic polymer may be polyacrylamide (PAM) or polyethylene oxide. The flocculating polymer may comprise a natural polymer. The natural polymer may be starch. The organic agglomerating polymer may be a cationic, anionic, nonionic or amphoteric polyacrylamide, a copolymer of acrylamide and diallyl dimethyl ammonium chloride, a copolymer of acrylamide and diallylaminoalkyl (meth) acrylates, a copolymer of acrylamide and dialkyldiaminoalkyl (meth) acrylamide, or a mixture thereof. 1 to 500 ppmw of flocculating polymer may be added to the treated stream.

[0051] Caustic soda or sodium citrate may be added to the oil sand stream prior to the conditioning with the aluminate for increasing the oil sand stream’s pH level and dispersing fines from bitumen.

[0052] A pH modifier may be added to the oil sand stream to assist agglomeration. The pH modifier may be an organic or inorganic acid, or carbon dioxide.

[0053] The treated stream may be mixed by hydrotransport in a pipeline or turbulence in a primary separation cell (PSC) feedwell.

[0054] The step of processing the treated stream to form a bitumen stream and a tailings stream may comprise recycling at least one oil sand bitumen containing tailings stream back into the oil sand steam prior to the aluminate addition to assist bitumen recovery or fines treatment.

[0055] The aluminate and silicate may be added upstream of bitumen froth treatment.

[0056] The aluminate and silicate may be added into a primary separation cell (PSC) for separating the oil sand stream. Bitumen froth from the PSC may be treated to produce the bitumen product, for instance using paraffinic froth treatment (PFT).

[0057] The aluminate and silicate may be added during hydrotransport of the oil sand stream.

[0058] Following hydrotransport, the treated stream may be introduced into a primary separation cell (PSC) for separating the treated stream. The bitumen froth from the PSC may be treated to produce the bitumen stream, for instance using paraffinic froth treatment (PFT).

[0059] 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 method comprising:
 - a. providing an oil sand stream comprising bitumen, solids, and water;
 - b. conditioning the oil sand stream with an aluminate to produce a conditioned stream;
 - c. treating the conditioned stream with a silicate to produce a treated stream comprising chemically-induced micro-agglomerates to assist bitumen extraction or froth cleaning; and
 - d. processing the treated stream to form a bitumen stream and a tailings stream.
2. The method of claim 1, wherein the oil sand stream has a fines content above 8 weight % or a bitumen content below 15 weight %, both based on a weight of the oil sand stream.
3. The method of claim 1 or 2, wherein the silicate is a polysilicate.
4. The method of claim 3, wherein the polysilicate is sodium silicate, potassium silicate, or a mixture thereof.
5. The method of claim 1, wherein the silicate comprises colloidal silica.
6. The method of claim 5, wherein the colloidal silica comprises cationic silica, anionic silica, modified colloidal silica, ammonium silica, low sodium silicate, or a mixture thereof.
7. The method of claim 5, wherein the colloidal silica is 7 to 50 nm, with a surface area between 60 and 400 m²/g SiO₂.
8. The method of claim 5, wherein the colloidal silica is 7 nm with a surface area between 320 and 400 m²/g SiO₂, 12 nm with a surface area of between 198 and 258 m²/g

SiO₂, 22 nm with a surface area between 110 and 150 m²/g SiO₂, 50 nm with a surface area between 60 and 90 m²/g SiO₂, or a combination thereof.

9. The method of any one of claims 1 to 8, wherein the aluminate comprises sodium aluminate.

10. The method of any one of claims 1 to 8, wherein the aluminate is potassium aluminate, aluminum sulfate, aluminum oxide, aluminum chloride, polyaluminum chloride, polyaluminum sulfate, or a mixture thereof.

11. The method of claim 1, wherein the aluminate comprises sodium aluminate and the silicate comprises colloidal silica.

12. The method of any one of claims 1 to 11, further comprising adding an organic agglomerating polymer to the treated steam.

13. The method of claim 12, wherein the organic agglomerating polymer comprises a flocculating polymer.

14. The method of claim 13, wherein the flocculating polymer comprises a synthetic polymer.

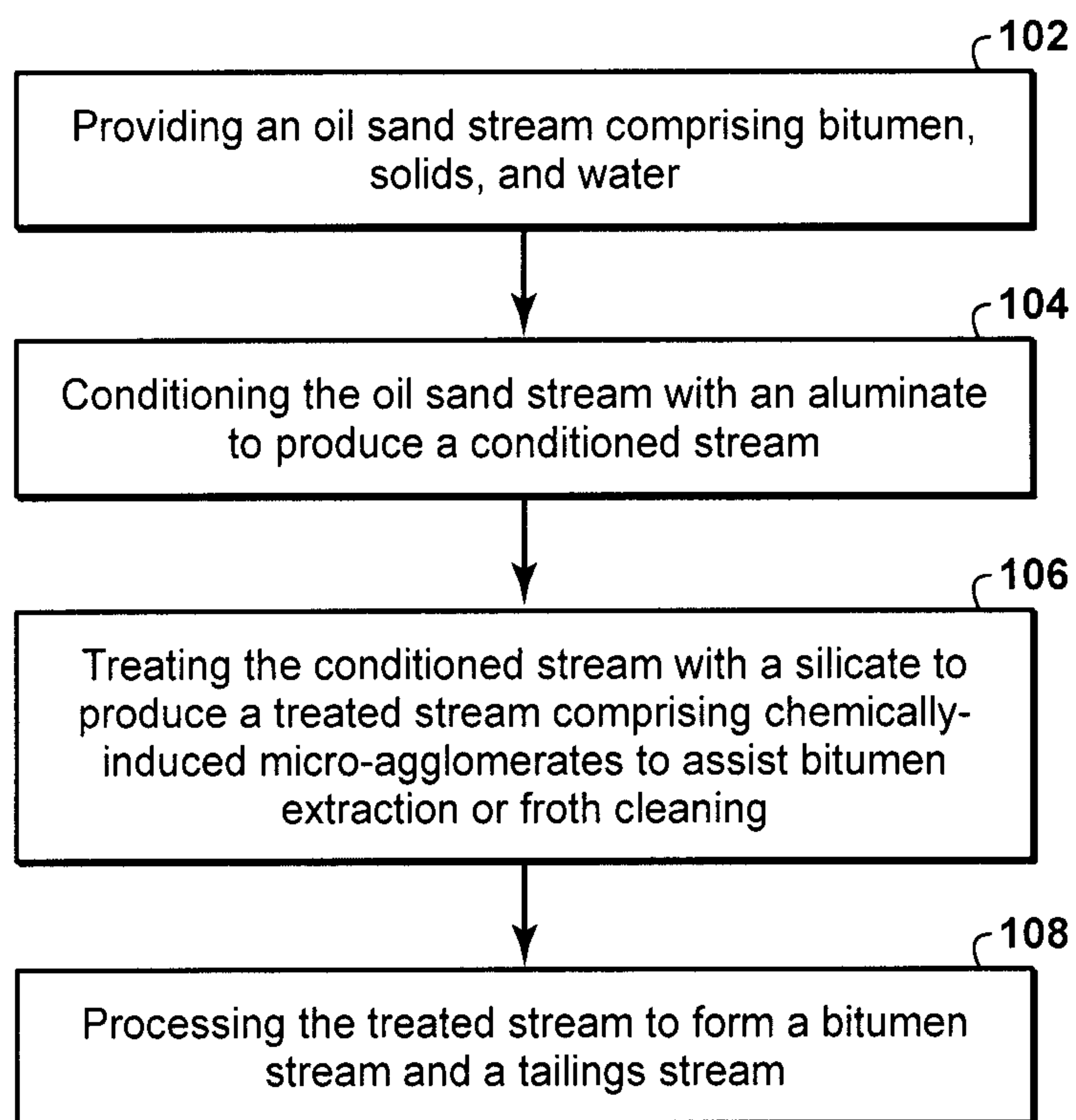
15. The method of claim 14, wherein the synthetic polymer is polyacrylamide (PAM) or polyethylene oxide.

16. The method of claim 13, wherein the flocculating polymer comprises a natural polymer.

17. The method of claim 16, wherein the natural polymer is starch.

18. The method of claim 12, wherein the organic agglomerating polymer is a cationic, anionic, nonionic or amphoteric polyacrylamide, a copolymer of acrylamide and diallyl dimethyl ammonium chloride, a copolymer of acrylamide and diallylaminoalkyl (meth) acrylates, a copolymer of acrylamide and dialkyldiaminoalkyl (meth) acrylamide, or a mixture thereof.
19. The method of any one of claims 13 to 17, wherein 1 to 500 ppmw of the flocculating polymer is added.
20. The method of claim 1, further comprising adding caustic soda or sodium citrate to the oil sand stream prior to the conditioning with the aluminate for increasing the oil sand stream's pH level and dispersing fines from bitumen.
21. The method of any one of claims 1 to 19, further comprising adding a pH modifier to the oil sand stream to assist agglomeration.
22. The method of claim 21, wherein the pH modifier is an organic or inorganic acid, or carbon dioxide.
23. The method of any one of claims 1 to 22, wherein 1 to 500 ppmw of elemental Al in the form of aluminate is added.
24. The method of any one of claims 1 to 23, wherein 1 to 500 ppmw of elemental Si in the form of silicate is added.
25. The method of any one of claims 1 to 24, wherein step d) comprises mixing the treated stream by hydrotransport in a pipeline or turbulence in a primary separation cell (PSC) feedwell.

26. The method of any one of claims 1 to 24, further comprising recycling at least one oil sand bitumen containing tailings stream back into the oil sand stream prior to the aluminate addition to assist bitumen recovery or fines treatment.
27. The method of any one of claims 1 to 24, wherein the aluminate and silicate are added upstream of bitumen froth treatment.
28. The method of any one of claims 1 to 24, wherein the aluminate and silicate are added into a primary separation cell (PSC) for separating the oil sand stream.
29. The method of claim 28, further comprising treating bitumen froth from the PSC to produce the bitumen product.
30. The method of any one of claims 1 to 24, wherein the aluminate and silicate are added during hydrotransport of the oil sand stream.
31. The method of claim 30, further comprising, following hydrotransport, introducing the treated stream into a primary separation cell (PSC) for separating the treated stream.
32. The method of claim 31, further comprising treating bitumen froth from the PSC to produce the bitumen stream.
33. The method of claim 29 or 32, wherein the treating bitumen froth comprises paraffinic froth treatment.

1/2**FIG. 1**

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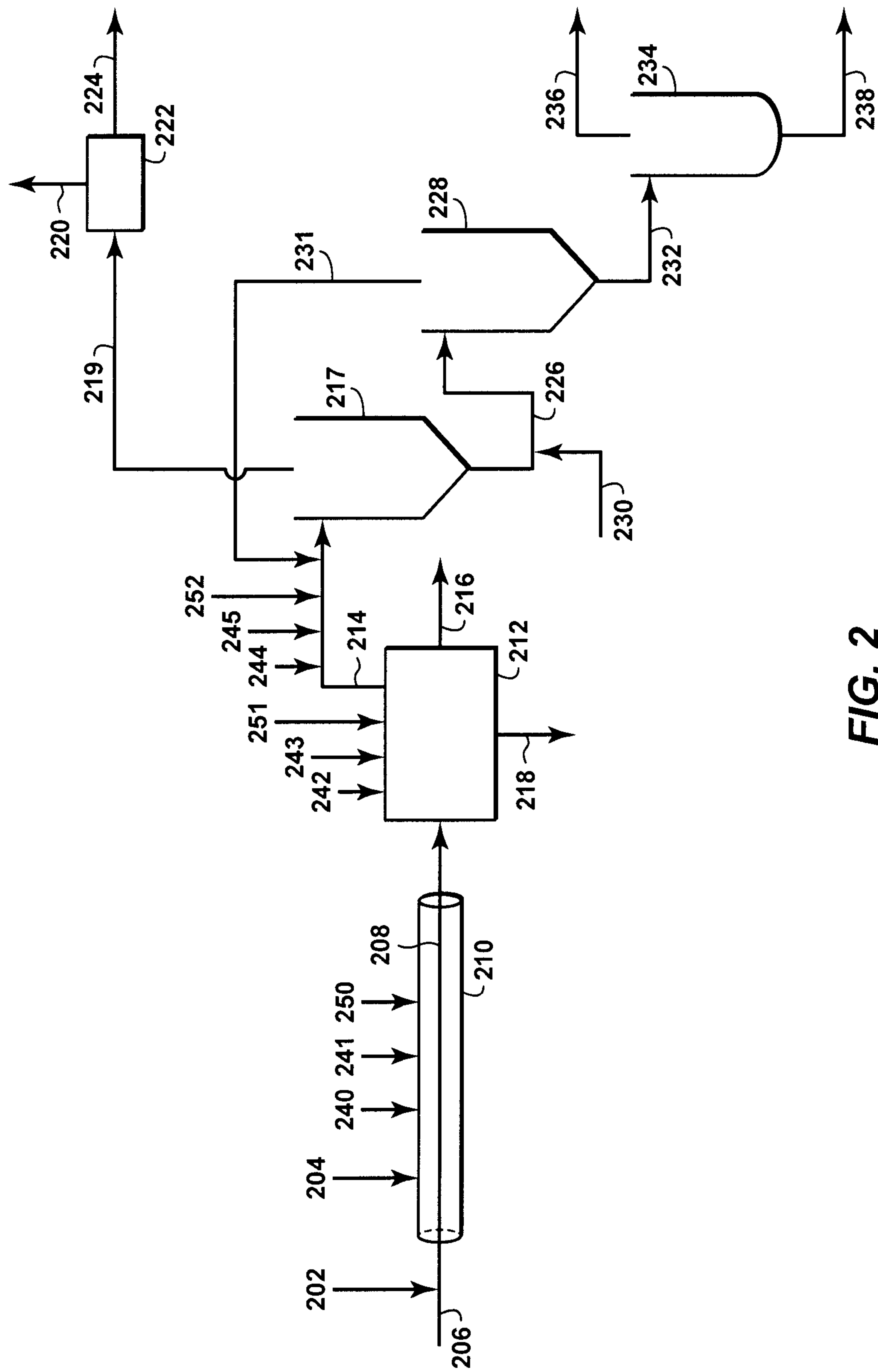


FIG. 2

