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(54) **Titre : TRAITEMENT DE MOUSSE PARAFFINIQUE A AGREGATION CONTROLEE**
(54) **Title: PARAFFINIC FROTH TREATMENT WITH CONTROLLED AGGREGATION**

(57) **Abrégé/Abstract:**

Described is a method of processing a bitumen froth comprising bitumen, water, coarse solids, and fines, the method comprising: producing a pre-treated bitumen froth by adding a seeding stream comprising asphaltene-mineral solids to the bitumen froth, the asphaltene-mineral solids being for seeding asphaltene precipitation and for controlling asphaltene precipitate morphology; producing a diluted pre-treated bitumen froth by adding paraffinic solvent to the pre-treated bitumen froth; and forming an overflow and an underflow by gravity separating the diluted pre-treated bitumen froth.



ABSTRACT

Described is a method of processing a bitumen froth comprising bitumen, water, coarse solids, and fines, the method comprising: producing a pre-treated bitumen froth by adding a seeding stream comprising asphaltene-mineral solids to the bitumen froth, the asphaltene-mineral solids being for seeding asphaltene precipitation and for controlling asphaltene precipitate morphology; producing a diluted pre-treated bitumen froth by adding paraffinic solvent to the pre-treated bitumen froth; and forming an overflow and an underflow by gravity separating the diluted pre-treated bitumen froth.

PARAFFINIC FROTH TREATMENT WITH CONTROLLED AGGREGATION

BACKGROUND

Field of Disclosure

[0001] The disclosure relates generally to the field of oil sand processing. More specifically, the disclosure relates to paraffinic froth treatment.

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. 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.

[0005] In an example of WBE, mined oil sands are mixed with water to create a slurry suitable for extraction. Caustic may be added to adjust the slurry pH to a desired level and thereby enhance the efficiency of the separation of bitumen.

[0006] Regardless of the type of WBE employed, the extraction process will typically result in the production of a bitumen froth comprising bitumen, water, and solids and a tailings stream comprising solids and water. The tailings stream may consist essentially of coarse solids and some fines and water. A typical composition of bitumen froth may be about 60 weight (wt.) % bitumen, 30 wt. % water, and 10 wt. % solids. A bitumen froth may be, for instance, 40-80 wt. % bitumen, 10-50 wt. % water, and 2-30 wt. % (or 5-15 wt. %) solids. The water and solids in the froth are considered as contaminants. The contaminants may be substantially eliminated or reduced to a level suitable for feed to an oil refinery or an upgrading facility, respectively. Elimination or reduction of the contaminants may be referred to as a froth treatment process. Elimination or reduction of the contaminants may be achieved by diluting the bitumen froth with a solvent. The solvent may comprise any suitable solvent, such as an organic solvent. For example, the organic solvent may comprise naphtha solvent and/or paraffinic solvent. Diluting the bitumen with solvent (also referred to as dilution) may increase the density differential between bitumen and water and solids. Diluting the bitumen with solvent may enable the elimination or reduction of contaminants using multi-stage gravity settlers. Use of the multi-stage gravity settlers may result in a "diluted bitumen froth" and another tailings stream. The another tailings stream may be commonly referred to as the froth treatment tailings. The froth treatment tailings may comprise residual bitumen, residual solvent, solids and water. The froth treatment tailings stream may be further processed to recover residual solvent, for instance in a tailings solvent recovery unit (TSRU). If the solvent is paraffinic solvent, the froth treatment tailings may be referred to as "paraffinic froth treatment tailings" and comprise precipitated asphaltenes.

[0007] Figure 1 is a flow diagram of a conventional paraffinic froth treatment (PFT). Bitumen froth (2) is added to a froth setting unit (FSU-1) (4) to produce a hydrocarbon-rich overflow (6) and a solids-rich underflow (8). Solvent (not shown) is removed from the hydrocarbon-rich overflow (6) to produce a bitumen product (not shown). Solvent (10) is added to the solids-rich underflow (8) and is fed to another froth settling unit (FSU-2) (12). FSU-2 (12) produces a second hydrocarbon-rich overflow (14) and a second solids-rich underflow (16). The second hydrocarbon-rich overflow (14) is added to the FSU-1 (4) as the solvent source and may be combined with the bitumen froth (2) before its addition to the FSU-1 (4), as illustrated. The second solids-rich underflow (16) may be combined with dilution water (18) and passed to a tailings solvent recovery unit (TSRU) (20). The TSRU produces a solvent stream (22) and tailings (24).

[0008] At a high level, PFT serves to separate water and solids from the bitumen. Most of the water and solids, along with precipitated asphaltenes, end up in the tailings. The degree of bitumen recovery is therefore an important parameter in PFT. Solvent recovery is another important parameter in PFT.

[0009] There is a need for an alternative or improved paraffinic froth treatment to recover bitumen.

SUMMARY

[0010] It is an object of the present disclosure to provide a paraffinic froth treatment to recover bitumen.

[0011] Described is a method of processing a bitumen froth comprising bitumen, water, coarse solids, and fines, the method comprising:

- a. producing a pre-treated bitumen froth by adding a seeding stream comprising asphaltene-mineral solids to the bitumen froth, the asphaltene-mineral solids being for seeding asphaltene precipitation and for controlling asphaltene precipitate morphology;

- b. producing a diluted pre-treated bitumen froth by adding paraffinic solvent to the pre-treated bitumen froth; and
- c. forming an overflow and an underflow by gravity separating the diluted pre-treated bitumen froth.

[0012] Also described is a method of processing a bitumen froth comprising bitumen, water, coarse solids, and fines, the method comprising:

- a. producing a pre-treated bitumen froth by adding a seeding stream comprising asphaltene-mineral solids to the bitumen froth, the asphaltene-mineral solids being for seeding asphaltene precipitation and for controlling asphaltene precipitate morphology, wherein the seeding stream comprises less than 5 weight % hydrocarbon liquid, based on a total weight of the seeding stream;
- b. producing a diluted pre-treated bitumen froth by adding paraffinic solvent to the pre-treated bitumen froth;
- c. forming an overflow and an underflow by gravity separating the diluted pre-treated bitumen froth;
- d. adding additional paraffinic solvent to the underflow and gravity separating a resulting stream to produce a second underflow and a second overflow;
- e. recycling the second overflow into step b) as a source of the paraffinic solvent; and
- f. removing at least a portion of the paraffinic solvent from the second underflow by vaporization in a tailings solvent recovery unit.

[0013] 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

[0014] 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.

[0015] Figure 1 is a flow diagram of a conventional paraffinic froth treatment.

[0016] Figure 2 is a flow chart of an embodiment of a paraffinic froth treatment described herein.

[0017] Figure 3 is a flow chart of an embodiment of a paraffinic froth treatment described herein.

[0018] Figure 4 is a flow diagram of an embodiment of a paraffinic froth treatment described herein.

[0019] Figure 5 is a bar graph showing a comparison of hydrocarbon carry-under in a pilot plant study of a process configuration shown in Figure 5 versus a conventional process.

[0020] Figure 6 is a flow diagram of an embodiment of a paraffinic froth treatment described herein.

[0021] Figure 7 is a flow diagram of an embodiment of a paraffinic froth treatment described herein.

[0022] 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

[0023] 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.

[0024] 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.

[0025] Throughout this disclosure, where a range is used, any number between or inclusive of the range is implied.

[0026] 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.

[0027] “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. %).

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.

[0028] “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.

[0029] “Fine particles”, “fine solids”, or “fines” are generally defined as those solids having a size of less than 44 microns (μm), that is, material that passes through a 325 mesh (44 micron).

[0030] “Coarse particles” or “coarse solids” are generally defined as those solids having a size of greater than 44 microns (μm).

[0031] The term “solvent” as used in the present disclosure should be understood to mean either a single solvent, or a combination of solvents.

[0032] 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.

[0033] 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.

[0034] 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 n-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.

[0035] The term “asphaltene-mineral solids” as used herein means asphaltenes precipitated on mineral solids.

[0036] In a conventional two-stage paraffinic froth treatment (PFT) as depicted in Figure 1, upon contacting with solvent, insoluble asphaltenes in the bitumen froth precipitate to form a solid phase. In the FSU-1, the precipitated asphaltenes, mineral solids, and water gravity separate from the hydrocarbon liquid phase and are removed through the underflow. Ideally, all of the liquid phase bitumen and solvent in the FSU-1 would be recovered in the overflow and only asphaltene solids, mineral solids, and water would be present in the FSU-1 underflow. However, in practice, some liquid hydrocarbon is carried down with the underflow. Some, but not all, of the hydrocarbon carried under in the FSU-1 is recovered by contacting with additional solvent and separated in the FSU-2. What is not recovered exists in the PFT process in the FSU-2 underflow and is sent to the TSRU. The hydrocarbon lost in the FSU-2 underflow is notable.

[0037] A majority of the hydrocarbon liquids carried under may be associated with the asphaltene solids, where the hydrocarbon liquid may be present within the macro- and micro-structure of the solid phase. These asphaltene solids may form when froth is contacted with solvent in inlet piping leading to the FSU-1. The precipitating asphaltenes may either form a solid asphaltene that grows from an asphaltene nucleation site or precipitate directly onto the surface of the mineral solids, forming an asphaltene-mineral solid. The structure and morphology of these solids may differ and depend on process variables such as solvent type, the amount of solvent relative to bitumen present at the time of contacting, froth composition, temperature, and mixing energy applied. Also, the structure of these solids could be influenced by solid surfaces available for the precipitated asphaltene to adsorb. By controlling the morphology of the precipitated asphaltene, the available volume/surface area for liquid hydrocarbon trapping could be reduced, thereby reducing the amount of hydrocarbons carried with the solid phase.

[0038] Without being bound by theory or promise, embodiments described herein may improve bitumen and/or solvent recovery of a conventional PFT process, by reducing the

amount of hydrocarbon carried under by controlling the solids that form in the process. The solids formed may be controlled by the addition of preferential adsorption surfaces, or “seeds”, to the process that dictate asphaltene solids growth in a desirable manner. For example, seeding the system with surfaces that constrains asphaltene adsorption to a denser phase, would lead the asphaltene precipitants to adsorb and grow in a different manner than would occur if they were adsorbed to the native asphaltene nucleation sites or mineral solids.

[0039] The seeds may be added to the froth, at the point of, or prior to, solvent contacting in the feed to FSU-1 through a slip stream containing such solids. Possible seeds include the solids present in the FSU-2 underflow, TSRU bottoms, and tailings. These are appropriate candidates because it has been observed that FSU-2 underflow and TSRU bottoms and tailings contain asphaltene-mineral solids but have less hydrocarbon liquids associated with them compared to the solids in the FSU-1 underflow. This suggests that asphaltenes and asphaltene-mineral solids may be denser in nature compared to those in the FSU-1 underflow, making them good seeds for this process.

[0040] Figure 2 is a flow chart of an embodiment of a paraffinic froth treatment (PFT) process. The method of processing a bitumen froth comprising bitumen, water, coarse solids, and fines, may comprise: producing (202) a pre-treated bitumen froth by adding a seeding stream comprising asphaltene-mineral solids to the bitumen froth, the asphaltene-mineral solids being for seeding asphaltene precipitation and for controlling asphaltene precipitate morphology; producing (204) a diluted pre-treated bitumen froth by adding paraffinic solvent to the pre-treated bitumen froth; and forming (206) an overflow and an underflow by gravity separating the diluted pre-treated bitumen froth.

[0041] The seeding stream may comprise less than 5 weight %, or less than 1 weight % hydrocarbon liquid, based on a total weight of the seeding stream.

[0042] The seeding stream may comprise 10 to 60 weight %, or 20 to 45 weight %, of the asphaltene-mineral solids, based on a total weight of the seeding stream.

[0043] A weight ratio of the asphaltene-mineral solids in the seeding stream to the bitumen in the froth may be 1:500 to 1:20 or 1:250 to 1:50.

[0044] The asphaltene-mineral solids may have an asphaltene content of at least 30 wt. %, based on a total weight of the asphaltene-mineral solids.

[0045] The seeding stream may comprise a paraffinic froth treatment underflow from a downstream froth settling stage. The seeding stream may comprise tailings solvent recovery unit (TSRU) tailings. The seeding stream may comprise dewatered TSRU tailings.

[0046] The step of producing a diluted pre-treated bitumen froth may be effected in a settling unit. The settling unit may be a froth settling unit.

[0047] The bitumen froth may be a product of water based extraction of mined oil sand.

[0048] The method may further comprise adding additional paraffinic solvent to the underflow and gravity separating a resulting stream to produce a second underflow and a second overflow. Solvent may be recovered from the second underflow to form TSRU tailings. Water may be removed from the TSRU tailings to form dewatered tailings. A portion of the second underflow may be used as at least a portion of the seeding stream. A portion of the TSRU tailings may be used as at least a portion of the seeding stream. A portion of the dewatered tailings is used as at least a portion of the seeding stream. A portion of the second overflow may be used as a source of the paraffinic solvent in the step of producing a diluted pre-treated bitumen stream.

[0049] A sufficient amount of paraffinic solvent may be added to achieve a diluted pre-treated bitumen froth having a paraffinic solvent to bitumen ratio of 0.5:1 to 2:1, or 0.7:1 to 1.5:1, or 0.8:1 to 1.2:1, on a weight basis.

[0050] Figure 3 is a flow chart of an embodiment of a paraffinic froth treatment (PFT) process. The method of processing a bitumen froth comprising bitumen, water, coarse solids, and fines may comprise producing (302) a pre-treated bitumen froth by adding a seeding

stream comprising asphaltene-mineral solids to the bitumen froth, the asphaltene-mineral solids being for seeding asphaltene precipitation and for controlling asphaltene precipitate morphology, wherein the seeding stream comprises less than 5 weight % hydrocarbon liquid, based on a total weight of the seeding stream; producing (304) a diluted pre-treated bitumen froth by adding paraffinic solvent to the pre-treated bitumen froth; forming (306) an overflow and an underflow by gravity separating the diluted pre-treated bitumen froth; adding (308) additional paraffinic solvent to the underflow and gravity separating a resulting stream to produce a second underflow and a second overflow; recycling (310) the second overflow into step b) as a source of the paraffinic solvent; and removing (312) at least a portion of the paraffinic solvent from the second underflow by vaporization in a tailings solvent recovery unit.

[0051] Asphaltene-mineral solids may be used for adding to bitumen froth for seeding asphaltene precipitation and for controlling asphaltene precipitate morphology in a paraffinic froth treatment process.

[0052] Paraffinic froth treatment underflow comprising asphaltene-mineral solids, from a downstream froth treatment stage, may be used for adding to bitumen froth may be used for seeding asphaltene precipitation and for controlling asphaltene precipitate morphology in an upstream froth treatment stage.

[0053] TSRU underflow comprising asphaltene-mineral solids may be used for adding to bitumen froth for seeding asphaltene precipitation and for controlling asphaltene precipitate morphology in a paraffinic froth treatment process.

[0054] Dewatered tailings comprising asphaltene-mineral solids may be used for adding to bitumen froth for seeding asphaltene precipitation and for controlling asphaltene precipitate morphology in a paraffinic froth treatment process.

[0055] Figure 4 is a flow diagram of an embodiment of a paraffinic froth treatment (PFT) process. Bitumen froth (402) is added to a froth setting unit (FSU-1) (404) to produce a hydrocarbon-rich overflow (406) and a solids-rich underflow (408). Solvent (not shown) is

removed from the hydrocarbon-rich overflow (406) to produce a bitumen product (not shown). Solvent (410) is added to the solids-rich underflow (408) and is fed to another froth settling unit (FSU-2) (412). FSU-2 (412) produces a second hydrocarbon-rich overflow (414) and a second solids-rich underflow (416). The second hydrocarbon-rich overflow (414) is added to the FSU-1 (404) as the solvent source and may be combined with the bitumen froth (402) before its addition to the FSU (404), as illustrated. A portion of the second solids-rich underflow (416) is passed to a TSRU (417) to produce a solvent stream (not shown) and tailings (not shown). Notably, a slip-stream is withdrawn from the second solids-rich underflow (416) and added to the bitumen froth (402) as a seeding stream (418).

[0056] Figure 6 is a flow diagram of an embodiment of a PFT process where seeds are drawn from TSRU bottoms. Bitumen froth (602) is added to a froth setting unit (FSU-1) (604) to produce a hydrocarbon-rich overflow (606) and a solids-rich underflow (608). Solvent (not shown) is removed from the hydrocarbon-rich overflow (606) to produce a bitumen product (not shown). Solvent (610) is added to the solids-rich underflow (608) and is fed to another froth settling unit (FSU-2) (612). FSU-2 (612) produces a second hydrocarbon-rich overflow (614) and a second solids-rich underflow (616). The second hydrocarbon-rich overflow (614) is added to the FSU-1 (604) as the solvent source and may be combined with the bitumen froth (602) before its addition to the FSU (604), as illustrated. The second solids-rich underflow (616) may be combined with dilution water (620) and is passed to a TSRU (622) to produce a solvent stream (624) and TSRU tailings (626). Notably, a slip-stream is withdrawn from the TSRU tailings (626) and added to the bitumen froth (602) as a seeding stream (628).

[0057] Figure 7 is a flow diagram of an embodiment of a PFT process where seeds are drawn from dewatered tailings (e.g. thickener underflow or solids from deposited tailings). Bitumen froth (702) is added to a froth setting unit (FSU-1) (704) to produce a hydrocarbon-rich overflow (706) and a solids-rich underflow (708). Solvent (not shown) is removed from the hydrocarbon-rich overflow (706) to produce a bitumen product (not shown). Solvent (710) is added to the solids-rich underflow (708) and is fed to another froth settling unit (FSU-2) (712). FSU-2 (712) produces a second hydrocarbon-rich overflow (714) and a

second solids-rich underflow (716). The second hydrocarbon-rich overflow (714) is added to the FSU-1 (704) as the solvent source and may be combined with the bitumen froth (702) before its addition to the FSU (704), as illustrated. The second solids-rich underflow (716) may be combined with dilution water (720) and is passed to a TSRU (722) to produce a solvent stream (724) and TSRU tailings (726). Notably, the TSRU tailings (726) may be dewatered (728) to produce dewatered tailings (730), which are added to the bitumen froth (702) as a seeding stream.

[0058] While the discussion has focused on two settling vessels (FSUs), any suitable number of settling vessels may be used.

[0059] Experimental

[0060] The concept shown in Figure 4 was tested in a 2.3 tpd froth capacity two stage FSU PFT pilot plant, operating the first stage FSU around 70°C and the second stage FSU (FSU-2) around 90°C. FSU-2 underflow was introduced to the froth feed (approximately 20% by mass of asphaltenes in froth) before contacting with a pentane solvent blend. The results from this experiment are shown in Figure 5, labeled “FSU-2 seeding FSU-1 Case”.

[0061] As a baseline, the conventional process was run without any “seeds” added to the froth. The results from this experimentation are shown in Figure 5, labeled “Base Case”.

[0062] Both cases were run at the same total solvent injection rate to the system.

[0063] Figure 5 shows the fraction of U/F Liquid Bitumen/Liquid Bitumen In for the “FSU-2 seeding FSU-1 Case” and “Base Case”. “U/F Liquid Bitumen” in the calculation is the liquid bitumen content of tailings (416) and tailings (24) for their respective cases. “Liquid Bitumen In” in the calculation is the liquid bitumen content of the bitumen froth (402) and bitumen froth (2) for their respective cases.

[0064] As can be seen from the results in Figure 5, it has been discovered that by seeding the FSU-1 feedstream with some of the solids-rich FSU-2 underflow stream that the process as disclosed herein decreased the overall liquid bitumen losses in the process as

compared to the conventional PFT process (see Figure 5 comparing the “FSU-2 seeding FSU-1 Case” and “Base Case”).

[0065] 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 of processing a bitumen froth comprising bitumen, water, coarse solids, and fines, the method comprising:
 - a) producing a pre-treated bitumen froth by adding a seeding stream comprising asphaltene-mineral solids to the bitumen froth, the asphaltene-mineral solids being for seeding asphaltene precipitation and for controlling asphaltene precipitate morphology;
 - b) producing a diluted pre-treated bitumen froth by adding paraffinic solvent to the pre-treated bitumen froth; and
 - c) forming an overflow and an underflow by gravity separating the diluted pre-treated bitumen froth;wherein the seeding stream comprises one or more of a paraffinic froth treatment underflow from a downstream froth settling stage, tailings solvent recovery unit tailings, and dewatered tailings solvent recovery unit tailings.
2. The method of claim 1, wherein the seeding stream comprises less than 5 weight % hydrocarbon liquid, based on a total weight of the seeding stream.
3. The method of claim 1, wherein the seeding stream comprises less than 1 weight % hydrocarbon liquid, based on a total weight of the seeding stream.
4. The method of any one of claims 1 to 3, wherein the seeding stream comprises 10 to 60 weight % of the asphaltene-mineral solids, based on a total weight of the seeding stream.
5. The method of any one of claims 1 to 3, wherein the seeding stream comprises 20 to 45 weight % of the asphaltene-mineral solids, based on a total weight of the seeding stream.
6. The method of any one of claims 1 to 5, wherein a weight ratio of the asphaltene-mineral solids in the seeding stream to the bitumen in the froth is 1:500 to 1:20.

7. The method of any one of claims 1 to 5, wherein a weight ratio of the asphaltene-mineral solids in the seeding stream to the bitumen in the froth is 1:250 to 1:50.
8. The method of any one of claims 1 to 7, wherein the asphaltene-mineral solids have an asphaltene content of at least 30 wt. %, based on a total weight of the asphaltene-mineral solids.
9. The method of any one of claims 1 to 8, wherein the seeding stream comprises the paraffinic froth treatment underflow from a downstream froth settling stage.
10. The method of any one of claims 1 to 8, wherein the seeding stream comprises the tailings solvent recovery unit tailings.
11. The method of any one of claims 1 to 8, wherein the seeding stream comprises the dewatered tailings solvent recovery unit tailings.
12. The method of any one of claims 1 to 11, wherein step b) is effected in a settling unit.
13. The method of claim 12, wherein the settling unit is a froth settling unit.
14. The method of any one of claims 1 to 13, wherein the bitumen froth is a product of water based extraction of mined oil sand.
15. The method of any one of claims 1 to 14, further comprising:
 - d) adding additional paraffinic solvent to the underflow and gravity separating a resulting stream to produce a second underflow and a second overflow.

16. The method of claim 15, further comprising recovering solvent from the second underflow to form tailings solvent recovery unit tailings.
17. The method of claim 16, further comprising removing water from the tailings solvent recovery unit tailings to form dewatered tailings.
18. The method of claim 15, wherein a portion of the second underflow is used as at least a portion of the seeding stream.
19. The method of claim 16, wherein a portion of the tailings solvent recovery unit tailings is used as at least a portion of the seeding stream.
20. The method of claim 17, wherein a portion of the dewatered tailings is used as at least a portion of the seeding stream.
21. The method of any one of claims 15 to 20, wherein at least a portion of the second overflow is used in step b) as a source of the paraffinic solvent.
22. The method of any one of claims 1 to 21, wherein a sufficient amount of paraffinic solvent is added to achieve a diluted pre-treated bitumen froth having a paraffinic solvent to bitumen ratio of 0.5:1 to 2:1, on a weight basis.
23. The method of any one of claims 1 to 21, wherein a sufficient amount of paraffinic solvent is added to achieve a diluted pre-treated bitumen froth having a paraffinic solvent to bitumen ratio of 0.7:1 to 1.5:1, on a weight basis.
24. The method of any one of claims 1 to 21, wherein a sufficient amount of paraffinic solvent is added to achieve a diluted pre-treated bitumen froth having a paraffinic solvent to bitumen ratio of 0.8:1 to 1.2:1, on a weight basis.

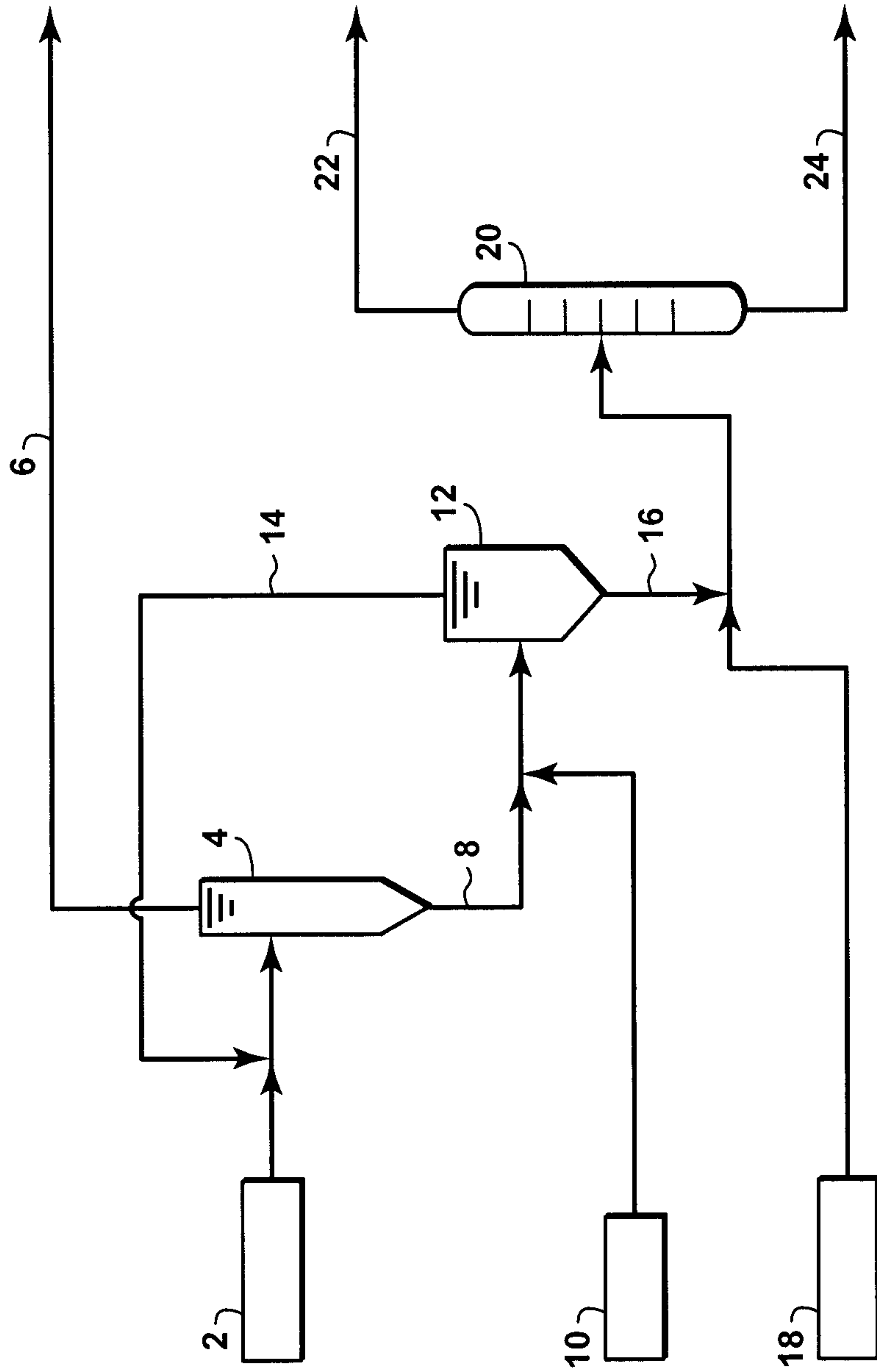
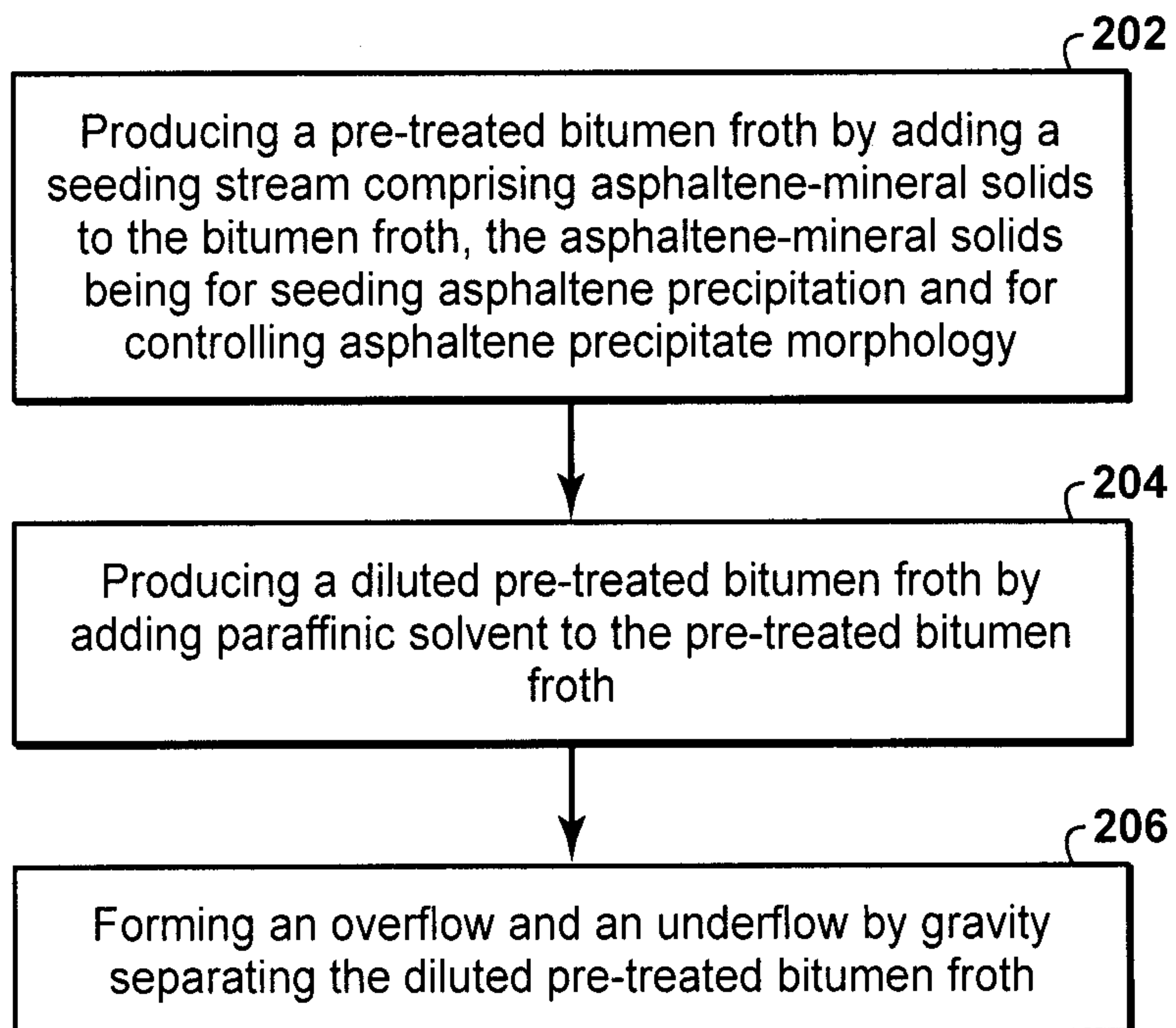
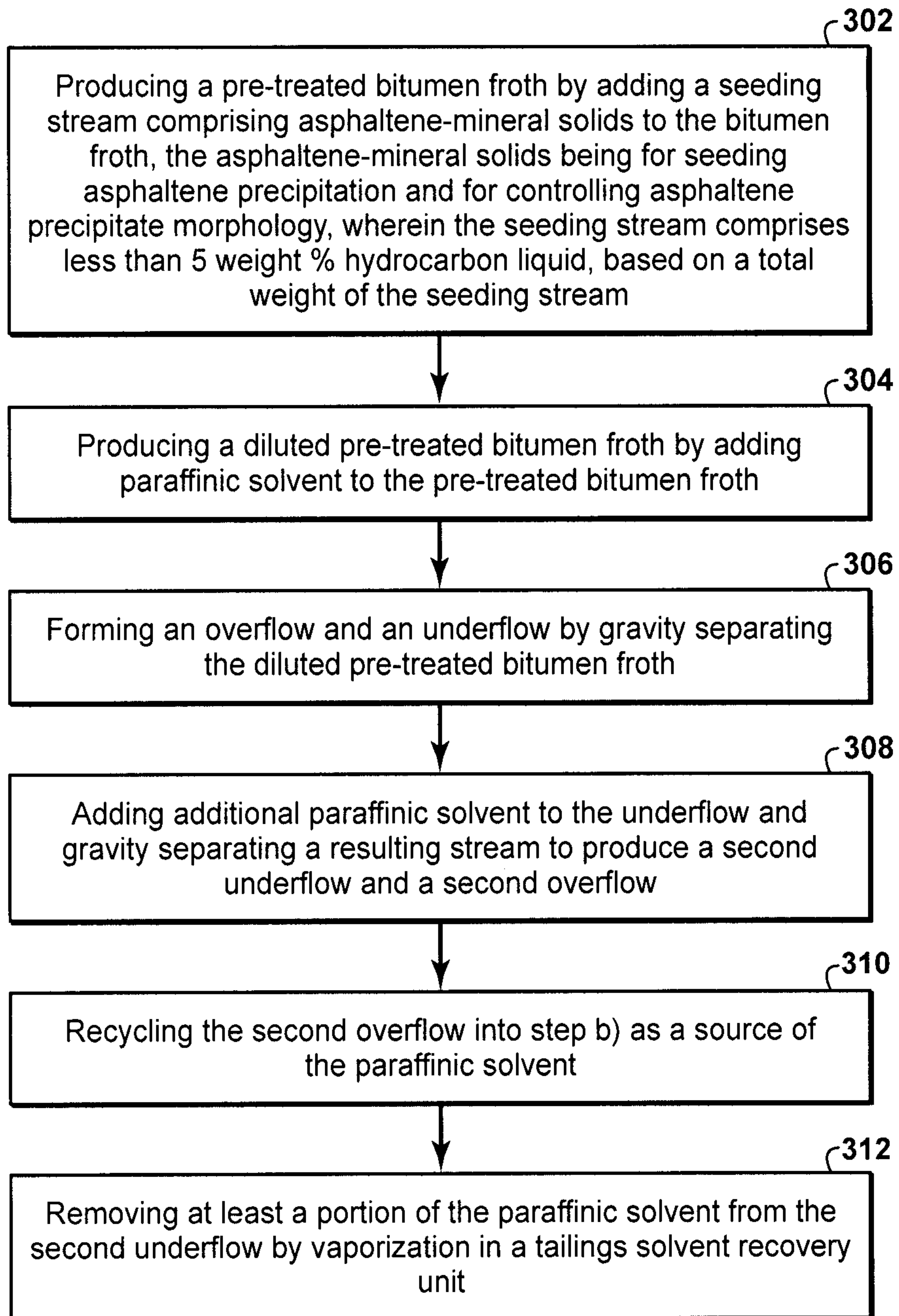


FIG. 1
(Prior Art)

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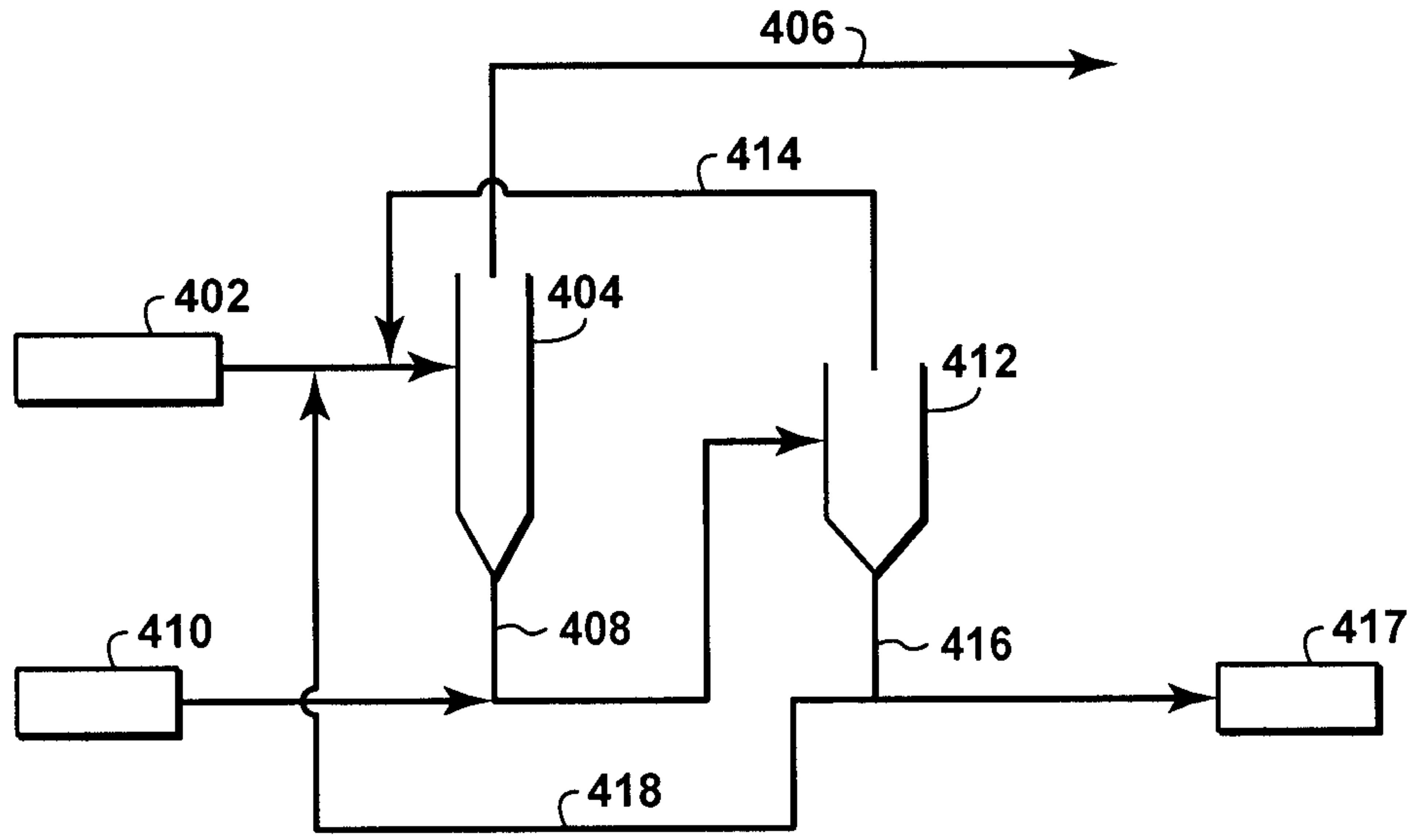


FIG. 4

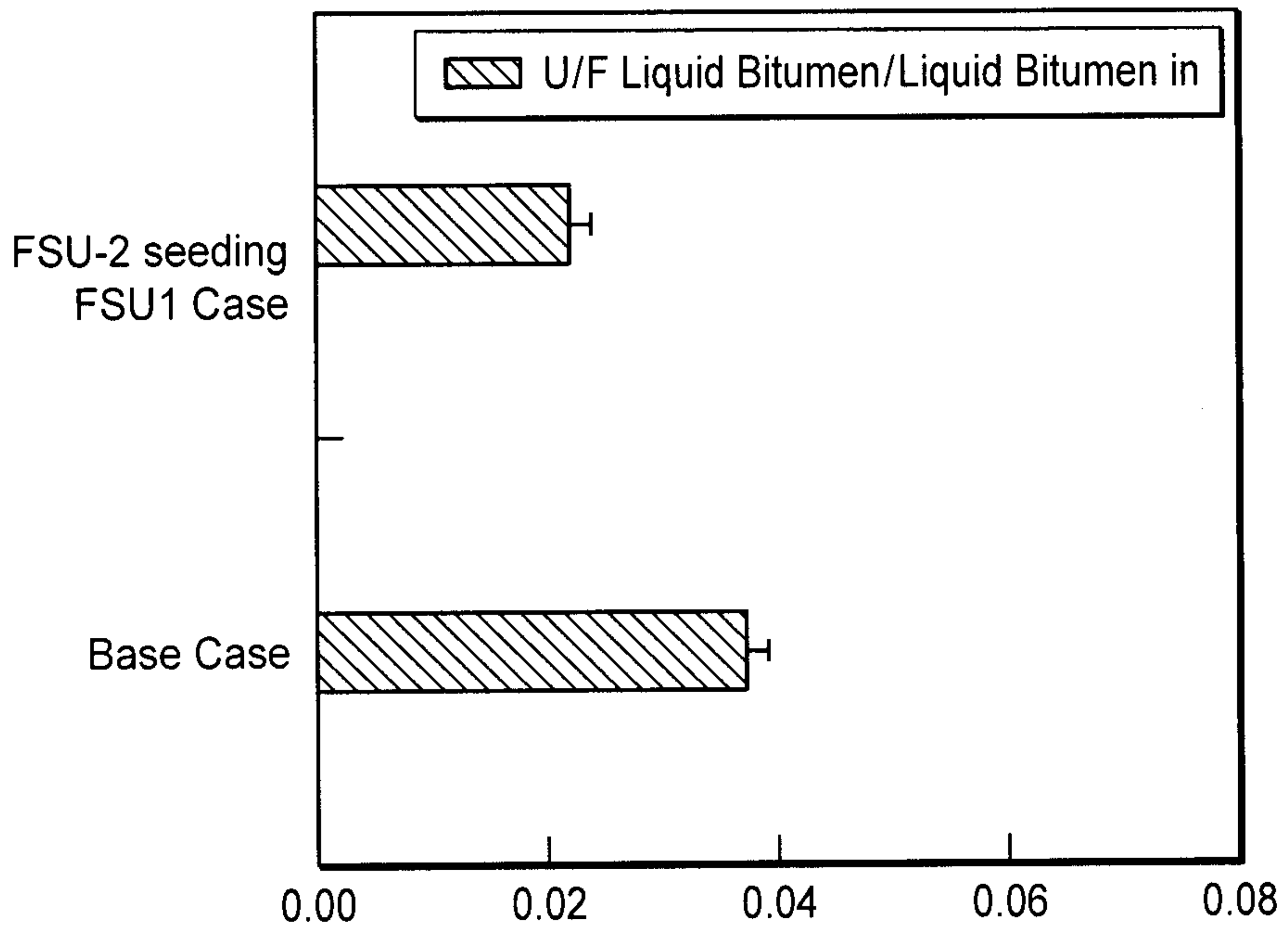


FIG. 5

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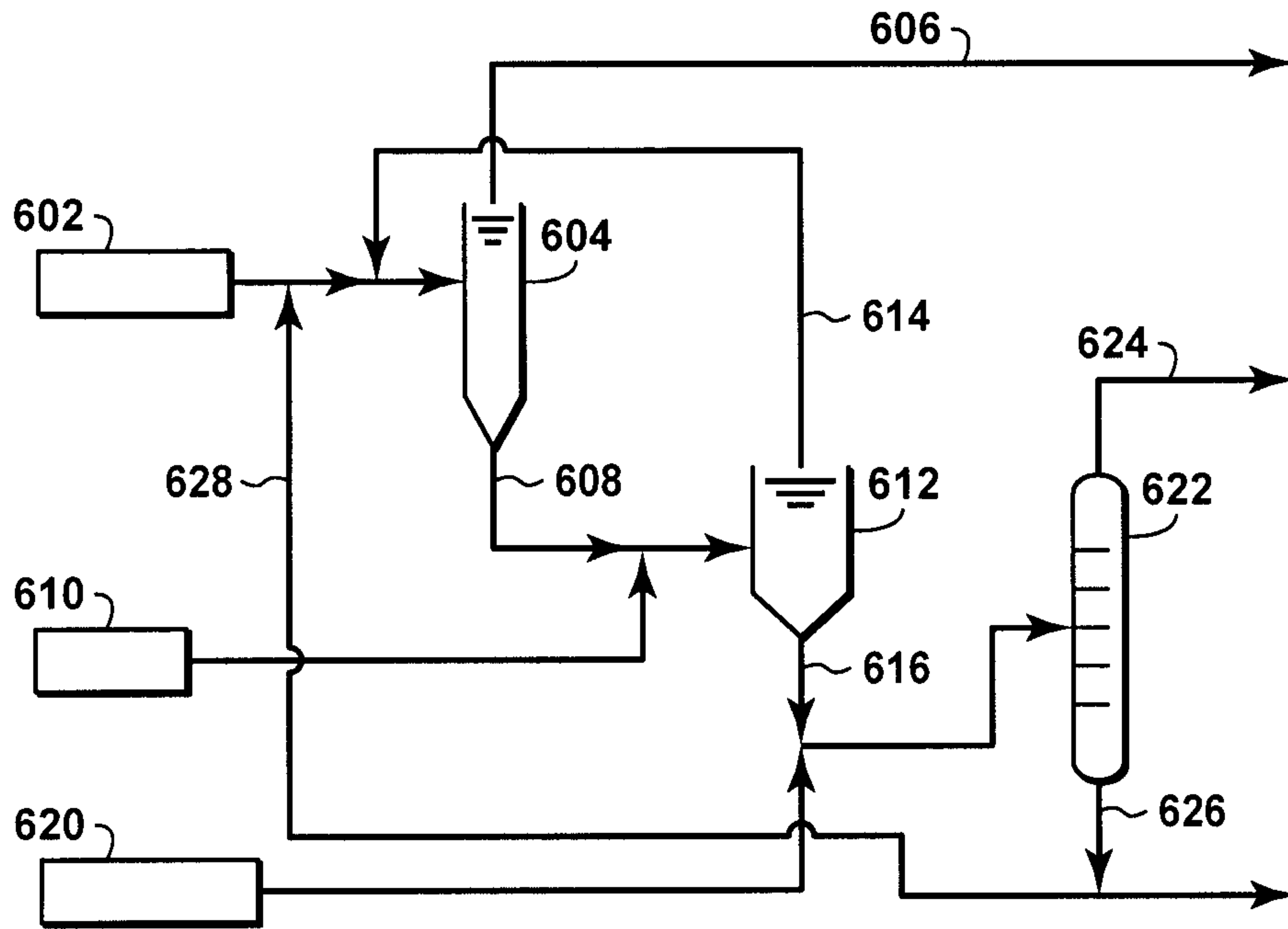


FIG. 6

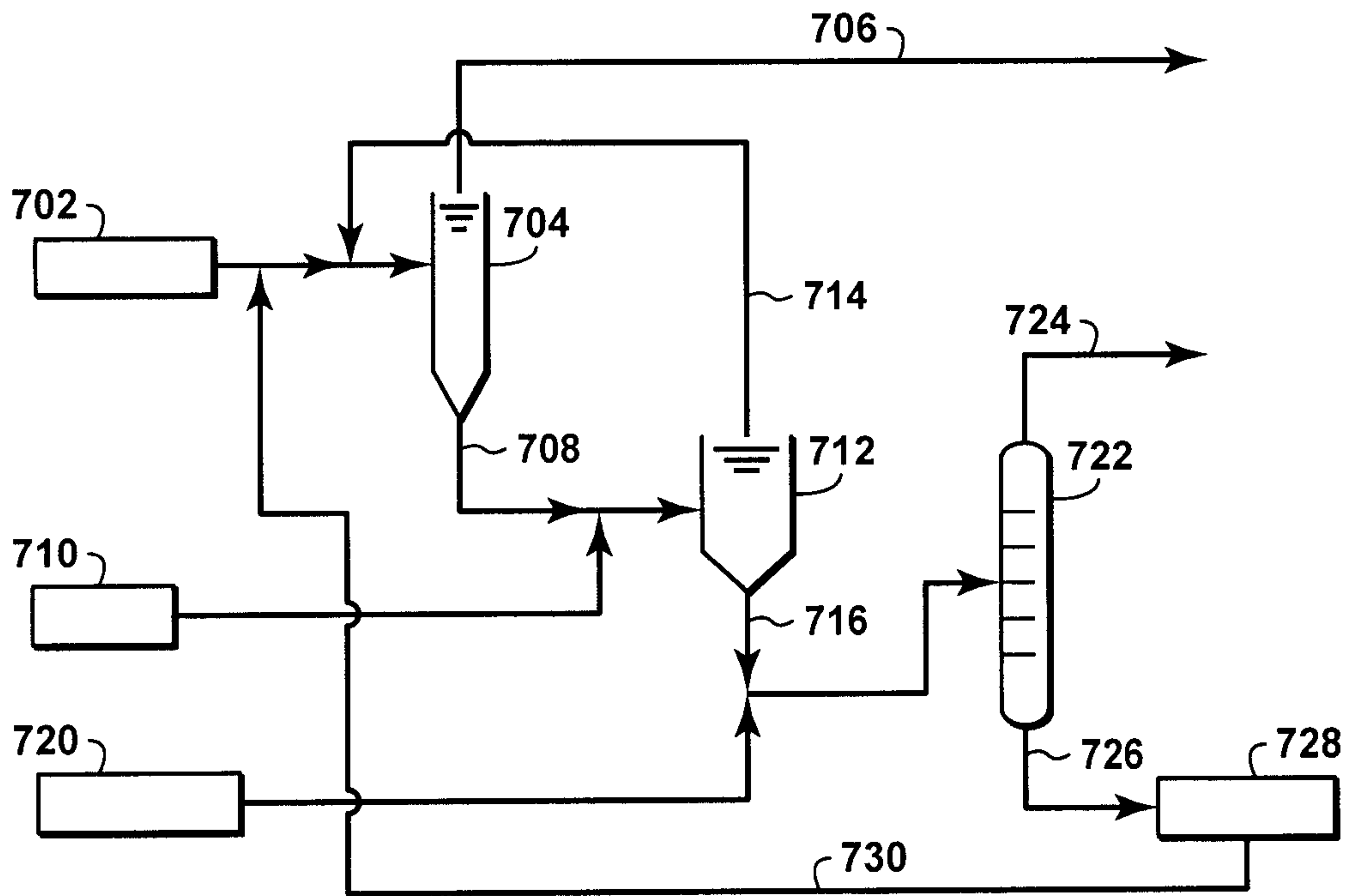


FIG. 7