

ABSTRACT

A first binder is added to oil sands tailings to bind solid particles together, and then water is separated from the oil sands tailings. Thereafter, an absorbent is added to the oil sands tailings to absorb water and increase shear strength. The oil sands tailings are then deposited at a deposition area. The absorbent may be added after deposition.

PROCESSING OIL SANDS TAILINGS USING A BINDER AND AN ABSORBENT

FIELD

[0001] The present disclosure is in the field of processing oil sands tailings.

BACKGROUND

[0002] Extracting bitumen from mined oil sands produces tailings comprising sand, fines (silts and clays), water, and small amounts of unrecovered bitumen. It is desirable to increase the solids content of these tailings to assist reclamation.

[0003] Certain oil sands extraction processes will be described below to illustrate how certain oil sands tailings may be formed. However, the following descriptions are by no means exhaustive of the ways in which oil sands tailings may be generated.

[0004] Oil sand extraction processes are used to liberate and separate bitumen from oil sands 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. 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.

[0005] One water-based extraction process is the Clark hot water extraction process (the "Clark Process"). This process typically requires that mined oil sands be conditioned for extraction by being crushed to a desired lump size and then combined with hot (e.g. 95°C) water and perhaps other agents to form a conditioned slurry of water and crushed oil sands. 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 sands. Other water-based extraction processes may use other temperatures and may include other conditioning agents, which are added to the oil sands 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.

[0006] An overall bitumen extraction process is depicted in Fig. 1. The water and oil sands slurry (100) is separated into three major streams in the PSC (101): bitumen froth (102), middlings (104) and PSC underflow (106). Further processing of each of these streams is explained below. Also shown in Fig. 1, is the solvent (108) added for froth treatment (110), bitumen (112), TSRU (tailings solvent recovery unit) tailings (114), flotation cells (116), recycle bitumen froth (118), flotation tailings (FT) (120), and an external tailings area (ETA) (122).

[0007] Regardless of the type of water-based extraction process employed, the process will typically result in the production of a bitumen froth (102) that requires treatment with a solvent. For example, in the Clark Process, a bitumen froth stream comprises bitumen, fine particulate solids (also referred to as mineral or inorganic 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.

[0008] Solvent is typically recovered from the diluted product bitumen component before the bitumen is delivered to a refining facility for further processing.

[0009] One PFT process will now be described further, although variations of the process exist. The PFT process may comprise at least three units: Froth Separation Unit (FSU), Solvent Recovery Unit (SRU) and Tailings Solvent Recovery Unit (TSRU). Two FSUs may be used, as shown in Fig. 2.

[0010] With reference to Fig. 2, mixing of solvent with the feed bitumen froth (200) is carried out counter-currently in two stages: FSU-1 and FSU-2, labeled as Froth Separation Unit 1 (202) and Froth Separation Unit 2 (204). The bitumen froth comprises bitumen, water, and fine solids (also referred to as mineral 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. Examples of paraffinic solvents are pentane or hexane, either used alone or mixed with isomers of pentanes or hexanes, respectively. An example of a paraffinic solvent is a mixture of iso-pentane and n-pentane. In FSU-1 (202), the froth (200) is mixed with the solvent-rich oil stream (201) from the second stage (FSU-2) (204). The temperature of FSU-1 (202) is maintained at, for instance, about 60°C to about 80°C, or about 70°C, while the solvent to bitumen (SB) ratio may be from 1.4:1 to 2.2:1 by weight or may be controlled around 1.6:1 by weight for a 60:40 mixture of n-pentane: iso-pentane. The overhead from FSU-1 (202) is the diluted bitumen product (205) (also referred to as the hydrocarbon leg) and the bottom stream from FSU-1 (202) is the tailings (207) comprising water, solids (inorganics), asphaltenes, and some residual bitumen. The residual bitumen from this bottom stream is further extracted in FSU-2 (204) by contacting it with fresh solvent (209), for instance, in a 25 to 30:1 (w/w) SB ratio at, for instance, about 80°C to about 100°C, or about 90°C. Examples of operating pressures of FSU-1 and FSU-2 are about 550 kPag and 600 kPag, respectively. The solvent-rich oil (overhead) (201) from FSU-2 (204) is mixed with the fresh froth feed (200) as mentioned above. The bottom stream from FSU-2 (204) is the tailings (211) comprising solids, water, asphaltenes and residual solvent, which is to be recovered in the Tailings Solvent Recovery Unit (TSRU) (206) prior to the disposal of the tailings (213) in an ETA. The recovered solvent (218) from TSRU (206) is directed to the solvent storage (210). Solvent from the diluted bitumen overhead stream (205) is recovered in the Solvent Recovery Unit (SRU) (208) and passed as solvent (217) to Solvent Storage (210). Bitumen (215) exiting the SRU (208) is also illustrated. 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.

[0011] As depicted in Fig. 1, the PSC underflow (106) from the PSC (101) is sent to an External Tailings Area (ETA) (122). The PSC underflow (106) is a coarse stream and is typically used as a building material at the ETA to contain tailings ponds of tailings with lower solids content.

[0012] Paraffinic froth treatment (PFT) tailings (for example TSRU tailings stream (213)) may comprise both coarse and fine solids and is sent for further treatment or disposed in an ETA.

[0013] As depicted in Fig. 1, from the PSC (101), the middlings stream (104), comprising bitumen and about 10-30% solids, or 20-25% is withdrawn and sent to the flotation cells (116) to further recover bitumen. The middlings (104), comprising bitumen, solids and water are processed by bubbling air through the slurry and creating a bitumen froth (118), which is recycled back to the PSC (101). The flotation tailings (FT) (120) from the flotation cells (116), comprising mostly solids and water, are sent for further treatment or disposed in an ETA.

[0014] In ETA tailings ponds, a liquid suspension of oil sands fines in water with a solids content greater than 2%, 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. Further densification to a solid state is very slow.

[0015] It would be desirable to have an alternative method of processing oil sands tailings.

SUMMARY

[0016] A first binder is added to oil sands tailings to bind solid particles together, and then water is separated from the oil sands tailings. Thereafter, an absorbent is added to the oil sands tailings to absorb water and increase shear strength. The oil sands tailings are then deposited at a deposition area. The absorbent may alternatively be added after deposition.

[0017] 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

[0018] 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

[0019] Fig. 1 is a flow diagram of a prior art process for extracting bitumen from mined oil sands.

[0020] Fig. 2 is a flow diagram of a prior art paraffinic froth treatment process.

[0021] Fig. 3 is flow diagram of a disclosed method of processing tailings.

[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] A first binder is added to oil sands tailings to bind solid particles together. Water is then separated from the oil sands tailings.

[0024] Thereafter, an absorbent is added to the oil sands tailings to absorb water and increase shear strength. The tailings are then deposited at a deposition area. The absorbent may alternatively be added after deposition. Because of the increased shear strength, the tailings will form a steeper slope and dewater more quickly.

[0025] A second binder may be added after transportation of the tailings to the deposition area, but before deposition, to bind particles together after shearing of solids caused by transportation.

[0026] After deposition, the tailings further dewater. Recovered water may be recycled into the extraction process or ore preparation process.

[0027] Tailings

[0028] The tailings feed is generated from bitumen extraction of mined oil sands. Certain oil sands extraction processes are described above to illustrate how certain oil sands tailings may be formed. However, the above descriptions are by no means exhaustive of the ways in which oil sands tailings may be generated. Non-limiting examples of suitable tailings

include flotation tailings (FT), fluid fine tailings (FFT), mature fine tailings (MFT), tailings from solvent recovery unit (TSRU) tailings, thickened tailings (TT), and combinations thereof.

[0029] The solids content of the tailings feed may be, for instance, 5 to 55 wt%, or 10 to 45 wt%, or 10 to less than 25 wt%, or any number between or inclusive of these ranges. Tailings with coarse solids contents such as PSC underflow tailings, also known as coarse sand tailings, generally do not require the type of dewatering and increase in shear strength described herein.

[0030] Additionally, where the solids content of a tailings stream is high enough (for instance 25 wt% or more), binders may be omitted. For instance, a FFT and/or MFT tailings stream with 25 wt% or more solids, or any number above this limit may be treated with the absorbent only. Optionally, a binder may be used on such a stream before and/or after the absorbent.

[0031] First Binder

[0032] The first binder is added to the tailings to bind solid particles together in order to assist water separation. The first binder may be, for instance, a flocculent, a coagulant, or a mixture thereof. The solids particles may comprise fines having particle sizes less than 44 microns,. Such fines are generally the most difficult to separate from the water without binder addition. The oil sands tailings may have a sand to fines ratio (SFR) of 0.01 to 6, 0.1 to 4, 0.3 to 1.5, 0.5 to 1, or any number between or inclusive of these ranges. The first binder may be an anionic, cationic, or non-ionic flocculent.

[0033] Examples of non-ionic polymer flocculants are polyacrylamide (PAM) and poly(ethylene oxide) (PEO).

[0034] Common cationic groups of polyelectrolyte flocculants are derived by introducing quaternary ammonium groups onto the polymer backbone, although polymers comprising sulfonium and phosphonium groups are also used as flocculants. A commonly used cationic polyelectrolyte flocculent is poly(diallyldimethyl ammonium chloride) (polyDADMAC).

[0035] In the anionic group of polyelectrolyte flocculants, mainly two types of polymers are commonly used, polymers comprising carboxyl functional groups and polymers comprising sulfonic acid groups. A representative of the former is poly(acrylic acid) and its derivatives. A representative of the latter is poly(styrene sulfonic acid) (PSSA).

[0036] The coagulant may be a metallic salt, for instance an aluminum, ferric, calcium, sodium aluminate, or sodium silicate salt, or a cationic, anionic, or non-ionic polymer.

[0037] The first binder may be added to the tailings in a region of high shear or turbulent flow to assist mixing. For instance, the first binder may be added to the tailings at an input of a settling vessel or thickener. In the settling vessel or thickener, solids may be removed as an underflow stream (for instance having 35-70 wt% solids, or 45-55 wt% solids (or any number between or inclusive of these ranges)), and water may be removed as an overflow stream (for instance having less than or equal to 0.5 wt% solids, or any number less than or equal to this limit).

[0038] The first binder dosage range may be 50 g/ton (dry solids) to 2000 g/ton (dry solids), or 50 g/ton (dry solids) to 700 g/ton (dry solids) or 50 g/ton (dry solids) to 300 g/ton (dry solids). The first binder dosage may also be any dosage within 50 g/ton to 2000 g/ton, or any dosage within 50 g/ton to 700 g/ton, or any dosage within 50 g/ton to 300 g/ton.

[0039] The first binder may be diluted with water, prior to addition, in a concentration of 0.01 to 2 wt%, or 0.05 to 0.5 wt%. The first binder may also be diluted with water in any concentration of and between 0.01 to 2 wt% or 0.05 to 0.5 wt%.

[0040] This step may recover on the order of 40-70 wt%, or 50-60 wt% of the water in the tailings (or any number between or inclusive of these ranges). The solids content after this step may be greater than 10 wt%, or greater than 30 wt% (or any number above these limits). By way of example only, with this step, a tailings stream with 10-25 wt% solids may be thickened to about 35-55 wt% solids, or any number between or inclusive of these ranges.

[0041] The water separated from the tailings may have a solids content of less than 5%, less than 1%, less 0.5 wt%, or any number equal to or less than these limits.

[0042] Absorbent

[0043] The absorbent is added to the tailings to absorb water and increase shear strength. The increased shear strength improves dewatering after deposition.

[0044] The absorbent may be a water-absorbing polymer, superplasticizer, geopolymer, absorbent clay (e.g. montmorillonite clay, bentonite clay, or overburden clay), superabsorbent fiber, cement, cement byproduct (e.g. Cement Kiln Dust (CKD)), desiccant, or a combination thereof.

[0045] The absorbent may be an absorbent clay (e.g. montmorillonite clay, bentonite clay, or overburden clay), superabsorbent fiber, cement, cement byproduct (e.g. Cement Kiln Dust (CKD)), or a combination thereof.

[0046] The superplasticizer may be a sulfonated melamine-formaldehyde condensate (SMF), sulfonated naphthalene-formaldehyde condensate (SNF), modified lignosulfonate (MLS), polycarboxylate derivative, or a combination thereof.

[0047] The geopolymer may be an organic polymer, (i.e. carbon-based), an inorganic polymer (e.g. silicon-based), or a natural biopolymer.

[0048] The organic polymer may be a natural polymer (e.g. rubber or cellulose), or a synthetic organic polymer (e.g. a textile fiber, plastic, film, or elastomer), or a combination thereof.

[0049] The desiccant may be a silica gel, activated charcoal, calcium sulfate, calcium chloride, absorbent clay (e.g. montmorillonite clay, bentonite clay, overburden clay) a molecular sieve, or a combination thereof. The water-absorbing polymer may be any suitable water-insoluble polymer, for instance non-ionic, cationic, anionic, ampholytic, and zwitterionic polymers. Suitable polymers may be cross-linked polyacrylates or polyacrylamides or acrylic-acrylamide copolymers, hydrolyzed cellulose-polyacrylonitrile or starch-polyacrylonitrile graft copolymers, cross-linked maleic anhydride copolymers, or a combination thereof.

[0050] Generally, a smaller particle size offers faster absorption and desorption/regeneration kinetics while a larger particle size is advantageous in material handling and separation. By way of example, a water-absorbing polymer particle may be in granular form with a particle size of about 10 to 10,000 microns, or about 100 to 6,000 microns, or any number between or inclusive of these ranges.

[0051] The absorbent may comprise two absorbents with different water absorbing kinetics, which may be the same type or different types of absorbents. In this way, the first absorbent absorbs water immediately to increase shear strength, and the second absorbent absorbs water at the deposition area, for instance at least one day after deposition.

[0052] The absorbent may be added to the tailings before or after deposition. After deposition, the absorbent may be added to the tailings, for instance, by a mechanical element. Examples of a mechanical element include, but are not limited to, an amphirole, a

mud farming machine, or another agriculture fertilizer equipment to enhance the strength of deposit.

[0053] The absorbent may be added in dry or liquid form along with a carrying fluid into an output of a settling vessel or during transportation in a pipeline. The carrying fluid may be a small tailings stream, an aqueous solution, or an organic solvent.

[0054] The absorbent dosage range may be about 50 g/ton (dry solids) to 10,000 g/ton (dry solids), or about 50 g/ton (dry solids) to 3000 g/ton (dry solids), or about 50 g/ton to 1000g/ton (dry solids), or any number between or inclusive of these ranges.

[0055] Second binder

[0056] A second binder may be added after transportation of the tailings to the deposition area, but before deposition, to bind particles together after shearing of solids caused by transportation.

[0057] By way of explanation, when tailings are pumped and piped to a deposition area, the tailings experience shear which breaks down flocculated tailings (flocs) into micro flocs, and reduces the strength of the material. As a result, the material would hold water and cannot release it rapidly, and would flow to a shallow slope. In order to recombine the small flocs together, the second binder may be added at or near the end of the pipeline. This second binder can be the same or different to the first binder used for the initial thickening. This second binder helps bind the small flocs together to form the larger flocs, enhance the permeability of the tailings, and increase the initial strength to form a steeper slope at the deposition area. A steep slope may be, for instance, 5-10%, or 2-5% from horizontal, or any number between or inclusive of these ranges. The second binder is added before deposition to assist mixing.

[0058] The second binder may be added in an area of high shear which precedes an area of gentle mixing to assist floc formation. For instance, the second binder may be injected into a pipeline, inline mixer, or into a static mixer before discharging. The second binder may be added before or after the absorbent.

[0059] The second binder may be a polymeric flocculant, either the same or a different type from the first binder. For instance, the second binder may comprise polyacrylamide (PAM), poly(ethylene oxide) (PEO), poly(diallyldimethyl ammonium chloride) (polyDADMAC), poly(acrylic acid), poly(styrene sulfonic acid) (PSSA), or a combination

thereof. Synthetic polymers can be tailor-made by controlling the molecular weight, molecular weight distribution, charge density and chemical structure. Accordingly, synthetic polymers can efficiently bind small flocs to large flocs, and enhance permeability, and therefore dewatering post deposition.

[0060] The second binder dosage range may be about 50 g/ton (dry solids) to 1000 g/ton (dry solids), or about 50 g/ton (dry solids) to 600 g/ton (dry solids), or about 50 g/ton (dry solids) to 300 g/ton (dry solids), or any number between or inclusive of these ranges. The second binder may be diluted with water, prior to addition, in a concentration of 0.01 to 5 wt%, or 0.1 to 1.0 wt%, or any number between or inclusive of these ranges.

[0061] Deposition

[0062] The tailings are deposited at a deposition area. The tailings may be deposited on a flat surface or on a slope of, for instance, 0.5 to 10 %, 1 to 4 wt%, or 0.5 to 2 wt% from horizontal, or any number between or inclusive of these ranges. A slope assists dewatering.

[0063] The tailings may be deposited to one deposition cell continuously over a period of days, for instance 7-21 days, and then allowed to settle and consolidate, before switching to another deposition cell. The deposited tailings will dewater through evaporation and drainage. The tailings may be deposited on a highly permeable material (e.g. coarse sand or strip) to assist drainage. Drained water is collected, at a water storage area, for recycling in the extraction process.

[0064] After some dewatering, another layer of tailings may be deposited on top of the previous layer. This may continue until a desired height is reached, for instance 5-20 meters per year or 7-10 meters per year.

[0065] When tailings deposition is complete, a coarse sand layer may be added to the top of deposition. The height of sand loading may be 2-20 or 5-10 meters, or any number between or inclusive of the ranges.

[0066] After deposition, most of the water in the tailings may be released in the first 3-5 days without loading. With loading, the water may be continuously released until it is completely consolidated. With water release, the volume of total deposit is reduced. The volume reduction may be, for instance, 10% to 60%, or 30% to 50%, or any number between or inclusive of these ranges.

[0067] Figure 3

[0068] As shown in Figure 3, a bitumen feed (300) is sent to a primary separation vessel (302). Bitumen froth (304) is sent to paraffinic froth treatment (PFT) (306). Middlings (308) are sent to flotation cells (310). Coarse sand tailings (312) are sent to an External Tailings Area (ETA) (314) for use as a building material to contain tailings ponds of tailings with lower solids content. A bitumen rich stream (316) from the flotation cells (310) is passed back into the PSV (302) for further bitumen extraction.

[0069] The ETA (314) is illustrated as two areas, west ETA (314a) which has a higher water content, and east ETA (314b) which has a lower water content.

[0070] Paraffinic froth treatment (PFT) (306) produces bitumen (317) and PFT tailings (318). PFT tailings (318) are mixed with a first binder (320) in a thickener (322) producing water (324) and a thickened tailings stream (326) which is sent to a deposition area (328). A second binder (330) is added to the thickened tailings stream (326) prior to deposition to bind particles together following shear caused by transportation and pumping. PFT tailings (318) are also sent to the External Tailings Area (ETA) (314).

[0071] Flotation tailings (FT) (332) are added to a static mixer (334) and then fed to a gravity settling vessel or a thickener (336) where a first binder (338) is added. The thickener produces water (340) and a thickened tailings stream (342). The thickened tailings stream (342) is mixed with an absorbent (344) and either sent to the deposition area (328) with a second binder (346), or to an External Tailings Area (ETA) (314) with a second binder (348).

[0072] From the West ETA (314a), FTT and/or MFT tailings (350) are combined with flotation tailings (332) in the static mixer (334), for thickening. From the West ETA (314a), FTT and/or MFT tailings (357) are mixed with thickened tailings (TT) (342) and a second binder (348) and are deposited at the East ETA (314b).

[0073] From the West ETA (314a), FTT and/or MFT tailings (352) are mixed with an absorbent (354) and (a) are mixed with a second binder (356) and deposited at deposition area (328), (b) as stream (359), are deposited at East ETA (314b), and/or (c), as stream (358), are mixed with thickened tailings (342) and then mixed with a second binder (346) and are deposited at deposition area (328).

[0074] Figure 3 illustrates more than one option for certain streams. Anywhere from one to all of these options may be employed in a single operation.

[0075] As utilized herein, 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.

[0076] The scope of the claims should not be limited by particular embodiments set forth herein, but should be construed in a manner consistent with the specification as a whole.

[0077] 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.

CLAIMS:

1. A method of processing oil sands tailings comprising:
 - (a) adding a first binder to the oil sands tailings to bind solid particles together, and then separating water from the oil sands tailings;
 - (b) thereafter, adding an absorbent to the oil sands tailings to absorb water and increase shear strength; and
 - (c) after (a), and before or after (b), depositing the oil sands tailings at a deposition area.
2. The method of claim 1, further comprising (d) after (a) and after transportation of the oil sands tailings to the deposition area but before (c), adding a second binder to the oil sands tailings, which is the same or different from the first binder, to bind solid particles together.
3. The method of claim 1 or 2, further comprising recovering the water from the oil sands tailings after deposition.
4. The method of any one of claims 1 to 3, wherein the absorbent comprises a water-absorbing polymer, superplasticizer, geopolymer, desiccant, or a combination thereof.
5. The method of any one of claims 1 to 3, wherein the absorbent comprises an absorbent clay, superabsorbent fiber, cement, cement byproduct, or a combination thereof.
6. The method of claim 5, wherein the absorbent comprises the absorbent clay, which comprises montmorillonite clay, bentonite clay, overburden clay, or a combination thereof.
7. The method of claim 4, wherein the absorbent comprises the superplasticizer, which comprises a sulfonated melamine-formaldehyde condensate (SMF), sulfonated naphthalene-formaldehyde condensate (SNF), modified lignosulfonate (MLS), polycarboxylate derivative, or a combination thereof.

8. The method of claim 4, wherein the absorbent comprises the geopolymer, which comprises an organic polymer, an inorganic polymer, a natural biopolymer, or a combination thereof.
9. The method of claim 8, wherein the geopolymer comprises the organic polymer, which comprises a natural polymer a synthetic organic polymer, or a combination thereof.
10. The method of claim 4, wherein the absorbent comprises the desiccant, which comprises silica gel, activated charcoal, calcium sulfate, calcium chloride, absorbent clay, a molecular sieve, or a combination thereof.
11. The method of claim 10, wherein the desiccant comprises the absorbent clay recited in claim 10, which comprises montmorillonite clay, bentonite clay, overburden clay, or a combination thereof.
12. The method of claim 4, wherein the absorbent comprises the water-absorbing polymer, which comprises a cross-linked polyacrylate or polyacrylamide or acrylic-acrylamide copolymer, a hydrolyzed cellulose-polyacrylonitrile or starch-polyacrylonitrile graft copolymer, a cross-linked maleic anhydride copolymer, or a combination thereof.
13. The method of claim 4 or 12, wherein the water-absorbing polymer is in granular form with a particle size range of 10 to 10,000 microns.
14. The method of claim 4 or 12, wherein the water-absorbing polymer is in granular form with a particle size range of 100 to 6,000 microns.
15. The method of any one of claims 1 to 14, wherein the absorbent comprises two absorbents with different water absorbing kinetics, for absorbing the water when the absorbent is added, and for absorbing water at least one day after deposition.
16. The method of any one of claims 1 to 15, wherein the deposition area has a slope of 0.5% to 10% from horizontal to assist dewatering.

17. The method of any one of claims 1 to 16, wherein the first binder comprises a flocculent and/or coagulant.
18. The method of any one of claims 1 to 16, wherein the first binder comprises an anionic, cationic, non-ionic flocculent, or a combination thereof.
19. The method of any one of claims 1 to 16, wherein the first binder comprises polyacrylamide (PAM), poly(ethylene oxide) (PEO), poly(diallyldimethyl ammonium chloride) (polyDADMAC), poly(acrylic acid), poly(styrene sulfonic acid) (PSSA), or a combination thereof.
20. The method of any one of claims 1 to 16, wherein the first binder is an aluminum, ferric, calcium, sodium aluminate, or sodium silicate salt.
21. The method of claim 2, wherein the second binder comprises a flocculant.
22. The method of claim 21, wherein the second binder comprises polyacrylamide (PAM), poly(ethylene oxide) (PEO), poly(diallyldimethyl ammonium chloride) (polyDADMAC), poly(acrylic acid), poly(styrene sulfonic acid) (PSSA), or a combination thereof.
23. The method of any one of claims 1 to 22, wherein the oil sands tailings comprise flotation tailings (FT).
24. The method of any one of claims 1 to 22, wherein the oil sands tailings comprise fluid fine tailings (FFT).
25. The method of any one of claims 1 to 24, wherein the oil sands tailings comprise mature fine tailings (MFT).
26. The method of any one of claims 1 to 22, wherein the oil sands tailings comprise tailings from a tailings solvent recovery unit (TSRU).

27. The method of any one of claims 1 to 22, wherein the oil sands tailings comprise thickened tailings (TT).
28. The method of any one of claims 1 to 22, wherein the oil sands tailings comprise a mixture of flotation tailings (FT), fluid fine tailings (FFT), and mature fine tailings (MFT).
29. The method of any one of claims 1 to 22, wherein the oil sands tailings comprise a mixture of:
thickened tailings (TT); and
fluid fine tailings (FFT) and/or mature fine tailings (MFT).
30. The method of any one of claims 1 to 29, wherein the oil sands tailings, prior to processing, have a solids content of 5 to 55 wt%.
31. The method of any one of claims 1 to 29, wherein the oil sands tailings, prior to processing, have a solids content of 10 to 45 wt%.
32. The method of any one of claims 1 to 29, wherein the oil sands tailings, prior to processing, have a solids content of 10 to less than 25 wt%.
33. The method of any one of claims 1 to 32, wherein step (a) comprises removing 40 to 70 wt% of water in the oil sands tailings.
34. The method of any one of claims 1 to 33, wherein the water separated from the oil sands tailings has a solids content of less than 5 wt%.
35. The method of any one of claims 1 to 33, wherein the water separated from the oil sands tailings has a solids content of less than 1.0 wt%.
36. The method of any one of claims 1 to 33, wherein the water separated from the oil sands tailings has a solids content of less than 0.5 wt%.

37. The method of any one of claims 1 to 36, wherein step (a) produces a tailings stream having 35-70 wt% solids.
38. The method of any one of claims 1 to 36, wherein step (a) produces a tailings stream having 45-55 wt% solids.
39. The method of any one of claims 1 to 38, wherein step (b) is performed during transportation of the oil sands tailings.
40. The method of any one of claims 1 to 39, further comprising, after step (c), allowing the tailings to dewater, then depositing additional tailings on top, then continuing until a desired height is reached, then depositing coarse sand on top.
41. The method of any one of claims 1 to 40, wherein the first binder is added in an amount of 50 g/ton to 2000 g/ton of tailings, on a dry solid basis.
42. The method of any one of claims 1 to 40, wherein the first binder is added in an amount of 50 g/ton to 700 g/ton of tailings, on a dry solid basis.
43. The method of any one of claims 1 to 40, wherein the first binder is added in an amount of 50 g/ton to 300 g/ton of tailings, on a dry solid basis.
44. The method of any one of claims 1 to 43, wherein the absorbent is added in an amount of 50 g/ton to 10,000 g/ton of tailings, on a dry solid basis.
45. The method of any one of claims 1 to 43, wherein the absorbent is added in an amount of 50 g/ton to 3000 g/ton of tailings, on a dry solid basis.
46. The method of any one of claims 1 to 43, wherein the absorbent is added in an amount of 50 g/ton to 1000 g/ton of tailings, on a dry solid basis.

47. The method of any one of claims 2, 21 and 22, wherein the second binder is added in an amount of 50 g/ton to 1000 g/ton of tailings, on a dry solid basis.
48. The method of any one of claims 2, 21 and 22, wherein the second binder is added in an amount of 50 g/ton to 600 g/ton of tailings, on a dry solid basis.
49. The method of any one of claims 2, 21 and 22, wherein the second binder is added in an amount of 50 g/ton to 300 g/ton of tailings, on a dry solid basis.
50. The method of claim 2, wherein:
the oil sands tailings comprise flotation tailings (FT);
the oil sands tailings, prior to step (a), have a solids content of 10 to less than 25 wt%; and
the absorbent is added in an amount of 50 g/ton to 1000 g/ton of tailings, on a dry solid basis.
51. The method of claim 2, wherein:
the oil sands tailings comprise flotation tailings (FT); and
the method further comprises, after (b), and before (c) and (d), adding fluid fine tailings (FFT) to the oil sands tailings.
52. The method of any one of claims 1 to 51, wherein the solids comprise fines with particle sizes of less than 44 microns, and wherein the oil sands tailings has a sand to fines ratio (SFR) is 0.01 to 6.
53. The method of any one of claims 1 to 51, wherein the solids comprise fines with particle sizes of less than 44 microns, and wherein the oil sands tailings has a sand to fines ratio (SFR) is 0.1 to 4.
54. The method of any one of claims 1 to 51, wherein the solids comprise fines with particle sizes of less than 44 microns, and wherein the oil sands tailings has a sand to fines ratio (SFR) is 0.3 to 1.5.

55. The method of any one of claims 1 to 51, wherein the solids comprise fines with particle sizes of less than 44 microns, and wherein the oil sands tailings has a sand to fines ratio (SFR) is 0.5 to 1.

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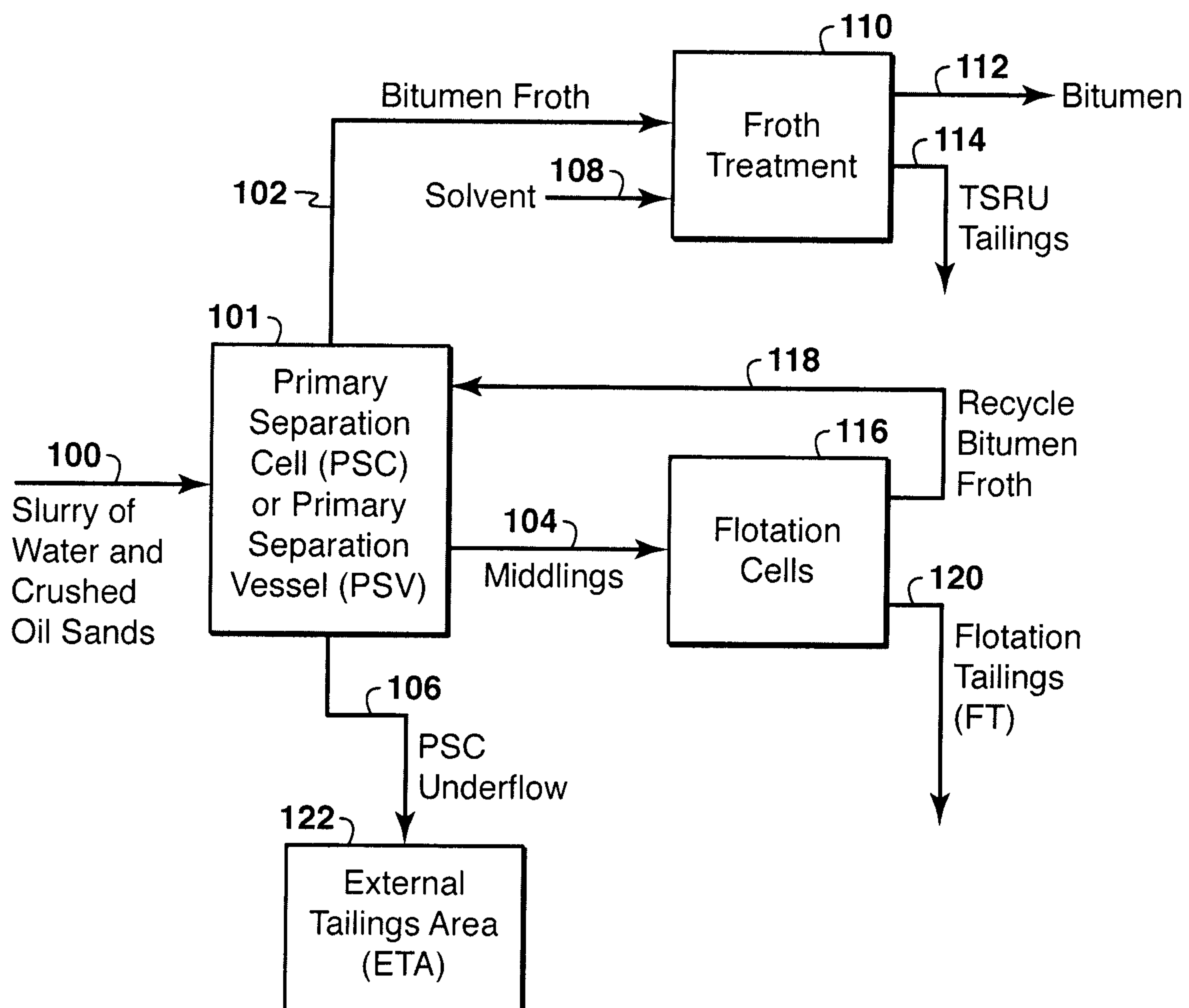


FIG. 1
(Prior Art)

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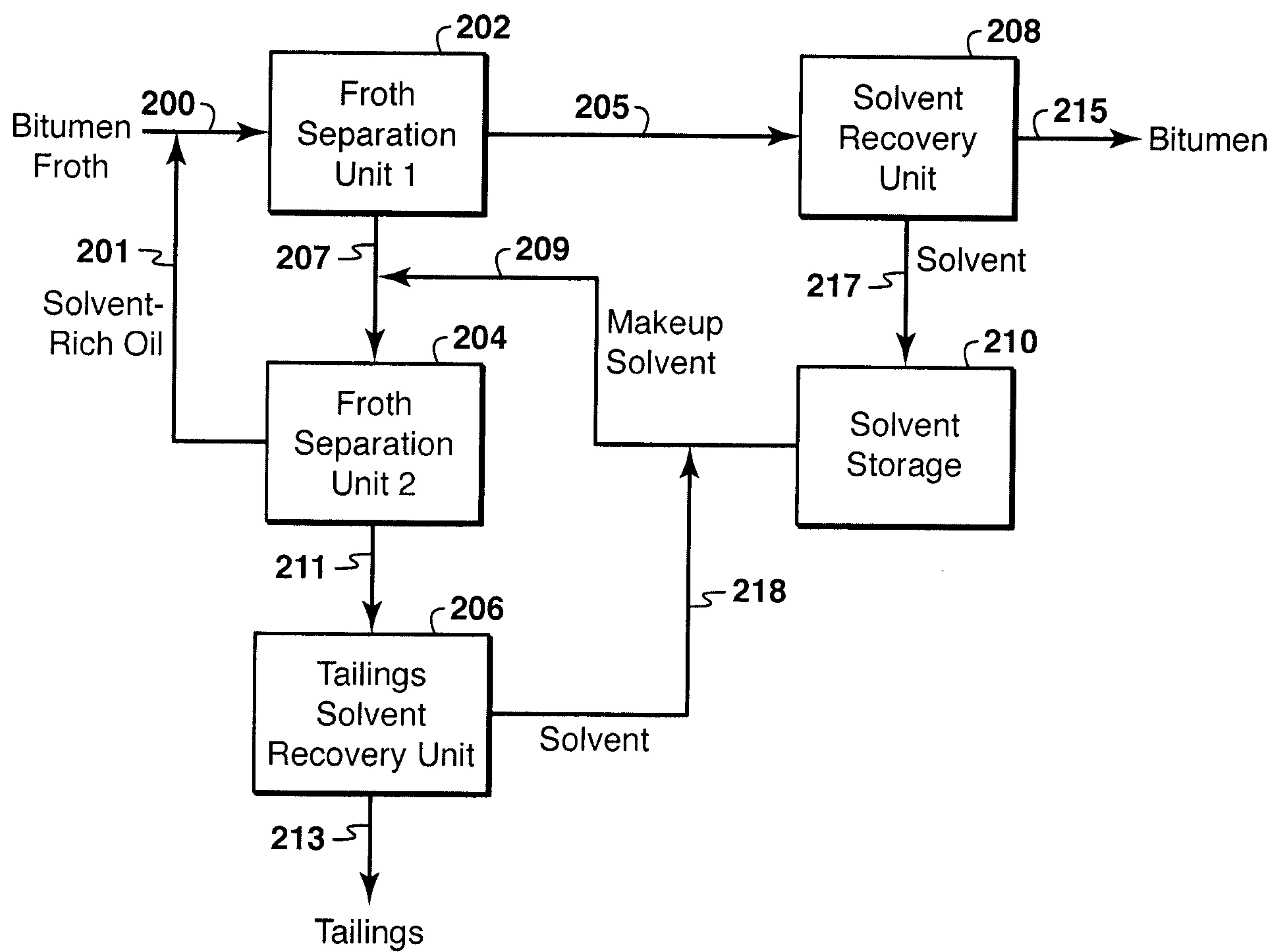


FIG. 2
(Prior Art)



