



(22) Date de dépôt/Filing Date: 2007/10/11

(41) Mise à la disp. pub./Open to Public Insp.: 2009/04/11

(45) Date de délivrance/Issue Date: 2011/01/18

(51) Cl.Int./Int.Cl. *B01D 21/01* (2006.01),
B03B 9/02 (2006.01), *C10G 1/00* (2006.01)

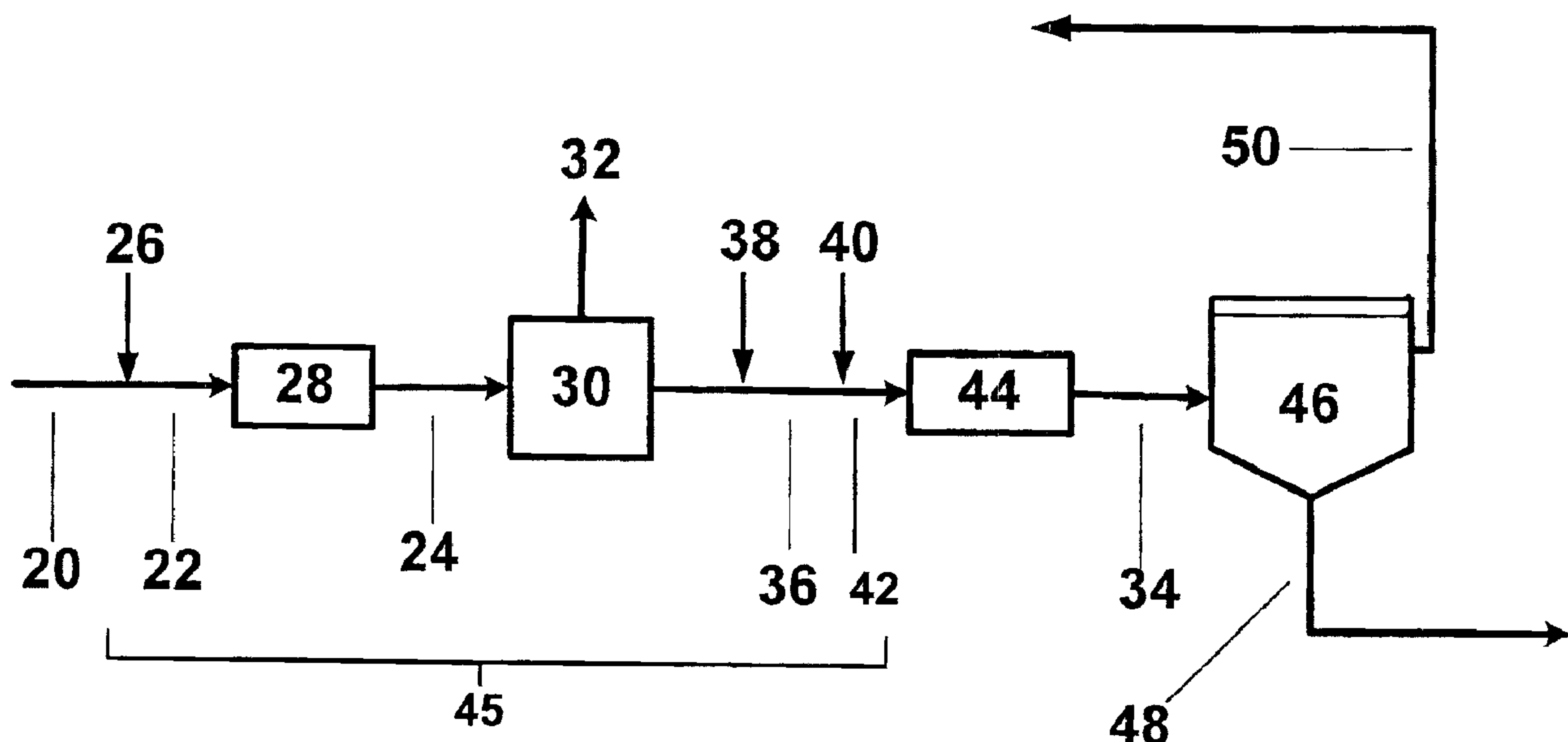
(72) Inventeurs/Inventors:
SETHI, AMAR JIT, CA;
STRAND, WILLIAM L., CA

(73) Propriétaires/Owners:
SETHI, AMAR JIT, CA;
B & N RESOURCES INC., CA

(74) Agent: EMERY JAMIESON LLP

(54) Titre : SYSTÈME ET PROCÉDE DE TRAITEMENT DE PRODUITS DE QUEUE

(54) Title: SYSTEM AND METHOD FOR TREATING TAILINGS



(57) Abrégé/Abstract:

A system and a method for producing dewatered fine tailings from tailings resulting from a process for recovering bitumen from oil sand. The method includes separating the tailings into fine tailings and coarse tailings, partially dewatering the fine tailings, chemically treating the partially dewatered fine tailings, and dewatering the chemically treated partially dewatered fine tailings in a high density thickener apparatus, thereby producing the dewatered fine tailings. The system includes an apparatus for separating the tailings into the fine tailings and the coarse tailings, an apparatus for partially dewatering the fine tailings, a chemical treatment subsystem for chemically treating the partially dewatered fine tailings, and a high density thickener apparatus for dewatering the chemically treated partially dewatered fine tailings to produce the dewatered fine tailings.

ABSTRACT

A system and a method for producing dewatered fine tailings from tailings resulting from a process for recovering bitumen from oil sand. The method includes separating the tailings into fine tailings and coarse tailings, partially dewatering the fine tailings, chemically treating the partially dewatered fine tailings, and dewatering the chemically treated partially dewatered fine tailings in a high density thickener apparatus, thereby producing the dewatered fine tailings. The system includes an apparatus for separating the tailings into the fine tailings and the coarse tailings, an apparatus for partially dewatering the fine tailings, a chemical treatment subsystem for chemically treating the partially dewatered fine tailings, and a high density thickener apparatus for dewatering the chemically treated partially dewatered fine tailings to produce the dewatered fine tailings.

SYSTEM AND METHOD FOR TREATING TAILINGS

TECHNICAL FIELD

5 A system and a method for treating tailings resulting from processes for recovering bitumen from oil sand.

BACKGROUND OF THE INVENTION

10 Oil sand is essentially a matrix of bitumen, solid mineral matter, and water.

 The bitumen component of oil sand consists of viscous hydrocarbons which behave much like a solid at normal in situ temperatures and which act as a binder for the other components of the oil sand matrix.

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 The solid mineral matter component of oil sand consists of sand, rock, silt and clay. Coarse solid material is generally considered to include solid mineral matter having a particle size greater than or equal to about 44 microns, while fine solid material is generally considered to include solid mineral matter having a particle size less than about 44 microns. Sand and rock are
20 therefore generally present in oil sand as coarse solid material, due to the relatively large size of individual particles of sand and rock. Silt and clay are generally present in oil sand as fine solid material, due to the relatively small size of individual particles of silt and clay.

 The water component of oil sand consists essentially of a film of connate water
25 surrounding the sand in the oil sand matrix, and may also contain particles of solid mineral matter within it.

 A typical deposit of oil sand will contain about 10% to 12% bitumen and about 3% to 6% water, with the remainder of the oil sand being made up of solid mineral matter. Of the total
30 amount of solid mineral matter, good quality oil sand deposits typically contain about 14% to 20% fine solid material and about 80% to 86% coarse solid material. Poorer quality oil sand deposits may contain 30% or more fine solid material. Oil sand extracted from the Athabasca area near

Fort McMurray, Alberta, Canada averages about 11% bitumen, 5% water and 84% solid mineral matter, with about 15% to 20% of the solid mineral matter being fine solid material.

Oil sand deposits are mined for the purpose of recovering bitumen from the oil sand, which bitumen is then upgraded to synthetic crude oil. Several different approaches to recovering the bitumen from the oil sand have been developed.

A conventional approach to recovering bitumen from oil sand is the use of a "hot water process" in which aggressive thermal action, aggressive chemical action and aggressive mechanical action are used to liberate and separate bitumen from the oil sand.

The hot water process includes several steps. In a first step, oil sand is conditioned by mixing the oil sand with hot water in a conditioning vessel which vigorously agitates the resulting slurry in order to completely disintegrate the oil sand. Sodium hydroxide (caustic) may be added to the slurry during conditioning to maintain a slightly basic pH in the conditioning vessel, which enhances the disintegration of the oil sand by chemically dispersing the fine solid material contained in the oil sand.

In a second step, the slurry of disintegrated oil sand undergoes a primary separation process in a primary separation vessel. The primary separation process separates the slurry into three streams. A solids stream, containing relatively large amounts of coarse solid material and relatively small amounts of bitumen and fine solid material, settles out from the slurry and is withdrawn from a lower portion of the primary separation vessel. A bitumen froth stream, containing relatively large amounts of air entrained bitumen and relatively small amounts of solid mineral matter, floats to the top of the slurry and is withdrawn from an upper portion of the primary separation vessel. A middlings stream, containing a relatively small amount of bitumen and a relatively large amount of fine solid material, is withdrawn from an intermediate portion of the primary separation vessel.

In a third step, the middlings stream is treated or scavenged, typically by froth flotation techniques, to recover a portion of the bitumen contained therein. The bitumen which is

recovered from the middlings stream may be returned to the primary separation process or may be combined with the bitumen froth stream.

5 In a fourth step, the bitumen froth stream is subjected to a froth treatment process in which solid mineral matter and water is separated from the bitumen froth to produce a “clean” and “dry” bitumen froth.

10 Tailings resulting from processes to recover bitumen from oil sand generally contain water, solid mineral matter, small amounts of residual bitumen, and other substances as further impurities. Such tailings may generally be described as “coarse tailings” if they contain a relatively high ratio by weight of coarse solid material relative to fine solid material, and such tailings may generally be described as “fine tailings” if they contain a relatively low ratio by weight of coarse solid material relative to fine solid material.

15 The various steps of the hot water process result in the production of both coarse tailings and fine tailings. Coarse tailings are produced by the primary separation process as the solids stream which is withdrawn from the lower portion of the primary separation vessel, fine tailings are produced by the froth treatment process as froth treatment tailings, and fine tailings are also produced by the treatment or scavenging of the middlings stream as middlings tailings.

20 The management of tailings resulting from processes to recover bitumen from oil sand presents significant challenges. Although coarse tailings may be effectively dewatered and disposed of as backfill or in berms, fine tailings (particularly those produced from the middlings stream) tend to be resistant to dewatering and difficult to dispose of in an environmentally appealing manner due to the small particle size of fine solid material and the complexities of the behaviour of clays and silts. These problems are exacerbated by the virtually complete disintegration of oil sand that occurs during the hot water process, which includes both physical and chemical dispersal of the fine solid material contained in the oil sand.

30 Conventionally, most fine tailings produced by the hot water process are deposited in tailings ponds, where they undergo a limited degree of settling to form mature fine tailings (“MFT”), a stable suspension of fine tailings having a solids content by weight of no greater than

about 30 percent. Mature fine tailings are not sufficiently solid to support most uses of the land occupied by the tailings ponds. In addition, due to their relatively low solids content (and thus high water content), mature fine tailings trap large amounts of valuable process water.

5 Another approach to recovering bitumen from oil sand is directed at “solids rejection” as a primary separation technique, in which oil sand is separated into a bitumen froth stream and a solids stream, without the production of a middlings stream.

10 One example of the solids rejection approach is described in Canadian Patent Application No. 2,030,934 (Strand), Canadian Patent Application No. 2,124,199 (Strand), Canadian Patent No. 2,123,076 (Strand et al), Canadian Patent Application No. 2,512,106 (Strand), and Canadian Patent Application No. 2,524,110 (Strand), all of which are assigned to Bitmin Resources Inc. (the “Bitmin Process”).

15 In the Bitmin Process, a countercurrent separator drum containing a spiral ribbon and mixer elements is utilized for primary separation of the oil sand. Oil sand is gently rolled from one end to the other end of the separator drum while warm water circulates in the opposite direction. The pH of the warm water in the separator drum is maintained at no greater than about 7 in order to limit the chemical dispersal of fine solid material contained in the oil sand.

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 Two streams are then removed from the opposite ends of the separator drum. A solids stream containing solid mineral matter (including coarse solid material and a small amount of fine solid material), water and a small amount of residual bitumen is removed from one end of the separator drum, and a bitumen froth stream containing bitumen, solid mineral matter (including
25 fine solid material and a small amount of coarse solid material) and water is removed from the other end of the separator drum.

 The solids stream, representing coarse tailings, is filtered using a horizontal belt filter apparatus to produce dewatered coarse tailings which may be disposed of as backfill, in
30 berms, or in some other manner. The bitumen froth stream is further processed to produce bitumen froth as a product stream and fine tailings. The fine tailings are dewatered in a thickener, following which all or a portion of the dewatered fine tailings may be co-filtered with the coarse

tailings to produce non-segregating tailings comprising the coarse tailings and the fine tailings, or the fine tailings may be disposed of in some other manner.

5 A second example of the solids rejection approach is described in Canadian Patent No. 2,332,207 (Lavender et al) and Canadian Patent No. 2,358,805 (Lavender et al), both of which are assigned to TSC Company Ltd. (the "TSC Process").

10 In the TSC Process, an assembly of three hydrocyclone packs or clusters arranged countercurrently in series are utilized for primary separation of the oil sand. Two streams are removed from the hydrocyclone assembly. A solids stream containing solid mineral matter (including coarse solid material and some fine solid material), water and a small amount of bitumen is removed as an underflow stream from the third hydrocyclone, and a bitumen froth stream containing bitumen, solid mineral matter (including fine solid material and some coarse solid material) and water is removed as an overflow stream from the first hydrocyclone.

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The solids stream, representing coarse tailings, is filtered using a horizontal belt filter apparatus to produce dewatered coarse tailings. The bitumen froth stream is further processed in a "product separator" to produce bitumen froth as a product stream and fine tailings. The fine tailings are recycled back to the hydrocyclone assembly for further processing in the hydrocyclone assembly.

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Other approaches to recovering bitumen from oil sand may be based upon variations of the hot water process, the Bitmin Process and the TSC Process, or may be based upon other technologies.

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Regardless of the approach which is used to recover bitumen from oil sand, the production of fine tailings as a result of the recovery process has thus far been virtually inevitable, due to the complex composition of oil sand and the challenges faced in efficiently and effectively recovering bitumen from oil sand.

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As a result, there continues to be a need for processes and systems for treating tailings resulting from processes for recovering bitumen from oil sand. There is a particular need

for processes and systems for dewatering fine tailings to recover process water therefrom and to provide dewatered fine tailings having improved chemical and physical properties.

SUMMARY OF THE INVENTION

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The present invention is directed at systems and methods for treating tailings resulting from processes for recovering bitumen from oil sand.

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The invention includes the use of chemical treatment and a high density thickener apparatus for the purpose of producing dewatered fine tailings from partially dewatered fine tailings. The invention may also include systems and methods for producing partially dewatered fine tailings from fine tailings. The invention may also include systems and methods for separating tailings into fine tailings and coarse tailings. The invention may also include systems and methods for dewatering coarse tailings to produce dewatered coarse tailings. The invention may also include methods for disposing fine tailings and coarse tailings.

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Tailings resulting from processes for recovering bitumen from oil sand may have a pH above 7 and may contain relatively high concentrations of carbonate ions and bicarbonate ions. The purpose of the chemical treatment is to provide the tailings with a water chemistry which is favourable for processing of the tailings. For example, the chemical treatment may remove carbonate ions and bicarbonate ions from the tailings in order to reduce the concentration of carbonate ions and bicarbonate ions in the tailings, and/or the chemical treatment may lower and/or neutralize the pH of the tailings.

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The chemical treatment may be applied to partially dewatered fine tailings. The chemical treatment may be comprised of facilitating cation exchange in the partially dewatered fine tailings in order to reduce the activity of clay particles contained within the partially dewatered fine tailings. Facilitating cation exchange in the partially dewatered fine tailings may be comprised of adding a suitable cation to the partially dewatered fine tailings. The added cation may be calcium ions.

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The chemical treatment may be comprised of adjusting the pH of the partially dewatered fine tailings to a substantially neutral pH and/or maintaining the pH of the partially dewatered fine tailings at a substantially neutral pH. The substantially neutral pH may be between about 6.5 and about 7.5.

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The chemical treatment may be comprised of reducing the pH of the partially dewatered fine tailings to less than about 6 in order to remove carbonate ions and bicarbonate ions from the partially dewatered fine tailings. The chemical treatment may be comprised of reducing the pH of the partially dewatered fine tailings to about 4 in order to remove substantially all carbonate ions and bicarbonate ions from the partially dewatered fine tailings.

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The chemical treatment may be comprised of reducing the pH of the partially dewatered fine tailings to produce acidic partially dewatered fine tailings in order to remove carbonate ions and bicarbonate ions from the partially dewatered fine tailings and then increasing the pH of the acidic partially dewatered fine tailings to a substantially neutral pH in order to produce neutralized partially dewatered fine tailings.

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The removal of carbonate ions and bicarbonate ions from the partially dewatered fine tailings may result in carbon dioxide being evolved from the partially dewatered fine tailings. The evolved carbon dioxide may be collected. The collected evolved carbon dioxide may be sequestered or may be used or disposed in some other manner.

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The pH of the partially dewatered fine tailings may be reduced in any suitable manner. For example, the pH of the partially dewatered fine tailings may be reduced by adding an acid to the partially dewatered fine tailings. The acid may be any suitable acid, such as for example sulphuric acid or sulphamic acid.

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The pH of the partially dewatered fine tailings may be increased in any suitable manner. For example, the pH of the partially dewatered fine tailings may be increased by adding a base to the partially dewatered fine tailings.

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The base may be comprised of the cations which are added to the partially dewatered fine tailings so that adding the base to the partially dewatered fine tailings results both in adding the cations to the partially dewatered fine tailings and in increasing the pH of the partially dewatered fine tailings. The base may therefore be comprised of an alkaline substance
 5 containing calcium ions, such as lime (i.e., calcium oxide or calcium hydroxide).

A flocculant may be added to the chemically treated partially dewatered fine tailings in order further to facilitate production of the dewatered fine tailings in the high density thickener apparatus.

10 The high density thickener apparatus may be comprised of any thickener type apparatus which is capable of producing an underflow stream having a relatively high solids content by weight in comparison with the underflow stream produced by a conventional thickener. For example, the high density thickener apparatus may be a deep cone paste thickener.

15 In a first embodiment, the invention is a method of producing dewatered fine tailings from partially dewatered fine tailings resulting from a process for recovering bitumen from oil sand, the method comprising:

- 20 (a) providing the partially dewatered fine tailings, wherein the partially dewatered fine tailings are comprised of water, fine solid material and coarse solid material, wherein the partially dewatered fine tailings have a ratio by weight of coarse solid material to fine solid material of less than about 2 to 1;
- 25 (b) reducing the pH of the partially dewatered fine tailings to less than about 6 in order to remove carbonate ions and bicarbonate ions from the partially dewatered fine tailings, thereby producing acidic partially dewatered fine tailings;
- 30 (c) adding calcium ions to the acidic partially dewatered fine tailings in order to facilitate cation exchange in the acidic partially dewatered fine tailings whereby the calcium ions are exchanged into the acidic partially dewatered fine tailings;

(d) increasing the pH of the acidic partially dewatered fine tailings to between about 6.5 and about 7.5, thereby producing neutralized partially dewatered fine tailings having a substantially neutral pH;

5 (e) adding a flocculant to the neutralized partially dewatered fine tailings; and

(f) dewatering the neutralized partially dewatered fine tailings in a high density thickener apparatus, thereby producing the dewatered fine tailings.

10 Preferably the partially dewatered fine tailings have a solids content by weight which is at least about 25 percent. Alternatively, preferably the partially dewatered fine tailings are froth treatment tailings resulting from the treatment of bitumen froth produced by the hot water process.

15 The pH of the partially dewatered fine tailings may be lowered to about 4 in order to facilitate removal of substantially all of the carbonate ions and the bicarbonate ions from the partially dewatered fine tailings.

20 The partially dewatered fine tailings may have a ratio by weight of coarse solid material to fine solid material of between about 0.1 to 1 and about 2 to 1. The partially dewatered fine tailings may have a ratio by weight of fine solid material to fine solid material plus water of between about 0.25 to 1 and about 0.35 to 1. The partially dewatered fine tailings may have a density of between about 1250 kg/m³ and about 1450 kg/m³. The partially dewatered fine tailings may have a solids content by weight of between about 25 percent and about 50 percent.

25 The dewatered fine tailings may have a ratio by weight of fine solid material to fine solid material plus water of between about 0.45 to 1 and about 0.60 to 1. The dewatered fine tailings may have a density of between about 1550 kg/m³ and about 1800 kg/m³. The dewatered fine tailings may have a solids content by weight of between about 50 percent and about 75
30 percent.

In a second embodiment, the dewatered fine tailings of the first embodiment are produced from fine tailings. As a result, the partially dewatered fine tailings are first produced from the fine tailings, and the dewatered fine tailings are then produced from the partially dewatered fine tailings.

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In the second embodiment, the invention is therefore a method of producing dewatered fine tailings from fine tailings resulting from a process for recovering bitumen from oil sand, the method comprising:

- 10 (a) providing the fine tailings, wherein the fine tailings are comprised of water, fine solid material and coarse solid material and wherein the fine tailings have a ratio by weight of coarse solid material to fine solid material of less than about 2 to 1;
- 15 (b) partially dewatering the fine tailings to produce partially dewatered fine tailings, wherein the partially dewatered fine tailings have a solids content by weight of at least about 25 percent;
- 20 (c) reducing the pH of the partially dewatered fine tailings to less than about 6 in order to remove carbonate ions and bicarbonate ions from the partially dewatered fine tailings, thereby producing acidic partially dewatered fine tailings;
- 25 (d) adding calcium ions to the acidic partially dewatered fine tailings in order to facilitate cation exchange in the acidic partially dewatered fine tailings whereby the calcium ions are exchanged into the acidic partially dewatered fine tailings;
- (e) increasing the pH of the acidic partially dewatered fine tailings to between about 6.5 and about 7.5, thereby producing neutralized partially dewatered fine tailings having a substantially neutral pH;
- 30 (f) adding a flocculant to the neutralized partially dewatered fine tailings; and

- (g) dewatering the neutralized partially dewatered fine tailings in a high density thickener apparatus, thereby producing the dewatered fine tailings.

The pH of the partially dewatered fine tailings may be lowered to about 4 in order to facilitate removal of substantially all of the carbonate ions and the bicarbonate ions from the partially dewatered fine tailings.

The fine tailings may have a ratio by weight of coarse solid material to fine solid material of between about 0.1 to 1 and about 2 to 1. The fine tailings may have a ratio by weight of fine solid material to fine solid material plus water of between about 0.05 to 1 and about 0.25 to 1. The fine tailings may have a density of between about 1100 kg/m³ and about 1250 kg/m³. The fine tailings may have a solids content by weight of between about 15 percent and about 30 percent.

The fine tailings may be partially dewatered in any manner which results in the production of partially dewatered fine tailings having the required composition as set out above. For example, the fine tailings may be partially dewatered in a conventional thickener apparatus. The conventional thickener apparatus may be comprised of one or more conventional thickeners.

In a third embodiment, the dewatered fine tailings of the first embodiment are produced from tailings. As a result, the tailings are first separated into fine tailings and coarse tailings, the partially dewatered fine tailings are then produced from the fine tailings, and the dewatered fine tailings are then produced from the partially dewatered fine tailings.

In a method aspect of the third embodiment, the invention is therefore a method of producing dewatered fine tailings from tailings resulting from a process for recovering bitumen from oil sand, the method comprising:

- (a) providing the tailings, wherein the tailings are comprised of water, fine solid material and coarse solid material;

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- (b) separating the tailings into fine tailings and coarse tailings, wherein the fine tailings have a ratio by weight of coarse solid material to fine solid material of less than about 2 to 1, and wherein the coarse tailings have a ratio by weight of coarse solid material to fine solid material of at least about 20 to 1;
- (c) partially dewatering the fine tailings to produce partially dewatered fine tailings, wherein the partially dewatered fine tailings have a solids content by weight of at least about 25 percent;
- 10 (d) reducing the pH of the partially dewatered fine tailings to less than about 6 in order to remove carbonate ions and bicarbonate ions from the partially dewatered fine tailings, thereby producing acidic partially dewatered fine tailings;
- 15 (e) adding calcium ions to the acidic partially dewatered fine tailings in order to facilitate cation exchange in the acidic partially dewatered fine tailings whereby the calcium ions are exchanged into the acidic partially dewatered fine tailings;
- 20 (f) increasing the pH of the acidic partially dewatered fine tailings to between about 6.5 and about 7.5, thereby producing neutralized partially dewatered fine tailings having a substantially neutral pH;
- (g) adding a flocculant to the neutralized partially dewatered fine tailings; and
- 25 (h) dewatering the neutralized partially dewatered fine tailings in a high density thickener apparatus, thereby producing the dewatered fine tailings.

The pH of the partially dewatered fine tailings may be lowered to about 4 in order to facilitate removal of substantially all of the carbonate ions and the bicarbonate ions from the partially dewatered fine tailings.

In a system aspect of the third embodiment, the invention is therefore a system for producing dewatered fine tailings from fine tailings resulting from a process for recovering bitumen from oil sand, the system comprising:

- 5 (a) an apparatus for partially dewatering the fine tailings in order to produce partially dewatered fine tailings;
- (b) a chemical treatment subsystem for chemically treating the partially dewatered fine tailings, the chemical treatment subsystem comprising:
 - 10 (i) a station for reducing the pH of the partially dewatered fine tailings to less than about 6 in order to remove carbonate ions and bicarbonate ions from the partially dewatered fine tailings, thereby producing acidic partially dewatered fine tailings;
 - 15 (ii) a station for adding calcium ions to the acidic partially dewatered fine tailings in order to facilitate cation exchange in the acidic partially dewatered fine tailings whereby the calcium ions are exchanged into the acidic partially dewatered fine tailings;
 - 20 (iii) a station for increasing the pH of the acidic partially dewatered fine tailings to between about 6.5 and about 7.5, thereby producing neutralized partially dewatered fine tailings having a substantially neutral pH; and
 - 25 (iv) a station for adding a flocculant to the neutralized partially dewatered fine tailings; and
- (c) a high density thickener apparatus for dewatering the neutralized partially dewatered fine tailings to produce the dewatered fine tailings.

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The station for reducing the pH of the partially dewatered fine tailings may reduce the pH of the partially dewatered fine tailings to about 4 in order to facilitate removal of

substantially all of the carbonate ions and the bicarbonate ions from the partially dewatered fine tailings.

The coarse tailings may have a ratio by weight of coarse solid material to fine solid material of between about 20 to 1 and about 30 to 1. The coarse tailings may have a ratio by weight of fine solid material to fine solid material plus water of less than about 0.10 to 1. The coarse tailings may have a density of between about 1650 kg/m³ and about 1750 kg/m³. The coarse tailings may have a solids content by weight of between about 60 percent and about 80 percent.

The tailings may be separated into the fine tailings and the coarse tailings in any suitable manner. For example, the tailings may be separated into the fine tailings and the coarse tailings by passing the tailings through a cyclone apparatus. The cyclone apparatus may be comprised of one or more cyclones and/or stages of cyclones. The cyclone apparatus may be comprised of a first stage cyclone and a second stage cyclone.

Separating the tailings into the fine tailings and the coarse tailings may be comprised of passing the tailings through the first stage cyclone, thereby producing a first overflow stream and a first underflow stream and passing the first underflow stream through the second stage cyclone, thereby producing a second overflow stream and a second underflow stream.

The fine tailings may be comprised of the first overflow stream. The fine tailings may be further comprised of the second overflow stream. The coarse tailings may be comprised of the second underflow stream.

The high density thickener apparatus which is used to dewater the partially dewatered fine tailings may produce an underflow stream comprised of the dewatered fine tailings and an overflow stream. At least a portion of the overflow stream from the high density thickener apparatus may be combined with the first underflow stream from the first stage cyclone before the first underflow stream is passed through the second stage cyclone.

The dewatered fine tailings and the coarse tailings may be transported in any suitable manner for any desired purpose. For example, the dewatered fine tailings may be transported in separate pipelines. The dewatered fine tailings and the coarse tailings may be transported by separate pipelines to a tailings disposal area.

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A flocculant may be added to the coarse tailings at an upstream end of the pipeline carrying the coarse tailings in order to inhibit the separation of the fine solid material and the coarse solid material in the pipeline.

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The density and/or solids content by weight of the coarse tailings may be adjusted before the coarse tailings are transported by pipeline. As one example, the density of the coarse tailings may be adjusted to be no greater than about 1750 kg/m^3 before the coarse tailings are transported by pipeline. As a second example, the solids content by weight of the coarse tailings may be adjusted to be no greater than about 70 percent before the coarse tailings are transported by pipeline.

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The density and/or solids content by weight of the coarse tailings may be adjusted in any suitable manner. For example, the density and/or solids content by weight may be adjusted by diluting the coarse tailings with water. The coarse tailings may be diluted with water obtained from the method of the invention or from some other source. For example, the coarse tailings may be diluted with at least a portion of the overflow stream from the high density thickener apparatus.

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The bulk fluid velocity of the coarse tailings while being transported through the pipeline carrying the coarse tailings may be maintained at or above a minimum bulk fluid velocity. The minimum bulk fluid velocity of the coarse tailings being transported through the pipeline may be about 3 meters per second.

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The coarse tailings may be transported through the pipeline carrying the coarse tailings in any suitable manner, having regard to the solids content by weight and the viscosity of the coarse tailings. As one example, in some embodiments the coarse tailings may potentially be transported through the pipeline carrying the coarse tailings using one or more centrifugal pumps.

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As a second example, in other embodiments the coarse tailings may be transported through the pipeline carrying the coarse tailings using one or more positive displacement pumps.

5 Where flocculant is added to the coarse tailings in order to inhibit the separation of the fine solid material and the coarse solid material in the pipeline, the flocculant is preferably added downstream of the pump or pumps.

10 Similarly, the dewatered fine tailings may be transported through the pipeline carrying the dewatered fine tailings in any suitable manner, having regard to the solids content by weight and the viscosity of the dewatered fine tailings. As one example, in some embodiments the dewatered fine tailings may potentially be transported through the pipeline carrying the dewatered fine tailings using one or more centrifugal pumps. As a second example, in other embodiments the dewatered fine tailings may be transported through the pipeline carrying the dewatered fine tailings using one or more positive displacement pumps.

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The invention may also involve methods of disposing dewatered fine tailings and coarse tailings resulting from processes for recovering bitumen from oil sand. The methods of disposing may be performed using dewatered fine tailings and/or coarse tailings produced using the method of the invention, or may be performed using dewatered fine tailings and/or coarse
20 tailings which have been produced using some other method or methods.

In a first method of disposing dewatered fine tailings and coarse tailings, the invention is a method of disposing dewatered fine tailings and coarse tailings resulting from a process for recovering bitumen from oil sand, the method comprising:

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- (a) providing the dewatered fine tailings, wherein the dewatered fine tailings are comprised of water, fine solid material and coarse solid material, wherein the dewatered fine tailings have a ratio by weight of coarse solid material to fine solid material of less than about 2 to 1, and wherein the dewatered fine tailings have a
30 solids content by weight of at least about 50 percent;

- (b) providing the coarse tailings, wherein the coarse tailings are comprised of water, fine solid material and coarse solid material, wherein the coarse tailings have a ratio by weight of coarse solid material to fine solid material of at least about 20 to 1, and wherein the coarse tailings have a solids content by weight of at least about 60 percent;
- (c) providing a tailings disposal area; and
- (d) depositing the dewatered fine tailings and the coarse tailings in the tailings disposal area in alternating layers.

The dewatered fine tailings may have a ratio by weight of fine solid material to fine solid material plus water of between about 0.45 to 1 and about 0.60 to 1. The dewatered fine tailings may have a density of between about 1550 kg/m³ and about 1800 kg/m³. The dewatered fine tailings may have a solids content by weight of between about 50 percent and about 75 percent.

The coarse tailings may have a ratio by weight of coarse solid material to fine solid material of between about 20 to 1 and about 30 to 1. The coarse tailings may have a ratio by weight of fine solid material to fine solid material plus water of less than about 0.10 to 1. The coarse tailings may have a density of between about 1650 kg/m³ and about 1750 kg/m³. The coarse tailings may have a solids content by weight of between about 60 percent and about 80 percent.

The dewatered fine tailings may have been subjected to chemical treatment before being deposited in the tailings disposal area. The chemical treatment may have been similar to the chemical treatment of partially dewatered fine tailings according to other embodiments of the invention. The dewatered fine tailings may have been subjected to chemical treatment during their production or following their production.

The dewatered fine tailings may therefore contain a relatively low concentration of carbonate ions and bicarbonate ions, may have a substantially neutral pH, and may have been

subjected to cation exchange whereby suitable cations have been exchanged into the dewatered fine tailings in order to reduce the activity of clay particles contained in the dewatered fine tailings. The suitable cations may be calcium ions.

5 The dewatered fine tailings and the coarse tailings may have similar and/or compatible water chemistry when they are deposited in the tailings disposal area, in order to avoid adverse chemical reactions between the dewatered fine tailings and the coarse tailings following their deposition in the tailings disposal area. For example, the coarse tailings may contain a relatively low concentration of carbonate ions and bicarbonate ions. The coarse tailings may also
10 have a relatively neutral pH. The coarse tailings may also contain suitable cations for cation exchange.

 The similar and/or compatible water chemistry of the coarse tailings may be achieved by subjecting the coarse tailings to some or all of the chemical treatment which is applied
15 to the partially dewatered fine tailings according to other embodiments of the invention. The coarse tailings may be subjected to chemical treatment either during their production or following their production.

 Alternatively, water recovered from the partially dewatered fine tailings in the
20 course of production of the dewatered fine tailings in accordance with the methods of the invention may be added to the coarse tailings in order to achieve some degree of similar and/or compatible water chemistry of the coarse tailings, by diluting the coarse tailings with water from chemically treated partially dewatered fine tailings.

25 Achieving a similar and/or compatible water chemistry for the dewatered fine tailings and the coarse tailings and/or subjecting the coarse tailings to some or all of the chemical treatment which is applied to the partially dewatered fine tailings may also cause the coarse tailings to flow more easily when deposited in layers in the tailings disposal area and may also cause the coarse tailings to exhibit a relatively lower angle of repose in the tailings disposal area so that the
30 coarse tailings deposit in the tailings disposal area as a nearly flat layer over the underlying layer of dewatered fine tailings.

The chemical treatment of the coarse tailings may therefore be comprised of:

- (a) reducing the pH of the coarse tailings to less than about 6 in order to remove carbonate ions and bicarbonate ions from the coarse tailings, thereby producing acidic coarse tailings;
- (b) adding calcium ions to the acidic coarse tailings in order to facilitate cation exchange in the acidic coarse tailings whereby the calcium ions are exchanged into the acidic coarse tailings; and
- (c) increasing the pH of the acidic coarse tailings to between about 6.5 and about 7.5, thereby producing neutralized coarse tailings having a substantially neutral pH.

A flocculant may be added to the coarse tailings in order further to facilitate dewatering of the coarse tailings in the tailings disposal area. Where coarse tailings which have a suitable water chemistry or which have been subjected to chemical treatment are transported in a pipeline, the flocculant may be added downstream of the pump or pumps.

The first method of disposing dewatered fine tailings and coarse tailings may be further comprised of collecting drained water which is drained over time from the dewatered fine tailings and the coarse tailings in the tailings disposal area.

The collection of drained water may be performed in any suitable manner. For example, the tailings disposal area may be provided with a drainage grid positioned in a lower portion of the tailings disposal area, and/or the tailings disposal area may be provided with vertical drains extending substantially vertically in the tailings disposal area.

The alternating layers of the dewatered fine tailings and the coarse tailings each have a thickness. The thickness of the alternating layers may be selected to enhance the further dewatering of the dewatered fine tailings. For example, the ratio of the thickness of the layers of the dewatered fine tailings to the thickness of the layers of the coarse tailings may be less than about 1 to 1 or may be less than about 0.5 to 1.

In a second method of disposing dewatered fine tailings and coarse tailings, the coarse tailings may be dewatered to produce dewatered coarse tailings. The coarse tailings may be dewatered in any suitable manner. For example, the coarse tailings may be dewatered by filtering
5 using a horizontal belt filter apparatus to produce the dewatered coarse tailings and belt filter filtrate. A flocculant may be added to the coarse tailings before the coarse tailings are filtered.

The belt filter filtrate may be recycled, may be further processed or may be disposed or used for some other purpose. For example, all or a portion of the belt filter filtrate may be
10 combined with the first underflow stream from the first stage cyclone.

The dewatered coarse tailings may have a solids content by weight of between about 6 percent and about 12 percent.

15 The dewatered coarse tailings may be combined with the dewatered fine tailings in order to produce combined dewatered tailings. The dewatered coarse tailings and the dewatered fine tailings may be combined in any desired proportion to produce the combined dewatered tailings.

20 The combined dewatered tailings may be used as backfill or in berms or may be used or disposed in some other manner.

BRIEF DESCRIPTION OF DRAWINGS

25 Embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a process flow diagram depicting a first embodiment of the invention in which partially dewatered fine tailings are processed to produce dewatered fine tailings.

30 Figure 2 is a process flow diagram depicting a second embodiment of the invention in which fine tailings are processed to produce dewatered fine tailings.

Figure 3 is a process flow diagram depicting a third embodiment of the invention in which tailings are processed to produce dewatered fine tailings and coarse tailings.

5 Figure 4 is a schematic vertical section drawing of a tailings disposal area according to a first method for disposing dewatered fine tailings and coarse tailings in which dewatered fine tailings and coarse tailings are deposited in the tailings disposal area in alternating layers.

10 Figure 5 is a schematic plan view of the tailings disposal area of Figure 4.

 Figure 6 is a process flow diagram including the third embodiment of the invention depicted in Figure 3, and a second method for disposing the dewatered fine tailings and coarse tailings in which coarse tailings are dewatered to produce dewatered coarse tailings and in which the dewatered fine tailings and dewatered coarse tailings are combined to produce combined
15 dewatered tailings.

 Figure 7 is a theoretical material balance for the process flow diagram of Figure 1, wherein the partially dewatered fine tailings are froth treatment tailings.

20 Figure 8 is a theoretical material balance for the process flow diagram of Figure 2, wherein the fine tailings are mature fine tailings.

 Figure 9 is a theoretical material balance for the process flow diagram of Figure 2, wherein the fine tailings are fine tailings produced by the Bitmin Process.

25 Figure 10 is a theoretical material balance for the process flow diagram of Figure 2, wherein the fine tailings are fine tailings produced by the TSC Process.

 Figure 11 is a theoretical material balance for the process flow diagram of Figure 3,
30 wherein the tailings are middlings tailings produced by the hot water process.

Figure 12 is a theoretical material balance for the process flow diagram of Figure 6, wherein the tailings are middlings tailings produced by the hot water process.

DETAILED DESCRIPTION

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The present invention is directed at methods and systems for treating tailings resulting from processes for recovering bitumen from oil sand. The invention may involve the dewatering of partially dewatered fine tailings to produce dewatered fine tailings. The invention may also involve the partial dewatering of fine tailings to produce the partially dewatered fine
10 tailings. The invention may also involve the separation of tailings into fine tailings and coarse tailings. The invention may also involve the disposal of dewatered fine tailings, coarse tailings and/or dewatered coarse tailings.

As used herein, "bitumen" is the hydrocarbon material typically contained in oil
15 sand deposits. As used herein, a "bitumen recovery process" includes any process by which bitumen is recovered or separated from a material which contains bitumen and non-hydrocarbon material such as solid mineral matter, water, etc.

As used herein, "coarse solid material" is solid mineral matter having a particle size
20 greater than or equal to about 44 microns, while "fine solid material" is solid mineral matter having a particle size less than about 44 microns.

As used herein, "ratio by weight of coarse solid material to fine solid material" is the weight of coarse solid material contained in tailings relative to the weight of fine solid material
25 contained in the tailings, expressed as a ratio.

As used herein, "fine tailings" are tailings which result from a process to recover bitumen from oil sand and which contain a relatively low ratio by weight of coarse solid material relative to fine solid material. The ratio by weight of coarse solid material to fine solid material for
30 fine tailings may be any ratio which represents that a significant proportion of fine solid material relative to coarse solid material is contained in the tailings, such that the properties of the tailings are significantly affected by the fine solid material contained therein. Although the ratio by weight

of coarse solid material to fine solid material for fine tailings may be as high as about 10 to 1, the ratio is preferably less than about 6 to 1, and more preferably is less than about 2 to 1.

As used herein, "coarse tailings" are tailings which result from a process to recover bitumen from oil sand and which contain a relatively high ratio by weight of coarse solid material relative to fine solid material. The ratio by weight of coarse solid material to fine solid material for coarse tailings may be any ratio which represents that a relatively insignificant proportion of fine solid material to coarse solid material is contained in the tailings, such that the properties of the tailings are not significantly affected by the fine solid material contained therein.

As used herein, "solids content" is the combined weight of fine solid material and coarse solid material contained in tailings relative to the total weight of the tailings, expressed as a percentage.

As used herein, "ratio by weight of fine solid material to fine solid material plus water" is the weight of fine solid material contained in tailings relative to the combined weight of fine solid material and water which is contained in the tailings, expressed as a ratio.

Several embodiments of the invention are described in the description that follows, with reference to Figures 1-12. Where a particular feature of the invention is common to two or more embodiments of the invention, the feature is identified by the same reference number in the description of such embodiments contained herein.

Referring to Figure 1, there is depicted a process flow diagram for a first embodiment of the invention in which partially dewatered fine tailings are processed to produce dewatered fine tailings.

In the first embodiment depicted in Figure 1, partially dewatered fine tailings (20) resulting from a process for recovering bitumen from oil sand are provided as a feed material. The partially dewatered fine tailings (20) are comprised of water, fine solid material and coarse solid material and have a ratio by weight of coarse solid material to fine solid material of less than about 2 to 1, and preferably have a solids content by weight of at least about 25 percent.

In a particular application of the first embodiment, the partially dewatered fine tailings (20) may be comprised of froth treatment tailings resulting from the treatment of bitumen froth produced by the hot water process. Such froth treatment tailings typically have a ratio by weight of coarse solid material to fine solid material of less than about 2 to 1, but may have a solids content by weight less than 25 percent. The first embodiment of the invention may be suitable for use with froth treatment tailings despite a relatively low solids content by weight due to the particular composition of froth treatment tailings. For example, froth treatment tailings may contain relatively lower amounts of clay particles as fine solid material and relatively higher amounts of heavy minerals as fine solid material in comparison with other fine tailings which may result from the processing of oil sand, which may reduce the effect of clay chemistry upon froth treatment tailings relative to other fine tailings which may result from the processing of oil sand.

If particular tailings (other than froth treatment tailings) do not meet the requirements of the partially dewatered fine tailings (20) with respect to the ratio of coarse solid material to fine solid material or solids content, they may be processed in accordance with the second embodiment of the invention, as described below.

The partially dewatered fine tailings (20) are delivered to a station (22) for reducing the pH of the partially dewatered fine tailings (20) to less than about 6, thereby producing acidic partially dewatered fine tailings (24). The station (22) may be comprised of any structure, device and/or apparatus which is suitable for reducing the pH of the partially dewatered fine tailings (20).

In the first embodiment depicted in Figure 1, the station (22) is comprised of an apparatus (26) for adding an acid to the partially dewatered fine tailings (20). The acid is preferably sulphuric acid or sulphamic acid. As depicted in Figure 1, the station (22) is also comprised of a mixer (28) for mixing the acid with the partially dewatered fine tailings (20).

The partially dewatered fine tailings (20) will typically contain equilibrium amounts of carbonate species such as carbon dioxide, carbonic acid, carbonate ions and bicarbonate ions as a carbonate system. Reducing the pH of the partially dewatered fine tailings (20) will shift the

equilibrium of the carbonate system and will likely result in the liberation of carbon dioxide from the acidic partially dewatered fine tailings (24).

The acidic partially dewatered fine tailings (24) may therefore optionally be delivered to an apparatus (30) for collecting carbon dioxide (32) which evolves from the acidic partially dewatered fine tailings (24). The apparatus (30) for collecting carbon dioxide (32) may be comprised of a carbon dioxide collection vessel (not shown), and may be further comprised of a compressor (not shown) for compressing the collected carbon dioxide (32) and/or a condenser (not shown) for separating water vapour from the collected carbon dioxide (32).

The acidic partially dewatered fine tailings (24) are then delivered to a station for adding calcium ions to the acidic partially dewatered fine tailings (24) and to a station for increasing the pH of the acidic partially dewatered fine tailings (24) to between about 6.5 and 7.5, thereby producing neutralized partially dewatered fine tailings (34) having a substantially neutral pH. The stations may be comprised of any structure, device and/or apparatus which is suitable for performing the required functions.

The purpose of adding calcium ions to the acidic partially dewatered fine tailings (24) is to facilitate cation exchange in the acidic partially dewatered fine tailings (24) whereby calcium ions are exchanged into the acidic partially dewatered fine tailings (24). In most circumstances, the acidic partially dewatered fine tailings (24) will contain large amounts of sodium as a cation which is adsorbed to the fine solid material, and the addition of calcium ions will result in the calcium ions being substituted into the acidic partially dewatered tailings (24) in place of the sodium ions. This in turn will lower the activity of the clay particles in the acidic partially dewatered fine tailings (24) and enhance the ability to dewater the neutralized partially dewatered fine tailings (34).

The reason for increasing the pH of the acidic partially dewatered fine tailings is that the neutralized partially dewatered fine tailings (34) will be more readily dewatered than the acidic partially dewatered fine tailings (24).

The stations for adding calcium to the acidic partially dewatered fine tailings (24) and for increasing the pH of the acidic partially dewatered fine tailings (24) may be separate stations or may be comprised of a single station. Furthermore, adding calcium ions to the acidic partially dewatered fine tailings (24) and increasing the pH of the acidic partially dewatered fine tailings (24) may be comprised of separate acts or a single combined act.

In the first embodiment depicted in Figure 1, adding calcium ions to the acidic partially dewatered fine tailings (24) and increasing the pH of the acidic partially dewatered fine tailings (24) is performed as a single combined act at a single station (36) by adding to the acidic partially dewatered fine tailings (24) an alkaline calcium containing substance such as lime (i.e., calcium oxide and/or calcium hydroxide), which simultaneously adds calcium ions to the acidic partially dewatered fine tailings (24) and increases the pH of the acidic partially dewatered fine tailings (24). In the first embodiment, the station (36) is therefore comprised of an apparatus (38) for adding lime to the acidic partially dewatered fine tailings (24). The station (36) may be further comprised of a mixer (not shown) for mixing the lime with the acidic partially dewatered fine tailings (24).

Following addition of the lime, the neutralized partially dewatered fine tailings (34) will have a water chemistry which is favorable for dewatering of the neutralized partially dewatered fine tailings (34) by flocculation.

The neutralized partially dewatered fine tailings (34) are therefore delivered to a station (40) for adding a flocculant to the neutralized partially dewatered fine tailings (34). The flocculant may be comprised of any suitable flocculant and may be added in any suitable amount. The station (40) may be comprised of any structure, device and/or apparatus which is suitable for adding a flocculant to the neutralized partially dewatered fine tailings (34).

In the first embodiment, the station (40) is comprised of an apparatus (42) for adding the flocculant to the neutralized partially dewatered fine tailings (34). The station (40) may be further comprised of a mixer (not shown) for mixing the flocculant with the neutralized partially dewatered fine tailings (34).

As described above and as depicted in Figure 1, the flocculant is added to the neutralized partially dewatered fine tailings (34) after the calcium ions have been added to the acidic partially dewatered fine tailings (24) and after the pH of the acidic partially dewatered fine tailings (24) has been increased to provide the neutralized partially dewatered fine tailings (34).

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These three acts could, however be performed in any order and, referring to Figure 1, a single mixer (44) may be provided for mixing both the lime and the flocculant with the acidic partially dewatered fine tailings (24) after their addition to the acidic partially dewatered fine tailings (24).

10

The station (22) for lowering the pH of the partially dewatered fine tailings (20), the combined station (36) for adding calcium ions to the acidic partially dewatered fine tailings (24) and for increasing the pH of the acidic partially dewatered fine tailings (24) and the station (40) for adding a flocculant to the neutralized partially dewatered fine tailings (34) therefore comprise a chemical treatment subsystem (45) which chemically treats the partially dewatered fine tailings (20) to prepare them for dewatering.

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As a result, after passing through the mixer (44) the neutralized partially dewatered fine tailings (34) are delivered to a high density thickener apparatus (46) for dewatering of the neutralized partially dewatered fine tailings.

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The high density thickener apparatus (46) may be comprised of any apparatus or combination of apparatus which is capable of producing an underflow stream which has a relatively high solids content by weight relative to the underflow stream typically produced by a conventional thickener apparatus. Typically a high density thickener apparatus (46) will exhibit a relatively large height to diameter ratio relative the height to diameter ratio of a conventional thickener apparatus.

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The high density thickener apparatus (46) may be comprised of an apparatus of the type used to produce paste consistency material from tailings, where paste consistency material or "paste" is defined as a mixture of coarse solid material, fine solid material and water which has a

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relatively high solids content, exhibits very little water bleed, and is relatively non-segregating. Such apparatus are often referred to as a deep cone paste thickener.

One exemplary deep cone paste thickener is the EIMCO™ Deep Cone™ Thickener, which is manufactured by FLSmidth Dorr-Oliver Eimco. Features of the EIMCO™ Deep Cone™ Thickener are described in U.S. Patent No. 5,718,510 (Farmery et al) and U.S. Patent No. 5,806,977 (Farmery et al). The EIMCO™ Deep Cone™ Thickener is described as having an ability to accommodate up to 20 times the solids mass flow and 10 times the hydraulic loading of conventional thickener apparatus.

The EIMCO™ Deep Cone™ Thickener is described as a deep cylindrical tank which is designed to maintain a deep bed of settled solids and to maximize gravity compression, thereby achieving discharge solids concentrations which can approach the limits of flowability. The EIMCO™ Deep Cone™ Thickener is provided with a mechanical rake mechanism which is designed to meet unusually high torque requirements which are necessitated by the deep bed of settled solids and by the high viscosity of the underflow as it approaches a paste consistency. The rake mechanism is also designed to keep thickened solids flowing toward the discharge outlet of the thickener and to assist with the releasing of water from the deep bed of settled solids.

A second exemplary deep cone paste thickener is the E-CAT™ Clarifier-Thickener, also manufactured by FLSmidth Dorr-Oliver Eimco. The E-CAT™ Clarifier-Thickener is described as a deep cylindrical tank with a steep-sided bottom cone which serves as a compaction zone for flocculated solid material. The E-CAT™ Clarifier-Thickener has no moving parts. Free water which is displaced from the solids bed in the compaction zone is directed to a central dewatering cone and recycle column where it rises to be returned to the inlet feedwell to provide influent dilution.

The high density thickener apparatus (46) is preferably an apparatus of the type referred to as a deep cone paste thickener. Although a deep cone paste thickener is a preferred high density thickener apparatus (46) for use in the invention, it is noted that the purpose of the invention and of the high density thickener apparatus (46) is not to produce a paste as defined above and having the properties listed above, but to produce an underflow stream which has a

relatively high solids content by weight relative to the solids content by weight which is achievable using a conventional thickener apparatus.

5 The high density thickener apparatus (46) therefore produces an underflow stream which is comprised of dewatered fine tailings (48). Referring to Figure 1, the high density thickener apparatus (46) also produces an overflow stream (50) which is comprised of water and small amounts of residual bitumen and fine solid material.

10 The underflow stream comprising the dewatered fine tailings (48) will typically have a solids content of at least about 50 percent and will typically have a ratio of fine solid material to fine solid material plus water of at least about 0.45 to 1. The dewatered fine tailings (48) may be disposed in a manner as described below, and due to the water chemistry of the dewatered fine tailings (48), further dewatering of the dewatered fine tailings (48) may be achieved following disposal of the dewatered fine tailings (48).

15

Depending upon its composition, the overflow stream (50) may be recycled as make-up process water for the bitumen recovery process, may be used as a diluent in the bitumen recovery process or in the process of the invention, or may be used or disposed of in some other suitable manner.

20

The overflow stream (50) may optionally be further processed before use and/or disposal in order to remove residual bitumen or other impurities therefrom. Further processing of the overflow stream (50) is desirable where the overflow stream (50) contains appreciable amounts of residual bitumen.

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The overflow stream (50) from the high density thickener apparatus (46) may also be comprised of two separate streams (not shown), wherein a relatively less dense overflow stream contains appreciable amounts of residual bitumen and other less dense material and wherein a relatively more dense overflow stream is comprised of relatively "clean" water. Such a two-phase overflow stream may be particularly desirable where the feed material for the first embodiment is froth treatment tailings, since froth treatment tailings typically contain an amount of hydrocarbon

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solvent or diluent and/or diluted residual bitumen which is preferably separated from the overflow stream (50).

Referring to Figure 2, there is depicted a process flow diagram for a second embodiment of the invention in which fine tailings are processed to produce dewatered fine tailings (48).

In the second embodiment depicted in Figure 2, fine tailings (60) resulting from a process for recovering bitumen from oil sand are provided as a feed material. The fine tailings (60) are comprised of water, fine solid material and coarse solid material, and have a ratio by weight of coarse solid material to fine solid material of less than about 2 to 1. The fine tailings (60) which are provided as the feed material for the second embodiment of the invention will generally have a lower solids content than the partially dewatered fine tailings (20) which are provided as the feed material for the first embodiment of the invention. In other words, the fine tailings (60) will generally have a solids content by weight which is less than about 30 percent.

The fine tailings (60) may result from any process for recovering bitumen from oil sand. For example, the fine tailings (60) may be comprised of or be a component of middlings tailings resulting from the hot water process, may be comprised of mature fine tailings (MFT) produced by the hot water process or some other process, or may be comprised of tailings produced by treating the bitumen froth stream obtained in a solids rejection process such as the Bitmin Process or the TSC Process. If such tailings do not meet the requirements of the fine tailings (60) with respect to the ratio of coarse solid material to fine solid material, they may be processed in accordance with the third embodiment of the invention, as described below.

The essential difference between the second embodiment of the invention as depicted in Figure 2 and the first embodiment of the invention as depicted in Figure 1 is that the second embodiment accepts fine tailings (60) as a feed material, while the first embodiment requires partially dewatered fine tailings (20) as the feed material. The second embodiment therefore provides a two stage process which involves partial dewatering of fine tailings (60) to produce partially dewatered fine tailings (20), followed by processing of the partially dewatered fine tailings (20) to produce dewatered fine tailings (48), while the first embodiment provides a

one stage process which involves processing of partially dewatered fine tailings (20) to produce dewatered fine tailings (48).

5 The partial dewatering of the fine tailings (60) to produce the partially dewatered fine tailings (20) may be performed using any dewatering process and/or apparatus which is suitable for producing partially dewatered fine tailings (20) having a solids content by weight of at least about 25 percent from the fine tailings (60).

10 Preferably, the partial dewatering of the fine tailings (60) is performed using a thickener apparatus (62). As depicted in Figure 2, the partial dewatering of the fine tailings (60) is performed using a conventional thickener apparatus as the thickener apparatus (62).

15 As used herein, a “conventional thickener apparatus” is comprised of a separation vessel which provides a relatively large settling/flotation area relative to the depth of the solids bed and which typically includes a rake mechanism for aiding in dewatering of the solids bed and/or for directing the solids toward the solids outlet of the vessel. A conventional thickener is distinguished from a deep cone paste thickener in that a conventional thickener is typically capable of producing an underflow stream which has a relatively lower solids content than the underflow stream produced by a deep cone paste thickener, but is well suited for partially dewatering feed
20 streams which have a relatively low initial solids content.

The fine tailings (60) may optionally be processed to recover residual bitumen therefrom before being subjected to partial dewatering to produce the partially dewatered fine tailings (20). The residual bitumen may be recovered using any suitable process and/or apparatus.
25 Referring to Figure 2, the fine tailings (60) may optionally be delivered to a flotation apparatus (64) where the fine tailings may be subjected to froth flotation to recover residual bitumen therefrom.

30 The necessity or desirability of recovering residual bitumen from the fine tailings (60) will depend upon the origin of the fine tailings (60) and upon economics. For example, if the fine tailings (60) are comprised of mature fine tailings (MFT) or some other type of tailings which may contain economically significant amounts of residual bitumen, it may be desirable to recover

residual bitumen from the fine tailings (60) before subjecting the fine tailings (60) to partial dewatering.

Following the optional flotation apparatus (64), the fine tailings (60) are delivered to a station (66) for adding a flocculant to the fine tailings (60). The flocculant may be comprised of any suitable flocculant and may be added in any suitable amount. The station (66) may be comprised of any structure, device and/or apparatus which is suitable for adding a flocculant to the fine tailings (60).

In the second embodiment, the station (66) is comprised of an apparatus (68) for adding the flocculant to the fine tailings (60). The station (66) is also comprised of a mixer (70) for mixing the flocculant with the fine tailings (60).

After passing through the mixer (70), the fine tailings (60) are delivered to the thickener apparatus (62) for partial dewatering of the fine tailings (60).

The thickener apparatus (62) produces an underflow stream which is comprised of the partially dewatered fine tailings (20). The thickener apparatus (62) also produces an overflow stream (72) which is comprised of water and small amounts of bitumen and fine solid material.

The underflow stream comprising the partially dewatered fine tailings (20) will typically have a solids content of at least about 25 percent and will therefore be suitable for dewatering in accordance with the first embodiment of the invention as depicted in Figure 1. If, however, the underflow stream does not have a solids content of at least about 25 percent, the underflow stream may be further processed to achieve a solids content of at least about 25 percent before being dewatered in accordance with the first embodiment of the invention as depicted in Figure 1.

Depending upon its composition, the overflow stream (72) may be recycled as make-up process water for the bitumen recovery process, may be used as a diluent in the bitumen recovery process or in the process of the invention, or may be used or disposed of in some other manner. The overflow stream (72) may be particularly valuable as make-up process water for the

bitumen recovery process because it may contain significant amounts of heat and because it may have a water chemistry which is similar to and/or compatible with the water chemistry of the bitumen recovery process.

5 Optionally, the overflow stream (72) may be further processed to recover residual bitumen therefrom or to further clarify the water comprising the overflow stream (72) before using or disposing of the overflow stream (72). For example, the overflow stream (72) may be subjected to froth flotation in a flotation apparatus (74) in order to recover residual bitumen therefrom.

10 Referring to Figure 3, there is depicted a process flow diagram for a third embodiment of the invention in which tailings are processed to produce dewatered fine tailings (48).

15 In the third embodiment depicted in Figure 3, tailings (80) resulting from a process for recovering bitumen from oil sand are provided as a feed material. The tailings (80) are comprised of water, fine solid material and coarse solid material. The tailings (80) which are provided as the feed material for the third embodiment of the invention will generally have a relatively higher ratio by weight of coarse solid material to fine solid material than the fine tailings (60) or the partially dewatered fine tailings (20) which are provided as the feed material for the
20 second embodiment and the first embodiment of the invention, respectively. In other words, the tailings (80) will generally have a ratio by weight of coarse solid material to fine solid material which is greater than about 2 to 1.

25 The tailings (80) may result from any process for recovering bitumen from oil sand. For example, the tailings (80) may be comprised of middlings tailings resulting from the hot water process.

30 The essential difference between the third embodiment of the invention as depicted in Figure 3 and the second embodiment of the invention as depicted in Figure 2 is that the third embodiment accepts tailings (80) as a feed material, while the second embodiment requires fine tailings (60) as the feed material. The third embodiment therefore provides a three stage process which involves separation of the tailings (80) into fine tailings (60) and coarse tailings, partial

dewatering of the fine tailings (60) to produce partially dewatered fine tailings (20), followed by processing of the partially dewatered fine tailings (20) to produce dewatered fine tailings (48).

The separation of the tailings (80) into the fine tailings (60) and the coarse tailings may be performed using any process and/or apparatus which is suitable for separating the tailings (80) to produce fine tailings (60) having a ratio by weight of coarse solid material to fine solid material of less than about 2 to 1 and coarse tailings having a ratio by weight of coarse solid material to fine solid material of at least about 20 to 1.

Preferably, the separation of the tailings (80) into the fine tailings (60) and the coarse tailings is performed by passing the tailings (80) through a cyclone apparatus (82). As depicted in Figure 3, the separation of the tailings (80) into the fine tailings (60) and the coarse tailings is performed using a first stage cyclone (84) and a second stage cyclone (86) as the cyclone apparatus (82). The cyclone apparatus (82) may be comprised of fewer than two cyclones or more than two cyclones as long as the cyclone apparatus (82) is capable of producing the fine tailings (60) and coarse tailings which have the required ratios of coarse solid material to fine solid material.

The cyclones (84,86) may be comprised of any suitable cyclone or hydrocyclone apparatus which is capable of producing an underflow stream comprising relatively coarse tailings and an overflow stream comprising relatively fine tailings.

Referring to Figure 3, the tailings (80) are delivered to the first stage cyclone (84). The tailings (80) are passed through the first stage cyclone (84) to produce a first overflow stream (88) and a first underflow stream (90).

The first underflow stream (90) is delivered to the second stage cyclone (86). The first underflow stream (90) is passed through the second stage cyclone (86) to produce a second overflow stream (92) and a second underflow stream (94).

All or a portion of the overflow stream (50) from the high density thickener apparatus (46) may be added to the first underflow stream (90) before the first underflow stream

(90) is passed through the second stage cyclone (86), to dilute the first underflow stream (90) in order to improve the operation of the second stage cyclone (86) and/or to impart to the first underflow stream (90) a water chemistry which is similar to and/or compatible with the water chemistry of the dewatered fine tailings (48).

5

All or a portion of the overflow stream (72) from the thickener apparatus (62) may also be added to the first underflow stream (90), in order to dilute the first underflow stream (90).

10 The first overflow stream (88) and the second overflow stream (92) are combined to provide a combined overflow stream (96). Typically this combined overflow stream (96) will have a ratio by weight of coarse solid material to fine solid material which is less than about 2 to 1 and will therefore be suitable for processing in accordance with the second embodiment of the invention as depicted in Figure 2. If, however, the combined overflow stream (96) does not have a
15 ratio by weight of coarse solid material to fine solid material which is less than about 2 to 1, the combined overflow stream (96) may be further processed to achieve a ratio by weight of coarse solid material to fine solid material which is less than about 2 to 1 before the combined overflow stream (96) is processed in accordance with the second embodiment of the invention as depicted in Figure 2.

20 If the combined overflow stream (96) has a ratio by weight of coarse solid material to fine solid material which is less than about 2 to 1, the fine tailings (60) will be comprised of the first overflow stream (88) and the second overflow stream (92) and will be processed in accordance with the second embodiment of the invention as depicted in Figure 2.

25 The second underflow stream (94) will typically have a ratio by weight of coarse solid material to fine solid material which is at least about 20 to 1. If, however, the second underflow stream (94) does not have a sufficiently high ratio by weight of coarse solid material to fine solid material, the second underflow stream (94) may be further processed to achieve a ratio by weight of coarse solid material to fine solid material which is at least about 20 to 1.

30

If the second underflow stream (94) has a ratio by weight of coarse solid material to fine solid material which is at least about 20 to 1, the coarse tailings (98) will be comprised of the second underflow stream (94).

5 The third embodiment of the invention as depicted in Figure 3 will therefore result in the production of the dewatered fine tailings (48) having a ratio by weight of coarse solid material to fine solid material which is less than about 2 to 1 and a solids content by weight which is at least about 50 percent. Preferably the dewatered fine tailings (48) will also have a ratio by weight of fine solid material to fine solid material plus water of at least about 0.45 to 1.

10 The third embodiment of the invention as depicted in Figure 3 will also result in the production of the coarse tailings (98) having a ratio by weight of coarse solid material to fine solid material which is at least about 20 to 1. Preferably the coarse tailings (98) have a solids content by weight of at least about 60 percent.

15 The dewatered fine tailings (48) and the coarse tailings (98) may be used or disposed of in any manner, either separately or together.

20 For example, the coarse tailings (98) can be used and/or disposed of as backfill or in berms, and the dewatered fine tailings could be deposited in a tailings disposal area such as a tailings pond.

 Preferably, however, the dewatered fine tailings (48) and the coarse tailings (98) are used and/or disposed of together according to one of two alternate methods.

25 A first method of disposing the dewatered fine tailings (48) and the coarse tailings (98) will be described with reference to Figures 3-5. A second method of disposing the dewatered fine tailings (48) and the coarse tailings (98) will be described with reference to Figure 6.

30 The first method of disposing the dewatered fine tailings (48) and the coarse tailings (98) may be used with any fine tailings having a ratio by weight of coarse solid material to fine solid material of less than about 2 to 1 and a solids content by weight of at least about 50 percent,

and with coarse tailings having a ratio by weight of coarse solid material to fine solid material of at least about 20 to 1 and a solids content by weight of at least about 60 percent.

5 Preferably the first method of disposing is used with dewatered fine tailings (48) which contain relatively low amounts of carbonate ions and bicarbonate ions, which have been subjected to cation exchange whereby calcium ions have been exchanged into the dewatered fine tailings (48) in order to reduce the activity of clay particles contained in the dewatered fine tailings (48) and which have a substantially neutral pH.

10 Preferably the first method of disposing is used with coarse tailings (98) which have a water chemistry which is similar to and/or compatible with the water chemistry of the dewatered fine tailings (48) and/or with coarse tailings (98) which have been subjected to some or all of the chemical treatment which may be applied to partially dewatered fine tailings (20) according to other embodiments of the invention. In other words, preferably the coarse tailings (98) contain
15 relatively low amounts of carbonate ions and bicarbonate ions. The coarse tailings (98) may also contain amounts of a suitable cation for cation exchange into the dewatered fine tailings (48) and may have a substantially neutral pH.

In Figures 3-5 and the description which follows, the first method of disposing is
20 used with dewatered fine tailings (48) and coarse tailings (98) which have been produced using the third embodiment of the method of the invention.

Referring to Figures 3-5, the first method of disposing the dewatered fine tailings (48) and the coarse tailings (98) involves depositing the tailings (48,98) in a tailings disposal area
25 (110). The first method utilizes the coarse tailings (98) to provide compressive loading on the dewatered fine tailings (48) in the tailings disposal area (110) to assist in achieving further dewatering of the dewatered fine tailings (48) in the tailings disposal area (110).

Referring to Figure 3, the method according to the third embodiment of the
30 invention may be performed some distance from the tailings disposal area (110). As a result, it may be necessary to transport the dewatered fine tailings (48) and the coarse tailings (98) to the tailings disposal area (110).

The tailings (48,98) may be transported to the tailings disposal area (110) in any suitable manner, such as, for example by truck or by rail. Preferably, however, the tailings (48,98) are transported to the tailings disposal area (110) by a fine tailings pipeline (112) and by a coarse
5 tailings pipeline (114) respectively.

The dewatered fine tailings (48) have a ratio by weight of coarse solid material to fine solid material of less than about 2 and therefore do not contain large amounts of coarse solid material. In addition, the dewatered fine tailings (48) will probably have a solids content by weight
10 of between about 50 percent and about 70 percent. As a result, the dewatered fine tailings (48) may be pumped through the fine tailings pipeline (112) using a fine tailings pump (116). It is expected that the dewatered fine tailings (48) will exhibit relatively low viscosity and/or shear strength and may exhibit shear thinning. As a result, it is expected by way of example that the fine tailings pump (116) may be comprised of one or more centrifugal pumps operated in the laminar
15 flow regime.

The coarse tailings (98) have a ratio by weight of coarse solid material to fine solid material of at least about 20 to 1 and a solids content by weight exceeding about 60 percent. The composition of the coarse tailings (98) therefore presents potential challenges for transporting the
20 coarse tailings (98) through the coarse tailings pipeline (114).

As one example, if the solids content by weight of the coarse tailings (98) exceeds about 70 percent, the coarse tailings (98) may be difficult to pump. As a result, if the solids content by weight of the coarse tailings (98) exceeds about 70 percent, the coarse tailings (98) may
25 be diluted with water to reduce their solids content. Preferably the coarse tailings (98) are diluted with at least a portion of the overflow stream (50) from the high density thickener apparatus (46), since the overflow stream (50) will have a water chemistry which is similar to the water chemistry of the dewatered fine tailings (48).

As a second example, if the bulk velocity of the coarse tailings (98) through the coarse tailings pipeline (114) is too low, some coarse solid material and fine solid material may settle out from the coarse tailings (98) in the coarse tailings pipeline (114), thereby clogging the
30

coarse tailings pipeline (114). As a result, the bulk velocity of the coarse tailings (98) through the coarse tailings pipeline (114) is preferably maintained to be at least about 3 meters per second.

5 The coarse tailings (98) are pumped through the coarse tailings pipeline (114) using a coarse tailings pump (118).

10 In order to further limit the amount of coarse solid material and fine solid material which settles out from the coarse tailings (98) in the coarse tailings pipeline (114), and in order to control the deposition angle of the coarse tailings (98) in the tailings disposal area (110), a station (120) for adding a flocculant to the coarse tailings (98) is preferably provided downstream of the coarse tailings pump (118). The flocculant may also further facilitate dewatering of the coarse tailings (98) in the tailings disposal area (110). The flocculant may be comprised of any suitable flocculant and may be added in any suitable amount. The station (120) may be comprised of any structure, device and/or apparatus which is suitable for adding a flocculant to the coarse tailings
15 (98).

20 In the third embodiment, the station (120) is comprised of an apparatus (121) for adding the flocculant to the coarse tailings (98). The station (120) may be further comprised of a mixer (not shown) for mixing the flocculant with the coarse tailings (98).

25 By controlling the solids content by weight of the coarse tailings (98) and the tendency of coarse solid material and fine solid material to settle out from the coarse tailings (98), it is expected by way of example that the coarse tailings pump (118) may be comprised of one or more centrifugal pumps.

30 Once the dewatered fine tailings (48) and the coarse tailings (98) have been transported to the tailings disposal area (110), they may be deposited in the tailings disposal area (110).

Referring to Figure 4 and Figure 5, the tailings disposal area (110) is comprised of a tailings pond (122). The tailings disposal area (110) is further comprised of a collection system

(124) for collecting drained water which drains from the dewatered fine tailings (48) and the coarse tailings (98) in the tailings disposal area (110).

5 The collection system (124) may be comprised of any structure, device or apparatus which is capable of collecting the water which is drained from the tailings (48,98). As depicted in Figure 4 and Figure 5, the collection system (124) is comprised of a drainage grid (126) and a system of vertical drains (128).

10 The drainage grid (126) is comprised of a network of interconnected drains (130) and pipes (132) which is positioned in a lower portion (134) of the tailings disposal area (110). The drains (130) communicate with the tailings pond (122) and are spaced so that they are distributed relatively evenly throughout the planar area covered by the tailings pond (122). The pipes (132) collect drained water from the drains (130) into one or more drainage conduits (136) which facilitate removal of the drained water from the tailings disposal area (110). The drainage
15 conduits (136) are connected with other conduits (not shown) and/or water storage facilities (not shown) which enable recycling of the drained water back to the bitumen recovery process, to the methods of the invention, or to other uses.

20 Each of the vertical drains (128) extends substantially vertically in the tailings pond (122). The system of vertical drains (128) is arranged so that the vertical drains (128) are distributed relatively evenly throughout the planar area covered by the tailings pond (122). The vertical drains (128) provide permeable vertical channels in the tailings pond (122) which enhance the ability of drained water to move vertically downward through the tailings pond (122) toward the drainage grid (126).

25

The first method of disposing the dewatered fine tailings (48) and the coarse tailings (98) is comprised of depositing the dewatered fine tailings (48) and the coarse tailings (98) in the tailings pond (122) in alternating layers. As depicted in Figure 5, the alternating layers begin with a layer of the coarse tailings (98) in the lower portion (134) of the tailings disposal area (110)
30 which cover the drainage grid (126) so that the coarse tailings (98) provide a relatively permeable area in the immediate vicinity of the drainage grid (126).

The thicknesses of the alternating layers of dewatered fine tailings (48) and coarse tailings (98) will depend upon the composition and properties of the dewatered fine tailings (48) and the coarse tailings (98), upon the relative amounts of dewatered fine tailings (48) and coarse tailings (98) which are available, and upon the objectives for the tailings disposal area (110) with respect to further dewatering of the dewatered fine tailings (48) and the coarse tailings (98).

Preferably the thickness of the layers of the dewatered fine tailings (48) is less than the thickness of the layers of the coarse tailings (98). More preferably, the ratio of the thickness of the layers of the dewatered fine tailings (48) to the thickness of the layers of the coarse tailings (98) is less than about 0.5 to 1. By providing relatively thin layers of the dewatered fine tailings (48), further dewatering of the dewatered fine tailings (48) may be enhanced, and by providing relatively thick layers of the coarse tailings (98), the compressive loading of the coarse tailings (98) upon the dewatered fine tailings (48) can also be enhanced.

For example, the thickness of the layers of the dewatered fine tailings (48) may be about 1 meter and the thickness of the layers of the coarse tailings (98) may be about 2.5 meters. The coarse tailings (98) will be very permeable due to the relatively high ratio by weight of coarse solid material to fine solid material contained therein. The dewatered fine tailings (48) will be relatively permeable due to the addition of the calcium ions and resulting cation exchange and due to the substantially neutral pH of the dewatered fine tailings (48).

As a result, the weight of the relatively thick layers of coarse tailings (98) upon the relatively thin layers of the dewatered fine tailings will result in further dewatering of the dewatered fine tailings (48) as well as further dewatering of the coarse tailings (98). The drained water which drains from the dewatered fine tailings (48) and the coarse tailings (98) will drain downward to the drainage grid (126), assisted by the system of vertical drains (128) extending substantially vertically through the tailings pond (122).

It is expected that the first method for disposing the dewatered fine tailings (48) and the coarse tailings (98) will over a relatively short period of time substantially increase the solids content by weight of both the dewatered fine tailings (48) and the coarse tailings (98).

It is also expected that by combining at least a portion of the overflow stream (50) from the high density thickener apparatus (46) with the first underflow stream (90) from the first stage cyclone (84), and/or by diluting the coarse tailings (98) with at least a portion of the overflow stream (50) from the high density thickener apparatus (46) as depicted in Figure 3, the water chemistry of the coarse tailings (98) will be very similar to the water chemistry of the dewatered fine tailings (48), with the result that the dewatered fine tailings (48) should not experience any significant degradation of their ability to be further dewatered due to contact with the coarse tailings (98).

Referring to Figure 6, the second method of disposing the dewatered fine tailings (48) and the coarse tailings (98) involves dewatering the coarse tailings (98) and then combining the dewatered fine tailings (48) and the dewatered coarse tailings to produce combined dewatered tailings, so that the dewatered fine tailings (48) and the coarse tailings (98) can be disposed of together as the combined dewatered tailings.

In the second method of disposing the dewatered fine tailings (48) and the coarse tailings (98), the dewatered fine tailings (48) and the coarse tailings (98) are produced in accordance with the third embodiment of the invention as depicted in Figure 3.

In the second method of disposing the dewatered fine tailings (48) and the coarse tailings (98), the coarse tailings (98) may first be delivered to a station (150) for adding a flocculant to the coarse tailings (98). The flocculant may be comprised of any suitable flocculant and may be added in any suitable amount. The station (150) may be comprised of any structure, device and/or apparatus which is suitable for adding a flocculant to the coarse tailings (34).

As depicted in Figure 6, the station (150) is comprised of an apparatus (152) for adding the flocculant and may be further comprised of a mixer (not shown) for mixing the flocculant with the coarse tailings (98).

Depending upon the properties of the coarse tailings (98), the addition of the flocculant to the coarse tailings (98) may not be required, in which case the station (150) for adding a flocculant to the coarse tailings (98) either may not be provided or may be bypassed.

In either case (i.e., either with or without a flocculant), the coarse tailings (98) are delivered to a horizontal belt filter apparatus (154). The coarse tailings (98) are filtered by the horizontal belt filter apparatus (154) to produce dewatered coarse tailings (156) and belt filter
5 filtrate (158).

The belt filter filtrate (158) may be recycled back to the bitumen recovery process or to the method of the invention, may be further processed, and/or may be disposed or used for some other purpose. As depicted in Figure 6, the belt filter filtrate (158) is recycled and combined
10 with the first underflow stream (90) from the first stage cyclone (84), thereby diluting the first underflow stream (90) and enhancing the performance of the second stage cyclone (86).

The dewatered coarse tailings (156) will typically have a solids content by weight of at least about 85 percent. The dewatered coarse tailings (156) are transported in a suitable manner,
15 such as by conveyor or by truck, to a tailings mixing facility (160).

The dewatered fine tailings (48), comprising the underflow stream from the high density thickener apparatus (46), are also transported in a suitable manner to the tailings mixing facility (160). As in the first method of disposing the dewatered fine tailings (48) and the coarse
20 tailings (98), the dewatered fine tailings (48) may, for example, be transported to the tailings mixing facility (160) using the fine tailings pump (116).

The tailings mixing facility (160) may be comprised of any area or structure which is suitable for combining the dewatered coarse tailings (156) and the dewatered fine tailings (48).
25 For example, the tailings mixing facility (160) may be comprised simply of a tailings pile where the tailings (48,156) can be mixed together using loaders and/or other earthmoving equipment, or the tailings mixing facility (160) may be comprised of a mixing apparatus.

The dewatered coarse tailings (156) and the dewatered fine tailings (48) are mixed
30 together at the tailings mixing facility (160) in suitable proportions to produce combined dewatered tailings (162). The suitable proportions of the dewatered coarse tailings (156) and the dewatered fine tailings (48) is dependent upon the relative amounts of the dewatered coarse

tailings (156) and the dewatered fine tailings (48) which are available and upon the desired properties and use of the combined dewatered tailings (162). Leftover dewatered coarse tailings (156) and/or dewatered fine tailings (48) may be disposed of according to the first method of disposing described above or may be used and/or disposed in some other manner.

5

Due to the high solids content by weight of the dewatered coarse tailings (156) and the relatively high solids content by weight of the dewatered fine tailings (48), the combined dewatered tailings (162) will typically not be saturated, and will therefore typically undergo only minimal additional drainage.

10

The combined dewatered tailings (162) may be disposed of as fill material or in berms or may be used and/or disposed in some other manner.

As can be seen, the first method of disposing the dewatered fine tailings (48) and the coarse tailings (98) offers the potential of further dewatering of the dewatered fine tailings (48) and thus recovery of additional drained water, while the second method of disposing the dewatered fine tailings (48) and the coarse tailings (98) offers the potential of reducing or eliminating the need for a dedicated tailings disposal area (110).

Theoretical material balances for the first embodiment, the second embodiment, the third embodiment and for the first and second methods for disposing the dewatered fine tailings (48) and the coarse tailings (98) are provided in the following examples, with reference to Figures 7-12.

25 Example 1

Example 1 relates to the first embodiment of the invention.

The process flow diagram for Example 1 is provided in Figure 1. A theoretical material balance for Example 1 is provided in Figure 7.

30

In the first embodiment of the invention, the feed material is partially dewatered fine tailings (20). In Example 1, the partially dewatered fine tailings (20) are froth treatment tailings produced by a froth treatment process in conjunction with the hot water process for recovering bitumen from oil sand. The material quantities in Example 1 are based upon the estimated quantity of froth treatment tailings which would result from the processing of 5000 tonnes per hour of oil sand using the hot water process.

In Example 1, the overflow stream (50) from the high density thickener apparatus (46) is comprised of two separate streams, wherein one of the streams contains appreciable amounts of residual bitumen and the other of the streams is comprised of relatively clean water.

Example 2

Example 2 relates to the second embodiment of the invention.

The process flow diagram for Example 2 is provided in Figure 2. A theoretical material balance for Example 2 is provided in Figure 8.

In the second embodiment of the invention, the feed material is fine tailings (60). In Example 2, the fine tailings (60) are mature fine tailings (MFT) resulting from the hot water process for recovering bitumen from oil sand. The material quantities in Example 2 are based upon the processing of 3000 m³/hour of mature fine tailings.

In Example 2, the fine tailings (60) are subjected to froth flotation in the flotation apparatus (64) before being delivered to the thickener apparatus (62), in order to recover residual bitumen which is contained within the mature fine tailings.

Example 3

Example 3 relates to the second embodiment of the invention.

The process flow diagram for Example 3 is provided in Figure 2. A theoretical material balance for Example 3 is provided in Figure 9.

In Example 3, the fine tailings (60) are fine tailings resulting from the Bitmin Process for recovering bitumen from oil sand. The material quantities in Example 3 are based upon the estimated quantity of fine tailings which would result from the processing of 5000 tonnes per hour of oil sand using the Bitmin Process.

In Example 3, the fine tailings (60) are not subjected to froth flotation in the flotation apparatus (64) before being delivered to the thickener apparatus (62), since the fine tailings (60) do not contain significant amounts of residual bitumen (in comparison with the mature fine tailings of Example 2).

Example 4

Example 4 relates to the second embodiment of the invention.

The process flow diagram for Example 4 is provided in Figure 2. A theoretical material balance for Example 4 is provided in Figure 10.

In Example 4, the fine tailings (60) are fine tailings resulting from the TSC Process for recovering bitumen from oil sand. The material quantities in Example 4 are based upon the estimated quantity of fine tailings which would result from the processing of 5000 tonnes per hour of oil sand using the TSC Process.

In Example 4, the fine tailings (60) are not subjected to froth flotation in the flotation apparatus (64) before being delivered to the thickener apparatus (62), since the fine tailings (60) do not contain significant amounts of residual bitumen (in comparison with the mature fine tailings of Example 2).

Example 5

Example 5 relates to the third embodiment of the invention and to the first method of disposing dewatered fine tailings (48) and coarse tailings (98).

5

The process flow diagram for Example 5 is provided in Figure 3. A theoretical material balance for Example 5 is provided in Figure 11.

10 In the third embodiment of the invention, the feed material is tailings (80). In Example 5, the tailings (80) are middlings tailings resulting from the hot water process for recovering bitumen from oil sand. The material quantities in Example 5 are based upon are based upon the estimated quantity of fine tailings which would result from the processing of 5000 tonnes per hour of oil sand using the hot water process.

15 In Example 5, the tailings (80) are processed to produce dewatered fine tailings (48) and coarse tailings (98). In Example 5, the overflow stream (72) from the thickener apparatus (62) is subjected to froth flotation in the flotation apparatus (74) to recover residual bitumen. In Example 5, the fine tailings (60) are comprised of the first overflow stream (88) from the first stage cyclone (84) and the second overflow stream (92) from the second stage cyclone (86). In
20 Example 5, the first underflow stream (90) from the first stage cyclone (84) is diluted before entering the second stage cyclone (86) with all or a portion of the overflow stream (50) from the high density thickener apparatus (46) and with a portion of the overflow stream (72) from the thickener apparatus (72). In the theoretical material balance of Figure 11, all of the overflow stream (50) from the high density thickener apparatus (46) is used to dilute the first underflow
25 stream (90) from the first stage cyclone (84).

In Example 5, the dewatered fine tailings (48) and the coarse tailings (98) are disposed using the first method of disposing the dewatered fine tailings (48) and coarse tailings (98), by being deposited in alternating layers in the tailings disposal area (110). The dewatered
30 fine tailings (48) and the coarse tailings (98) undergo further dewatering in the tailings disposal area, thereby producing the settled coarse tailings and the settled fine tailings referred to in Figure

11, and thereby facilitating the reclamation of additional water from the dewatered fine tailings (48) and the coarse tailings (98).

Example 6

5

Example 6 relates to the third embodiment of the invention and to the second method for disposing dewatered fine tailings (48) and coarse tailings (98).

10 The process flow diagram for Example 6 is provided in Figure 6. A theoretical material balance for Example 6 is provided in Figure 12.

15 In the third embodiment of the invention, the feed material is tailings (80). In Example 6, the tailings (80) are middlings tailings resulting from the hot water process for recovering bitumen from oil sand. The material quantities in Example 6 are based upon are based upon the estimated quantity of fine tailings which would result from the processing of 5000 tonnes per hour of oil sand using the hot water process.

20 In Example 6, the tailings (80) are processed to produce dewatered fine tailings (48) and coarse tailings (98). In Example 5, the overflow stream (72) from the thickener apparatus (62) is subjected to froth flotation in the flotation apparatus (74) to recover residual bitumen. In Example 6, the fine tailings (60) are comprised of the first overflow stream (88) from the first stage cyclone (84) and the second overflow stream (92) from the second stage cyclone (86). In Example 6, the first underflow stream (90) from the first stage cyclone (84) is diluted before entering the second stage cyclone (86) with all or a portion of the overflow stream (50) from the high density thickener apparatus (46) and with all of the belt filter filtrate (158). In the theoretical material balance of Figure 12, all of the overflow stream (50) from the high density thickener apparatus (46) is used to dilute the first underflow stream (90) from the first stage cyclone (84).

25 In Example 6, the dewatered fine tailings (48) and the coarse tailings (98) are disposed using the second method of disposing the dewatered fine tailings (48) and coarse tailings (98), by producing the dewatered coarse tailings (156) and then combining the dewatered fine

tailings (48) and the dewatered coarse tailings (156) to produce the combined dewatered tailings (162).

5 The invention therefore provides for the production of dewatered fine tailings (48) having a relatively high solids content by weight and a potential for further dewatering using conventional dewatering techniques, through the use of chemical treatment and specific methods and combinations of apparatus.

10 While not intending to be bound by theory, it is believed that the chemical treatments which are used in producing the dewatered fine tailings (48) facilitate the production of non-interacting flocs of fine solid material having reduced face to face repulsion and less tendency to adopt edge to face "house of cards" structures.

15 As a result, such non-interacting flocs may be relatively more dense and compact in comparison with flocs produced using conventional dewatering methods, and dewatered fine tailings comprising such non-interacting flocs may potentially be further dewatered. It is estimated that following further dewatering of the dewatered fine tailings which are produced using the invention, the final solids content by weight of the fine tailings may be about 80 percent.

20 The invention also provides for the production of dewatered fine tailings (48) from tailings (80), from fine tailings (60) or from partially dewatered fine tailings (20) resulting from processes for the recovery of bitumen from oil sand. The invention also provides for the production of coarse tailings (98) from tailings (80) and for the production of dewatered coarse tailings (156) from coarse tailings (98). Finally, the invention provides for the disposal of
25 dewatered fine tailings (48) and coarse tailings (98) in a single tailings disposal area (110) and for the production and disposal of combined dewatered tailings (162) comprising dewatered coarse tailings (156) and dewatered fine tailings (48).

30 The methods for disposing the dewatered fine tailings (48) and the coarse tailings (98) involve either depositing the dewatered fine tailings (48) and the coarse tailings (98) in alternating layers or dewatering of the coarse tailings (98) to produce dewatered coarse tailings

(156) and combining the dewatered coarse tailings (156) and the dewatered fine tailings (48) to produce combined dewatered tailings (162).

In either method for disposing, it is believed to be desirable that the coarse tailings (98) have a water chemistry which is similar to and/or compatible with the water chemistry of the dewatered fine tailings (48). The similar and/or compatible water chemistry may be achieved by diluting the coarse tailings (98) with water recovered in the course of producing the dewatered fine tailings (48) using the methods of the invention or by chemically treating the coarse tailings (98).

It is believed that similar and/or compatible water chemistry is desirable for at least two reasons.

First, a similar and/or compatible water chemistry reduces the potential for adverse chemical reactions between the dewatered fine tailings (48) and the coarse tailings (98). For example, it is believed that under anaerobic conditions, clays contained in the dewatered fine tailings (48) and the coarse tailings (98) may disperse if the coarse tailings (98) contain relatively high amounts of carbonate ions and bicarbonate ions relative to the dewatered fine tailings (48).

Second, a similar and/or compatible water chemistry may improve the handling properties of the coarse tailings (98). For example, the coarse tailings (98) may flow relatively more easily and may exhibit a relatively low angle of repose, which is particularly advantageous for the first method of disposing the dewatered fine tailings (48) and the coarse tailings (98).

In this document, the word “comprising” is used in its non-limiting sense to mean that items following the word are included, but items not specifically mentioned are not excluded. A reference to an element by the indefinite article “a” does not exclude the possibility that more than one of the elements is present, unless the context clearly requires that there be one and only one of the elements.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of producing dewatered fine tailings from tailings resulting from a
5 process for recovering bitumen from oil sand, the method comprising:
 - (a) providing the tailings, wherein the tailings are comprised of water, fine solid material and coarse solid material;
 - 10 (b) separating the tailings into fine tailings and coarse tailings, wherein the fine tailings have a ratio by weight of coarse solid material to fine solid material of less than about 2 to 1;
 - (c) partially dewatering the fine tailings to produce partially dewatered fine tailings,
15 wherein the partially dewatered fine tailings have a solids content by weight of at least about 25 percent;
 - (d) reducing the pH of the partially dewatered fine tailings to less than about 6 in order to remove carbonate ions and bicarbonate ions from the partially dewatered fine
20 tailings, thereby producing acidic partially dewatered fine tailings;
 - (e) adding calcium ions to the acidic partially dewatered fine tailings in order to facilitate cation exchange in the acidic partially dewatered fine tailings whereby the calcium ions are exchanged into the acidic partially dewatered fine tailings;
25
 - (f) increasing the pH of the acidic partially dewatered fine tailings to between about 6.5 and about 7.5, thereby producing neutralized partially dewatered fine tailings having a substantially neutral pH;
 - 30 (g) adding a flocculant to the neutralized partially dewatered fine tailings; and

- (h) dewatering the neutralized partially dewatered fine tailings in a high density thickener apparatus, thereby producing the dewatered fine tailings.

2. The method as claimed in claim 1 wherein the dewatered fine tailings have a solids
5 content by weight of at least about 50 percent.
3. The method as claimed in claim 1 wherein the dewatered fine tailings have a ratio
by weight of fine solid material to fine solid material plus water of at least about 0.45 to 1.
- 10 4. The method as claimed in claim 2 wherein the coarse tailings have a solids content
by weight of at least about 60 percent.
5. The method as claimed in claim 1 wherein the high density thickener apparatus is
comprised of a deep cone paste thickener.
- 15 6. The method as claimed in claim 5 wherein partially dewatering the fine tailings is
comprised of partially dewatering the fine tailings in a conventional thickener apparatus.
7. The method as claimed in claim 1 wherein reducing the pH of the partially
20 dewatered fine tailings is comprised of adding an acid to the partially dewatered fine tailings.
8. The method as claimed in claim 7 wherein the acid is sulphuric acid.
9. The method as claimed in claim 1 wherein increasing the pH of the acidic partially
25 dewatered fine tailings and adding calcium ions to the acidic partially dewatered fine tailings is
comprised of adding lime to the acidic partially dewatered fine tailings.
10. The method as claimed in claim 1, further comprising collecting carbon dioxide
which evolves from the acidic partially dewatered fine tailings.
- 30 11. The method as claimed in claim 1 wherein separating the tailings into fine tailings
and coarse tailings is comprised of passing the tailings through a cyclone apparatus, thereby

producing the fine tailings as an overflow stream and producing the coarse tailings as an underflow stream.

12. The method as claimed in claim 11 wherein the cyclone apparatus is comprised of a first stage cyclone and a second stage cyclone.

13. The method as claimed in claim 12 wherein separating the tailings into fine tailings and coarse tailings is comprised of passing the tailings through the first stage cyclone, thereby producing a first overflow stream and a first underflow stream and passing the first underflow stream through the second stage cyclone, thereby producing a second overflow stream and a second underflow stream, wherein the fine tailings are comprised of the first overflow stream and the second overflow stream, and wherein the coarse tailings are comprised of the second underflow stream.

14. The method as claimed in claim 13 wherein dewatering the neutralized partially dewatered fine tailings in the high density thickener apparatus produces an underflow stream and an overflow stream and wherein the underflow stream is comprised of the dewatered fine tailings, further comprising combining at least a portion of the overflow stream with the first underflow stream before passing the first underflow stream through the second stage cyclone.

15. The method as claimed in claim 4, further comprising transporting the coarse tailings by a pipeline.

16. The method as claimed in claim 15, further comprising adding a flocculant to the coarse tailings at an upstream end of the pipeline in order to inhibit the separation of the fine solid material and the coarse solid material from the coarse tailings in the pipeline.

17. The method as claimed in claim 16, further comprising adjusting the solids content of the coarse tailings to no greater than about 70 percent by weight before transporting the coarse tailings in the pipeline.

18. The method as claimed in claim 16 wherein the coarse tailings are transported through the pipeline at a bulk fluid velocity of at least about 3 meters per second.

19. The method as claimed in claim 16 wherein transporting the coarse tailings through the pipeline is comprised of pumping the coarse tailings through the pipeline using a centrifugal pump.

20. The method as claimed in claim 4, further comprising depositing the dewatered fine tailings and the coarse tailings in a tailings disposal area.

10

21. The method as claimed in claim 20 wherein depositing the dewatered fine tailings and the coarse tailings in the tailings disposal area is comprised of depositing the dewatered fine tailings and the coarse tailings in the tailings disposal area in alternating layers.

15 22. The method as claimed in claim 21, further comprising collecting drained water which is drained over time from the dewatered fine tailings and the coarse tailings in the tailings disposal area.

20 23. The method as claimed in claim 22 wherein collecting drained water is comprised of providing the tailings disposal area with a drainage grid positioned in a lower portion of the tailings disposal area.

25 24. The method as claimed in claim 23 wherein collecting drained water is further comprised of providing the tailings disposal area with vertical drains extending substantially vertically in the tailings disposal area.

30 25. The method as claimed in claim 21 wherein the coarse tailings have a concentration of carbonate ions and bicarbonate ions, further comprising reducing the concentration of carbonate ions and bicarbonate ions in the coarse tailings before depositing the coarse tailings in the tailings disposal area.

26. The method as claimed in claim 25 wherein the coarse tailings have a substantially neutral pH when they are deposited in the tailings disposal area.

27. The method as claimed in claim 4, further comprising filtering the coarse tailings
5 using a belt filter apparatus in order to produce dewatered coarse tailings.

28. The method as claimed in claim 27, further comprising adding a flocculant to the coarse tailings before filtering the coarse tailings.

10 29. The method as claimed in claim 27, further comprising combining the dewatered coarse tailings with the dewatered fine tailings to produce combined dewatered tailings.

30. The method as claimed in claim 29 wherein the dewatered coarse tailings have a solids content by weight of at least about 90 percent.

15

31. The method as claimed in any one of claims 1 to 30 wherein the coarse tailings have a ratio by weight of coarse solid material to fine solid material of at least about 20 to 1.

32. A method of producing dewatered fine tailings from fine tailings resulting from a
20 process for recovering bitumen from oil sand, the method comprising:

(a) providing the fine tailings, wherein the fine tailings are comprised of water, fine solid material and coarse solid material and wherein the fine tailings have a ratio by weight of coarse solid material to fine solid material of less than about 2 to 1;
25

(b) partially dewatering the fine tailings to produce partially dewatered fine tailings, wherein the partially dewatered fine tailings have a solids content by weight of at least about 25 percent;

30 (c) reducing the pH of the partially dewatered fine tailings to less than about 6 in order to remove carbonate ions and bicarbonate ions from the partially dewatered fine tailings, thereby producing acidic partially dewatered fine tailings;

- (d) adding calcium ions to the acidic partially dewatered fine tailings in order to facilitate cation exchange in the acidic partially dewatered fine tailings whereby the calcium ions are exchanged into the acidic partially dewatered fine tailings;

5

- (e) increasing the pH of the acidic partially dewatered fine tailings to between about 6.5 and about 7.5, thereby producing neutralized partially dewatered fine tailings having a substantially neutral pH;

- 10 (f) adding a flocculant to the neutralized partially dewatered fine tailings; and

- (g) dewatering the neutralized partially dewatered fine tailings in a high density thickener apparatus, thereby producing the dewatered fine tailings.

15 33. The method as claimed in claim 32 wherein the dewatered fine tailings have a solids content by weight of at least about 50 percent.

34. The method as claimed in claim 32 wherein the dewatered fine tailings have a ratio by weight of fine solid material to fine solid material plus water of at least about 0.45 to 1.

20

35. The method as claimed in claim 32 wherein the high density thickener apparatus is comprised of a deep cone paste thickener.

25 36. The method as claimed in claim 35 wherein partially dewatering the fine tailings is comprised of partially dewatering the fine tailings in a conventional thickener apparatus.

37. The method as claimed in claim 32 wherein reducing the pH of the partially dewatered fine tailings is comprised of adding an acid to the partially dewatered fine tailings.

30 38. The method as claimed in claim 37 wherein the acid is sulphuric acid.

39. The method as claimed in claim 32 wherein increasing the pH of the acidic partially dewatered fine tailings and adding calcium ions to the acidic partially dewatered fine tailings is comprised of adding lime to the acidic partially dewatered fine tailings.

5 40. The method as claimed in claim 32, further comprising collecting carbon dioxide which evolves from the acidic partially dewatered fine tailings.

41. A method of producing dewatered fine tailings from partially dewatered fine tailings resulting from a process for recovering bitumen from oil sand, the method comprising:

10

(a) providing the partially dewatered fine tailings, wherein the partially dewatered fine tailings are comprised of water, fine solid material and coarse solid material, wherein the partially dewatered fine tailings have a ratio by weight of coarse solid material to fine solid material of less than about 2 to 1;

15

(b) reducing the pH of the partially dewatered fine tailings to less than about 6 in order to remove carbonate ions and bicarbonate ions from the partially dewatered fine tailings, thereby producing acidic partially dewatered fine tailings;

20

(c) adding calcium ions to the acidic partially dewatered fine tailings in order to facilitate cation exchange in the acidic partially dewatered fine tailings whereby the calcium ions are exchanged into the acidic partially dewatered fine tailings;

25

(d) increasing the pH of the acidic partially dewatered fine tailings to between about 6.5 and about 7.5, thereby producing neutralized partially dewatered fine tailings having a substantially neutral pH;

(e) adding a flocculant to the neutralized partially dewatered fine tailings; and

30

(f) dewatering the neutralized partially dewatered fine tailings in a high density thickener apparatus, thereby producing the dewatered fine tailings.

42. The method as claimed in claim 41 wherein the partially dewatered fine tailings are froth treatment tailings.

43. The method as claimed in claim 41 wherein the partially dewatered fine tailings
5 have a solids content by weight of at least about 25 percent.

44. The method as claimed in claim 43 wherein the dewatered fine tailings have a solids content by weight of at least about 50 percent.

10 45. The method as claimed in claim 43 wherein the dewatered fine tailings have a ratio by weight of fine solid material to fine solid material plus water of at least about 0.45 to 1.

46. The method as claimed in claim 43 wherein the high density thickener apparatus is comprised of a deep cone paste thickener.

15

47. The method as claimed in claim 43 wherein reducing the pH of the partially dewatered fine tailings is comprised of adding an acid to the partially dewatered fine tailings.

48. The method as claimed in claim 47 wherein the acid is sulphuric acid.

20

49. The method as claimed in claim 43 wherein increasing the pH of the acidic partially dewatered fine tailings and adding calcium ions to the acidic partially dewatered fine tailings is comprised of adding lime to the acidic partially dewatered fine tailings.

25 50. The method as claimed in claim 43, further comprising collecting carbon dioxide which evolves from the acidic partially dewatered fine tailings.

51. A system for producing dewatered fine tailings from fine tailings resulting from a process for recovering bitumen from oil sand, the system comprising:

30

- (a) an apparatus for partially dewatering the fine tailings in order to produce partially dewatered fine tailings;

(b) a chemical treatment subsystem for chemically treating the partially dewatered fine tailings, the chemical treatment subsystem comprising:

- 5 (i) a station for reducing the pH of the partially dewatered fine tailings to less than about 6 in order to remove carbonate ions and bicarbonate ions from the partially dewatered fine tailings, thereby producing acidic partially dewatered fine tailings;
- 10 (ii) a station for adding calcium ions to the acidic partially dewatered fine tailings in order to facilitate cation exchange in the acidic partially dewatered fine tailings whereby the calcium ions are exchanged into the acidic partially dewatered fine tailings;
- 15 (iii) a station for increasing the pH of the acidic partially dewatered fine tailings to between about 6.5 and about 7.5, thereby producing neutralized partially dewatered fine tailings having a substantially neutral pH; and
- 20 (iv) a station for adding a flocculant to the neutralized partially dewatered fine tailings; and
- (c) a high density thickener apparatus for dewatering the neutralized partially dewatered fine tailings to produce the dewatered fine tailings.

25 52. The system as claimed in claim 51 wherein the station for reducing the pH of the partially dewatered fine tailings is comprised of an apparatus for adding an acid to the partially dewatered fine tailings.

30 53. The system as claimed in claim 51 wherein the station for adding calcium ions to the acidic partially dewatered fine tailings and the station for increasing the pH of the acidic partially dewatered fine tailings are comprised of an apparatus for adding lime to the acidic partially dewatered fine tailings.

54. The system as claimed in claim 51 wherein the process for recovering bitumen from oil sand produces tailings and wherein the tailings are comprised of water, fine solid material and coarse solid material, further comprising an apparatus for separating the tailings into the fine
5 tailings and coarse tailings.

55. The system as claimed in claim 54 wherein the apparatus for separating the tailings into the fine tailings and coarse tailings is comprised of a cyclone apparatus.

10 56. The system as claimed in claim 55 wherein the cyclone apparatus is comprised of a first stage cyclone and a second stage cyclone.

57. The system as claimed in claim 56 wherein the first stage cyclone and the second stage cyclone are configured so that the tailings are passed through the first stage cyclone, thereby
15 producing a first overflow stream and a first underflow stream, so that the first underflow stream is passed through the second stage cyclone, thereby producing a second overflow stream and a second underflow stream, so that the fine tailings are comprised of the first overflow stream and the second underflow stream, and so that the coarse tailings are comprised of the second underflow stream.

20

58. The system as claimed in claim 57 wherein the high density thickener apparatus produces an underflow stream and an overflow stream, wherein the underflow stream is comprised of the dewatered fine tailings, and wherein the system is configured so that at least a portion of the overflow stream is combined with the first underflow stream before the first underflow stream is
25 passed through the second stage cyclone.

59. The system as claimed in claim 54, further comprising a belt filter apparatus for dewatering the coarse tailings in order to produce dewatered coarse tailings.

30 60. The system as claimed in claim 59, further comprising a tailings mixing facility for mixing the dewatered coarse tailings with the dewatered fine tailings to produce combined dewatered tailings.

61. The system as claimed in claim 51 wherein the high density thickener apparatus is comprised of a deep cone paste thickener.

5 62. The system as claimed in claim 61 wherein the partial dewatering apparatus is a conventional thickener apparatus.

63. The system as claimed in claim 61 wherein the conventional thickener apparatus produces an underflow stream and an overflow stream and wherein the underflow stream is
10 comprised of the partially dewatered fine tailings, further comprising a bitumen recovery apparatus for recovering bitumen from the overflow stream.

64. The system as claimed in claim 63 wherein the bitumen recovery apparatus is comprised of a froth flotation apparatus.

15

65. The system as claimed in claim 51, further comprising an apparatus for collecting carbon dioxide which evolves from the acidic partially dewatered fine tailings.

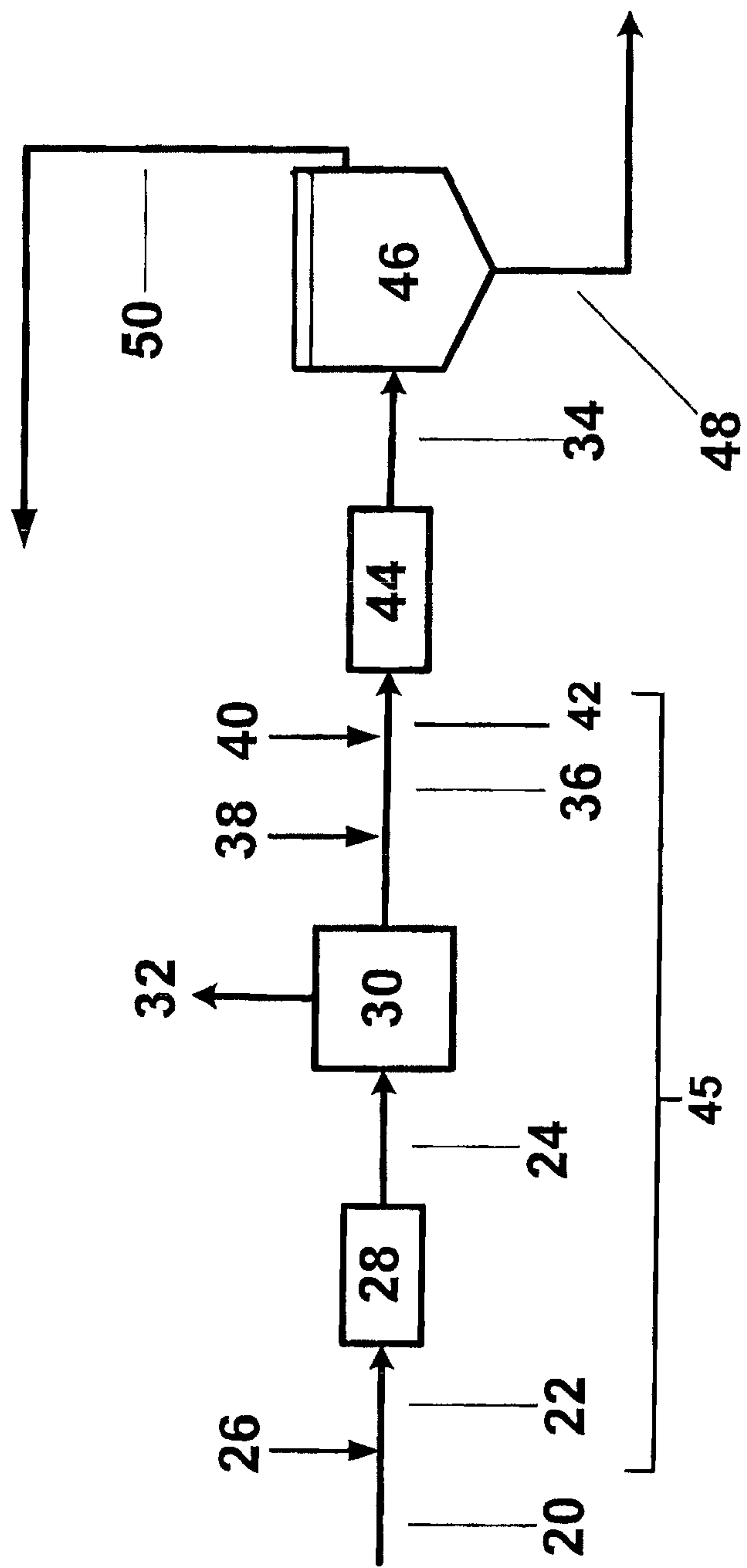


FIG-1

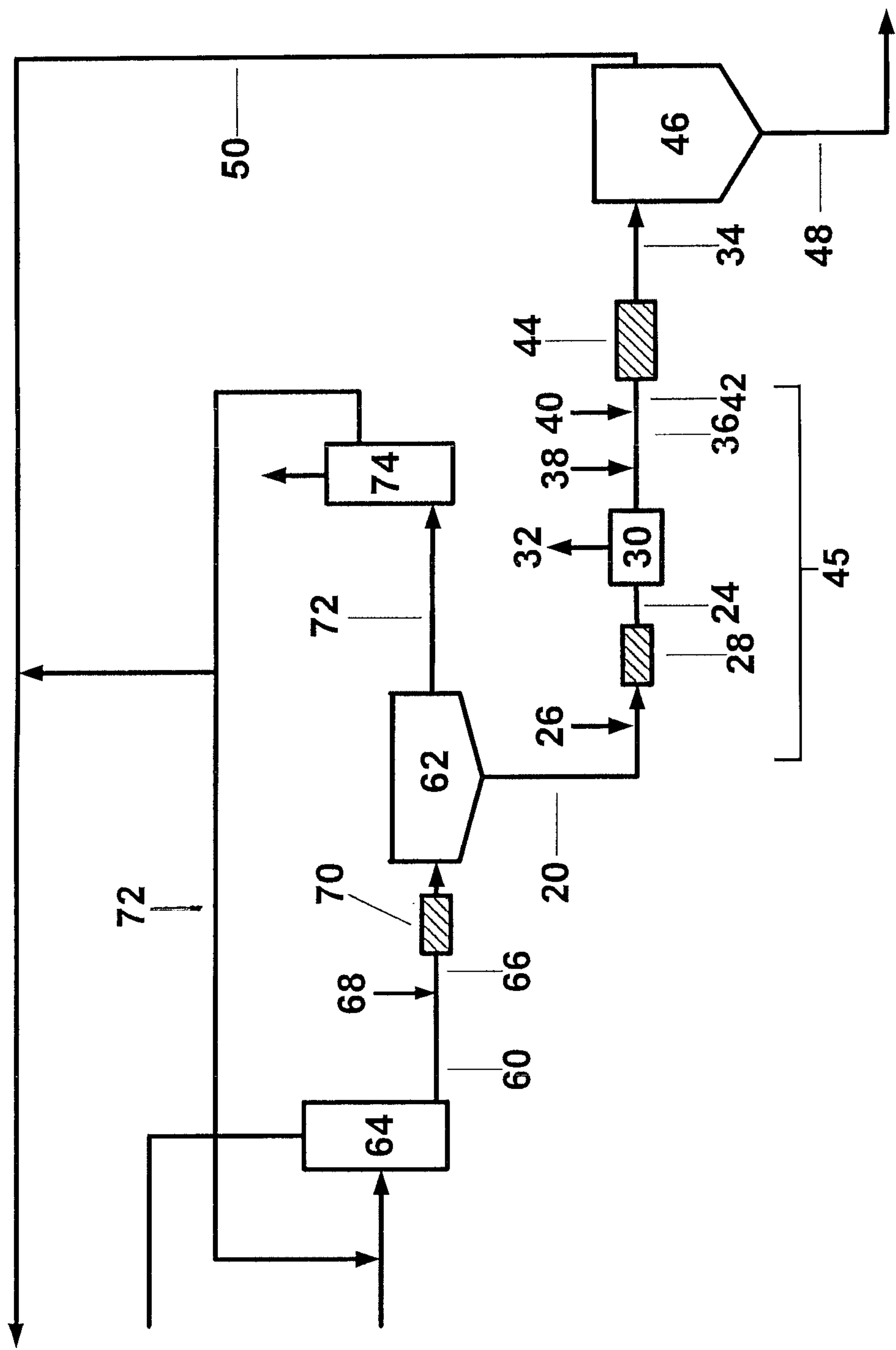


FIG-2

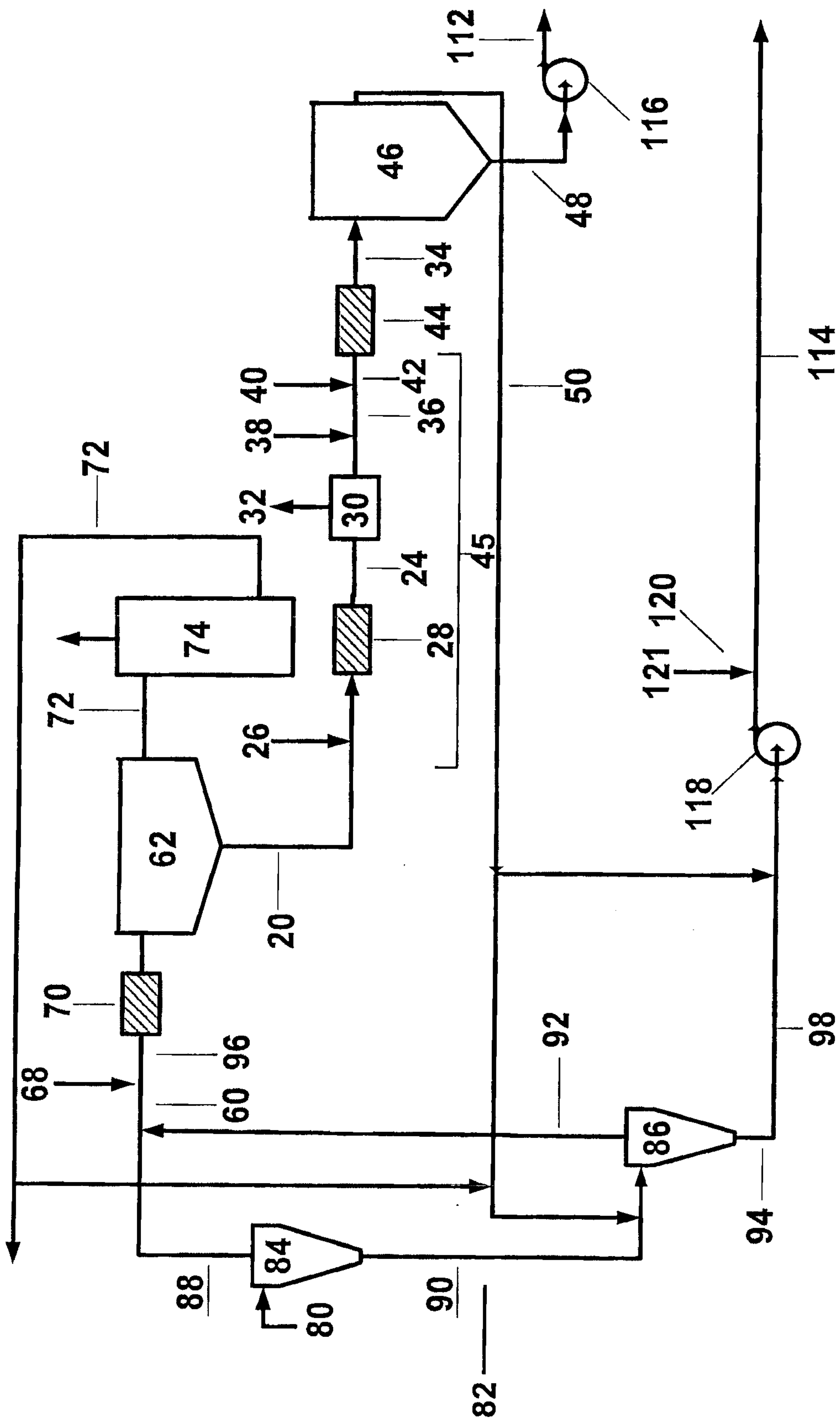


FIG-3

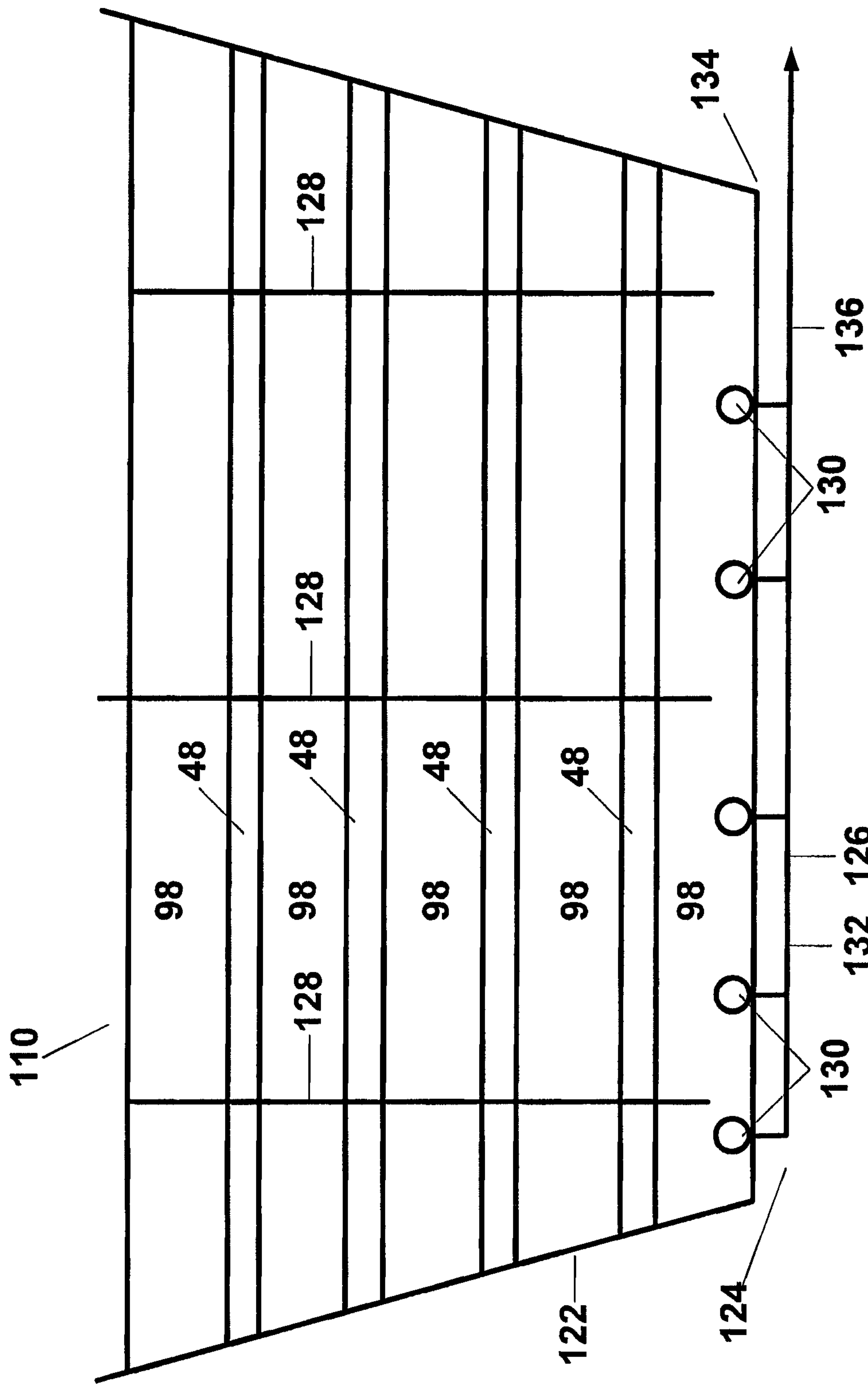


FIG-4

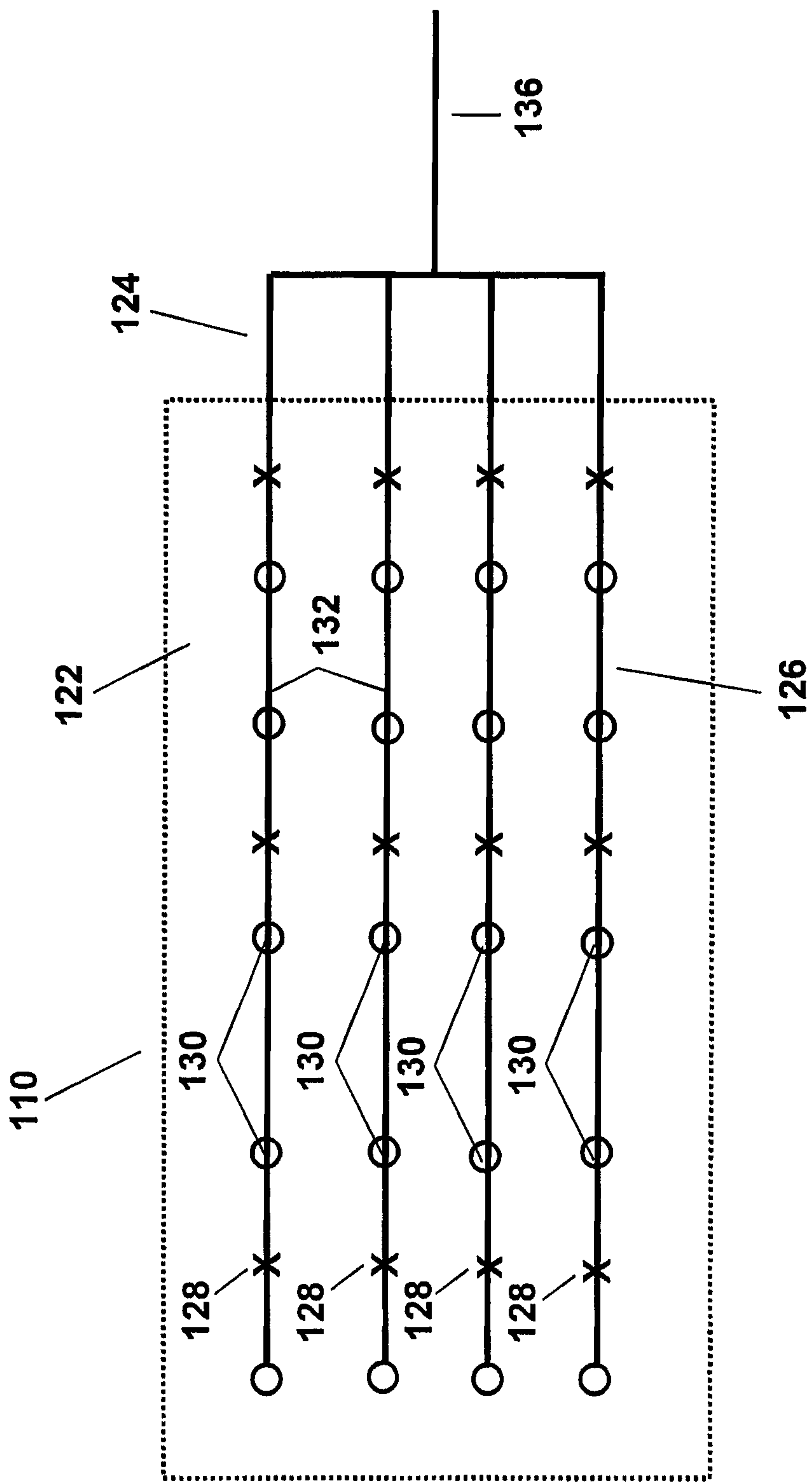


FIG-5

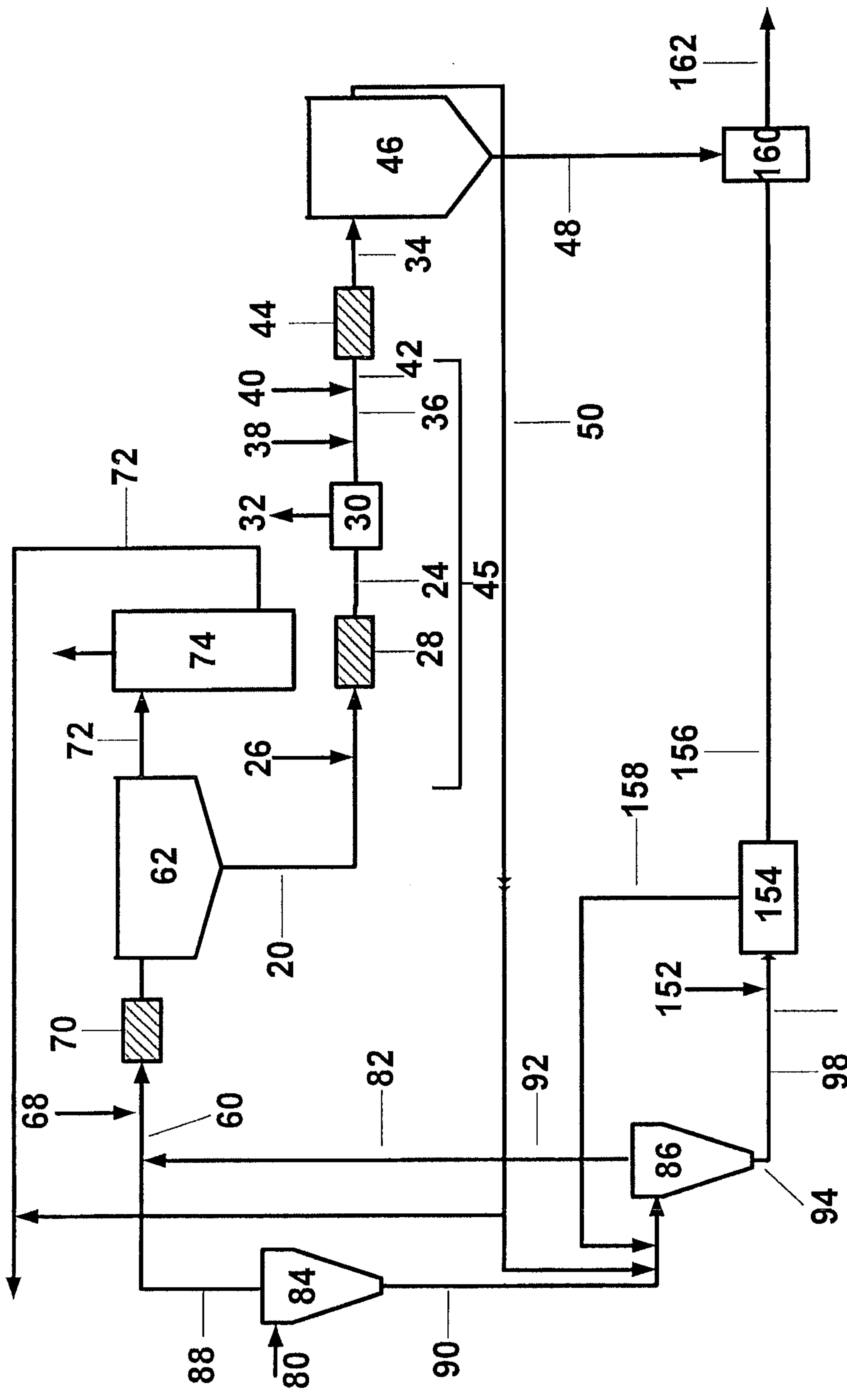


FIG-6

FROTH TREATMENT TAILINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)									
STREAM NO.	20	26	32	38	40	48	50	50	
STREAM DESCRIPTION (FROTH TREATMENT TAILINGS)	FROTH TREATMENT TAILINGS	H2SO4 ADDITION	CO2	CaO ADDITION	FLOCCULANT ADDITION	DEWATERED FINE TAILINGS	OVERFLOW STREAM (WATER)	OVERFLOW STREAM (RESIDUAL BITUMEN)	
BITUMEN, tph	10.0					4.8	0.2	5.0	
WATER, tph	250.0				0.01	42.4	206.8	0.8	
MINERALS, tph	87.5					86.8	0.4	0.2	
DILUENT, tph	22.2					14.5	0.2	7.5	
Fines, tph	52.5					51.8	0.4	0.2	
Coarse, tph	35.0					35.0	0.0	0.0	
TOTAL MASS, tph	369.7					148.5	207.6	13.6	
REL. DENSITY	1.144					1.487	1.001	0.854	
VOL. FLOW, m3/h	323					100	207	16	
FINES/ (FINES+WATER) USgpm	1424					440	914	70	
BITUMEN %wt.	0.174					0.550			
WATER %wt.	2.71					3.23	0.10	36.88	
MINERALS (Solids Content) %wt.	67.63					28.54	99.60	6.00	
DILUENT %wt.	23.67					58.48	0.20	1.80	
Fines %wt.	6.00					9.75	0.10	55.32	
Coarse %wt.	60.00					59.70	100.00	100.00	
Coarse/Fine Ratio	40.00 0.67/1					40.30	0.00	0.00	
SP. HT. kJ/kg C	3.21					1.97	4.19	1.85	
TEMPERATURE C	75.00					75.00	75.00	75.00	
ENTHALPY kJ/hx10E6	89.05					21.95	65.23	1.88	

FIG. 7

MATURE FINE TAILINGS (3000 CUBIC METERS PER HOUR)								
STREAM NO.	60	72	64	OVERFLOW FROM FLOTATION APPARATUS (64)	60	68	20	72
STREAM DESCRIPTION (MATURE FINE TAILINGS)	MATURE FINE TAILINGS (BEFORE FLOTATION)	RECYCLE DILUTION WATER	FEED TO FLOTATION APPARATUS (64)	OVERFLOW FROM FLOTATION APPARATUS (64)	MATURE FINE TAILINGS (AFTER FLOTATION)	FLOCCULANT ADDITION	PARTIALLY DEWATERED FINE TAILINGS	OVERFLOW STREAM FROM THICKENER APPARATUS
BITUMEN, tph	144.0	28.4	172.4	103.4	69.0		35.6	33.4
WATER, tph	2483.3	2350.8	4834.1	133.0	4701.2	0.09	1941.2	2760.0
MINERALS, tph	971.7	11.8	983.5	59.1	924.4		924.4	13.8
		0.0						
Fines, tph	874.6	11.8	886.3	53.3	833.1		833.1	13.8
Coarse, tph	97.2	0.0	97.2	5.8	91.3		91.3	0.0
TOTAL MASS, tph	3599.0	2391.0	5990.0	295.5	5694.5		2901.1	2807.2
REL. DENSITY								
VOL. FLOW, m3/h	1.200	1.003	1.113	1.144	1.111		1.244	1.003
USgpm	3000	2384	5383	258	5125		2332	2798
Fines/ (Fines + Water)	13219	10503	23722	1138	22584		10276	12331
BITUMEN %wt.	0.260		0.155				0.300	
WATER %wt.	4.00	1.19	2.88	35.00	1.21		1.23	1.19
MINERALS (Solids Content) %wt.	69.00	98.32	80.70	45.00	82.56		66.91	98.32
	27.00	0.49	16.42	20.00	16.23		31.86	0.49
Fines %wt.	90.00	100.00	90.12	90.12	90.12		90.12	100.00
Coarse %wt.	10.00	0.00	9.88	9.88	9.88		9.88	0.00
Coarse/Fine Ratio	0.111/1				0.110/1		0.110/1	
SP. HT. kJ/kg C	3.18	4.16	3.58	2.68	3.63		3.11	4.15
TEMPERATURE C	20.00	85.00	50.00	50.00	50.00		50.00	50.00
ENTHALPY kJ/hx10E6	228.58	844.87	1073.4	39.7	1033.79		451.24	583.16

FIG. 8

MATURE FINE TAILINGS (3000 CUBIC METERS PER HOUR)						
STREAM NO.	68	32	38	40	48	50
STREAM DESCRIPTION (MATURE FINE TAILINGS)	H2SO4 ADDITION	CO2 EVOLUTION	CaO ADDITION	FLOCCULANT ADDITION	DEWATERED FINE TAILINGS	OVERFLOW STREAM
BITUMEN, tph					34.3	1.3
WATER, tph				0.09	679.2	1262.0
MINERALS, tph					921.9	2.5
Fines, tph					830.5	2.5
Coarse, tph					91.3	0.0
TOTAL MASS, tph					1635.3	1265.8
REL. DENSITY					1.532	1.001
VOL. FLOW, m3/h					1068	1264
Fines/(Fines + Water) USgpm					4705	5571
BITUMEN %wt.					0.550	0.10
WATER %wt.					2.10	99.70
MINERALS (Solids Content) %wt.					41.53	
Fines %wt.					56.37	0.20
Coarse %wt.					90.09	100.00
Coarse/Fine Ratio					9.91	0.00
					0.110/1	
SP. HT. kJ/kg C					2.27	4.19
TEMPERATURE C					49.00	49.00
ENTHALPY kJ/hx10E6					182.13	259.94

FIG. 8

FINE TAILINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)						
STREAM NO.	60	68	20	72	26	
STREAM DESCRIPTION (BITMIN PROCESS)	FINE TAILINGS	FLOCCULANT ADDITION	PARTIALLY DEWATERED FINE TAILINGS	OVERFLOW STREAM	H2SO4 ADDITION	
BITUMEN, WATER, MINERALS,	23.5 3149.3 607.1	0.06	5.8 679.3 594.7	17.7 2470.0 12.4		
Fines, Coarse,	303.5 303.6		291.1 303.6	12.4 0.0		
TOTAL MASS,	3779.8		1279.8	2500.0		
REL. DENSITY	1.110		1.401	1.003		
VOL. FLOW, m3/h	3406		914	2492		
USgpm	15009		4027	10982		
Fines/ (Fines+Water)	0.088		0.300			
BITUMEN %wt.	0.62		0.45	0.71		
WATER %wt.	83.32		53.07	98.80		
MINERALS (Solids Content) %wt.	16.06		46.47	0.49		
Fines %wt.	49.99		48.95	100.00		
Coarse %wt.	50.01		51.05	0.00		
Coarse/Fine Ratio	1.00/1		1.04/1			
SP. HT. kJ/kg C	3.65		2.64	4.17		
TEMPERATURE C	50.00		50.00	50.00		
ENTHALPY kJ/hx10E6	689.99		169.18	520.81		

FIG. 9

FINE TAILINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)						
STREAM NO.	32	38	40	48	50	
STREAM DESCRIPTION (BITMIN PROCESS)	CO2 EVOLUTION	CaO ADDITION	FLOCCULANT ADDITION	DEWATERED FINE TAILINGS	OVERFLOW STREAM	
BITUMEN, tph				5.4	0.4	
WATER, tph			0.06	237.3	442.0	
MINERALS, tph				593.8	0.9	
				0.0		
Fines, tph				290.2	0.9	
Coarse, tph				303.6	0.0	
TOTAL MASS, tph				836.5	443.3	
REL. DENSITY				1.776	1.001	
VOL. FLOW, m3/h				471	443	
USgpm				2075	1951	
Fines/ (Fines+Water)				0.550		
BITUMEN %wt.				0.64	0.10	
WATER %wt.				28.36	99.70	
MINERALS (Solids Content) %wt.				70.99	0.20	
Fines %wt.				48.87	100.00	
Coarse %wt.				51.13	0.00	
Coarse/Fine Ratio				1.05		
SP. HT. kJ/kg C				1.82	4.19	
TEMPERATURE C				50.00	50.00	
ENTHALPY kJ/hx10E6				76.28	92.90	

FIG. 9

FINE TAILINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)						
STREAM NO.	60	68	20	72	26	32
STREAM DESCRIPTION (TSC PROCESS)	FINE TAILINGS	FLOCCULANT ADDITION	PARTIALLY DEWATERED FINE TAILINGS	OVERFLOW STREAM	H2SO4 ADDITION	CO2 EVOLUTION
BITUMEN, WATER, MINERALS,	22.1 3032.1 891.4	0.09	11.9 1137.1 881.9	10.2 1895.0 9.5	0.50	0.50
Fines, Coarse,	497.1 394.2		487.7 394.2	9.5 0.0		
TOTAL MASS,	3945.5		2030.9	1914.6		
REL. DENSITY	1.162		1.365	1.003		
VOL. FLOW, m3/h	3397		1488	1909		
USgpm	14968		6557	8411		
Fines/(Fines + Water)	0.141		0.300			
BITUMEN %wt.	0.56		0.59	0.53		
WATER %wt.	76.85		55.99	98.97		
MINERALS (Solids Content) %wt.	22.59		43.42	0.49		
Fines %wt.	55.77		55.30	100.00		
Coarse %wt.	44.23		44.70	0.00		
Coarse/Fine Ratio	0.793/1		0.808/1			
SP. HT. kJ/kg C	3.44		2.74	4.17		
TEMPERATURE C	50.00		50.00	50.00		
ENTHALPY kJ/hx10E6	677.68		278.42	399.26		

FIG. 10

FINE TAILINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)					
STREAM NO.	38	40	48	50	
STREAM DESCRIPTION (TSC PROCESS)	CaO ADDITION	FLOCCULANT ADDITION	DEWATERED TAILINGS	SECOND THICKENER OFLOW	
BITUMEN, WATER, MINERALS,	0.67	0.09	11.2 397.1 880.4 0.0	0.7 740.0 1.5	tph tph tph
Fines, Coarse,			486.2 394.2	1.5 0.0	tph tph
TOTAL MASS,			1288.6	742.2	tph
REL. DENSITY			1.726	1.001	
VOL. FLOW,			747	741	m3/h
Fines/(Fines + Water)			3291	3267	USgpm
BITUMEN			0.550		%wt.
WATER			0.87	0.10	%wt.
MINERALS (Solids Content)			30.81	99.70	%wt.
			68.32	0.20	
Fines			55.22	100.00	%wt.
Coarse			44.78	0.00	%wt.
Coarse/Fine Ratio			0.811/1		
SP. HT.			1.91	4.19	kJ/kg C
TEMPERATURE			50.00	50.00	C
ENTHALPY			122.89	155.53	kJ/hx10E6

FIG. 10

MIDDLEINGS TAILINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)					
STREAM NO.	80	88	90	60	68
STREAM DESCRIPTION (MIDDLEINGS TAILINGS)	TAILINGS	FIRST OVERFLOW STREAM (CYCLONE)	FIRST UNDERFLOW STREAM (CYCLONE)	FINE TAILINGS	FLOCCULANT ADDITION
BITUMEN, tph	70.0	52.6	17.4	65.6	0.07
WATER, tph	4545.0	2935.0	1610.0	5145.0	
MINERALS, tph	4000.0	706.2	3293.8	1152.8	
Fines, tph	600.0	366.2	233.8	506.8	0.07
Coarse, tph	3400.0	340.0	3060.0	646.0	
TOTAL MASS, tph	8615.0	3693.8	4921.2	6363.4	0.07
REL. DENSITY	1.400	1.133	1.700	1.126	
VOL. FLOW, m3/h	6153	3259	2894	5653	0.07
Fines/(Fines + Water) USgpm	27113	14360	12753	24912	
BITUMEN %wt.	0.81	1.43	0.35	1.03	0.07
WATER %wt.	52.76	79.46	32.72	80.85	
MINERALS (Solids Content) %wt.	46.43	19.12	66.93	18.12	0.07
Fines %wt.	15.00	51.86	7.10	43.96	
Coarse %wt.	85.00	48.14	92.90	56.04	0.07
Coarse/Fine Ratio	5.67/1		13.08/1	1.27/1	
SP. HT. kJ/kg C	2.64	3.53	1.97	3.57	0.07
TEMPERATURE C	50.00	50.00	50.00	50.00	
ENTHALPY kJ/hx10E6	1135.65	651.91	483.74	1136.7	

FIG.11

MIDDLLINGS TAILINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)				
STREAM NO.	20	72	72	72
STREAM DESCRIPTION (MIDDLLINGS TAILINGS)	PARTIALLY DEWATERED FINE TAILINGS	OVERFLOW STREAM (BEFORE FLOTATION)	FROTH FROM FLOTATION APPARATUS (74)	OVERFLOW STREAM (AFTER FLOTATION)
BITUMEN, tph	22.9	42.7	34.2	8.5
WATER, tph	1136.7	4008.3	58.6	3949.7
MINERALS, tph	1132.8	20.0	4.9	15.2
Fines, tph	486.8	20.0	4.9	15.2
Coarse, tph	646.0	0.0	0.0	0.0
TOTAL MASS, tph	2292.3	4071.1	97.7	3973.4
REL. DENSITY	1.437	1.003	1.035	1.002
VOL. FLOW, m3/h	1595	4058	94	3964
USgpm	7028	17883	416	17467
Fines/(Fines + Water)	0.300			
BITUMEN %wt.	1.00	1.05	35.00	0.22
WATER %wt.	49.59	98.46	60.00	99.40
MINERALS (Solids Content) %wt.	49.42	0.49	5.00	0.38
Fines %wt.	42.97	100.00	100.00	100.00
Coarse %wt.	57.03	0.00	0.00	0.00
Coarse/Fine Ratio	1.33/1			
SP. HT. kJ/kg C	2.53	4.16	3.18	4.18
TEMPERATURE C	50.00	50.00	50.00	50.00
ENTHALPY kJ/hx10E6	290.28	846.40	15.55	830.86

FIG. 11

MIDDLEINGS TAILLINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)						
STREAM NO.	26	32	38	40	48	50
STREAM DESCRIPTION (MIDDLEINGS TAILLINGS)	H2SO4 ADDITION	CO2 EVOLUTION	CaO ADDITION	FLOCCULANT ADDITION	DEWATERED TAILLINGS	OVERFLOW STREAM
BITUMEN, tph					22.2	0.7
WATER, tph				0.11	462.7	674.0
MINERALS, tph					1131.4	1.4
Fines, tph					485.4	1.4
Coarse, tph					646.0	0.0
TOTAL MASS, tph					1616.3	676.0
REL. DENSITY					1.757	1.001
VOL. FLOW, m3/h					920	675
USgpm					4053	2975
Fines/(Fines + Water)					0.512	
BITUMEN %wt.					1.37	0.10
WATER %wt.					28.62	99.70
MINERALS (Solids Content) %wt.					70.00	0.20
Fines %wt.					42.90	100.00
Coarse %wt.					57.10	0.00
Coarse/Fine Ratio					1.33/1	
SP. HT. kJ/kg C					1.84	4.19
TEMPERATURE C					50.00	50.00
ENTHALPY kJ/hx10E6					148.62	141.66

FIG. 11

MIDDLINGS TAILINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)					
STREAM NO.	50	90	27	92	
STREAM DESCRIPTION (MIDDLINGS TAILINGS)	OVERFLOW STREAM (CYCLONE DILUTION)	TOTAL CYCLONE DILUTION	FEED TO SECOND STAGE CYCLONE	SECOND OVERFLOW STREAM (CYCLONE)	SECOND UNDERFLOW STREAM (CYCLONE)
BITUMEN, tph	2.7	3.4	20.8	12.9	7.8
WATER, tph	1260.0	1934.0	3544.0	2210.0	1334.0
MINERALS, tph	4.8	6.2	3300.0	446.6	2853.4
Fines, tph	4.8	6.2	240.0	140.6	99.4
Coarse, tph	0.0	0.0	3060.0	306.0	2754.0
TOTAL MASS, tph	1267.5	1943.5	6864.7	2669.5	4195.2
REL. DENSITY	1.002	1.002	1.420	1.115	1.720
VOL. FLOW, m3/h	1265	1940	4834	2395	2439
USgpm	5572	8547	21300	10552	10748
Fines/ (Fines + Water)	0.22	0.18	0.30	0.48	0.19
BITUMEN %wt.	99.40	99.51	51.63	82.78	31.80
WATER %wt.	0.38	0.32	48.07	16.73	68.02
MINERALS (Solids Content) %wt.					
Fines %wt.	100.00	100.00	7.27	31.48	3.48
Coarse %wt.	0.00	0.00	92.73	68.52	96.52
Coarse/Fine Ratio					27.74/1
SP. HT. kJ/kg C	4.18	4.19	2.59	3.63	1.93
TEMPERATURE C	50.00	50.00	50.00	50.00	50.00
ENTHALPY kJ/hx10E6	45.2	406.70	890.4	484.78	405.67

FIG. 11

MIDDLEINGS TAILINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)						
STREAM NO.	98	98	98	48		
STREAM DESCRIPTION (MIDDLEINGS TAILINGS)	COARSE TAILINGS	SETTLED COARSE TAILING	COARSE RECLAIM WATER	SETTLED FINE TAILING	FINE RECLAIM WATER	TOTAL RECLAIM WATER
BITUMEN, WATER, MINERALS,	7.8 1334.0 2853.4	7.8 618.5 2853.4	0.0 715.5 0.0	22.2 324.0 1131.4	0.0 138.7 0.0	0.0 854.2 0.0
Fines, Coarse,	99.4 2754.0	99.4 2754.0	0.0 0.0	485.4 646.0	0.0 0.0	0.0 0.0
TOTAL MASS,	4195.2	3479.7	715.5	1477.6	138.7	854.2
REL. DENSITY	1.720	2.019	1.000	1.892	1.000	1.000
VOL. FLOW, m3/h	2439	1724	716	781	139	854
USgpm	10748	7595	3153	3442	611	3764
Fines/(Fines + Water)		0.138		0.600		
BITUMEN %wt.	0.19	0.22	0.00	1.50	0.00	0.00
WATER %wt.	31.80	17.77	100.00	21.93	100.00	100.00
MINERALS (Solids Content) %wt.	68.02	82.00	0.00	76.57	0.00	0.00
Fines %wt.	3.48	3.48	100.00	42.90	100.00	100.00
Coarse %wt.	96.52	96.52	0.00	57.10	0.00	0.00
Coarse/Fine Ratio	27.74/1					
SP. HT. kJ/kg C	1.93	1.39	4.20	1.55	4.20	4.20
TEMPERATURE C	50.00	20.00	20.00	20.00	20.00	20.00
ENTHALPY kJ/hx10E6	405.67	97.01	60.10	45.71	11.65	71.75

FIG. 11

MIDDLEINGS TAILINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)						
STREAM NO.	80	88	90	60	68	20
STREAM DESCRIPTION (MIDDLEINGS TAILINGS)	TAILINGS	FIRST OVERFLOW STREAM (CYCLONE)	FIRST UNDERFLOW STREAM (CYCLONE)	FINE TAILINGS	FLOCCULANT ADDITION	PARTIALLY DEWATERED FINE TAILINGS
BITUMEN, WATER, MINERALS,	70.0 4545.0 4000.0	52.5 2925.0 704.8	17.5 1620.0 3295.2	65.5 4977.4 1148.7	0.07	14.9 1129.1 1129.5
Fines, Coarse,	600.0 3400.0	364.8 340.0	235.2 3060.0	502.2 646.6		482.9 646.6
TOTAL MASS,	8615.0	3682.3	4932.7	6191.7		2273.5
REL. DENSITY						
VOL. FLOW, m3/h USgpm	1.400 6153 27113	1.134 3248 14313	1.698 2905 12800	1.129 5484 24166		1.440 1578 6955
Fines/(Fines + Water)	0.117	1.43	0.35	1.06		0.300
BITUMEN %wt.	0.81	79.43	32.84	80.39		0.65
WATER %wt.	52.76	19.14	66.80	18.55		49.66
MINERALS (Solids Content) %wt.	46.43					49.68
Fines %wt.	15.00	51.76	7.14	43.72		42.76
Coarse %wt.	85.00	48.24	92.86	56.28		57.24
Coarse/Fine Ratio	5.67/1		13.01/1	1.29/1		1.34/1
SP. HT. kJ/kg C	2.64	3.53	1.97	3.56		2.53
TEMPERATURE C	50.00	50.00	50.00	50.00		50.00
ENTHALPY kJ/hx10E6	1135.65	649.73	485.91	1101.3		287.84

FIG. 12

MIDDLLINGS TAILLINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)						
STREAM NO.	72		72	26	32	38
STREAM DESCRIPTION (MIDDLLINGS TAILLINGS)	OVERFLOW STREAM (BEFORE FLOTATION)	FROTH FROM FLOTATION APPARATUS (74)	OVERFLOW STREAM (AFTER FLOTATION)	H2SO4 ADDITION	CO2 EVOLUTION	CaO ADDITION
BITUMEN, tph	37.7	30.1	7.5			
WATER, tph	3848.3	51.7	3796.6			
MINERALS, tph	19.2	4.3	14.9			
Fines, tph	19.2	4.3	14.9			
Coarse, tph	0.0	0.0	0.0			
TOTAL MASS, tph	3905.2	86.1	3819.1			
REL. DENSITY						
VOL. FLOW, m3/h	1.003	1.035	1.002			
USgpm	3893	83	3810			
Fines/(Fines + Water)	17155	367	16788			
BITUMEN %wt.	0.96	35.00	0.20			
WATER %wt.	98.54	60.00	99.41			
MINERALS (Solids Content) %wt.	0.49	5.00	0.39			
Fines %wt.	100.00	100.00	100.00			
Coarse %wt.	0.00	0.00	0.00			
Coarse/Fine Ratio						
SP. HT. kJ/kg C	4.16	3.18	4.18			
TEMPERATURE C	50.00	50.00	50.00			
ENTHALPY kJ/hx10E6	812.32	13.70	798.62			

FIG. 12

MIDDLINGS TAILINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)						
STREAM NO.	40	48	50	50	50	50
STREAM DESCRIPTION (MIDDLINGS TAILINGS)	FLOCCULANT ADDITION	DEWATERED TAILINGS	OVERFLOW STREAM	OVERFLOW STREAM (PROCESS WATER RECYCLE)	OVERFLOW STREAM (DILUTE SECOND CYCLONE FEED)	
BITUMEN, WATER, MINERALS,	0.11	18.0 465.1 1127.5	0.7 664.0 2.0	0.0 0.0 0.0	0.7 664.0 2.0	
Fines, Coarse,		480.9 646.6	2.0 0.0	0.0 0.0	2.0 0.0	
TOTAL MASS,		1610.6	666.7	0.0	666.7	
REL. DENSITY						
VOL. FLOW,		1.757	1.002	1.002	1.002	1.002
USgpm		917	665	0	665	
Fines/(Fines + Water)		4039	2932	0	2932	
BITUMEN		0.508	0.10	0.10	0.10	0.10
WATER		1.12	99.60	99.60	99.60	99.60
MINERALS (Solids		28.88	0.30	0.30	0.30	0.30
Content)		70.00				
Fines		42.66	100.00	100.00	100.00	100.00
Coarse		57.34	0.00	0.00	0.00	0.00
Coarse/Fine Ratio		1.34/1				
SP. HT.		1.85	4.19	4.19	4.19	4.19
TEMPERATURE		50.00	50.00	50.00	50.00	50.00
ENTHALPY		148.59	139.59	0.0	0.0	139.6

FIG. 12

MIDDINGS TAILINGS FROM PROCESSING OIL SAND (5000 TONNES PER HOUR)						
STREAM NO.	90	92	98	156	158	162
STREAM DESCRIPTION (MIDDINGS TAILINGS)	FEED TO SECOND STAGE CYCLONE	SECOND OVERFLOW STREAM (CYCLONE)	COARSE TAILINGS	DEWATERED COARSE TAILINGS	BELT FILTER FILTRATE	COMBINED DEWATERED TAILINGS
BITUMEN, WATER, MINERALS,	21.5 3390.4 3308.5	13.0 2052.4 444.0	8.5 1338.0 2864.5	5.1 231.6 2853.3 0.0	3.4 1106.4 11.2	23.1 696.7 3980.8
Fines, Coarse,	242.9 3065.6	137.4 306.6	105.4 2759.0	99.8 2753.4	5.6 5.6	580.8 3400.0
TOTAL MASS,	6720.3	2509.4	4211.0	3090.0	1121.0	4700.6
REL. DENSITY						
VOL. FLOW, m3/h	1.435 4684 20641	1.122 2236 9853	1.720 2448 10788	2.316 1334 5879	1.006 1114 4909	2.088 2251 9918 0.455
Fines/(Fines + Water)	0.32	0.52	0.20	0.17	0.30	0.49
BITUMEN %wt.	50.45	81.79	31.77	7.50	98.70	14.82
WATER %wt.	49.23	17.69	68.02	92.34	1.00	84.69
MINERALS (Solids Content) %wt.						
Fines %wt.	7.34	30.95	3.68	3.50	50.00	14.59
Coarse %wt.	92.66	69.05	96.32	96.50	50.00	85.41
Coarse/Fine Ratio	12.62/1		26.17/1	27.57/1		5.85/1
SP. HT. kJ/kg C	2.56	3.60	1.93	1.13	4.16	1.37
TEMPERATURE C	50.00	50.00	50.00	50.00	50.00	50.00
ENTHALPY kJ/hx10E6	858.6	451.58	407.05	173.92	233.13	322.51

FIG. 12

