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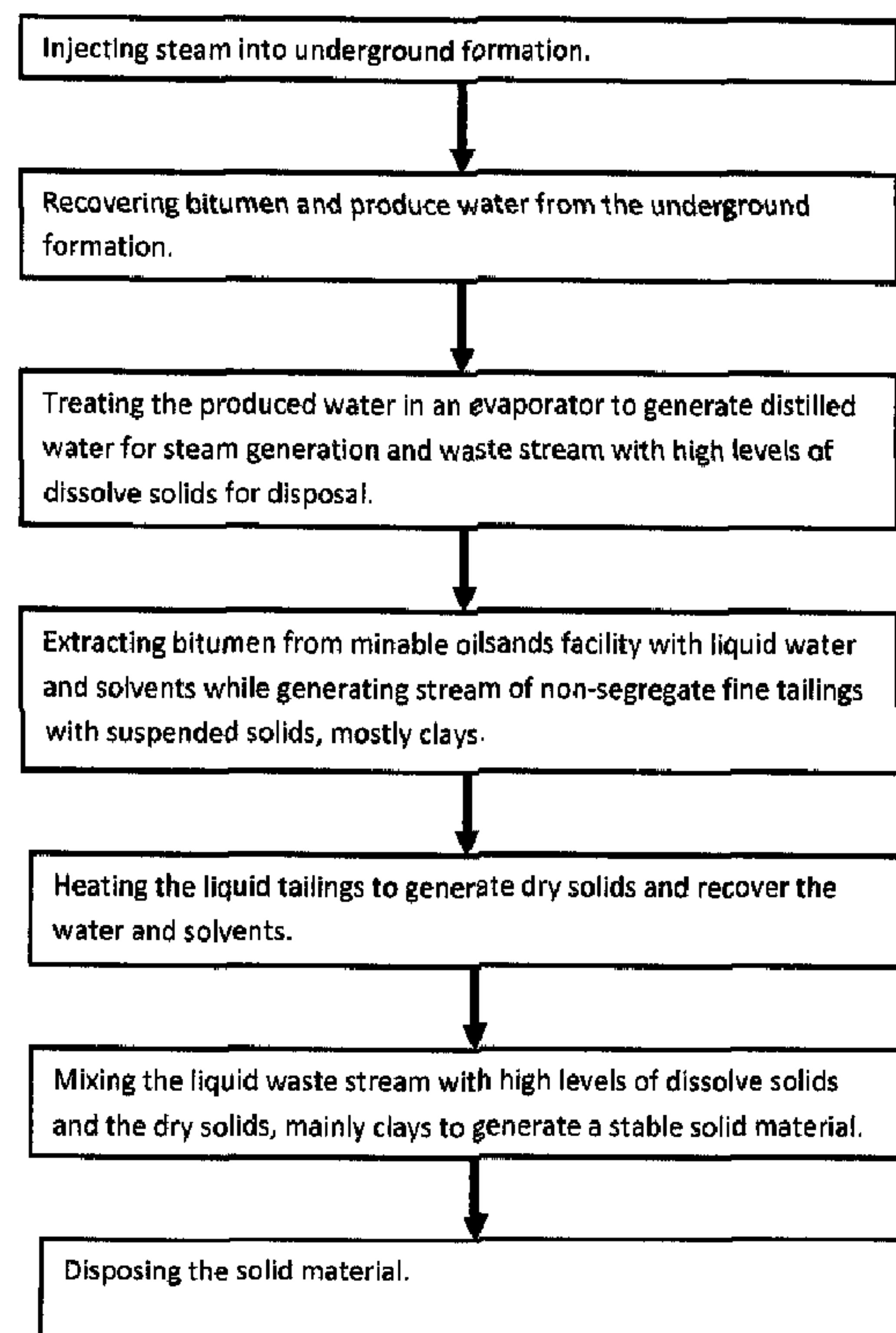
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(54) **Titre : INSTALLATION D'ELIMINATION SUR PLACE DES DECHETS DE SABLES BITUMINEUX MINABLES**

(54) **Title: COMPOUND INSITUE AND MINABLE OILSANDS WASTE DISPOSAL**



(57) **Abrégé/Abstract:**

The present invention is a method and a system for treating and disposing waste streams generated by insitue oilsands facility, like SAGD, and open mine oilsands extraction facility. Fine tailings generated by the open mine extraction facility are dried and mixed with liquid concentrated brine or blow-down waste stream generated by insitue water treatment plan. The compound solid waste can be effectively disposed in a landfill.

ABSTRACT OF THE INVENTION

The present invention is a method and a system for treating and disposing waste streams generated by insitue oilsands facility, like SAGD, and open mine oilsands extraction facility. Fine tailings generated by the open mine extraction facility are dried and mixed with liquid concentrated brine or blow-down waste stream generated by insitue water treatment plan. The compound solid waste can be effectively disposed in a landfill.

COMPOUND INSITUE AND MINABLE OILSANDS WASTE DISPOSAL

FIELD OF THE INVENTION

The present invention generally related to the field of disposal of insitue liquid waste like evaporator and crystallizer blow-down and the disposal of open mine oilsand extraction plant tailing waste.

BACKGROUND

There are two types of oilsands in Alberta – Minable and-non-minable. The non-minable oilsand are located at higher depths that are not practically to mine. The extraction of the two type of oilsands formation is significantly different – the minable formation is mined and trucked to an extraction plant. The sand and other solids, together with some oil remains are disposed in a tailing pond. In the process a stable non-segregate stable tailings are generated and accumulate in the tailing pond. To extract the non-minable oilsands formation steam, sometime with solvents, is injected into the underground formation. The most used methods are the SAGD and the CSS. Bothe using wells directed to the underground oilsands formation. The steam requires to treat the water to remove contaminates, mainly dissolved solids and organics. There are few method currently used to treat the water. The methods include softening, membrane and evaporation. In the last years the evaporation process to treat the water gained popularity due to the ability to use brackish water with high levels of dissolve solids. The water source for the minable extraction plants and the non-minable are significantly different – most of the minable extraction plants are using river water from the Athabasca river as their water source while most the SAGD and CSS non minable extraction facilities are using water wells as their water source. The two processes are eventually generating a very different liquid disposals streams - the insitue (like SAGD and CSS) extraction facilities generates a disposal stream with high levels of dissolved solids, mainly salts while the minable extraction facilities generates disposal stream with high levels if suspended solids, mainly clay.

In recent year there was a push toward ZLD systems in insitue oilsands production plants. One problem with the dissolve solids generated by insitue ZLD system is considered to be more challenging for disposal. This is due to the fact that the solids, mainly salts, are intent to easily absorb water and due to this hygroscopic behavior, dissolved back to a liquid waste. When this occur, the land fill became challenging, especially in wet seasons with rainfall where leaching become a significant concern.

ZLD systems were used commercially by the insitue industry. One example is PetroCanada Mackay River SAGD where ZLD system was used. In this plant an evaporator was used to treat the water while the disposal flow was directed to a crystallizer and possibly a filter press and a dryer. It was found that although achieving ZLD waste is achievable, the waste with the high level of salts have the tendency to absorb water like rain and complex its disposal in a landfill. (See Petrocanada presentation “Zero Liquid Discharge at MacKay River. Presented by Gary Giesbrecht at the CHOA on February 13, 2007)

The present invention is combined the two waste streams, treat them with intensive heat to dry the water from the clay and combined the two streams to generate a more stable disposal waste.

US patent 3,837,872 issued on Sept. 24, 1974 to Conner describes a solidification method for liquid waste by mixing an aqueous solution of an alkali metal silicate with the waste fluid and a silicate setting agent to cause the silicate and setting agent from the group consisting of portland cement, lime, gypsum and calcium chloride to react with each other. The reaction converts the mixture into a consolidated chemically and physically stable solid product that is substantially insoluble in water and in which

pollutants are entrapped in the solidified silicate so that the waste material is rendered nonpolluting for disposal.

US patent 3,980,558 issued on Sept. 14, 1976 to Thompson describes a process for permanently disposing of liquid or semi-liquid wastes containing soluble toxic materials comprises admixing the liquid or semi-liquid waste, such as aqueous sludge from the manufacture of phosphoric acid containing soluble and insoluble arsenic, sulfur and like toxic compounds, with a solidifying agent consisting essentially of a hydraulic cement in amounts sufficient to provide a fluid mass that will set to a contiguous rock-like solid upon standing, and then allowing the admixture to set to a contiguous rock-like solid mass which is insoluble in water. The soluble and insoluble toxic materials of the waste are wholly entrapped in the contiguous rock-like solid mass which thereby prevents them from being leached into the surrounding environment when exposed to ambient moisture. The liquid or semi-liquid waste and hydraulic cement being admixed in an amount of at least about 9 lbs. hydraulic cement per gallon of said waste based upon the waste containing from about 30 to about 40 volume % solids; and allowing the admixture to set to a contiguous rocklike solid insoluble in water whereby said toxic materials are entrapped and prevented from leaching into the surrounding environment.

US patent 4,149,968 issued on Apr. 17, 1979 to Kupiec describes a process for converting a liquid-containing, polluting waste, having metallic ions, into an inert, nonpolluting material, comprising adding and mixing a neutralizing agent, to adjust the pH value of said waste to between a value greater than 6 and up to about 11, adding and mixing with said waste bentonite clay having a weight up to 30% of the weight of the waste, and thereafter adding and mixing, with said mixture, portland cement having a weight up to 50% of the weight of the waste, the reaction time being from about 1/2 to about 5 hours to form a solid mass is formed. The quantities of bentonite and cement control the consolidation of materials and govern physical factors, such as the hardness and the chemical characteristics of the resultant material. This resulting product is chemically and physically stable; a solidified product which is almost completely insoluble in water, and in which, pollutants are encapsulated in the matrix so that the waste material is rendered non-polluting and fit for ultimate disposal.

US patent 4,209,335 issued on Jun.24, 1980 to Katayama et al. describes Solidification and fixation of waste containing toxic contaminants by use of composition made up of hydraulic cement and additive containing aluminum sulfate, alum, ferrous sulfate and ferric sulfate and alkaline metal salt selected from group consisting of alkaline metal carbonate, bicarbonate and silicate.

US patent 4,880,468 issued on Nov. 14, 1989 to Bowlin et al. describes a waste solidification composition comprising hydraulic Portland cement, fly ash and fumed silica material to solidifying agglomerations of solid and liquid waste materials such as drilling muds and cuttings that result from the drilling of an oil and gas well.

US patent 5,370,185 issued on Dec. 6, 1994 to Cowan et al. describes combining an aqueous drilling fluid containing clay such as prehydrated bentonite with a slurry of Portland cement in oil. The resulting composition is used for primary cementing operations for oil wells.

US patent 5,673,753 issued on Oct. 7, 1997 to Hale et al. describes in-situ converting drilling mud to a cement by addition of blast furnace slag. The in-situ solidification of water based drilling muds to compressive strengths well in excess of that required for casing support zonal isolation and borehole stability. The method includes injecting drilling fluid into the borehole, adding blast furnace slag to the

drilling fluid, displacing the drilling fluid to a preselected location in the borehole and allowing the drilling fluid to solidify in-situ.

US patent US 8,127,843 issued on Mar.6, 2012 to Solomon et al. describes Solidification of water treatment wastewater brines from oil production operations. Converted concentrated wastewater brines from water treatment systems in heavy oil recovery operations to solids suitable for landfill using Portland cement. The method includes injecting steam into a geologic formation, recovering an oil-water mixture, separating the oil and the water from the oil-water mixture, concentrating the separated water to produce a concentrated wastewater brine, adding a cementitious alkali formulation to the concentrated wastewater brine to produce a wet cement-brine mixture and allowing the wet cement-brine mixture to solidify.

The proposed solidification process eliminates expensive drying equipment for wastewater brine solids, as well as the associated operation and maintenance of expensive dewatering equipment.

US Patent Application Publication US 2012/0090509A1 published on Mar.6, 2012 by Albert utilizing drilling byproducts from gas and oil wells to make commercially-marketable concrete. The drill cuttings and flow-back byproducts are treated with a calcium oxide dewatering agent to form a waste slurry, and the waste slurry is then added to a concrete mixing process consists essentially of cement, a coarse aggregate, and water as the final component, after all of the other components of the concrete-mixing process have already been blended together.

SUMMARY OF THE INVENTION

The current invention is a method and system for treating and solid disposing of insitue liquid waste and a minable tailing stream.

The most common disposal method of insitue water treatment liquid waste is injecting it to a disposal well. The insitue disposal stream typically containing large levels of dissolve solids from the boilers blow down (package boilers of OTSG) if evaporating water treatment facility is used, the concentration brine can also disposed into a disposal well. As disposal wells are the preferred disposal method by the operators due to the minimum cost for treating the waste stream, they not always feasible. In additional, when large amounts of disposal liquids are injected underground, it eventually might immigrant and have impact on the environment. In some locations salt caverns are generated to address the precipitation of the disposal liquid. The salty water used to generate the salt cavern together with the disposal water from the evaporator are injecting into a disposal well. The environment regulators in Canada are aware to this problem and in some location disposal wells are not approved to use. A solid disposal of the waste solids within the waste stream is preferred as solid disposal are more stable and do not migrant to other locations. There are few methods to generate solid waste from insitue liquid stream. Some facilities used a solid disposal of waste stream. The method commercially used include crystallizer, filter to recovering the precipitation dissolved solid crystals and a dryer to dry the solid waste to prepare it for disposal. There were few problems with this particular solid waste. It is hygroscopic and if it comes in contact with water it will easily dissolved to create liquid waste that can migrant. Rain or other precipitations can generate this problem and the solid waste; mainly salts should be protected from precipitation. Another problem is the use of dryer at the insitue location. Because the insitue is a steam based process the dryer heat cannot be effectively recovered and it is wasted to the environment.

A different extraction process that is used to recover bitumen from oilsands and it is the open mine extraction facility. This type of extraction is used where the deposits of the oilsands are close to the surface so they can be mined. The extraction process generates a different type of liquid waste stream

that is called tailings. The tailings include water, clay solvents and other contaminants as asphaltene, dissolved solids, heavy metals hydrocarbons et'c. Major different between the two type of the waste streams generated the insitue extraction and the open mine extraction is that in the insitue liquid waste stream most of the solids are dissolved (salts) while in the open mine extraction most of the solids are fine suspended solids, mainly fine clay that was trapped in the sand and bitumen and released by the extraction process.

The current invention integrates these different waste material and treated them in a way to combine them into a solid material that will be more stable then the insitue dissolved material to achieve a better environmentally disposal method. Another advantage is the elimination of the need to fully dry the dissolved solids waste generated in the insitue water treatment.

DETAILED DESCRIPTION OF THE INVENTION

The present invention integrating the two different waste streams generated by insitue and minable oilsands extraction facilities to generate a stable solids that can be effectively disposed in a landfill. The mine oilsands extraction facility includes water based extraction, possibly with the aid of solvents. The present processes includes mixing oilsand ore with warm water, possibly with chemicals like NaOH, solvents etc'. Separation the hydrocarbons and some water in a primary separation vessel to generate flow of course tailings (mainly flow of sand and rocks). The coarse tailing flow directed to the tailing pond where the coarse tailings are easily separated to recyclable water and sand that is used in the tailing pond construction. The recovered hydrocarbons and froth flow are treated in floatation cells, possibly with the help of solvents. The froth treatment typically includes solvents that recovers addition hydrocarbons and can remove asphaltin from the bitumen to produce high quality product. The fine tailings from the floatation cells and from the froth treatment facility can be further treated to recover heat and additional water in a thickening facility where thickening tailings is generated. The major advantage of the thickening processes its ability to recover additional process water while maintaining the heat energy within the feed fine tailings. The waste streams that include solids , mainly fine clay particles possibly with asphaltene, with liquid, mainly solvents and water are heated in a dryer to generate dry solid stream after the liquids removed. Depending on the temperature the clay can be calculated and crystal water removed. In this process Kaoline transferred into Metakaolin. This can be done in a single process facility or in two steps where in the first stem the liquid evaporate to generate a solid waste while in the second step the dry solids are heated to remove crystal water, generate calcinated solids and meta kaoline which are "water starving" solids capable to chemically react with liquid water.

The insitue oilsands extraction facility includes injecting steam, possibly with solvents, to an underground formation through an injection well and recovering the bitumen and the water through a production well. Due to the nature of the process, large amount of water is required for steam generation. The steam mobilizes the bitumen and separates it from the sands. The bitumen and water mix is recovered back to the surface. The process water includes recycle water and make-up water. The process water includes significant amounts of dissolve solids as well as hydrocarbons and solvent remains. To generate steam the water is treated to remove hardness and other contamination. The water quality produces by the water treatment process dictated by the steam generation facility. Where OTSG is used for generation the steam, the water can include relatively high levels of dissolved solids (typically up to 8,000 TDS). Oil removal and Ion exchange are used to treat the water to a DCSG quality. The blow-down from the boiler that contains high concentration of dissolved solids is disposed in disposal wells. Another steam generation method is to use package boiler with mud drum and/or steam drum. The water requirement for this method of steam generation is higher than of the OTSG and de-mineralization on is required. Typically the water is treated with evaporator after de-oiling to remove

the oil contamination. The water is evaporated to generate distilled water stream and brine stream. The brine stream includes the dissolved solids that were in the feed water. The brine concentration can reach up to 200,000 TDS. The brine can be further treated in crystallizer, possibly with filter press to generate wet solids. The wet solids from the crystallizer are not suitable for disposal as they contain too much water. The solids from the crystallizer are further dried with a dryer to evaporate the liquid water remains into the atmosphere while generating dry solids. One problem with disposing the dried solids is the hygroscopic nature of the TDS, mainly salts. These solids easily dissolved back when they contact water which complicates the landfill disposal. When the solids dissolve, they can flow and contaminate the environment. The method and system described is design to prevent this problem by combining the two very different waste flow from the open mine (suspended solids like fine clay) and the insitue oil extraction facility (dissolve solids mainly salts). The combine flow will be more stable then the solids from the insitue process. It will also minimize the dust problem of the open mine dried tailings. In one embodiment it will reduce the need to further dry the dissolved solids in the insitue extraction process as the mixture with the dry "water starving" solids of the open mine tailings will tie the excess water within the insitue dissolved solids waste stream while generating a stable solids. ZLD system is a cost effective option if there are no disposal wells. The cost of 3rd party disposal is estimate to be in the range of \$100-\$150 /m³ and the water balance improves as close to 100% of the water recycled back to the process. Problems with the evaporation and crystallizer are the water soluble organics that are dissolved by the water from the bitumen and the solvents and are non-volatile. These accumulate in the crystallizer and increase the viscosity of the crystallizer while generating denser and abrasive slurry. By purging the crystallizer concentrated liquids water soluble organics are removed from the crystallizer to prevent accumulating. The concentrated liquids are mixed with the dry fine tailings solids to generate a stable solid material for effective disposal in landfill without free liquids and without leaching.

FIGURE A1 describes a flow diagram of another embodiment of the present invention. The process includes the following steps:

Extracting bitumen from minable oilsands ore while generating liquid stream that includes solids, water and solvent.

Recovering portion of the liquids from the solids, water and solvent stream.

Heating the solids and liquid stream with steam to evaporate portion of the water and solvent liquids.

Extracting heat from the gas phase while condensing the evaporated water and solvent into liquid phase and recycling the liquids back to the extraction process.

Heating the solids that include clay to combust any solvent or organic contamination remains within the solids and generating dry solids.

FIGURE A2 describes a flow diagram of another embodiment of the present invention. The process includes the following steps:

Extracting bitumen from minable oilsands ore while generating stream comprising of solids, water and solvent.

Recovering portion of the liquids from the solids, water and solvent stream.

Heating the non-segregated solids and liquid stream with steam to evaporate portion of the water and solvent liquids.

Condensing the evaporated water and solvent into liquid phase and recycling the liquids back to the extraction process.

Heating the solids that include clay to combust any solvent or hydrocarbon remains within the solids and generating dry solids.

FIGURE A3 describes a flow diagram of another embodiment of the present invention. The process includes the following steps:

Mining oilsands ore, mixing the mined oilsand ore with extraction water.

Separating course solids for disposal

Adding solvents to the froth to recover oil and remove asphaltene.

Recovering solvents and water while generating fine tailings that includes fine solids, water, solvents and hydrocarbon remains.

Heating the fine tailings to evaporate at least portion from the water, solvents and hydrocarbons to generate solids rich material.

Recovering the evaporate heat while condensing the evaporated water and solvent into liquid phase and recycling the liquids back to the extraction process.

Further heating the solids in the present of oxygen to combust any solvent or hydrocarbon remains within the solids and generating dry solids.

Mixing the dry solids with disposal liquid or slurry from insitue oilsasnd facility to dry the excessive liquids and generate dust free stable solid material.

FIGURE 1 describes a schematic flow diagram of the proposed invention process. The process includes the following steps:

Injecting steam into underground formation.

Recovering bitumen and produce water from the underground formation.

Treating the produced water in an evaporator to generate distilled water for steam generation and waste stream with high levels of dissolve solids for disposal.

Extracting bitumen from minable oilsands facility with liquid water and solvents while generating stream of non-segregate fine tailings with suspended solids, mostly clays.

Heating the liquid tailings to generate dry solids and recover the water and solvents.

Mixing the liquid waste stream with high levels of dissolve solids and the dry solids, mainly clays, to generate a stable solid material.

Disposing the solid material.

FIGURE 2 describes a schematic flow diagram of the proposed invention process. The process includes the following steps:

producing bitumen and produce water from an underground formation.

Treating the produced water in an evaporator to generate distilled water for steam generation and waste stream with high levels of dissolve solids for disposal.

Extracting bitumen from minable oilsands facility with liquid water and solvents while generating stream of non-segregate fine tailings with suspended solids, mostly clays.

Heating the liquid tailings to generate dry solids and recover the water and solvents.

Mixing the liquid waste stream with high levels of dissolve solids and the dry solids, mainly clays to generate a stable solid material.

Disposing the solid material.

FIGURE 3 describes a schematic flow diagram of the proposed invention process. The process includes the following steps:

Extracting bitumen and produce water from an underground formation through a well in insitue extraction facility.

Separating the produced bitumen and produced water.

De-oiling the produced water to remove excessive oil.

Treating the produced water to generate boiler feed water and waste liquid stream.
 Extracting bitumen from minable oilsands ore while generating non-segregated tailings.
 Mixing the insitue waste liquid stream and the minable non-segregated tailings.
 Heating the mixture to evaporate the liquids and generate dry solids.
 Disposing the solid material.

FIGURE 4 describes a flow diagram of another embodiment of the present invention. The process includes the following steps:

Extracting bitumen and produce water from an underground formation through a well in insitue extraction facility.
 Separating the produced bitumen and produced water.
 De-oiling the produced water to remove excessive oil.
 Evaporating the produced water to generate boiler feed water and waste liquid stream, where the evaporation system can include MVC evaporator, MED evaporator or MSF evaporator possibly with crystallizer to treat the evaporator brine and increase the brine solids concentration.
 Extracting bitumen from minable oilsands ore while generating non-segregated tailings.
 Mixing the insitue waste liquid stream and the minable non-segregated tailings.
 Heating the mixture to evaporate the liquids and generate dry solids.
 Disposing the solid material.

FIGURE 5 describes a flow diagram of another embodiment of the present invention. The process includes the following steps:

Injecting steam, possibly with solvents, for insitue bitumen extraction.
 Producing bitumen and water from an underground formation through a well in insitue extraction facility.
 Separating the produced bitumen and produced water.
 Evaporating the produced water to generate boiler feed water and insitue brine.
 Generating steam with the boiler feed water.
 Extracting bitumen from minable oilsands ore while generating non-segregated solids, water and solvent stream. (non-segregated tailings)
 Heating the non-segregated solids and liquid stream to evaporate the liquids and generate dry solids.
 Mixing the insitue waste liquid brine stream and the dry solids.
 Disposing the solid material.

FIGURE 6 describes a flow diagram of another embodiment of the present invention. The process includes the following steps:

Injecting steam, possibly with solvents, for insitue bitumen extraction.
 Producing bitumen and water from an underground formation through a well in insitue extraction facility.
 Separating the produced bitumen and produced water.
 Evaporating the produced water to generate boiler feed water and insitue brine.
 Generating steam with the boiler feed water.
 Extracting bitumen from minable oilsands ore while generating solids, water and solvent stream. (Also referrers as fine tailings)
 Mechanically recovering portion of the liquids, mainly water and solvents, from the non-segregated solids, water and solvent stream to generate slurry.
 Heating the non-segregated solids and liquid stream to evaporate the liquids and generate dry solids.
 Mixing the insitue waste liquid brine stream and the dry solids.

Disposing the solid material.

FIGURE 7 describes a flow diagram of another embodiment of the present invention. The process includes the following steps:

Injecting steam, possibly with solvents, for insitue bitumen extraction.

Producing bitumen and water from an underground formation through a well in insitue extraction facility.

Separating the produced bitumen and produced water.

Treating the produced water by evaporation, membrane filtration, softening or combination thereof, to generate boiler feed water and insitue liquid waste stream.

Generating steam with the boiler feed water.

Extracting bitumen from minable oilsands ore while generating solids, water and solvent stream.

Recovering portion of the liquids from the solids, water and solvent stream.

Heating the non-segregated solids and liquid stream to evaporate the liquids and generate dry solids that includes clay.

Heating the dry solids that includes clay to create at least portion of: calcinating, generating metaKaolin, releasing crystal water evaporate the liquids and generate dry solids.

Mixing the insitue waste liquid brine stream and the dry solids.

Disposing the solid material.

FIGURE 8 describes a flow diagram of another embodiment of the present invention. The process includes the following steps:

Extracting bitumen and produce water from an underground formation through a well in insitue extraction facility.

Separating the produced bitumen and produced water.

De-oiling the produced water to remove excessive oil.

Treating the produced water to generate boiler feed water and waste liquid stream where the water treatment process include an evaporation process, a lime softening process, or both.

Spreading the insitue waste liquid or slurry stream in a thin layer in a designated area.

Extracting bitumen from minable oilsands ore while generating fine tailings.

Heating the fine tailings to evaporate the liquids and generating dry solids.

Spreading the minable dry solids waste on top the insitue liquid or slurry layer to remove any excessive liquid and to stabilize the disposal area.

Figure 9 further describes the present invention. Produced emulsion 2 that include water with dissolve and suspended solids, bitumen and possibly solvents are recovered from production well 1. The emulsion is separated in separation vessels 3 into to gas, bitumen and possibly solvents 4 and produced water 5. The produced water 5 is de-oiled 6 where organics are removed 7. The de-oiled stream 8 is treated in evaporation facility to remove contaminations, mainly dissolve solids. Other option (not shown) is to treat portion of the water in an ion exchange process (hot / warm lime softener) while treating only portion of the flow in evaporation facility to remove dissolved solids, mainly salts. The de-oiled stream 8, possibly with blow down water from the steam generation facility 17 is fed 20 into evaporator 23. The evaporator shown is MVC (Mechanical Vapor Compression) type evaporator where water vapor 25 from the brine sump 29 are compressed by a mechanical vapor compressor 21 into falling film heat exchanger 26 where condensation occurs to generate distilled water 30 which is high quality BFW (Boiler Feed Water). Brine from the sump 27 is recycled by pump 28 and fed to the falling film heat exchanger where it is cooling the vapor while evaporating. To maintain the brine 29 concentration to prevent exceeding the maximum recommended concentration in the evaporator as

recommended by the evaporator supplier for the feed water composition and the process used in the evaporator (typically not to exceed 150000 TDS), brine 31 remove to a crystallizer where additional water is evaporated and recovered from the brine 31 with steam heat energy. Low pressure steam 18 generated at the steam generation facility 12 is heating the brine water 35 at the crystallizer. Brine 37 is circulated through pump 36 and heated 35 in heat exchanger 33 with the LP (Low Pressure) steam 18. Vapor 40 is generated in the crystallizer 40 from the heated brine 34. The condensate from the heating LP steam 32 is recovered and used as BFW. The generated water vapor 40 if condensed in condenser 41 where heat Q is recovered and used in other usage in the process. The water crystallizer condensate 42 is used as BFW for the steam generation 19. HP (High Pressure) steam 15 is generated in steam generation facility 12 and injected into a steam injection well 16 for bitumen recovery. The steam generation facility can include any commercial available steam generation technology like Industrial / Package boiler, forced circulation boilers or OTSG. Highly concentrated brine with high levels of dissolved solids and solids phase crystals 38 are removed from the crystallizer 39. The liquid phase concentrated brine 38 is mixed with dry fine particles 51 that includes dry clay particles that are generated by drying fine tailings stream generated in an open mine oilsands extraction plant. In one option the drying process includes exposure to high temperature, like in kiln type combustion dryer, The dry powder 51 will include calcinated or de-hydrated "water starving" materials that react with water to generate crystals like metakaolin. These type of materials are highly effective in converted the concentrated brine into a stable solid material that can be safely disposed in a landfill with minimum risk of leaches to the surrounding environment. The concentrated liquids from the crystallizer 38, rich in dissolved solids are mixed 43 in any commercially available mixer with the dry fine particle solids 51 generated by the dryer of the non segregated fine particulate solids in the mine extracted oilsands plant. The actual mixing can be at the dryer itself. For that option, the high TDS liquids are added to the last portion of the dryer and mixed with the fine particles inside the dryer itself. Other option is to mix the open mine dry solids and the crystallizer liquid in a rotating mixed which also agglomerate the solids to particles that can be easily disposed in landfill.

Figure 10 further describes the present invention. A typical Oilsands extraction mine facility is briefly described (See "Past, Present and Future Tailings, Tailing Experience at Albion Sands Energy" presentation by Jonathan Matthews from Shell Canada Energy on December 8, 2008 at the International Oil Sands Tailings Conference in Edmonton, Alberta). Mined Oil sand feed is transferred in trucks to an ore preparation facility, where it is crushed in a semi-mobile crusher 3. It is also mixed with hot water 57 in a rotary breaker 5. Oversized particles are rejected and removed to landfill. The ore mix goes through slurry conditioning, where it is pumped through a special pipeline 7. Chemicals and air are added to the ore slurry 8. The conditioned aerated slurry flow is fed into the bitumen extraction facility, where it is injected into a Primary Separation Cell 9. To improve the separation, the slurry is recycled through floatation cells 10. Oversized particles are removed through a screen 12 in the bottom of the separation cell. From the flotation cells, the coarse and fine tailings are separated in separator 13. The fine tailings flow to thickener 18. To improve the separation in the thickener, flocculant is added 17. Recycled water 16 is recovered from the thickener and fine tailings are removed from the bottom of thickener 18. The froth is removed from the Primary Separation Cell 9 to vessel 21. In this vessel, steam 14 is injected to remove air and gas from the froth. The recovered froth is maintained in a Froth Storage Tank 23. The steam can be produced in a standard high pressure steam boiler 40, in OTSG, or by a COGEN, using the temperature in a gas turbine tail (not shown). The boiler consumes fuel gas 38 and air 39. The coarse tailings 15 and the fine tailings 19 are removed and sent to tailing processing area or to a tailing pond. The tailing ponds are built in such a way that the sand tailings are used to build the containment areas for the fine tailings. The tailing sources come from Extraction Process. They include the cyclone underflow tailings 13, mainly coarse tailings and the fine tailings from the thickener 18, where

flocculants are added to enhance the solid settling and recycling of warm water. Another source of fine tailings is the Froth Treatment Tailings, where the tailings are discarded by the solvent recovery process characterized by high fines content, relatively high asphaltene content, and residual solvent. (See "Past, Present and Future Tailings, Tailing Experience at Albion Sands Energy" a presentation by Jonathan Matthews from Shell Canada Energy on December 8, 2008 at the International Oil Sands Tailings Conference in Edmonton, Alberta). A sand dyke 55 contains a tailing pond. The sand separates from the tailings and generates a sand beach 56. Fine tailings 57 are put above the sand beach at the middle-low section of the tailing pond. Some fine tailings are trapped in the sand beach 56. On top of the fine tailing is the recycled water layer 58. The tailing concentration increases with depth. Close to the bottom of the tailing layer are the MFT (Mature Fine Tailings). (See "The Chemistry of Oil Sands Tailings: Production to Treatment" presentation by R.J. Mikula, V.A. Munoz, O.E. Omotoso, and K.L. Kasperski of CanmetENERGY, Devon, Alberta, Natural Resources Canada on December 8, 2008 at the International Oil Sands Tailings Conference in Edmonton, Alberta). The recycled water 41 is pumped from a location close to the surface of the tailing pond (typically from a floating barge). The fine tailings are pumped from the deep areas of the fine tailings 60. Fuel 48 and oxidizing gas 49 are injected into a dryer / DCSG. The fine tailings 60 from the tailing pond or directly from the froth treatment of the extraction facility are thickened in a thickening facility like a centrifugal separator 31. These commercially available units recover additional water 33 from the fine tailings while increasing the solids concentration in the thickened fine tailings 43. The dryer 50 described in figure 10 is a horizontal, counter flow rotating dryer. However, any available dryer / DCSG that can generate gas and solids from the MFT can be used as well. The fine tailings 43 turn into gas and solids as the liquids within the tailings flow is converted to steam. The solids 51 are recovered in a dry form. If high temperatures are used, the tailings can be calcinated and de-hydrated where crystal water is removed from the solids as well. This is a function of the tailings chemical composition as well as the temperature in the dryer. The dryer gas discharge 47 is condensed in heat exchanger 61 to generate condensate 62. The heat discharged from the dryer is recycled back to the extraction process through heat exchanger 61 to generate the hot extraction liquid 57, mainly water with possibly solvents. The generated condensate from the evaporated tailings can be added to the extraction liquid 63, possibly after pH adjustment (not shown). The dry fine solids 51 are combined and mixed with in-situ oil sands facility liquid stream 30 that contained high levels of dissolved solids, mainly salts possibly with non-volatile dissolved hydrocarbons. The mixing stabilizes the liquids 30 from the in-situ oil sands facility by contacting them with the fine solids, which might have been calcinated and de-hydrated levels that are highly efficient in stabilizing the liquids to a stable solid material that can be safely disposed in a land fill without the risk of leaching to the surrounding environment. The dried dry solids from the in-situ oil sands facility tailings can contaminate the surrounding by creating dust, especially in windy conditions. By adding the liquids and the solids together the dust problem is solved as a stable solid material is generated by mixing the two flows and disposing the generated solid in a land fill.

Figure 11 describes generating the dry solids material in the open mine extraction facility in two steps where in the first step the water and solvents are recovered for further use in the extraction process by the use of "dry" superheated steam and a second step where the dried solids are further heated in the presence of oxygen in direct contact with a flame combustion where solids might be calcinated and hydrates broken and released generating "water starving" solids capable of solidifying. A SD-DCSG (Steam Drive Direct Contact Steam Generator) 30 (also called dry Steam drive dryer) integrated into an open mine oil sands extraction plant for generating the hot extraction water while consuming the Fine Tailings (stream of liquids mainly water and solvents with high levels of non-segregated fine suspended solids) generated by the extraction process. Flow 36 is superheated steam. The steam flows to enclosure 30 which is a steam driven dryer. Fine Tailings (FT) contaminated liquid 34, is also injected into enclosure 30 as the water source for generating steam. The liquid component within stream 34 evaporates and is

transferred into steam, vapors and solids. The remaining solids 35 are removed from the system. The generated steam 31 is at the same pressure (less the flow losses within the dryer 30) as that of the drive steam 36 but at a lower temperature because a portion of its energy was used to drive the liquid water 7 through a phase change. The generated steam is also at a temperature that is close to (or slightly higher than) the saturated temperature of the steam and solvents at the pressure inside the enclosure 30. The produce steam 33 is fed into a heat exchanger / condenser where the water and solvents are condensed and recovered and recycled back to the extraction process. The steam 36 is flowing upwards in the rotating dryer 30 where low quality liquid water with solvents and solids from the open mine extraction facility 34 is injected to the up-flow steam. At least a portion of the injected liquid is converted into steam at a lower temperature and is at the approximately the same pressure as the dry driving steam 36. The generated steam can be saturated ("wet") steam at a lower temperature than the driving steam. A portion of the generated steam 32 is recycled through compressing device 39. The compression is only designed to create the steam flow through heat exchanger 38 and create the up flow in the SD-DCSG 30. The compressing unit 39 can be a mechanical rotating compressor. Another option is to use high pressure steam 40 and inject it through ejector to generate the required over pressure and flow in line 36. Any other commercially available unit to create the recycle flow 36 can be used as well. The produced steam, after its pressure is slightly increased to generate the recycle flow 36, and possibly after the contaminants are removed in a dry separator or wet scrubber to protect the heater 38, flows to heat exchanger 38 where additional heat is added to the recycled steam flow 32 to generate a heated "dry" steam 36. This steam is used to drive the SD-DCSG / dryer as it is injected into its lower section 30 and the excess heat energy within the driving steam is used to evaporate the injected water and liquid solvents and generate additional steam 31. There are several commercial options and designs to supply the heat 37 to the process. The produced steam 31 or just the recycled produced steam 32 can be cleaned of solids carried with the steam gas by an additional commercially available system (not shown). The system can include solids removal; this heat exchanger can be any commercially available design. The heat source can be fuel combustion where the heat transfer can be radiation, convection or both. Another possibility can be to use the design of the re-heat heat exchanger typically used in power station boilers to heat the medium / low pressure steam after it is released from the high pressure stages of the steam turbine to generate the superheated steam 36. To further remove any organic contaminants in the solids (or slurry discharge from the rotating steam drive dryer, an additional combustor 10 is added. In Fig. 11 a rotating combustor was added, however, any type of combustor, like fluid bed can be added as well. Hydrocarbon or carbon gas, liquid or solid fuel 11 is injected into the rotating combustor 10 and burned with pre-heated air 12. The solids 35 are heated within the kiln 10 and hydrocarbon and organic contaminate is combusted in the oxygen environment within the enclosure 10. In case the solids include crystal water within their structure, these water will be break out of the molecules and leave the system in gas stage. Kaolin within the feed will be also converted to metakaolin and other solids can be calcinated due to the direct combustion process. Heat 37A is recovered from the heat exchanger 19 from the generated combustion gas and steam mixture 13. The generated solids 14 are cooled in fluid bed structure 15 or any other commercially available design 15 with flow of atmospheric combustion air 16. The cooled solids 17 are removed from the system for further use like stabilization of wet areas or mixture with insitue waste liquids.

Figure 12 describes another embodiment of generating the dry solids material in the open mine extraction facility in two steps where in the first step the water and solvents are recovered for further use in the extraction process. A SD-DCSG (Steam drive dryer) 11 with a non-direct heat exchanger 13 to heat the process water 14 and with the combustion of the NCG hydrocarbons 17 as part of generating the driving steam 9. FT (Fine Tailings) or MFT (Mature Fine Tailings) 7 are injected into a Steam Driven dryer / SD-DCDG. In Figure12, a vertical fluid bed SD-DCSG is schematically represented. Any other dryer

designs can be used as well, like the horizontal rotating SD-dryer or any other design. The fine tailings 7 which containing water, solids and possibly solvents as well as other hydrocarbons as well) are mixed with the dry super-heated steam flow 9 that is used as the energy source to transfer the liquid phase in flow 7 to gas (steam and hydrocarbon) phase by direct contact heat exchange. The FT 7 solids are removed in a stable form 12 for further combustion to remove by combustion any organic contamination and generate a water starving solids, possibly dehydrated. The produced steam 8 is condensed in a non-direct heat exchanger / condenser 13. The water condensation heat is used to heat the extraction process water 14. With some tailings types, off gas like NCG (Non Condensed Gases) or light hydrocarbons that are breaking away due to the heat 17 are generated due to the presence of hydrocarbons, like solvents used in the froth treatment or oil remains that were not separated and remained with the tailings feed and did not condensed with the condensing vapors in condensed 13. The gas 17 is burned, together with other fuel 20 like natural gas, syngas or any other fuel. The combustion heat is used, through non-direct heat exchange, to produce the superheated driving steam 9 used to drive the process. The amount of energy in the NCG hydrocarbons 17 recovered from typical oilsands tailings even that from a solvent froth treatment process is not sufficient to generate the steam 9 to drive the SD-DCSG / dryer. It can provide only a small portion of the process heat energy used to generate the driving steam 9. One option is to use a standard boiler 18 designed to generate steam from liquid water feed 19 from a separate source. Another option is to use a portion of the produced steam condensate 23 as the liquid water feed to generate the driving steam 9. The condensate will be treated to bring it to BFW quality. Treatment units 24 are commercially available. Another option to generate the driving steam 9 is to recycle a portion of the produced steam 8. The recycled produced steam 21 is compressed 22. The compression is needed to overcome the pressure drop due to the recycle flow and to generate the flow through the heater 18 and the SD-DCSG 11. The compression can be done using a steam ejector with high pressure additional steam or with the use of any available low pressure difference mechanical compressor. The recycled produced steam 21- possibly after additional cleaning, like wet scrubbing, to remove contaminants like silica- is indirectly heated by combustion heater 18. The temperature in enclosure 11 where the dry driving steam 9 heating the wet solids 7 to generate dry solids is less than typical combustion temperature, and the environment within enclosure 11 where the heating takes place is oxygen free and containing mainly steam, possibly with some solids levels. To remove any non-volatile remaining contaminate within the solids, the generated solids 12 are further exposed to a direct combustion heat in combustor 18 or a separate combustor to combust any remaining contamination. The combustion heat is recovered to other purposes like generating the driving steam. Another advantage is that the solids leaving enclosure 11, can be in a slurry form and still contain liquids like water and hydrocarbons as they will be further dried in the combustor 18 where any liquid remains will be evaporated and any organic material remain will be combusted as the environment within the combustor includes combustion gas that containing oxygen. Additional effect due to the combustion is the potential of generating "water starving" solids 31 by removing crystal water from the solids molecules and calcinations. Where the feed contains clay and Kaolin, Metakaolin will be generated in the combustion process. This natural reaction is due to the heat exposure. The generation of these reactions is mainly depends on the solids composition within feed 7.

Figure 13 describes another embodiment of generating the dry solids material in the open mine extraction facility in two stages where in the first stage the water and solvents are recovered with dry steam for further use in the extraction process. And in the second stage the remaining solids are further directly heated with a combustion heat in combustion gas environment where organic contaminations are combusted. Block A describes an open mine oilsands extraction plant as described in Fig. 10. Fine tailings 19A generated in the process, possibly with additional fine tailings 14 like solvent extraction froth treatment fine tailings are pre-heated in heat exchanger Q2 to generate heated fine tailings 7. (The

term "Tailings" is used in this invention to describe a liquid stream that include water, solvents and hydrocarbons with high levels of fine suspended solids like fine clays) The heated fine tailings 7 is fed into enclosure 11 where it is directly mixed with low pressure (close to atmospheric pressure) dry super heated steam 9 that is converted most of the liquids within the pre-heated tailings 7 to vapor gas phase 8. Heat Q4 is recovered from the vapor 8 while condensing the vapor to liquid phase 10, mostly water and solvents, and recycle the liquid back to the extraction plant at block A. The heat within vapor 8 is also used, directly or indirectly, to heat the process extraction water 52 to generate the hot extraction water 52A required in the open mine extraction plant in Block A. Enclosure 11 can be any direct contact dryer / evaporator design, this includes fluid bed dryer design, rotating dryer, rotating internal paddles, venturi flash design or any other commercially available design. Solids 12 removed from enclosure 11 and into enclosure 25 where they are further directly heated with combustion gases. Enclosure 25 is a kiln design that includes heat exchange section that can include chains 27 and/or lifting paddles 26 to mix the solids 12 with the combustion gas. The remaining water in solids 12 evaporates at the elevated heat while organics remains within the solids 12 are combusted. Carbon or hydrocarbon Fuel 23, like natural gas, coal or asphaltene is injected 23 and combusted within the rotating kiln 25. Due to the high temperature within the kiln 25, some type of solids loses their molecule crystal water and can also go through de-hydration / calcinating process. The hot solids are cooled down while heating the combustion air 20. The heat exchange between the hot solids and the air is enhanced by the use of lifting paddles 22 and optionally chains 27. The dry possibly un-hydrated and possibly calcinated solids 21 are recovered for disposal, possibly with further mixture with liquid waste streams to generate a solid stable material that can be used for backfill. The combustion gases discharged from kiln 28 are cleaned in unit 29 to remove solids 30 that can block the heat exchanger 32. Heat Q1 is recovered from the combustion gas 31. The heat Q1 is used to generate the driving steam Q3 or for pre-heated the liquid feed 7 as Q2 heat.

Figure 14 describes another embodiment of the present invention. Block A describes an open mine oilsands extraction plant as described in Fig. 10. The thickened tailings that include fine suspended solids, water, solvents and possibly some levels of dissolved solids 7 are pre-heated in heat exchanged / condensed 7A and injected into enclosure 11 where it mixed with superheated steam 9. The dry superheated steam evaporated liquid water and solvent from feed 7B. The evaporation energy in gas phase stream 8 is recovered in condenser 7A and further in condenser 13 where the remaining heat energy in stream 7C is recovered while heating the cold extraction water 52. The condensed liquids 10 recycled back to the extraction facility. The solids rich stream 12 from dryer 11 is directed to enclosure 20 that include an internal combustion. Carbon based fuel 21 is combusted within enclosure 20 with pre-heated air 22. The solids exposed and mixed with the combustion gas where any organics that were not evaporate and removed by the steam in enclosure 11 combusted. Any liquids remains evaporate from the solids. Due to the high combustion temperature, if the solids include crystal water within their molecules, the water will break away generating dehydrated "water starving" solids like metakaolin. The hot solids 23 are cooled with the intake combustion air 26 in heat exchanger 25 to generate pre-heated combustion air 22 and cooled solids 27 for disposal or for further treatment like mixing with liquid waste stream to stabilizing these streams while generating solid material that can be disposed in landfill or for backfill. The heat from combustion gas 24 from enclosure 20 is recovered in heat exchanger 29 to generate the driving steam 9. Enclosure 20 can be a rotating kiln or any other available design.

Figure 15 describes another embodiment of the present invention. Block A describes an open mine oilsands extraction plant with superheated steam extraction enclosure 11 as described in Fig. 14. The solids rich discharge 12 from the steam dryer is entered to a cyclone heat exchanger 36 where the solids exposed to the heat from discharged combustion gas from a kiln 30. The heated solids 37 entered the

kiln 30 and heated with combustion energy generated by combustor 35. Any remaining organics are combusted in the kiln. Due to the high temperatures in the kiln some solids can undergo chemical reactions like the release of crystal water, calcinations and other changes that are typical to the particular solids composition. The hot discharged solids are cooled in fluid bed heat exchanger with the feed combustion air 31. The produced solids 33 are disposed, possible after mixing with additional liquid waste streams. To control the temperature portion of the feed air is by-passed directly to the cyclones 36. The combustion gas discharged from the cyclones 38 is cleaned in electric precipitator 39 to remove solids within the combustion gas. Heat Q 41 is recovered from the combustion gas in heat exchanger 40. The heat can be used to generate the driving steam 9 and for pre-heat the liquid feed 7. The combustion gas 45 after the combustion heat was recovered is released in a stack 44.

CLAIMS

1. A method for disposing insitue and minable oil sands waste streams includes:

Injection steam underground to recover oil;

recovering water from the produced fluid;

treating the produce water to generate water for steam production and concentrated insitue waste water stream with dissolved solids;

extracting bitumen in open mine extraction plant while generating waste stream comprised of water, solvents, organic contaminates and suspended solids, mainly clay.

evaporating the liquid phase while generating dry solids from the suspended solids.

mixing the dried suspended solids with the insitue waste water stream with dissolved solids.

2. A method for generating solids in open mine extraction plant with water and solvent recovery includes:

separation bitumen from water, solvents and fine suspended solids stream while generating tailing stream comprising of water, solvents and solids;

heating the mixture with steam to evaporate the water and solvents and generating solids stream and gas stream;

condensing the evaporated gas to recover the evaporation heat while generating liquid water and solvent stream;

recycling the liquids back to the extraction process;

combusting carbon based fuel to generate heat and combustion gas;

directly heating the solids stream with t he combustion heat to combust any organics remains within the solids and remove water including crystal water within the solids.

3. A system for disposing insitue and minable oil sands waste streams includes:

production well for producing fluid containing bitumen, fluidly connected to;

separator for separating water from the produced fluid, fluidly connected to;

water treatment plant evaporator for producing dematerialized water and concentrated brine flow;

open mine extraction plant generating fine tailings, fluidly connected to;

fine tailings dryer for generating dry tailings; and

mixer mixing said dry tailings with said concentrated brine flow.

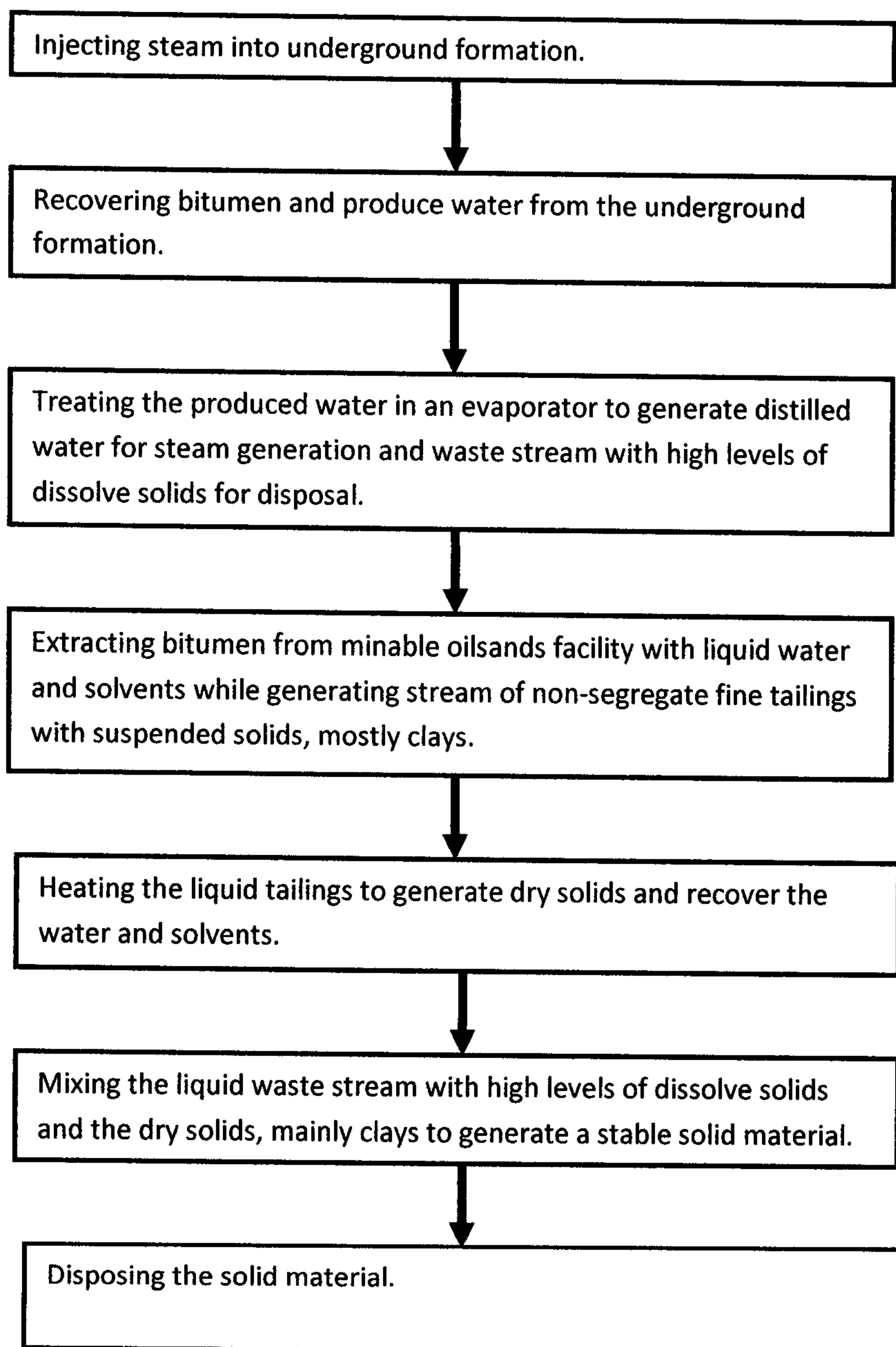


FIG. 1

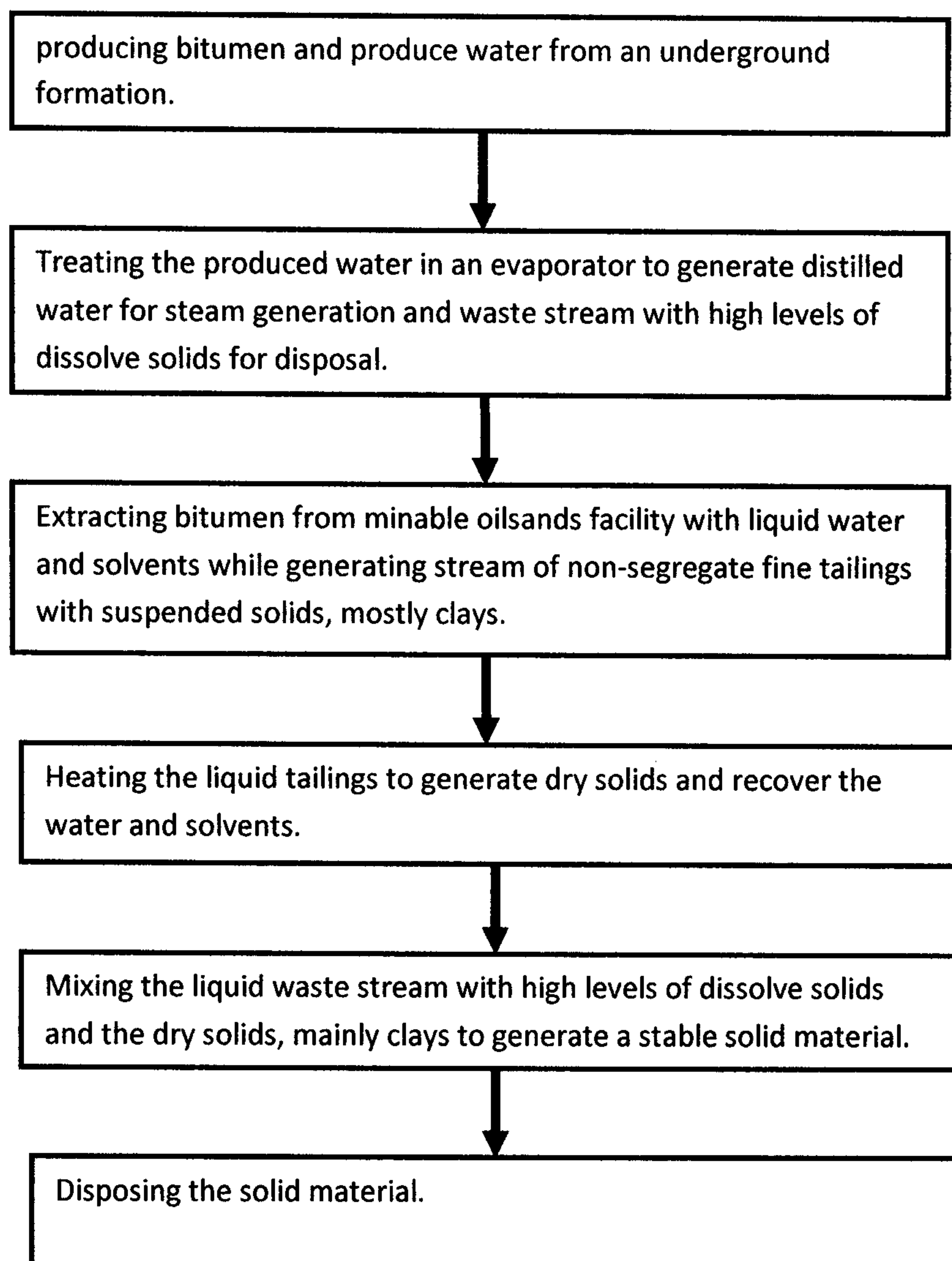


FIG. 2

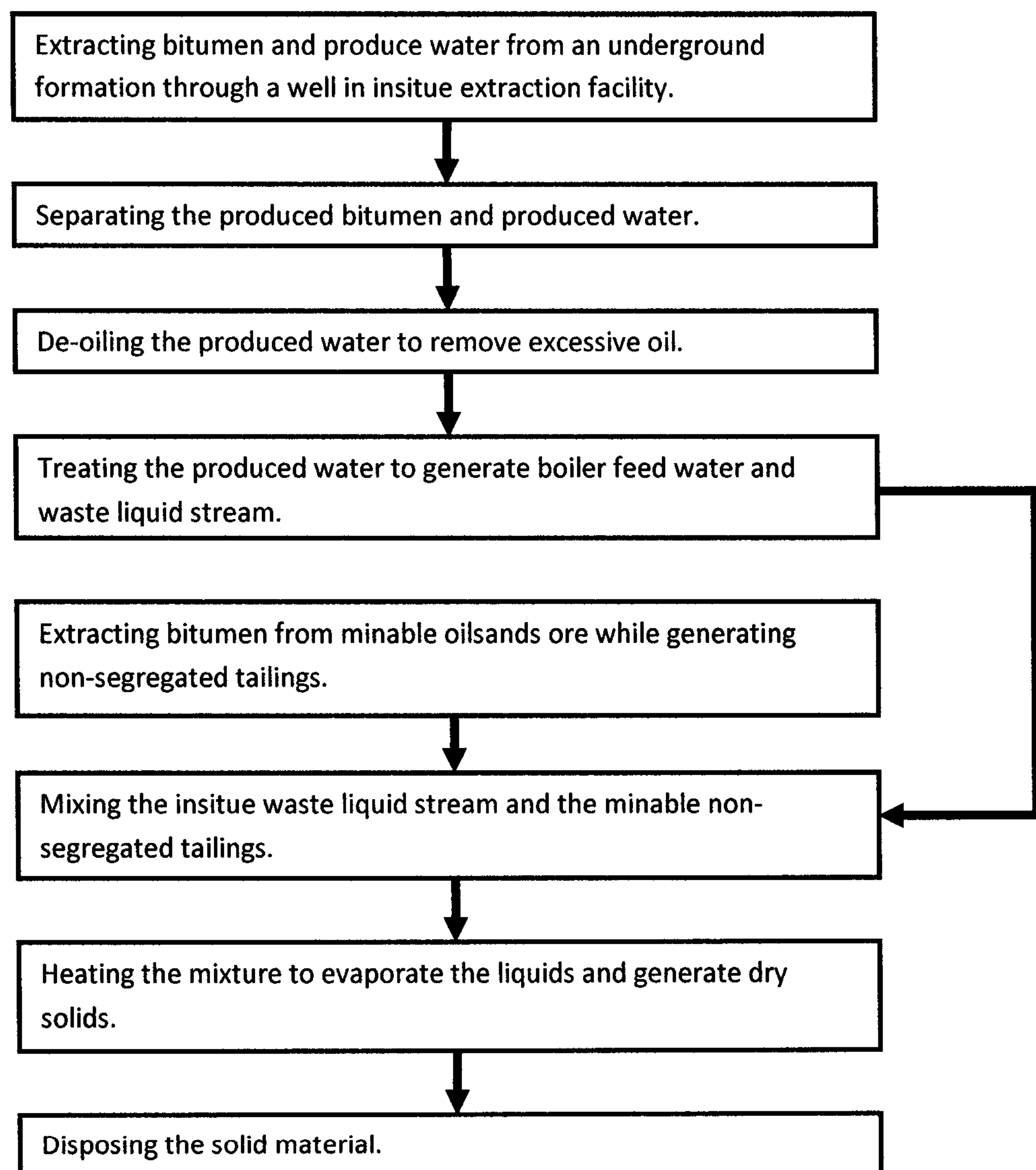


FIG. 3

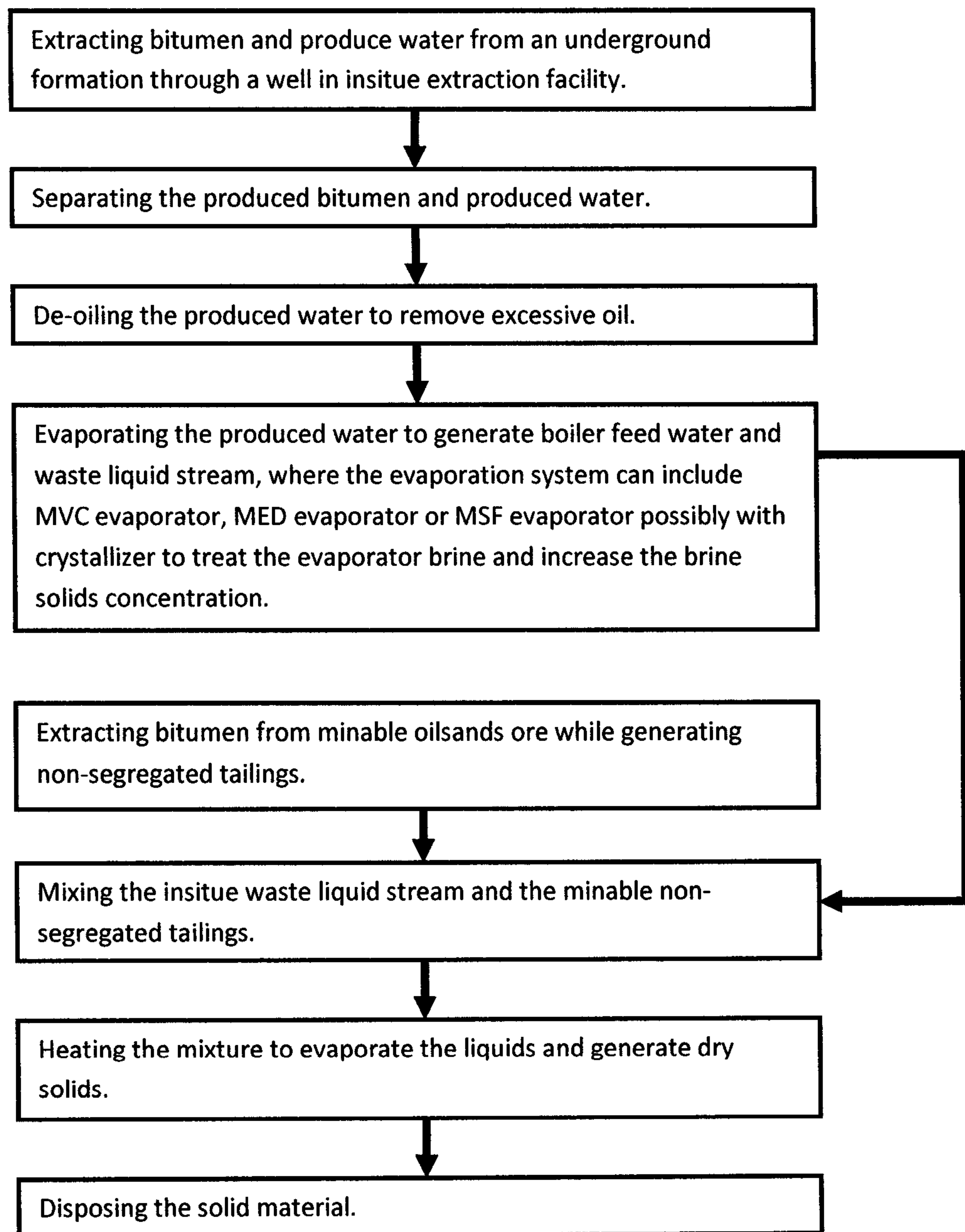


FIG. 4

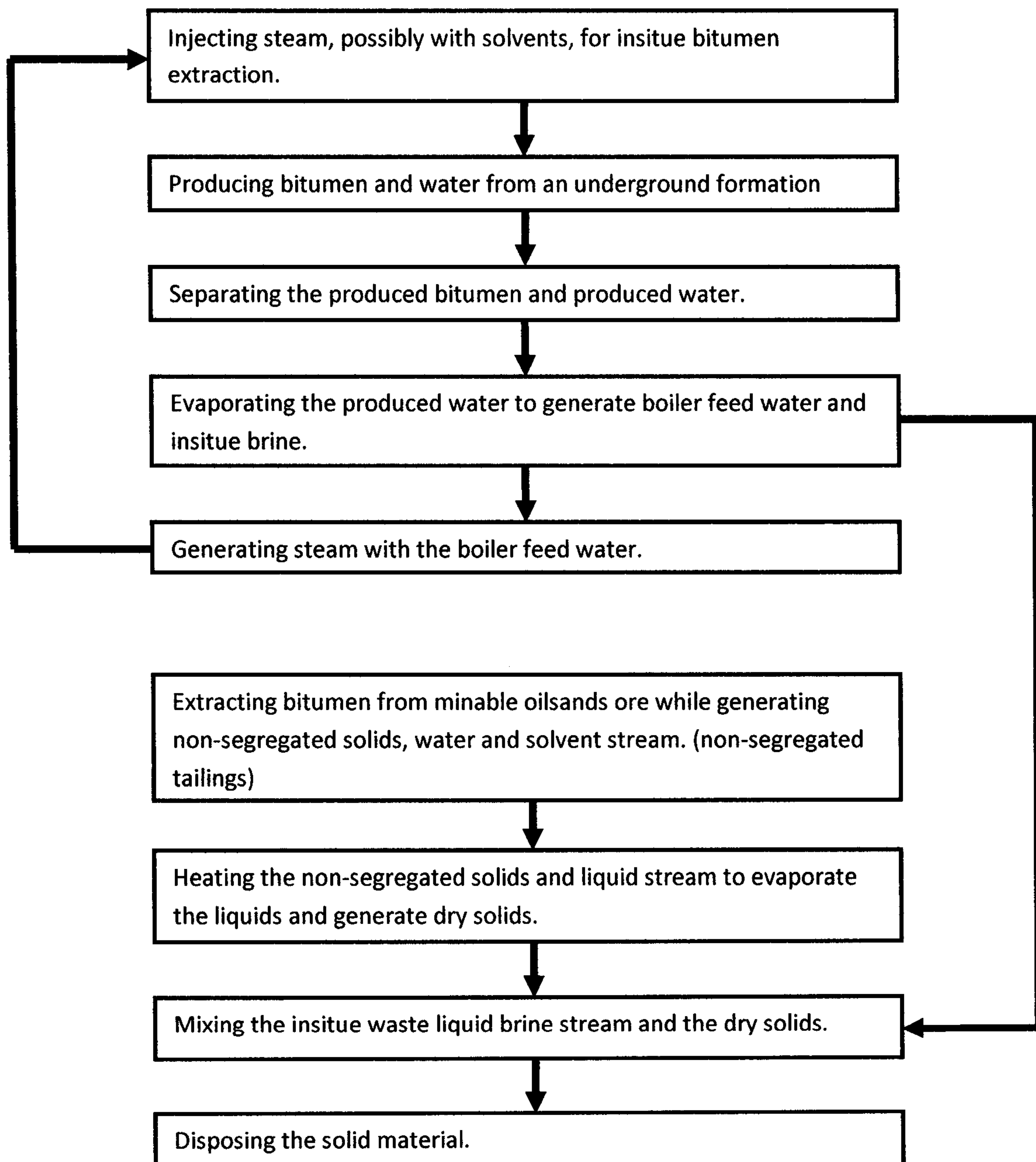


FIG. 5

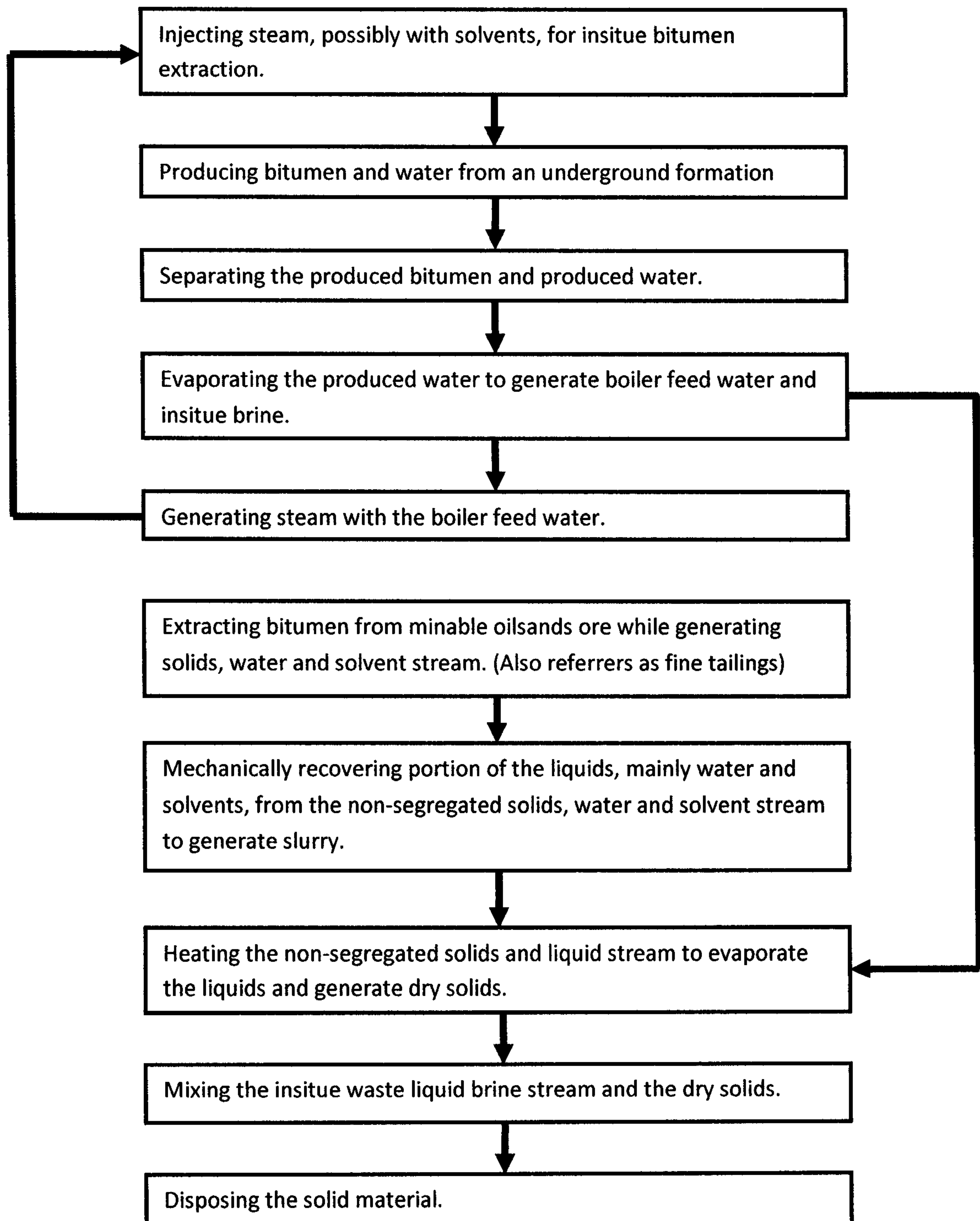


FIG. 6

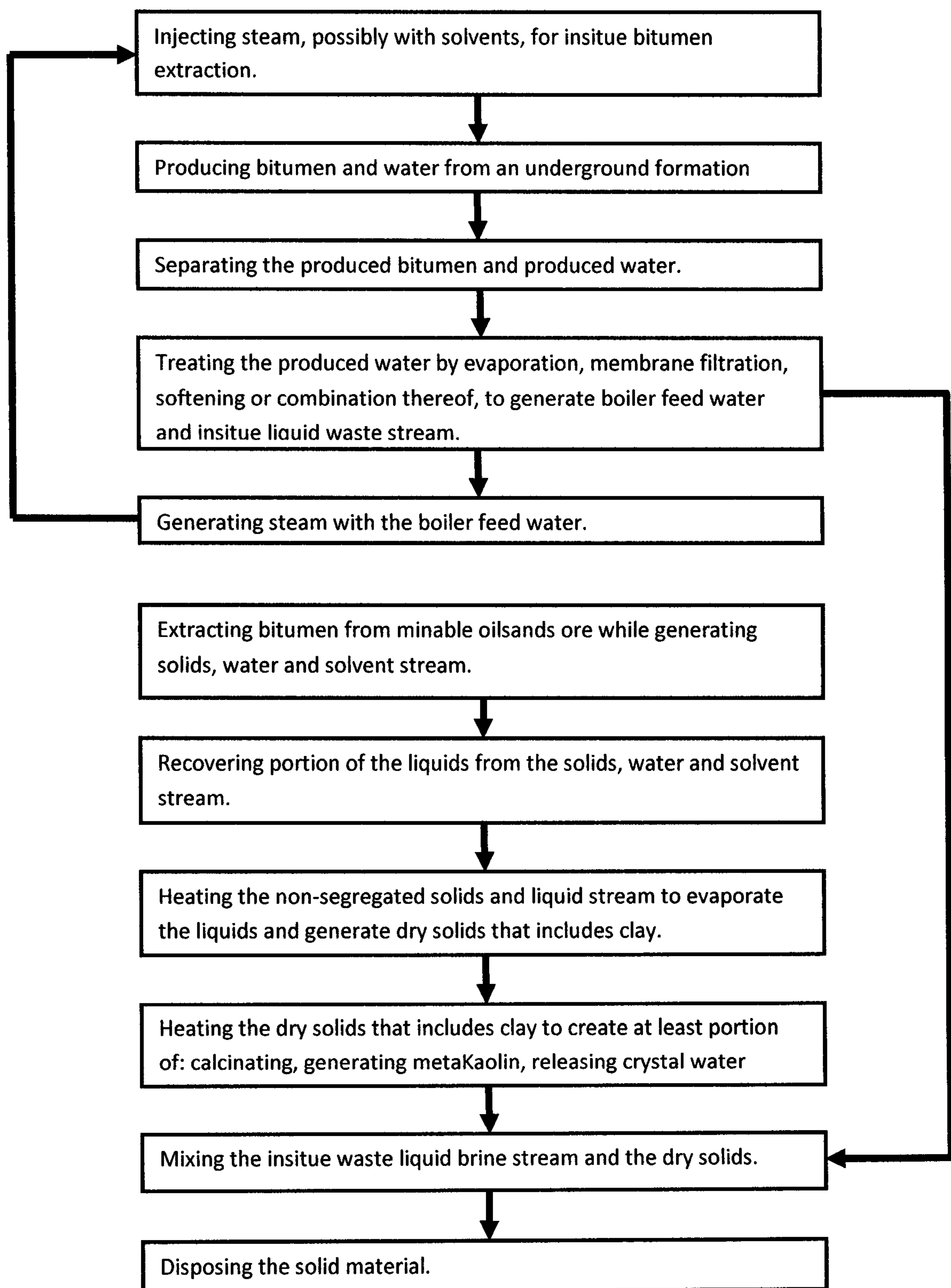


FIG. 7

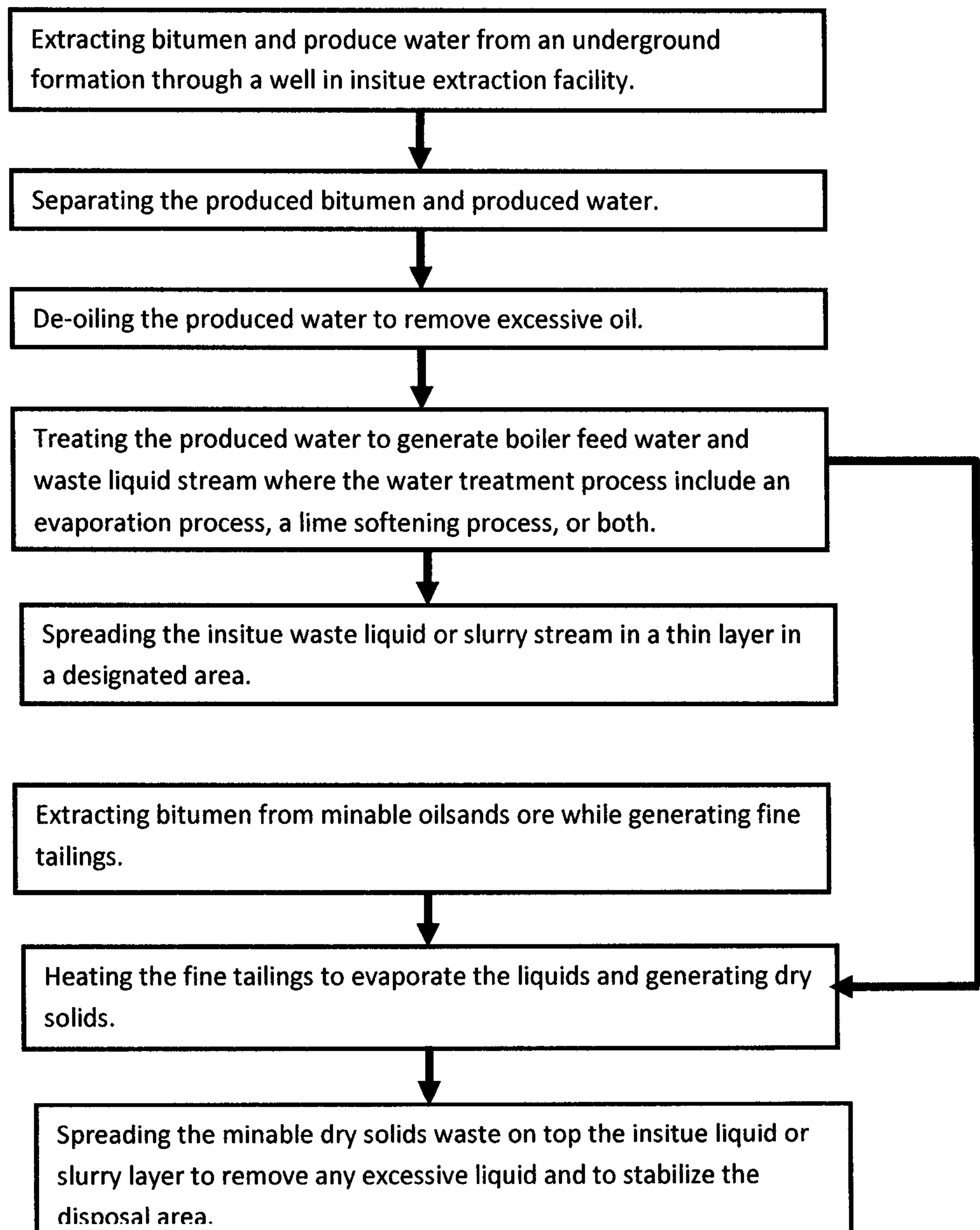
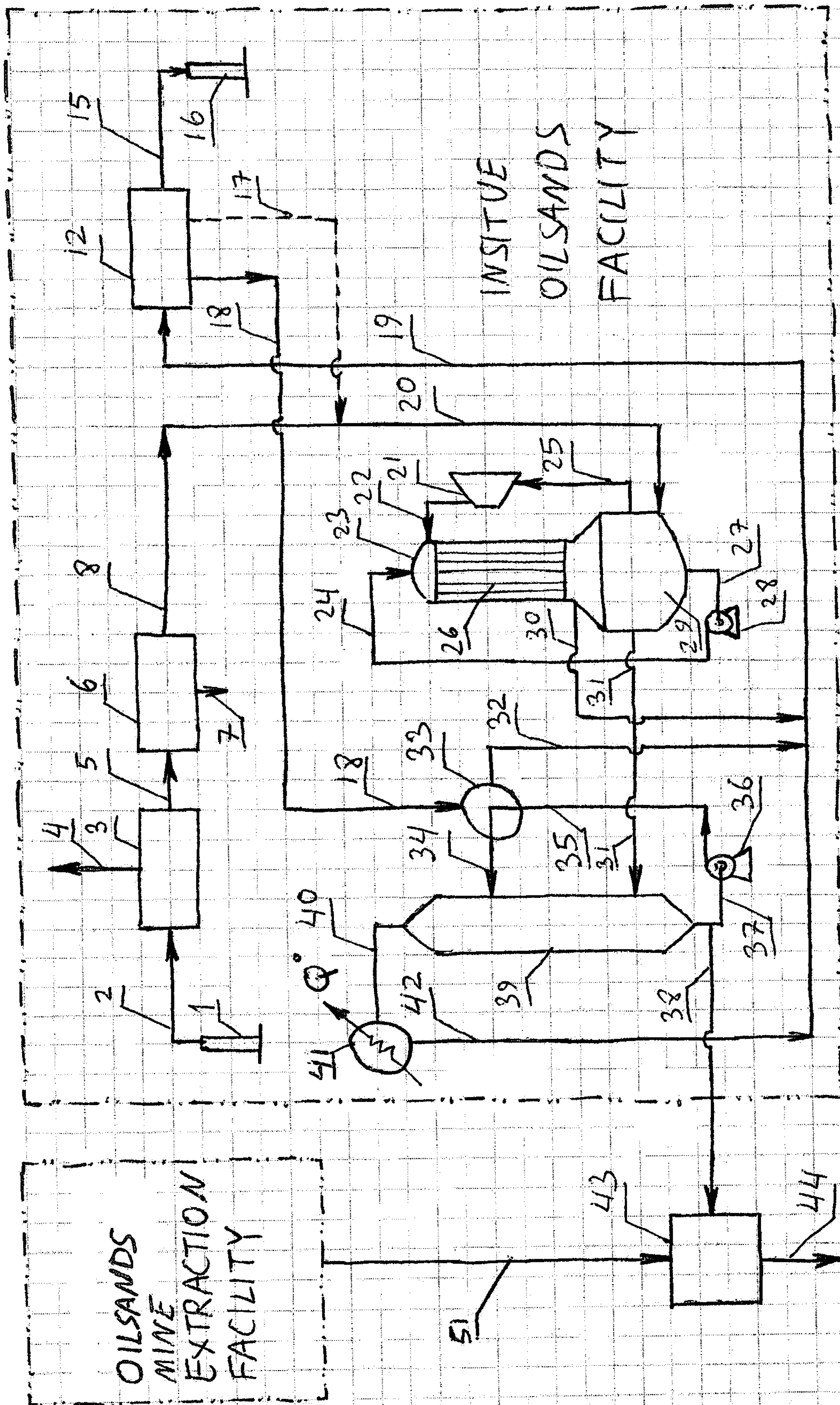


FIG. 8



915.

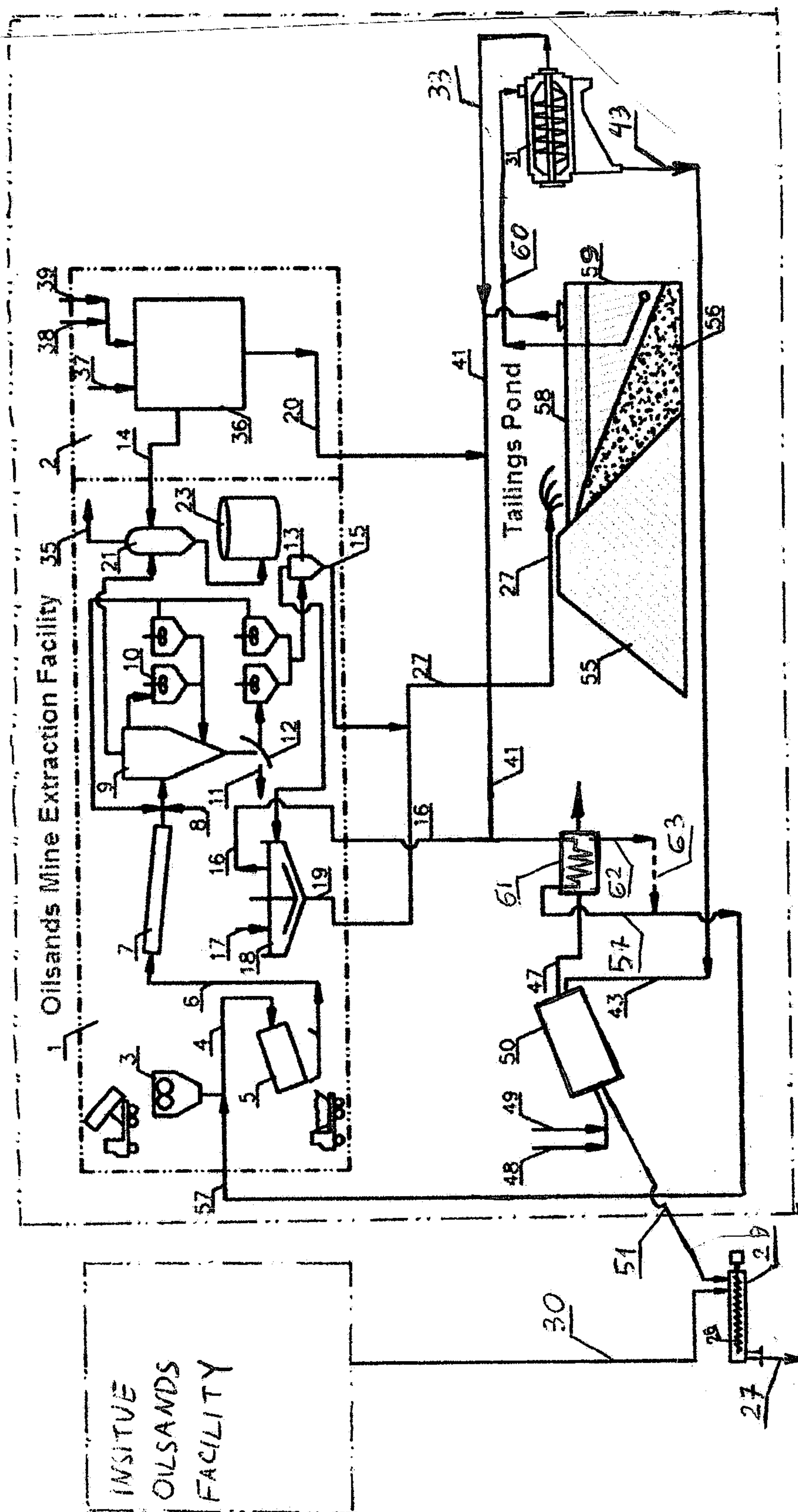


FIG. 10

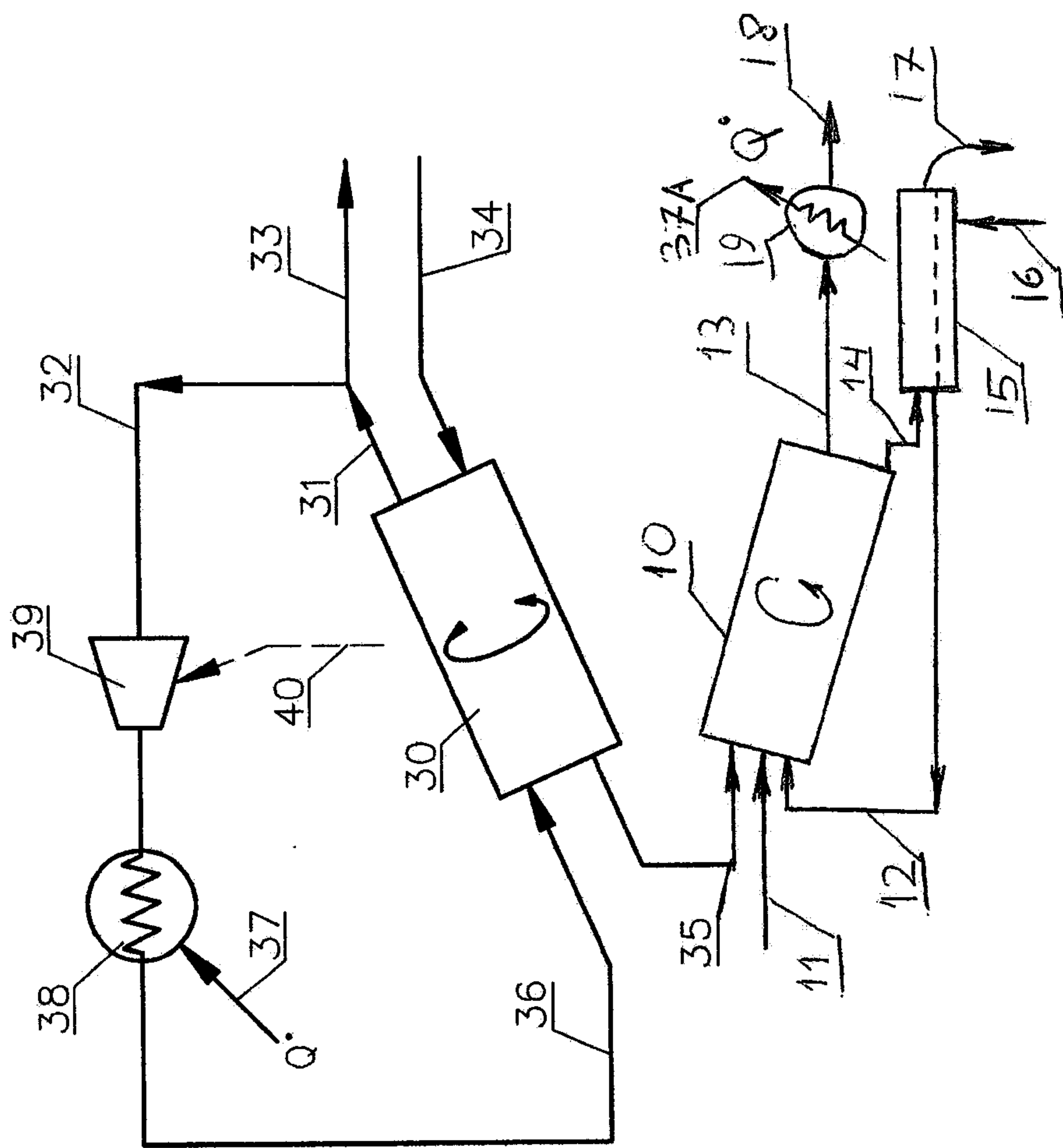


FIG. 11

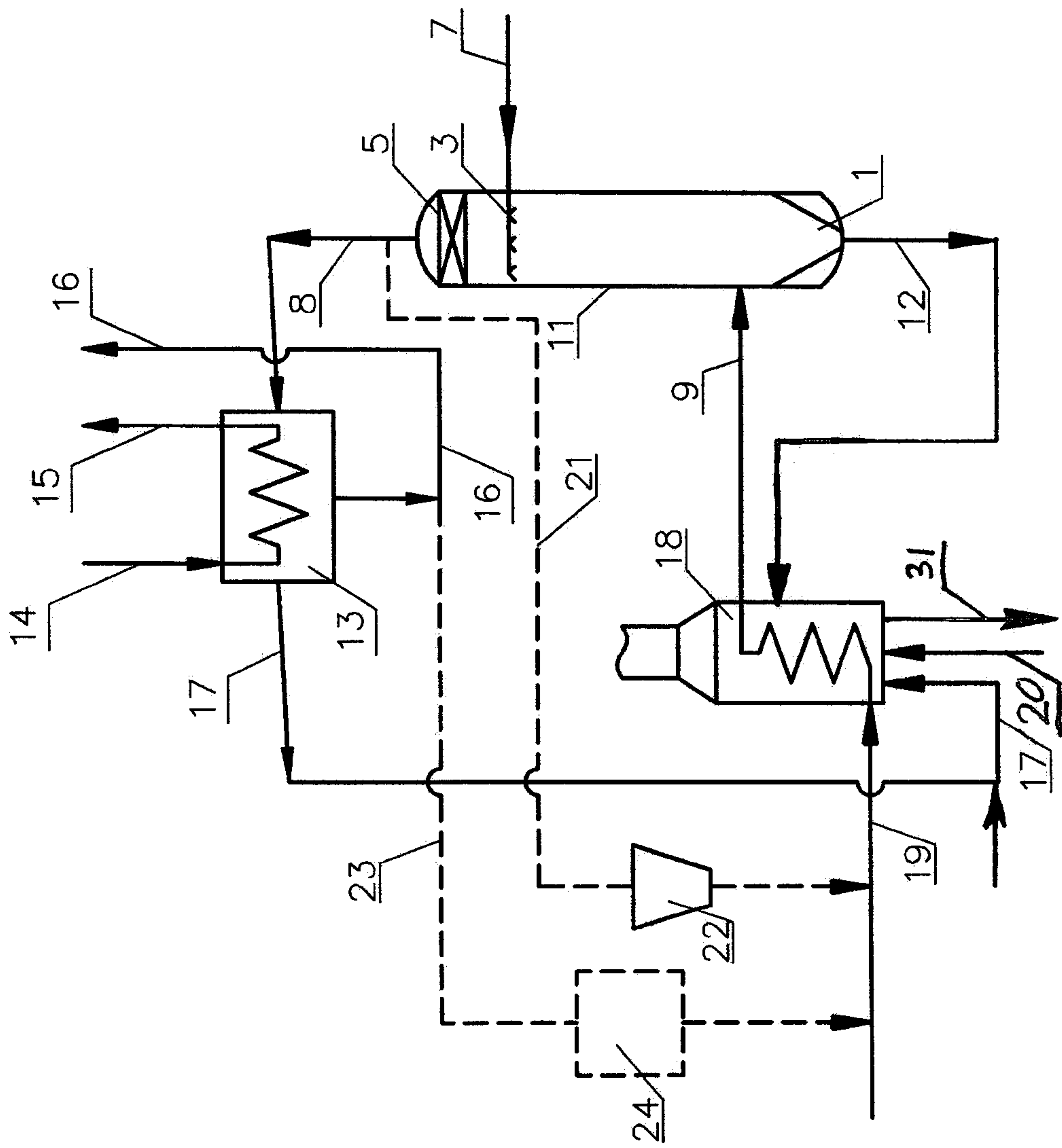


FIG. 12

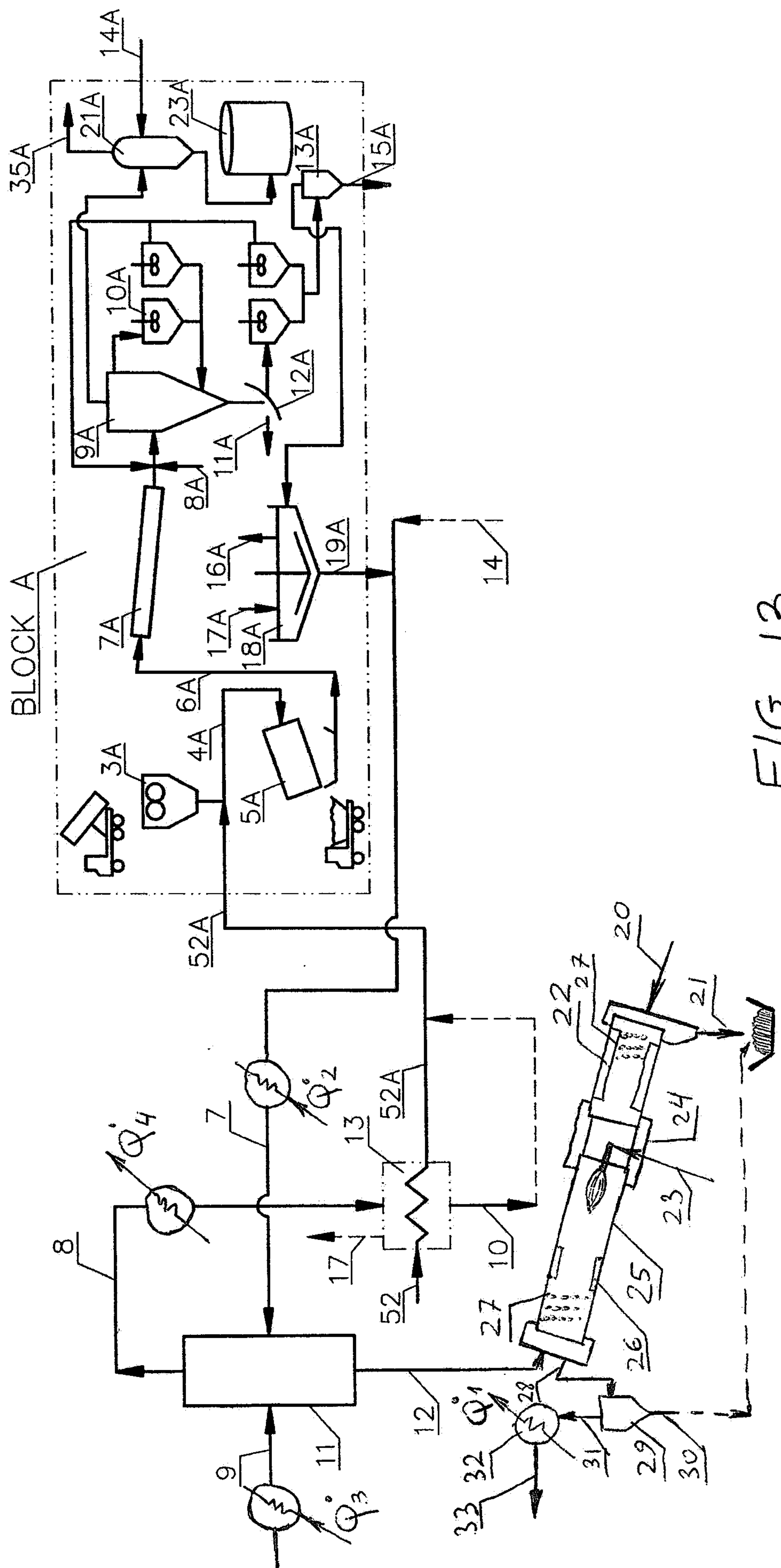


FIG. 13

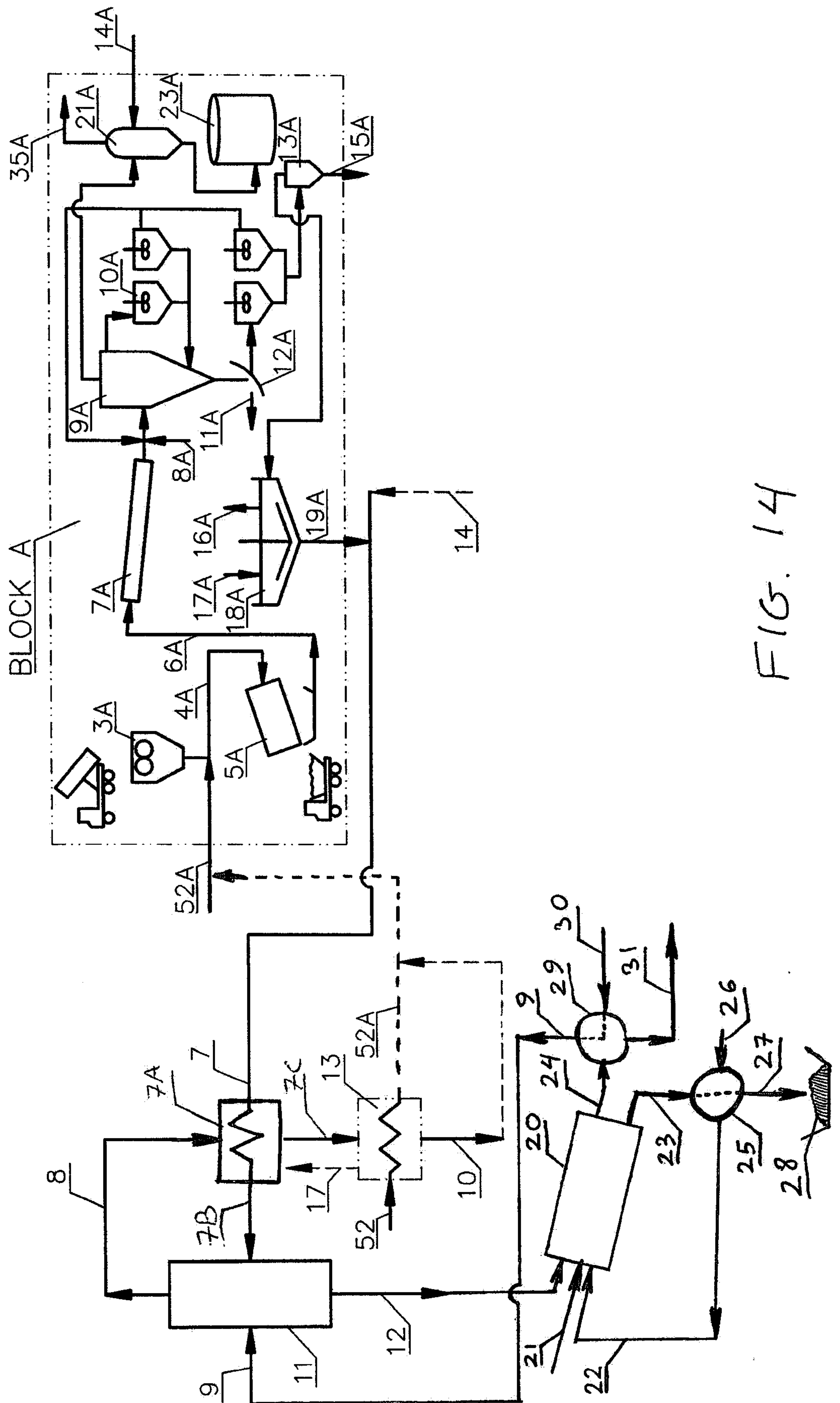


FIG. 14

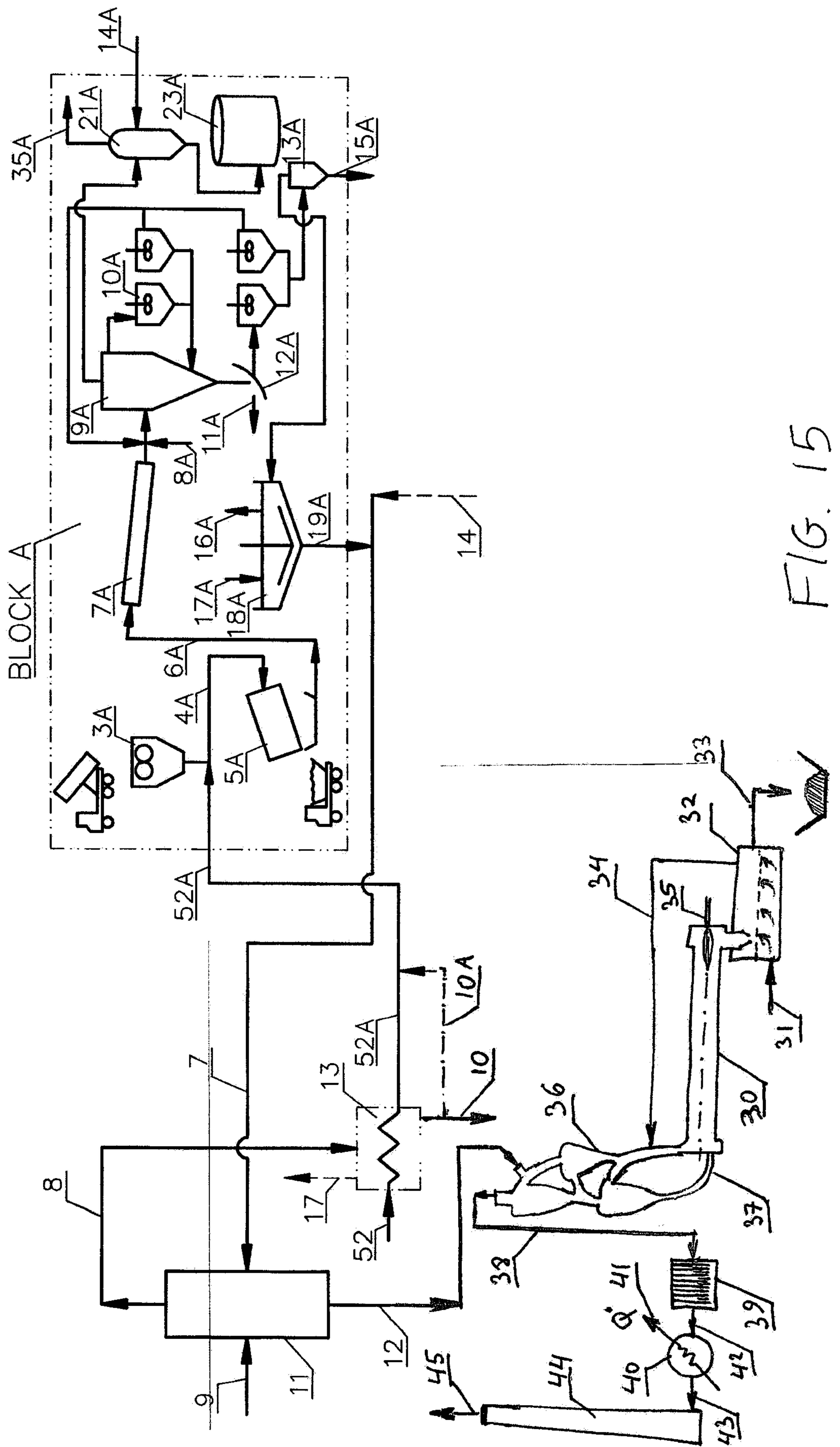


FIG. 15

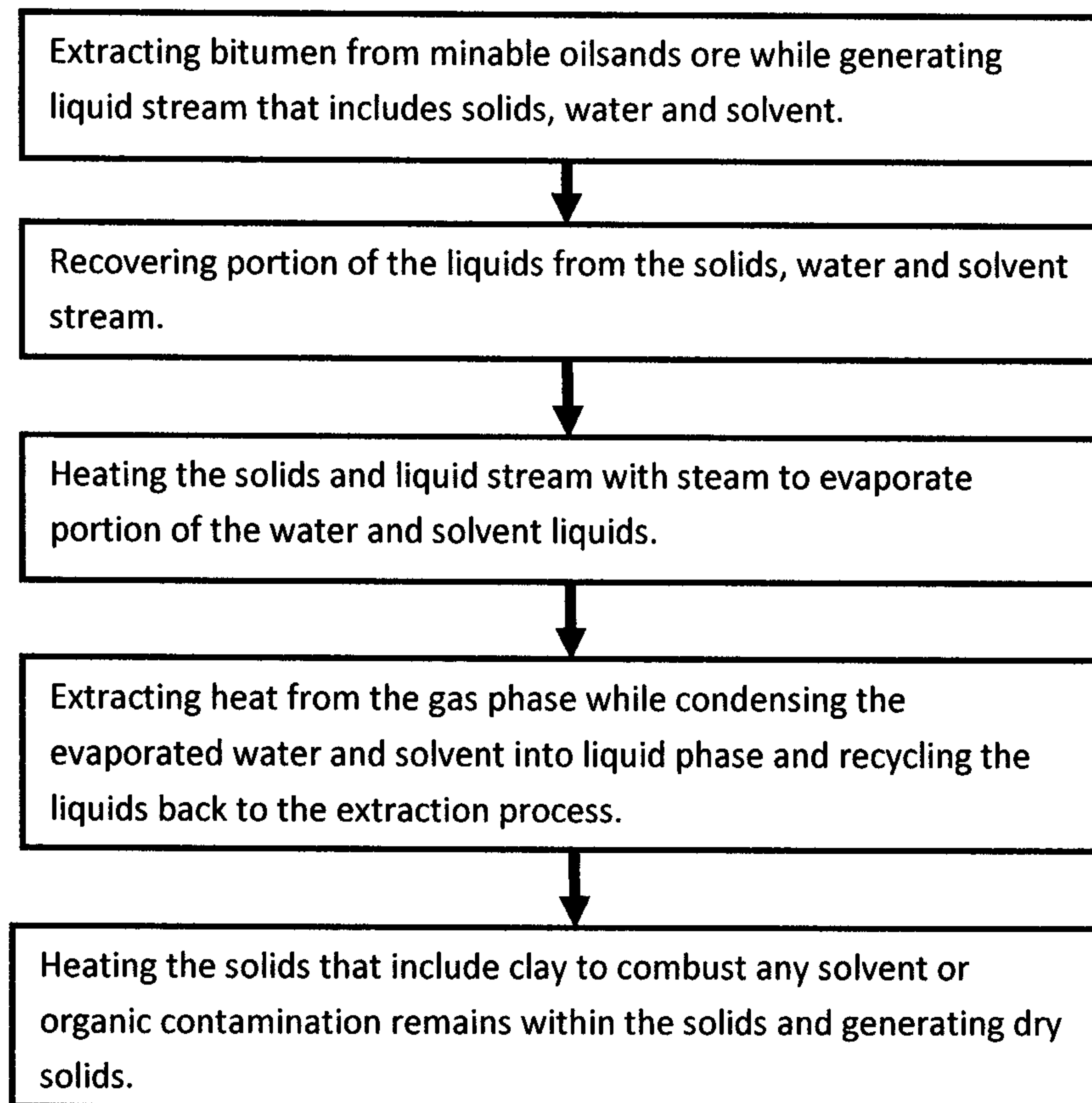


FIG. A1

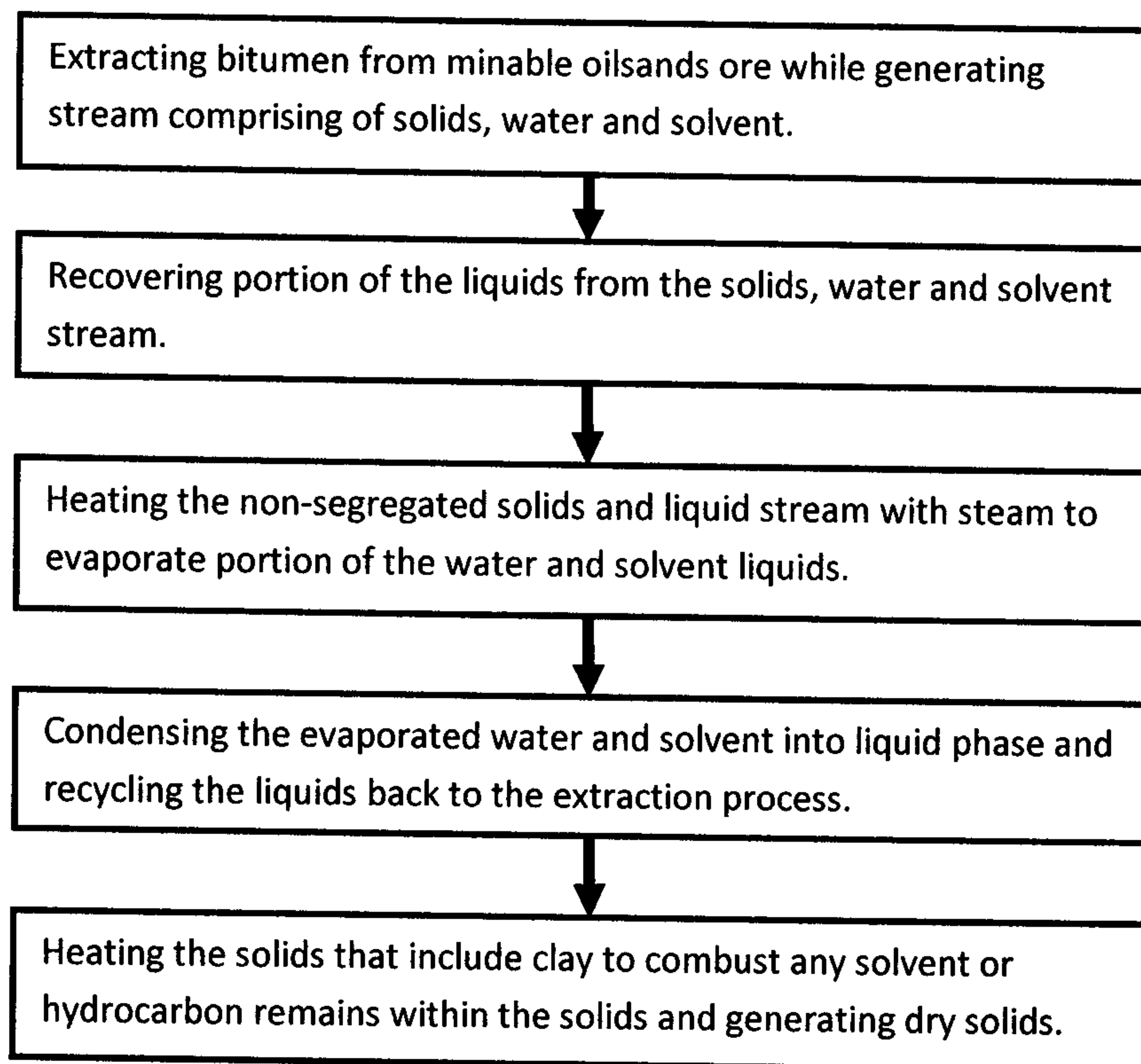


FIG. A2

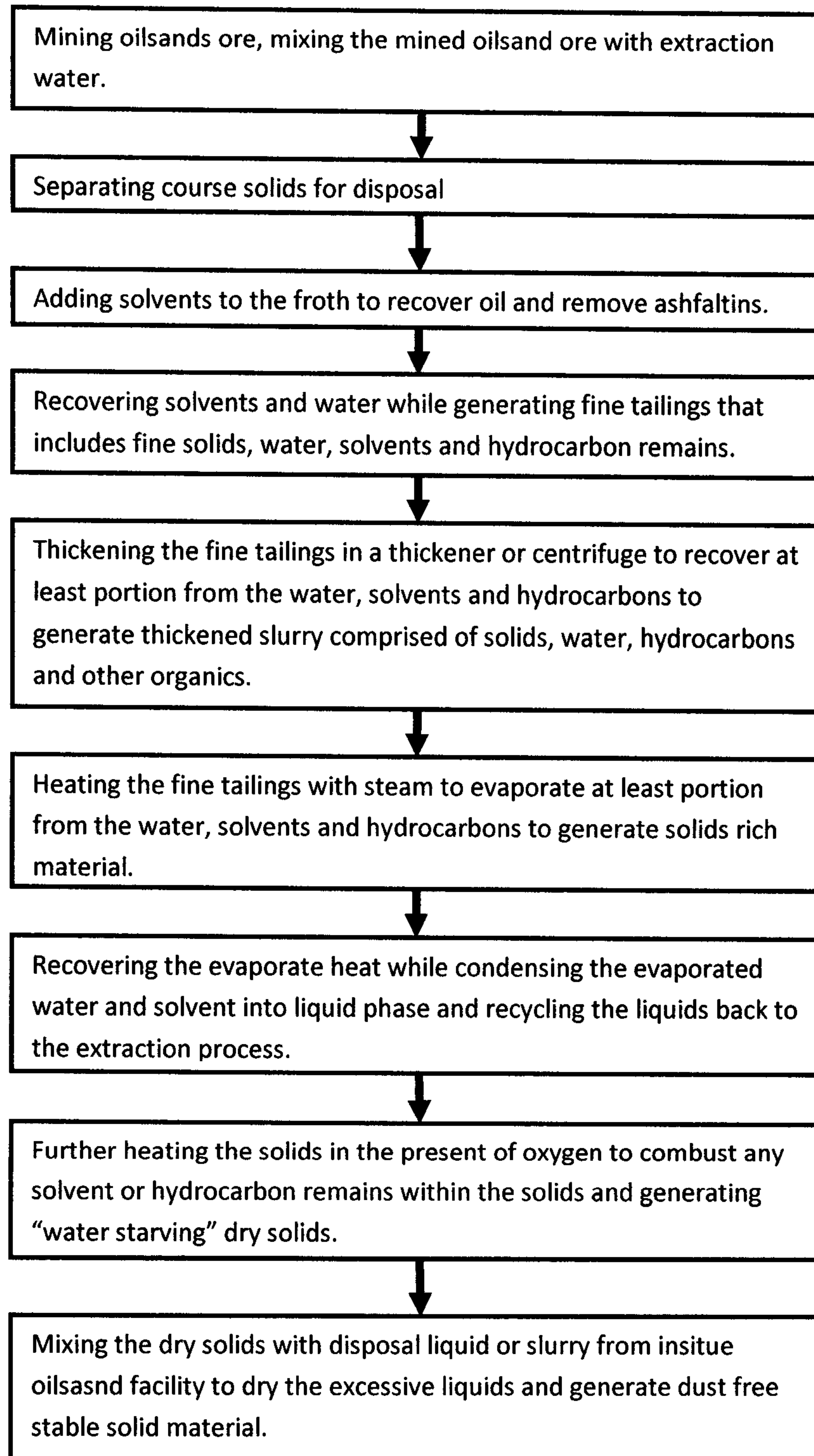


FIG. A3

Injecting steam into underground formation.



Recovering bitumen and produce water from the underground formation.



Treating the produced water in an evaporator to generate distilled water for steam generation and waste stream with high levels of dissolve solids for disposal.



Extracting bitumen from minable oilsands facility with liquid water and solvents while generating stream of non-segregate fine tailings with suspended solids, mostly clays.



Heating the liquid tailings to generate dry solids and recover the water and solvents.



Mixing the liquid waste stream with high levels of dissolve solids and the dry solids, mainly clays to generate a stable solid material.



Disposing the solid material.