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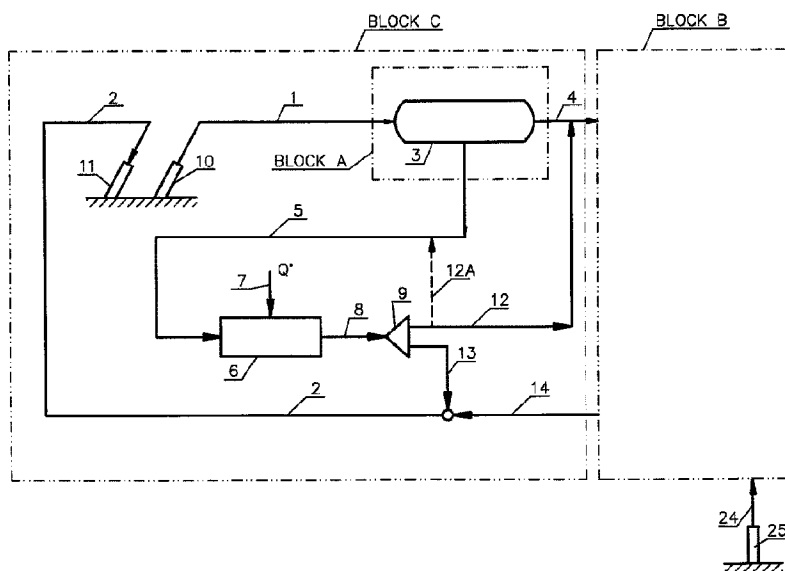
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(54) Titre : SYSTEME DE GENERATION DE VAPEUR A CONTACT INDIRECT

(54) Title: NON-DIRECT CONTACT STEAM GENERATION



(57) Abrégé/Abstract:

The present invention is a system and method for steam production for oil production. The method includes generating hot driving fluid, indirectly using the hot driving fluid to heat water containing solids and organics, separating solids, and using the steam for generating hot process water or for underground injection. The system includes a non- direct contact heat exchanger connected to a separator for collecting and separating the solids from the gas. The water feed of the present invention can be water separated from produced oil and/or low quality water salvaged from industrial plants, such as refineries and tailings from an oilsands mine.

ABSTRACT OF THE DISCLOSURE

The present invention is a system and method for steam production for oil production. The method includes generating hot driving fluid, indirectly using the hot driving fluid to heat water containing solids and organics, separating solids, and using the steam for generating hot process water or for underground injection. The system includes a non- direct contact heat exchanger connected to a separator for collecting and separating the solids from the gas. The water feed of the present invention can be water separated from produced oil and/or low quality water salvaged from industrial plants, such as refineries and tailings from an oilsands mine.

Non-Direct Contact Steam Generation

BACKGROUND OF THE INVENTION

Field of the Invention

[01] This application relates to a system and method for producing steam from contaminated water feed to recover oil. This invention further relates to processes and systems for indirectly using hot fluid heat energy for generating additional steam from contaminated water, and using this produced steam for various applications in the oil industry, and possibly in other industries. The produced steam can be used to generate hot process water in the mining oilsands industry. It can also be used for underground injection for Enhanced Oil Recovery. The drive hot fluid, like steam, is generated using a commercially available, non-direct heater, steam boiler, co-gen, OTSG, or any other standard heater or steam generation system. Contaminates, like suspended or dissolved solids within the low quality water feed, can be removed in a stable solid (Zero Liquid Discharge) system.

[02] This application presents a system and method for generating steam at a controllable pressure with solids waste removal. The current application is using a non-direct heat transfer to the contaminate water (like fine tailings). This is done indirectly, through a metal wall that is heated with a heating fluid (preferably steam, however thermal oil or combustion gas can be used as well). The current application also describes a system to indirectly generate the steam from the contaminate water by transferring the water within the tailings into steam, using the heat and the water with in the steam to generate hot water, and using the hot water for oilsands extraction. The ability to use the driving hot fluid, such as steam, indirectly through a heat exchanger is a significant advantage as the heating steam can be recycled back as the heating fluid in a closed system. The heating fluid can be any type of fluid capable of transferring thermal heat energy as there is no mixture between the thermal driving fluid and the tailings. The focus of the current invention is on the use of FT (Fine Tailings) or MFT (Mature Fine Tailings) from an open mine oilsands extraction facility to generate hot process water and solid waste. However, it can be applied to other processes as well, for example, the use of water treatment sludge waste from water softening facilities, or other wet streams with large solid contamination content. The driving steam is generated by a commercially available, non-direct steam generation facility. The driving steam is indirectly used to transfer liquid water into steam and solid waste. The current invention also suggests a system and apparatus to generate the steam and solids from the contaminate tailings. The system includes a longitude heated enclosure with a mechanical means to transfer the generated solids and slurry within the enclosure, and to prevent solids build-up and subsequent fouling within the enclosure. The system can further include a collector to collect and separate the produced steam and solids, possibly from plurality of longitude steam generated enclosures connected to a common separator.

[03] The steam can be generated by a standard, commercially available industrial (package) boiler or can be provided directly from a power station. The most suitable steam will be a medium pressure steam, as would be typically used for heating purposes. A cost efficient, hence effective, system would be to employ a high pressure steam turbine to generate electricity. The discharge steam from the turbine, at a lower pressure, can be effective as a driving heating steam. Due to the fact that

the first stage turbine, which is the smallest size turbine, produces most of the power (due to a higher pressure), the cost per Megawatt of the steam turbine will be relatively low. The efficiency of the system will not be affected as the discharged steam will be used to drive the water out from the fine tailings, or other sludge, through a heat exchanger with means to mobilize the solids, as described in this application.

[04] During the generation of steam from a highly contaminated liquid feed, like tailings, the mechanical property of the liquid feed changes with the heat transfer and the conversion of the water into vapor, increasing the solid content (like the clay and sand when FT or MFT is used) to produce a solid waste that can be easily disposed of and that can support traffic. The vapor water and heat is used to generate the extraction hot water. In this process, the MFT properties are changing from a liquid phase to a thick paste phase and eventually to stable solids. This phase change, the changing heat transfer coefficient through the metal wall combined with the presence of clay and abrasive sand and oil contaminates make the final stage of the non-direct contact heat transfer very challenging. This invention will also suggest a system to introduce mechanical energy to the heat transfer volume while allowing an effective heat transfer area and an effective system arrangement, including an effective arrangement for combining such units into a single, maintainable system. The system includes the collection of the steam generators discharge and the solids separation from the steam.

[05] The driving steam is generated in a Non-Direct Steam Generator (like a steam boiler with a steam drum and a mud drum), or "Once-Through Steam Generator" (OTSG) COGEN that uses the heat from a gas turbine to generate steam, or any other available design. The heat transfer and combustion gases are not mixed and the heat transfer is done through a wall (typically a metal wall), where the pressure of the generated steam is higher than the pressure of the combustion. This allows for the use of atmospheric combustion pressure. The product is pure steam (or a steam and water mixture, as in the case of the OTSG) without combustion gases.

[06] There are several applicable patents and disclosures issued in the field of the present invention. US patent No. 7,591,309 issued to Minnich et al. on September 22, 2009 describes the use of steam for operating a pressurized evaporation facility where the pressurized vapor steam is injected into an underground formation for EOR. The steam heats the brine water which is boiled to generate additional steam. To prevent the generation of solids in the pressurized evaporator, the internal surfaces are kept wet by liquid water and the water is pre-treated to prevent solid build up. The concentrated brine is discharged for disposal or for further treatment in a separate crystallizing facility to achieve a Zero Liquid Discharge (ZLD) system.

[07] Canadian patent application 2,677,479 by Spiers et al describes a drying process for tailings. The tailings are dried in a dryer where the tailings water is converted to steam. The generated steam is condensed and its heat is used to pre-heat the tailings. Make-up Steam is also used to dry the tailings. The liquid water extracted from the tailings is used in the extraction facility.

[08] This invention's method and system for indirectly generating steam from fine tailings for extraction of heavy bitumen includes the steps as described in the patent figures and their descriptions.

[09] The advantages and objectives of the present invention are described in the patent application and in the attached figures and their descriptions.

[10] These and other objectives and advantages of the present invention will become apparent from a reading of the attached specifications and appended claims.

SUMMARY OF THE INVENTION

[11] The method and system of the present invention is for steam production for extraction of heavy bitumen by using fine tailings in a non-direct steam generation process. The produced water vapor is further used as part of an above ground oil extraction facility or for an underground formation. The method includes the following steps: (1) Generating hot fluid stream, like a steam stream; (2) Using the heat to indirectly evaporate liquid water with significant levels of solids, oil contamination and other contaminants (like tailings) without mixing the steam gas with the liquid water; (3) Indirectly converting the liquid phase water into gas phase steam and solids contaminants; (4) Removing the solid contaminants that were supplied with the water for disposal or further treatment; (6) Using the generated steam for directly or indirectly heating process water for an above ground oilsands mine or using the produced steam for injection into an underground oil formation through a SAGD or CSS steam injection well.

[12] In another embodiment, the invention can include a non-direct contact steam generation system from fine tailings comprising: (1) a longitude enclosure with heated wall; (2) The heated wall is heated with the use of steam with steam supply line and condensate recovery line. (3) The enclosure length is at least twice longer than its diameter; (4) The enclosure includes mechanical moving internals, preferably longitude rotating internals, capable of mobilizing solids from heat transfer areas and mobilizing solids through the enclosure to the discharge.

[13] In another embodiment, the enclosure is connected to a separation unit, capable of separating the generated steam from the solids, where the separation unit includes any commercially available separation unit, like a cyclone, centrifugal, mesh, electrostatic, or combinations of different units.

[14] In another embodiment, several enclosures are connected to a common collector unit that separates the solids and slurry from the gas phase. Several efficient horizontal and vertical arrangements are disclosed.

[15] The system and method's different aspects of the present invention are clear from the following drawing descriptions describing the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[16] FIGURE 1, 1A, 1B,1C, 1D, 1F, 1G, 1H, 1I, 1J and 1K show the conceptual flowchart of the method and the system of the presented invention.

[17] FIGURE 2A describes the prior art for generating the hot process water used for oilsands extraction. Steam 2 is used in commercially available heat exchanger 1 to heat the process water 4. Many types of shell and tube or any other commercially available heat exchangers can be used. The steam condensate 3, after its heat was recovered to heat the process water, is recycled and used again in the boilers for generating additional steam. The process water 4 is heated through heat exchanger 1 to generate the hot extraction process water 5, typically at temperatures in the range of 70-90 C. The hot extraction water is mixed with the oilsands to generate slurry and separate the oil from the sand.

[18] FIGURE 2B describes the proposed method for indirectly generating the hot process water for oilsands extraction. Similar to the prior art, steam 11 is used to provide the heat energy to drive the process. The steam condensate 12 is recycled back to the boiler in a closed system. Fine tailings stream 13 is heated indirectly by the steam 11 up to the stage it is transferred to a solid material and gas phase that contains mainly steam, as well as other hydrocarbons, like solvents, and non-condensed gas components 15. The solids 17 are removed from the gas phase 18 at separator 16. The water vapor 18 is condensed while heating process water 14 to generate hot extraction water 20. The hot extraction water 20 is further mixed with the mined oilsands. The solids 17 can be separated from the gas phase in slurry form that includes a controlled amount of water. The solids along with their water content are at a high temperature close to the produced steam 18 temperature. The hot solids and the water they contain are mixed with air 9 in a mixture 8. There are commercially available mixing machines that can be used to generate the mixture between the solids rich slurry and the air 9. The heat within flow 17 is used to evaporate additional water to the air flow 9. Due to the partial evaporation pressure in the air (the partial water vapor pressure in comparison to the other gases in the air, like nitrogen) additional water will evaporate to the air while reducing the temperature of the solids and the remaining humidity within the solids. The humid air 5 is separated from the remaining solids 4 and released to the atmosphere (possibly after dust removal). The cooled solids from the fine tailings or the mature fine tailings 4, with a controlled amount of moisture to prevent dust, is tracked 3 back to the mine and used as back-fill where it can support traffic. The indirect heating of the fine tailings is with the use of heat exchanger 10. The heat exchanger may be highly susceptible to fouling, or the accumulation of solid material along its inner surfaces. Accordingly, in one embodiment of the invention, the heat exchanger is a spiral heat exchanger (such as those designed by Tranton, Germany). The spiral heat exchanger is less susceptible to fouling and, in case fouling occurs, it is much easier to clean by the plant operators crew with less down time. In another embodiment, Self-cleaning heat exchange technology can be applied in most spiral heat exchangers with any self cleaning technology known in the art. The fouling prone fluid flows inside the spiral with solid particles that are producing a scouring action on the walls of the spiral partitions as they travel. A distribution system in the inlet spiral feed chamber provides a uniform distribution of the cleaning particles into the spiral. The particles are carried to a separator where they separated from the liquid and are recycled in a controllable way back to the spiral heat exchanger inlet. However, other heat exchangers capable of indirect transfer of heat from either a liquid or gaseous substance to a fine tailings or to a SAGD produced fluid with water, solvents, bitumen, solids, gas and any other contaminants may be used. Accordingly, in another embodiment of the invention, the heat exchanger is a self-cleaning heat exchanger of any self cleaning technology known in the art; for example, self cleaning circulating fluidized bed exchangers designed by Klaren BV, Holland. Self-cleaning heat exchange technology can be applied in most vertically oriented shell and tube exchangers. Examples include circulating scraping devices, turbulence inducing or heat exchangers with an on-line cleaning design (using circulating balls), etc.

[19] FIGURE 3 describes the proposed method for indirectly generating the hot process water for oilsands extraction. Steam 12 is used to provide the heat energy to drive the process. The steam condensate 5 is recycled back to the boiler in a closed system (not shown). Fine tailing stream 7 is heated indirectly by the steam and the condensate in two stages. In the first stage 6, defined as pre-heating, the MFT is heated without a phase change. The heated tailings 9 are still in a liquid phase. Steam is supplied to a non-direct contact steam generator 10, where the heat energy of the condensing steam 12 is used to evaporate the tailings to generate steam (water vapor) and solid waste. Mechanical energy is introduced to the tailings during the process 10. One example of a system to perform the process in unit 10 is described in Figure 4. The solid discharge 15 is separated from the gas flow 13 and

tracked back to a landfill location. The solid lean gas flow 16 mainly contains steam from the tailings water that were evaporated and which are used for heating the process water 4 to generate hot extraction process water 3 by direct or non-direct heat exchange 17. Any contamination NCG (non condensing gas) 18, like light hydrocarbons resulting from hydrocarbons and solvent within the tailing feed 7, are separated. They can be further combusted as a fuel source in a boiler (not shown). The hot process water is mixed with oilsands ore to generate slurry and separate the oil from the sand and clay.

[20] FIGURE 4 shows a non-direct tailings steam generation system. Fine tailings 6, like MFT, are fed into a non-direct contact steam generator 1 that includes a heat exchanger in the form of a longitudinal externally heated pipe 2. The external wall of the pipe 2 is continually heated, preferably with steam 7, to generate heat flow to the internal volume of the pipe that is sufficient to evaporate the water within the tailings 6. The driving steam 7 condensate 8 is recycled, possibly after recovering its heat through a heat exchanger to pre-heat the tailings or for other purposes, back to the boiler to generate additional driving steam 7 (not shown). The driving steam 7 can be replaced with other methods of heating pipe 2, such as thermal oil. Pipe 2 includes internal rotating element 9 to provide mechanical energy into the tailings, especially into the dried tailings close to the discharge end. The mechanical mixing energy is designed to mobilize the solids within pipe enclosure 2, increase the heat exchange efficiency with the slurry, and clean the surface of the tube to increase the heat transfer efficiency. The rotating element 9 can include screws, scoops or any commercially available rotating internals. Two rotating screws 13 and 14 can be used as well, where, due to the rotating movement, the screws will clean each other while mixing and mobilizing the slurry and solids. To enhance the heat exchange to the tailings, the heat exchanger is extended in the longitudinal direction where the length L is at least twice the diameter D.

[21] FIGURE 4A shows a non-direct, tailings steam generating system. Fine tailings 6, like MFT, are fed into a non-direct contact steam generator 1 that includes a heat exchanger in the form of a longitudinal externally heated pipe 2. System 1 is described in Figure 4. The discharge from the steam generator 1 is fed into a separator 10. The solids are collected at the bottom of the separator and discharged through discharge hopper 13 to reduce the discharge pressure through double valves 12 and 14. The system can include additional separation units to separate fine solid particles. This can include one or more internal cyclones 11 to separate carry-on solid particles from the gas flow. External separation units, like external cyclones 17, can be used as well. The produced solids lean stream 20 is used as a water and heat source to generate the hot extraction process water.

[22] FIGURE 4B shows a non-direct, tailings steam generating system with melted salt as heat transfer medium instead of steam. Figure 4B is substantially similar to Figure 4A but where the heat source is melted salt 2. The melted salt is continually circulated where hot salt 7 is supplied to the system with the colder salt 8, after heat energy is used to generate steam from liquid feed 6. The use of melted salt bath enclosure 1 has the advantage that the pressure in the heated enclosure 1 is much lower than with the use of steam as the heating fluid, with good heat transfer coefficient.

[23] FIGURE 5 shows the vertical arrangement of non-direct contact longitude steam generators and a center collector / separator for the produced gas and solids. The longitude steam generator is described in Figure 4. Driving steam 12 is used to evaporate the fine tailings 13 and convert it into steam and solids. The solids are removed with the help of mechanical rotating energy 15 to transfer the solids to the center collector 16. Several longitude steam generators are arranged on top of each other where their discharge is collected by a collector 16. The collector has a gas (steam) discharge outlet 17 at its

upper section and solids discharge 20 at its lower section. The lower section can include a cone to reduce the solids discharge diameter. The collecting container 16 can include an apparatus to remove solids deposits (not shown). Such an apparatus can move through the longitude axis and use mechanical energy or pressurized fluid to clean vessel 16 walls.

[24] FIGURE 5A shows the horizontal arrangement of non-direct contact longitude steam generators and a center collector / separator for the produced gas and solids. The longitude steam generator is described in Figure 4. Driving steam 12 is used to evaporate the fine tailings 13 and convert it into steam and solids. The solids inside the steam generator 2 are mobilized with the help of mechanical rotating energy 15 to transfer the solids to the center collector 16 and remove any fouling from the heat transfer wall of the steam generator. Several longitude steam generators 1 and 2, and possibly 3, 4 and 5, can be arranged with their discharge connected to centralized collector 16. The longitude steam generators 1 and 2 can be arranged from both sides of the collector 16. Additional steam generators can be added also from additional directions of the centralized collector 16, like 3, 4 and 5. The collector has a gas (steam) discharge outlet 17 at its upper section and solids discharge outlet 20 at its lower section. The collecting container 16 can include an apparatus 22 to remove solids deposits from the collecting enclosure 16. This apparatus 22 is capable of moving inside enclosure 16, close to its wall and scraping deposits, possibly with a rotating movement and with the help of a pressurized fluid. Another option is to add an internally rotating element inside enclosure 16 that will mobilize solids and slurry to the bottom discharge (not shown). The solids 20 are discharged through outlet 19.

[25] FIGURE 5B shows an arrangement of non-direct contact longitude steam generators inside a common heating steam enclosure with a common collector / separator for the produced gas and solids. The structure of each longitude steam generator 34 is described in Figure 4, with the notable difference that the steam generator of Figure 5B does not include the double wall as the heating steam is enclosed in enclosure 30. Driving steam 31 is used to evaporate the fine tailings 32 and convert it into steam and solids. The driving steam condensate is discharged from outlet 29 at the bottom of the heating steam enclosure 35. The solids are removed with the help of mechanical rotating energy 37 to transfer the solids to the center collector 16. Several longitude steam generators are arranged with their discharge connected to the discharge collector side 42. The discharge collector has a gas (steam) discharge outlet 41 at its upper section and solids discharge outlet 40 at its lower section. The discharge collector 42 can include an apparatus to remove solids deposits (not shown). A single heating steam enclosure 35 heats multiple longitude steam generators 34. The driving steam 31 and the produced steam generated from the tailings 32 are separated and can be at a different pressures due to the separation between the heating enclosure 35 and the discharge cover 42. Typically, the pressure of the driving steam in enclosure 35 is higher than the pressure on the discharge side 42.

[26] FIGURE 6 is a schematic view of the invention, with an open mine oilsands extraction facility, where the hot process water for the ore preparation is generated from condensing the steam produced from the fine tailings. A typical mine and extraction facility is briefly described in block diagram 1 (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 via trucks to an ore preparation facility, where it is crushed in a semi-mobile crusher 3. It is also mixed with hot water 52 in a

rotary breaker 5. Oversized particles are rejected and removed to a 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. Air is injected at 8 to generate an aerated slurry flow. The conditioned aerated slurry flow is fed into the bitumen extraction facility, where it is injected into a Primary Separation Cell 9. To improve 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 floatation 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 froth 100 is directed to a froth treatment plant at BLOCK 7. This process is characterized by the use of different types of hydrocarbon based solvents 101. There are different technologies and different type of solvents in use within the process. During the process most of the solvents are recovered and recycled in the process. Tailings 103 from a tailings solvent recovery unit, commonly identified by the industry as TSRU tailings, are then disposed of. Due to the fact that the solvents helps in removing asphaltins from the froth, the TSRU tailing stream from the froth treatment block 7 includes asphaltins, and fine solids that were introduced with the froth flow, bitumen components, solvents and water remains. The froth treatment tailings 103 are heated in heater 31 where the water and light hydrocarbons evaporate and are separated 37 from the solids, asphaltins, and heavy hydrocarbons fractures, and a pre-designed amount of moisture remains within the solids to prevent dust. 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 tailing water from the oilsands mine facility 1 is disposed of in a tailing pond, described in BLOCK 6. The tailing pond is 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 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 are the Froth Treatment Tailings 103, 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 Albian 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 the tailings pond. The sand separates from the tailing 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 tailings 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 pond 43. MFT (Mature Fine Tailing) 43 is pumped from the lower section of the tailing pond and is then directed to the non-direct contact steam generator (NDCSG) 31. Prior to injection into the non-direct contact steam generator, the fine tailings can be heated in heat exchanger 39. The heat can be supplied from hot tailing streams, like 15, that are sent to the tailings pond. In this case, the tailing stream will be fed as stream 51 into the MFT pre-heating heat exchanger 39 (not shown). Another option is to use the condensate 35 from the NDCSG 31 for pre-heating the MFT. For that option, the condensate 35 will be fed as stream 51 into the pre-heating heat exchanger 39. Heat exchanger 39 can be any available design that can heat thick material like MFT. There are many commercially available heat exchangers; some

include self-cleaning designs that can be used at 39. The fine tailings 33 are fed into the NDCSG 31 where they are heated to a stage where the water evaporates into steam, slurry and solids. The slurry and solids are mobilized with the help of mechanical energy, like a longitude rotating screw 34. However, any available NDCSG that can transfer the MFT to gas and solids can be used as well. Under the heat and pressure conditions inside the NDCSG, the MFT turns into gas and solids, as the water is converted to steam. The solids are recovered at the bottom of the collector / separator 37 in a dry form or in a semi-dry, semi-solid slurry form 51. The semi- dry slurry form is stable enough to be sent back into the oilsands mine without the need for further drying, to support traffic. The water vapor that was generated from heating the fine tailings in the NDCSG is used to heat the extraction facility process water 62. During this process they are also condensed and can be added to the extraction process as well. In unit 60, the water vapors are condensed while the process water 62 is heated, generating hot process water 52 used for the extraction process. Non condensable gas (NCG) 61 can be recovered after the water vapor condenses. The NCG 61 can occur as a result of hydrocarbons and solvents in the tailing feed 43. It can be combusted as an energy source. Another option is to inject the NCG 61 for froth aeration in 8 to replace, at least partly, the used air (not shown). The solvents within the gas phase 38 will be condensed into the process water 62. Light solvents and hydrocarbons components can be recovered from the NCG 61 using commercially available vapour recovery systems and then recycled back to the froth treatment facility at BLOCK 7 where it can be used as solvent. Unit 60 can be arranged directly or indirectly, as described in units 70 and 77. In a non-direct heat exchanger / condenser the produced steam 71 (which is also flow 38), is condensed on the heat exchanger where the cold process water is heated. The condensate 72 and the hot process water do not mix. The condensed steam 72 can be added to the heated process water 73 at a later stage (not shown). The heated process water 73 is flow 52 and is used in the extraction plant of BLOCK 5. NCG 75 are removed from the system where they can be burned or injected to the froth for enhancing the separation of the bitumen from the water. Unit 77 describes a direct contact heat exchanger that can be used as unit 60 for recovering the heat and water from the produced steam while generating hot process water. The produced steam 38 is injected at 78, where it is mixed with the cold process water 79 to generate hot process water 76 which includes the condensed steam that is converted into liquid water. The hot process water includes the water from the produced steam. The heated process water 76 is flow 52 and is used in the extraction plant of BLOCK 5. Any generated NCG 80 is removed and used for combustion, froth separation, or for other various uses. The temperature of the discharged hot water 57 is between 70C-95C, typically in the 80C-90C range. The hot water is supplied to the ore preparation facility. The separated dry solids 36 can be mixed 90 with additional MFT 95, possibly after thickening. Any commercially available mixing method 90 can be used in the process: a rotating mixer, Z type mixer, screw mixer, extruder, or any other commercially available mixer (not shown). Ambient air 93 can be blown 91 using blower 92 and mixed with the hot solids 36 and potentially additional mature fine tailings 95, possibly after thickening. Additional water will be removed from the additional MFT 95 (and possibly from the hot solids discharge 36, if they discharged from separator 37 in a slurry form). The water is removed in a vapour form to the air 91 during the mixing process 90 to generate humid air 94. The humid air is separated from the cooled solids 96 in a separator. The cooled solids 96 include a controlled moisture amount to prevent dust, but the remaining water content is sufficiently low to allow trucking 54 the solid waste 96 to be used as back-fill and to support traffic. By continually consuming the fine tailing water 43, the oil sand mine facility can use a much smaller tailing pond as a means of separating the recycled water from the fine tailing. This solution will allow for the creation of a sustainable, fully recyclable water solution for the open mine oilsands facilities.

[27] FIGURE 7 includes a Non-direct contact steam generator and an insitu underground heavy oil extraction through steam injection. Emulsion of water, bitumen, solvents, and gas is produced from a production well 10, like a SAGD well. The produced flow 1 is separated in a separator 3 (located in BLOCK A) to generate water rich flow 5 with contaminates like sand, hydrocarbons, solvents, etc, and hydrocarbons rich flow 4. There are a few commercial designs for separators that are currently used by the industry that can be used in this process. Chemicals can be added to the separation process. The hydrocarbon rich flow 4 is further treated in processing plant at BLOCK B. Flow 4 is further separated into produced water and produced bitumen, usually diluted with light hydrocarbons to enhance the separation process and to reduce the viscosity which allows the flow of the bitumen in the transportation lines. In BLOCK B, the produced water that remained with the flow 4 is de-oiled and used, usually with make-up water from water wells, for generating steam 6. The water rich flow 5, at a high temperature that is close to the produced emulsion temperature, is pumped into a heater 6 where it is heated with heat 7 to transfer a portion of the hot produced water into steam and possibly transfer a portion of the solvents within the water to a gas phase. In one embodiment of the invention, the heater is a closed system of heated molten salts. Such systems are commercially available. A common salts mixture is potassium nitrate and sodium nitrite with combustion heat source. A common arrangement will be a shell and tube heat exchanger where the molten salts are at the shell side. Self cleaning heat exchanger arrangements can be used as well. As an example, self cleaning circulating fluidized bed exchangers designed by Klaren BV, Holland with molten salts as the heat source can be used. Self-cleaning heat exchange technology can be applied in most vertically oriented shell and tube exchangers. Examples include circulating scraping devices, turbulence inducing or heat exchangers with an on-line cleaning design (using circulating balls) where the heat source is molten salts and the cleaning is implemented only on the produced water side. The advantage in the usage of the melted salt heater is that the heat transfer is at high temperatures and low pressures. To achieve the same heat transfer flux and temperature with steam as the heat source, high pressure on the heating steam side will have to be used. The mixture of the gas phase and liquid phase 8 is separated in a separator 9 to the gas phase, composed mainly from steam possibly with light hydrocarbons and solvents. The generated steam, possibly with hydrocarbon solvents 13, is added to a "standard" 100% quality steam 14 generated in a boiler, OTSG, or any other facility, like COGEN. The combined streams of steam, possibly with solvents, are injected 2 into the underground formation through steam injection well 11. Additional solvents can be added to the injection steam 2- it is a common practice to add solvents to the generated steam for injection. It is known that hydrocarbons that are mixed with the steam can improve the oil recovery. The liquid phase water 12 with solids and other contaminates, like hydrocarbon solvents, is recycled back to the produced water 4 for treatment in the base plant at BLOCK B. Based on the water contaminates level and the tendency for foaling, portion 12A of the discharged water 12 from heater 6 can be recycled back into the heater 6 to generate additional steam 13. The liquid water 12 is at a high saturated temperature so as to recycle and minimize the amount of consumed heat. Liquid flow 12 heat can be recovered for pre-heating produce water flow 5 or for any other use. The additional steam 13 can include solvents in a gas phase as well as other solid contaminates. The facility described in BLOCK C can be located on the well pad, in close proximity to the injection and production wells, where the main oil treatment plant and the water treatment plant in BLOCK B, typically referred to as "Central Processing facilities", are located remotely where a few pads (Block C) are connected to a single Central Processing Facility (BLOCK B).

[28] FIGURE 7A includes steam driven Non-direct contact heat exchanger steam generator and an insitu underground heavy oil extraction through steam injection. Figure 7A has similarities to Figure 7. Produced water flow 5, with contaminates like sand, hydrocarbons, solvents etc, is heated in heat

exchanger 6, operated by steam 30. The heat exchanger can be a shell and tube heat exchanger, possibly with self cleaning capabilities. Self-cleaning heat exchange technology can be applied in most vertically oriented shell and tube exchangers. Examples include circulating scraping devices, turbulence inducing or heat exchangers with an on-line cleaning design (using circulating balls), etc. An additional example for a heat exchanger that can be self cleaning is self-cleaning circulating fluidized bed exchangers or spiral heat exchangers with or without self cleaning capabilities. The heated produced water 8 is separated in separator 9 to gas phase 13 containing steam and hydrocarbons gas, like solvents, and liquid phase 12 containing saturated liquid water and additional contaminants, like heavy hydrocarbons, dissolved solids, and suspended solids. A portion of the saturated water 12A can be recycled to the heat exchanger feed produced water 5. The portion of the recycled flow is a function of the fouling in the heat exchanger 6 due to the increase in the contamination due to a phase change of water and light hydrocarbons. Heat from the saturated produced water 12 can be recovered in heat exchanger 7 to heat the boiler feed water (BFW) 14 that is supplied from the water treatment plant in the SAGD facility in BLOCK B. Heat exchanger 7 is a spiral heat exchanger that is not prone to fouling and is easy to clean. Any other heat exchanger with or without self cleaning capabilities can be used as well. The BFW source is the produced water within the bitumen 4 as the separation in BLOCK A does not remove all the produced water from the product and the produced water that was used for steam production 12B after the heat was recovered at the heat exchanger 7. Heat exchanger 7 can be a spiral heat exchanger or any other type of heat exchanger, like shell and tube. High quality Boiler Feed Water 14 from the water treatment plant at the central processing facility at BLOCK B can be pre-heated at heat exchanger 7 to generate pre-heated boiler feed water 14A while recovering heat from the heated produced saturated water 12 at separator 9. A portion 12A of the separated saturated water 12 can be recycled back to the feed of heat exchanger 5 where additional liquid water phase will be converted to gas phase due to the heat energy it received in heat exchanger 6. The steam to operate the heat exchanger 6 is generated in the OTSG. The BFW 14B is fed into economizer 20 and into the steam generator 22 where 80% steam is generated. The 80% steam is separated in separator 27. The blow down water 28 is used to generate low pressure steam and is used as a heat and water source. If the BFW 14B is high quality (like in the case that the water treatment in BLOCK B is based on an evaporation plant where the BFW is distilled water with very low levels of dissolved solids), it is possible to recycle a portion of the blow down 26 to the OTSG. A portion of the produced steam 30 is used as the heat source for heat exchanger 6. The steam produced locally on the well pad from the produced water 5 and the make-up steam 32 is injected 2 to the underground formation through injection well 2. The condensate 29 from the driving steam 30 is recycled back to the boiler after going through the economizer (due its high saturated water temperature).

[29] FIGURE 8 includes a steam driven Non-direct contact heat exchanger steam generator and an insitu underground heavy oil extraction through steam injection. Figure 8 has similarities to Figure 7 and 7A. BLOCK B describes a thermal oil central facility for bitumen processing and water treatment plant. The facility extracts the bitumen and removes some contaminants, as well as water, and possibly adds dilbit to allow effective piping of the product. The produced water within the product is treated to remove oil contamination. The de-oiled water is further treated in a water treatment plant by various commercially available methods like evaporation, reverse osmosis, and others to produce Boiler Feed Water (BFW) 14 that can be used in the boiler to produce steam. The BFW 14 is heated in an economizer 23 within boiler 20. The heated water flows to the boiler heat exchanger between steam drum 18 and mud drum 19. The combustion heat from the combustion 21 is heating the boiler pipe to generate the high pressure steam in the steam drum 18. A small amount (1%-3%) of Blow-down is discharged from the mud drum 22. The blow-down can be added to flow 5 from separator 3 or, possibly after heat

recovery, can be added to flow 4 and directed to the base plant at BLOCK B. Portion 7 from the 100% quality steam 17 is used to operate a heat exchanger 6 to generate additional steam, possibly with solvents from contaminated produced water 5. The water used to generate the additional steam 13 is water separated at or close to the well pad from the hot produced emulsion of bitumen, water and other materials like solvents and gases. The additional steam is generated in heat exchanger 6. Due to severe fouling conditions, heat exchanger 6 can include self cleaning capabilities. In the diagram, the heat exchanger includes internally rotating element 16 to remove deposits. Any other form of fouling resistant heat exchanger, possibly with inline cleaning capabilities, can be used as well. From the heat exchanger, the flow pressure is controlled by a valve 16 to reduce the pressure so as to flash a portion of the liquid phase to a gas phase and separate the liquid phase from the gas phase in vessel 9. The liquid phase 12, possibly after recovering its heat to the produced water 5 or to the BFW 14, is directed to the produced bitumen flow and returned to the main plant. A portion of flow 12 can be recycled back to the water feed 5 from separator 3 to evaporate additional liquids and increase the contaminated concentration in the discharged flow 12. The produced steam 13 can include other gases like solvents and light hydrocarbons introduced with the produced water 5. Solid contaminants introduced with the produced water 5, like silica fumes, can be in the produced steam 13. To resolve the solid contamination problem, the produced steam 13 is cleaned in unit 26 to remove contaminants. The solid removal can include any commercially available package for removing solids from a hot gas stream. It can include an electrostatic precipitation separator, a wet scrubber using saturate water with chemicals (like magnesium salts), or any other system to remove the contaminants 28, like silica, from the gas stream. The cleaned steam and hydrocarbon flow, 27 after the solids were removed, is used for underground injection through an injection well 11. Additional steam 17A from the boiler can be added as well and injected into the underground formation. The produced emulsion 1 is produced from the production well 10 and separated as described in FIGURE 7 and 7A in BLOCK A to generate a bitumen rich flow 4 and water rich flow 5. The produced water flow 5 is used in the steam generator heat exchanger 6 while the bitumen rich flow with the remaining water is directed to the central processing facility at BLOCK B.

[30] FIGURE 9 includes steam driven Non-direct contact heat exchanger steam generator and an insitu underground heavy oil extraction with saturated liquid boiler feed water scrubber. BLOCK C includes a boiler system with condensed water recycle feed 15. Steam 7 produced in the boiler is directed to heat exchanger 6 where the steam temperature is used to heat separated produced water 5. Due to the heat transfer within the heat exchanger, a portion of the produced water is converted to gas within the heat exchanger 6. Another option is that the heated produced water will be maintained under high pressure that prevents the generation of the gas phase within the heat exchanger 6 where steam 13, possibly with other gases, will be generated in flash vessel 9 where the liquid phase 12 is separated from the gas phase 13 and a portion 12A of the produced liquid phase 12, especially if a phase transfer within the heat exchanger 6 is prevented to reduce fouling. The produced steam 13, possibly with additional hydrocarbons, like solvents, and contaminants, like silica, are washed in vessel 26 with saturated water, possibly with additional chemical additives 13A, like Magnesium salts such as magnesium chloride, caustics, or any other material that can be effective in reducing contaminants levels in the produced steam gas phase. Clean condensed boiler feed water 29 from heat exchanger 6 is directed to wet scrubber 26 where it is recycled and used to scrub contaminants from the produced steam and gas 13. The scrubber contaminated liquid 28 is discharged, together with the liquid from the separator 9, to the central processing facility at BLOCK B by flow 4. The saturated liquid from scrubber 9 can also be recycled with produced water 5 to heat exchanger 6 where it is heated and additional steam is generated. The produced steam 27 is used for injection into the underground formation for oil recovery, possibly with additional make-up steam 17A produced by a boiler at BLOCK C from treated water 14.

[31] FIGURE 10 describes a method with 3 steps for water and solvents recovery from liquid fine tailings that includes a mixture of liquid water and valuable hydrocarbon solvents. There is a safety advantage to using a mixture of hydrocarbons solvents with water from the flammability perspective. Hydrocarbon solvents tailings are very risky, especially where high temperatures are involved to evaporate the solvents. When the solvents tailings includes water, the flammability risk is reduced. The fine particles within the hydrocarbon solvent will stay in an aqua form with the water after the hydrocarbon solvents evaporated. This will cause the creation of a fine tailings liquid stream, possibly with hydrocarbons solvents remains. The described method addressing that problem, while allowing the recovery of the valuable solvents and while allowing the use of liquid water in the extraction mixture and recovering the water component of the tailings in an additional step. The FIRST step includes fine tailings which include water, hydrocarbon solvents, asphaltins, fine clay particles, and other contaminates which are heated indirectly in heater 3. The heater includes a rotating enclosure, possibly with internals to mobilize the tailing solids. Rotating internals with a fixed enclosure can be used as well. Due to the heat transfer through the enclosure wall, liquid hydrocarbons solvents, possibly with some liquid water, changes phase from liquid to vapour gas. The vapour 9 that was generated in the first stage is separated from the solids and slurry 14 in separator 8. The separated solids can include solvent hydrocarbons remains and liquid water. The separated gas phase 9 is directed to heat exchanger / condenser 10 where the heat 13 is used to heat cold process water or for any other use within the extraction process. The condensed liquid solvents 11, which can include water, are recycled back to the process. Non condensed gas 12 can be cleaned and released, or burned to recover caloric value and remove contaminates. The solids with the liquids remains, possibly in a slurry form, are directed to the SECOND step. The solids 15 are directed to a direct contact combustion enclosure 17 where they are directly mixed with combustion gas and heated by the combustion reaction. A hydrocarbon, like natural gas, or carbon fuel, like petcoke 18, is mixed with air and combusted 20 to generate heat and combustion gas. If the fuel includes sulfur, additional chemicals, like lime stone can be added to the combustion stage with the fuel 18 or with the heated tailings 15. The combustion and mixing enclosure 17 is a rotating enclosure, possibly with internals to enhanced the mixture between the solids and the combustion gas to evaporate all the liquid remains within the solids. A portion (preferably as much as possible) of the hydrocarbons and carbons remains in the tailing flow 15 will be fully or partly burned from the heat generated by combustion 20. The hot gas and solids mixture 21 is separated in separator 22. The hot combustion gas 16 that includes water vapours from the water remains in slurry 15, are directed to the FIRST STEP where they are used as the heat source to non-directly heat enclosure 3 for indirectly evaporating the solvents in the first step. After the indirect heating of the evaporation enclosure in STEP 1, the mixture 2 of the combustion gas and steam is directed to heat exchanger 6 where the heat is recovered from flow 2 and the water vapour is condensed to liquid water 5 that can be used as extraction water. The heat within gas phase flow 2 is used to heat the process extraction water. Heat exchanger / condenser 6 can be of a non-direct contact or direct contact type where the cold process water is directly mixed with the combustion gas and steam. The cooled combustion gas 7 is released to the atmosphere, possibly after further cleaning. In the THIRD STEP the hot solids from the combustion steps 25 are mixed with water based tailings 26. (Tailings 26 are different from solvent tailings 1 as tailings 26 do not include recoverable solvents. Tailings 26 can also be Mature Fine Tailings from tailing pond.) The heat within the hot solids 25 is used to evaporate additional water from tailings 26. Air 27 can be added as well to reduce the water vapor partial pressure and by that reduce the temperature of the solid tailings further by removing additional liquid water from the water based tailings 26. In addition, if the fuel 18 in the combustion stage was a low quality fuel that included sulfur, and if lime was used to react with the sulfur, the oxygen within air 27 will react to generate gypsum

while consuming additional water during this reaction. The hot solids from the combustion stage, together with additional tailings and air, are mixed within enclosure 29. Enclosure 29 includes rotating internals to enhance the mixture 28. The amount of water tailings 26 is controlled to maintain sufficient water moisture within the solids 28 to prevent dust but at the same time, to be sufficiently stable to be used as back-fill and to support traffic. The solids 32 are separated from the humid air 31 and are trucked 33 to the mine site where they can be used as back-fill for effective disposal. In the three step process described above, one potential disadvantage of the non-direct heat transfer in the first step, resulting in lower temperature and evaporating heat transfer rates is overcome because the first step is mostly used to evaporate solvents which required a lower heat and temperature for their transfer where the remaining water, and possibly heavier hydrocarbons, will be evaporated in the second step of direct contact with combustion gas.

[32] FIGURE 10A describes a method with 3 steps for water and solvents tailings processing similar to FIGURE 10 but with a fluid bed combustion direct contact heating. Steps 1 and 3 were described above in FIGURE 10. The SECOND STEP includes a fluid bed combustion furnace to directly heat and possibly combust hydrocarbons and carbons remains within the tailings 15 after most of the light solvents were recovered in the FIRST STEP. Fuel 18, that can be carbon or hydrocarbon fuel, is combusted with air 19 in a fluid bed enclosure. The combustion is done at the lower section of the enclosure where the tailings 15 after most of the solvents removed are injected to the upper section of the fluid bed combustor above the combustion. Carbon and hydrocarbons within the tailings are combusted or transferred to gas and solid components within the fluid bed due the heat, and the combustion gas and oxygen. Due to the combustion heat, the water within tailing solids 15 evaporates to generate a mixture of steam and combustion gas 23. The hot gas flow 16 is used at the first step as the heat source to evaporate the light valuable solvents. In the fluid bed enclosure 17, the direct contact heat transfer is a counter flow type, where the combustion gas is flowing upwards while the tailings are flowing downwards where they are discharged from the bottom of the enclosure.

[33] FIGURE 11 describes recycling of hot particles for heating and evaporates at least a portion of the fine tailings while heating the particles by direct contact with combustion gas. Figure 11 includes two rotating enclosures – enclosure 11 for mixing the fine tailings 16 with hot solid particles 5 and enclosure 4 to directly heat the solid particles while combusting and hydrocarbons or carbons remains with the remaining tailings. Fine tailings from open mine bitumen extraction process that can include solvent remains from solvent extraction process are introduced into a rotating enclosure 11 where it is mixed with hot particles 5. Hot articles 5 can be made of sand, crushed aggregate, ceramic or metal like alloy steel. The particles can be any rounded shape, preferably in the shape of full or hollow balls. Enclosure 11 rotation enhances the mixture and mobilizes it to the discharge end 10. It is possible to use rotating internals or vertical fluid bed design to mobilize the mixture 12, possibly in a slurry form. To increase the heat transfer to the tailings, enclosure 11 can be heated with combustion gas 9. Due o the heat of the hot particles 5, liquid phase changed to vapor phase 13 and remove from the enclosure. The vapour phase 13 includes solvents and water. The vapour condensed in condenser 24 where the recovered solvents and liquid water 25 is recycled back to the extraction process while the condensation heat 27 is recovered for use within the extraction process as well. The particles and the fine tailings remains 10, mainly solids, possibly with heavy solvents, water, hydrocarbons and other contaminate materials that are captured within the solids, are directed to a rotating combustion enclosure 4. To enhance the mixture between the combustion gas and particles 5, lifting internals like scoops 7 can be used. The heat source is carbon or hydrocarbon fuel 1 combusted 3 with air 2, possibly with combustion gas circulation 8. The fine solids for disposal and the hot particles that were heated by the combustion are separated. The fine solids 6 that were part from tailing stream 16 are separated from hot particles 5 that are recycled to re-heat tailing stream 16. The fine solids 6 are mixed 19 with additional tailings 17

and air 18 as to use the heat within the hot solids discharged from the combustion enclosure to evaporate additional water to generate humid air and by that consume additional tailings 18. The amount of the additional tailings is controlled to maintain sufficient humidity within the waste solid discharge to prevent dust but at the same time to generate a solid waste that can be back-fill and support traffic. The humid air 21 is separated from the stable solid waste 22 that is trucked for disposal as filling material.

[34] FIGURE 11A described hot particles recycle as the heat source for fine tailings evaporation and fluid bed combustor to combust the tailings solids remains and generate the hot recycled particles. Fine tailings 18 injected into rotation enclosure 2. The enclosure includes internal spiral to mobilize and mix the hot particles 13 and the tailings 18. The heat evaporate portion of the tailings 20. The evaporated gas condensed 22 and recycled back to the extraction process. Non Condensed Gases 21 can be combusted or scrubbed to remove hydrocarbon contaminates. The tailings and particles 11 directed to enclosure 1 which is a fluid bed combustor. Air 6 and fuel are injected and combusted in a fluid-bed enclosure. The particles together with the tailings solids 11, possibly with water, solvents, hydrocarbons, asphaltins and other contaminates are injected to the fluid bed reactor. The carbons material is combusted while the water remains evaporates within the high temperature combustion bed 7. Additional fuel, like pet coke or coal can be added with solids stream 11. Another option with the current low natural gas prices is to use natural gas with the air 6 as the fuel source. The fluid bed combustor can include cyclone 9 to recycled carry-on solids 8 back to the bed. Carry on solids 14A can be removed from the discharged combustion gas 10. Commercial available separation technology, like electrostatic precipitator can be used to scrub solid particles. The hot fine solids introduced with the tailing stream 18 and the recycled particles are discharged 12 from the combustion enclosure bottom. The solid flow separated to the solids for disposal 14 and the hot recycled particles 13. The hot recycled particles can be made of sand, ceramic particles, aggregates or metal spheres. The Solids for disposal 14 and 14A are mixed with additional tailing water 15 in mixer 4 to reduce the solids temperature, evaporate additional water and prevent dust. The disposed solids are stable sufficiently to support traffic.

CLAIMS

I claim:

1. A method for oil extraction, said method comprising the steps of:
producing fluid from a production well located on a well pad;
proximate to the production well, separating the produced fluid into a water rich fluid and a bitumen rich fluid;
flowing the bitumen rich fluid to a remote central process facility;
proximate to the production well, heating the water rich fluid to produce a gas phase comprising steam and a liquid discharge stream;
proximate to the production well, separating the gas phase from the liquid discharge stream;
and
injecting said gas phase through an injection well into an underground formation where the injection well is located proximate to the production well.
2. The method of claim 1 wherein:
said production well is a Steam-Assisted Gravity Drainage (SAGD) well; and
said steps proximate to the production SAGD well are located on a SAGD well pad.
3. The method of any one of claims 1-2, further comprising the steps of:
flowing the liquid discharge together with the bitumen rich fluid to the remote central process facility.
4. The method of any one of claims 1-3, further comprising the steps of:
separating bitumen and produced water from said bitumen rich fluid at said remote central process facility to generate separated produced water; and
treating said separated produced water to remove contaminants selected from a group consisting of: bitumen, hydrocarbons, dissolved solids, and suspended solids to generate treated produced water.
5. The method of any one of claims 1-4, further comprising the step of removing solids from the gas phase to form a solids-free gas steam for injection into an underground formation.
6. The method of any one of claims 4, further comprising the steps of:
generating steam from treated produced water; and
injecting said generated steam into an injection well located on the well pad.
7. The method of any one of claims 1-6, wherein producing the gas phase comprises:
transferring heat from high pressure steam through a heat exchanger for heating the water rich fluid.
8. The method of claim 6, wherein said generated steam is remotely produced at a central process facility.
9. The method of claim 6, wherein said remotely produced steam is added to said gas phase.

10. The method of any one of claims 7, further comprising the steps of:
proximate to the production well, generating high pressure steam; and
indirectly heating the water rich fluid through a heat exchanger, to transfer the liquid phase containing water to produce the gas phase containing steam.
11. The method of any one of claims 1-9, wherein producing the gas phase comprises:
combusting fuel to generate heat;
heating a heat transfer medium with said combustion heat; and
heating the water rich fluid with the heated heat transfer medium.
12. The method of any one of claims 1-11, where the water rich fluid comprises liquid phase solvents, the method further comprising the steps of:
heating the water rich fluid to evaporate the solvents; and
injecting the evaporated solvents together with the produced gas containing steam through an injection well.
13. The method of any one of claims 1-12, where the water rich fluid is pressurized such that the gas phase is produced at an injection pressure.
14. The method of any one of claims 1-13, wherein the gas phase further comprises hydrocarbon solvents, and further comprising the steps of:
removing contaminants selected from a group containing solids and liquids from said gas phase to produce a solids free steam; and
injecting said solids free steam into an underground formation.
15. A system for oil extraction, said system comprising:
a production well for producing oil and water;
a separator fluidly connected to the production well for generating water rich fluid and a bitumen rich fluid;
a heat exchanger located proximate to the production well fluidly connected to the separator for heating the water rich fluid to generate a gas phase comprising steam and a liquid discharge flow;
an injection well located proximate to the heat exchanger and to the production well, the injection well being fluidly connected to the heat exchanger for injecting said gas phase into an underground formation; and
a central process facility located remotely from the injection and production wells for processing said bitumen rich phase and the liquid discharge flow for generating treated produced water for steam production and oil product.
16. The system of claim 15, said system comprising a steam generator for combustion fuel for generating steam from said generated treated produced water.
17. The system of any one of claims 15 -16 where said injection well and production well are SAGD wells located on a SAGD well pad.
18. The system of any one of claims 15 -17 where said heat exchanger is pressurized to allow injection of the gas phase at the injection well.

19. The system of any one of claims 15-18, said system comprising a steam generator for combustion fuel for generating steam from said generated treated produced water.

20. The system of any one of claims 15-18, said system comprising a combustion heater located proximate to the production well fluidly connected to said heat exchanger for generating heated fluid stream as the heat source for said heat exchanger.

21. The system of claim 20 where in said fluid stream selected from a group containing steam, melted salt and thermal oil.

22. The system of any one of claims 15-21 comprising a separator with a discharge outlet for discharging waste containing material selected from a group containing solids and liquids and an outlet for discharging clean gas phase in fluid connection with said heat exchanger and said injection well.

23. The system of any one of claims 15-21 wherein said heat exchanger comprises an enclosure with an internal rotating element capable of moving slurry and solids, wherein the longitude enclosure is externally heated with heating fluid, the enclosure further comprising an inlet to feed said water rich fluid at one end of the longitude enclosure and a discharge outlet at the other end for discharging contaminants and the produced gas containing steam, where the rotating element is located between the inlet and the discharge outlet.

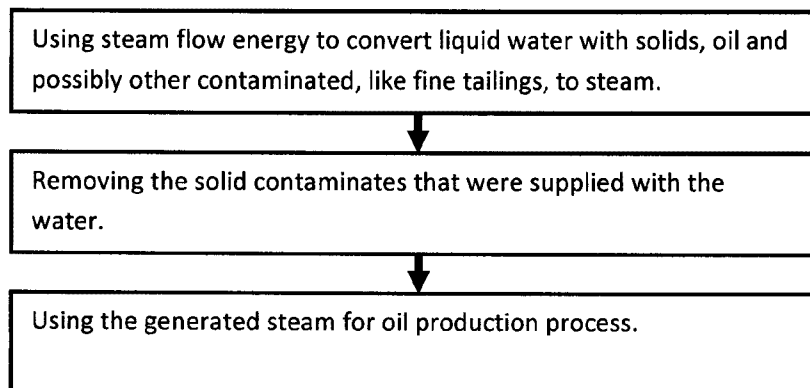


FIG. 1

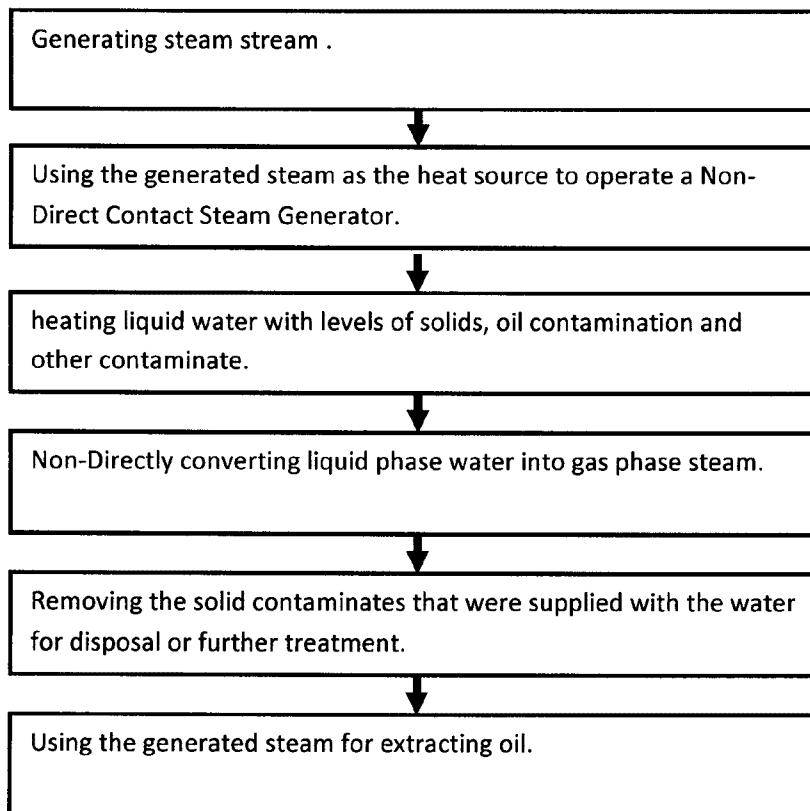


FIG. 1A

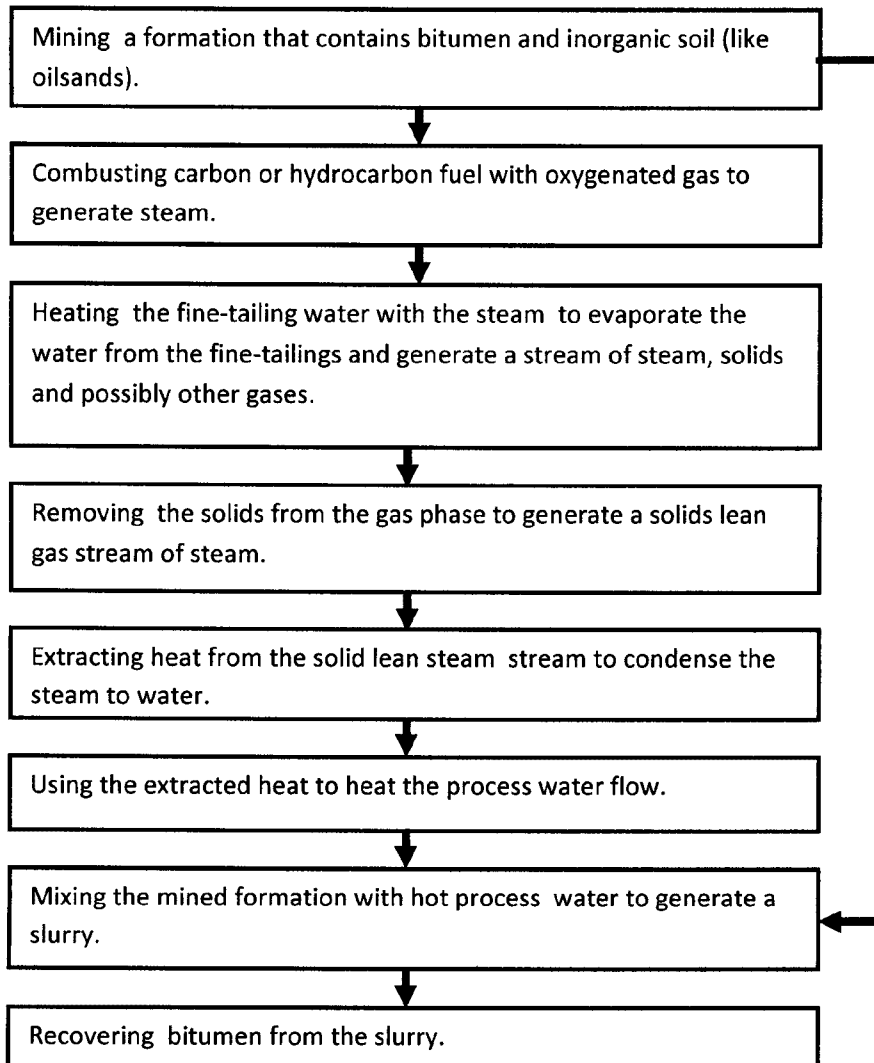


FIG. 1B

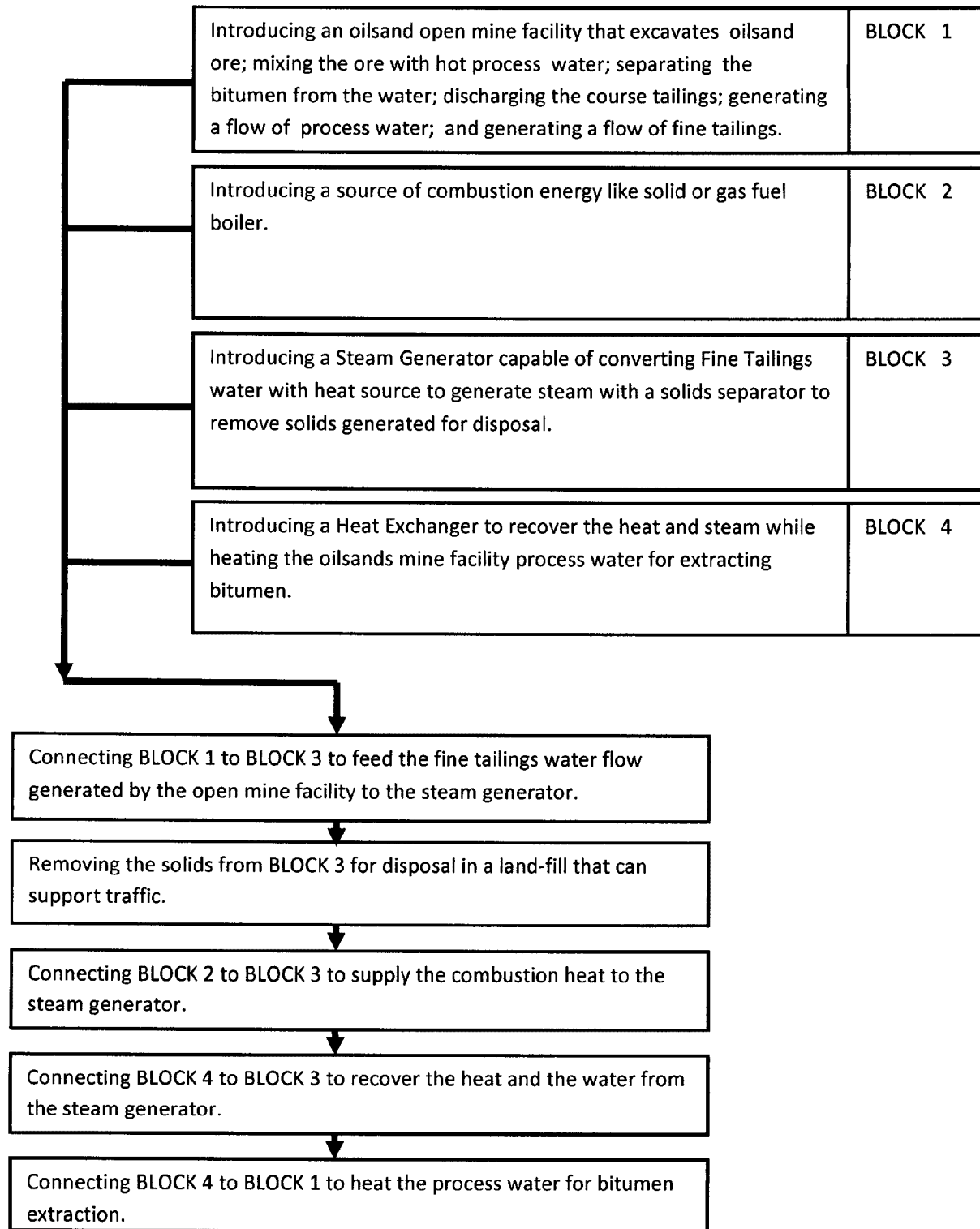


FIG. 1C

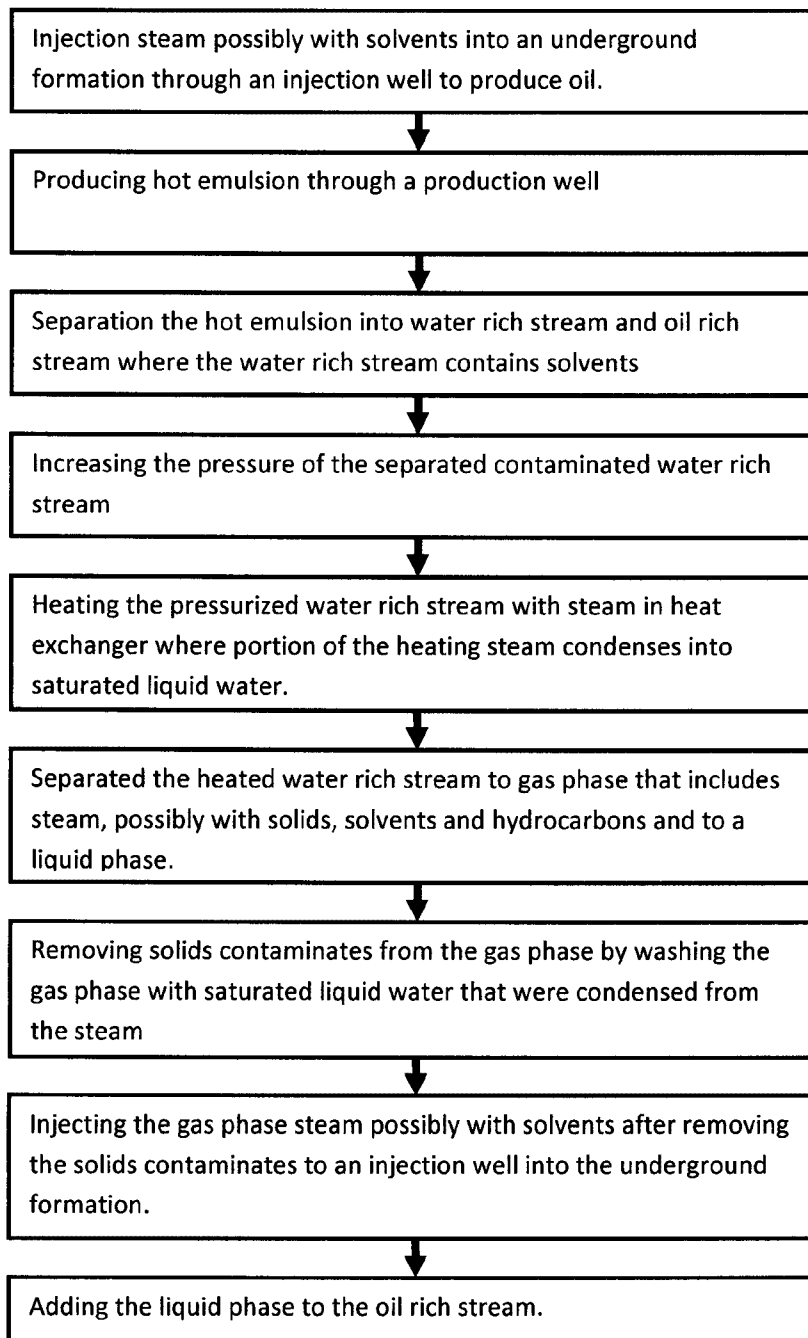


FIG. 1D

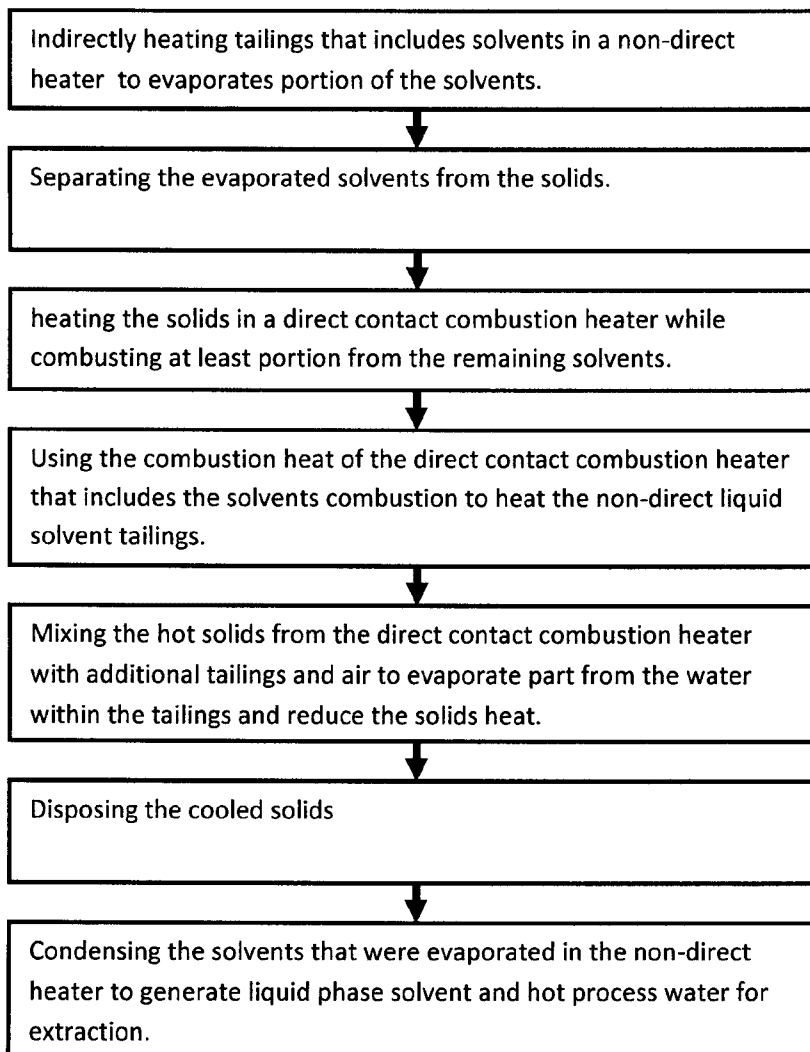


FIG. 1E

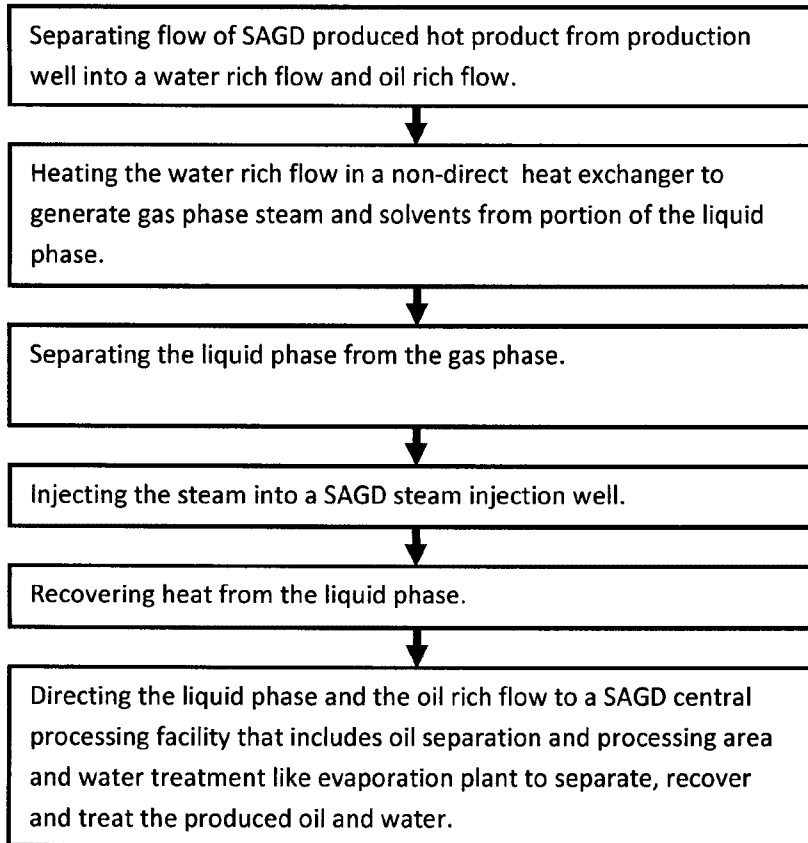


FIG. 1F

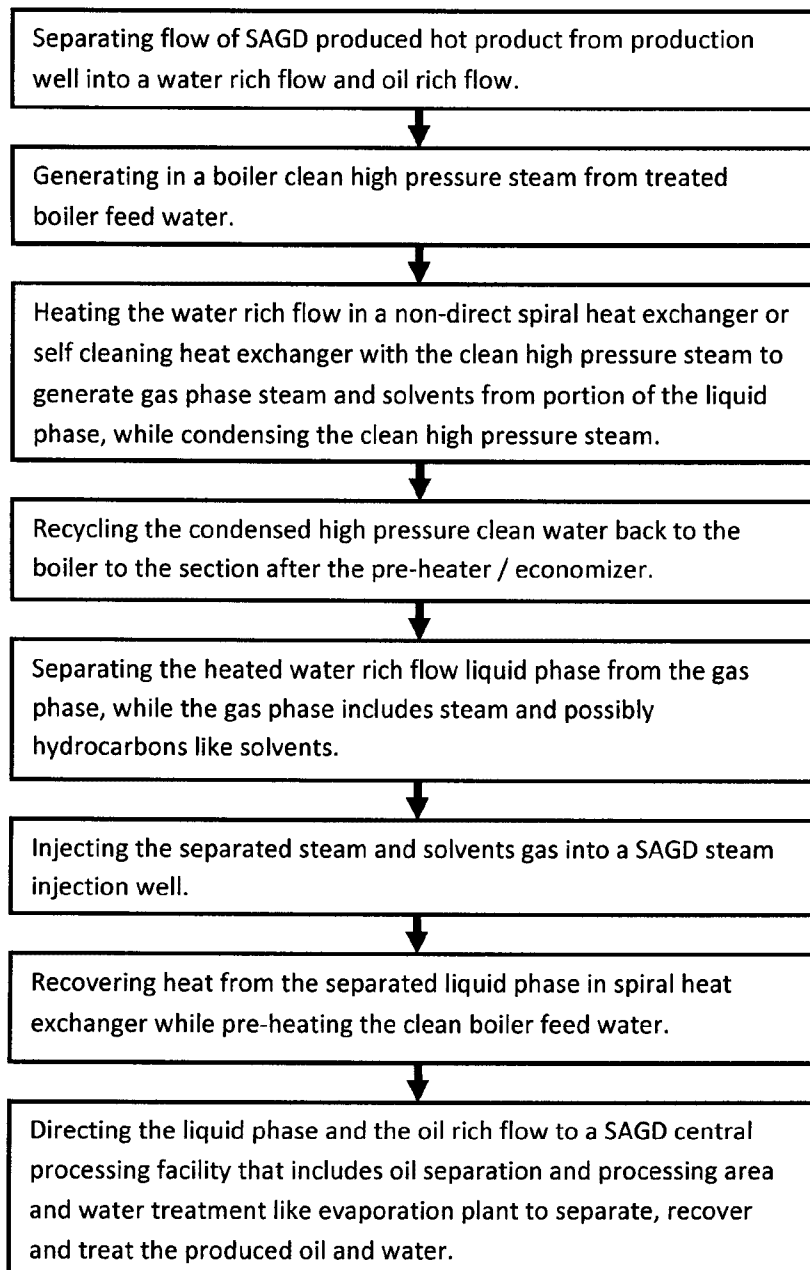


FIG. 1G

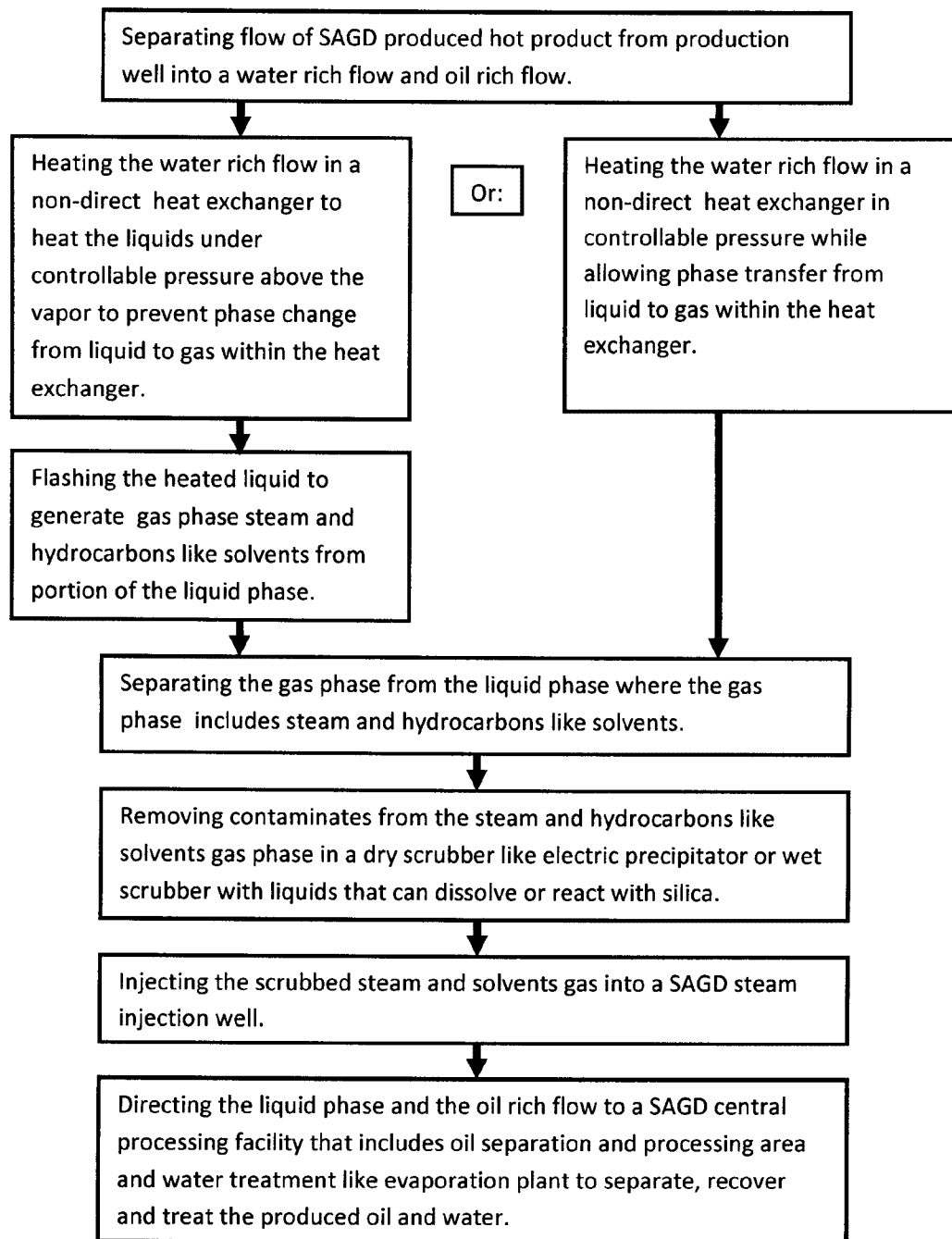


FIG. 1H

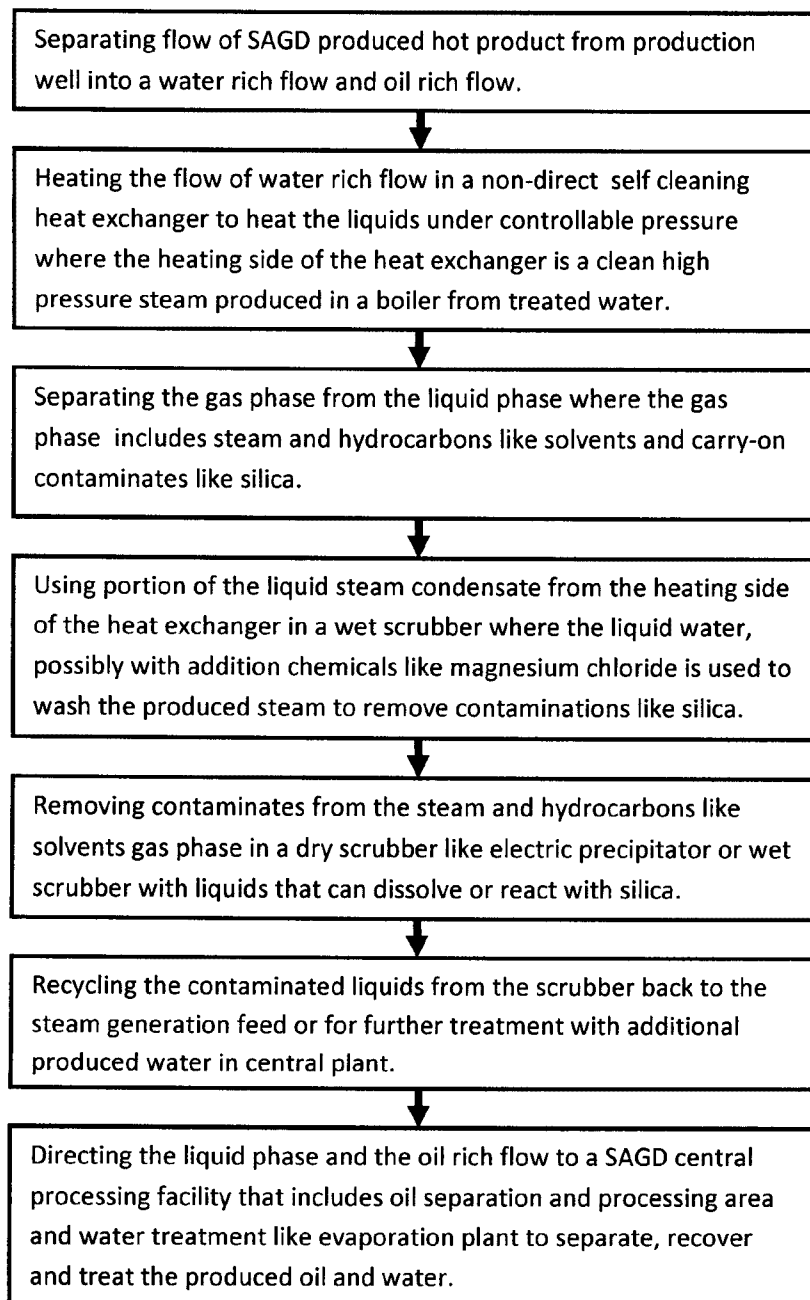


FIG. 11

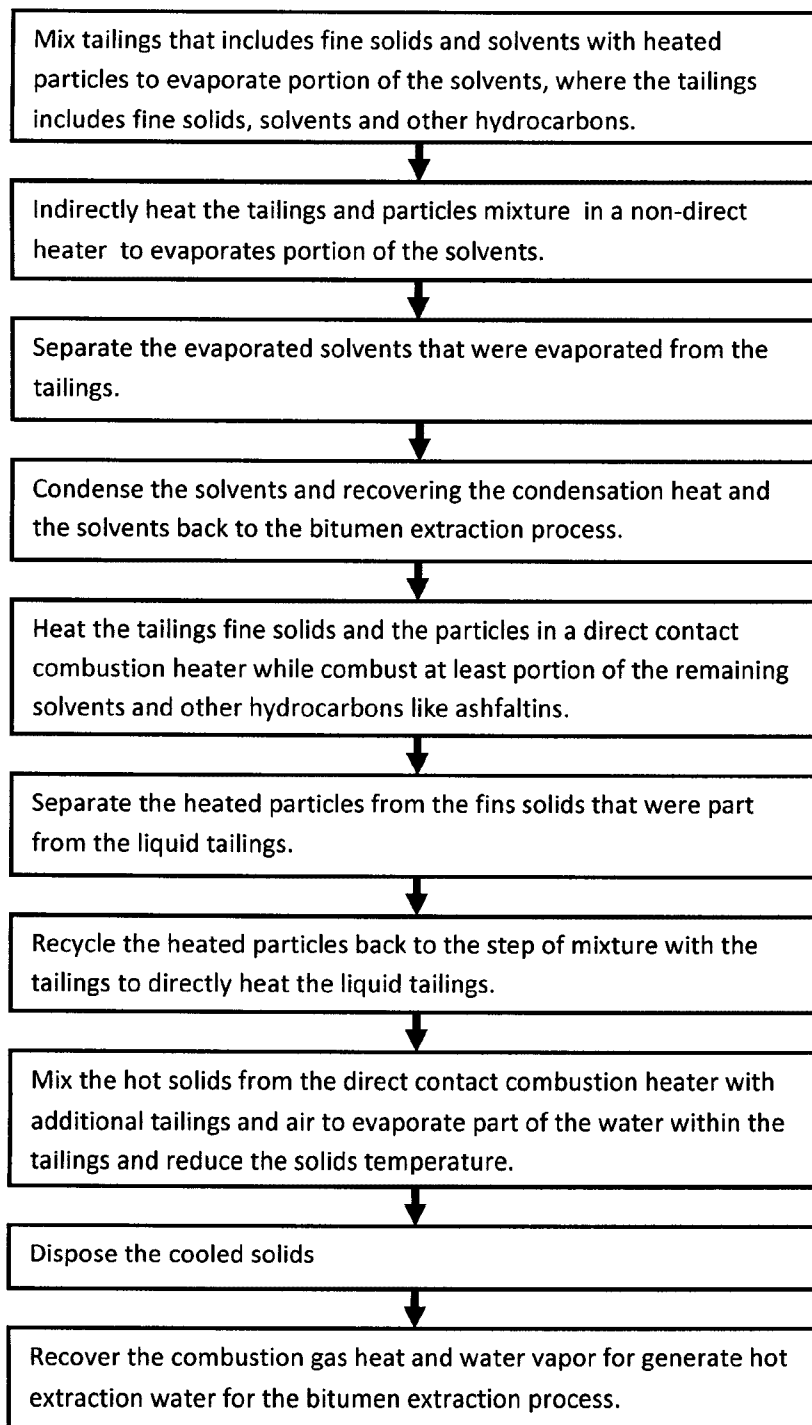


FIG. 1J

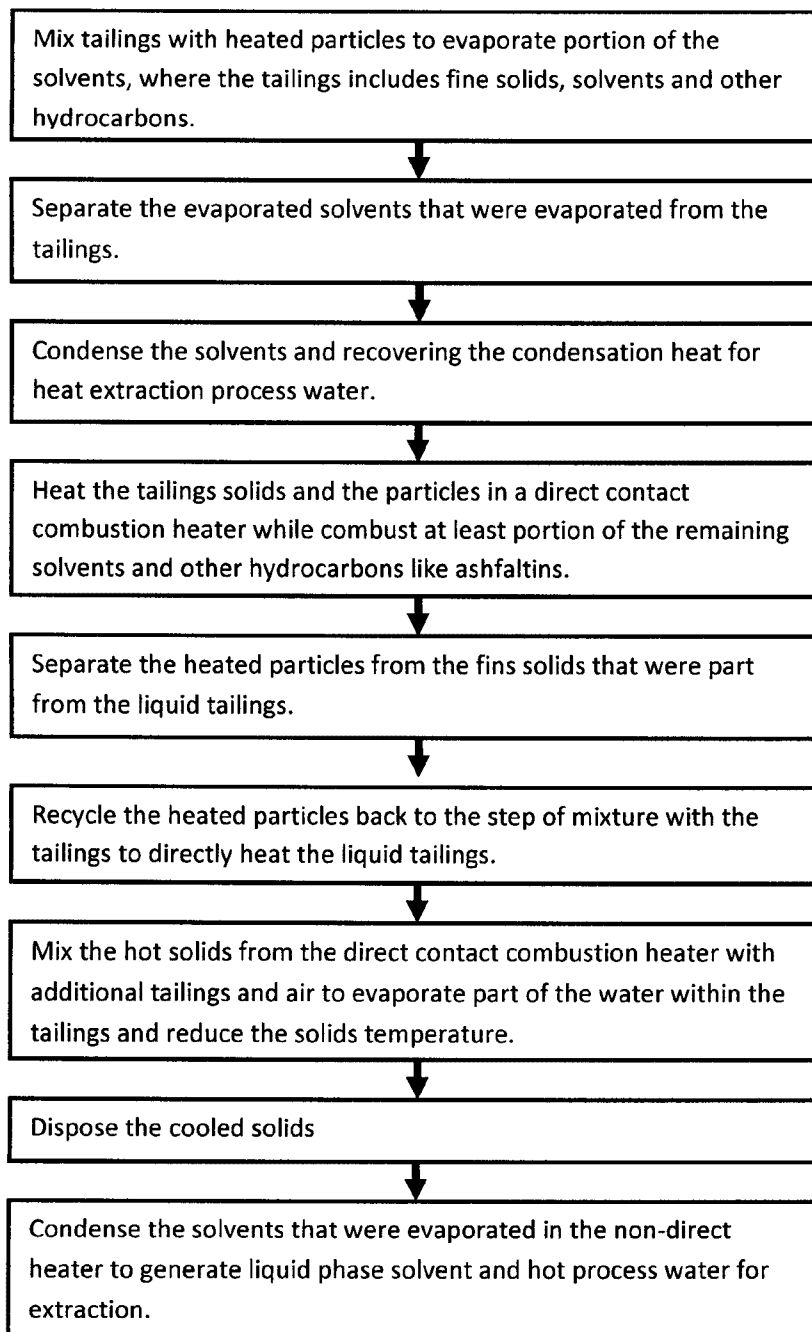
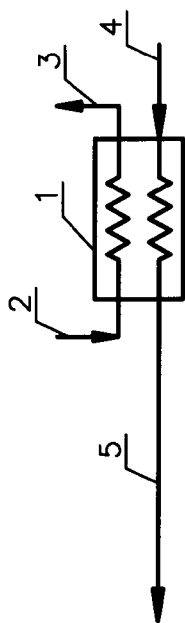


FIG. 1K



Prior Art

FIG. 2A

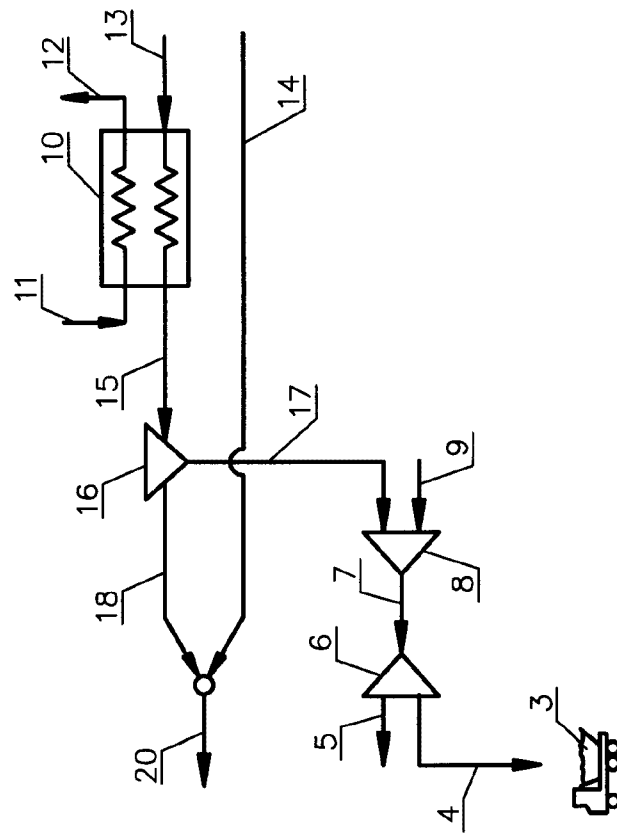


FIG.2B

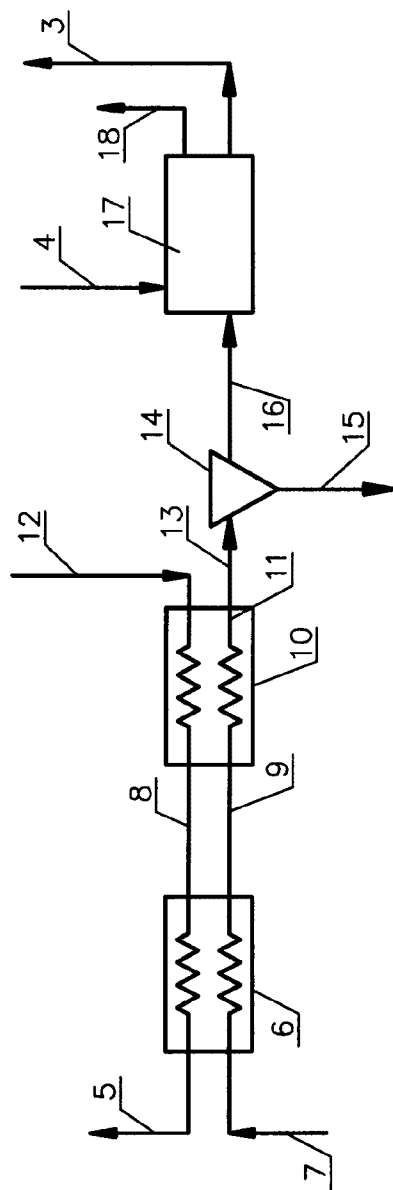


FIG.3

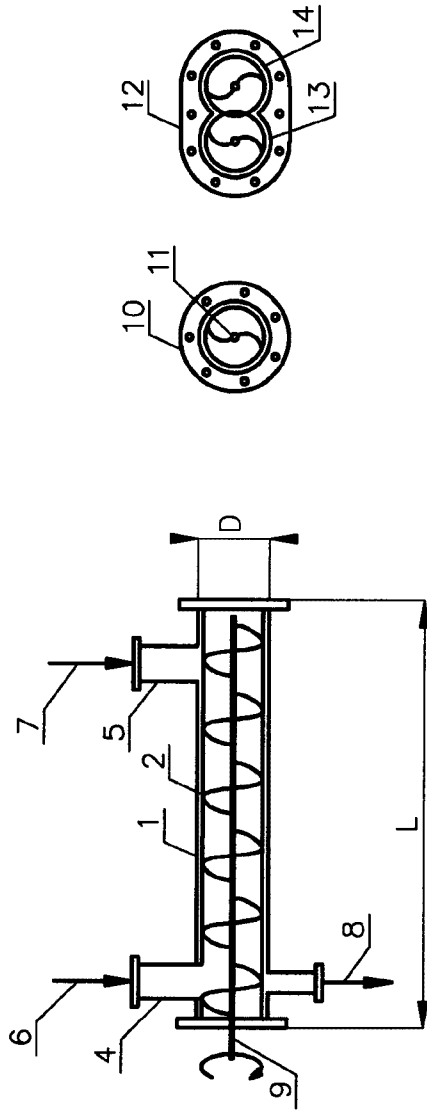


FIG.4

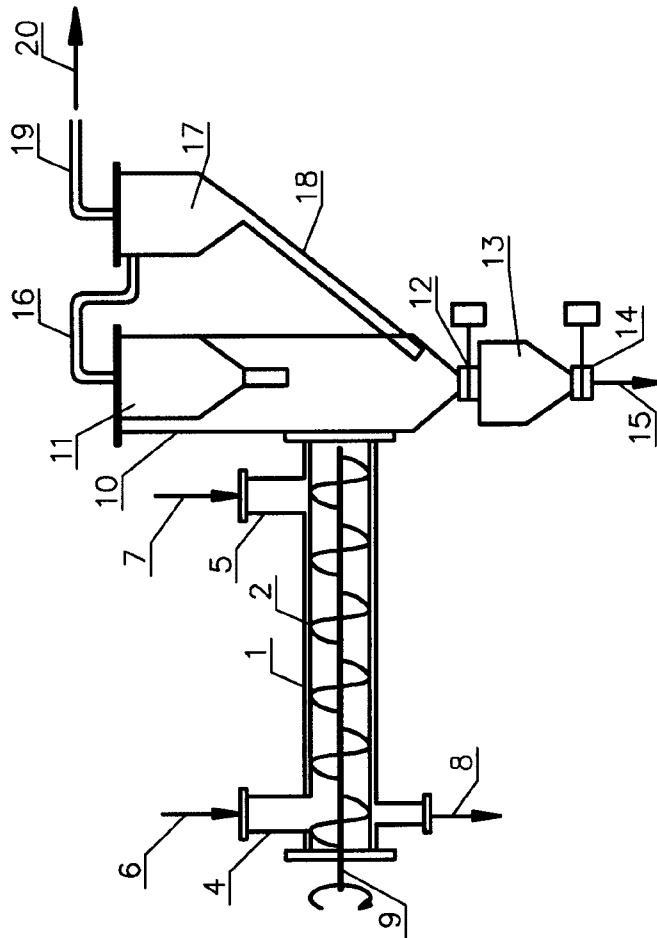


FIG.4A

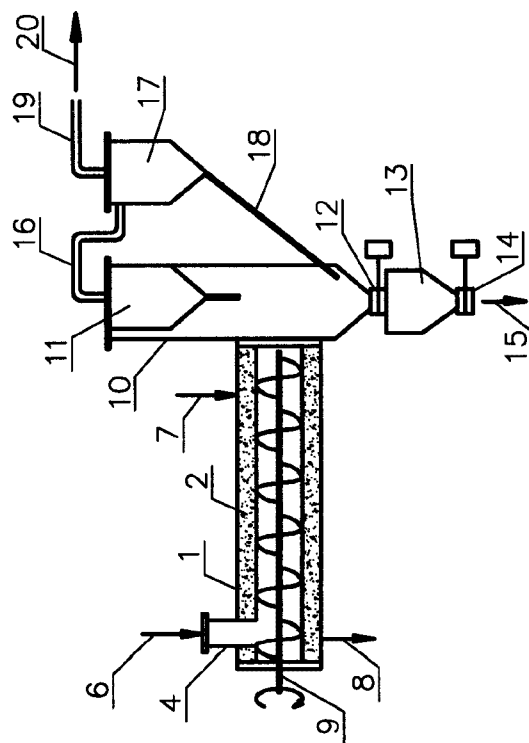


FIG. 4B

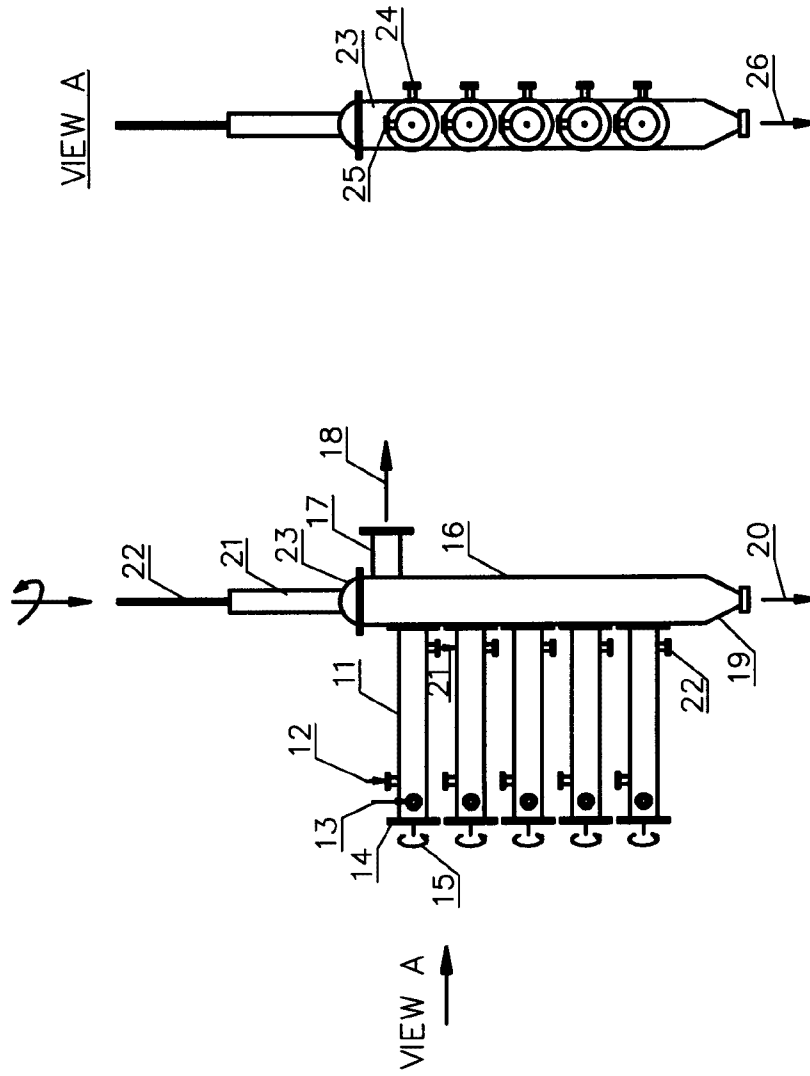


FIG.5

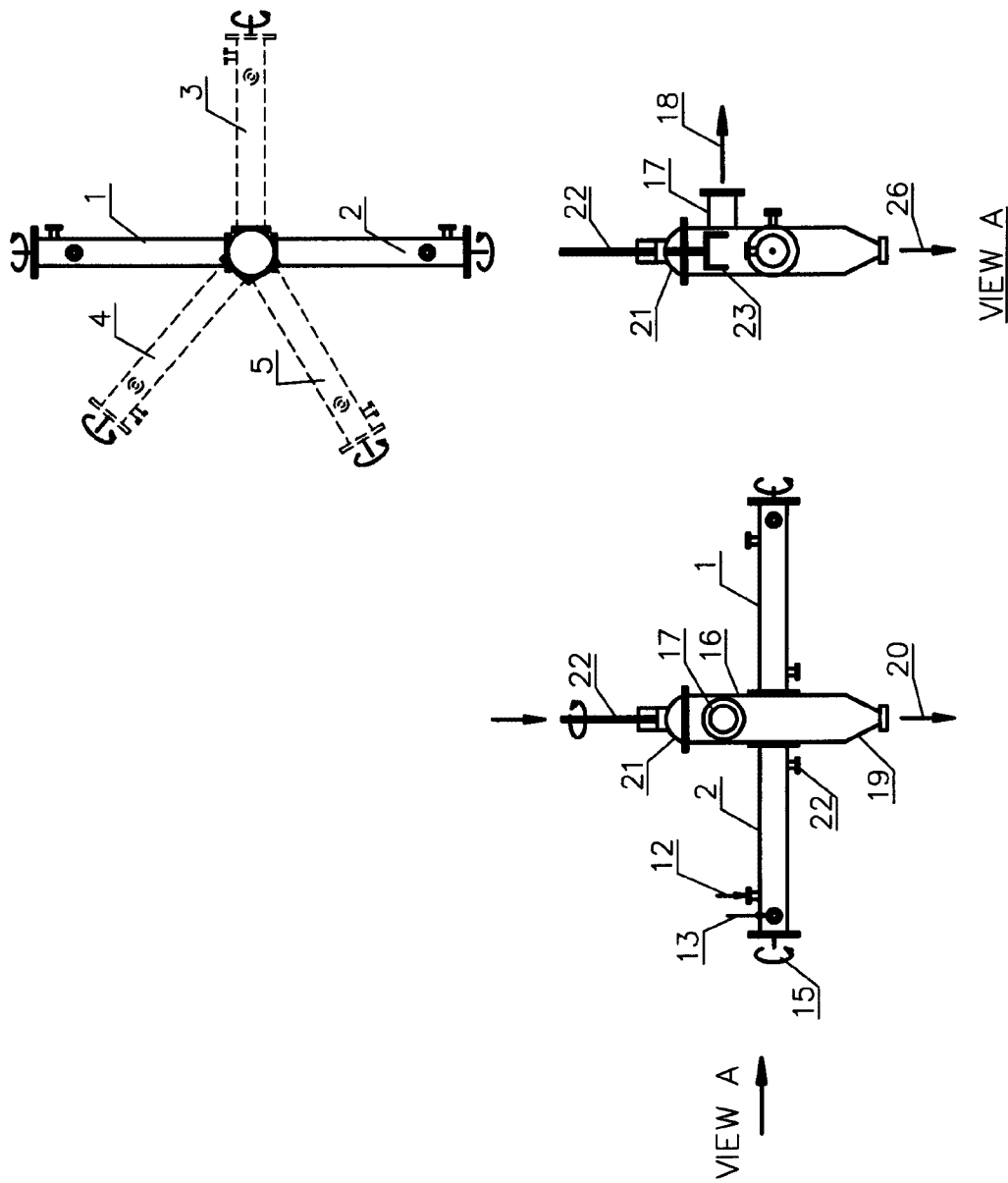


FIG.5A

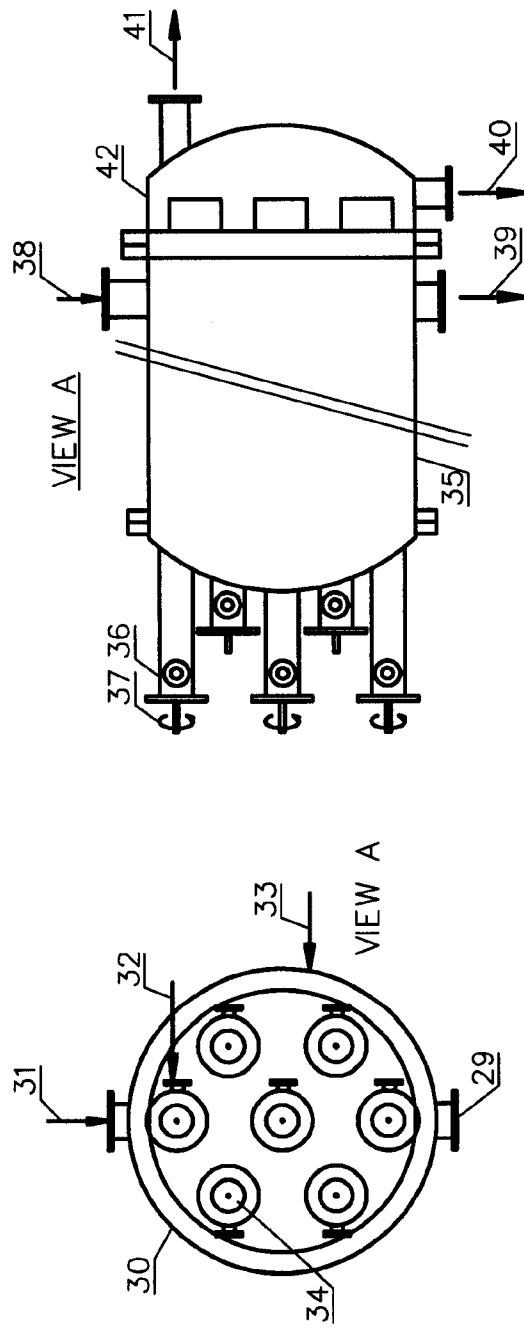


FIG.5B

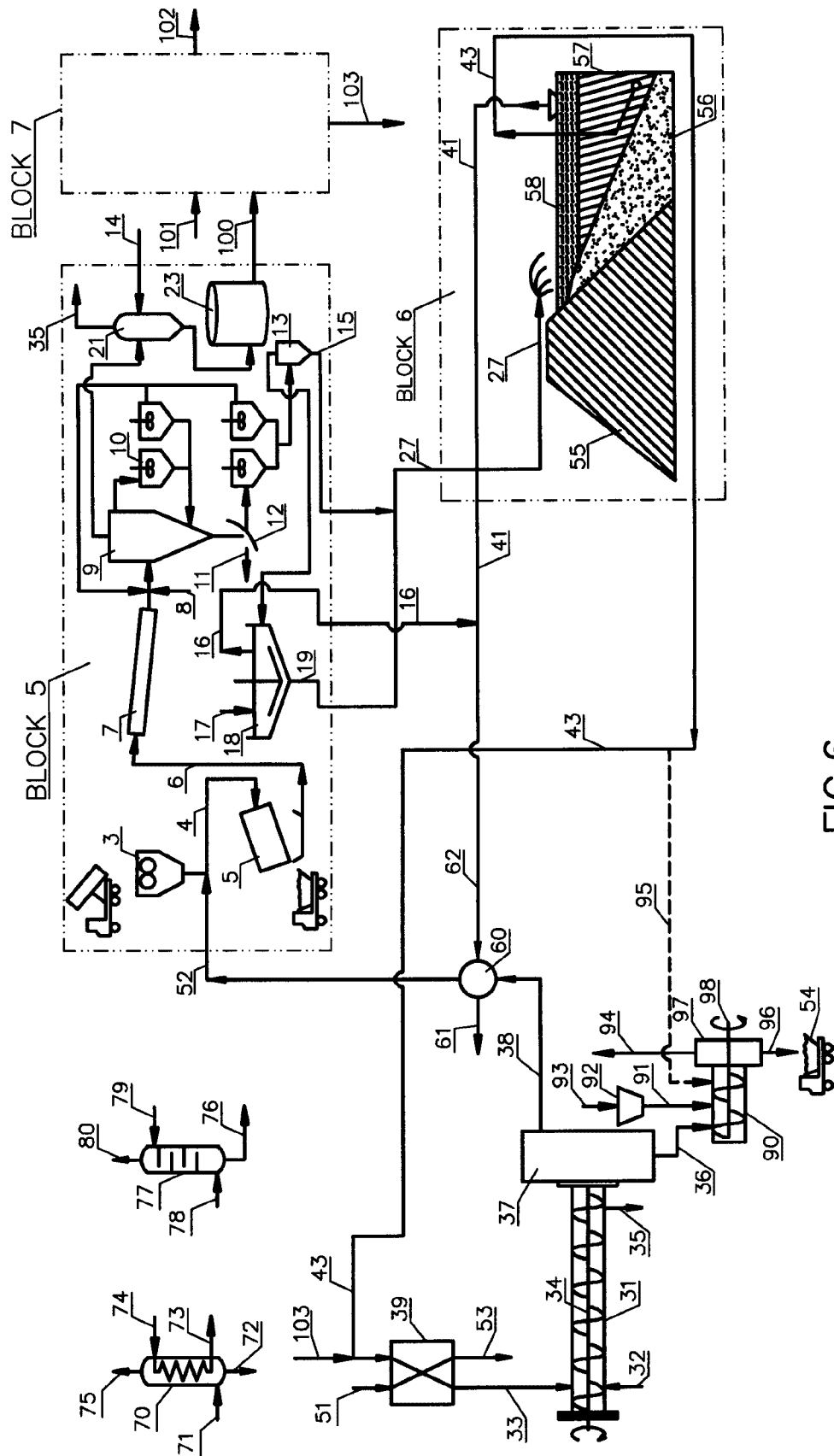


FIG.6

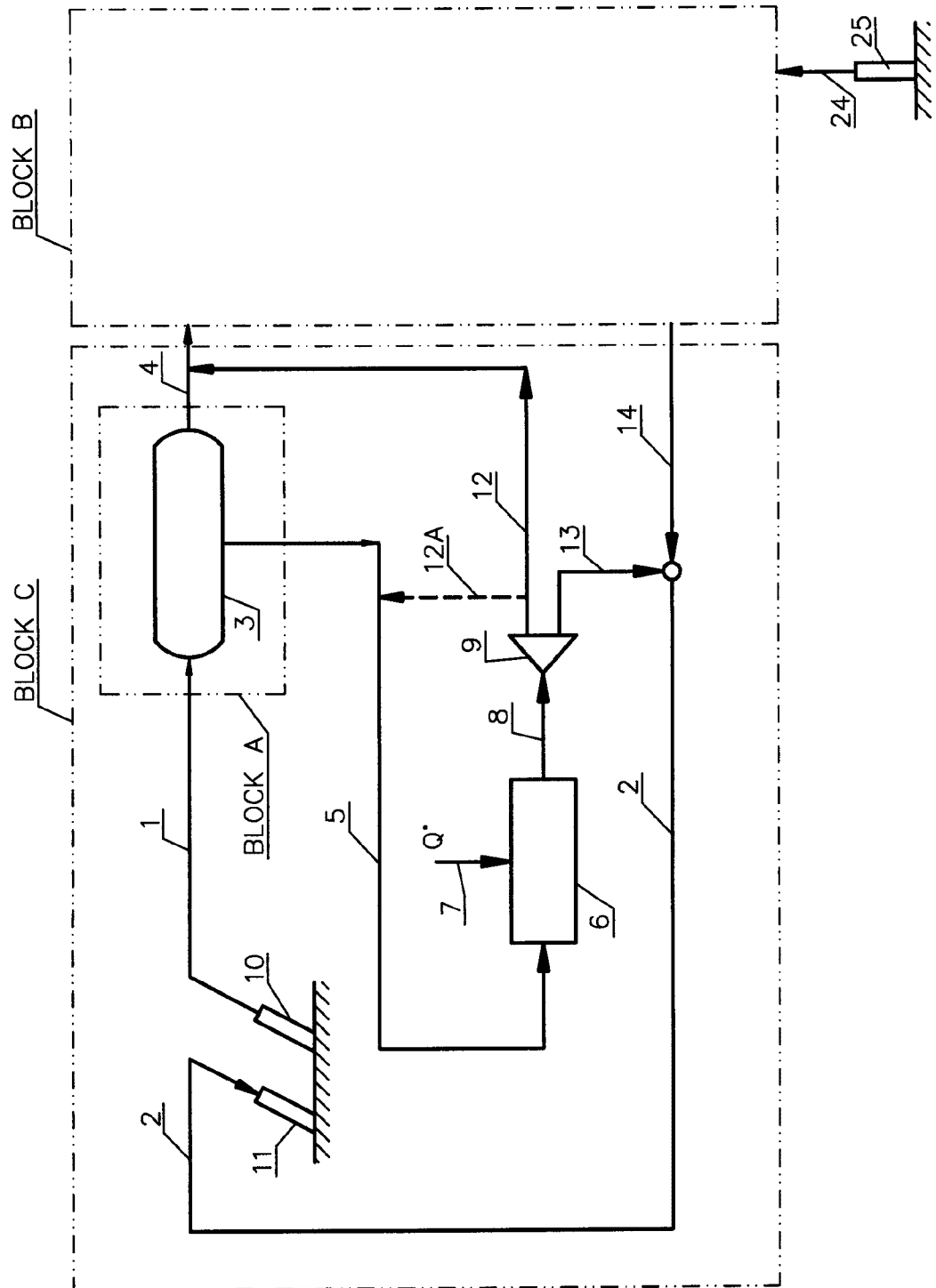


FIG.7

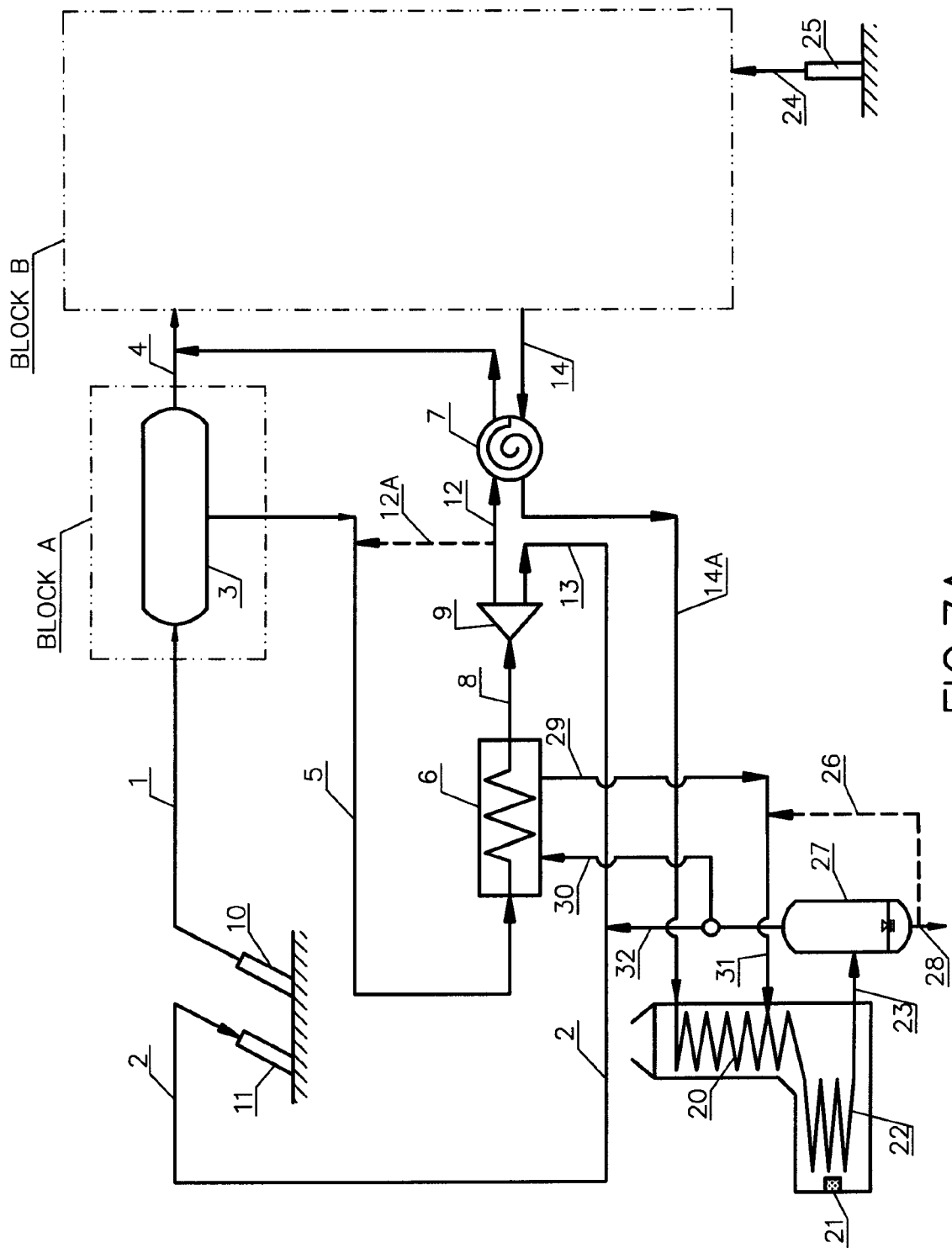


FIG. 7A

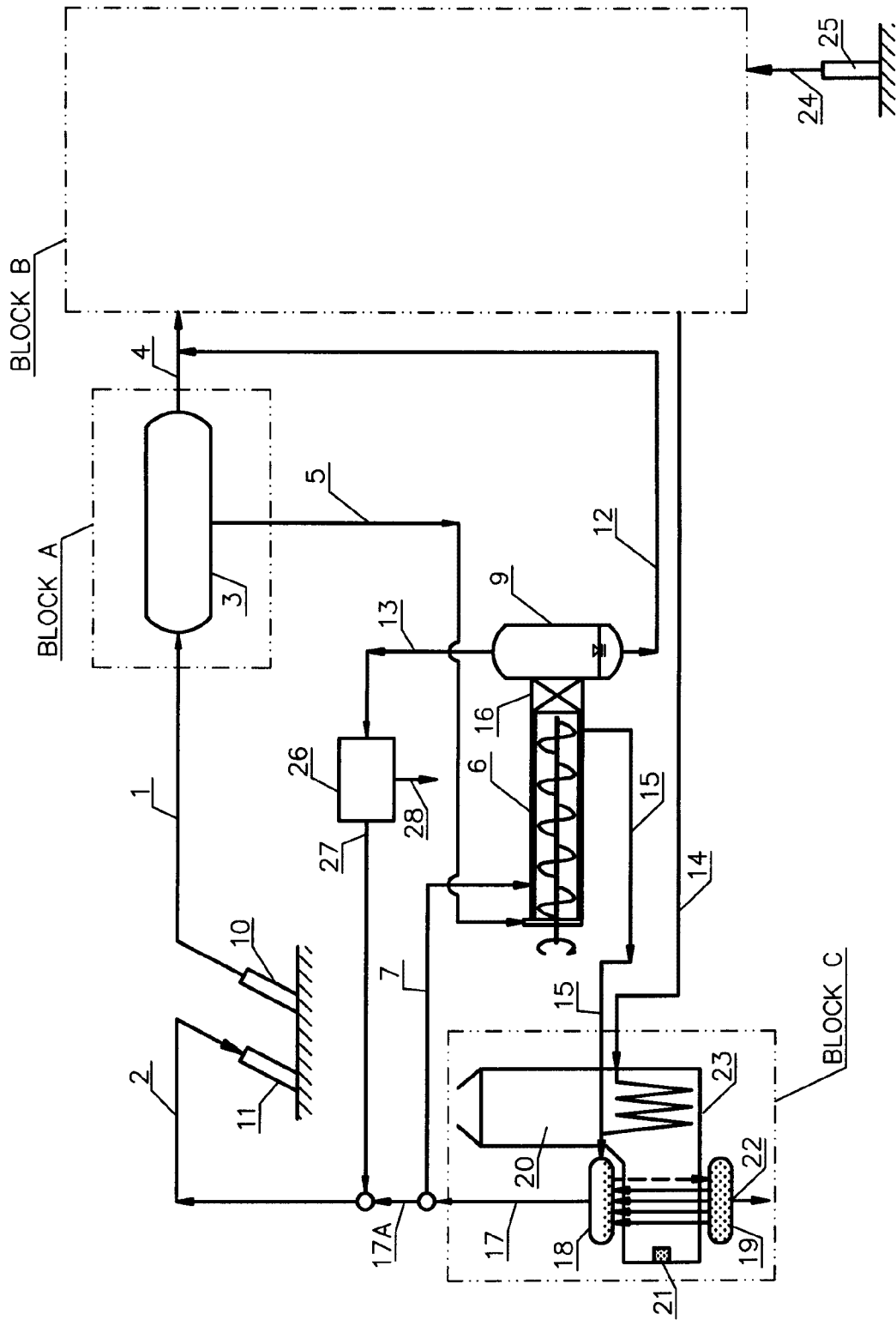


FIG.8

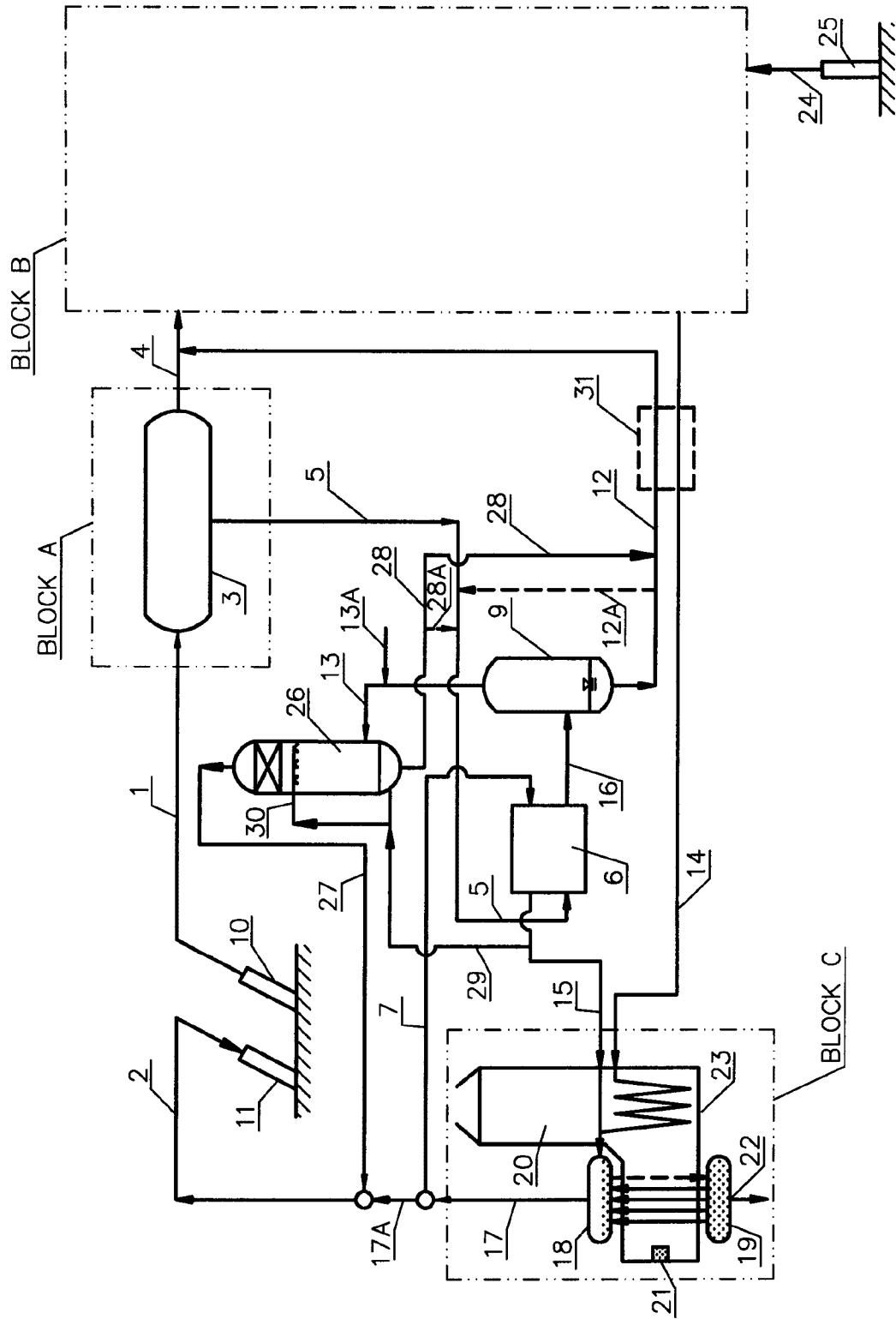


FIG.9

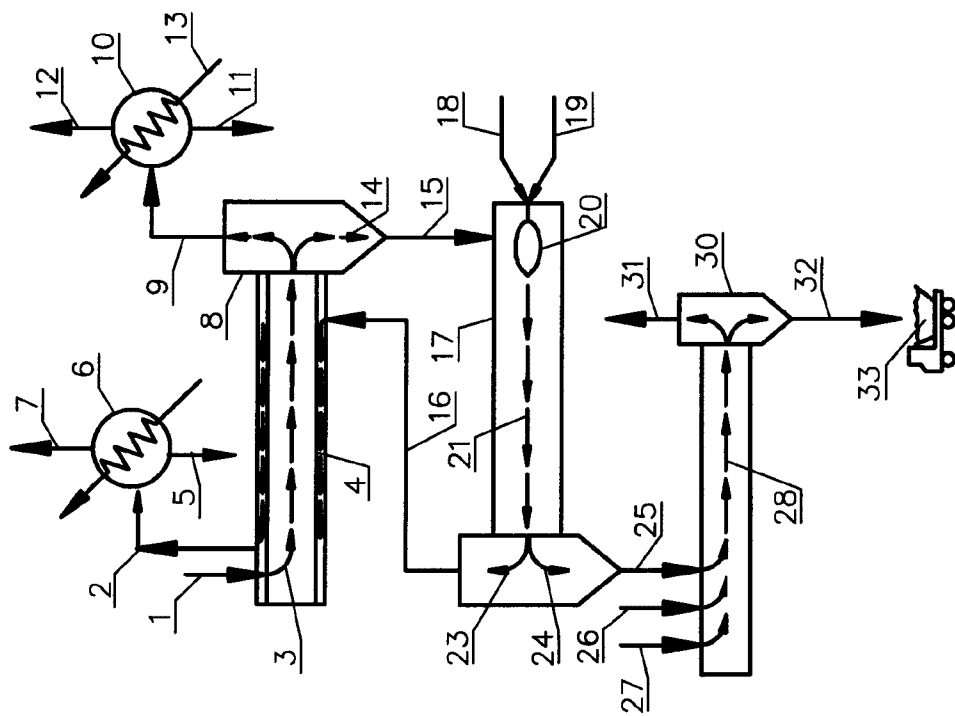


FIG.10

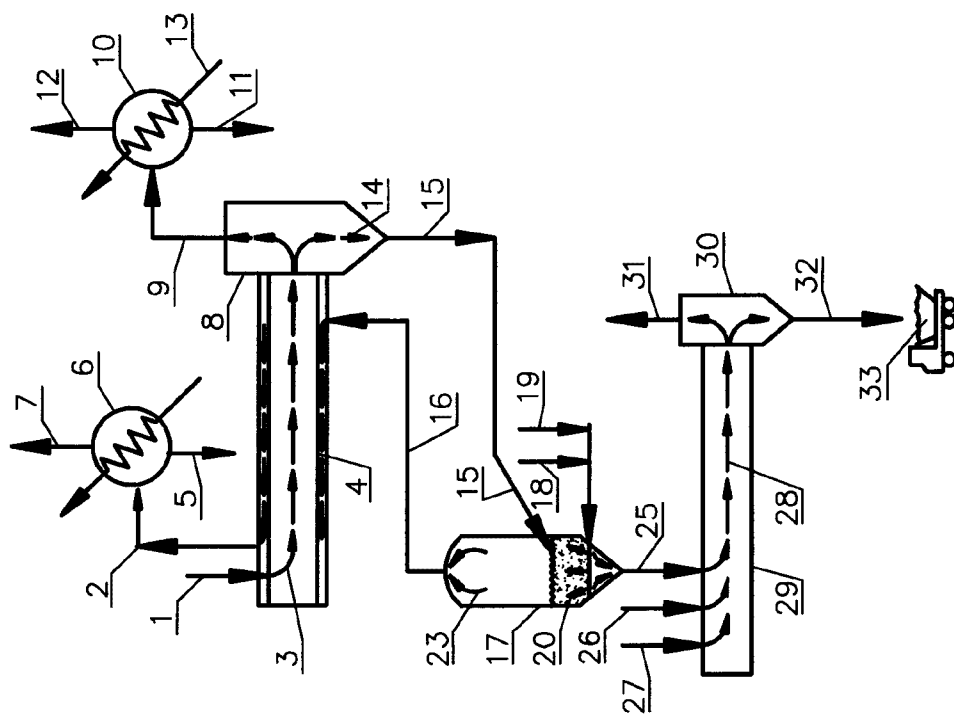


FIG.10A

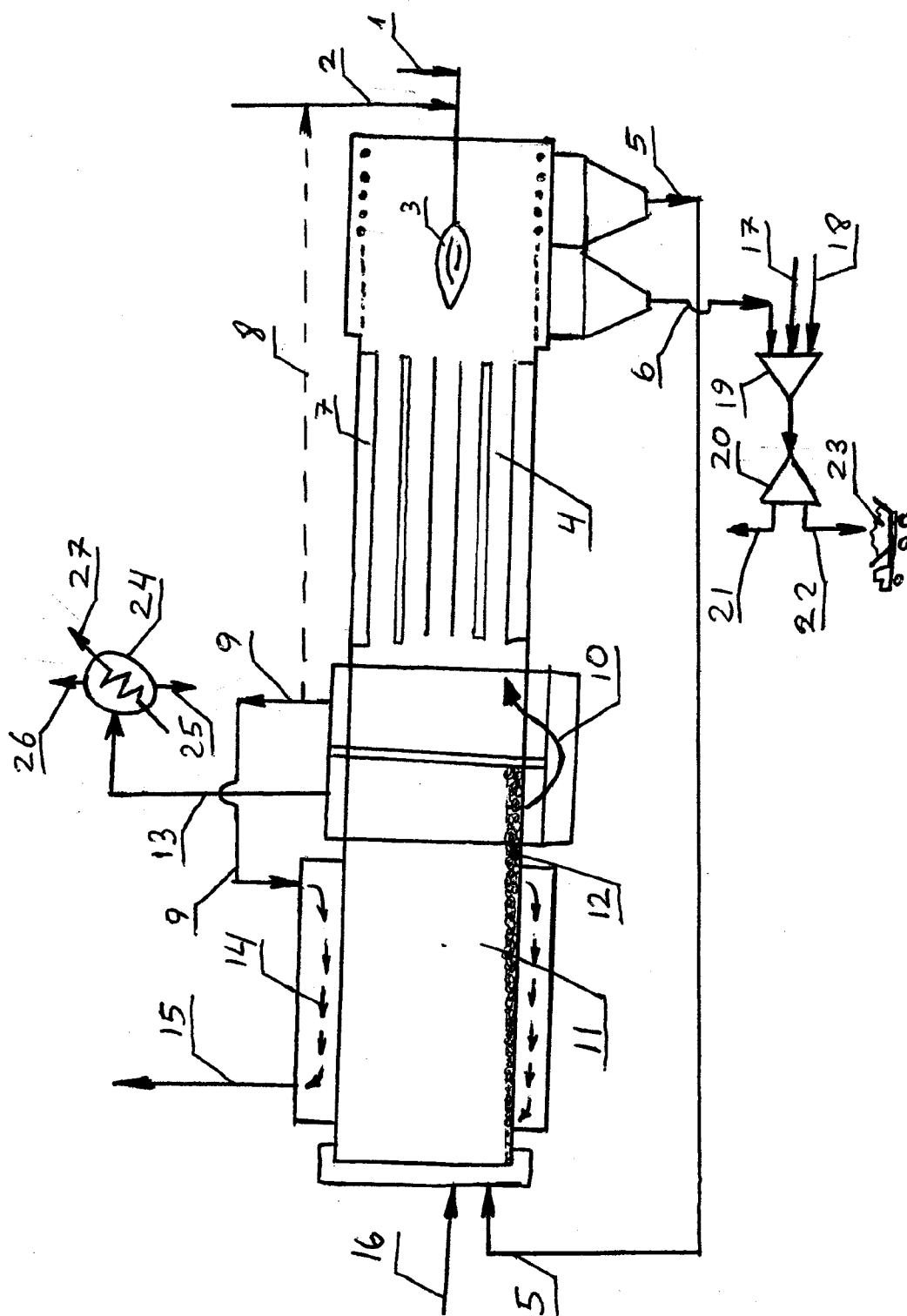


FIG. 11

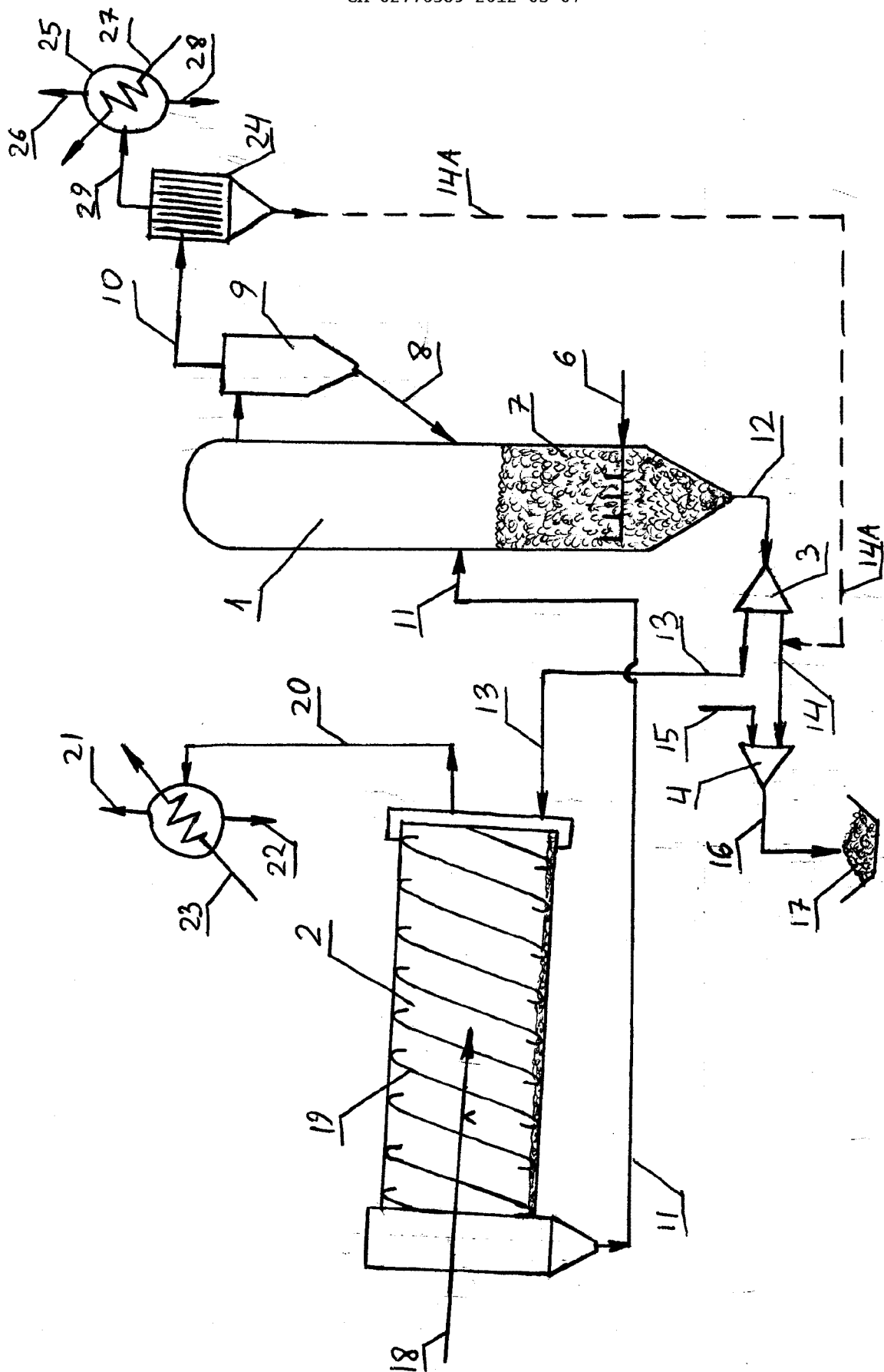


FIG. 11A

