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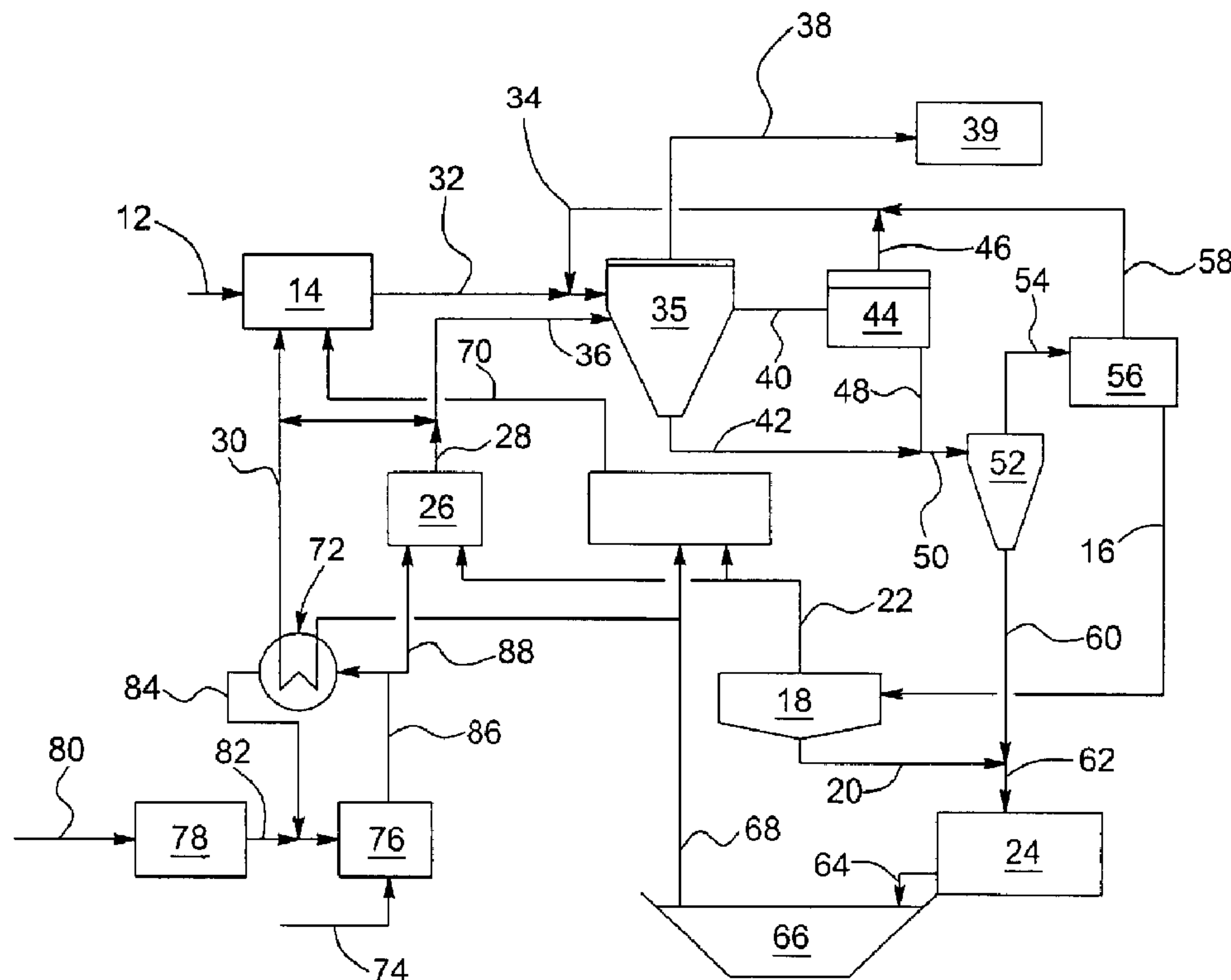
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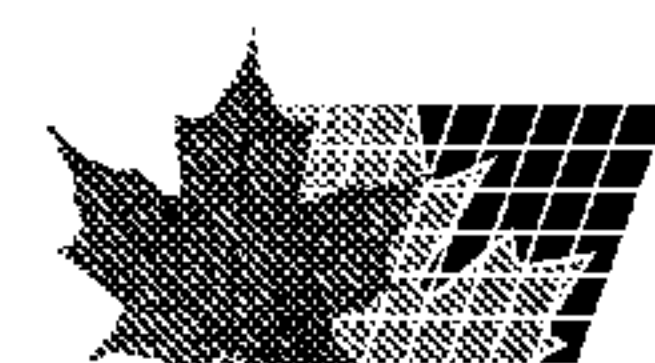
(54) **Titre : PROCÉDE D'INTEGRATION D'EAU ET DE CHALEUR POUR OPERATION DE SABLES BITUMINEUX AVEC INJECTION D'ÉCOULEMENT DIRECT DE TROP-PLEIN D'AGENT ÉPAISSISSEUR CHAUD**

(54) **Title: HEAT AND WATER INTEGRATION PROCESS FOR AN OIL SAND OPERATION WITH DIRECT STEAM INJECTION OF WARM THICKENER OVERFLOW**



(57) **Abrégé/Abstract:**

A heat and water integration process for an oil sands operation includes subjecting warm oil sands tailings to thickening to produce thickened tailings and warm water overflow; subjecting the warm water overflow to direct steam injection (DSI) to produce steam



(57) Abrégé(suite)/Abstract(continued):

heated thickener water; providing the steam heated thickener water to a unit of the oil sand operation; and producing the warm oil sands tailings from the oil sands operation. The oil sand operation unit may be an oil sand ore preparation unit and/or a primary separation unit, for example. The heated thickener water can replace water taken from pond inventories. The DSI may use excess, low quality, wet, low pressure and/or blow-down steam. The process enables improved heat and water usage in oil sands processing.

ABSTRACT

A heat and water integration process for an oil sands operation includes subjecting warm oil sands tailings to thickening to produce thickened tailings and warm water overflow; subjecting the warm water overflow to direct steam injection (DSI) to produce steam heated thickener water; providing the steam heated thickener water to a unit of the oil sand operation; and producing the warm oil sands tailings from the oil sands operation. The oil sand operation unit may be an oil sand ore preparation unit and/or a primary separation unit, for example. The heated thickener water can replace water taken from pond inventories. The DSI may use excess, low quality, wet, low pressure and/or blow-down steam. The process enables improved heat and water usage in oil sands processing.

HEAT AND WATER INTEGRATION PROCESS FOR AN OIL SAND OPERATION WITH DIRECT STEAM INJECTION OF WARM THICKENER OVERFLOW

FIELD OF THE INVENTION

- 5 The present invention generally relates to the field of oil sands processing and in particular relates to a heat and water integration process for reuse of hot thickener overflow water.

BACKGROUND

- 10 Oil sands processing requires hot water for a number of unit operations. In particular, oil sands ore preparation and primary separation cells require hot water.

It is known to recuperate water from fresh river sources or from large ponds used to store water previously used and affected by the oil sands processing. The recycle pond water can be heated and used in oil sands extraction operations, for example.

- 15 However, recycle process water contains a number of contaminants such as residual bitumen, suspended mineral solids and various salts. Due to the composition of recycle process water, heating in conventional indirect heating devices – such as shell and tube or plate heat exchangers – results in fouling of heat transfer surfaces. One known mitigation measure to combat this fouling is to
20 install exchanger areas to facilitate maintenance and cleaning of heat transfer areas.

- Thickeners are used in oil sands extraction and froth treatment operations to increase the solids concentration of an input stream and produce overflow water. Thickener overflow water has been considered for reuse in upstream extraction processes after being heated to desired temperatures. However, as thickeners are
25 prone to upsets, the variable composition of thickener overflow leads to fouling of heat exchanger transfer areas. Thickener water is viewed as having low quality heat making it unsuitable for many applications in oil sands processing.

Direct steam injection is also known for heating bitumen froth prior to froth treatment, as disclosed in Canadian patent No. 2,455,011 (Gaston et al.).

However, it has been generally viewed that direct steam injection is not suitable for several heating applications since the steam/condensate are lost to the process fluid, thus requiring higher upstream make-up water and water treatment requirements to compensate for the lost steam/condensate. This is particularly the case for steam generation systems that produce high quality steam, e.g. over 600 psia, for steam/power cogeneration applications. In these high quality steam generation systems, it is important to recycle a maximum amount of condensate for reuse as steam to maintain economic feasibility and such high quality steam/condensate is not misused for general stream heating.

In summary, known practices and techniques for providing hot water to oil sands operations have various drawbacks and inefficiencies, and there is indeed a need for a technology that overcomes at least some of those drawbacks and inefficiencies.

SUMMARY OF THE INVENTION

The present invention responds to the above-mentioned need by providing a process for heat and water integration of an oil sands extraction and bitumen production operation.

In one embodiment, the invention provides a heat and water integration process for an oil sands operation, comprising:

- subjecting an oil sands tailings stream to thickening to produce a thickened tailings component and a water overflow component;
- subjecting at least a portion of the water overflow component to direct steam injection to produce a steam heated thickener water;
- providing the steam heated thickener water to a unit of the oil sand operation; and
- producing the oil sands tailings from the oil sands operation.

In one aspect, the unit of the oil sand operation is selected from (i) an oil sand ore preparation unit and (ii) a primary separation unit.

In another optional aspect, the primary separation unit receives an oil sand slurry and froth for separation and at least a portion of the steam heated thickener water is used as froth under-wash in the primary separation unit.

5 In another optional aspect, the oil sand ore preparation unit receives oil sand ore and at least a portion of the steam heated thickener water is used as hot slurrying medium in the oil sand ore preparation unit.

In another optional aspect, the process includes supplying ambient recycle water from a pond to the unit of the oil sands operation.

10 In another optional aspect, the process includes combining a portion of the ambient recycle water with a portion of the warm water overflow component to produce a warm process water stream and supplying the warm process water stream to an oil sand ore preparation unit.

15 In another optional aspect, the process includes heating a portion of the ambient recycle water in a heat exchanger to produce a heated recycle water and supplying the heated process water to an oil sand ore preparation unit.

In another optional aspect, the process includes heating a portion of the ambient recycle water in a heat exchanger to produce a heated recycle water and supplying the heated process water to a primary separation unit.

20 In another optional aspect, the primary separation unit receives an oil sand slurry and froth for separation and at least a portion of the steam heated thickener water and the heated recycle water are combined and used as froth under-wash in the primary separation unit.

25 In another optional aspect, the process includes providing steam from a central steam source; using a first portion of the steam in the direct steam injection; and using a second portion of the steam for heating the ambient recycle water in the heat exchanger.

In another optional aspect, the warm water overflow component has a temperature between about 20°C and about 45°C higher than the recycle pond water.

30 In another optional aspect, the direct steam injection heats the warm water overflow component from an initial temperature between about 20°C and about 50°C to a

temperature of the steam heated thickener overflow between about 70°C and about 90 °C.

In another optional aspect, the temperature of the steam heated thickener overflow is between about 75°C and about 85°C.

- 5 In another optional aspect, the direct steam injection has a steam input between about 20 to 90 kG/ t of oilsand.

In another optional aspect, the steam input is between about 150 tonnes/hr and about 300 tonnes/hr.

- 10 In another optional aspect, the direct steam injection comprises maintaining sufficient backpressure on the steam heated thickener water downstream of the direct steam injection so as to sub-cool the warm water overflow component.

In another optional aspect, the direct steam injection uses steam selected from the group consisting of excess steam, low quality steam, wet steam, low pressure steam and blow-down steam.

- 15 In another optional aspect, the direct steam injection uses steam having a pressure at least 45 psia.

In another optional aspect, the direct steam injection uses steam containing non-condensable gases.

In another optional aspect, the direct steam injection uses saturated steam.

- 20 In another optional aspect, the direct steam injection uses steam generated by a low pressure boiler.

In another optional aspect, the direct steam injection uses steam generated from condensate blowdown.

- 25 In another optional aspect, the process includes providing a knock-out or steam trap system upstream of the direct steam injection.

In another optional aspect, the process is conducted at least in wintertime.

- The invention also provides a system for implementing the process and its embodiments as described above and herein. The system includes a thickener that produces a thickened tailings component and a warm water overflow component, a
30 direct steam injection device for subjecting at least a portion of the warm water

overflow component to direct steam injection to produce a steam heated thickener water; a unit of the oil sand operation for receiving at least part of the steam heated thickener water.

5 BRIEF DESCRIPTION OF THE DRAWINGS

Fig 1 is a process flow diagram of a bitumen production operation with direct steam injection (DSI) for hot thickener water.

Fig 2 is a process flow diagram of a bitumen extraction operation with hot thickener water DSI heating and integration.

- 10 Fig 3 is a process flow diagram of a froth treatment operation with a thickener for the froth treatment tailings.

DETAILED DESCRIPTION

- 15 Fig 1 illustrates an embodiment of the process of the present invention. In this embodiment, a bitumen production operation 10 receives oil sand 12 and produces a bitumen product 14. The bitumen production operation 10 also receives other process streams and produces output streams. One output stream is a warm tailings stream 16, which contains mineral solids such as sand, silt and clay, residual bitumen and components thereof and water in varying proportions depending on the particular source and processing conditions that generated the tailings.

- 20 In one aspect, the warm tailings stream 16 is produced by a tailings solvent recovery unit (TSRU) for treating the solvent diluted tailings from a bitumen froth separation unit (FSU). The TSRU recovers the solvent from the solvent diluted tailings and generates TSRU tailings. In another optional aspect, the warm tailings stream 16 is derived from middlings and/or bottoms of a primary separation vessel (PSV). More
25 regarding the source of the warm tailings stream 16 and related reutilization of water and heat will be discussed further herein-below.

- Referring to Figs 1 and 2, the warm tailings stream 16 is supplied to a thickener 18 for producing a thickener underflow component 20 and a warm water overflow component 22. The thickener 18 may have a variety of constructions and structural
30 or operational aspects to achieve the separation. In one operational aspect, the

thickener is as generally described in Canadian patent application No. 2,454,942 (Hyndman et al.), though it may alternatively have various other constructions. The thickener may produce only the thickener underflow component 20 and the warm water overflow component 22 or it may have other outlets for producing additional streams such as a recovered hydrocarbon stream (not illustrated).

The thickener underflow component 20 may then be provided to a tailings disposal equipment or piping 24 and eventually be fed to a tailings pond.

The warm water overflow component 22 is subjected to direct steam injection (DSI) 26 to produce steam heated process water 28. The steam heated process water 28 can then be used in the bitumen production operation 10.

Fig 1 illustrates an embodiment wherein the DSI 26 is used to heat thickener overflow water 22 by direct steam injection and the steam heated process water 28 is used as hot process water within the bitumen production process area.

Fig 2 illustrates an embodiment wherein the DSI 26 is used to heat thickener overflow water 22 by direct steam injection and the steam heated process water 28 is used as hot process water in an ore preparation area and as froth wash water in a primary separation vessel (PSV).

It is noted that the figures do not show miscellaneous extraction process water connections for mixing, flushing, etc., which are present in a bitumen extraction operation.

Referring to Fig 2, the oil sand 12 is mixed with hot process water 30 which may contain excess steam heated thickener overflow 28 to form oil sand slurry 32 that is conditioned, i.e. liberates the bitumen from the sand in a conditioning slurry pipeline. It is noted that other names such as hydro-transport slurry pipeline are used in literature. In the illustrated embodiment, flotation froth 34 from a downstream unit is injected into the conditioned oil sand slurry 32 upstream of the separation cell 35 (also referred to as a "primary separation vessel (PSV)" and "sep cell" herein). An amount of the steam heated process water 28 may be added to the sep cell as froth under-wash 36 to improve the froth quality by washing and heating the bitumen froth as it rises through a hot water layer. In order to stabilize the hot water layer within the sep cell, the water temperature is higher than the feed slurry, preferably 10°C higher and still preferably 20°C higher. The sep cell 35 produces a bitumen froth

overflow 38 that is transferred to froth treatment 39. Note that the bitumen production module 10 of Fig 1 encompasses froth treatment in which steam is a utility.

Referring to Fig 2, the sep cell 35 also produces a middlings stream 40 and a
5 bottoms stream 42. Preferably, the middlings stream 40 is subjected to middling flotation 44 to produce flotation tailings 48 and middling flotation froth 46 to make up part of the flotation froth 34. The middling floatation 44 may be conventional or column floatation.

The sep cell bottoms tailings 42 are combined with the middling flotation tailings 48
10 and the combined stream 50 is fed to a tailings cyclones 52. Cyclone overflow 54 is processed by final flotation 56 (either conventional or column) to recover the remaining portion 58 to make up the flotation froth 34.

In one aspect, the warm tailings stream 16 is at least partially produced as underflow from the final floatation unit 56 which treats derivative middlings and
15 bottoms streams from the sep cell 35. The warm tailings stream 16 is processed by one or more thickeners 18 for water and heat recovery.

The thickeners 18 may also recover water from other warm tailings streams including froth treatment tailings (also referred to as TSRU tailings). A portion of recovered thickener water 22 is DSI heated and used where possible to minimize
20 heat and water requirements from cold recycle water and indirect steam heat exchangers. The steam heated thickener water 28 is employed as warm process water in extraction for flushing and other process operations.

Still referring to Fig 2, the thickened tailings 20 from the thickener 18 are combined with cyclone tailings 60 as overall extraction tailings 62 that are transferred to the
25 tailing disposal area 24. Tailing water 64 is collected in a tailings pond 66 where suspended minerals settle and the tailings water cools to ambient conditions for reuse in bitumen extraction as recycle water 68.

Recycle water 68 is returned to extraction for general use as extraction water 70 (generally cold for flush purposes) and heated by steam heat exchangers 72 for use
30 as hot process water 30 in ore preparation and optionally as part of the froth underwash water 36. The steam heat exchangers 72 use natural gas 74 or other fuel sources supplied to steam boilers 76. A water treatment plant 78 treats water

make-up 80, typically river water, to produce treated water 82, so as to maintain condensate inventory for steam production. Condensate 84 from the steam heat exchangers 72 is recycled to steam boilers 76 to produce steam 86.

In one preferred aspect of the present invention, the steam used for the DSI is
5 selected from excess, low quality, wet, low pressure or blow-down steam. For instance, low quality, wet or low pressure steam which are not suited to many oil sand processing applications may be advantageously used for heating the thickener overflow water to produce steam heated thickener water which has high quality heat for reuse in extraction or production processes. In addition, in large oil sand
10 processing facilities in which large amounts of steam are generated, there is a corresponding large amount of condensate generated and blowdown is periodically required. This excess blowdown condensate may be used to generate steam for thickener water DSI effectively dumping the blowdown condensate into the thickener water. Furthermore, the steam may be generated by retrofitting a plant with a low
15 pressure boiler or the like along with a thickener for recovering heat and water from the oil sand processing operation for recycling. Retrofitting oil sand plants with a boiler and thickener enables the water recovered as thickener overflow to offset the water lost as condensate in DSI, in addition to the low quality heat recovery from the thickener. Understanding of the overall plant allows matching appropriate steam and
20 condensate streams with the DSI heating of thickener overflow water. In some embodiments, condensate that would otherwise be dumped is recycled as steam into the thickener water for heating and reuse in oil sand processing operations. In one aspect, the DSI steam used for thickener water heating has a temperature between 140 to 215 °C and a pressure between 50 and 400 psia and may contain
25 non-condensable gases such as carbon dioxide, air and the like that may be purged to maintain condensing steam heat exchangers. There may be a knock-out or steam trap system (not illustrated) just upstream of the DSI unit. The knock-out or steam trap system may be used to remove water from the steam, for example when above 10-15% water, and the removed water may be recycled back into the process.

30 The excess thickener overflow water 22 is thus heated by DSI units 26 that may be operated in series or parallel. The arrangement of series or parallel DSI permits selective heating of excess thickener water to match specific temperature requirements for the end use of the steam heated process water. For example, the

steam heated thickener water 28 supplied as froth under-wash 36 would be heated to the temperature needed for cleaning/heating the froth 34 separated in the sep cell 35.

For DSI operations, the water treatment capacity to supply treated water 80 is increased to reflect the lost condensate associated with the portion of the steam injected as direct injection steam 88 into the DSI units.

The DSI heating of thickener overflow water for reuse in the oil sand extraction or bitumen production operation reduces capital as DSI unit have a lower cost compared to exchangers, improves reliability for instance due to no fouling of exchanger surfaces and recovery of both heat and water via the thickener. Thickeners are prone to upsets leading to thickener water with variable compositions which can cause abrupt increases in solids or hydrocarbon content causing fouling of heat exchanger surfaces. DSI allows robust heating of thickener overflow water to replace or offset conventional heat exchanged hot process water from recycle pond water. In addition, the thickener water is provided about 20°C to about 45°C hotter than the ambient temperature of recycle water, since tailings ponds cool tailings water while allowing suspended solids to settle out to mature fine tailings. It is also noted that overflow water from thickeners are further advantageous in this respect since the flow rates of the thickener overflow streams is sufficiently moderate that the increase make-up water required for the DSI heating is exceeded by the cost and efficiency savings achieved by the process of the present invention. Large volumes of water to be DSI heated would experience erosion of the cost advantage due to the increased make-up water to produce steam. It is also noted that, in one aspect, the thicker overflow DSI heating complements existing exchanger heating arrangements since the quantity of water produced by the thickener normally will not replace all the exchangers. Thus, there is a combination of DSI and exchanger heaters for providing the hot water requirements to the bitumen production and oil sand extraction operations. This equipment mix also provides mutual redundancy.

In another optional aspect, the water make-up 80 may be supplied from the recycle water system which would thus provide a closed loop on water usage, i.e. no net water import to the system.

It is also noted that the DSI heating may be conducted in a manner as disclosed in Canadian patent application No. 2,735,311 (van der Merwe).

DSI units also rely on steam at pressures above the water pressure. Where this steam is produced by boilers that require high quality condensate for reliable operation, steam production is associated with significant utility infrastructure for the recovery of steam condensate and make-up water treatment. As DSI units can utilize purged steam with non-condensables without infrastructure to return condensate, the DSI provides an alternate process method for recovery and reuse of the energy in low quality steam and minimize costs associated with infrastructure.

Referring now to Fig 3, in another embodiment, the thickener 18' may be associated with a froth treatment operation 39 to thicken froth treatment tailings. The bitumen froth 38 is fed to a dearator 89 and then to primary and secondary stage froth separation units 90, 92 which are arranged in a counter-current configuration. Fresh solvent 94 which may be paraffinic or naphthenic is added to the second stage froth separation unit 92. The high diluted bitumen 96 is treated in a solvent recovery unit which may include two flash vessels 98, 100 to produce recovered solvent 102 and solvent recovered bitumen 104. The second stage froth separation unit 92 produces an underflow 106 that is solvent diluted tailings which are treated in a tailings solvent recovery unit which may include first and second stage flash or stripping vessels 108, 110 to recover solvent stream 111. These stripping vessels 108, 110 may be fed with steam 112. The solvent recovered tailings 114 from the second stage stripping vessel 110 may be provided as the warm tailings stream 16 to the thickener 18'.

Engineering studies and calculations were effectuated for average conditions to identify direct steam injection for thickener overflow water for reducing energy in terms of steam requirements to supply hot process water with a temperature of 85°C which is typical for use in oil sands ore preparation. The steam was considered with an enthalpy of 571 kJ/kg. Note that t/t refers to metric tonnes per metric tonnes.

	Process water recycled from tailings pond	0.792 t/t oilsand
30	Total Hot Process Water (HPW) for extraction	0.40 t/t oilsand
	Warm Process Water recovered from thickener	0.48 t/t oilsand
	Excess Warm Process Water (WPW) without DSI	0.085 t/t oilsand

HPW for froth under wash (FUW)	0.062 t/t oilsand
Steam for hot process water without DSI	575 kg/t oilsand
Steam for FUW with DSI	48 kg/t oilsand
Total Steam for HPW with DSI to FUW	533 kg/t oilsand

- 5 The analysis identified the application of DSI units for heating warm process water recovered from extraction thickeners reduces the energy required for processing oil sand and improves the overall efficiency for bitumen extraction. It is noted that this calculation data has not been optimized and it should be understood that additional energy may be recovered in variants of the present invention, for instance by finding
- 10 additional uses for the heated thickenner water in other oil sands process units and applications.

Finally, it should be understood that the present invention is not limited to the embodiments, aspects, examples and figures.

CLAIMS

1. A heat and water integration process for an oil sands operation, comprising:
 - subjecting an oil sands tailings stream to thickening to produce a thickened tailings component and a water overflow component;
 - subjecting at least a portion of the water overflow component to direct steam injection to produce a steam heated thickener water;
 - providing the steam heated thickener water to a unit of the oil sand operation; and
 - producing the oil sands tailings from the oil sands operation.
2. The heat and water integration process of claim 1, wherein the unit of the oil sand operation is selected from (i) an oil sand ore preparation unit and (ii) a primary separation unit.
3. The heat and water integration process of claim 2, wherein the primary separation unit receives an oil sand slurry and froth for separation and at least a portion of the steam heated thickener water is used as froth under-wash in the primary separation unit.
4. The heat and water integration process of claim 2, wherein the oil sand ore preparation unit receives oil sand ore and at least a portion of the steam heated thickener water is used as hot slurring medium in the oil sand ore preparation unit.
5. The heat and water integration process of claim 1, comprising supplying ambient recycle water from a pond to the unit of the oil sands operation.
6. The heat and water integration process of claim 5, comprising combining a portion of the ambient recycle water with a portion of the water overflow component to produce a process water stream and supplying the process water stream to an oil sand ore preparation unit.

7. The heat and water integration process of claim 5, comprising heating a portion of the ambient recycle water in a heat exchanger to produce a heated recycle water and supplying the heated process water to an oil sand ore preparation unit.
8. The heat and water integration process of claim 5, comprising heating a portion of the ambient recycle water in a heat exchanger to produce a heated recycle water and supplying the heated process water to a primary separation unit.
9. The heat and water integration process of claim 8, wherein the primary separation unit receives an oil sand slurry and froth for separation and at least a portion of the steam heated thickener water and the heated recycle water are combined and used as froth under-wash in the primary separation unit.
10. The heat and water integration process of any one of claims 7 to 9, comprising:
 - providing steam from a central steam source;
 - using a first portion of the steam in the direct steam injection; and
 - using a second portion of the steam for heating the ambient recycle water in the heat exchanger.
11. The heat and water integration process of any one of claims 5 to 10, wherein the water overflow component has a temperature between about 20°C and about 45°C higher than the recycle pond water.
12. The heat and water integration process of any one of claims 1 to 11, wherein the direct steam injection heats the water overflow component from an initial temperature between about 20°C and about 50°C to a temperature of the steam heated thickener overflow between about 70°C and about 90 °C.
13. The heat and water integration process of claim 12, wherein the temperature of the steam heated thickener overflow is between about 75°C and about 85°C.

14. The heat and water integration process of any one of claims 1 to 13, wherein the direct steam injection has a steam input between about 20 to 90 kG/ t of oilsand.

15. The heat and water integration process of claim 14, wherein the steam input is between about 150 tonnes/hr and about 300 tonnes/hr.

16. The heat and water integration process of any one of claims 1 to 15, wherein the direct steam injection comprises maintaining sufficient backpressure on the steam heated thickener water downstream of the direct steam injection so as to sub-cool the water overflow component.

17. The heat and water integration process of any one of claims 1 to 16, wherein the direct steam injection uses steam selected from the group consisting of excess steam, low quality steam, wet steam, low pressure steam and blow-down steam.

18. The heat and water integration process of any one of claims 1 to 17, wherein the direct steam injection uses steam having a pressure at least 45 psia.

19. The heat and water integration process of any one of claims 1 to 18, wherein the direct steam injection uses steam containing non-condensable gases.

20. The heat and water integration process of any one of claims 1 to 19, wherein the direct steam injection uses saturated steam.

21. The heat and water integration process of any one of claims 1 to 20, wherein the direct steam injection uses steam generated by a low pressure boiler.

22. The heat and water integration process of any one of claims 1 to 21, wherein the direct steam injection uses steam generated from condensate blowdown.

23. The heat and water integration process of any one of claims 1 to 22, comprising providing a knock-out or steam trap system upstream of the direct steam injection.

24. The heat and water integration process of any one of claims 1 to 23, wherein the process is conducted at least in wintertime.

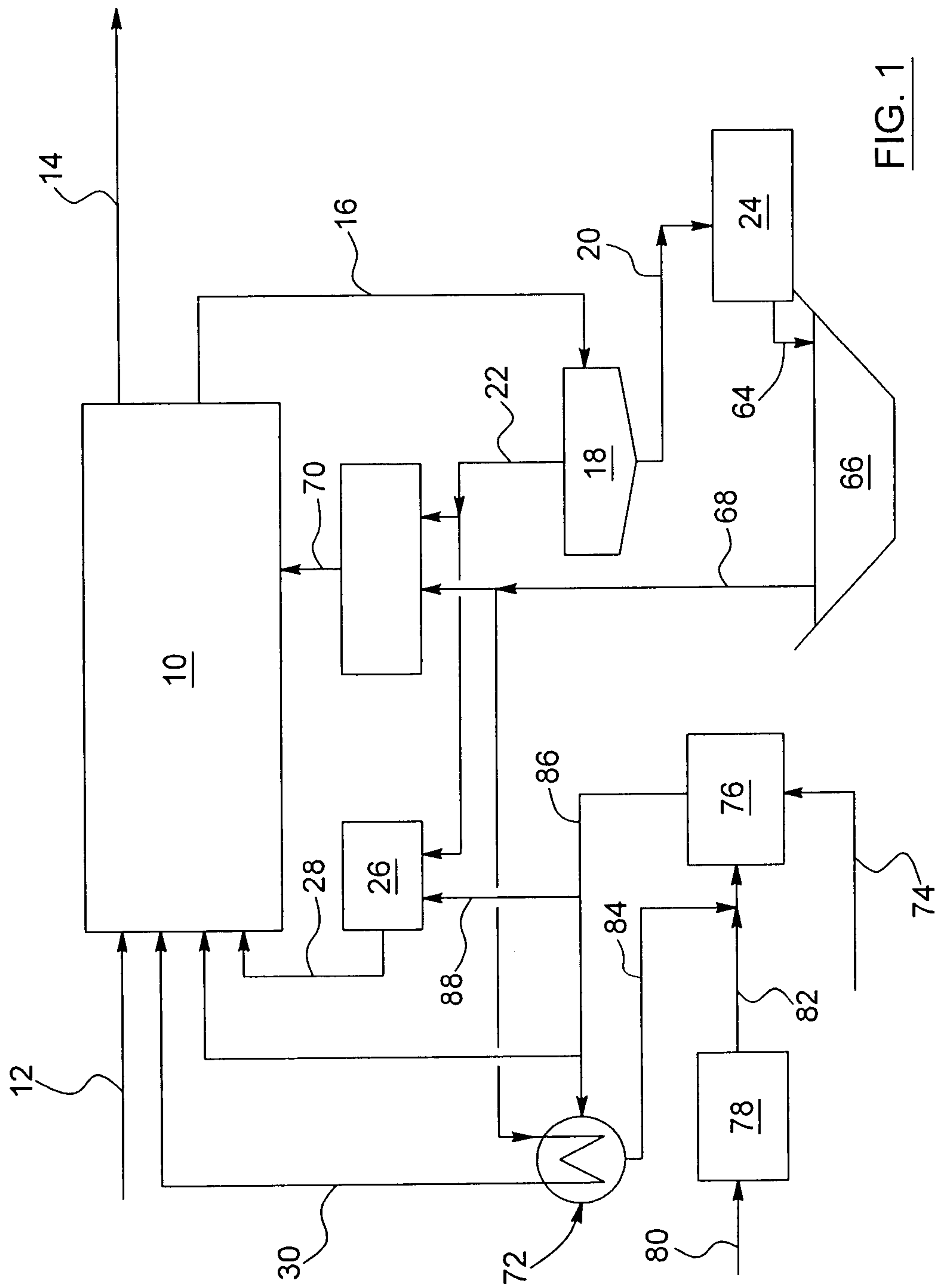


FIG. 1

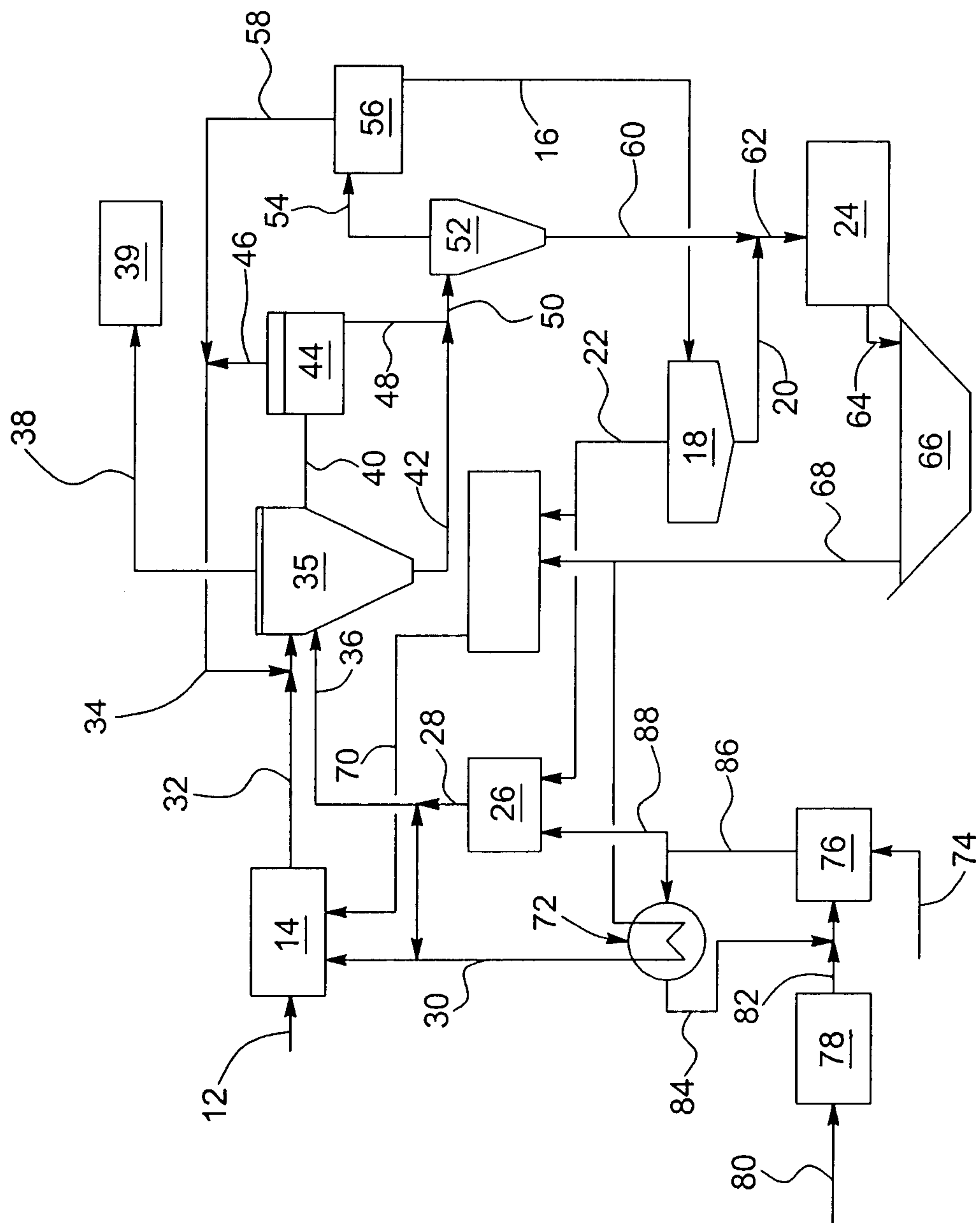


FIG. 2

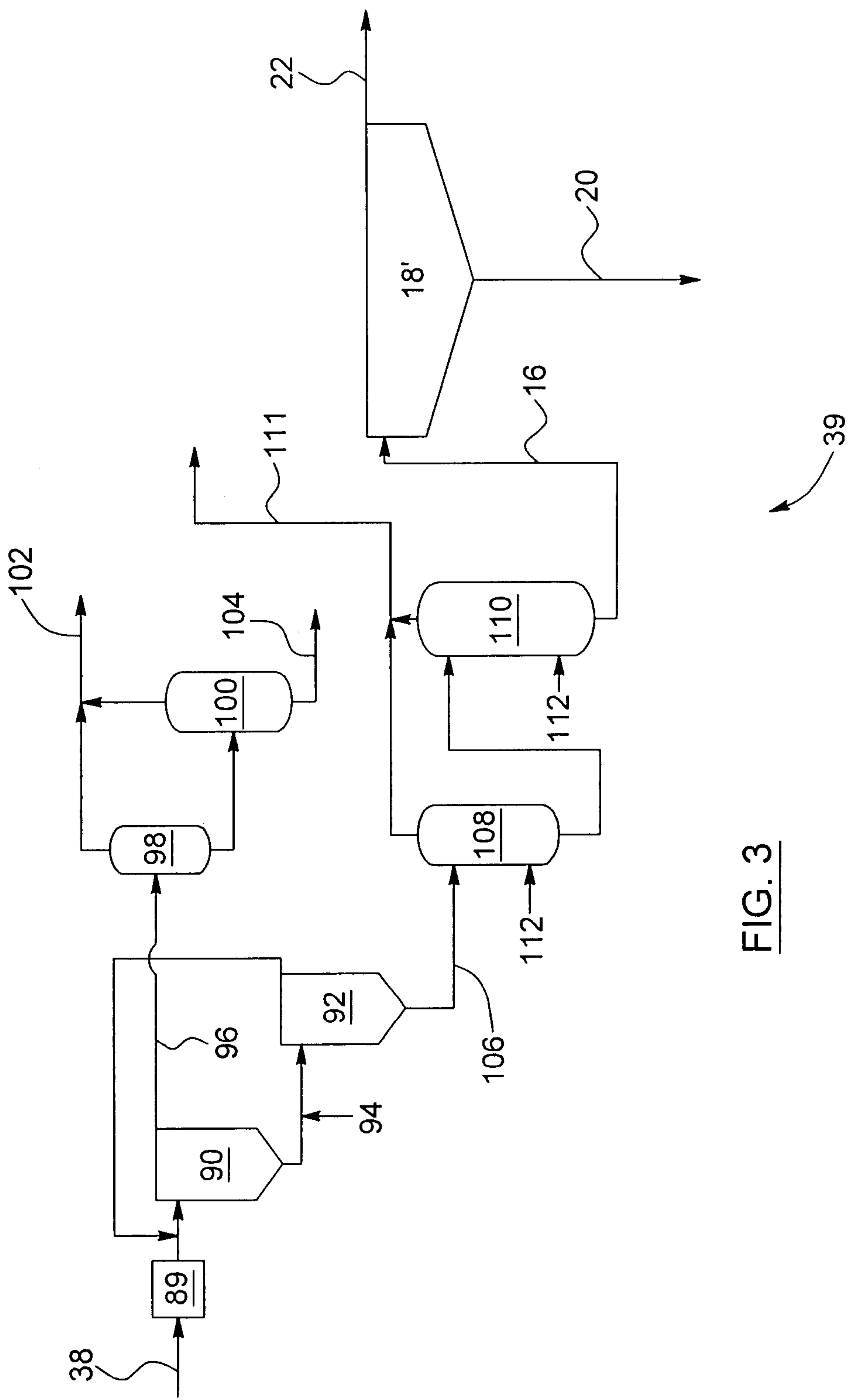


FIG. 3

