

(51) International Patent Classification:
B03D 1/02 (2006.01)(21) International Application Number:
PCT/CA2014/050666(22) International Filing Date:
14 July 2014 (14.07.2014)

(25) Filing Language: English

(26) Publication Language: English

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602 - 12th Avenue SW, Calgary, Alberta T2R 1J3 (CA).(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM,
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM,
ZW.(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

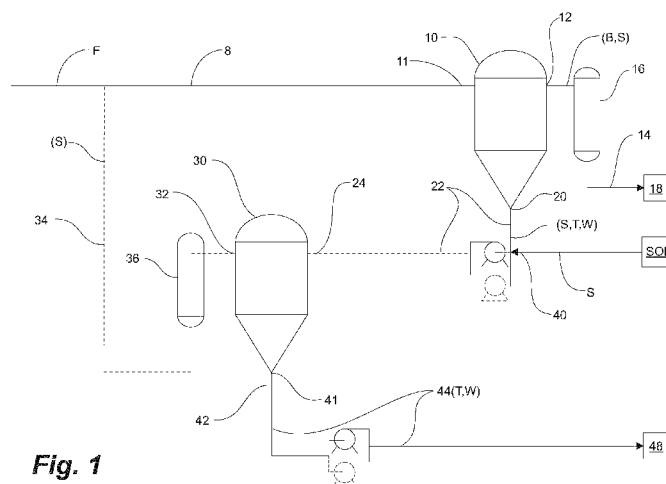
(54) Title: SINGLE-STAGE BACKUP TRANSITIONAL ARRANGEMENT FOR PARTIALLY OFFLINE MULTI-STAGE
FROTH SEPARATION UNITS

Fig. 1

(57) Abstract: A method for temporarily bypassing an offline oilsand froth settling unit (FSU) of a multi-stage FSU system in the event of failure of the offline FSU while maintaining operability, maximizing separation performance and minimizing propagation of the disturbance to other systems. The offline FSU is isolated and the underflow stream of the remaining operational stage is split between a reject stream directing solids and water to a tailing solvent recovery unit and a solvent-enriched recycle stream for comingling with bitumen froth as a feedstream to the inlet to the operational FSU. Solvent addition stream is re-routed from inter-stage addition to bypass the reject tailings stream and join the recycle stream, aiding in continued FSU operation for separation of maltenes and solvent from rejected solids and water. Dilbit product is recovered from the online FSU.

“SINGLE-STAGE BACKUP TRANSITIONAL ARRANGEMENT FOR PARTIALLY OFFLINE MULTI-STAGE FROTH SEPARATION UNITS”

FIELD

Embodiments disclosed herein relate to vessels for separation of components of slurries, and more particularly, to multi-stage vessel and method of use for separation of components of a bitumen froth therein.

BACKGROUND

Many industrial processes require solid particles to be separated from a continuous liquid phase. In gravity separators, a slurry stream comprising liquid and solid particles is delivered to a vessel where the solid particles settle by gravity and are removed from the bottom of the vessel, while the clarified liquid is removed from the top of the vessel.

In the case of bitumen recovery, mined oilsand is typically mixed with warm water. The resulting slurry is piped to a primary gravity separation cell or separation vessel (PSV) where the coarse solids fall to the bottom, a middlings stream containing some bitumen, fine solids and water is removed from the middle of the vessel, and a froth containing bitumen, water and some fine mineral solids is removed from the top of the PSV. Typically, the froth comprises about 60% bitumen, 30% water and 10% fine solids.

The froth is further processed for removal of water and solids from the bitumen to permit further processing of the bitumen. It is known to use centrifuges, gravity separation vessels and inclined plate settlers to separate the bitumen from

1 the water and the solids. The froth is typically diluted with a hydrocarbon solvent to
2 reduce the viscosity and density of the oil phase prior to this further processing.

3 One such known froth separation process is taught in Canadian
4 Patent 2,502,329 to Tipman et al. In this case, multiple stages of separation occur in
5 three separate froth separation vessels which are utilized in a counter-current
6 process for removal of water and solids from bitumen froth. Bitumen froth is diluted
7 with solvent and added to the first froth separation vessel. The underflow is
8 removed, mixed with additional solvent and is pumped to the second froth
9 separation vessel. The overflow from the second vessel is returned to the first
10 vessel and the underflow is mixed with additional solvent and is pumped to the third
11 froth separation vessel. The overflow from the third vessel is pumped to the second
12 vessel and the underflow is removed for tailings handling. The overflow from the
13 first vessel is removed to a separation vessel for removal of solvent therefrom and
14 the bitumen recovered is pumped to a facility for upgrading.

15 It is known to use one or the other of naphthenic and paraffinic
16 solvents to reduce the viscosity and density of the oil phase of bitumen froth. As a
17 hydrocarbon, bitumen predominately comprises maltenes, the marketable
18 component, and some asphaltenes. In the case of paraffinic solvents, when
19 sufficient solvent is added, much of the asphaltenes aggregate upon contact
20 between the solvent and the heavy hydrocarbon fraction. Large aggregates
21 typically form between the water droplets, mineral solids and the rejected
22 asphaltenes. Formation of aggregates aids in separation of the bitumen and
23 solvent from the solids, including both aggregates and mineral solids, and water.

Thus, conventional methods of separation are typically costly, require multiple pumps and other auxiliary equipment and require large volumes of solvent commensurate with the number of separation units employed.

Further, due to the difficult nature of the materials handled, particularly tailings related streams, oilsands operations are subject to and sensitive to periodic interruptions in materials handling. Such interruptions domino wherein a backup of, or failure of, a single-stage can quickly and negatively affect additional stages. Further, even a short interruption can lead to vessel operation failure with vessels and piping blocked with solids.

The settling units known as froth separation units (FSUs) produce a bitumen and solvent overflow and a solids and water underflow. The overflow is directed to a solvent recovery unit (SRU) to separate bitumen and solvent, and the underflow is directed to a tailing solids recovery unit (TSRU). The nature of the materials passing through the TSRU is that periodic failures unfortunately occur, causing a chain reaction of failures back to the FSU and a costly shutdown.

There is therefore an interest in froth separation apparatus and methods which are cost and energy effective, have a smaller footprint, and have means for recovery from interruptions.

SUMMARY

Embodiments disclosed herein enable a multi-stage FSU system to be reorganized for operation on one FSU. Reorganization or restructuring of the process streams includes bypassing one or more other stages in the event of at

1 least one FSU being compromised. A single-stage backup transitional arrangement
2 is provided for instances when multi-stage FSU's go partially offline. Continued
3 operation with a single stage FSU maintains operability and maximizes separation
4 at performance approximating that of the multi-stage operations. Accordingly,
5 despite localized disruption due to one stage of a multi-stage FSU system going
6 offline for one reason or another, propagation of the disturbance to other connected
7 systems is minimized, both upstream and downstream of the FSU system. A
8 reliable method for a transitional bypass circuit around the offline FSU is provided at
9 low cost and with convenience.

10 In a conventional two-stage FSU embodiment, and using paraffinic
11 solvent, recovery of the maltene portion of the bitumen froth feedstream can reach
12 98%. Using the bypass embodiments described herein, maltene recovery can be
13 maintained in the order of about or greater than 95% while repair operations
14 facilitate a return to two-stage operation.

15 FSU failure, such as due to plugging, pump failure and the like, can
16 take a considerable time to resolve, impacting production and the operability of
17 upstream and downstream facilities. More than a mere bypass, the remaining FSU
18 or FSU's are capable of sustained operation at a substantially full process flow
19 capacity until such time as the problem FSU is back online.

20 In one embodiment, two-stages of FSU are protected by a process
21 arrangement permitting single-stage operation. One area of frequent failure is in
22 downstream handling of tailings, typically coupled downstream of the second-stage
23 of a two-stage system or the last stage of a multi-stage FSU system. Thus, in

1 arrangements disclosed herein, the second or last stage can be bypassed. While
2 early stages are less vulnerable, such operational units are still subject to various
3 mechanical or process failures. Therefore, as contemplated herein, arrangements
4 include instances in which the first-stage FSU can go offline, and transitional bypass
5 arrangements are herein provided to enable continued backup operations on the
6 second or latter stage FSU alone, bypassing the first-stage FSU.

7 Applicant favors two-stages of FSU, a greater number of stages
8 requiring proportionally greater capital costs. Accordingly, while first, intermediate
9 or latter stages of multi-stage systems can be bypassed for operation on other
10 stages of the system, embodiments are described herein in the context of two-stage
11 FSU systems.

12 In an aspect, at least due to the difficult handling of underflow
13 materials, two or more redundant underflow pumps or a series of pumps are
14 provided in parallel for at least the vulnerable stage of the multi-stage system. One
15 or more of the pumps are made available in standby mode in the event of a failure
16 of the other on-stream pump, including for normal operations in two-stage mode. Of
17 note, in the event a single-stage of a multi stage FSU system goes offline, the
18 underflow pump or pumps of the remaining operational stage are required to handle
19 a higher recirculatory flow, including recirculation of a portion of the underflow
20 tailings stream. Accordingly, in another aspect, the two or more redundant
21 underflow pumps are sized so that each of series of pumps independently can
22 manage the increased recirculatory stream flow in the event of the loss of one
23 stage. Alternatively, the capacity of each pump stream is maintained as

1 conventionally designed for normal backup, parallel operation, however both are
2 simultaneously pressed into service together for use in tandem for enabling
3 increased recirculatory capacity when required.

4 Accordingly, for complete flexibility to react to either stage failing, one
5 provides first and second redundant underflow pumps at the first and second
6 underflow streams respectively. In the case of the operation of the first FSU, one
7 operates at least one of the first redundant pumps for normal delivery of the first
8 underflow stream to the second FSU in normal multi-stage FSU operations. If the
9 second FSU goes offline, one operates both of the first redundant pumps for
10 delivery of an increased recirculating flow of the first underflow stream to first and
11 second bypass streams for single-stage FSU operations.

12 In short, the remaining operational stage or stages of the FSU system
13 has its ultimate underflow stream split between a reject tailing stream directing
14 solids and water to a downstream TSRU and to a recycle stream, including solvent
15 enrichment, directed back to the inlet of the operational FSU. The usual stream of
16 the solvent addition is re-routed to bypass the reject tailings stream for exclusively
17 joining and solvent-enriching the recycle stream, aiding in FSU operation for
18 separation of maltenes and solvent from solids and water.

19 In one broad aspect then, a method of operating a system of two-
20 stages of froth separation units (FSU) as a single-stage FSU system is provided.
21 Froth comprising bitumen, mineral solids and water and separation of the froth
22 normally occurs in the two-stage froth separation system for producing a dilbit
23 product stream of bitumen and solvent, a solvent-enriched recycle stream for

1 comingling with the bitumen froth to form a diluted bitumen froth as a feedstream to
2 the system, and a reject tailings stream of predominately mineral solids and water.
3 In normal operations, the two-stage FSU system is operated by receiving the
4 feedstream at a first inlet to a first-stage FSU for producing the dilbit product stream
5 at a first product outlet and a first underflow stream directed to a second inlet of a
6 second-stage FSU, adding solvent to the first underflow stream before the second
7 inlet, and producing a second product stream at a second product outlet of the
8 second-stage FSU for forming the recycle stream and a second underflow stream at
9 a second underflow outlet forming the reject tailings stream.

10 The two-stage FSU system can be operated as a single-stage FSU
11 system for bypassing an offline FSU of the two-stage FSU, comprising: isolating the
12 offline FSU at the offline product outlet, at the offline inlet, and at the offline
13 underflow outlet; directing the froth to the inlet of the online FSU; splitting the
14 underflow stream of the online FSU into first and second bypass streams; and re-
15 directing the solvent addition to the first bypass stream, wherein the first bypass
16 stream forms the solvent-enriched recycle stream to the online inlet, and the second
17 bypass stream forms the reject tailings stream.

18 In one aspect the offline FSU is the second-stage FSU and
19 accordingly, the one isolates the second-stage FSU at the second product outlet, at
20 the second inlet, and at the second underflow outlet; splits the first underflow stream
21 into the first and second bypass streams; and re-directs the solvent addition to the
22 first bypass stream, wherein the first bypass stream forms the solvent-enriched
23 recycle stream to the first inlet and the second bypass stream forms the tailings

1 stream. The froth remains directed to the first inlet. The flow rate of the first and
2 second bypass streams can be split about 50:50 by volume. Further, one can
3 provide redundant underflow pumps at the underflow stream of the operating FSU
4 for management of the higher recirculatory flow rates of the first bypass stream
5 during single-stage FSU operations.

6 In another aspect, when the offline FSU is the first-stage FSU, one
7 isolates the first-stage FSU at the first product outlet, at the first inlet, and at the first
8 underflow outlet; directs the feedstream to the second inlet; splits the second
9 underflow stream into the first and second bypass streams; and re-directs the
10 solvent addition to the second bypass stream, wherein the first bypass stream forms
11 the recycle stream and the second bypass stream forms the tailings stream.

12 BRIEF DESCRIPTION OF THE DRAWINGS

13
14 Figure 1 is a flow diagram of a two-stage froth separation system, for
15 separation of at least bitumen, solids and water from a bitumen froth using utilizing
16 two froth settling or separation units (FSU);

17 Figure 2A is a flow diagram of the two FSU's according to Fig. 1
18 wherein a second FSU is offline and the system is re-configured for sole operation
19 of a first-stage FSU;

20 Figure 2B is a flow diagram of the two FSU's according to Fig. 1
21 wherein the first-stage FSU is offline and the system is re-configured for sole
22 operation of the second FSU; and

Figure 3 is a graph illustrating an example of the effect of production rates on maltene recovery using a backup bypass arrangement implementing single-stage operations for a system normally operated as a multi-stage FSU system.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

As shown in Fig. 1, Applicant normally implements an embodiment of a multi-stage froth separation system, for separation of at least bitumen, solids and water from a bitumen froth utilizing several, typically two, froth settling or separation units (FSU). The solids can include mineral solids and asphaltene aggregates.

In embodiments, a bitumen froth F results from conventional production/extraction of bitumen from oilsand processes. The bitumen froth F typically comprises about 60% bitumen, 30% water and 10% fine solids, the bitumen being, in one example, about 16 to about 22% asphaltene and the balance being maltene.

The froth F and solvents S or solvent-rich stream are comingled for dilution of the froth F, for at least reducing the viscosity and density of the oil phase therein, and forming a solvent-diluted bitumen froth feedstream 8. Hence, a first-stage FSU 10 receives the feedstream 8. The solvent S can be a single solvent, a mixture of solvents or solvent mixed with other components recycled from the froth separation system as described below, including water and solids, as is understood by those of skill in the art. In a paraffinic process, as well as being a

viscosity/density modifier, the paraffinic solvent encourages asphaltene precipitation as agglomerates for recovery with mineral solids.

The first FSU 10 is a settling or separation vessel having a first inlet 11 and first product outlet 12. Separation occurs in the first FSU 10. Typically a first product stream of predominately clarified bitumen B and solvent S, substantially free of solids and water, is recovered at the first product outlet 12 as a diluted bitumen or dilbit 14. The dilbit 14 can be routed through a first surge vessel 16 before delivery to a solvent recovery unit (SRU) 18 for recovery of a majority of the solvent S from the bitumen B. Recovered solvent from the SRU (not detailed) is recyclable to various stages of the system processes including back to froth treatment. The bitumen B portion recovered from the FSU is directed to product or upgrading.

The first FSU 10 has a first underflow outlet 20 at a bottom thereof for removal of a first underflow stream 22. The first underflow stream 22 contains predominately water W, solids T and can still contain some bitumen B and solvent S. The presented embodiment illustrates a conical bottom vessel however other vessel configurations are contemplated.

The first underflow stream 22 is directed to a second inlet 24 of a second-stage FSU 30 for further separation of solvent S and residual bitumen from water W and solids T. While not detailed herein, additional stages can be provided in a like manner.

A second product stream of predominately solvent, and some water, is recovered at second product outlet 32 as a solvent-enriched recycle stream 34.

1 The second product stream from second product outlet 32 can be routed through a
2 second surge vessel 36 for forming the recycle stream 34. Recycle stream 34 is
3 directed back towards the first inlet 11 for comingling with the bitumen froth F and
4 forming feedstream 8, in particular for introducing solvent S to the first FSU 10. A
5 majority of the solids T and water W are recovered at a second underflow outlet 41
6 and a second underflow stream 42 as a reject tailings stream 44. The reject tailings
7 stream 44, containing tailings solids T, water W and some solvent S is directed to a
8 tailings solvent recovery unit (TSRU) 48. Solvent S received from the TSRU is
9 typically combined with the solvent recovered from the SRU.

10 As introduced above, in paraffinic solvent extraction, solvent S in the
11 recycle stream 34 to the first FSU 10 aids in the precipitation of at least a portion of
12 asphaltenes for subsequent collection with the mineral portion of the tailings solids
13 T. Removal of at least a portion, of the asphaltenes from the bitumen leaves a
14 maltene-enriched product stream in the dilbit 14.

15 To this end, a further solvent addition inlet 40 is provided for the
16 addition of additional solvent S that reports, via solvent-enriched recycle stream 34,
17 to the first FSU 10. Solvent is added interstage, or intermediate the first underflow
18 stream 22 and the second inlet 24, the solvent being provided through the solvent
19 addition inlet 40, normally in fluid communication with the first underflow stream 22,
20 for mixing therewith and delivery to the second FSU 30. A majority of the added
21 solvent S is readily separated in the second FSU 30 and reports at the second
22 product outlet 32. The recycle stream 34 from second product outlet 32 can be
23 routed through a second surge vessel 36 before recycle to the first FSU 10.

1 In the event one stage of the multi-stage FSU system is compromised
2 and goes offline, a bypass flow arrangement is implemented to provide for orderly
3 transition from multi-stage to a single-stage FSU operation, the restructuring
4 occurring for use of a remaining operating FSU while the offline FSU is repaired. It
5 is anticipated that the bypass of an offline FSU would be temporary for timely return
6 to multi-stage FSU operations. A combination of proper direction of the feedstream
7 of the operating FSU, rerouting of the addition of solvent S and an apportionment of
8 the operating underflow stream is provided for achieving acceptable bitumen and
9 solvent recoveries from the remaining, operational FSU. In terms of economics,
10 FSU systems are likely limited to two-stages. While one offline FSU could be
11 transitioned to two or more remaining online or operational FSU's, the description is
12 phrased in the context of one of a first or a second FSU going offline, the other of
13 the second or first FSU remaining online. Thus, one can at least temporarily
14 operate the two-stage FSU system as a single-stage FSU system with the
15 remaining operating FSU.

16 Generally, whether it is the first or second FSU that goes offline, one
17 isolates the inlets and outlets of the offline FSU, isolating whichever of the first or
18 second product stream, and whichever of the first or second underflow stream that
19 is associated with or related to the offline FSU. If the second FSU goes offline, one
20 isolates the second product stream, the second inlet and the second underflow
21 outlet stream. Further, one ensures that the feedstream is directed to either of the
22 second or first inlet of the online FSU. One also splits, at the operating FSU, the
23 other of the second or first underflow stream associated with the operating and

1 online FSU into first and second bypass streams. Finally, one re-directs the
2 addition of solvent, before making the usual addition to the online underflow stream,
3 instead to comingle with the first bypass stream, wherein the first bypass stream
4 forms the solvent-enriched recycle stream and the second bypass stream forms the
5 reject tailings stream.

6 In other words, in the event one of the first or second FSU goes
7 offline, one can at least temporarily operate the two-stage FSU system as a single-
8 stage FSU system with one or more remaining operating FSUs by isolating, at the
9 offline FSU, the first or second product stream, the first or second inlet and the first
10 or second underflow outlet associated with the offline FSU. Further one ensures
11 that the feedstream is being directed to the second or first inlet associated with
12 online FSU. The product stream of the online FSU forms the dilbit. Also one splits,
13 at the operating FSU, the first or second FSU's reject stream associated therewith
14 into first and second bypass streams. Lastly, one re-directs the addition of solvent
15 to the first bypass stream, wherein the first bypass stream forms the solvent-
16 enriched recycle stream and the second bypass stream forms the reject tailings
17 stream.

18 Whether a stage or stages of the multistage FSU system is
19 compromised or not is monitored and can be evidenced by a variety of factors such
20 as change in flow rate, pressure, and stream quality or characteristics. In the case
21 that the monitoring determines one or more of the stages are compromised then
22 single stage operations are implemented. In this multistage FSU system, one might
23 classify at least two stages of FSU as a first-stage FSU and an ultimate-stage FSU.

1 In a two stage FSU system, the ultimate FSU is the second stage FSU. Thus, the
2 feedstream of bitumen, mineral solids, water and feed solvent is directed to the first-
3 stage FSU. The feed solvent is the solvent-enriched recycle stream from the
4 ultimate-stage FSU. The first-stage FSU is normally the stage at which the ditbit
5 product is recovered. The final, last or ultimate-stage FSU is normally the stage at
6 which the reject tailings is produced. The added solvent is introduced intermediate
7 the stages, or interstage, prior to the inlet of the ultimate-stage and after the outlet
8 of the underflow from the first-stage FSU. Therefore, where the monitoring
9 determines one or more of the stages are compromised, one isolates the one or
10 more compromised stages, termed collectively as an offline FSU. The remaining
11 one or more stages remain operational and are termed collectively as an online
12 FSU. To manage the system one isolates the offline FSU and directing the
13 feedstream to the online FSU. The method includes recovering the dilbit product
14 stream from the online FSU and splitting the tailings reject stream from the online
15 FSU into first and second bypass streams. Regarding the bypass streams, the
16 added solvent is directed to the first bypass stream, wherein the first bypass stream
17 forms the solvent-enriched recycle stream; and second bypass stream is directed
18 as the reject tailings stream.

19 In one embodiment, where at least a temporary bypass of an offline
20 FSU would be required, is the case of second FSU blockage. As introduced earlier,
21 the reject tailings stream 44, often containing in the order of up to about 20% solids
22 T, is difficult to handle and can periodically block or plug the flow streams. Such a
23 disruption can occur at second underflow outlet 41. Accordingly, the second FSU

30 can be compromised and go offline, having no useable outlet for the reject tailings stream 44. Such FSU vessels are large and the processes have some inertia even during the duration of an orderly shutdown of the system. Solids accumulation and resulting blockage causing, or indeed continuing while going offline, can be significant and cause longer term outage.

Turning to Fig. 2A, a bypass flow arrangement is implemented for orderly transition from a two-stage operation to a single-stage FSU operation, the restructuring occurring for sole use of the first FSU 10 in the event the operation of the second FSU 30 is compromised and goes offline. It is anticipated that the bypass of an offline FSU would be temporary.

A combination of rerouting of addition of solvent S and an apportionment of first underflow stream 22 is provided for acceptable bitumen and solvent recoveries from the remaining, operational, first FSU 10.

Whatever the nature of the upset, the recovery of the water W and solids S at a second underflow outlet 41 or reject tailings stream 44 is compromised and is involuntarily or voluntarily placed offline. Thus, to ensure continuous removal of tailings solids T and water W from the system, the first underflow stream 22 from the first FSU 10 is now directed, at least in part, to the TSRU 48.

The first underflow stream 22 is split to form, in part, the recycle stream 34 back to the first inlet 11 and to form, in part, the reject tailings stream 44. Accordingly, the first underflow stream 22, now the sole outlet for tailings solids T and water W, is now connected to both of a recycle bypass 50 and a tailings bypass

52. The recycle and tailings bypasses 50,52 are fluidly connected at a location between the first underflow outlet 20 and the second FSU 30.

Typically the first underflow stream 22 is fluidly driven from the first FSU 10 to the second FSU 30 by a suitable solids-capable, first-stage pump or first-stage pumps 54. The bypasses 50,52 are located downstream of first-stage pumps 54, so as to receive the first underflow stream 22, and before or upstream of the second inlet 24 so as to divert flow from the offline FSU. A portion of the recycle bypass 50 recirculates through the operating FSU, despite there being no significant increase in the dilbit 14. The pumps 54 are now managing a recirculatory load as well as the flow-through mass rates of the reject tailings stream 44. Accordingly, if the pumps 54 are not already suitably sized for the increased throughout, one or more redundant and parallel sets of the pumps 54 are placed online.

One or more parallel sets of redundant underflow pumps are located at each of the first and second underflow streams. Allowing for proper design considerations contemplating pressure drop, fluid velocity and solids carrying capacities, the piping for the underflow stream line is designed for flow rates within a specified range of rates. For example, in normal multi-stage FSU operations, the underflow piping 22 from first underflow outlet 20 for the first-stage FSU is designed for flow rates for carrying steady-state streams of water, solids and added solvent.

In an embodiment as shown, first and second redundant underflow pumps 54,74 are located at the first and second underflow streams 22,44 respectively. In the case of the operation of the first FSU 10, one operates at least one of the first redundant pumps 54 for delivery of the first underflow stream 22 to

1 the second FSU 30 in normal multi-stage FSU operations. If the second FSU 30
2 goes offline, one operates both of the first redundant pumps 54,54 for delivery of the
3 first underflow stream 22 to first and second bypass streams 50,52 for single-stage
4 FSU operations. In embodiments, a third set of redundant pumps can be provided.

5 In an alternative embodiment, the integrity and performance of the
6 increased recirculatory stream flow of the recycle bypass 50 can be aided using a
7 pre-existing product pump 136 situated at the second surge vessel 36, if
8 appropriately designed for this service. Accordingly, as shown in Fig. 2A, the
9 recycle bypass 50 can be routed to the second surge vessel 36 via line 51, pump
10 136 acting to boost the recycle stream 34 to join the bitumen froth F.

11 Solvent addition is still provided, however, so as to minimize loss of
12 solvent S with the reject tailing stream 44, the solvent addition is diverted to be
13 fluidly connected ultimately with the froth for comingling therewith. The recycle
14 bypass 50 can fluidly connect with one of a variety of arrangements to connect
15 solvent S with the feedstream 8. As shown, the solvent addition is connected
16 downstream of the intersection of the recycle bypass 50 and tailings bypass 52,
17 avoiding involvement and loss associated with the tailings bypass 52. The solvent
18 addition inlet 40 is diverted from the first underflow stream 22 with a solvent bypass
19 56.

20 The recycle stream in bypass 50 is a comingled solvent and underflow
21 stream 22. The solvent bypass 56 is directed to carrying solvent S to the recycle
22 bypass 50 already carrying the recirculatory underflow stream 22. In paraffinic
23 solvent cases, solvent addition with recirculatory underflow stream aids in

1 asphaltene treatment. Thus, in one instance as shown in Fig. 2A, the solvent
2 bypass is a pump-bypassing solvent bypass 56, in fluid communication between the
3 solvent addition inlet 40 and the bypass recycle 50, simply bypassing the underflow
4 pumps 54 to join the bypass recycle 50. There can be capital and operational-
5 related economic optimization at the pump and underflow piping. The flow capacity
6 of the pump and underflow stream 22, sized to manage normal operation with both
7 stages of FSU's, remains appropriate to handle the recirculatory rates during one-
8 stage operation as they are no longer handling the added solvent stream. The
9 solvent bypasses the pumps and piping for stream 22 and the ultimate piping for
10 bypass 50 is designed to handle the recirculatory stream 22 and the added solvent
11 S.

12 As would be understood by those skilled in the art, appropriate block
13 valves, routing piping and flushing systems are provided. Control valves, not
14 shown, can be provided at each of the recycle bypass and the tailings bypass for
15 controlling the relative flows thereto or the system can be designed such that the
16 bypasses are hydraulically balanced for the correct rates by line sizing and length.
17 Block valves disable/enable the bypass flow paths respectively. As shown in Fig.
18 2A, for the purposes of illustration, block valves are shown that are related to the
19 disabling or isolation of the offline second FSU 30.

20 An inlet block valve 60 blocks or isolates the usual flow of first
21 underflow stream 22 to the second FSU 30, the bypass recycle 50 departing
22 upstream thereof. A recycle block valve 62 blocks or isolates the usual flow of

1 recycle to the first inlet 11 to the first FSU 10, the bypass recycle 50 joining
2 downstream thereof.

3 Similarly, the inlet block valve 60 isolates the usual flow of first
4 underflow stream 22 to the second FSU 30, the tailings bypass 52 departing
5 upstream thereof. A tailings block valve 64 isolates the discharge of reject tailings
6 stream 44 usually flowing from the second FSU 30, the tailings bypass 52 joining
7 downstream thereof.

8 A solvent addition block valve 66 isolates the usual addition of solvent
9 to the first underflow stream 22, the recycle bypass 50 departing upstream thereof.

10 Clearly, in normal operation, there are corresponding block valves (not
11 shown) used to incapacitate or isolate the various bypass lines in normal
12 operations.

13 Simply, the two-stage FSU system is operated as a single-stage FSU
14 system for bypassing an offline second-stage FSU by isolating the second-stage
15 FSU 30 at the second product outlet 32, at the second inlet 24, and at the second
16 underflow outlet 41. The first underflow stream 22 is split into first and second
17 bypass streams 50,52. The solvent addition is re-directed into to the first bypass
18 stream 50. The first bypass stream 50 and added solvent S form the recycle stream
19 34 and the second bypass stream 52 forming the reject tailings stream 44.

20 Turning to Fig. 2B, a bypass flow arrangement is implemented to
21 provide for orderly transition from a two-stage operation to a single-stage FSU
22 operation, the restructuring occurring for sole use of the second FSU 30 while the
23 first FSU 10 is compromised and is offline.

1 In the event that the first FSU 10 is involuntarily or voluntarily placed
2 offline, and to ensure continuous operation including bitumen recovery and removal
3 of tailings solids T and water W from the system, the stream 42 from the second
4 underflow outlet 41 from the second-stage FSU 30 continues to be directed to the
5 TSRU 48, however, only a portion of the stream 42 forms a reject tailing stream 44.
6 A portion of the second underflow stream 42 is re-directed to join the recycle stream
7 34. Similarly addition of solvent S is directed to join the recycle stream 50 while
8 avoiding incorporation and loss with the tailings bypass 52 forming the reject tailings
9 stream 44.

10 The second underflow stream 42, normally the second reject tailings
11 stream 44, is split into recycle bypass 50 and tailings bypass 52 to form,
12 respectively, the recycle stream 34 back to the first inlet 11 and, the reject tailings
13 stream 44. While the reject tailings stream 44 remains substantially the same and
14 the sole outlet for tailings solids T and water W, it now forms the tailings bypass 52.
15 In this embodiment, the second-stage is the last or ultimate-stage and the existing
16 flow path for the reject tailings stream 44 remains the same.

17 Typically the second underflow stream 42 is fluidly driven from the
18 second FSU 30 to the TSRU 48 by a suitable solids-capable second-stage pump or
19 pumps 74. The recycle bypass 50 is located downstream of the second-stage
20 pumps 74, so as to receive the second underflow stream 42, and yet located before
21 the TSRU 48 so as to divert a portion of the flow to the recycle stream 34.

22 Addition of solvent S for comingling with the recycle stream 34 is
23 maintained. To minimize loss of solvent S, the solvent addition inlet 40 is diverted

1 to join the recycle bypass 50, avoiding involvement and ineffective comingling and
2 loss with the reject tailings stream 44. The solvent addition is diverted from the,
3 now blocked, first underflow stream 22 again using the solvent bypass 56, in fluid
4 communication between the solvent addition inlet 40 and bypass recycle 50. The
5 stream of dilbit 14 is now routed from the second product outlet 32 to flow to the
6 SRU 18, the usual first product outlet 12 blocked at the first FSU 10.

7 As would be understood by those skilled in the art, appropriate block
8 valves, routing piping and flushing systems are provided. As was the case for Fig.
9 2A, and for the purposes of illustration, only block valves are shown in Fig. 2B that
10 are related to the disabling or isolation of the offline first FSU 10.

11 A first-stage inlet block valve 80 blocks the usual flow of the diluted
12 feedstream to the first inlet 11 of first-stage FSU 10. The dilute feedstream 8 is
13 therefore directed to the second inlet 24 of the second-stage FSU 30 through
14 feedstream bypass 81 departing upstream of valve 80. A second-stage recycle
15 block valve 82 blocks the usual flow of product from the second product outlet 32.
16 A product bypass 83 fluidly connects the second product outlet 32 and dilbit 14.
17 The solvent addition block valve 66 again blocks the usual additional of solvent S to
18 the first underflow stream 22, the recycle bypass 50 departing upstream thereof for
19 directing solvent S to the recycle bypass 56. There are corresponding block valves
20 (not shown) used to incapacitate the various bypass lines.

21 Simply, in order to operate the two-stage FSU system as a single-
22 stage FSU system, for bypassing an offline first-stage FSU one isolates the first-
23 stage FSU at the first product outlet 12, at the first inlet 11, and at the first underflow

1 outlet 20. The feedstream 8 is directed to the second inlet 24. To provide for both
2 solvent recycle and tailings removal, one splits the second underflow stream 42 into
3 a first bypass stream 50, re-directs the solvent addition to the first bypass stream
4 50, the first bypass stream 50 and solvent additional forming the recycle stream 34
5 and the balance of the second underflow stream 42 forming the reject tailings
6 stream 44.

7 8 EXAMPLE

9 In an example in which feedstream flow rates for single stage
10 operations remain basically at full or 100% of the design feedstream rates, the rate
11 of underflow from the online FSU can be split about evenly, the recycle bypass
12 stream being about that of the tailings bypass stream, in other words a ratio of
13 about 50:50 by volume. Generally, in a fanciful example, in normal multistage
14 operations, a nominal 200 units of froth F and 160 units of a recycle stream 34
15 (predominately solvent S) is delivered to comingle with the froth to beget 360 units
16 of feedstream 8 and might result in about 100 units of tailings reject 44 and 260
17 units of ditbit 14. About 160 units of solvent are recovered from the SRU and TSRU
18 for recycle to the system. Accordingly, in single stage operation, and retaining a
19 rate of 200 units of froth F, the recycle bypass 50 routes 160 units of solvent S to
20 comingle with the 200 units of froth F. Using 100% redundant pumping capacity,
21 the underflow of 100 units is increased to 200 units, 100 units of underflow being
22 recycled through the recycle bypass 34 to join with the 200 units of froth and 160
23 units of solvent. Further, for maintenance of the mass balance integrity, 100 units of

underflow are directed as a tailing bypass to ensure removal of water and solids from the system. This illustrates a 100% redundant recirculation case with a 50%:50% split of the recycle and tailings bypasses. Clearly, as the stream quality varies from multi-stage to single stage operation, the example rates vary accordingly from the nominal rates provided above for ease of illustration.

In instances where the rate of the feedstream for single-stage FSU operations is diminished from the design rate of the multi-stage FSU operations, the ratio of the first and second bypass streams can even increase to those greater than the example 50:50, up to and including ratios in the order of about 90:10, in other words 90% to the recycle bypass and 10% to the tailings bypass. Higher ratios typically correspond to feedstream rates at less than the nominal design rate, the tailings-reporting fraction being reduced and thus less of the pumping capacity directed to tailings recycle.

In simulations, one can examine the effect of the extent of recirculation on the bitumen recovery. Herein, three single stage scenarios are simulated for review. Paraffinic solvent is used, the percentage of asphaltenes in the bitumen froth amenable to pentane-solvent treatment being identified as C5A%. All scenarios are compared to a base case of two-stage FSU operation.

In Table 1, in a first scenario (A), for illustration only, a case of no recirculation is shown wherein only solvent is directed along the recycle bypass to the froth.

TABLE 1

Example	Base Case Two-stage FSUs	(A) Single stage FSU With No Recirculation
C5A% in Bitumen Feed:	18.2%	18.2%
Bitumen Product C5A% Target:	11.9%	11.9%
FSU Feed Rate :	100%	100%
FSU Underflow Recirc %:	0%	0%
At nominal 200 units froth, units of bypass tailings	100	100
At nominal 200 units froth, bypass recycle	0	0
Bitumen Recovery:	92.5%	83.6%

In Table 2, in second scenario (B), a case of 100% redundant recirculation is shown wherein solvent is directed to the froth and a portion of the underflow is also directed along the recycle bypass to the froth. A second parallel set of pumps is employed wherein the underflow pumping capacity is twice that normally provided during two-stage operation.

TABLE 2

	(B) Single-stage FSU - With Recirculation (100% Spare Pumping Capacity)			
C5A% in Bitumen Feed:	18.2%	18.2%	18.2%	18.2%
Bitumen Product C5A% Target:	11.9%	11.9%	11.9%	11.9%
FSU Feed Rate :	100%	80%	60%	20%
FSU Underflow Recirc %:	50%	60%	70%	90%
At nominal 200 units froth, units of bypass tailings	100	80	60	20
At nominal 200 units froth, units of bypass recycle	100	120	140	180
Bitumen Recovery:	88.1%	88.9%	89.8%	91.6%

In Table 3, in a third scenario (C), a case of 200% redundant recirculation is shown, wherein two redundant parallel pumping circuits are provided, three parallel pump circuits in total, wherein solvent is directed to the froth and a large recirculating load of the underflow is also directed along the recycle bypass to the froth.

A second and a third parallel set of pumps is employed wherein the underflow pumping capacity is three-times that normally provided during two-stage operation.

TABLE 3

	(C) Single-stage FSU - With Recirculation (200% Spare Pumping Capacity)			
C5A% in Bitumen Feed:	18.2%	18.2%	18.2%	18.2%
Bitumen Product C5A% Target:	11.9%	11.9%	11.9%	11.9%
FSU Feed Rate :	100%	80%	60%	20%
FSU Underflow Recirc %:	67%	73%	80%	93%
At nominal 200 units froth, unit of bypass tailings	66	54	40	14
At nominal 200 units froth, units of bypass recycle	134	146	160	186
Bitumen Recovery:	89.5%	90.1%	90.7%	91.9%

In other examples, different grades of bitumen froth, and different choices regarding the acceptable target fraction of asphaltenes in the dilbit will result in different bitumen recoveries.

Turning to Fig. 3 the recovery of maltene for delivery to the SRU 18 is shown for one stage transitional operation for a range of feedstream rates. As stated, for a two-stage FSU embodiment, and using paraffinic solvent, recovery of

1 the maltene portion of the bitumen froth feedstream can reach 98%. At design plant
2 rates of about 200 kbpd of partially deasphalted bitumen (a majority of which is
3 maltene), and using the bypass embodiments described herein, models predict
4 maltene recovery can be maintained in the order of about or greater than about
5 95% at full feed rates while repair operations facilitate a return to two-stage
6 operation. By lowering the rate of the diluted bitumen feedstream during the upset
7 state, the efficiency of maltene recovery can be even higher, albeit at lower overall
8 product rate. Increased feedstream will result in lower maltene recovery rates,
9 although the efficiency is not expected to fall below about 95% in most design
10 scenarios.

11

**THE EMBODIMENTS IN WHICH AN EXCLUSIVE PROPERTY OR
PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

1. A method of operating multiple stages of a multistage froth separation units (FSU) as a single-stage FSU system, comprising:

monitoring operations of the multistage FSU system wherein a feedstream of bitumen, mineral solids, water and feed solvent is directed to a first-stage FSU of the multistage FSU system and added solvent being introduced intermediate the multiple stages, various streams being produced therefrom including a dilbit product stream recovered from the first-stage FSU, a tailings reject stream from an underflow stream of an ultimate-stage FSU, and a solvent-enriched recycle stream from the overflow of the ultimate-stage FSU as feed solvent to the feedstream, underflow of each earlier FSU being directed to an inlet to each subsequent FSU, and where the monitoring determines one or more of the stages are compromised,

isolating the one or more compromised stages collectively as an offline FSU, the remaining one or more stages remaining operational and collectively as an online FSU;

isolating the offline FSU;

directing the feedstream to the online FSU;

recovering the dilbit product stream from the online FSU;

splitting the tailings reject stream from the online FSU into first and second bypass streams;

1 directing the added solvent to the first bypass stream, wherein the first
2 bypass stream forms the solvent-enriched recycle stream; and

3 directing the second bypass stream as the reject tailings stream.

4
5 2. The single-stage FSU method of claim 1 wherein the offline
6 FSU is the ultimate-stage FSU, further comprising:

7 isolating the ultimate-stage FSU at a second product outlet, at a
8 second inlet, and at a second underflow outlet;

9 continuing to receive the feedstream at the online FSU;

10 splitting a first underflow stream from the online FSU into the first and
11 second bypass streams;

12 directing the added solvent to the first bypass stream to comeingle
13 therewith and form the solvent-enriched recycle stream;

14 directing the solvent-enriched recycle stream to the first inlet to
15 comeingle with the froth; and

16 recovering a dilbit product from the online FSU.

1 3. The single-stage FSU method of claim 1 wherein the offline
2 FSU is the first-stage FSU, comprising:

3 isolating the first-stage FSU at a first product outlet, at a first inlet, and
4 at a first underflow outlet;

5 directing the feedstream to the online FSU;

6 splitting the tailings reject stream from the online FSU into first and
7 second bypass streams;

8 directing the added solvent to the first bypass stream to comingle
9 therewith and form the solvent-enriched recycle stream;

10 directing the second bypass stream as the reject tailings stream; and

11 recovering the dilbit product from the online FSU.

12
13 4. A method of operating a system of two-stages of froth
14 separation units (FSU) as a single-stage FSU system, the froth comprising bitumen,
15 mineral solids and water, the separation of the froth normally occurring in the two-
16 stage froth separation system for producing a dilbit product stream of bitumen and
17 solvent, a solvent-enriched recycle stream for comingling with the bitumen froth to
18 form a diluted bitumen froth as a feedstream to the system, and a reject tailings
19 stream of predominately mineral solids and water,

20 operating the two-stage FSU system by receiving the feedstream at a
21 first inlet to a first-stage froth separation unit (FSU) for producing the dilbit product
22 stream at a first product outlet and a first underflow stream directed to a second
23 inlet of a second-stage FSU, adding solvent to the first underflow stream before the

1 second inlet, and producing a second product stream at a second product outlet of
2 the second-stage FSU for forming the recycle stream and a second underflow
3 stream at a second underflow outlet forming the reject tailings stream; and

4 operating the two-stage FSU system as a single-stage FSU system for
5 bypassing an offline FSU, of the first or second-stage FSU, for operation on an
6 online FSU, of the other of the second or first-stage FSU, comprising:

7 isolating the offline FSU at an offline product outlet, at an offline
8 inlet, and at an offline underflow outlet of the respective first or second
9 product outlet, inlet, or underflow outlet of the offline FSU;

10 directing the feedstream to the online inlet of the respective
11 second or first inlet of the online FSU;

12 splitting an online underflow stream of the respective second or
13 first underflow outlet of the online FSU, into first and second bypass streams;

14 redirecting the solvent, before addition to the online underflow
15 stream, instead to comingling with the first bypass stream, wherein the first
16 bypass stream and solvent forms the solvent-enriched recycle stream for
17 comingling with the froth;

18 directing the second bypass stream to form the reject tailings
19 stream; and

20 recovering the dilbit product from an online product outlet of the
21 online FSU.

22

1 5. The single-stage FSU method of claim 4 wherein the offline
2 FSU is the second-stage FSU, further comprising:
3 isolating the second-stage FSU at the second product outlet, at the
4 second inlet, and at the second underflow outlet;
5 splitting the first underflow stream into the first and second bypass
6 streams;
7 directing the solvent addition, before addition to the first underflow
8 stream, instead to comeingle with the first bypass stream to form the solvent-
9 enriched recycle stream;
10 directing the solvent-enriched recycle stream to the first inlet to
11 comeingle with the froth; and
12 recovering the dilbit product from the first product outlet.

13
14 6. The single-stage FSU method of claim 5 wherein the flow rate
15 of the first underflow stream to the first and second bypass streams is split about
16 50:50 by volume between the first and the second bypass streams.

17
18 7. The single-stage FSU method of claim 5 wherein the re-
19 directing of the solvent addition to the first-stage FSU comprises re-directing the
20 solvent addition to the first bypass stream, wherein the first bypass stream forms
21 the solvent-enriched recycle stream.

1 8. The single-stage FSU method of claim 4 or 5 wherein
2 the feedstream rate for single-stage FSU operations remains about
3 the same as it was for multi-stage FSU operations; and
4 the ratio of the first and second bypass streams is split about 50:50 by
5 volume the first and the second bypass streams.

6
7 9. The single-stage FSU method of claim 4 or 5 wherein
8 the feedstream rate for single-stage FSU operations is diminished
9 from that for multi-stage FSU operations; and
10 the ratio of the first and second bypass streams increase to those
11 greater than about 50:50 by volume the first and the second bypass streams.

12
13 10. The single-stage FSU method of any one of claims 5 to 7
14 further comprising:
15 providing first redundant underflow pumps at the first underflow
16 stream;
17 operating at least one of the first redundant pumps for delivery of the
18 first underflow stream to the second FSU in multi-stage FSU operations; and
19 operating two or more of the first redundant pumps for delivery of the
20 first underflow stream to first and second bypass streams in single-stage FSU
21 operations.

22

1 11. The single-stage FSU method of claim 4 wherein the offline
2 FSU is the first-stage FSU, comprising:
3 isolating the first-stage FSU at the first product outlet, at the first inlet,
4 and at the first underflow outlet;
5 directing the feedstream to the second inlet;
6 splitting the second underflow stream into the first and second bypass
7 streams;
8 directing the solvent addition to the first bypass stream, wherein the
9 first bypass stream forms the solvent-enriched recycle stream and the second
10 bypass stream forms the tailings stream; and
11 recovering the dilbit product from the second product outlet.

12
13 12. The single-stage FSU method of claim 01 wherein the flow rate
14 of the first underflow stream to the first and second bypass streams is split about
15 50:50 by volume.

16
17 13. The single-stage FSU method of claim 01 wherein
18 the feedstream rate for single-stage FSU operations remains about
19 the same as it was for multi-stage FSU operations; and
20 the ratio of the first and second bypass streams is split about 50:50 by
21 volume.

1 14. The single-stage FSU method of claim 01 wherein
2 the feedstream rate for single-stage FSU operations is diminished
3 from that for multi-stage FSU operations; and
4 the ratio of the first and second bypass streams is greater than 50:50
5 by volume.

6
7 15. The single-stage FSU method of claim 01 further comprising:
8 providing second redundant underflow pumps at the second underflow
9 stream;
10 operating at least one of the second redundant pumps for delivery of
11 the second underflow stream to the second FSU in multi-stage FSU operations; and
12 operating both of the second redundant pumps for delivery of the
13 second underflow stream to first and second bypass streams in single-stage FSU
14 operations.

15
16 16. The single-stage FSU method of any one of claims 4 to 15
17 wherein the solvent is a paraffinic solvent.

1 17. A method of operating a system of multi-stage froth separation
2 units (FSU) as a single-stage FSU system, comprising:

3 directing a bitumen froth of bitumen, mineral solids and water, and
4 solvent comingled therewith, as a feedstream to a first FSU of a multi-stage system,
5 the first FSU producing a first product stream of predominately bitumen and solvent,
6 and a first underflow outlet stream of predominately mineral solids and water;

7 directing the first underflow outlet stream to at least a second FSU and
8 adding a solvent intermediate therealong, the at least a second FSU producing a
9 second product stream of predominately solvent for comingling with the bitumen
10 froth, and a second underflow outlet stream of predominately mineral solids and
11 water; and

12 in the event one of the first or the at least a second FSU goes offline,
13 being collectively an offline FSU, at least temporarily operating the two-stage FSU
14 system as a single-stage FSU system with one or more remaining FSUs,
15 collectively an operating FSU, comprising:

16 isolating, at the offline FSU, the first or second product stream,
17 the first or second inlet, and the first or second underflow outlet associated
18 with the offline FSU;

19 directing the feedstream to the respective second or first inlet
20 associated with the operating FSU;

21 splitting, at the operating FSU, the respective second or first
22 underflow outlet stream associated with the operating FSU into first and
23 second bypass streams;

1 directing the addition of solvent to the first bypass stream,
2 wherein the first bypass stream forms the solvent-enriched recycle stream
3 and the second bypass stream forms the reject tailings stream; and
4 recovering the dilbit product from the respective product outlet
5 associated with the operating FSU.

6
7 18. The single-stage FSU method of claim 167 wherein the offline
8 FSU is the second-stage FSU, further comprising:

9 isolating the second-stage FSU at the second product outlet, at
10 the second inlet, and at the second underflow outlet;

11 splitting the first underflow stream into the first and second
12 bypass streams;

13 directing the solvent addition to the first bypass stream, wherein
14 the first bypass stream forms the solvent-enriched recycle stream and the
15 second bypass stream forms the tailings stream; and

16 recovering the dilbit product from the first product outlet.
17

18 19. The single-stage FSU method of claim 168 wherein the offline
19 FSU is the first-stage FSU, comprising:

20 isolating the first-stage FSU at the first product outlet, at the
21 first inlet, and at the first underflow outlet;

22 directing the feedstream to the second inlet;

1 splitting the second underflow stream into the first and second
2 bypass streams;
3 directing the the solvent addition to the second bypass stream,
4 wherein the first bypass stream forms the recycle stream and the second
5 bypass stream forms the tailings stream; and
6 recovering the dilbit product from the second product outlet.

7
8 20. The single-stage FSU method of any one of claims 167 to 19
9 wherein the solvent is a paraffinic solvent.

10

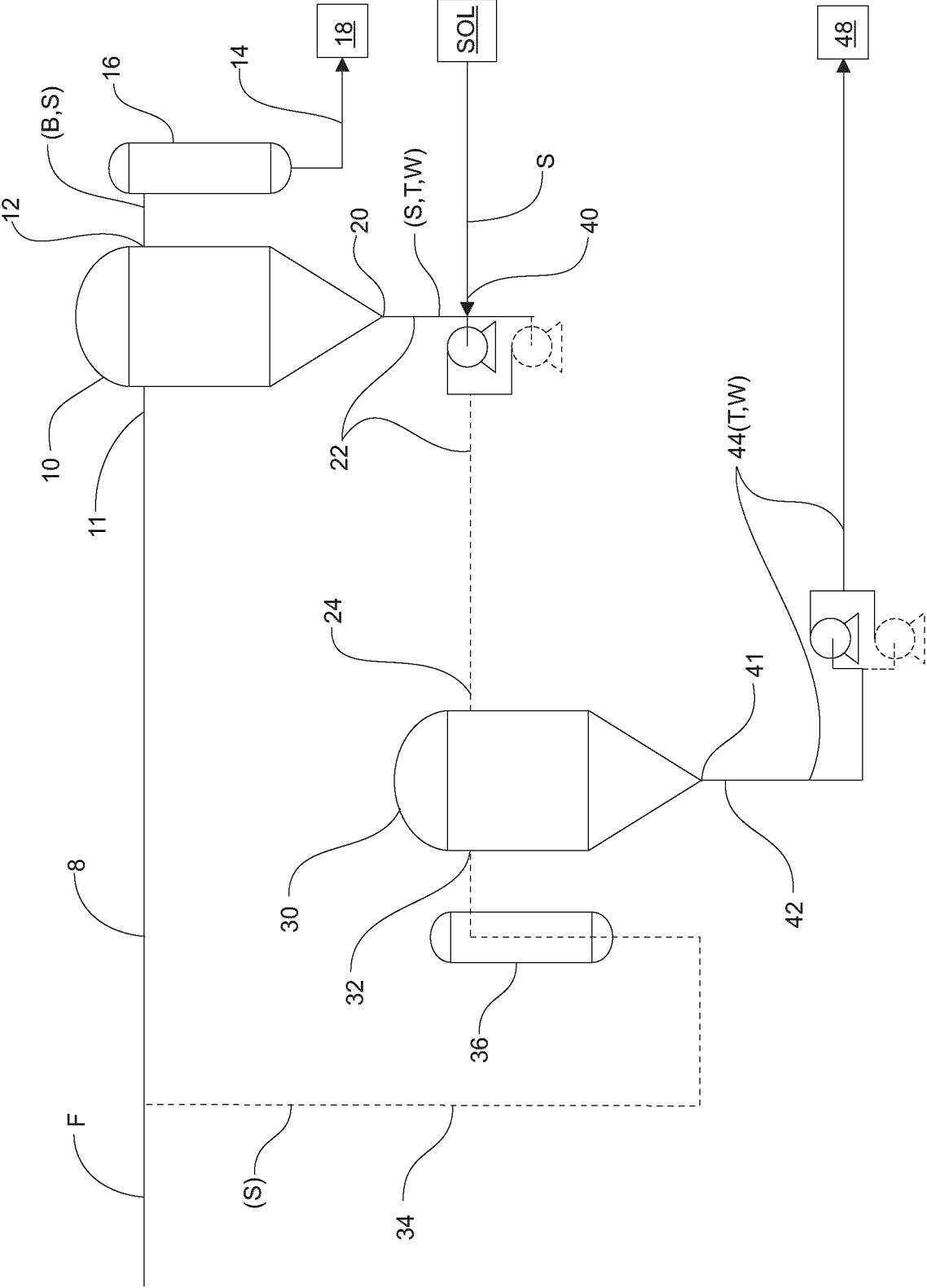


Fig. 1

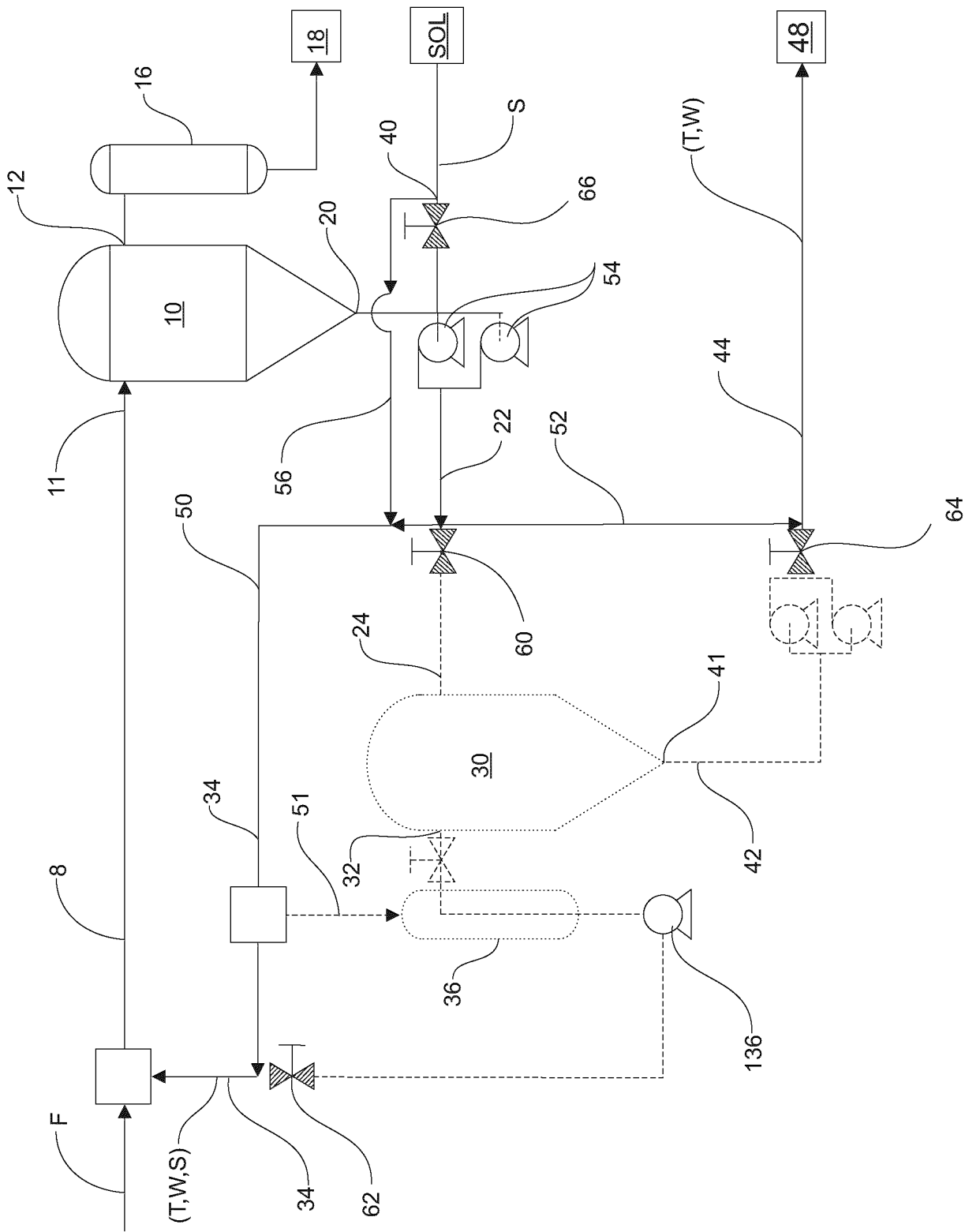


Fig. 2A

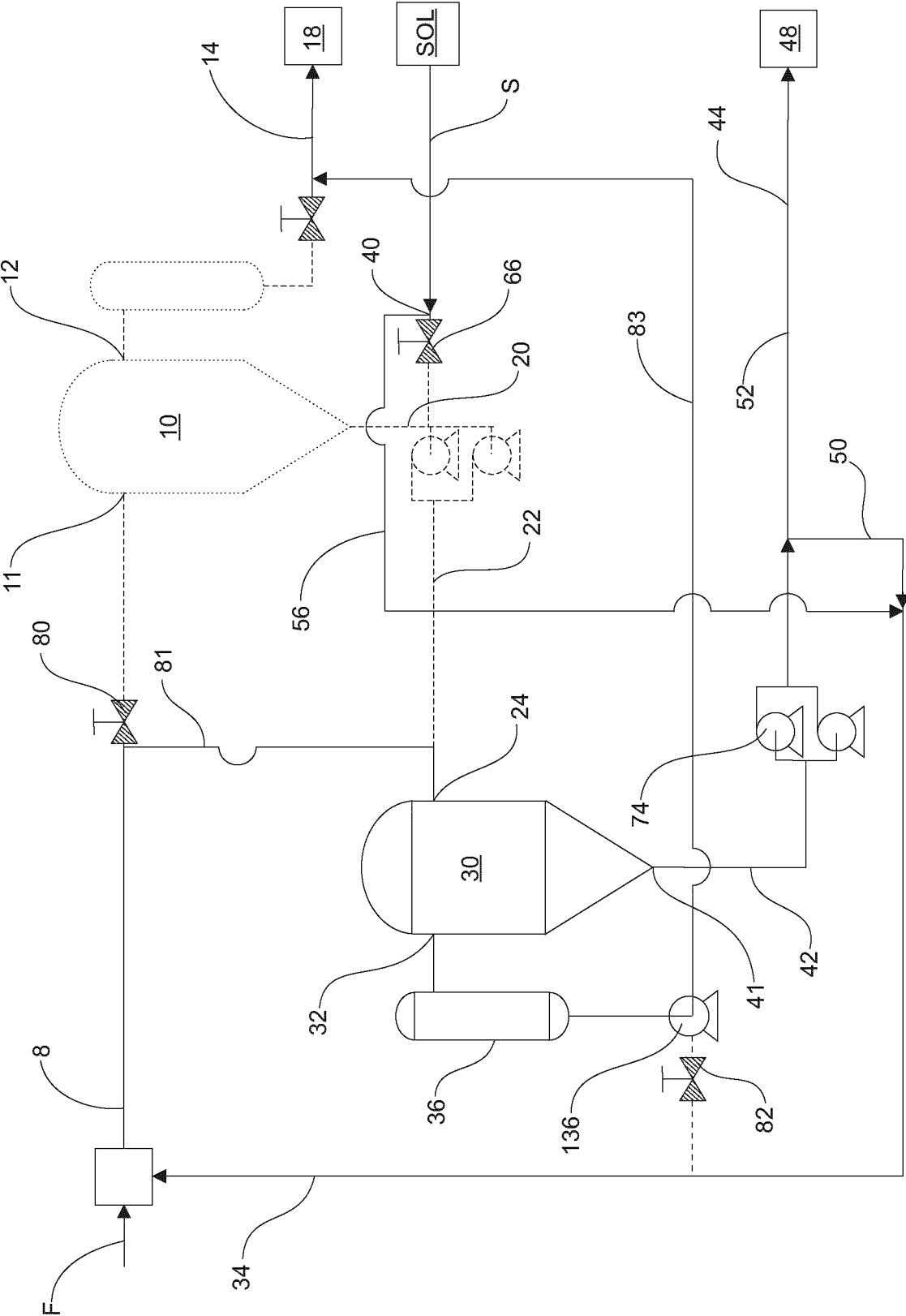
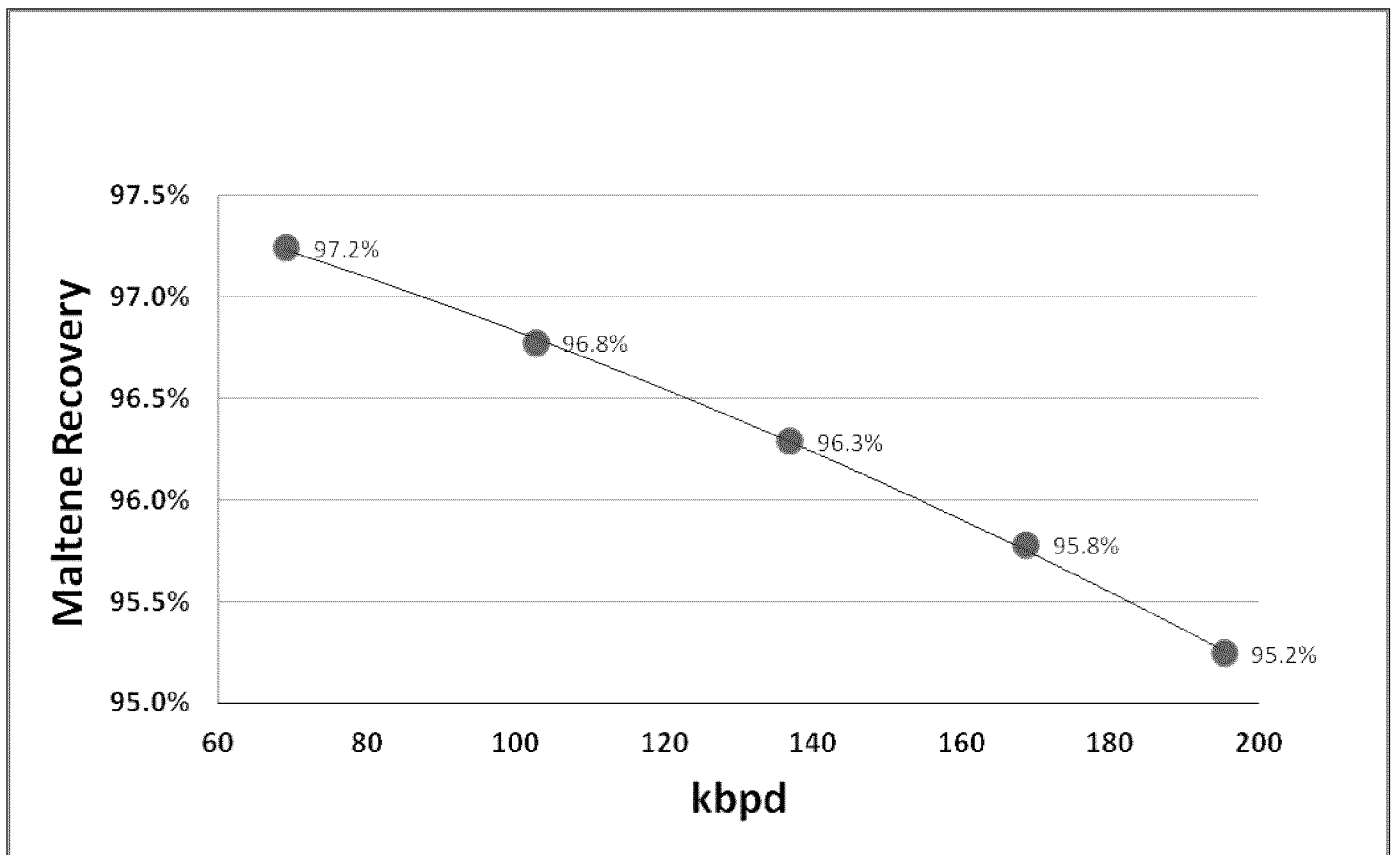


Fig. 2B

**Fig. 3**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CA2014/050666A. CLASSIFICATION OF SUBJECT MATTER
IPC: **B03D 1/02** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: **B03D 1/02** (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)

Keywords: bitumen, froth, FSU, SRU, bypass, offline, paraffinic, maltenes, flocs, multi stage, underflowDatabases: Totalpatent, Scopus

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CA 2 502 329 A1 (TIPMAN et al.) 24 Sept. 2006 (24-09-2006)	
A	CA 2 232 929 A1 (BIRKHOLZ) 25 Sept. 1998 (25-09-1998)	
A	CA 2 640 914 A1 (MCDONALD et al.) 10 March 2009 (10-03-2009)	
A	US 2013/0075306 A1 (MILANI et al.) 28 March 2013 (28-03-2013)	

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
19 March 2015 (19-03-2015)Date of mailing of the international search report
31 March 2015 (31-03-2015)Name and mailing address of the ISA/CA
Canadian Intellectual Property Office
Place du Portage I, C114 - 1st Floor, Box PCT
50 Victoria Street
Gatineau, Quebec K1A 0C9
Facsimile No.: 001-819-953-2476Authorized officer
Patrick Mamputu: 1-819-994-9537

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CA2014/050666

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
CA2502329A1	24 September 2006 (24-09-2006)	CA2502329A1 CA2502329C	24 September 2006 (24-09-2006) 15 June 2010 (15-06-2010)
CA2232929A1	25 September 1998 (25-09-1998)	CA2232929A1 CA2232929C CA2200899A1	25 September 1998 (25-09-1998) 25 May 2004 (25-05-2004) 25 September 1998 (25-09-1998)
CA2640914A1	10 March 2009 (10-03-2009)	CA2640914A1 CA2640914C US2010089800A1	10 March 2009 (10-03-2009) 09 August 2011 (09-08-2011) 15 April 2010 (15-04-2010)
US2013075306A1	28 March 2013 (28-03-2013)	US2013075306A1 CA2790766A1	28 March 2013 (28-03-2013) 22 March 2013 (22-03-2013)