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(54) Title: APPARATUS AND METHOD FOR BITUMEN FROTH STORAGE

(57) Abrégé/Abstract:

An apparatus and methodology for storing bitumen froth comprising a fluidized bottom, froth first feed holding tank for maintaining effective tank capacity while reducing overall solid bed build up at side walls and minimizing sloughing of solids to the froth discharge outlet. Froth is fed to the tank through one or more feed inlets located between the froth outlet and side walls for fluidizing settling solids. The feed inlets urge solids to settle in sub-beds about the feed inlets, the height of which that manifests adjacent the side walls being less than some design threshold height; if not, then successive feed inlets are located between the side walls and the previous feed inlets to build further sub-beds that have a height at the wall that is less than the threshold height.

ABSTRACT

An apparatus and methodology for storing bitumen froth comprising a fluidized bottom, froth first feed holding tank for maintaining effective tank capacity while reducing overall solid bed build up at side walls and minimizing sloughing of solids to the froth discharge outlet. Froth is fed to the tank through one or more feed inlets located between the froth outlet and side walls for fluidizing settling solids. The feed inlets urge solids to settle in sub-beds about the feed inlets, the height of which that manifests adjacent the side walls being less than some design threshold height; if not, then successive feed inlets are located between the side walls and the previous feed inlets to build further sub-beds that have a height at the wall that is less than the threshold height.

1 **"APPARATUS AND METHOD FOR BITUMEN FROTH STORAGE"**

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FIELD

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BACKGROUND

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Embodiments disclosed herein relate to the field of processes for recovering bitumen from oil sand and, more particularly, to a fluidized froth holding tank for improved froth handling.

Oil sands extracted from deposits, such as those found in Alberta, Canada, comprise water-wet sands that are held together by a matrix of viscous heavy oil or "bitumen". Bitumen recovery processes can involve extracting the oil sands from mines, slurry conditioning the oil sands, such as with hot water, for transport to extraction and froth treatment. The bitumen, water, sand, silt and clay matrix is transported for further processing via a primary separation process and downstream froth treatment processes such as froth separation units (FSUs). FSU's, are commonly used in which bitumen-rich froth and solvent are fed to the FSU, whereby mineral and non-mineral solids separate (via gravity) from the solvent diluted bitumen. Solvent is later recovered in various solvent recovery processes.

Such processes are subject to the vagaries of large scale materials processing resulting in the occasional need for surge between the various stages. In one instance, it is known to provide surge capacity between the primary separation and froth treatment stages using an intermediate froth storage or holding

1 tank. The tank receives bitumen froth and ultimately discharges the entire contents
2 for transport to the FSU or other downstream processing, however, during
3 continuous or surge operation, free solids can settle to the bottom. The tank has a
4 discharge located at the bottom and solids tend build up as a sloped bed on the
5 bottom forming a semi-stable bed surface at an angle of repose angled from a low
6 point, at the tank discharge, to one or more high points spaced from the tank
7 discharge.

8 Main issues arising with solids build up include: accumulation reduces
9 tank holding capacity with dead volume lost to solids and commensurate loss of
10 operating capacity, accumulation at a high side of the bed places inordinate loading
11 on the tank side walls, and periodic sloughing of solids from the bed surface can
12 overwhelm and block the discharge (e.g. outflow/pump suction line), which is
13 typically mitigated by maintaining a liquid level above the solids build up and this
14 itself contributes to additional operating capacity loss.

15 Prior solutions include an acceptance of lost storage volume by
16 designing larger tanks and with the use of reinforced construction to resist the
17 increased pressure on tank walls from the dead load including reinforced floor and
18 foundation.

19 Build up and sloughing issues have been addressed using tanks
20 having conical-shaped bottoms to both urge solids to the discharge with minimal to
21 no accumulation and to keep the solids flowing to avoid periodic sloughing. The
22 lower conical walls of such tanks are typically angled to avoid solids build up.
23 Further, mechanical aids such as rotating rakes can be used to guide solids towards

1 the discharge, however the costs of operating and maintaining rakes capable of
2 guiding highly viscous media is extremely high. Conical vessels significantly add to
3 the height, supporting structure and capital cost.

4 There is interest in providing an improved, generally flat bottomed
5 froth holding tank for storing bitumen froth that is reliable, low cost and maintains
6 the capacity to effectively store froth over extended periods of time.

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8 BRIEF DESCRIPTION OF DRAWINGS

9 Figure 1 is a schematic cross-sectional illustration of the buildup of a
10 bed of solid materials in prior art flat-bottomed froth holding tanks showing the
11 minimum surface level of fluid allowable (to prevent sloughing of solids) in the tank;

12 Figure 2 is a schematic representation of a froth holding tank
13 according to one embodiment described herein illustrating an array of fluidization
14 feed nozzles and a side discharge;

15 Figure 3A depicts a top view of the froth holding tank according to
16 another embodiment illustrating an array of fluidization feed nozzles, a side
17 discharge and a recirculation line from discharge to froth inlet;

18 Figure 3B illustrates a detailed cross-section of the general bed
19 formation about a typical feed nozzle,

20 Figures 4A and 4B are plan view and cross-sectional side views
21 respectively of a tank utilizing embodiments of the fluidized bottom for overall bed
22 height reduction, the tank of Fig. 4A having one example configuration of a first
23 circular array of feed nozzles;

1 Figures 5A and 5B are plan view and cross-sectional side views
2 respectively of a tank utilizing embodiments of the fluidized bottom for overall bed
3 height reduction, the tank having one example configuration of first and second
4 circular and generally concentric arrays of feed nozzles;

5 Figures 6A and 6B are plan view and cross-sectional side views
6 respectively of an alternate embodiment of a froth holding tank having an internal
7 annular element for aiding in side wall relief in combination with the example first
8 circular array of feed nozzles shown in Figs. 4A and 4B;

9 Figures 7A and 7B are plan view and cross-sectional side views
10 respectively of an alternate embodiment of a froth holding tank having an internal
11 annular element for aiding in side wall relief in combination with the example first
12 and second circular and generally concentric arrays of feed nozzles;

13 Figures 8A and 8B are cross-sectional side view and plan views
14 respectively of an alternate embodiment of the tank of Figs. 6A and 6B having a pair
15 of vertically stacked internal annular elements, Fig. 8A having feed nozzles also
16 illustrated therein;

17 Figures 9A and 9B are cross-sectional side view and plan views
18 respectively of an alternate embodiment of a tank having internal annular elements
19 and transverse shed elements for aiding in reduced bed formation, fluidization feed
20 nozzles being omitted from the illustration;

21 Figures 10A and 10B are cross-sectional side view and plan views
22 respectively of an alternate embodiment of a froth holding tank having a plurality of
23 conical skirts about each feed nozzle for minimizing bed formation, and

In accordance with the present description, apparatus and methodology for settling solids management in a froth surge or holding tank is provided. Generally, a flat bottomed tank is provided with arrays of fluidization nozzles for maintaining one of or a combination of characteristics including maintaining any solids in a stable, generally fluidized state for eventual discharge. Where solids do settle, if any, a series of low elevation, conical-sloped beds or sub-beds are formed, thereby minimizing the height of solids accumulation against the tank side walls. Settled solids are discouraged from settling adjacent side walls, or in some embodiments even to substantially eliminate the settling of solids at all, thereby resulting in the ability to store froth for longer periods of time (e.g. for a minimum of four hours, and upwards of approximately fifteen to twenty hours).

16 It is understood herein that the term solids includes that which settles
17 in a typical tank environment, including mineral, or combinations of mineral, bitumen
18 and trapped water as is known in the oilsands of northern Alberta, Canada.
19 Oilsands are also referred to in the art as oil-sands, oil sands and tar sands and
20 tarsands.

21 In embodiments described herein, froth holding tanks have a chamber
22 formed within a vessel having a substantially flat bottom wall and cylindrical side
23 walls. The bottom wall can be slightly sloped to a discharge outlet that can aid in

1 maintenance, including cleaning, but does not significantly impact structural height
2 and related considerations. Slight sloping of the bottom wall can include a minimal
3 slope below a normal angle of repose of settled solids without embodiments
4 described herein would suffer the same accumulation disadvantages as flat bottom
5 tanks.

6 Froth is delivered to the tank through at least one froth feed inlet or
7 nozzle located at or near the bottom wall and directed generally upwardly into the
8 chamber for suspending solids thereabove in a fluidized state within the chamber.
9 Froth is removed from the tank through at least one outlet located at or near the
10 bottom wall. In embodiments, around each feed inlet is formed a sub-bed in the
11 form of an inverted cone or a funnel. A plurality of feed inlets produces a plurality of
12 sub-beds, each of which has a low height and when arranged as set forth herein,
13 obviates side wall loading and sloughing risk. Simplistically, a bed of settled solids
14 that would normally build up at side walls to a maximum bed height that exceeds
15 design criteria is interrupted by a feed nozzle for fluidizing the solids settling thereat
16 and forming a sub-bed. The sub-bed resets the build-up of settled solids to a new
17 bed height about the periphery of the funnel. A sub-bed that is sufficiently spaced
18 from a side wall could also build up to a maximum bed height that exceeds design
19 criteria. Accordingly, froth is introduced at spaced locations between the outlet and
20 the side walls as necessary to form a series of sub-beds as necessary to maintain
21 the maximum bed height at an elevation equal to or below a design threshold
22 height. The threshold height can be equal to or less than the height that imposes a
23 maximum loading on the side walls; the maximum loading typically including a

1 factor of safety. The desired bed height may range from approximately 0
2 (substantially no settling of solids) to a pre-determined maximum threshold height of
3 the bed contacting the side walls.

4 In further embodiments, internal annular elements within chamber
5 provide additional side wall relief by directing solids radially inwardly away from the
6 walls.

7 Further, conical skirts about one or more of the feed inlet (and
8 possibly the outlet), having conical slopes at or about the angle of repose, can
9 minimize or eliminate bed formation, all of the active settling solids being engaged
10 by the feed inlets (and outlets, where applicable) for fluidization.

11 A methodology for holding froth produced from extracted oil sands
12 between froth processing stages is provided, wherein the froth contains at least
13 bitumen and solids, the method comprising: introducing the froth into a tank,
14 fluidizing the settling solids in the froth such that the solids remain suspended in the
15 froth or distribute to form a bed of solids having a maximum height of less than a
16 maximum threshold height.

17 The above-mentioned and other features of the present apparatus and
18 methodology will be best understood by reference to the following description of the
19 embodiments.

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DESCRIPTION OF THE EMBODIMENTS

As will be appreciated by those of skill in the art, embodiments of holding tanks taught herein are suitable for extended storage of froth streams produced as a result of an oil sands extraction process. The froth typically comprises a bitumen-to-solids ratio of about 4:1. Solids in the froth are largely fine solids, typically having a size less than about 44 microns. Froth is therefore significantly different than initial oil sands slurries in the extraction process which have a bitumen-to-solids ratio of about 1:8 in which the solids include both coarse and fine solids. Holding tanks according to embodiments taught herein are generally unsuitable for use for storage of oil sand slurries and particularly for extended periods of time.

An improved fluidized froth holding tank is provided having regard to Figs. 1 – 11. The holding tank is configured to receive, store and inventory bitumen-rich feed for froth intermediate treatment stages of oil sands operations, namely receiving highly-viscous produced froth from extracted oil sands and discharging same to downstream treatment vessels. Using embodiments described herein, it is desired that such a tank firstly promote and maintain the suspension of solids therein during typical operations. It is further desired that such a tank distribute settling solids, forming a series of low-elevation, conical-sloped beds, thereby minimizing the height of any accumulations of solids that do settle.

With reference to Fig. 1, a cross-sectional illustration of the typical accumulation of settled solids in known, prior art flat-bottomed froth holding tanks. In the case of a central outlet, over time, solids accumulate radially about the outlet,

1 forming a large sloped bed having an inverted conical fluid section, or funnel, with
2 the outlet at the bottom of the funnel. At the base of the funnel, presenting at the
3 side walls, the height of the accumulation of solids, in larger tanks in the order of 38
4 meters in diameter, can reach bed heights as high as 11 meters. As the solids build
5 up, a semi-stable bed surface forms at an angle of repose angled upwardly from the
6 tank outlet. A steady state operation of sorts is reached as solids continue to settle,
7 accumulation on the bed surface and periodically slough down the bed surface to
8 the outlet. Such sloughing results in slugging at the outlet and can even
9 occasionally block the outlet. The accumulated solids significantly reduce overall
10 tank holding capacity, reducing inventory and surge capacity, or requiring the
11 design of larger tanks to compensate for lost volume. Further, the high side wall
12 accumulation of solids requires corresponding structural designs to resist the
13 loading.

14 With reference to Figs. 2 through 11, embodiments taught herein are
15 designed to introduce froth to the tank in such a manner so as to locally fluidize
16 settling solids pending withdrawal or removal from the tank, interrupting or
17 distributing bed formation for minimizing the maximum bed height of accumulated
18 solids. Formation of an array of smaller, low-elevation sloped sub-beds within the
19 tank can reduce the dead volume lost to accumulation and minimizes or
20 substantially eliminates the effect of sloughing. One can improve or maintain high
21 tank inventory capacity, can allow for economy of tank material and other structure
22 construction considerations, and can even allow for larger diameter, flat-bottomed

1 tanks to be used without having to construct stronger reinforced foundations
2 compared to conical-bottomed tanks of equivalent size and capacity.

3 As shown in Fig. 2, one embodiment of the present froth tank 10
4 comprises a vessel having an inner cylindrical chamber 12 having side walls 14 and
5 a bottom wall 16. In one embodiment, the bottom wall 16 of the tank is generally
6 horizontal. In an alternative embodiment, the bottom wall 16 may nearly-flat or
7 slightly sloped from horizontal, the angle being somewhat less than a normal angle
8 of repose of the typical settled solids, in contradistinction from conical bottom tanks.
9 In embodiments, a slightly sloped bottom wall might be in the order of up to about
10 an angle less than 10° from horizontal. The top of the tank 10 may be open or
11 closed to the external environment. Where closed, the tank 10 may comprise a top
12 wall as known to those in the art.

13 Tank 10 can include at least one entry inlet 18 for introducing froth into
14 the chamber 12. The froth may be introduced via entry 18 positioned substantially
15 at or near the bottom of tank 10, through the bottom wall 16, through side wall 14 or
16 through an elevated entry inlet 18a, with or without an anti-syphon system in order
17 to avoid backflow.

18 Froth is discharged or removed from the tank 10 via outlet 22. Outlet
19 22 is positioned substantially at or near bottom wall 16, and may be located
20 adjacent a side wall 14 per Figs. 2 and 3A, or along the bottom wall 16 such per
21 Figs. 4A-10B. Outlet 22 can be positioned at a minimum elevation equal to the
22 elevation of entry 18 within chamber 12.

1 In one embodiment, the froth is pumped into chamber 12 through one
2 or more feed inlets or nozzles 20 positioned low in the chamber 12 such as adjacent
3 the bottom wall 16. Each feed inlet 20 can direct a flow of froth upwardly into the
4 chamber 12 to engage solids settling therein. For example, froth flow rate via inlets
5 20 may be sufficient to maintain an approximate feed vertical component velocity of
6 at least 0.5 m/s at the inlets 20. In one embodiment, secondary feed inlet nozzles
7 20a may be oriented horizontally, or substantially parallel with the bottom wall 16,
8 such as to direct settling or settled solids towards vertically-oriented inlets 20. As
9 shown in Fig. 3A, froth may be recirculated from outlet 22 back to into chamber 12
10 via entry 18 when froth processing rates fall below that optimal for management of
11 settled solids within chamber 12.

12 The size, location and capacity of the feed inlets 20 is configured to
13 maintain and distribute suspended solids in a stable, generally fluidized state
14 pending recovery from outlet 22. Figs. 2 and 3A show example arrangements of
15 feed inlet arrays 21 capable of fluidizing a large portion of the solids settling over the
16 bottom wall 16. For example, Fig. 2 shows a tree-like array 21 distributed about a
17 substantial portion of the bottom wall 16.

18 The one or more feed inlets 20 are located intermediate the outlet 22
19 and the side walls 14, each feed inlet 20 fluidizing solids settling thereabout and
20 forming a bed 23 of solids about its respective feed inlet 20, each bed 23 that
21 reaches the side walls 14 having a maximum height of less than a threshold height.
22 If a bed reaches a height greater than the threshold height at or before reaching the

1 side walls, then a successive feed inlet is located between the previous or first feed
2 inlet and the side walls 14.

3 As shown in Fig. 3B, each feed inlet 20 produces its own small,
4 inverse-conical sub-bed of solids thereabout, the inverse base height having a low
5 elevation and at about a threshold elevation per the tank wall loading design criteria.
6 In an embodiment, feed inlets 20 may be designed to fluidize an inverse cone
7 having an inverse base height of about three meters, at a base diameter of about
8 10.4 meters, assuming an angle of repose of settled solids of about 30 degrees.
9 With feed inlet 20 effective inlet offset from the bottom wall 16 of one meter, the
10 maximum inverse base height is four meters, being significantly less than the 11
11 meters of the prior art. At the side wall 14 the threshold height could be about four
12 meters. As the inverse base has a diameter smaller than the side wall 14 diameter,
13 there is variation of the bed height along the side wall 14, the threshold height being
14 an approximate value and subject to variation. A safety factor could be applied to
15 ensure that greater heights, such as between two sub-beds, are within the design
16 height and the maximum inverse base heights are lower than the threshold heights.

17 Feed inlets 20 or array 21 of feed inlets 20 can be spaced areally so
18 that at least the sub-beds of settling solids formed adjacent the side walls 14 have
19 an elevation below a design loading threshold. The spacing of the feed inlets 20
20 and resulting sub-beds in the array 21 is such that many adjacent sub-beds about
21 may intersect at the threshold elevation.

22 The size, location and position of the feed inlets 20 and arrangement
23 thereof can vary depending upon the size and capacity of tank 10 and upon the

1 characteristics of the froth. It is desired that the size, location and position of the
2 feed inlets 20 are configured to fluidize relatively large solids (e.g. maximum
3 approximate size of 250 microns and average diameter of 20 – 22 microns), in fluid
4 having relatively low viscosity (e.g. >100cP), by providing sufficient spacing and
5 discharge velocity of the inlets 20.

6 With reference to Figs. 4A and 4B, in one embodiment, the feed inlets
7 20 can be arranged in a circular array 21 about a centrally-located outlet 22. The
8 array 21 of feed inlets 20 direct settling solids to form a series of smaller sub-beds
9 23. For example, in smaller tanks, typically about 18 meters in diameter, an array
10 21 of at least four inlets 20 can be positioned at pre-determined locations about
11 outlet 22, wherein four smaller sub-beds 23 of solids are formed, each having a low
12 inverse base design height shown in dashed circles. Radially outside the design
13 height, the height of the sub-bed 23 increases. Thus, the lateral extent of design
14 height of peripheral sub-beds 23 and the maximum elevation thereof, is arranged to
15 coincide at about the side wall 14. As shown in Fig. 4B, the radial proximity of the
16 feed inlets 20 to the outlet 22 results in a localized and low sub-bed 23 height and
17 substantially insignificant sloughing issues.

18 Having regard to Figs. 5A and 5B, such as is the case for larger tanks
19 typically about 38 meters in diameter, the feed inlets 20 may be configured to form
20 two or more circular arrays 21a, 21b within the chamber 12 and around outlet 22.
21 The number of feed inlets 20 and arrangement thereof, result in a low inverse base
22 design height, shown in dashed circles, that covers a substantial portion of the
23 bottom wall 16.

1 As shown in Fig. 5B, the desired threshold inverse base height of
2 settled solids H1 can be achieved with the progressive addition of feed inlets 20
3 spaced between the outlet 22 and the side walls 14. The inverse base height of
4 solids in prior art tanks lacking feed inlets can be significantly higher (H3) than the
5 threshold base design height in smaller tanks of the present design having one feed
6 inlet 20 (H2), or in larger tanks of the present design wherein successive feed inlets
7 20 (H1) are provided, each of which interrupts the growth of the height of the sub-
8 beds 23 about each feed inlet 20.

9 Simply, where the one or more feed inlets 20 are arranged as first
10 array 21a, and where beds 23 about the array 21a would reach the side wall 14
11 having a maximum height greater than the threshold height, then the beds 23 need
12 to be interrupted with additional and successive feed inlets (e.g. arranged as feed
13 array 21b). This, one or more successive feed inlets 20 can be located between the
14 first array 21a and the side wall 14 for fluidizing the settling solids in the froth about
15 one or more successive feed inlets 20 such that settling solids about each of the
16 one or more successive feed inlets 20 form one or more successive beds 23 of
17 solids, each successive bed 23 reaching the side wall 14 having a maximum height
18 less than the threshold height.

19 As further shown in Fig. 5B, where tanks 10 comprise only one or a
20 first feed inlet 20 or array 21 of feed inlets 20, the height of the resulting sub-beds
21 23 increases beyond the design threshold height at the extent of the dashed circles,
22 the maximum bed height between the first feed outlets 21a and side wall 14 may be
23 greater than the threshold or design height H1. The spacing between a first circular

1 array 21a and a successive circular array 21b is such that the maximum height H2
2 (e.g. 5 meters) of first sub-beds 23 can be greater than the side wall threshold
3 height H1 (e.g. 4 meters). However, being spaced from the side wall 14, higher bed
4 heights H2 do not impose extra force on side wall 14 and are not of significant
5 import.

6 The sub-bed 23 height, from the second or successive feed inlets
7 array 21b, results in bed heights less than or about the threshold or design height
8 H1.

9 Tank 10 may further be configured to comprise one or more directing
10 elements for urging or guiding of settling solids in a manner to optimize fluidization
11 thereof.

12 In one embodiment, having regard to Figs. 6A, 6B, 7A and 7B, tank 10
13 may be configured to have directing means comprising at least one internal annular
14 element 24 for urging settling solids away from side wall 14 or towards one or more
15 inlets 20. At least one, side wall 14 located, internal annular element 24 may extend
16 inwardly from side wall 14 at an incline at or steeper than the angle of repose to
17 avoid hold-up of solids thereon and directing settled solids radially inwards, thereby
18 aiding in side wall 14 relief. Tank 10 may be configured to minimize or negate any
19 pressure gradient above or below at least one annular element 24, thereby allowing
20 for the use of lighter-gauge steel in the manufacture thereof.

21 Having regard to Figs. 8A and 8B, tank 10 may be configured to
22 comprise a plurality of vertically-stacked internal annular elements 24. For example,
23 it may be desirable to provide vertically-stacked annular elements 24 as backup

1 should failure of one element occur, or to distribute high weight loads off of each
2 individual element. It should be understood that one or more internal annular
3 elements 24 may be used alone or in combination with any configuration of inlets
4 20, thereby optimizing the capacity of tank 10.

5 In another embodiment, having regard to Figs. 9A and 9B, tank 10
6 may be configured to have directing means comprising at least one transverse shed
7 element 26 for minimizing or distributing solid bed 23 formation. Shed elements 26
8 may be inclined at or steeper than the angle of repose, and may extend across or
9 substantially across the diameter of tank 10. Tank 10 may comprise a plurality of
10 vertically stacked transverse shed elements 26. Tank 10 may be configured to
11 minimize or negate any pressure gradient above or below shed elements 26,
12 thereby allowing for the use of lighter-gauge steel in the manufacture thereof. It
13 should be understood shed elements 26 may be used alone or in combination with
14 annular elements 24 and with any configuration of feed inlets 20, thereby optimizing
15 the capacity of tank 10.

16 In yet another embodiment, having regard to Figs. 10A and 10B, tank
17 10 may be configured to have directing means comprising at least one inverse
18 conical skirt 28 having an apex towards the bottom wall 16 for minimizing or
19 distributing the solid bed 23 formation. At the each apex, a feed inlet 20 is located
20 for fluidizing solids and minimizing or distributing sub-bed 23 formation. One or
21 more of the conical skirts 28 may be angled at, or slightly less than, the angle of
22 repose, for urging most solids settling thereon to flow or slough towards the feed
23 inlet 20 and be re-fluidized. Thus tank 10 may be configured to minimize or negate

1 any bed loading above or below at least one conical skirt 28, thereby allowing for
2 the use of lighter-gauge steel in the manufacture thereof. It should be understood
3 that one or more conical skirts 28 and feed inlets 20 may be used alone or in
4 combination with annular elements 24, shed members 26, thereby optimizing the
5 capacity of tank 10.

6 Having regard to Fig. 11, the capacity of tank 10 may be optimized
7 through the use of one or more velocity enhancement means 30 for increasing
8 fluidization. Velocity flow through feed inlets 20 may be enhanced by creating
9 suction or lower pressure at the feed inlets 20, causing solids and surrounding
10 media to be drawn into and pushed out of inlets 20 at high velocities (arrows). Such
11 enhancement means 30 may comprise, for example, the use of a diffuser, an
12 eductor, or the like.

13 A methodology for storing or handling bitumen froth produced from
14 extracted oil sands between bitumen processing stages is provided, the method
15 comprising introducing the bitumen froth into the tank 10, and suspending or
16 distributing settling solids in the bitumen froth in a fluidized bed within the tank 10
17 until such time as the bitumen froth is removed from the tank 10.

18 The present disclosure provides a detailed description of various
19 elements required to operate a fluidized froth holding tank, but many other known
20 elements such as valves, pumps and other tanks interconnected to tank 10, and
21 required to operate the present apparatus and method, have not been described
22 herein.

1 Example embodiments of the present invention are described in the
2 following Examples, which are set forth to aid in the understanding of the present
3 tank 10, and should not be construed to limit in any way the scope of the invention
4 as defined in the claims which follow thereafter.

5
6 EXAMPLE 1 – Testing of a Small Fluidized Froth Tank

7 With reference to Fig. 4A, simulation analyses were performed to
8 assess the capacity of a fluidized froth holding tank having a diameter of 18 meters
9 to function as a froth storage tank for extended periods of time. The flow rate of
10 bitumen froth feed into and out of the tank was 1100 m³/hr. The froth feed had an
11 approximate temperature of 60°C, an approximate viscosity of 0.5 Pa.s, an
12 approximate feed density of 1050 kg/m³ and density of the solids of 2650 kg/m³.

13 The flow rate of the bitumen froth feed out of the tank was 1100 m³/hr.

14 It was estimated that the froth feed into the tank had the following
15 approximate mineral distribution: fine particles smaller than 44 microns 60.60wt%
16 and sand of 39.40wt%. The largest size of the sand was estimated to have a
17 diameter of approximately 250 microns.

1 As such, using Stock's law, the settling velocity of the particles is
 2 shown in Table 1:

3 TABLE 1

Particle Size	Settling Rate:	
Micron	m/h	m/s
45	0.0094	2.60E-06
75	0.0313	8.68E-06
150	0.1875	5.21E-05
250	0.3750	1.04E-04

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5 A total of four inlets, each inlet having an internal diameter (ID) of 6 or
 6 8 inches, were used, the size of which being selected to achieve the desired
 7 velocity. As shown in Table 2, the desired discharge velocity of each inlet was
 8 significantly higher than the settling velocity for the largest mineral particles, thereby
 9 optimizing mixing and fluidization of the fluids in the tank.

10 TABLE 2

Number of nozzles	ID Nozzle	Radius Nozzle	Area Nozzle	Total A 4 nozzles	Flow 4 nozzles	Velocity each Nozzle
	Inch	m	m ²	m ²	m ³ /hr	m/s
4	6	0.0762	0.01824	0.073	1100	4.2
4	8	0.1016	0.03243	0.130	1100	2.4

11

1 EXAMPLE 2 – Testing of Large diameter Fluidized Froth Tank

2 With reference to Fig. 5A, simulation analyses were performed to
 3 assess the capacity of a fluidized froth tank having a diameter of 38 meters to
 4 function as a froth storage tank. The flow rate of bitumen froth feed into and out of
 5 the tank was 1100 m³/hr.

6 A total of 13 inlets were used, having an ID of 3 or 4 inches, the size
 7 of which being selected to achieve the desired velocity. As shown in Table 3, the
 8 desired discharge velocity of each inlet was significantly higher than the settling
 9 velocity for the largest mineral particles, thereby optimizing mixing and fluidization of
 10 the fluids in the tank.

11 TABLE 3

Number of nozzles	ID Nozzle	Radius Nozzle	Area Nozzle	Total A 4 nozzles	Flow 4 nozzles	Velocity each Nozzle
	inches	M	m2	m2	m3/hr	m/s
13	4	0.0508	0.00811	0.105	1100	2.9
13	3	0.0381	0.00456	0.059	1100	5.2

12
 13 Although a few embodiments have been shown and described, it will
 14 be appreciated by those skilled in the art that various changes and modifications
 15 might be made without departing from the scope of the invention. The terms and
 16 expressions used have been used as terms of description and not of limitation, and
 17 there is no intention in the use of such terms and expressions of excluding
 18 equivalents of the features shown and described or portions thereof, it being
 19 recognized that the invention is defined and limited only by the claims that follow.

20

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

1. A tank for holding froth from extracted oil sands, the froth
5 containing at least bitumen and solids, the tank comprising:

a side wall and a bottom wall forming an inner storage chamber
having side walls,

one or more feed inlets located adjacent the bottom wall for
introducing the froth upwardly into to the chamber,

10 an outlet located adjacent the bottom wall for removing froth from the
chamber,

wherein the one or more feed inlets are located intermediate the outlet
and the side walls, each feed inlet for fluidizing solids settling thereabout and
forming a bed of solids about the feed inlet, each bed that reaches the side walls
15 having a maximum height of less than a threshold height.

2. The tank of claim 1, wherein the threshold height is that less
than that capable of imposing a threshold loading on the side walls.

20 3. The tank of claim 1 wherein, when a height of a bed about a
first feed inlet of the one or more feed inlets would reach the side wall at a height
that exceeds the threshold height, one or more successive feed inlets are located
intermediate the first feed inlet and the side walls.

4. The tank of claim 1, 2 or 3, wherein the bottom wall is generally horizontal.

5. The tank of any one of claims 1 to 4, wherein some of the one or more inlets is positioned substantially at or near the bottom wall.

6. The tank of claim 5, wherein some of the one or more inlets is positioned through the bottom wall, through the side wall, or through an elevated inlet.

10

7. The tank of any one of claims 1 to 6, wherein the one or more feed inlets comprises a plurality of inlets arranged in an array for fluidizing solids settling thereat and forming a plurality of sub-beds thereabout each one or more feed inlet.

15

8. The tank of claim 7, wherein each sub-bed formed thereabout has a maximum height of less than a threshold height.

9. The tank of claim 7, wherein the one or more inlets is positioned to form one or more arrays of feed inlets spaced about and circumferentially about the outlet.

20

10. The tank of claim 9, wherein the spacing of the one or more inlets minimizes sloughing of solids and prevents outlet blockage.

11. The tank of any one of claims 1 to 10, wherein the tank further comprises sloped directing elements for guiding settling solids in the chamber towards one or more of the feed inlets.

12. The tank of claim 11, wherein one or more directing elements comprises at least one internal annular element projecting from the side walls for directing the solids away from the side walls.

13. The tank of claim 12, wherein the at least one internal annular elements are vertically stacked within the chamber.

14. The tank of claim 11, wherein the one or more directing elements comprise at least one transverse member extending across the chamber.

15. The tank of claim 14, wherein the at least one transverse members are offset.

16. The tank of claim 11, wherein the directing elements comprise at least one conical skirt encircling at least one of the one or more feed inlets for directing settling solids to the encircled feed inlet.

17. The tank of claim 11, wherein the directing elements comprise at least one internal annular element, at least one transverse member, at least one conical skirt or a combination thereof.

5 18. A method for holding froth from extracted oil sands between froth processing stages is provided, the froth containing at least bitumen and solids, the method comprising:

introducing the froth into a holding tank having side walls;

fluidizing the settling solids in the froth about one or more froth feed
10 inlets located intermediate a discharge and the side walls such that the solids remain suspended in the froth about each feed inlet; and

settling solids about each of the one or more feed inlets to form one or more bed of solids, each bed reaching the side walls having a maximum height less than a threshold height.

15

19. The method of claim 18 wherein the one or more feed inlets are first feed inlets, and where beds about the first feed inlets reach the side walls having a maximum height greater than the threshold height, further comprising:

5 locating one or more successive feed inlets between the first feed inlets and the side walls for fluidizing the settling solids in the froth about one or more successive feed inlets such that settling solids about each of the one or more successive feed inlets form one or more successive beds of solids, each successive bed reaching the side walls having a maximum height less than the threshold height.

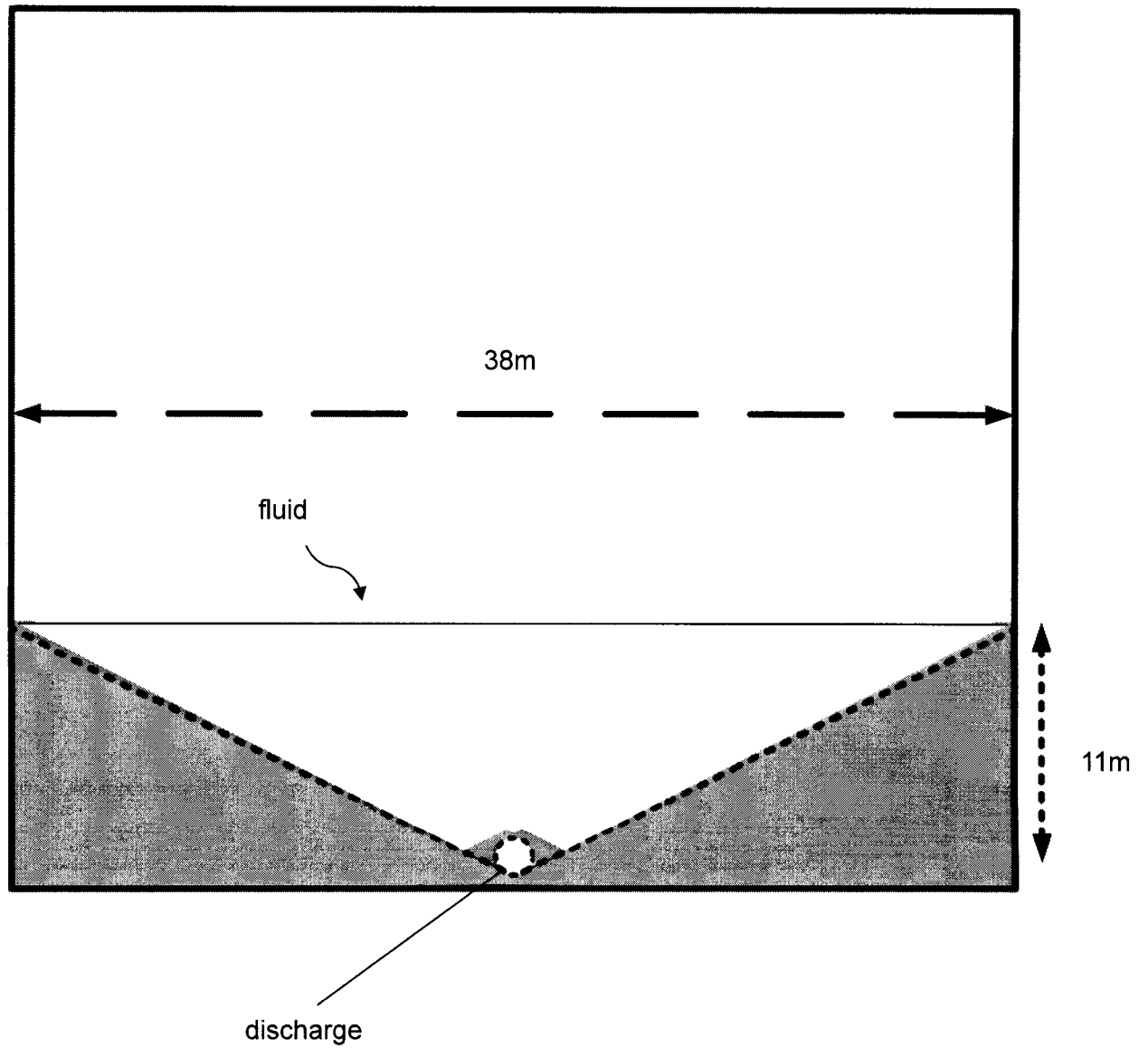
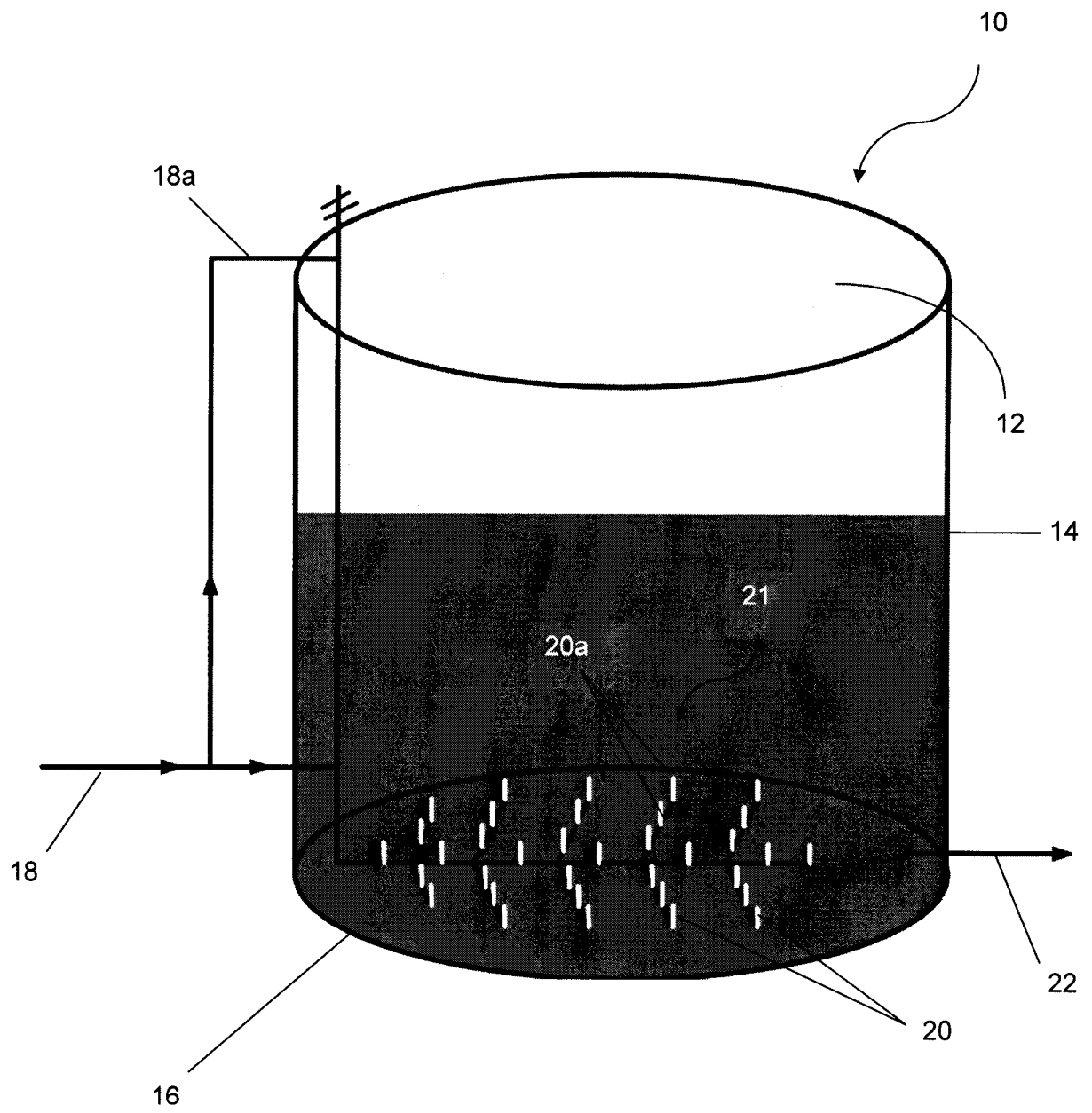
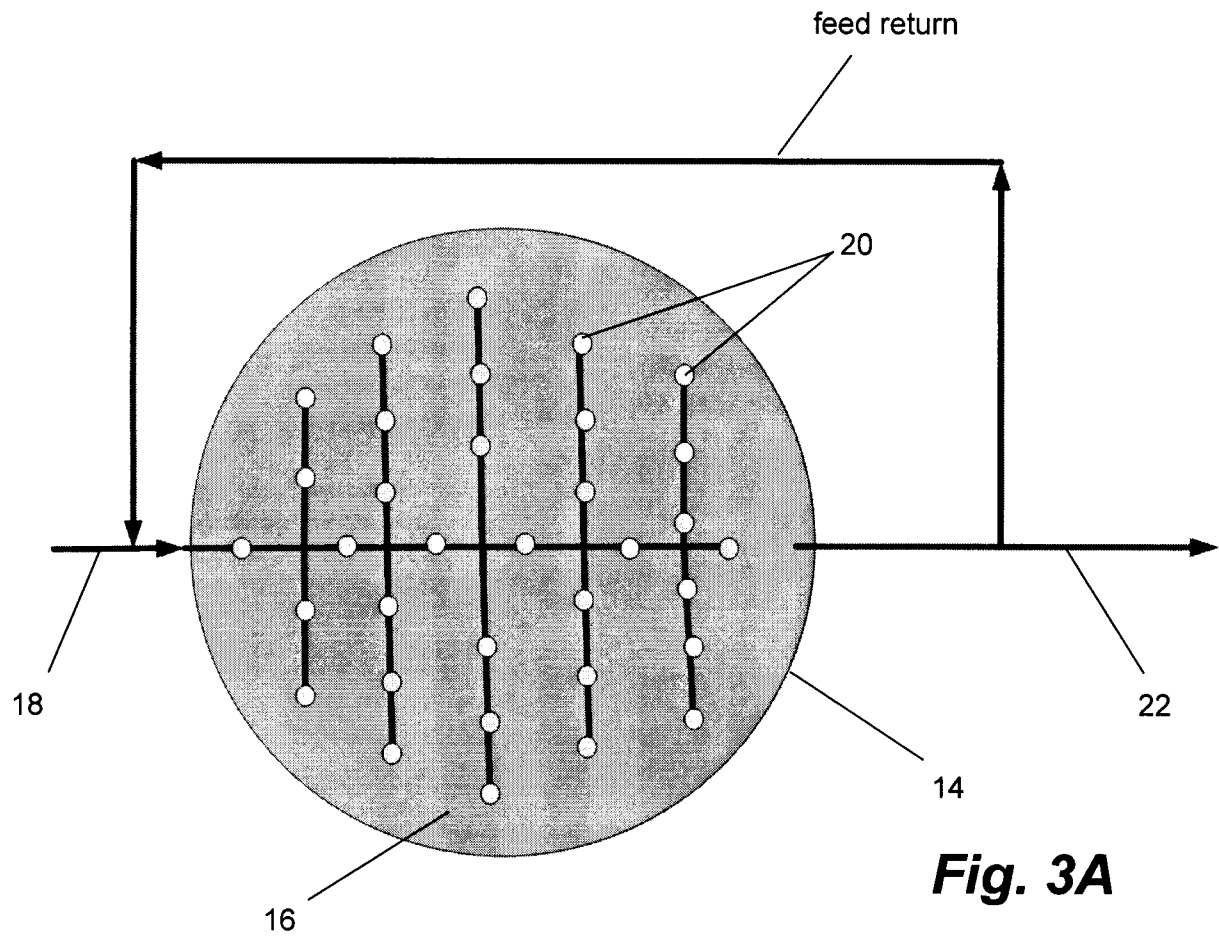
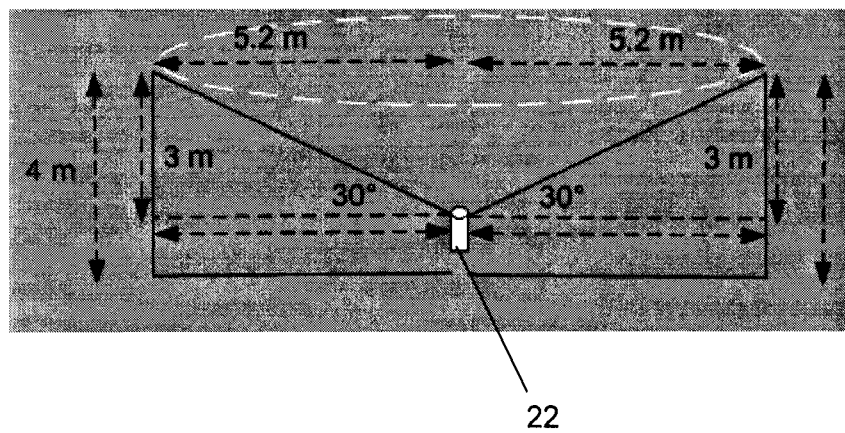
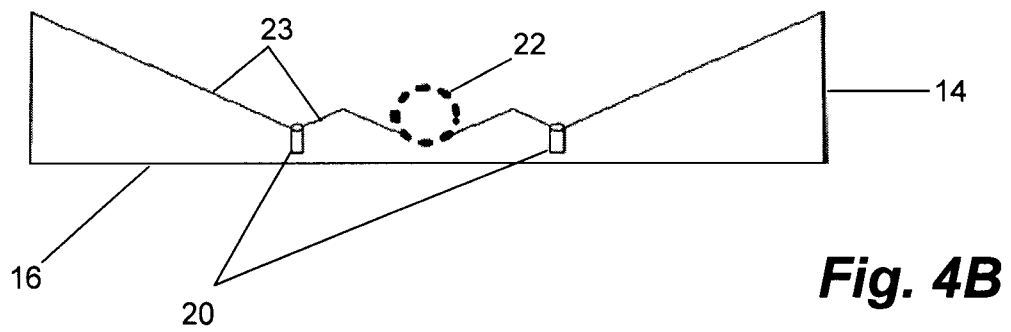
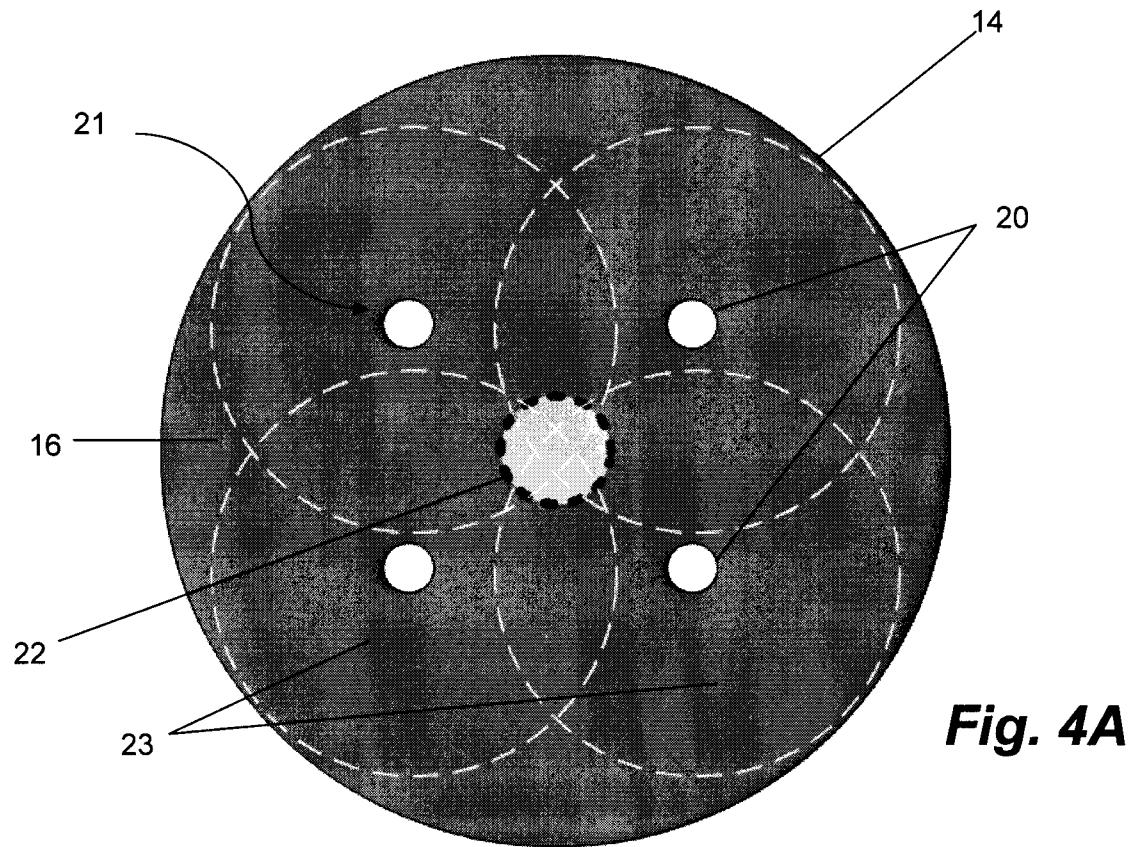


Fig. 1 (Prior Art)

**Fig. 2**

**Fig. 3A****Fig. 3B**



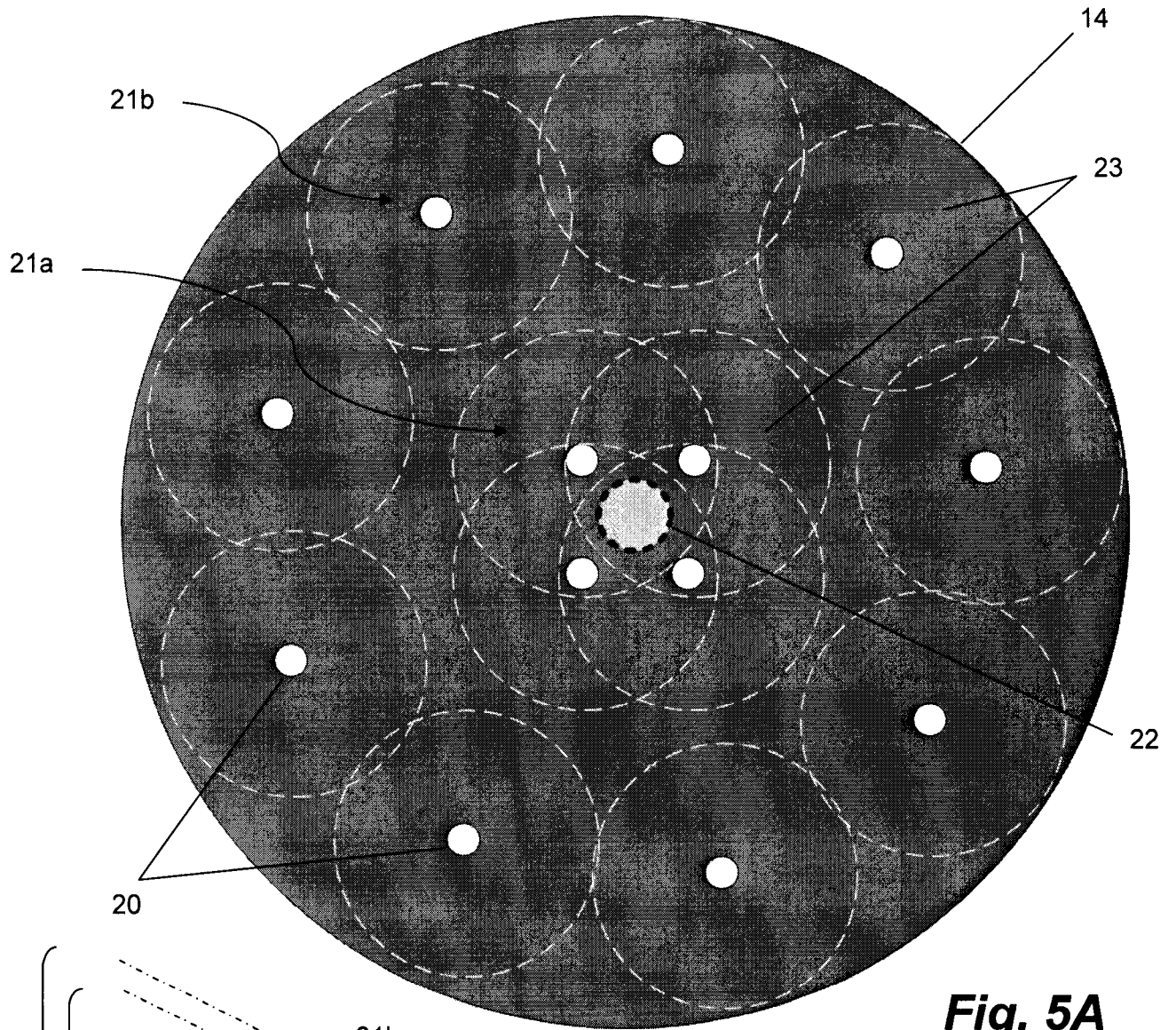


Fig. 5A

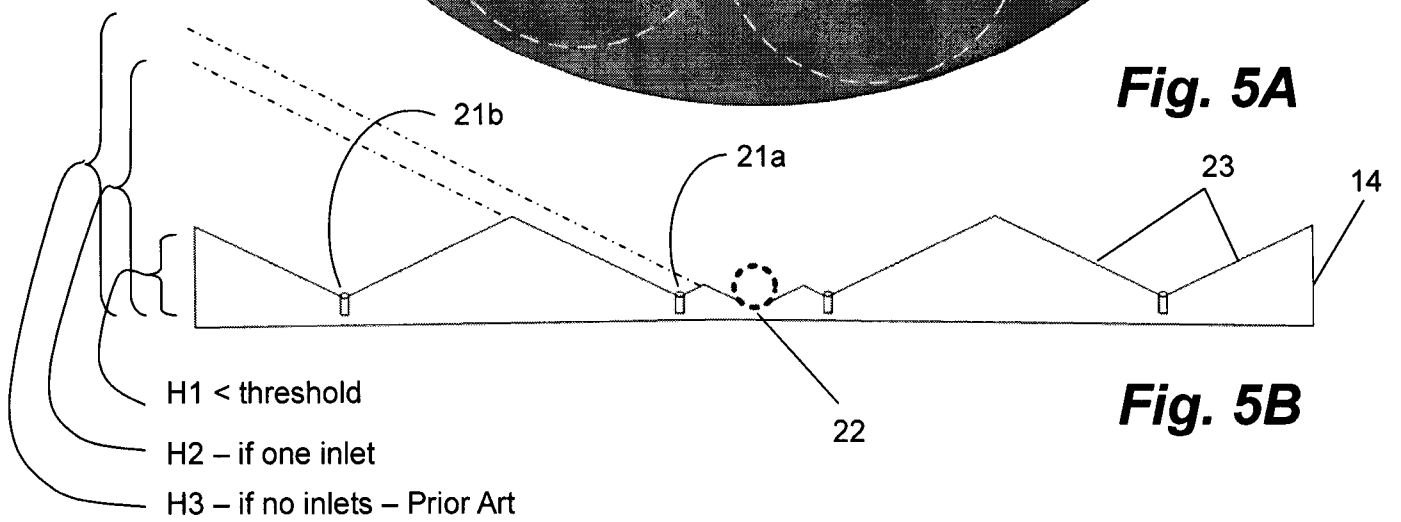


Fig. 5B

H1 < threshold
H2 – if one inlet
H3 – if no inlets – Prior Art

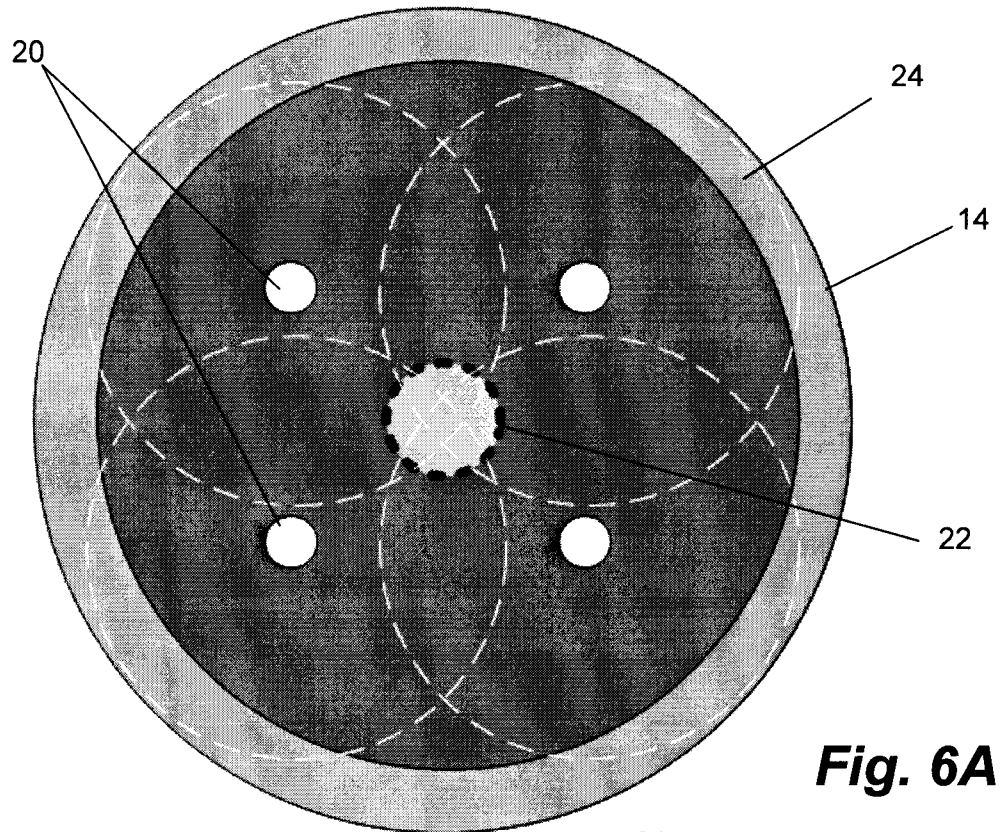


Fig. 6A

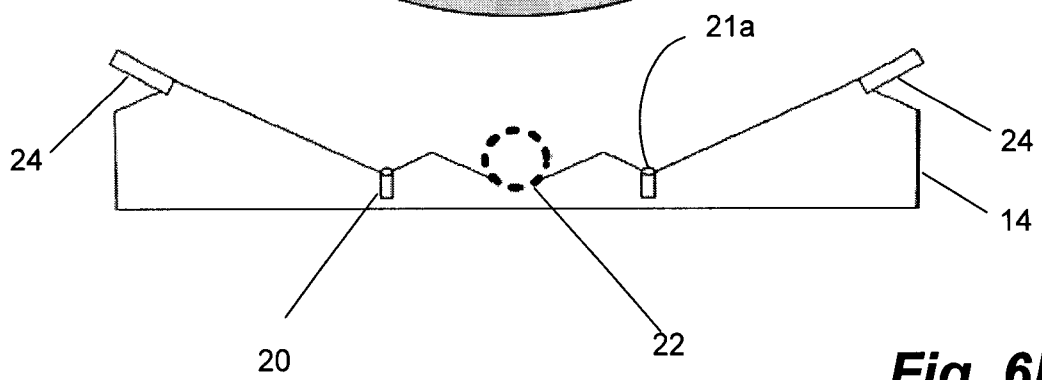


Fig. 6B

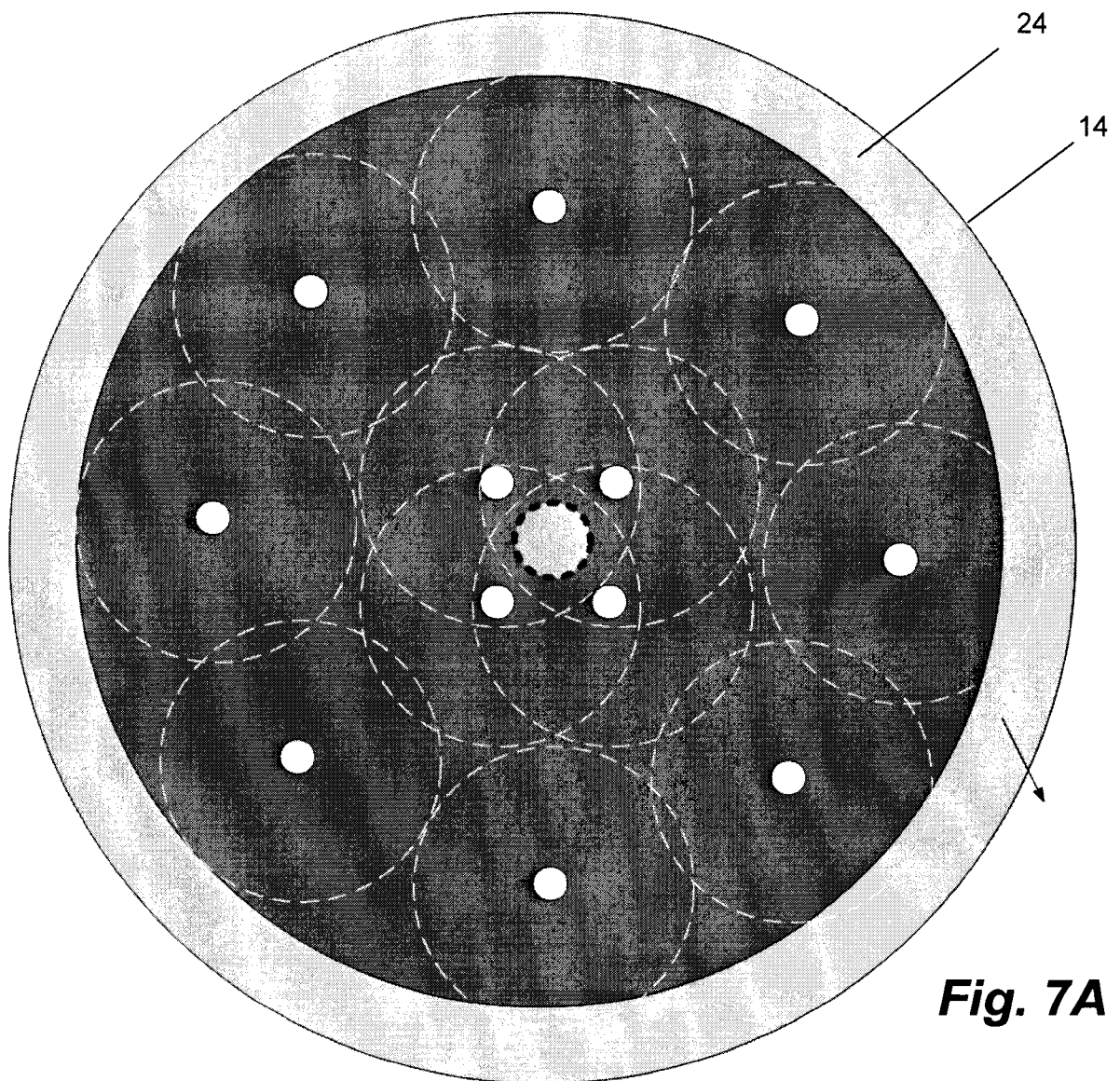


Fig. 7A

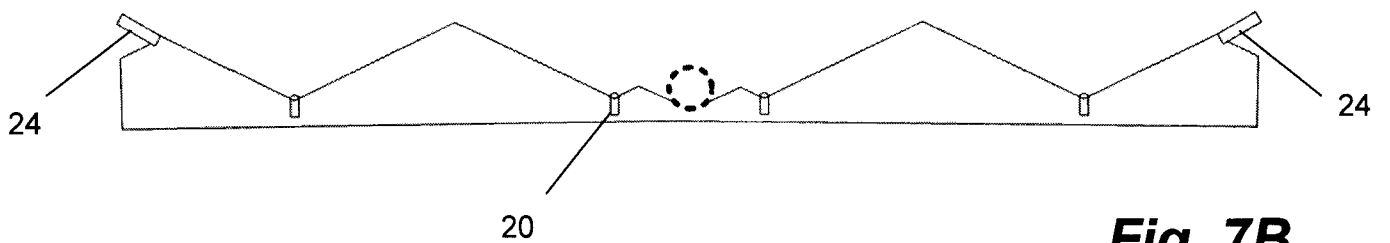


Fig. 7B

Fig. 8B

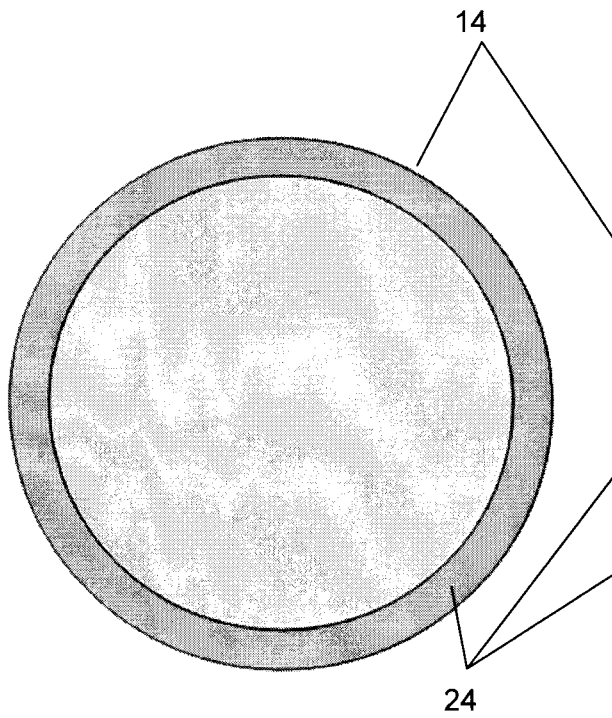


Fig. 8A

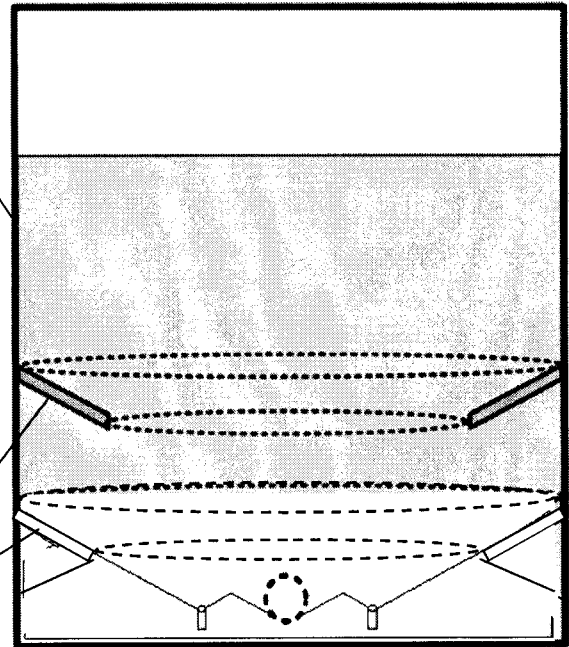


Fig. 9B

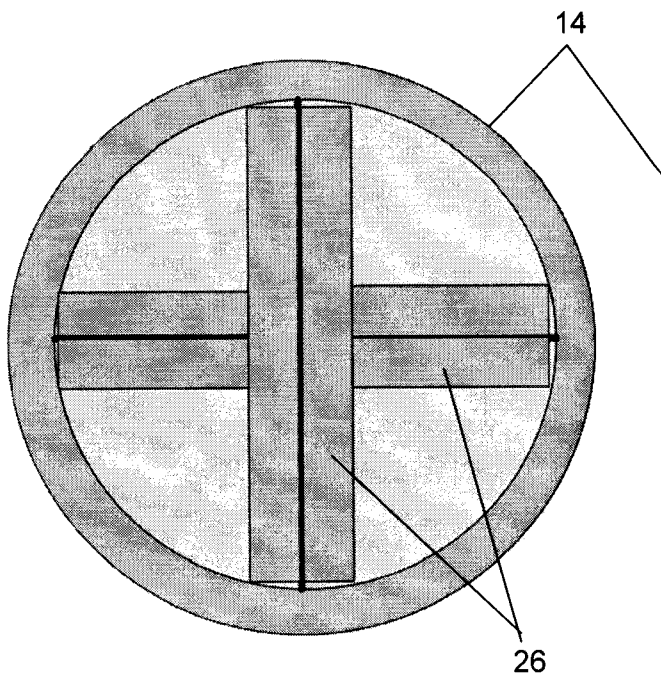
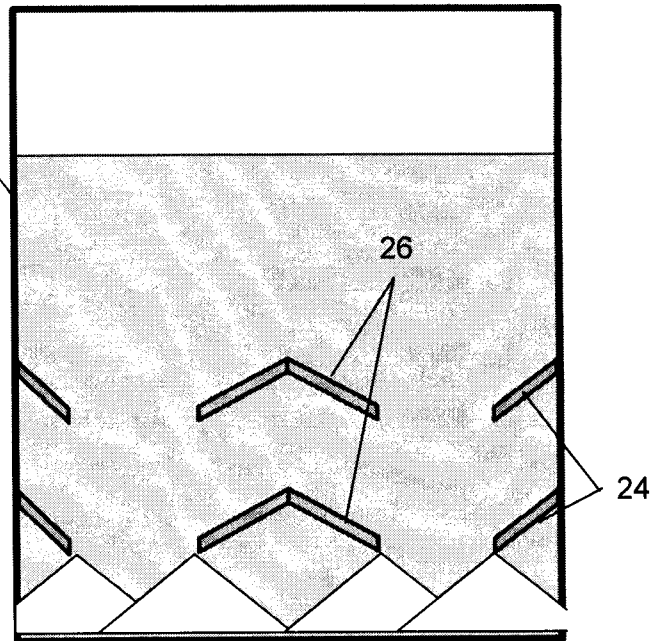


Fig. 9A



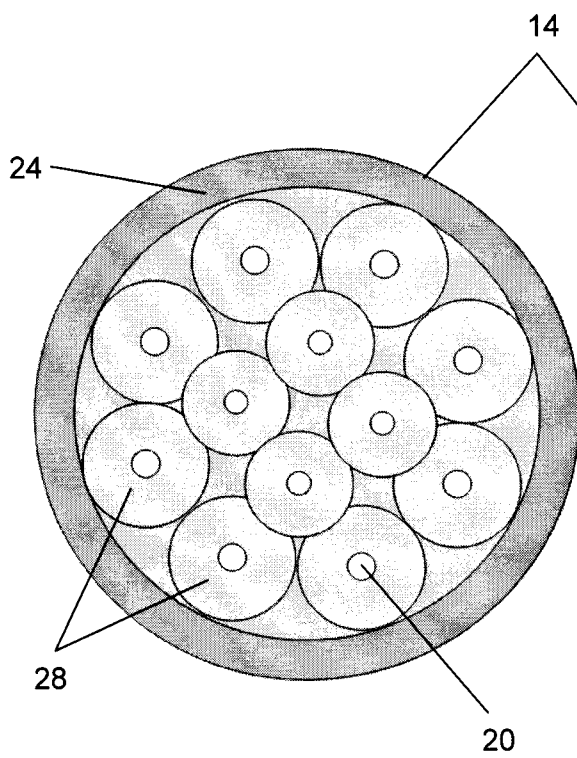


Fig. 10B

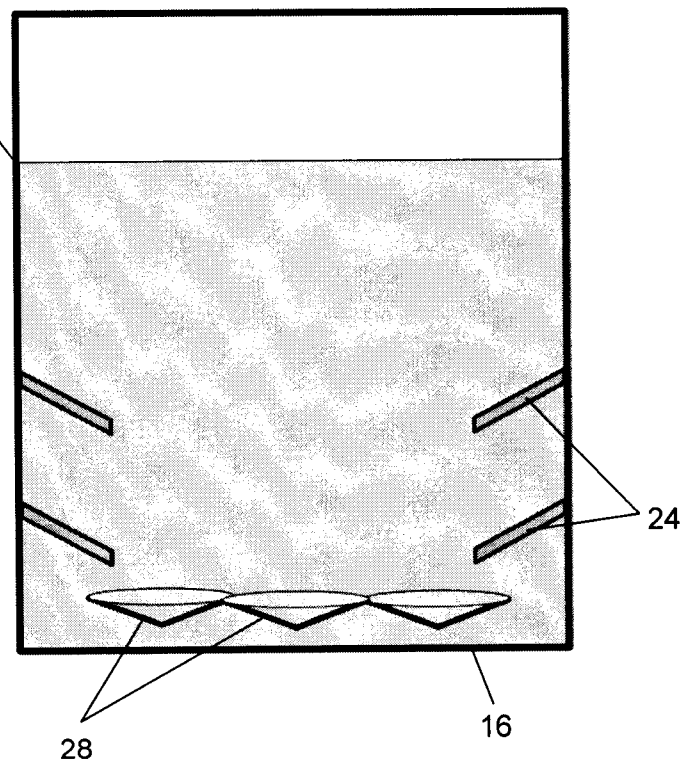


Fig. 10A

