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(56) Related Art
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GB 1374109
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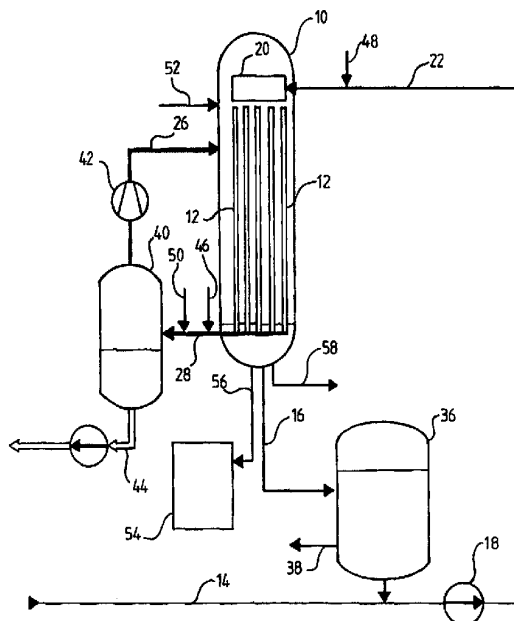
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(54) Title: FILTERING METHOD AND APPARATUS

(57) Abstract

The present invention relates to a filtering method, in which the suspension to be filtered is passed into contact with the filtering surface of the filter element, whereby due to the pressure difference prevailing across the filtering surface the filtrate flows through the filtering surface and separated solids substantially remain in the suspension. According to the invention the suspension to be filtered is passed to flow downwards along the filtering surface, whereby the filtering through the filtration surface takes place from the falling film and the separated solids are discharged with the falling film without forming a harmful solids layer on the filtering surface. An even liquid film falling on the filtering surface is generated by recirculating suspension from the bottom of the filter to the upper part of the filter element. The invention also relates to an apparatus for realizing the method, which may be applied especially for clarifying green liquor.



FILTERING METHOD AND APPARATUS

The present invention relates to a method of filtering suspension and an apparatus for realizing said method.

5 The present invention may be applied for filtering green liquor containing finely divided matter, generated, for example, in the chemical circulation of a pulp mill.

10 A significant subprocess in the manufacture of sulphate cellulose is the recovery of cooking chemicals. Part of said regeneration is formed by the manufacture of white liquor by causticizing, whereby lime milk and green liquor are allowed to react in order to form lime sludge and white liquor. The green liquor is generated when a
15 chemical melt containing sodium chemicals is led from the bottom of the furnace of a soda recovery boiler to a separate dissolving vessel, in which the melt is dissolved in a dilute liquor. The most significant sodium chemicals of the green liquor are sodium carbonate and
20 sodium sulphide. The green liquor also contains insoluble compounds, such as metal oxides, silicates, soot and other impurities. Said dregs containing impurities must be discharged from chemical circulation, since the dregs otherwise concentrates in the chemical circulation and
25 disturbs the manufacture of white liquor in causticizing. The cleaning of green liquor is generally performed in clarifiers. When the mills become larger and the environmental regulations more stringent cleaning by sedimentation principle results in large apparatuses, the
30 diameters of which exceed 30 meters. Moreover, clarifiers are always liable to disturbances, whereby too impure green liquor is obtained even from the correctly dimensioned apparatuses.

35 An alternative method is to clean green liquor by filtering. Since the dregs mainly consist of finely divided matter, the filterability of which is poor and

which rapidly clog the filtering surface, said method results in a filtering apparatus, which has a large surface area and is thus expensive. A cake containing fine particles must thus be removed from the surface often, whereby it, of course, remains thin. When such a cake is washed off, a very dilute slurry is obtained, which must be further concentrated in several process stages.

10 In order to improve the filterability, for example, lime sludge obtained from the causticizing process is used as filtration aid, by means of which a filtering layer having good filtering capacity when filtering finely divided green liquor is formed on the surface of the filter element. Said method results, however, in additive costs and increased amount of waste being transported to a landfill site.

20 The filterability of a suspension, which is difficult to filter, has been suggested to be improved also in such a way that the formation of a filter cake on the filtering surfaces is prevented by removing separated solids by causing a strong shear force on the suspension close to the filtering surface, which mixes solids back to the suspension to be filtered. The problem with this cross-flow filtration has been large liquid volumes, which must be circulated in order to generate sufficient velocity and turbulence to remove the separated solids from the filtering area.

30 The purpose of the present invention is to provide a filtering method and apparatus, by means of which said disadvantages may be eliminated. The present invention provides thus a simpler and more economic method and apparatus for filtering liquid-solids suspensions, especially those which have so far been difficult to filter. Although the background of the problem has been

discussed above in view of the green liquor, it is apparent that it is only an example and that the invention may be applied to be used also for filtering other liquid-solids suspensions, such as kaolin sludge, clarified white liquor, soda liquor, bleaching effluent of cellulose, and liquids containing fines, e.g. white water.

According to a first aspect of the present invention there is provided a method of filtering a suspension, in which the suspension to be filtered is brought into contact with a filtering surface, the filtering surface having a pressure difference prevailing thereacross generated by having a higher gas pressure on one side of the filtering surface than on the other, whereby the filtrate flows through the filtering surface and the separated solids substantially remain in the suspension, characterized in that the filtering surface is arranged so that the suspension to be filtered flows downwardly over said one side of the filtering surface in a falling film, whereby filtration takes place from the falling film on the filtering surface.

According to a second aspect of the present invention there is provided a method of cleaning green liquor, characterized in that the green liquor is caused to flow along one side of a filtering surface of a filter element as a falling film, the filter element having a pressure difference prevailing across the filtering surface generated by having a higher gas pressure on said one side of the filtering surface than on the other side of the filtering surface whereby the clarified green liquor flows through the filtering surface and the separated green liquor dregs remains in the falling green liquor film.

According to a third aspect of the present invention there is provided a filtering apparatus for filtering solids from a suspension, said apparatus comprising at least one filter

element provided with a filtering surface through which
filtrate flows while the solids substantially remain in the
suspension, whereby the filtering apparatus is provided
with at least means for passing the suspension to be
5 filtered to the or each filter element and means for the
discharge of the filtrate, characterized in the said means
for passing the suspension to be filtered are arranged in
such a way that the suspension is passed to the upper part
of the or each filter element to flow as a falling film
10 downwards on one side of the filtering surface, said
filtering surface having a pressure differing thereacross
generated by a higher gas pressure on said one side of the
filtering surface than on the other side of the filtering
surface.

15 Throughout this specification and the claims, the words
"comprise", "comprises" and "comprising" are used in a non-
exclusive sense.

20 According to a preferred embodiment a filter is provided
with means for recirculating the non-filtered suspension to
the upper part of the filtering surface.

The present invention realizes the cross-flow filtration in
25 a new manner, whereby shear forces preventing

generation of solids cake on the filtering surface is carried out by passing suspension to be filtered to flow due to the gravitational force during the filtration down on the filtering surface. Due to the pressure difference part of the liquid is filtered there from the falling film through the filtering surface.

A continuous downwards flowing liquid film is most suitably generated by recirculating non-filtered suspension to the upper part of the filtering surface and the suspension to be filtered is supplied and mixed to the circulation flow. The generation of an even liquid film on the filtering surface requires rather large liquid amounts, generally larger than what flows into the apparatus, and that is why the recirculation of the suspension is necessary for having an efficient filtration.

All arrangements, in which the invention may be realized, are applicable for filter element in a filter according to the present invention. Such elements are most preferably a lamella, a tube and a disc. Most usually the filtrate is discharged through a filter channel inside the element, such as a tube. If so desired, the suspension to be filtered may be passed into the element, whereby the filtration takes place in an opposite direction.

The separated solids tend to accumulate on the filtering surface. By maintaining the flow velocity high enough the generation of the solids layer may be completely prevented, since separating solid particles are entrained with the falling liquid. If a solids layer tends to be generating, it may be prevented by lowering the pressure difference for a moment, whereby the flow through the filtering surface ends or slows down and the "grip" of the layer from the filtering surface loosens and it gets

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loose to flow with the suspension flow. In order to remove the harmful solids cake flow in the falling film may be intensified also locally in a restricted area at a time. The increase of the flow is generated by means of one or more liquid jets.

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The attachment of solids on the filtering surface may also be prevented by vibration. There are both mechanic and acoustic of such vibration apparatuses known per se.

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The suspension to be filtered is brought to distribute on the filtering surface in the same way as in the falling film evaporators. A liquid distribution tray, a perforated plate or like device, to which the suspension to be filtered is passed and the bottom of which is provided with openings, through which the suspension is allowed to flow evenly on the filtering surfaces, may be arranged above the filter elements.

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The pressure difference across the filtering surface may be generated by joining the filter to an apparatus known per se in order to generate a vacuum. The filter elements may thereby be assembled in an atmospheric vessel or freely in atmosphere.

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A required pressure difference may be maintained also by pressurizing the pressure vessel filter with gas. The gas may be arranged in a closed circulation system. The applied gas may be inert or reactive relative to the suspension to be filtered. Reactive gas is added, when so desired, during the filtration in order to realize desired reactions.

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The gas possibly penetrating the filtering surface may be separated from the filtrate either in the filter element by removing it from a separate conduit than the filtrate, most preferably from above the liquid surface through the

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upper part of the element, or in a separate vessel outside the filter.

5 The filtration may take place either continuously or batchwise. In continuous filtration new suspension is supplied, and thickened suspension is discharged continuously. If, however, as clean dregs as possible are desired to be obtained, which with green liquor means efficient alkali removal from the dregs, it is possible
10 to perform the filtration batchwise.

In batch process non-filtered suspension is not discharged continuously, but the feed of the suspension is stopped during the filtration and the suspension is
15 allowed to be thickened by recirculating. Thereafter washing water is supplied to the filter and filtration continues. The washing water being mixed with the dregs removes impurities from the dregs, according to the above mentioned example, alkali. At the same time the water
20 penetrating the filtering surface washes the filtering surface improving the filtration capacity. The dregs are removed as slurry to be further treated and a new filtration cycle may be begun.

25 An even more efficient treatment of dregs is provided, if a cake is formed of dregs for washing. In this kind of process the apparatus is provided with a separate slurry vessel. There the recirculation pump draws the suspension to be recirculated from the slurry vessel, to which the
30 slurry flows from the bottom of the filter. The process is started by filling the slurry vessel with suspension to be filtered, whereafter the recirculation and filtration of the suspension is started. Slurry from the filter is not removed from the slurry vessel, but it is
35 allowed to thicken there, which takes place when liquid is removed as filtrate. When the solids content of the sludge is as desired, the bottom conduit of the filter is

- closed and the filter is allowed to be filled with slurry. The pressure difference still prevails in a full filter, whereby liquid is infiltrated through the filtering surface, on which a solids cake is generated.
- 5 After the filtration the slurry remained between the filter elements or otherwise in the filter is removed and brought back to the slurry vessel. When the bottom of the filter is closed, a cake remains due to the pressure difference on the surface of the elements, from where the
- 10 gas flowing through the cake and the filter element removes humidity. The generated cake is removed by washing with water and blowing with gas to be passed for further treatment (washing and drying).
- 15 In connection with such a batch process it is possible also to carry out dregs washing, now as an efficient displacement washing. So far it has been necessary to carry out the dregs washing in separate apparatuses. The washing takes place by filling the filter with water
- 20 after the drying of the cake and by emptying the filtered water then to the washing vessel. The cake is finally removed, as above, by washing with water and blowing with gas and the dregs-water mixture is passed for further treatment.
- 25 If so desired the whole treatment of the material to be filtered, such as green liquor, is desired to be performed in the same apparatus (filter) the previous alternative may be further developed in such a way that
- 30 after the washing and drying the cake is loosened dry by blowing and removed, for example, through the opened lower end of the filter.
- 35 In batch process it is possible to adjust the capacity by pressure difference or by extending the interval between the cycles.

The present invention is described more in detail below, by way of example, with reference to the accompanying drawings in which:

- 5 Fig. 1 schematically illustrates a preferred embodiment of the apparatus for realizing the invention;
Fig. 2 schematically illustrates the principle of the filtering method according to the invention; and
Fig. 3 schematically illustrates a second embodiment of the apparatus for realizing the invention.

10 The filtering apparatus in Fig. 1 comprises a pressure-proof vessel 10, to which vertical filter elements 12 are provided. Each filter element, lamella, preferably consists of two perforated plates coated with supporting
15 and filtering cloth. The filter elements are suspended inside vessel 10 or otherwise appropriately attached so that the filtration in accordance with the invention is possible. The filter element is substantially in a vertical position, whereby the liquid film flows along
20 the filtering surfaces of the filter element. The filter element may also be an element inclined relative to the normal.

The suspension to be filtered is passed through a conduit
25 14 to the recirculation system of the filter, comprising a pipe line 16, 22 and a recirculation pump 18. The material to be filtered is passed to the upper part of the filter to a perforated plate 20, which has openings at each of the filter element, through which
30 the material to be filtered may flow to the filtering surfaces of each filter element. When flowing due to the gravitational force along the filtering surfaces 24, as shown in Fig. 2, the liquid containing solids forms a dense liquid film 30 on the filtering surface,
35 which film substantially prevents the pressurized gas in vessel 10 from penetrating the filtering surface. The pressure gas is passed to the

vessel through conduit 26. Due to the pressure difference caused by the gas the filtrate penetrates through the filtering surface to the filtrate channel 32 surrounded by filtering surfaces, where filtrate 34 flows downwards and ends up in a discharge conduit 28 in the lower part of the element, along which the filtrates from all filter elements are discharged from vessel 10.

The non-filtered suspension accumulates to the bottom of the vessel, from where it is passed along conduit 16 to vessel 36 and is further recirculated to the upper part of the filter elements. In continuous filtration part of it is continuously discharged for further treatment along conduit 38. The sludge may be recirculated also directly from the bottom of the filter without an intermediary vessel 36.

The majority of the suspension to be recirculated flows down the filtering surface carrying the separated solids therewith. Thus it is possible to prevent the generation of the cake. The amount of the suspension to be recirculated must be such that an even and continuous falling film is generated on the filtering surface.

In the filtration the pressure difference may be reduced across filter element to remove a thin solids layer possibly attached to the filtering surface, whereby the filtration slows down and the layer loosens to be entrained with the downwards flowing liquid layer. The removal of the layer may be facilitated also by changing the pressure difference opposite, for example, by stopping the feed of the pressure gas from conduit 26 and by feeding gas from conduit 46 through filtrate channels.

The attachment of the solids on the filtering surface may be prevented also by providing vessel 10 or elements 12 with a vibration apparatus.

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In batch filtration process the apparatus in accordance with Fig. 1 operates in the following way. The sludge vessel 36 is filled with the suspension to be filtered through conduit 14 either through the filter (conduits 22 and 16) or by feeding directly (not shown) to the vessel. After filling the vessel 36 the filtration is begun by recirculating the suspension by a recirculation pump 18. The filtrate flows to the vessel 40. More suspension is supplied through conduit 14 according to the surface level of the sludge vessel. Sludge is not removed from the vessel 36, but it is allowed to be thickened there.

When the desired dregs concentration is achieved in the vessel 36, the bottom of the filter is closed and the recirculation pump 18 pumps the content of the vessel 36 to the vessel 10. Due to the pressure difference prevailing in the filter the filtrate is pressed through the filtering surface 24 and a cake is generated on the surface. In the end of the filtering cycle the non-filtered suspension is removed from the filter and returned to the vessel 36 through conduit 16. When the pressure difference prevails, the cake remains on the surface of the filtering element, through which the gas flowing therethrough removes water. The generated cake is removed by washing with water, which may be supplied, for example, through conduit 48 to the upper end of the elements or through conduit 50 from the inner part of the filter elements. Finally air may also be blown through conduit 46. Dregs-water mixture is removed to a separate open dregs vessel 54 along line 56.

Now the filter is ready to begin a new filtering cycle.

It is also possible to carry out the washing of the dregs in the same filter. There, prior to the removal of the cake conduit 16 is closed, vessel 10 is filled with water through conduit 48, 50 or 52. The washing water filtered

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through the cake is discharged to a separate washing water vessel through line 58. After the washing the cake is removed as described above.

- 5 The process may be further improved in such a way that the cake is removed dry. Consequently, after the removal of the washing water and the drying of the cake (gas through conduit 26) the cake is removed from the filtering surface by blowing gas through conduit 46, whereby the gas coming from the inside of the elements drops the cake to the bottom of the vessel 10, from which the cake may be removed, for example, by opening the bottom end of the vessel.
- 10
- 15 It is illustrated in Fig. 3, how the batch filtration may be carried out in another way, if less dregs washing than that in the above described filtration is sufficient, whereby no filtration cake is formed during the washing, either. The reference numbers are analogous to those in Fig. 1, only they are preceded by "1".
- 20

The suspension to be filtered is passed through conduit 114 to the recirculation system of the filter, which system comprises a pipe line 116, 122 and a recirculation pump 118. Sludge is not discharged during the filtration cycle, but it is allowed to thicken and accumulate to the lower part of the filter. Also the feed of the suspension to be filtered from line 114 is stopped in order to thicken the sludge. Then washing water is supplied from line 115. Filtration is continued, whereby sludge is recirculated and washing water being mixed with the dregs removes impurities, such as alkali in the treatment of green liquor, from the dregs. Also a second cleaning effect is achieved with the washing water, when the water (filtrate) passing through the filtering surface washes the filtering surface and thus improves the filtration capacity, in other words the surface is cleaned for the

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next filtration cycle. After a sufficient washing, the dregs are discharged for further treatment through line 156, whereafter a new filtration cycle may begin.

5 In an apparatus in accordance with Fig. 2 a filtrate flow from the lower end of the element 12 is passed along conduit 28 to a separator 40, in which the gas possibly entrained with the filtrate to the separator, is separated. The separated gas is passed through a
10 compressor 42 back to the pressure vessel 10 in the filtration process. The gas thus circulates in a closed system, which has the advantage that the gas does not react with the material being filtered. The filtrate is passed from the separator along conduit 44 for further
15 treatment.

In the apparatus of Fig. 3 the gas which has passed through the filtering surface is discharged through the upper parts of the elements along line 141, whereas the
20 filtrate is discharged from the lower part of the elements along line 128 as in Fig. 1. Since the gas is separated from the filtrate already in the element, the filtrate obtained is gas-free already in line 128, and a separate gas discharge vessel is not necessary. The
25 pressure of the separated gas is raised in the blower 142 and the gas is returned to the filter vessel 110.

Following advantages are achieved with the present invention when applying it in the filtration of green
30 liquor or like materials:

- the cleanliness of the green liquor to be filtered is better secured; the settling and separation of the dregs in the green liquor varies in the clarifier;
- the sludge volumes to be treated are smaller than in
35 the clarifier, because the dregs content is higher. The sludge volumes to be treated are approximately 1/5 of the corresponding sludge amount in the clarifier;

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- the filtering apparatus requires considerably smaller space than the clarifier;
- no filtering aids are required;
- the filtering capacity is higher compared with the conventional cake filtration;
- 5 - if batch process is used, longer filtration cycles are obtained than when using known batch filtration methods, such as the conventional cake filtration;
- cleaning of green liquor and the treatment of the dregs separated therefrom is possible in the same apparatus (the cake may be removed dry), no separate dregs washing apparatus is required; and
- 10 - dilution washing of green liquor dregs is possible, whereby the treatment thereof with the actual dregs filter is facilitated.
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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of filtering a suspension, in which the suspension to be filtered is brought into contact with a filtering surface, the filtering surface having a pressure difference prevailing thereacross generated by having a higher gas pressure on one side of the filtering surface than on the other side of the filtering surface, whereby the filtrate flows through the filtering surface and the separated solids substantially remain in the suspension, characterized in that the filtering surface is arranged so that the suspension to be filtered flows downwardly over said one side of the filtering surface in a falling film, whereby filtration takes place from the falling film on the filtering surface.
2. A method of filtering a suspension in accordance with claim 1, characterized in that the falling film carries the separated solids therewith thus preventing the generation of a solids layer on the filtering surface.
3. A method of filtering a suspension in accordance with claim 1 or 2, characterized in that the falling film falls evenly on the filtering surface and is generated by recirculating the non-filtered suspension to an upper position of the filtering surface.
4. A method of filtering a suspension in accordance with claim 1, 2 or 3, characterized in that the pressure difference used in the filtration is generated by applying a vacuum to said other side of the filtering surface.
5. A method of filtering a suspension in accordance with claim 1, 2 or 3, characterized in that the pressure difference used in the filtration is generated by pressurizing a pressure vessel encompassing said one side of the filtering surface with gas.

6. A method of filtering a suspension in accordance with claim 5, characterized in that the gas is inert with respect to the suspension to be filtered.

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7. A method of filtering a suspension in accordance with claim 5, characterized in that the gas is reactive with respect to the suspension to be filtered.

10 8. A method of filtering a suspension in accordance with any one of claims 1-7, characterized in that the pressure difference used in the filtration is decreased or momentarily reversed so as to prevent generation of a solids layer.

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9. A method of filtering a suspension in accordance with any one of claims 1-7, characterized in that flow in the falling film is intensified for a time in an area of the falling film so as to prevent generation of a solids layer.

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10. A method of filtering a suspension in accordance with claim 9, characterized in that the increase of flow is carried out by means of one or more liquid jets.

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11. A method of filtering a suspension in accordance with any one of claims 1-7, characterized in that the prevention of generation of a solids layer is aided by vibration of the filtering surface.

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12. A method of filtering a suspension in accordance with any one of the preceding claims, characterized in that the filtration is continuous, whereby sludge is continuously discharged during the filtration

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13. A method of filtering a suspension in accordance with any one of claims 1-11, characterized in that the

filtration is performed batchwise, whereby feed of the suspension to be filtered is stopped during the filtration and finally sludge thickened during the filtration is discharged.

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14. A method of filtering a suspension in accordance with claim 13, characterized in that the thickened sludge is washed by mixing with washing liquid and filtering at the same time.

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15. A method of filtering a suspension in accordance with claim 13, characterized in that a final filtration takes place by pressing sludge with pressure against the filtering surface in order to generate a filtration cake and to remove the filtrate through the filtering surface.

15

16. A method of filtering a suspension in accordance in claim 15, characterized in that the filtration cake is dried with gas.

20

17. A method of filtering a suspension in accordance with claim 15 or 16, characterized in that the filtration cake is washed prior to its being removed by bringing the filtration cake into contact with water and by filtering and removing the water.

25

18. A method of filtering a suspension in accordance with any one of claims 15-17, characterized in that the filtration cake is discharged by washing with water by sludging the cake.

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19. A method of filtering a suspension in accordance with any one of the preceding claims, characterized in that the suspension to be filtered is green liquor generated in the manufacture of cellulose.

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20. A method of cleaning green liquor, characterized in that the green liquor is caused to flow along one side of a filtering surface of a filter element as a falling film, the filter element having a pressure difference prevailing across the filtering surface generated by having a higher gas pressure on said one side of the filtering surface than on the other side of the filtering surface whereby the clarified green liquor flows through the filtering surface and the separated green liquor dregs remains in the falling green liquor film.

21. A method of cleaning green liquor in accordance with claim 20, characterized in that non-filtered green liquor is recirculated to an upper position of the filter element in order to obtain an even film on the filtering surface.

22. A method of cleaning green liquor in accordance with claim 21, characterized in that the green liquor dregs is washed with a dilution wash.

23. A filtering apparatus for filtering solids from a suspension, said apparatus comprising at least one filter element provided with a filtering surface through which filtrate flows while the solids substantially remain in the suspension, whereby the filtering apparatus is provided with at least means for passing the suspension to be filtered to the or each filter element and means for the discharge of the filtrate, characterized in the said means for passing the suspension to be filtered are arranged in such a way that the suspension is passed to the upper part of the or each filter element to flow as a falling film downwards on one side of the filtering surface, said filtering surface having a pressure difference thereacross generated by a higher gas pressure on said one side of the filtering surface than on the other side of the filtering

surface.

24. Apparatus in accordance with claim 23,
characterized in that the filtering apparatus is further
5 provided with recirculation means for recirculating the
suspension to an upper position of the or each filter
element.

25. Apparatus in accordance with claim 23,
10 characterized in that the filtering apparatus is further
provided with distribution means for liquid, such as a
perforated plate, through the perforations of which the
suspension to be filtered flows to the filtering surface or
surfaces.

26. Apparatus in accordance with claim 23,
characterized in that the filter element or elements are
arranged in a pressure vessel.

27. Apparatus in accordance with claim 23,
characterized in that the filter element or elements are
arranged in a vessel at atmospheric pressure or space and
that the pressure difference is achieved by vacuum means in
operative association with said other side of the filtering
25 surface.

28. Apparatus in accordance with claim 23,
characterized in that it further comprises means for
removing sludge from the filtration process.

29. Apparatus in accordance with claim 24,
characterized in that the recirculation means comprise a
sludge vessel.

30. Apparatus in accordance with claim 26,
characterized in that the vessel is further provided with
means for passing gas to the vessel.

31. Apparatus in accordance with claim 26,
characterized in that it is further provided with gas
recirculation means for recirculating the gas in the
5 process.

32. Apparatus in accordance with claim 31,
characterized in that the gas recirculation means comprise
an apparatus for raising the gas pressure.
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33. Apparatus in accordance with claim 23,
characterized in that the or each filter element comprises
a filtrate channel having means for removing gas from said
filter element and means for removing the filtrate from the
15 element.

34. Apparatus in accordance with claim 23,
characterized in that the filtering apparatus is provided
with means for vibrating it or the or each filter elements
20 in order to prevent generation of a solids layer.

35. Apparatus in accordance with claim 23,
characterized in that the or each filter element is
arranged substantially vertically.
25

36. Apparatus in accordance with claim 23,
characterized in that the filtering apparatus is further
provided with one or more movable liquid jets in order to
increase the liquid flow locally on the filtering surface
30 or surfaces for preventing formation of a solids layer in
the effective range of a liquid jet.

37. Apparatus in accordance with claim 23,
characterized in that the or each filter element comprises
35 a filtrate channel, which is in connection with means for
passing gas and water through the filtering surface.

38. Apparatus in accordance with claim 23,
characterized in that the or each filter element is in
communication with means for passing the water thereto.

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Dated this 2nd day of November 1998

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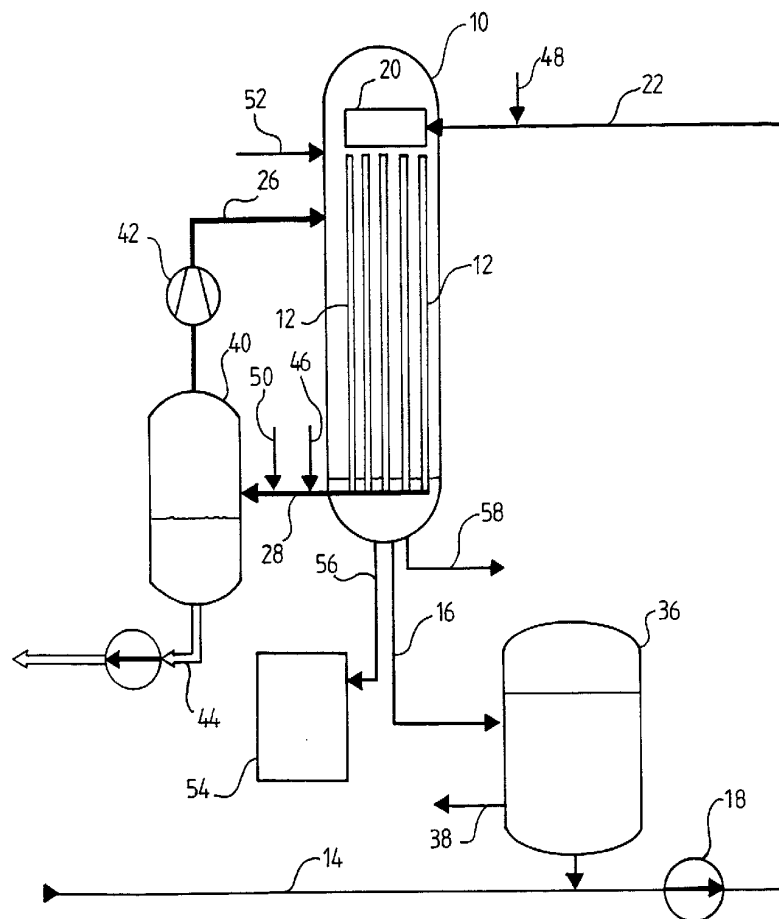


FIG.1

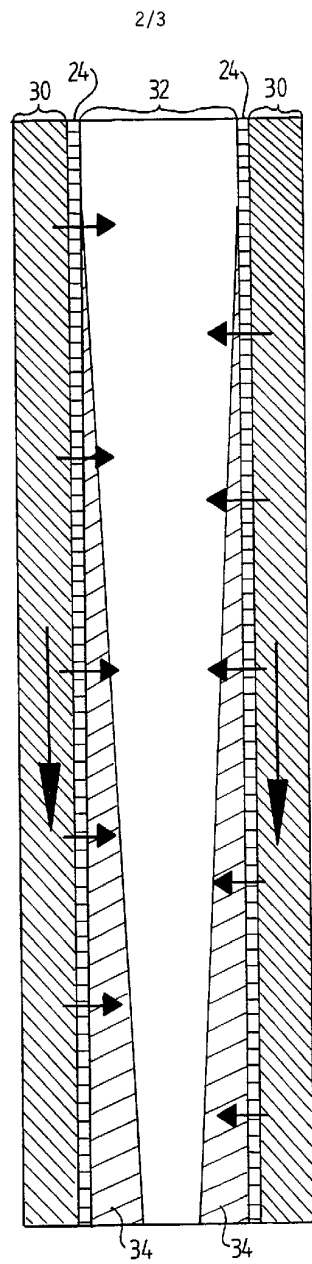


FIG. 2

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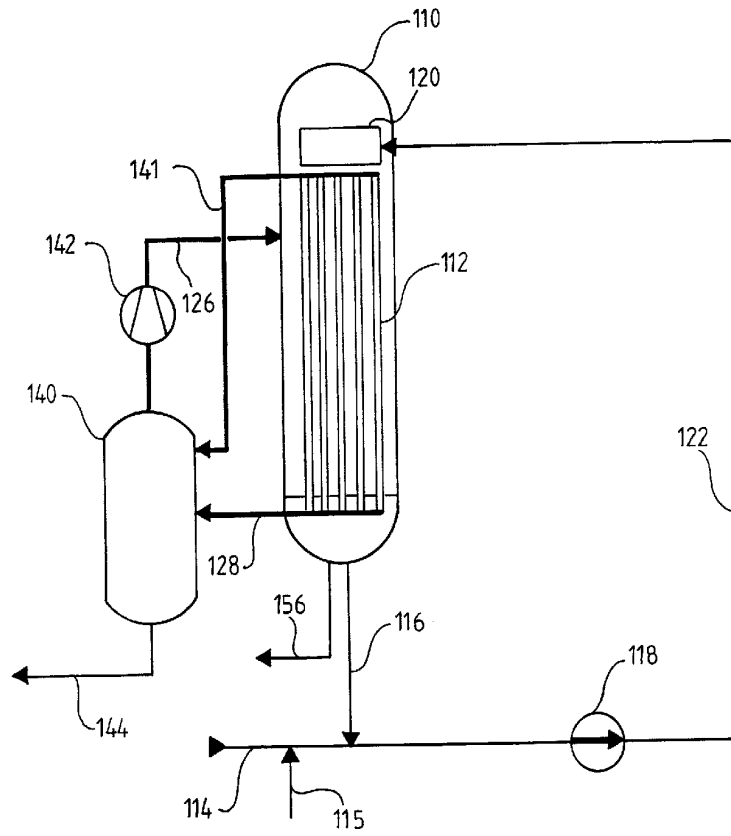


FIG. 3