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4. A Separation System for the Separation of Particles From Liquid and Gaseous Media

FIG. 8 shows a separation system 800 that represents another embodiment of the present invention in which materials are more efficiently separated from a source liquid (gaseous) medium. In separation system 800, these particles settle on separation elements installed in the separation unit 801 shown in FIG. 9, while the settled particles are periodically backwashed with the processed liquid (gaseous) medium and eliminated from the system.

Separation system 800 includes a pump 802 for feeding a source liquid (gaseous) medium through feed line 805, first valve 820 (preferably a trigger valve) and inlet 825 to a separation unit 801 containing filter elements or membrane element 830. A first pressure gauge 835 is operably connected to inlet 825 for measuring the pressure of the source liquid (gaseous) medium passing through first valve 820. A hydraulic accumulator 838 is liquid (gaseous) medium connected with at least one liquid (gaseous) medium outlet 840 for processed liquid (gaseous) medium. The processed liquid (gaseous) medium is the liquid (gaseous) medium that has passed through separation element 830 such as but not limited to the separation element

produced in accordance with one embodiment of the present invention. A second pressure gauge 842 is operably connected with a liquid (gaseous) medium outlet 840 for liquid (gaseous) medium and measures the pressure of the processed liquid (gaseous) medium directed to hydraulic accumulator 838. A second valve 848 is placed in the liquid (gaseous) medium line 849 for unprocessed liquid (gaseous) medium connected to at least one outlet 850 for unprocessed liquid (gaseous) medium. A third valve 855 is placed in the liquid (gaseous) medium line 858 for processed liquid (gaseous) medium that is connected to outlet 840 for processed liquid (gaseous) medium. A by-pass line 860 runs between the feed line 805 for the source liquid (gaseous) medium and the line 849 for unprocessed liquid (gaseous) medium. A fourth valve 865 is placed on by-pass line 860 to regulate the amount of recycling of the unprocessed liquid (gaseous) medium returning to the liquid (gaseous) medium feed line 805 with the source liquid (gaseous) medium.

In separation system 800, in the filtration mode, the source liquid (gaseous) medium in feed line 805 is supplied via pump 802 through the trigger valve 820 to the liquid (gaseous) medium inlet 825 for the source liquid (gaseous) medium. One part of the source liquid (gaseous) medium fed into the separation unit 801 containing separation element 830 is removed as processed liquid (gaseous) medium through liquid (gaseous) medium outlet 840 for processed liquid (gaseous) medium. One portion of the processed liquid (gaseous) medium begins filling hydraulic accumulator 838 and the other portion of processed liquid (gaseous) medium is directed through liquid (gaseous) medium line 858 for processed liquid (gaseous) medium and valve 855 to a storage vessel (not shown) for the end user. The other part of the source liquid (gaseous) medium fed into separation unit 801 is removed as unprocessed liquid (gaseous) medium through outlet 850 for unprocessed liquid (gaseous) medium, line 849 and valve 848 and discharged. Alternatively under certain conditions, the unprocessed liquid (gaseous) medium is recycled through by-pass line 860 and valve 865 to feed line 805 for a second pass through separation unit 801. Flow rates and pressures of the processed and unprocessed liquid (gaseous) medium are controlled by valves 855 and 848, and pressure gauges 842 and 868, respectively. By-pass regulating valve 865 is set to have pump 802 running within its set parameters.

As hydraulic accumulator 838 gradually fills up, the pressure of the processed liquid (gaseous) medium increases as indicated by pressure gauges 842. Once the specified pressure is achieved indicating that hydraulic accumulator 838 has been filled, a liquid (gaseous) medium

section 870 of a pressure transducer 875 measuring pressure of the processed liquid (gaseous) medium signals the separation system 800 to carry out back flushing of separation unit 801. The value of the specified pressure depends on the design of separation unit 801.

The reason for an increase in pressure is apparent to those skilled in the art because during the operation of separation unit 801 to remove suspended materials contained in the source liquid (gaseous) medium, these materials are retained by the separation elements 830 within separation unit 801. Pressure is sensed a liquid (gaseous) medium section 878 of transducer 875 measuring pressure of unprocessed liquid (gaseous) medium. Once the pressure specified by the system design and filtration regime is reached, liquid (gaseous) medium section 878 of the transducer 875 measuring pressure of unprocessed liquid (gaseous) medium sends a signal to open a fifth valve 880 that is an electric valve operably connected to transducer 875, which transfers separation system 800 from the operating to the flushing mode.

In the flushing mode, the pressure in liquid (gaseous) medium the pipe 849 for the unprocessed liquid (gaseous) medium becomes less than that in liquid (gaseous) medium the pipe 858 for the processed liquid (gaseous) medium, the flow of the source liquid (gaseous) medium through the inlet 825 for the source liquid (gaseous) medium is shut. The processed liquid (gaseous) medium in accumulator 838 flows through outlet 840 for processed liquid (gaseous) medium back through the filter elements 830 in system 801 to flush out the retained particles. Due to pressure differential, the processed liquid (gaseous) medium from hydraulic accumulator 838 containing the removed particles is rejected from the system through liquid (gaseous) medium pipe 805 for unprocessed liquid (gaseous) medium, by-pass line 860, valve 865, line 885 and a fifth valve 880, an electric valve operably connected to transducer 875.

During the flushing operation of separation system 800, the liquid (gaseous) medium pressure of the processed liquid (gaseous) medium drops to a prescribed value defined by the design of separation unit 801. This pressure drop is measured by pressure regulator 842 and registered by the liquid (gaseous) medium section 870 of transducer 875 measuring pressure of processed liquid (gaseous) medium. At this prescribed value, transducer 875 sends a signal to close electric valve 880 based on signal received from the liquid (gaseous) medium section 870 measuring pressure of the processed liquid (gaseous) medium. After valve 880 is closed, the back flushing regime and separation system 800 are switched to the operation mode again.

The separation system of the present invention overcomes the disadvantages of prior art systems by having an increased efficiency owing to an increase in the yield of processed liquid (gaseous) medium upon separation, an increase of life of the system's separation elements due to increase in pressure differential during flushing.

Example 6

The separation system according to the above description comprising an operating unit 801 with a separation element 830 was used to filter a reference aqueous solution having a concentration of suspended particles equal to 10 mg/l. After the filtering operation, the system performs flushing at increasing pressure differential to 0.07 MPa. The time between flushings was, on the average, 7 minutes. The efficiency of the separation system operating at a rate of 500 l/h was such that 10 % of the processed liquid (gaseous) medium was consumed in the flushing step.

The fields of application for the membrane cards, membrane packages, separation elements, separation units, and separation systems of the various embodiments of the present invention include: (a) treatment, reclamation, recycling and reuse of industrial in-feed and wastewater; (b) desalination of sea water; (c) liquid separation for a wide variety of liquid industrial chemicals; and (d) membrane-based separation technology for the removal of sulfur and mercaptans from crude oil, natural gas, condensate and refined petroleum products.

Without departing from the spirit and scope of this invention, those with ordinary skills in the art can make various changes and modifications to each of the various embodiments of the present invention to adapt to various other applications. As such, these changes and modifications are properly, equitably, and intended to be within the full range of equivalents of the following claims.

Claims:

1. A method for producing a membrane card used for separation of particles from a liquid (gaseous) medium comprising the steps of:
 - a) exposing a polymeric film to a bombardment with heavy ions to form a certain track density in the film;
 - b) etching pores in resulting tracked film with an etching solution to ensure pore density in the film corresponding to track density;
 - c) laminating the resulting porous track membrane to a porous substrate by means of an adhesive; and
 - d) producing a membrane card with the specified parameters.
2. The method of claim 1, wherein said heavy ions are selected from the group of ions consisting of krypton, argon, xenon, bismuth, and combinations thereof.
3. The method of claim 1, wherein said track density is in a range of about 10^7 cm^{-2} to about 10^9 cm^{-2} .
4. The method of claim 1, wherein the size of said pores is in a range of about 0.01 to about 1 μm .
5. The method of claim 1, wherein said etching solution is an alkaline solution.
6. The method of claim 5, wherein said polymeric film is a fluoropolymeric film.
7. The method of claim 6, wherein said fluoropolymer film is polyvinylidene fluoride.
8. The method of claim 7, wherein said alkaline solution is an alkaline solution of potassium permanganate.
9. The method of claim 8, wherein said alkaline solution also contains salts of alkali metals in sufficient concentration to increase the boiling point of the resulting alkali-metal-containing solution to temperatures greater than 100°C .
10. The method of claim 9, wherein said etching is carried out at temperatures in a range of about 100 to about 150°C .
11. The method of claim 10, wherein said etching solution circulates along said tracked film at a flow rate resulting in Reynolds Number from about 100 to about 500.
12. The method of claim 11, wherein said etching is carried out for a period in a range from about 1 to about 24 hours.

13. The method of claim 12, wherein at least the temperature, flow rate and time are controlled so that the etching step takes place with overheating of the etching solution by not more than 1°C.
14. The method of claim 13, wherein said alkali metal salt is sodium chloride.
15. The method of claim 1, wherein said adhesive is sprayed onto one surface of the substrate at a concentration of about 1 to about 30 g/m² and the porous track membrane is laminated to the porous substrate.
16. The method of claim 15, wherein said glue is applied to the surface of the substrate at a concentration in a range of about 1 to about 30 drops of adhesive per square meter and the porous track membrane is laminated to the porous substrate.
17. The method of claim 1, wherein the membrane card is spirally wound around a tube for collection of liquid (gaseous) medium to form a separation unit to be installed in a separation system.
18. The method of claim 17, wherein a plurality of the membrane cards are formed into a separation element in which (a) each of the membrane cards is folded in half with the porous substrate facing outward and having a glue joint around the perimeter of the porous substrate, (b) at least two membrane cards are bent along a bending line to expose outward projections on each of the membrane cards which projections are placed so that the bending lines of the membrane cards are adjacent to perforations in the collection tube, (c) a drain is placed between the exposed porous substrate of each of the outward projections, and (d) adhesive is deposited along the glue joint and the bending line of each membrane card to join the drain to the membrane card to form a plurality of membrane packages for the separation element.
19. The method of claim 17, wherein a plurality of membrane cards are formed into a separation element in which (a) each of the membrane cards is bent to form projections on each of the membrane cards and a central section between each of the projections with the porous substrate facing outside the bend and having a glue joint around the perimeter of the porous substrate, (b) each of the central sections is pressed onto the liquid (gaseous) medium collection tube so that each of the projections extend outward from the bending line, (c) a drain is inserted between the porous substrate of each of the projections, and (d) adhesive is deposited along the glue joint and the bending line to join the drain to each of the membrane cards to form the membrane packages for the separation element.

20. The method of claim 19, wherein a sheet of a turbulizer made of a porous gauze-like material is attached to project outward from the perforated collection tube.
21. The method of claim 19, wherein said porous gauze-like material is the same for use in the drain and the turbulizer.
22. The method of claim 19, wherein said porous gauze-like material has different properties for use in the drain and the turbulizer.
23. A method for producing a separation system used in the separation of particles from a liquid (gaseous) medium comprising the steps of:
- a) exposing a fluoropolymer film to a bombardment with heavy ions to form a certain track density in the film;
 - b) cutting the resulting tracked film into a plurality of separate sections;
 - c) etching the sections of tracked film with an etching solution to provide the sections of film with a density of pores corresponding to the track density;
 - d) laminating the resulting sections of the porous track membranes to a porous substrate by means of an adhesive;
 - e) producing a membrane card with the parameters specified;
 - f) forming a glue joint around of the perimeter of the porous substrate of the membrane cards;
 - g) bending each of the membrane cards along a bending line to be adjacent to another membrane card to form a projection and a central section between each of the projections so that the porous substrate faces outward;
 - h) pressing the central section of each of the membrane cards onto a liquid (gaseous) medium collection tube so that each of the projections extends outwardly from the collection tube and the bending lines of at least two of the membrane cards pressed onto the collection tube are adjacent to its perforations;
 - i) inserting a porous gauze-like drain between the porous substrate of each of the outward projections of each of a plurality of membrane cards so that at least one drain is in contact with the perforations in the collection tube;
 - j) depositing adhesive along the glue joint of each of the membrane cards to join the drain to the membrane card and the membrane packages to the collection tube;

- k) attaching at least a sheet of a turbulizer to the central section of each of the membrane cards and between the projections so that the turbulizers of the separation elements project outwardly from the liquid (gaseous) medium collection tube; and
 - l) producing a separation system containing a plurality of the resulting membrane packages operably attached to the liquid (gaseous) medium collection tube.
24. The method of claim 23, wherein said heavy ions are selected from the group of ions consisting of krypton, argon, xenon, bismuth, and combinations thereof.
25. The method of claim 24, wherein said track density is in a range of about 10^7 cm^{-2} to about 10^9 cm^{-2} .
26. The method of claim 24, wherein the size of said pores is in a range of about 0.01 to about $1 \mu\text{m}$.
27. The method of claim 24, wherein said etching solution is in an alkaline solution.
28. The method of claim 27, wherein said fluoropolymer film is polyvinylidene fluoride.
29. The method of claim 28, wherein said alkaline solution is an alkaline solution of potassium permanganate
30. The method of claim 29, wherein said alkaline solution also contains salts of alkali metals in sufficient concentration to increase the boiling point of the resulting etching solution to temperatures greater than 100°C .
31. The method of claim 30, wherein said etching is carried out at temperatures in a range of about 100 to about 150°C .
32. The method of claim 31, wherein said etching solution is circulated along said tracked film at a flow rate resulting in Reynolds Number from about 100 to about 500 .
33. The method of claim 32, wherein said etching is carried out for a period in a range of about 1 to about 24 hours.
34. The method of claim 33, wherein said conditions of temperature, flow rate and time are controlled so that the etching step takes place with overheating of the etching solution by not more than 1°C .
35. The method of claim 34, wherein said alkali metal salt is sodium chloride.
36. The method of claim 23, wherein the section of cut tracked film is placed within a cassette to carry out step (c) by fixing one ending of the film on one of a plurality of fixed supports, extending the free end of the film around the remainder of the fixed supports, fixing the

free end to a turning support, and turning the turning support to provide a preliminary stretching of the film before etching.

37. The method of claim 36, wherein the cassette is placed in the etching solution.

38. The method of claim 23, wherein said adhesive is sprayed onto one surface of the substrate at a concentration of about 1 to about 30 g/ m² and the porous track membrane is laminated to the porous substrate.

39. The method of claim 23, wherein said adhesive is applied to one surface of the substrate at a concentration in a range of about 1 to about 30 g/ m² and the porous track membrane is laminated to the porous substrate.

40. A method for producing a separation system useful in the separation of materials from a liquid (gaseous) medium comprising the steps of:

- a) exposing a continuous roll of polymeric film to a bombardment with heavy ions to form a certain track density in the film;
- b) etching the continuous roll of tracked film as the roll passes through an etching solution to provide the sections of film with a density of pores corresponding to the track density;
- c) laminating the resulting roll of porous track membranes to a roll of porous substrate by means of an adhesive;
- d) cutting the continuous roll of backed porous track membranes into a plurality of membrane cards;
- e) forming a glue joint around the perimeter of the porous substrate of the membrane cards;
- f) bending the adjacent membrane cards along the respective bending lines to form projections and a central section between each of the projections so that porous substrate faces outward;
- g) pressing the central section of each of the membrane cards onto a liquid (gaseous) medium collection tube so that each of the projections extends outwardly from the collection tube and the bending lines of at least two of the membrane cards pressed onto the collection tube are adjacent to its perforations;

- h) inserting a porous gauze-like drain between the porous substrate of each of the outward projections of each of a plurality of membrane cards so that at least one drain is in contact with the perforations in the collection tube;
 - i) depositing adhesive along the glue joint of each membrane card to join the drain to the membrane card and the collection tube;
 - j) attaching at least a sheet of a turbulizer made of a porous gauze-like material on the porous membrane surface of each of the central sections and between the projections so that the turbulizers project outward from the perforated liquid (gaseous) medium collection tube; and
 - k) producing a separation system containing a plurality of membrane cards operably attached to the liquid (gaseous) medium collection tube.
41. A method for producing a membrane card useful in the separation of materials from a liquid (gaseous) medium comprising the steps of:
- a) exposing a fluoropolymer film to a bombardment of heavy ions to provide the film with a track density;
 - b) etching pores in the resulting tracked film with an etching solution to provide the film with a density of the pores corresponding to the track density;
 - c) determining the maximum diameter of the pores of the resulting porous track membrane; and
 - d) laminating the porous track membrane having the desired maximum pore size to a porous substrate by means of an adhesive; and
 - e) producing a membrane card containing a porous substrate and having the parameters specified.
42. The method of claim 41, wherein step (c) comprises:
- a) installing a liquid-impregnated membrane into a cell;
 - b) filling the cell with a liquid;
 - c) feeding a gas into the cell;
 - d) measuring the differential pressure on the cell;
 - e) placing the cell within a closed container so that the cell and closed vessel are in liquid (gaseous) medium communication;

- f) applying a non-destructive pressure differential on the membrane while simultaneously pumping liquid from the closed container;
 - g) feeding a gas having the same composition as the liquid to the resulting cavity in the vessel created by the removal of the liquid from the vessel;
 - h) continuously measuring the pressure and pressure difference over the surface of the membrane;
 - i) recording the pressure over the surface of the membrane at which the pressure difference disappears on the membrane;
 - j) determining the value of the coefficient of surface tension of the liquid at the pressure recorded during step i; and
 - k) calculating the value of the maximum pore size based on Laplace's formula.
43. A method for the determination of the maximum diameter of membrane pores comprising:
- a) installing a liquid-impregnated membrane into a cell;
 - b) filling the cell with a liquid;
 - c) feeding a gas into the cell;
 - d) measuring the pressure of the cell;
 - e) placing the cell within a closed container so that the cell and closed vessel are in liquid (gaseous) medium communication;
 - f) applying a non-destructive pressure on the membrane while simultaneously pumping liquid from the closed container;
 - g) feeding a gas having the same composition as the liquid to the resulting cavity in the vessel created by the removal of the liquid from the vessel;
 - h) continuously measuring the pressure and pressure difference over the surface of the membrane;
 - i) recording the pressure over the surface of the membrane at which the pressure difference disappears on the membrane;
 - j) determining the value of the liquid surface tension coefficient at the pressure recorded during step (g); and
 - k) calculating the value of the maximum pore diameter based on Laplace's formula.

44. A method for the separation of materials from a liquid (gaseous) medium comprising the steps of:
- a) exposing a polymeric film to a bombardment with heavy ions to form a certain track density in the film;
 - b) etching pores in the resulting tracked film with an etching solution to provide the film with a density of the pores corresponding to the track density;
 - c) laminating the resulting porous track membrane to a porous substrate by means of an adhesive;
 - d) producing a membrane card with the parameters specified; and
 - e) installing the membrane card in a separation unit.
45. The method of claim 44, wherein said separation unit has at least one inlet for source liquid (gaseous) medium, and at least one outlet for each of the processed and unprocessed liquid (gaseous) media.
46. The method of claim 45, wherein said separation unit has means for changing the separation unit from a processing mode to a back flushing mode after a predetermined time based on a pressure differential between the pressure in the outlet for processed liquid (gaseous) medium and the outlet for unprocessed liquid (gaseous) medium.
47. The method of claim 46, wherein said means is carried out by a transducer.
48. The method of claim 47, wherein said transducer has first and second sections, the first section for receiving a signal of the pressure reading from the processed liquid (gaseous) medium outlet and the second section for receiving a signal from the pressure reading of the unprocessed liquid (gaseous) medium outlet, for recording a pressure differential between the pressure in the processed liquid (gaseous) medium outlet and the unprocessed liquid (gaseous) medium outlet, and for sending a signal to in response to the resulting pressure differential to change the separation unit from a processing mode to a back flushing mode.
49. The process of claim 48, wherein pressure in the processed liquid (gaseous) medium outlet increases over that of the unprocessed liquid (gaseous) medium outlet to a predetermined level because a build-up of particles that had been suspended in the source liquid (gaseous) medium increases the pressure differential that is recorded by said transducer to switch the separation unit to the back flushing mode.

50. The process of claim 49, wherein a hydraulic accumulator connected with the processed liquid (gaseous) medium outlet is designed to siphon off a portion of the processed liquid (gaseous) medium during the processing mode to provide the necessary processed liquid (gaseous) medium during the back flushing mode.
51. The method of claim 50, wherein the processing mode comprises the following steps:
- a) feeding a source liquid (gaseous) medium through the source liquid (gaseous) medium inlet to the separation unit;
 - b) passing a portion of the source liquid (gaseous) medium through the membrane card;
 - c) removing the processed liquid (gaseous) medium through the processed liquid (gaseous) medium outlet;
 - d) removing the other portion of the source liquid (gaseous) medium that is unprocessed through an unprocessed liquid (gaseous) medium outlet;
 - e) continuously measuring the pressure in the processed liquid (gaseous) medium and the unprocessed liquid (gaseous) medium outlets;
 - f) continuously measuring the pressure differential between the processed liquid (gaseous) medium and the unprocessed liquid (gaseous) medium outlets; and
 - g) continuing the processing mode until the transducer changes the system to the back flushing mode.
52. The method of claim 51, wherein the back flushing mode comprises the following steps:
- a) closing the flow of source liquid (gaseous) medium through the source liquid (gaseous) medium inlet to stop the processing mode;
 - b) closing the flow of the unprocessed liquid (gaseous) medium through the unprocessed liquid (gaseous) medium outlet;
 - c) recycling the processed liquid (gaseous) medium from the hydraulic accumulator by reversing the normal flow of the processed liquid (gaseous) medium back through the processed liquid (gaseous) medium outlet into the separation unit;
 - d) back flushing the processed liquid (gaseous) medium through the membrane card in the separation unit;
 - e) removing the back flushed processed liquid (gaseous) medium through the source inlet;

- f) passing the back flushed processed liquid (gaseous) medium through a by-pass line to the unprocessed outlet
- g) continuously measuring the pressure in the processed liquid (gaseous) medium and unprocessed liquid (gaseous) medium outlets;
- h) continuously measuring the pressure differential between the processed liquid (gaseous) medium and the unprocessed liquid (gaseous) medium outlets; and
- i) continuing the back flushing mode until the transducer changes the separation unit to the processing mode.

53. The method of claim 52, wherein the pressure in the processed liquid (gaseous) medium outlet decreases because the removal of particles from the membrane card into unprocessed liquid (gaseous) medium in the back flushing operation decreases the pressure differential that is recorded by said transducer to change the separation unit to the processing mode.

54. A separation system for the separation of particles from a liquid (gaseous) medium comprising:

- a) a separation unit containing separation elements having at least one source liquid (gaseous) medium inlet, at least one processed and at least one unprocessed liquid (gaseous) medium outlet;
- b) a pump for feeding a source liquid (gaseous) medium through the source liquid (gaseous) medium inlet;
- c) a first valve in the source liquid (gaseous) medium inlet;
- d) a first pressure gauge in the source liquid (gaseous) medium inlet for measuring the pressure of the source liquid (gaseous) medium passing through the first valve;
- e) a hydraulic accumulator in liquid (gaseous) medium communication with the processed liquid (gaseous) medium outlet;
- f) a second pressure gauge in the processed liquid (gaseous) medium outlet for measuring the pressure of the processed liquid (gaseous) medium passing to the hydraulic accumulator;
- g) a second valve in the unprocessed liquid (gaseous) medium outlet;
- h) a third valve in the processed liquid (gaseous) medium outlet;
- i) a first by-pass line between the source liquid (gaseous) medium inlet and the unprocessed liquid (gaseous) medium outlet;

- j) a fourth valve on the first by-pass line;
 - k) a second by-pass line connected between the unprocessed outlet and the fourth valve;
 - l) a fifth valve on the second by-pass line; and
 - m) a transducer having first and second sections, the first section for receiving a signal of the pressure reading of the second pressure gauge in the processed liquid (gaseous) medium outlet and the second section for receiving a signal of the pressure reading of the first pressure gauge in the unprocessed liquid (gaseous) medium outlet, for recording a pressure differential between the pressure in the processed liquid (gaseous) medium outlet and the unprocessed liquid (gaseous) medium outlet and for sending a signal to the fifth valve in response to the resulting pressure differential to control the respective opening and closing of the first and fifth valves for the processing mode and the back flushing mode.
55. A process for the separation of particles from a liquid (gaseous) medium comprising the steps of:
- a) exposing a fluoropolymer film to a bombardment of heavy ions to provide the film with a track density;
 - b) cutting the resulting tracked film into a plurality of separate sections;
 - c) etching the sections of tracked film with an etching solution to provide the sections of film with a density of pores corresponding to the track density;
 - d) laminating the resulting sections of the track membranes to a porous substrate by means of an adhesive;
 - e) producing a membrane card with the parameters specified;
 - f) forming a glue joint around the perimeter of the porous substrate of at least two of the membrane cards;
 - g) bending each of the membrane cards along a bending line to be adjacent to another membrane card to form a projection and a central section between each of the projections so that the porous substrate faces outward;
 - h) pressing the central section of each of the membrane cards onto a liquid (gaseous) medium collection tube so that each of the projections extend outward from the collection tube and the bending lines of at least two of the membrane cards pressed onto the collection tube are adjacent to its perforations;

- i) interspersing a porous gauze-like drain between the porous substrate of each of the outward projections of each of a plurality of membrane cards so that at least one drain is in contact with the perforations in the collection tube;
- j) depositing adhesive along the glue joint of each membrane card to join the drain to the membrane card and the membrane packages to the collection tube;
- k) attaching at least a sheet of a turbulizer to the central section of each of the membrane cards and between the projections so that the turbulizers of the separation elements project outward from the liquid (gaseous) medium collection tube; and
- l) producing a separation unit containing a plurality of membrane packages operably attached to the liquid (gaseous) medium collection tube; and
- m) assembling a separation system.

56. The process of claim 55, wherein said separation system has at least one source liquid (gaseous) medium inlet, at least one processed and at least one unprocessed liquid (gaseous) medium outlet.

57. The process of claim 56, wherein said separation system has regulating means for changing from a processing mode to a back flushing mode after a predetermined time based on a pressure differential between the pressure in the processed liquid (gaseous) medium outlet and the unprocessed liquid (gaseous) medium outlet.

58. The process of claim 57, wherein said regulating means is a transducer.

59. The process of claim 58, wherein said transducer has first and second sections, the first section for receiving a signal of the pressure reading of the processed liquid (gaseous) medium outlet and the second section for receiving a signal of the pressure reading of the unprocessed liquid (gaseous) medium outlet, and wherein said transducer senses a pressure differential between the pressure of the processed liquid (gaseous) medium outlet and pressure of the unprocessed liquid (gaseous) medium outlet and sends a signal to in response to the resulting pressure differential to change the separation system from the processing mode to the back flushing mode.

60. The process of claim 59, wherein pressure in the processed liquid (gaseous) medium outlet increases over that of the pressure in the unprocessed liquid (gaseous) medium outlet to a predetermined level because of a build-up of particles that have been suspended in the source

liquid (gaseous) medium resulting in an increase in the pressure differential that is recorded by said transducer to result in a change from the processing mode to the back flushing mode.

61. The process of claim 60, wherein a hydraulic accumulator in liquid (gaseous) medium communication with the processed liquid (gaseous) medium outlet is designed to siphon off a portion of the processed liquid (gaseous) medium during the processing mode to provide the necessary processed liquid (gaseous) medium during the back flushing mode.

62. The process of claim 61, wherein the processing mode comprises the following steps:

- a) feeding a source liquid (gaseous) medium through the source liquid (gaseous) medium inlet to the separation unit;
- b) passing a portion of the source liquid (gaseous) medium through membrane card;
- c) removing the processed liquid (gaseous) medium through the processed liquid (gaseous) medium outlet;
- d) removing the other portion of the source liquid (gaseous) medium that is unprocessed through an unprocessed liquid (gaseous) medium outlet;
- e) continuously measuring the pressure in the processed liquid (gaseous) medium and unprocessed liquid (gaseous) medium outlets;
- f) continuously measuring the pressure differential between the processed liquid (gaseous) medium and the unprocessed liquid (gaseous) medium outlets; and
- g) continuing the processing mode until the transducer changes the separation unit to the back flushing mode.

63. The process of claim 61, wherein the back flushing mode comprises the following steps:

- a) closing the flow of source liquid (gaseous) medium through the source liquid (gaseous) medium inlet to terminate the processing mode;
- b) closing the flow of the unprocessed liquid (gaseous) medium through the unprocessed liquid (gaseous) medium outlet;
- c) recycling the processed liquid (gaseous) medium from the hydraulic accumulator by reversing the normal flow of the processed liquid (gaseous) medium back through the processed liquid (gaseous) medium outlet into the separation system;
- d) back flushing the processed liquid (gaseous) medium through the backed membrane in the separation system;

- e) removing the back flushed processed liquid (gaseous) medium through the source inlet;
- f) passing the back flushed processed liquid (gaseous) medium through a by-pass line to the unprocessed liquid (gaseous) medium outlet
- g) continuously measuring the pressure in the processed liquid (gaseous) medium and unprocessed liquid (gaseous) medium outlets;
- h) continuously measuring the pressure differential between the processed liquid (gaseous) medium and the unprocessed liquid (gaseous) medium outlets; and
- i) continuing the back flushing mode until the transducer changes the separation system to the processing mode.

64. The process of claim 63, wherein the pressure in the processed liquid (gaseous) medium outlet decreases because of the removal of particles from the membrane card into the back flushing processed liquid (gaseous) medium resulting in a decrease in pressure differential that is recorded by said transducer to change the separation system to the processing mode.

65. A separation unit for separation of particles from liquid (gaseous) media comprising a membrane card and a drain to form at least one membrane package, and at least one turbulizer that is spirally wound onto a collection tube so that the processed liquid (gaseous) medium is collected through the drain, said membrane package having the membrane card folded in half and a drain interspersed between the porous substrate surfaces of the two halves of the membrane card, said membrane package having a length determined by the formula:

$$L=3/\sqrt{2k_2/k_1},$$

where: L is length of the membrane package, meters (m)

k_1 is the drain parameter, $\text{m}^3/\text{hr} \cdot \text{MPa}$;

k_2 is the membrane card parameter, $\text{m}^3/\text{hr} \cdot \text{MPa} \cdot \text{m}^2$.

66. The separation unit of claim 65, wherein said membrane card is a track membrane backed with a porous substrate.

67. The process of claim 23, wherein the length of the membrane package is determined by the formula:

$$L=3/\sqrt{2k_2/k_1},$$

where: L is length of the membrane package, meters (m)

k_1 is the substrate parameter, $\text{m}^3/\text{hr} \cdot \text{MPa}$;

k_2 is the membrane parameter, $\text{m}^3/\text{hr} \cdot \text{MPa} \cdot \text{m}^2$.

68. The process of claim 17, wherein a plurality of the membrane cards are formed into a separation element in which (a) a first sheet of a turbulizer made from a porous gauze-like particle is used to form a top sheet of the package, (b) a sheet of a drain made from a gauze-like particle is interspersed between the porous substrate of upper and lower sheets of the membrane card so that the processed liquid (gaseous) medium is collected through the drain, and (c) a second sheet of the turbulizer is used to form a bottom sheet of the package.