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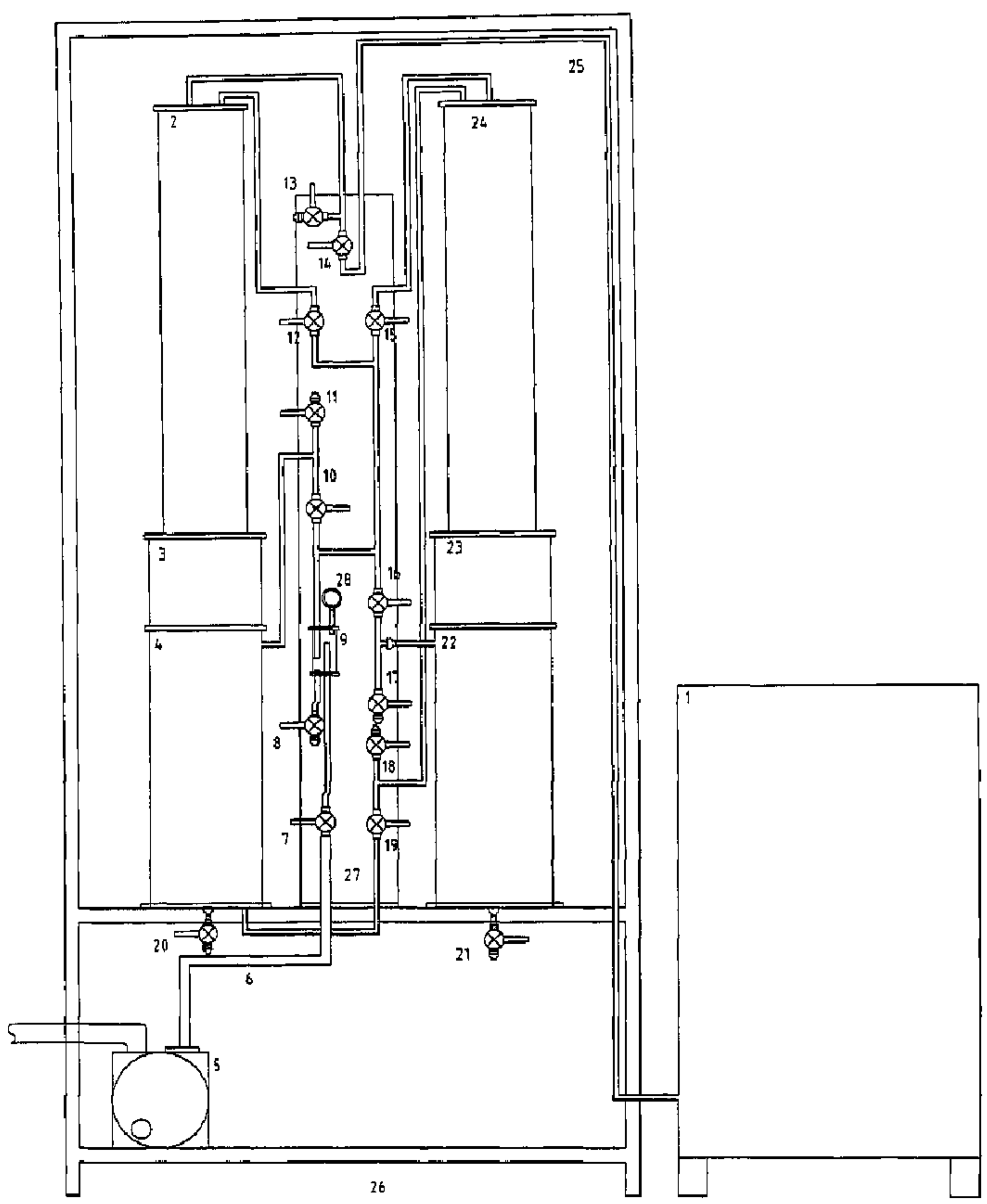
(54) Titre : PROCEDE ET APPAREIL POUR LA SEPARATION DE SOLIDES ET DE SUSPENSIONS LIQUIDES AU MOYEN D'UNE FILTRATION ASSISTEE PAR DESOBSTRUCTION DES FILTRES
(54) Title: METHOD AND APPARATUS FOR SEPARATION OF SOLIDS AND LIQUID SUSPENSIONS BY FILTER UNCLOGGING AIDED FILTRATION



(57) Abrégé/Abstract:
A method of separating solid particles from a liquid suspension, including steps of filtering the liquid suspension in closed circuit, through a filter in a filtering direction, forming particles on a surface of a filter fabric. The direction of the liquid suspension filtering is

(57) Abrégé(suite)/Abstract(continued):
reversed, thereby passing the liquid through the filter in a reverse direction , re-suspending the solid particles. The filtering and reversing are repeated until substantially all the liquid suspension has passed through the filter in the filtering direction, and a solid particle residue is formed on the surface of the filter fabric. An airflow circuit independently adds and removes air from the liquid suspension circuit, controlling the filtering and reversing.

ABSTRACT

A method of separating solid particles from a liquid suspension, including steps of filtering the liquid suspension in closed circuit, through a filter in a filtering direction, forming particles on a surface of a filter fabric. The direction of the liquid suspension filtering is reversed, thereby passing the liquid through the filter in a reverse direction , re-suspending the solid particles. The filtering and reversing are repeated until substantially all the liquid suspension has passed through the filter in the filtering direction, and a solid particle residue is formed on the surface of the filter fabric. An airflow circuit independently adds and removes air from the liquid suspension circuit, controlling the filtering and reversing.

METHOD AND APPARATUS FOR SEPARATION OF SOLIDS AND LIQUID SUSPENSIONS BY FILTER UNCLOGGING AIDED FILTRATION

TECHNICAL FIELD OF THE INVENTION

[01] The present invention relates to size separation by filtration of solid particles in suspension, using synthetic fabrics of known mesh, and to a process of avoiding filter clogging by using vacuum to simultaneously revert suspension flow direction and produce air suction, and in a particular form, to an apparatus for separating and collecting fungal spores. In this particular form, the spores must be bigger than the mesh of the second filter, which is 10 μm and smaller than the mesh of the first filter, which is 44 μm. The mixed solid particles with spores in suspension can be variable in diameter, but should be all bigger than 44 μm.

BACKGROUND ART

[02] U.S. patent US 41 13618, allows the simple filtration of solids in suspension, in order to be discarded and then collected. Additionally, clogging is tackled using the reverse flow direction through a set of hydraulic valves, and the elastic properties of the filtration fabric to allow the collection of the filter cake. The filter cake is collected by the use of active carbon that condenses part of the suspension particles though electrostatic forces, otherwise they would return to the suspension during the flaking off the fabric, that must occur to discard the filter cake. The filtration is limited by the formation of a filtration layer and by the mesh of the fabric used, which must lie between 100 (150 μm) and 350 mesh (40 μm) to be effective. This dimensions, that are bigger than the size of the particles to be recovered, allow the passage of some of the particles that should be recovered before and during the formation of the filtration layer.

[03] Japanese patent JP5705321 1, and U.S. patent US6159373 concerns to processes for cleaning filters used to clarify liquids from a suspension using filtration. The processes used to avoid clogging are performed after stopping the filtration process, and involve the return of the solid particles to the suspension, allowing the recovery of the clean liquid, and discard the unwanted solids in a concentrated suspension. JP57053211 uses a process of flowing compressed air through the filter elements to ressuspend the precipitated

solid particles, whereas US6159373 uses a process of high liquid pressure to accomplish said ressuspension.

[04] Other methods currently employed to separate or filtrate solids in suspension use low efficiency processes, loosing great amount of the solids to be recovered, or being unable to recover all the liquid, that should be clarified. They are unable to separate and collect the solids in suspension, and have problems to avoid clogging of filter membranes, when these are used. All this problems are greatly enhanced when the size of the particles to be separated decreased, especially below 50 μm.

[05] Furthermore, these methods do not allow the separation of solid particles by their sizes, when they are all in the same suspension, neither the collection of the desired fractions.

[06] Currently there is no apparatus to separate fungus spores from other particles in suspensions, in the 0,1 - 1000 μm size range, because of the water volume used, and of the clogging problem of the filter membranes, which becomes more important when the concentration of the suspension increases near the collector filter membrane, due to the formation of a thin layer of particles over the said membrane, that progressively slows and/or stops the filtration process.

SUMMARY OF THE INVENTION

[07] Exemplary embodiments comprise a method of filtration using a series of filters of different mesh, made of appropriate filter fabrics, in a closed circuit. This process of filtration is aided by a process of continuous filter unclogging based on reverse flow of the suspension and air suction through the filter, which also allows the drying and collection of the desired solid residue.

[08] Accordingly, an exemplary embodiment relates to a method of separation by unclogging aided filtration of solid particles in suspension, characterized in that it is performed in a closed circuit, using air pressure differences as a flowing force, and as a way, to reverse the flow direction of suspension and obtain air suction through the filter fabrics, allowing a light drying and the collection of the desired fractions of solid particles.

[09] Another exemplary embodiment relates to an apparatus for carrying out the above mentioned method, characterized in that it comprises the following:

[10] a) A filtration system, with a plurality of vessels, wherein the suspension flows, and the solid particles are separated by size filtration by appropriate filters;

[11] b) A vacuum system wherein vacuum is achieved and applied to the reservoirs, providing the flow force that allows the filtration to occur, and the reverse suspension flow direction and air suction to take place through the filter fabrics to unclog the filters;

[12] c) A control system, wherein the vacuum can be checked by monitoring elements and controlled through valves adapted to regulate air flow to and from the vessels; this system also comprises valves adapted to control the direction of suspension flow.

[13] Exemplary embodiments are also directed to a method for unclogging of filter fabrics during the filtration process, by reversing the flow suspension direction and by air suction through said filter fabric, and by the repetition of these procedures as many times as necessary to make a continuous non-uniform flow of the suspension through the filter fabric, allowing the passage of all the suspension through the filter to obtain the dry solid particles residue in the surface of the filter fabric.

BRIEF DESCRIPTION OF THE DRAWINGS

[14] Fig. 1 - Show a schematic representation of an example of the present invention, developed to extract fungal spores.

Drawing description:

[15] 1-Reservoir tank with the initial suspension, containing the spores mixture and other solid particles from which the spores should be separated.

[16] 2-Reservoir at the top side of first filter.

[17] 3-First filter (44 um)

[18] 4-Reservoir at the bottom side of first filter.

[19] 5-Vacuum pump.

[20] 6-Vacuum transport tubes.

[21] 7-Control valve to vacuum admission to the system.

[22] 8-Cleaning valve of vacuum system liquid trap.

[23] 9-Vacuum system liquid trap.

[24] 10-Vacuum control valve of reservoir 4.

[25] 11-Air entrance control valve to reservoir 4.

[26] 12-Vacuum control valve of reservoir 2.

[27] 13-Air entrance control valve to reservoir 2.

[28] 14-Suspension admission control valve to reservoir 2.

[29] 15-Vacuum control valve of reservoir 24.

[30] 16-Vacuum control valve of reservoir 22.

[31] 17-Air entrance control valve to reservoir 22.

[32] 18-Air entrance control valve to reservoir 24.

[33] 19-Suspension admission control valve to reservoir 24.

[34] 20-Cleaning valve of reservoir 4.

[35] 21-Cleaning valve of reservoir 22.

[36] 22-Reservoir at the bottom side of second filter.

[37] 23-Second filter (10 um).

[38] 24-Reservoir at the top side of second filter.

[39] 25-Suspension transport tubes.

[40] 26-Metal support structure for filtration, vacuum and control systems.

[41] 27-Metal plate support for the control system.

[42] 28-Vacuum controller.

DETAILED DESCRIPTION OF THE INVENTION

[43] This invention uses the solid particles tridimensional form characteristics, which can be used when solids are in suspensions, to separate through wet filtration, a mixture of solid particles with different diameters, that can be retained in filtration fabrics of appropriate mesh dimensions, to separate a given set of particles of known said diameter, from others of also known set of said diameter. When said filtration is performed with particles under 100 μm of said diameter, a clogging layer is formed, that is overcome in this invention, by the use of a closed circuit under vacuum, to allow reverse suspension flow

direction and air suction through the said filtration fabric. The solid particles can then be dryed, using air suction and collected on the top of the said filtration fabric.

[44] The said separation process, is achieved in this invention, by the use of two filters with filtration fabric membrane, placed one after another, in a closed circuit, where the suspension flows. The first said filter having the mesh appropriate to collect the solid particles with bigger diameter, and the second said filter having the appropriate mesh to collect the solid particles with smaller diameter.

[45] The said wet filtration process, accordingly to the broad form of the invention, preferably uses two vessels, one on the top of the filter , and another under the filter. The process starts by filling the first vessel with appropriate suspension and is characterized by vacuum application to the vessel placed after the filtration membrane, and at the same time by air flow into the vessel placed before the filtration membrane, causing pressure over the fabric membrane due to the pressure of the liquid on the top vessel, and the vacuum in the under vessel, causing the liquid to flow through the membrane fabric filter.

[46] The clogging of the filter fabric membrane, which occurs during the filtration process, is overcome by the reverse flow direction of the suspension and by the air suction through the membrane fabric of the filter in the reverse direction of the suspension flow during filtration. The said reverse flow direction and air suction are applied during a short period, just enough to allow a few air bubbles to appear in the suspension in the reverse direction of suspension flow during filtration. The said method to overcome clogging, comprises:

[47] a) Initiating said separation, by said filtration under vacuum, until the flow stops or becomes too slow, caused by clogging of the filter fabric, and then,

[48] b) stopping air entrance in the vessel placed before the filtration fabric, and simultaneously starting to apply vacuum in this vessel. At the same time stopping to apply vacuum in the vessel after the filter fabric and simultaneously allowing the air entrance in this vessel, and

[49] c) allowing the reverse flow direction of suspension to occur until air bubbles start passing through the suspension, allowing the clogging layer to re-suspend again, and then

[50] d) stopping air entrance in the vessel placed after the filtration fabric, and simultaneously starting to apply vacuum in this vessel. At the same time stopping to apply vacuum in the vessel before the filter fabric and simultaneously allowing the air entrance in this vessel, and

[51] e) allowing the said suspension filtration to occur again until the flow stops or becomes too slow again, and then

[52] f) repeating the procedure in c), that means to perform the said reverse flow direction and air suction through the filter fabric again, and

[53] g) the succession of said filtration and said reverse flow and air suction, should be performed as many times as necessary to filter all the fed suspension.

[54] This separation process is accomplished by performing the filtration and the process of overcome clogging, in the both filtration filter fabrics, and is complemented by the elimination of the solids retained in the first filter fabric and by the collection of the solids in the second filter fabric.

[55] The collection can be made after drying the solids according to the following procedures:

[56] a) After the said suspension filtration, all the suspension flow through the filter fabric, but the solid particles remain wet, although if the vacuum is kept in the vessel under the filtration fabric, with the air flowing through the solid deposit in the fabric, during relatively long periods, that will be enough to dry the solid residue resting on the filter fabric.

[57] b) the speed of the drying process can be increased, by alternating, the air flow direction during the drying process, by

[58] c) closing the vacuum in the vessel under the filter fabric, and at the same time let the air flow into this vessel, and stop the air flow to the vessel before the filter fabric and apply vacuum to this vessel, and just after the vacuum drops,

[59] d) repeat the operation stated in a), until the vacuum drops again, and alternate operations c) and a) until the solid residue moisture reaches the desired level.

[60] The collection of solids is performed by cleaning the fabric surface using a soft scraper tool to collect it, avoiding hurting the surface.

[61] The vacuum used to perform the operations should be in the range from -0,9 bar to -0,2 bar.

[62] The fabric used can be made from several materials, but should allow a certain degree of deformation without losing the mesh properties under the stated vacuum conditions.

Description of a particular form of the invention

[63] Apparatus to separate fungal spores from solid medium, shown in Fig. 1.

[64] Fungal spores must be bigger than 11 μm and smaller than 44 μm (average diameter 22 μm, 95 % ranging from 12 to 31 μm), mixed with solid medium particles used for growing the fungus, of variable diameter but all bigger than 44 μm.

Apparatus support structure:

[65] Painted iron, with support bars and plates for the said three systems, over four metallic bars with wheels and breaks (Fig 1).

Apparatus constitution:

[66] This apparatus is constituted by a support structure and three interconnected systems:

[67] 1st System: the filtration system.

[68] 2nd System: the vacuum system.

[69] 3rd System: the control system.

[70] The filtration system constitution:

[71] Initial PVC reservoir (1), with 1000 l capacity and four transparent acrylic glass cylindrical reservoirs, in the following succession order (2, 4, 24, 22). Reservoir size: (2), and (24) - 88 cm height and 18 cm diameter; (4) and (22) - 58 cm height and 25 cm diameter.

[72] Two filters, with cylindrical shape, made of hard PVC, 10 cm hight x 20 cm diameter, with nylon filtration fabric (supplied by Lockertex U.K.). First filter (3) with 44 μm mesh and second filter (23) with 11 μm mesh.

[73] Suspension transport tubes (25) in flexible PVC, 10 cm diameter.

[74] The reservoirs (2, 4, 24, and 22) are placed in succession, connected by the filters (3, 23) or by the suspension transport tubes (25).

The filtration system operation:

[75] The system is fed with suspension from the reservoir (1), through one tube (25), to the reservoir (2). The reservoir (2) is connected to the reservoir (4) by the filter (3), both supported by the support structure. The filter (3) stands in an easy operating aperture that has two closing rubber o-rings, one at the upper part and another at the lower part and which are strongly attached to the vessels, to allow the application of said vacuum. The reservoir (24) is fed with suspension from reservoir (4), by a tube (25). The reservoir (24) is connected to the reservoir (22) by the filter (23), both supported by the support structure, and using an easy operating aperture as described to filter (3). Both reservoirs (4) and (22) have draining tubes (25).

The vacuum system constitution:

[76] Vacuum pump (5) Telstar (Spain), Torricelli type, model G6, 6 m3/h, 1450 rpm, 0.33 cv, 220 V, 50 Hz.

[77] Liquid trap (9), built in PVC.

[78] Air suction tubes (6), in flexible PVC, 8 cm diameter.

[79] The vacuum pump is connected to the reservoirs (2), (4), (24) and (22), through vacuum pipes (6), with the vacuum trap (9) placed to avoid liquid suspension suction into the pump.

The vacuum system operation:

[80] The vacuum pump (5), is connected to the lower end of the vacuum trap (9) through a tube (6). The vacuum trap (9) upper end is connected to all reservoirs (2), (4), (24) and (22), allowing air suction to the said reservoirs. Each of the said reservoirs has attached an air entrance (13), (11), (18) and (17) respectively, allowing air flow, if necessary. In reservoirs (4) and (22), the said air entrance is connected through a tube (6) and in reservoirs (2) and (24), the said air entrance is connected through a tube (25).

The control system constitution:

[81] Vacuum controller (28) (0 to -1 bar).

[82] Suspension flow control hydraulic valves (14), (20), (19) and (21).

[83] Air entrance control hydraulic valves (8), (13), (11), (18) and (17).

[84] Vacuum control hydraulic valves (7), (12), (10), (15) and (16).

[85] The control system operation:

a) Vacuum system monitoring:

[86] The vacuum controller is connected to the upper part of the liquid trap, allowing the acquisition of information about the vacuum in each part of the system, allowing to it to make the decisions to close or open the air and/or vacuum valves to perform the vacuum and air flow cycles.

b) Filtration system control

[87] B.1-Suspension flow control to reservoir (2) by valve (14)

[88] B.2-Drainage control of reservoir (4) by valve (20)

[89] B.3-Suspension flow control to reservoir (24) by valve (19)

[90] B.4-Drainage control of reservoir (22) by valve (2 I)

c) Vacuum system control

[91] C.1-Liquid trap (9) vacuum control by valve (7) and air flow and/or liquid drainage control by valve (8).

[92] C.2-Reservoir (2) vacuum control by valve (12), and air flow control by valve (13).

[93] C.3-Reservoir (4) vacuum control by valve (10), and air flow control by valve (II).

[94] C.4-Reservoir (24) vacuum control by valve (15), and air flow control by valve (18).

[95] C.5-Reservoir (22) vacuum control by valve (16), and air flow control by valve (17).

Example l:

[96] This example relates to the procedure used to separate clamydospores of the fungus *Pochonia chlamydosporia* from the solid medium in which it was produced. The medium particles diameter ranges between 44 μm and 2000 μm, and the diameter of

clamydospores is bigger than 10 μm and smaller than 44 μm (average diameter 22, μm, and 95% confidence interval ranging from 12 to 31 μm)

A. Initial situation:

[97] A.1-Keep all valves closed except valves (7) and (8).

[98] A.2-Keep vacuum pump (5) off.

[99] A.3-Keep valves (7) and (8) open.

[100] A.4-Fill reservoir (1) with 102 to 103 l/day of raw suspension with a mixture of particles of said medium and 200 to 1000 g of said clamydospores.

B. Starting work:

[101] B.1-Close valves (7) and (8).

[102] B.2-Put vacuum pump (5) on.

[103] B.3-Open valve (7).

C. Filling of reservoir (2).

[104] C.1-Open valve (10).

[105] C.2-When vacuum reaches -0.4 bar, open valve (14).

[106] C.3-Open also valve (12) to speed the filling of reservoir (2).

[107] C.4-When the suspension reaches the top of reservoir (2), close valve (14).

D. Filtration through filter (3).

[108] D. 1-Keep valve (10) open.

[109] D.2-Close valve (12).

[110] D.3-Open valve (13).

[111] D.4-When all suspension passes to reservoir 4, close valve (10).

E. Filling of reservoir (24).

[112] E.1-Open valve (16).

[113] E.2-When vacuum reaches -0.4 bar, open valve (19).

[114] E.3-Open valve (15) to speed the filling of reservoir (24).

[115] E.4-When all suspension passes to reservoir (24), close valve (19).

F. Filtration through filter (23).

[116] F. l-Keep valve (16) open.

[117] F.2-Close valve (15).

[118] F.3-Open valve (18).

[119] F.4-When all suspension passes to reservoir (22), close valve (18).

[120] F.5-Open valve (17).

[121] F.6-Open valve (21), and let the suspension to be discarded flow out.

[122] F.7-After emptying out the reservoir (22) close valve (2 I).

G. Filter unclogging during filtration.

[123] G.1-Unclogging of filter (3).

[124] G.1.1-Close valves (10) and (13).

[125] G.1.2-Open valve (12) and then slowly open valve (11).

[126] G.1.3-After the reverse direction of suspension flow progresses to cause air suction, let some air bubbles pass through filter (3) and then close valves (12) and (II).

[127] G.1.4-Quickly after last operation, open valves (10) and (13).

[128] G.2-Unclogging of filter (23).

[129] G.2. 1-Close valves (16) and (18).

[130] G.2.2-Open valve (15) and then slowly open valve (17).

[131] G.2.3-After the reverse direction of suspension flow progresses to cause air suction, let some air bubbles pass through filter (23) and then close valves (15) and (17).

[132] G.2.4-Quickly after the previous operation, open valves (16) and (18).

[133] G.3-The operations G.1 and G.2 should be repeated as many times as necessary to complete the filtrations D. and F.

H. Clamydospores drying operation.

[134] H.1-Let valves (16) and (18) open until the air flow passes through the filter (23) and vacuum reaches -0.2 bar or less.

[135] H.2-Close valves (16) and (18) and open valve (15), and let the vacuum reach -0.9 bar.

[136] H.3-Open the valve (17) and let the air flow through filter (23) until the vacuum reaches -0.2 bar or less.

[137] H.4-Repeat operations H. I to H.3 four to six times until the clamydospores moisture reaches the desired level.

I. Finishing the extraction.

[138] I.1-Let all reservoirs without suspension.

[139] 1.2-Close all valves except valves (13), (18) and (7).

[140] 1.3-Open valve (S), until the vacuum reaches O.

[141] 1.4-Turn the Vacuum pump (5) off.

[142] 1.5-Keep the valve (7) open.

[143] 1.6-Open the aperture of filter (23), and collect the clamydospores, by scraping them to an appropriate container, with a soft tool, to avoid hurting the filter fabric.

[144] 1.7-Open the aperture of filter (3) and discard the medium particles, by scraping it out, with a soft tool, to avoid hurting the filter fabric.

[145] Further suggestions and exemplifications that broaden the field and scope, either of the invented method or the particular apparatus presented here, will be appreciated.

WHAT IS CLAIMED IS:

1. A method for separating solid particles from a liquid suspension, comprising

filtering the liquid suspension in a closed liquid suspension circuit through a filter in a filtering direction thereby forming solid particles on a surface of a filter fabric,

reversing a direction of the liquid suspension, thereby passing the liquid suspension through the filter in a reverse direction, re-suspending the solid particles, and

repeating the filtering and reversing until substantially all of the liquid suspension passes through the filter in the filtering direction and a solid particle residue forms on the surface of a filter fabric;

wherein an airflow circuit independently adds and removes air from the liquid suspension circuit, controlling the steps of filtering and reversing.

2. The method according to claim 1, wherein the liquid suspension circuit comprises:

a first vessel positioned before the filter in the filtering direction, and

a second vessel positioned after the filter in the filtering direction.

3. The method according to claim 2, wherein the airflow circuit is independent of the liquid suspension circuit.

4. The method according to claim 3, wherein the airflow circuit controls the filtering in the filtering direction by adding air to the first vessel and independently removing air from the second vessel, and

wherein the airflow circuit controls reversing the direction by adding air to the second vessel and independently removing air from the first vessel.

5. The method according to claim 4, wherein vacuum is created in the second vessel at the same time air pressure is increased in the first vessel, causing the liquid suspension to flow from the first vessel through the filter to the second vessel.

6. The method according to claim 4, wherein reversing the direction of the liquid suspension passes air bubbles through the filter fabric and through at least a portion of the liquid suspension located after the filter in the reverse direction, and re-suspends sufficient solid particles to unclog the filter.

7. The method according to claim 6, wherein the filtering and the reversing the liquid suspension is repeated to provide a continuous non-uniform flow of suspension through the filter, passing substantially all the liquid suspension through the filter and forming a solid particle residue on the surface of a filter fabric.

8. The method according to claim 7, wherein the filter comprises a plurality of filter fabrics, wherein the plurality of filter fabrics comprise mesh of different coarseness, arranged in the liquid suspension circuit from most coarse to least coarse in the filtering direction.

9. The method according to claim 7, further comprising passing air alternately through the solid particle residue in the filtering direction and reverse direction by the airflow circuit, substantially drying the solid particle residue.

10. A method for unclogging filter fabrics during a filtration process, comprising:

alternately changing the direction of a flow of a liquid suspension through the filter fabrics from a filtering direction to a reverse direction whereby air bubbles pass through the filter fabric, and

repeating the changing of direction of the liquid suspension flow, substantially passing all the liquid suspension through the filter fabric to obtain dry solid particle residue on the surface of the filter fabric.

11. An apparatus for carrying out the method according to claim 1, comprising:

a) a filtration system comprising:

a plurality of vessels, and

a filter adapted to separate the liquid suspension and the solid particles by size;

b) a vacuum system adapted to provide a force to the plurality of vessels for liquid suspension flow in the filtering direction, and a force for liquid suspension flow in the reverse direction;

c) control system comprising:
air valves adapted to control airflow to and from the vessels,
hydraulic valves adapted to control the liquid suspension flow, and
monitoring elements adapted to check the vacuum;

d) a connection between the vacuum system and filtration system, located within the vessels,

wherein the control system controls the liquid suspension flow circuit independent from the air flow circuit.

12. The apparatus according to claim 11, wherein the filtration system comprises column vessels.

13. The apparatus according to claim 11, wherein the vacuum provides air pressure between -0.2 and 0.9 bar, inclusive.

14. The apparatus according to claim 11, wherein the control system further comprises:
a vacuum controller;
a plurality of suspension flow hydraulic control valves;
a plurality of air entrance control hydraulic valves; and
a plurality of vacuum control hydraulic valves.

15. The method according to claim 1, wherein the solid particles comprise fungal spores and culture medium particles.

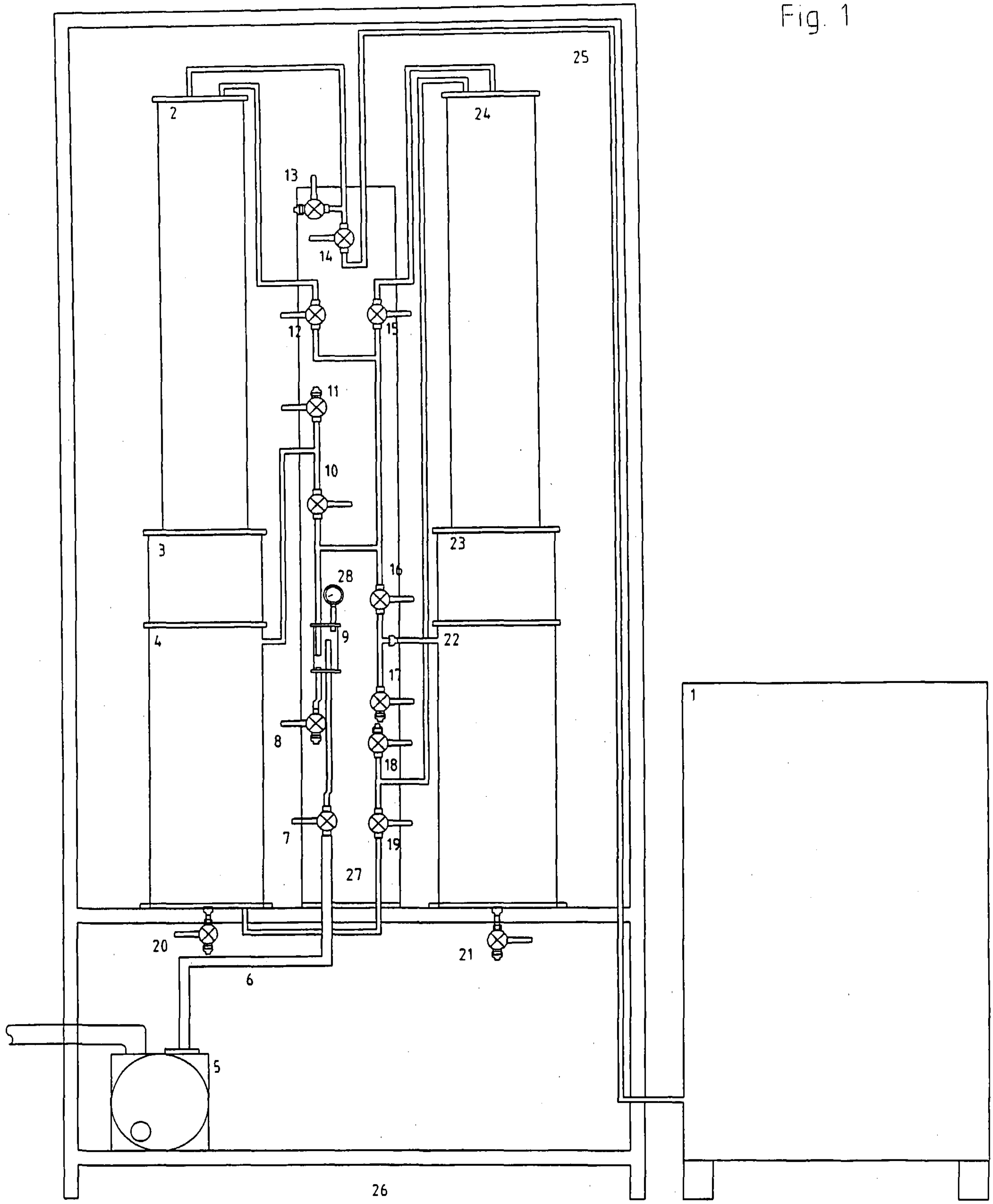
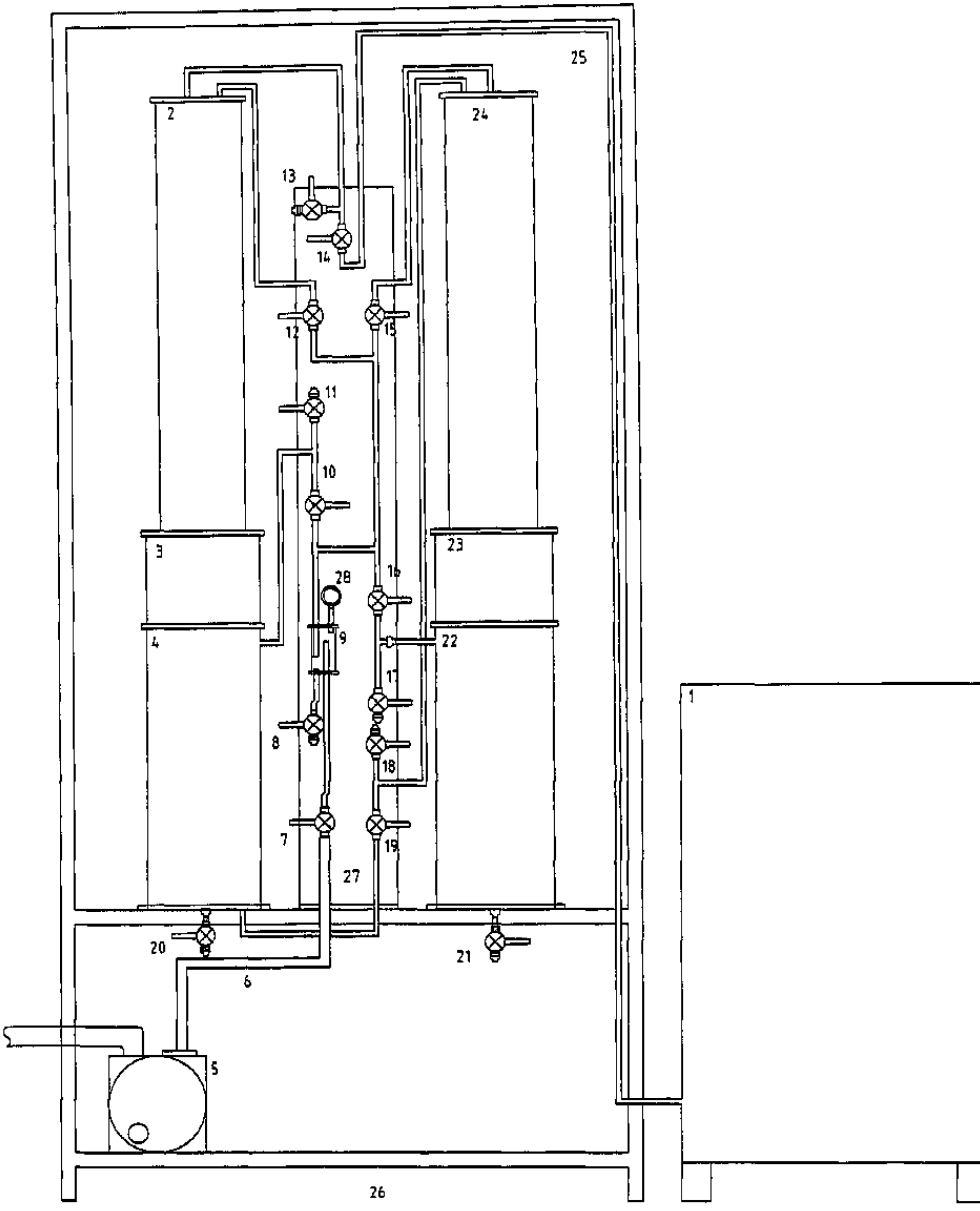


Fig. 1



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