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(54) **CLEANING APPARATUS**

REINIGUNGSVORRICHTUNG

APPAREIL DE NETTOYAGE

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Description**Field of the Invention**

[0001] The present invention relates to the cleaning of substrates using a solvent-free cleaning system which requires the use of only limited quantities of water. Most particularly, the invention is concerned with the cleaning of textile fibres by means of such a system, and provides an apparatus adapted for use in this context.

Background to the Invention

[0002] Dry cleaning is a process of major importance within the textile industry, specifically for the removal of hydrophobic stains which are difficult to remove by traditional aqueous washing methods. However, most commercial dry cleaning systems currently employ toxic and potentially environmentally harmful halocarbon solvents, such as perchloroethylene. The use of these solvents, and the need for their storage, treatment, and/or disposal creates major effluent problems for the industry, and this inevitably increases costs.

[0003] More recently, the use of carbon dioxide as an alternative to such systems has been reported. Thus, systems which employ liquid carbon dioxide in combination with surfactants containing a CO₂-philic functional moiety have been proposed, whilst the use of more conventional surfactants in combination with supercritical carbon dioxide has also been disclosed. However, a major problem with carbon dioxide is its lower solvent power relative to other solvents. Furthermore, some of the procedures rely on the use of high pressure systems, and this is a clear disadvantage, since it presents an inherent safety risk, thereby lessening the attractiveness of the procedures.

[0004] Even more widely used are aqueous cleaning processes, which do not suffer from the disadvantages associated with the use of potentially toxic solvents or high pressure carbon dioxide systems, but still create very significant environmental difficulties in terms of the vast quantities of aqueous effluent which are generated. As a consequence, the use of these aqueous cleaning processes necessitates the development of sophisticated waste treatment systems.

[0005] In the light of the difficulties and disadvantages associated with traditional aqueous and dry cleaning processes, the present inventors have previously devised a new approach to the problem, which allows the deficiencies demonstrated by the methods of the prior art to be overcome and provides a process for the cleaning of substrates, particularly for the cleaning of textile fibres. The method which is provided eliminates the requirement for the use of, on the one hand, potentially harmful solvents or carbon dioxide in either the liquid or supercritical state or, on the other hand, large volumes of aqueous fluids, but is still capable of providing an efficient means of cleaning and stain removal, whilst also yielding economic and environmental benefits. The process employs a cleaning formulation which is essentially free of organic solvents and requires the use of only limited amounts of water.

[0006] Thus, in WO-A-2007/128962 there is disclosed a method and formulation for cleaning a soiled substrate, the method comprising the treatment of the moistened substrate with a formulation comprising a multiplicity of polymeric particles, wherein the formulation is free of organic solvents. Preferably, the substrate is wetted so as to achieve a substrate to water ratio of between 1:0.1 to 1:5 w/w, and optionally, the formulation additionally comprises at least one cleaning material, which typically comprises a surfactant, which most preferably has detergent properties. In preferred embodiments, the substrate comprises a textile fibre and the polymeric particles may, for example, comprise particles of nylon, most preferably in the form of nylon chips.

[0007] The use of this cleaning method, however, presents a requirement for the cleaning chips to be efficiently separated from the cleaned substrate at the conclusion of the cleaning operation, and it is this issue that is addressed by the present invention. WO-A-01/71083 discloses a laundry appliance which comprises a drum for receiving articles to be laundered, the drum comprising at least two rotatable drum portions and a drive capable of operating the drum in a plurality of different drum modes, including a mode in which the rotatable drum portions are driven so as to cause relative rotation between them. A controller controls the appliance to perform a plurality of different wash programmes, each wash programme having an associated drum mode.

[0008] It has, however, been the concern of the present inventors to provide an apparatus which facilitates the efficient cleaning of soiled substrates using the method of WO-A-2007/128962, but which additionally allows for the efficient separation of the substrate from the cleaning media at the conclusion of the cleaning process. This has now been achieved by means of the apparatus of the present invention, which provides a novel design requiring the use of two internal drums capable of independent rotation, and which finds application in both industrial and domestic cleaning processes.

Summary of the Invention

[0009] Thus, according to a first aspect of the present invention, there is provided an apparatus for use in the cleaning of soiled substrates, said apparatus comprising a casing which contains a rotatably mounted cylindrical cage concen-

trically located within a rotatably mounted cylindrical drum having a greater diameter than said cage, wherein said cage and said drum are concentrically located within a stationary cylindrical drum having a greater diameter than said rotatably mounted drum, wherein said casing includes access means, allowing access to the interior of said cylindrical cage, and wherein said rotatably mounted cylindrical cage and said rotatably mounted cylindrical drum are adapted to rotate independently.

[0010] Said access means typically comprises a hinged door mounted in the casing, which may be opened to allow access to the inside of the cylindrical cage, and which may be closed in order to provide a substantially sealed system. Preferably, the door includes a window.

[0011] Said stationary cylindrical drum, rotatably mounted cylindrical cage and rotatably mounted cylindrical drum may be mounted vertically within said casing but, most preferably, are mounted horizontally within said casing. Consequently, in the preferred embodiment of the invention, said access means is located in the front of the apparatus, providing a front-loading facility. When the stationary cylindrical drum, rotatably mounted cylindrical cage and rotatably mounted cylindrical drum are vertically mounted within the casing, the access means is located in the top of the apparatus, providing a top-loading facility. However, for the purposes of the further description of the present invention, it will be assumed that said stationary cylindrical drum, rotatably mounted cylindrical cage and rotatably mounted cylindrical drum are mounted horizontally within said casing.

[0012] Said rotatably mounted cylindrical cage and said rotatably mounted cylindrical drum are adapted to rotate independently, such that said cage and said drum may both rotate simultaneously in the same or in opposite directions. Alternatively, one of said cage or said drum may rotate whilst the other is at rest.

[0013] Rotation of said rotatably mounted cylindrical cage and said rotatably mounted cylindrical drum is effected by use of drive means, which typically comprises electrical drive means, in the form of an electric motor, adapted to drive said cage and said drum independently or simultaneously in the same or in opposite directions. Operation of said drive means is effected by control means which may be programmed by an operative.

[0014] Said stationary cylindrical drum is a similar feature to that which is found in conventional commercial and domestic washing machines, and is adapted to provide the same functions as in said machines. Thus, said stationary drum is connected to the standard plumbing features of the apparatus and may additionally comprise means for circulating air within said apparatus, and for adjusting the temperature and humidity therein. Said means may typically include, for example, a recirculating fan, an air heater, a water atomiser and/or a steam generator. Additionally, sensing means may also be provided for determining the temperature and humidity levels within the apparatus, and for communicating this information to the control means.

[0015] Said rotatably mounted cylindrical cage comprises a plurality of perforations in its cylindrical side walls, thereby allowing for ingress and egress of fluids, fine particulate materials and discrete particulate materials. Said perforations typically have a diameter of from 5-10 mm, preferably from 6-9 mm, most preferably from 7-8 mm.

[0016] The cylindrical side walls of the rotatably mounted cylindrical drum are also perforated to permit the ingress and egress of fluids and fine particulate materials, but are adapted so as to prevent the ingress or egress of discrete particulate materials. Consequently, the perforations typically have a diameter of less than 5 mm, most preferably less than 2.5 mm.

[0017] Said rotatably mounted cylindrical cage is of the size which is to be found in most commercially available washing machines and tumble driers, and typically has a capacity in the region of 50-500 litres. Generally said cage comprises a cylinder with a diameter in the region of 40-100 cm, preferably 50-90 cm, most preferably 60-80 cm, and a length of between 30 and 100 cm, preferably between 40 and 90 cm, most preferably from 50 to 80 cm.

[0018] Said rotatably mounted cylindrical drum is concentrically located outside said rotatably mounted cylindrical basket and, consequently, has greater cross-sectional dimensions than said basket. Thus, typically said drum comprises a cylinder with a diameter in the region of 50-120 cm, preferably 60-100 cm, most preferably 70-90 cm, and a length of between 30 and 100 cm, preferably between 40 and 90 cm, most preferably from 50 to 80 cm.

[0019] Said stationary cylindrical drum is concentrically located outside said rotatably mounted cylindrical drum and, consequently, has greater cross-sectional dimensions, and generally slightly greater length, than said rotatably mounted drum. Thus, typically said drum comprises a cylinder with a diameter in the region of 55-140 cm, preferably 65-105 cm, most preferably 75-95 cm, and a length of between 31 and 105 cm, preferably between 41 and 95 cm, most preferably from 51 to 85 cm.

[0020] Said apparatus is designed to operate in conjunction with soiled substrates and cleaning media comprising a solid particulate material, which is most preferably in the form of a multiplicity of polymeric particles. Ideally, these polymeric particles should be efficiently circulated to promote effective cleaning and the apparatus, therefore, preferably includes circulation means. Thus, the inner surface of the cylindrical side walls of said rotatably mounted cylindrical drum preferably comprises a multiplicity of spaced apart circulation paddles, typically in the form of oblong-shaped protrusions affixed essentially perpendicularly to said inner surface. Said paddles are adapted so as to promote efficient circulation of said solid particulate material. Typically said apparatus comprises from 3 to 12 of said paddles.

[0021] Preferably, said apparatus additionally comprises separation means located between said rotatably mounted

cylindrical cage and said rotatably mounted cylindrical drum. In a preferred embodiment of the invention, said separation means comprises a plurality of reservoir baffles, which are fixedly mounted between the cylindrical walls of said rotatably mounted cylindrical cage and said rotatably mounted cylindrical drum and are adapted so as to facilitate controlled flow of said solid particulate material between said cage and said drum. Most preferably, said apparatus comprises two spaced apart crescent shaped reservoir baffles concentrically mounted between said cage and said drum, and of essentially equal length to said cage, arranged at opposite sides of said cage, so as to provide spaces at two locations through which ingress and egress of materials from said cage to said drum may occur.

[0022] In preferred embodiments of the invention, there is also provided suction means, in order to facilitate the efficient removal of residual solid particulate material at the conclusion of the cleaning operation. Preferably, said suction means comprises a suction chamber. Preferably, said suction chamber is located in the base of said apparatus, below said stationary cylindrical drum, said rotatably mounted cylindrical cage and said rotatably mounted cylindrical drum and is adapted to operate at the conclusion of the cleaning operation.

[0023] Preferably, said suction chamber comprises a chamber which may be extended out of the body of the apparatus, such that it may be located beneath the access means through which cleaned substrate is removed from the apparatus of the invention, in order that residual solid particulate material may be collected therein, as a consequence of the combined effects of gravity and applied suction. Typically, suction is applied by means of a vacuum pump, and is activated when said suction chamber is extended out of the body of the apparatus.

[0024] Optionally, said suction means may also comprise localised suction means, typically in the form of a suction gun, which may be directed to localised parts of the cleaned substrate so as to remove remaining residual solid particulate cleaning material. Preferably, said suction gun comprises a headpiece including an aperture attached to flexible tubing, through which suction may be applied.

[0025] Preferred embodiments of the invention additionally comprise recirculation means, thereby facilitating recirculation of said solid particulate material from said suction means to said rotatably mounted cylindrical drum, for re-use in cleaning operations. Preferably, said recirculation means comprises ducting connecting said suction means and said rotatably mounted cylindrical drum. More preferably, said ducting comprises separating means for separating said solid particulate material from debris removed from the soiled substrate during the cleaning process, and purification means, adapted to remove debris from the air flow and permit expulsion of the filtered air stream to the atmosphere. Typically, said separating means comprises a cyclone, and said purification means comprises a filter.

[0026] In operation, during a typical cycle, said rotatably mounted cylindrical cage and said rotatably mounted cylindrical drum are adapted to rotate independently in the same direction during the cleaning process. Thus, solid particulate material which falls through the perforations in the bottom of said rotatably mounted cylindrical cage and between said reservoir baffles into said rotatably mounted cylindrical drum is carried by means of said circulation paddles to the top side of said rotatably mounted cylindrical cage, wherein it is caused, by means of gravity to fall between said reservoir baffles and the perforations in said rotatably mounted cylindrical cage, back into said cage, thereby to continue the cleaning operation.

[0027] At the completion of the cleaning cycle, rotation of said rotatably mounted cylindrical cage continues, whilst rotation of said rotatably mounted cylindrical drum is stopped, thus allowing said solid particulate matter to fall through the perforations in the bottom of said rotatably mounted cylindrical cage and between said reservoir baffles into said rotatably mounted cylindrical drum, where it is allowed to collect. In practice, it is found that the amount of said solid particulate material which accumulates in the bottom of said rotatably mounted cylindrical drum is too great if this is allowed to remain at rest. Consequently means for removal of the material from this location must be provided. Optionally, this may be in the form of an associated reservoir, wherein the material may temporarily be transferred. Preferably, however, the material is removed by frequent changes in the direction of rotation of the drum, or by incremental movement of the drum in the opposite direction to the cage, whereby the solid particulate material is retained between successive pairs of reservoir baffles until removal of the material from the cage has been completed.

[0028] Thus, according to a second aspect of the present invention, there is provided a method for cleaning a soiled substrate, said method comprising the treatment of the moistened substrate with a formulation comprising solid particulate cleaning material, said formulation being free of organic solvents, wherein said method is carried out in an apparatus according to the first aspect of the invention, and wherein said solid particulate cleaning material is re-usable in further cleaning procedures according to the method of the invention.

[0029] Preferably, said method comprises the steps of:

- (a) loading at least one soiled substrate into an apparatus according to the first aspect of the invention via the access means, said apparatus containing a solid particulate cleaning material which is free of organic solvents located in at least one of the rotatably mounted cylindrical cage and the rotatably mounted cylindrical drum;
- (b) closing the access means so as to provide a substantially sealed system;
- (c) operating the apparatus for a first cycle, wherein said rotatably mounted cylindrical cage and said rotatably mounted cylindrical drum are both caused to rotate in the same direction, wherein said first cycle comprises a wash

cycle;

(d) operating the apparatus for a second cycle, wherein said rotatably mounted cylindrical cage continues to rotate in the same direction, but said rotatably mounted cylindrical drum (i) is caused to initially cease rotation and (ii) subsequently is subjected to incremental movements in the opposite direction to the cage, whereby the solid particulate cleaning material is retained between successive pairs of reservoir baffles until removal of the material from the cage has been completed, wherein said second cycle comprises a cycle for removal of said solid particulate cleaning material from said at least one substrate;

(e) removing the cleaned at least one substrate from the apparatus; and

(f) removing any remaining solid particulate cleaning material.

[0030] Preferably, said remaining solid particulate material is removed by shaking the at least one substrate in the vicinity of suction means, preferably comprising a suction chamber, wherein said remaining solid particulate material is collected. Most particularly, said step of removing any remaining solid particulate cleaning material also includes the step of applying localised suction means to localised parts of the cleaned substrate, said localised suction means preferably comprising a suction gun.

[0031] Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", means "including but not limited to", and is not intended to (and does not) exclude other moieties, additives, components, integers or steps.

[0032] Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

[0033] Features, integers, characteristics, compounds, chemical moieties or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith.

Brief Description of the Drawings

[0034] The invention will now be further illustrated by reference to the following drawings, wherein:

Figure 1 shows the apparatus according to the invention prior to loading a soiled substrate comprising garments into the apparatus;

Figure 2 illustrates the apparatus according to the invention during the wash cycle of the method of the invention;

Figure 3 depicts the apparatus according to the invention during the cycle of the method of the invention for removal of said solid particulate cleaning material;

Figure 4 shows the apparatus according to the invention during unloading of the cleaned substrate;

Figure 5 illustrates the step of removing remaining solid particulate cleaning material from the substrate using the suction chamber;

Figure 6 depicts the use of a suction gun for removal of further remaining solid particulate cleaning material from localised parts of the cleaned substrate.

Figure 7 shows a recirculation system for collecting solid particulate cleaning material and returning it to the rotatably mounted cylindrical cage and the rotatably mounted cylindrical drum; and

Figure 8 illustrated the action of a cyclone in separating the solid particulate cleaning material from solid waste material generated during the method of the invention.

Detailed Description of the Invention

[0035] The apparatus according to the invention may be used for the cleaning of any of a wide range of substrates including, for example, plastics materials, leather, paper, cardboard, metal, glass or wood. In practice, however, said apparatus is principally designed for use in the cleaning of substrates comprising textile fibre garments, and has been shown to be particularly successful in achieving efficient cleaning of textile fibres which may, for example, comprise either natural fibres, such as cotton, or man-made and synthetic textile fibres, for example nylon 6,6, polyester, cellulose

acetate, or fibre blends thereof.

[0036] Most preferably, the solid particulate cleaning material comprises a multiplicity of polymeric particles. Said polymeric particles may comprise any of a wide range of different polymers. Specifically, there may be mentioned polyalkenes such as polyethylene and polypropylene, polyesters and polyurethanes. Preferably, however, said polymeric particles comprise polyamide particles, most particularly particles of nylon, most preferably in the form of nylon chips or beads. Said polyamides are found to be particularly effective for aqueous stain/soil removal, whilst polyalkenes are especially useful for the removal of oil-based stains. Optionally, copolymers of the above polymeric materials may be employed for the purposes of the invention.

[0037] Whilst, in one embodiment, the method of the invention envisages the cleaning of a soiled substrate by the treatment of a moistened substrate with a formulation which essentially consists only of a multiplicity of polymeric particles, in the absence of any further additives, optionally in other embodiments the formulation employed may additionally comprise at least one cleaning material. Preferably, the at least one cleaning material comprises at least one surfactant. Preferred surfactants comprise surfactants having detergent properties. Said surfactants may comprise anionic, cationic and/or non-ionic surfactants. Optionally, said at least one cleaning material is mixed with said polymeric particles but, in a preferred embodiment, each of said polymeric particles is coated with said at least one cleaning material.

[0038] Various nylon homo- or co-polymers may be used, including Nylon 6 and Nylon 6,6. Preferably, the nylon comprises Nylon 6,6 homopolymer having a molecular weight in the region of from 5000 to 30000 Daltons, preferably from 10000 to 20000 Daltons, most preferably from 15000 to 16000 Daltons.

[0039] The polymeric particles are of such a shape and size as to allow for good flowability and intimate contact with the textile fibre. A variety of shapes of particles can be used, such as cylindrical, spherical or cuboid; appropriate cross-sectional shapes can be employed including, for example, annular ring, dog-bone and circular. The particles may have smooth or irregular surface structures and can be of solid or hollow construction. Particles are preferably of such a size as to have an average mass in the region of 5-50 mg, more preferably from 10-30 mg. In the case of the most preferred chips, the preferred average particle diameter is in the region of from 1.5-6.0 mm, more preferably from 2.0-5.0 mm, most preferably from 2.5-4.5 mm, and the length of the cylindrical chips is preferably in the range from 2.0-6.0 mm, more preferably from 3.0-5.0 mm, and is most preferably in the region of 4.0 mm.

[0040] Prior to treatment according to the method of the invention, the soiled substrate is moistened by wetting with water, in order to provide additional lubrication to the cleaning system and thereby improve the transport properties within the system. Thus, more efficient transfer of the at least one cleaning material to the substrate is facilitated, and removal of soiling and stains from the substrate occurs more readily. Most conveniently, the substrate may be wetted simply by contact with mains or tap water. Preferably, the wetting treatment is carried out so as to achieve a substrate to water ratio of between 1:0.1 to 1:5 w/w; more preferably, the ratio is between 1:0.2 and 1:2, with particularly favourable results having been achieved at ratios such as 1:0.2, 1:1 and 1:2. However, in some circumstances, successful results can be achieved with substrate to water ratios of up to 1:50, although such ratios are not preferred in view of the significant amounts of effluent which are generated.

[0041] The method of the invention has the advantage that, other than this aqueous treatment, it is carried out in the absence of added solvents - most notably in the absence of organic solvents - and, consequently, it shows distinct advantages over the methods of the prior art in terms of safety and environmental considerations, as well as in economic terms. However, whilst the formulation employed in the claimed method is free of organic solvents, in that no such solvents are added to the formulation, it will be understood that trace amounts of such solvents may inevitably be present in the polymeric particles, the substrate, the water, or other additives, such as cleaning materials, so it is possible that the cleaning formulations and baths may not be absolutely free of such solvents. However, such trace amounts are insignificant in the context of the present invention, since they do not have any impact on the efficiency of the claimed process, nor do they create a subsequent effluent disposal problem and the formulation is, therefore, seen to be essentially free of organic solvents.

[0042] The apparatus and the method of the present invention may be used for either small or large scale batchwise processes and find application in both domestic and industrial cleaning processes.

[0043] In the method according to the second aspect of the invention, the ratio of solid particulate cleaning material to substrate is based on a nominal "liquor ratio" in terms of a conventional dry cleaning system, with the preferred ratio being in the range of from 30:1 to 0.1:1 w/w, preferably in the region of from 10:1 to 1:1 w/w, with particularly favourable results being achieved with a ratio of between 5:1 and 1:1 w/w, and especially at around 4:1 w/w. Thus, for example, for the cleaning of 5 g of fabric, 20 g of polymeric particles, optionally coated with surfactant, would be employed.

[0044] As previously noted, the method of the invention finds particular application in the cleaning of textile fibres. The conditions employed in such a cleaning system are very much in line with those which apply to the conventional dry cleaning of textile fibres and, as a consequence, are generally determined by the nature of the fabric and the degree of soiling. Thus, typical procedures and conditions for the wash cycle are in accordance with those which are well known to those skilled in the art, with fabrics generally being treated according to the method of the invention at, for example, temperatures of between 30 and 90°C for a duration of between 20 minutes and 1 hour in the substantially sealed system

provided by the apparatus according to the first aspect of the invention.

[0045] The cycle for removal of solid particulate material may be performed at room temperature and it has been established that optimum results are achieved at cycle times of between 2 and 30 minutes, preferably between 5 and 15 minutes.

[0046] In the embodiment of the invention wherein the formulation comprises at least one cleaning material, it is preferred that the polymeric particles should be coated with the at least one surfactant, in order to achieve a more level distribution of the said surfactant on the particles and, consequently, on the substrate, as the particles contact the substrate during the cleaning process. Typically, this coating process requires that the polymeric particles should be mixed with 0.5%-10%, preferably 1%-5%, most preferably around 2% of the at least one surfactant, and the resulting mixture held at a temperature of between 30° and 70°C, preferably 40° and 60°C, most preferably in the region of 50°C, for a time of between 15 and 60 minutes, preferably between 20 and 40 minutes, with the most satisfactory results being obtained when the treatment is carried out for approximately 30 minutes.

[0047] The results obtained are very much in line with those observed when carrying out conventional aqueous and dry cleaning procedures with textile fabrics. The extent of cleaning and stain removal achieved with fabrics treated by the method of the invention is seen to be very good, with particularly outstanding results being achieved in respect of hydrophobic stains and aqueous stains and soiling, which are often difficult to remove. The method also finds application in wash-off procedures applied to textile fibres subsequent to dyeing processes, and in scouring processes which are used in textile processing for the removal of dirt, sweat, machine oils and other contaminants which may be present following processes such as spinning and weaving. The attendant drawbacks associated with the use of solvents in conventional dry cleaning processes, in terms of both cost and environmental considerations, are avoided, whilst the volumes of water required are significantly lower than those associated with the use of conventional aqueous washing procedures, again offering significant advantages in terms of cost and environmental benefits.

[0048] The method of the invention has been shown to be particularly successful in the removal of cleaning material from the cleaned substrate after processing and tests with cylindrical nylon chips comprising nylon 6,6 polymer have indicated bead removal efficacy of 99.95% from a 5 minute cycle.

[0049] Additionally, it has been demonstrated that re-utilisation of the polymer particles is possible, and that particles can be satisfactorily re-used in the cleaning procedure, although some deterioration in performance is generally observed following three uses of the particles. When re-using particles, optimum results are achieved when using particles coated with the at least one coating material which are then re-coated prior to re-use.

[0050] Referring to the figures provided herewith, there is seen in Figure 1 an apparatus 1 according to the invention comprising a casing 2 and door 3 including window 4, and housed within the casing is a rotatably mounted cylindrical cage 5 having perforations 6. With the door 3 in the open position, garment 7 may be placed in rotatably mounted cylindrical cage 5.

[0051] Figure 2 provides an illustration of apparatus 1 during the wash cycle wherein garments 7 are in the rotatably mounted cylindrical cage 5 which is rotating in the direction of arrows A, with the rotatably mounted cylindrical drum 8 rotating in the same direction, as indicated by arrows B. Nylon chips 9 are also in the rotatably mounted cylindrical cage 5 and fall through the perforations 6 in the bottom of said cage 5 through the lower gap between reservoir baffles 10 into the rotatably mounted cylindrical drum 8, and are then carried by means of circulation paddles 11 by rotation of the drum 8 to the top side of the rotatably mounted cylindrical cage 5, thereby re-entering said cage via the upper gap between reservoir baffles 10 to again take part in the wash cycle. The stationary cylindrical drum (not shown) is of greater diameter than said rotatably mounted cylindrical cage 5 and said rotatably mounted cylindrical drum 8, and located concentrically around said rotatably mounted cylindrical drum.

[0052] In Figure 3, there is shown the chip removal cycle, wherein chips 9 in the rotatably mounted cylindrical cage 5, rotating in the direction of arrows A, fall through the perforations 6 in the bottom of the cage 5 through the lower gap between reservoir baffles 10 into the rotatably mounted cylindrical drum 8. Drum 8 moves incrementally in the direction of arrow C, opposite to the direction of rotation of cage 5, thereby allowing chips 9 to be retained between circulation paddles 11 in the space between drum 8 and reservoir baffles 10.

[0053] At the conclusion of the wash and chip removal cycles, as shown in Figure 4, the door 3 may be opened to allow removal of garments 7. At the same time, suction chamber 12, incorporating garment mesh 13, which retains the garments 7 but allows chips to fall to the bottom of the chamber, is also opened, to facilitate removal of remaining chips attached to garments 7.

[0054] As seen from Figure 5, the garments 7 may be shaken to cause the remaining chips 9 to become detached and collected, by means of the applied suction, in the suction chamber 12.

[0055] Figure 6 illustrates the use of a suction gun comprising a headpiece 14 and flexible tubing 15 in the removal of remaining cleaning chips from shirt pocket 16.

[0056] Turning to Figure 7, there is illustrated a recirculation system comprising ducting 17, 18, 19 cyclone 20, filter 21 and exhaust pipe 22. Thus, in operation, nylon chips are collected in suction chamber 12 and transferred via ducting 17 to cyclone 20, wherein lint and other lighter solid particulate material is separated and exits the system via ducting

18, filter 21 and exhaust pipe 22, whilst the heavier nylon chips fall through ducting 19, and are thereby returned to the rotatably mounted cylindrical drum 8.

[0057] Finally, in Figure 8 can be seen the action of cyclone 20, wherein the mixture of nylon chips and other lighter solid particulate material enters to cyclone through ducting 17 and is separated by the action of the cyclone, such that the lighter material 23 exits via ducting 18, whilst the nylon chips 9 fall through ducting 19.

[0058] The method of the invention will now be exemplified, though without in any way limiting the scope of the invention, by reference to the following examples:

Examples

[0059] Experiments were conducted in order to ascertain cleaning efficiency using the apparatus and method according to the invention.

Example 1

[0060] The polymer particles comprised cylindrical nylon chips comprising Nylon 6,6 polymer having a molecular weight in the region of 15000-16000 Daltons, with average dimensions of 4 mm in length and 2-3 mm in diameter, and an average particle weight of 30-40 mg.

[0061] The fabric to be cleaned comprised soiled and stained Nylon 6,6 fibres, and the wetted dyed fabric was loaded into an apparatus according to the invention containing 75 g (air dry mass) of polymer particles. The temperature was raised to 40 °C and maintained at 40°C for 10 minutes, then increased to 70°C at a rate of 2°C per minute, and then maintained at 70°C for 20 minutes to complete the wash cycle, after which time the cycle for removal of the nylon chips was operated for 5 minutes before the fabric was removed from the apparatus, rinsed and dried. Complete removal of the soiling and staining was achieved and the fabric was found to be free of residual nylon chips.

Example 2

[0062] The fabric to be cleaned comprised a soiled cloth of mercerised cotton stained with coffee in an aqueous transport medium. This pre-soiled fabric sample was placed in an apparatus according to the invention containing 75 g (air dry mass) of polymer particles comprising cylindrical chips of Nylon 6,6 polymer, with average dimensions of 4 mm in length and 4 mm in diameter. The pre-soiled fabric sample was wetted with tap water before commencement of cleaning to give a substrate to water ratio of 1:1. The apparatus was operated on the cleaning cycle for 30 minutes to a maximum of 70°C with a cooling stage at the end of the cycle, then the cycle for removal of the nylon chips was operated for 5 minutes. Once this was complete, the cleaned fabric was removed from the apparatus and dried flat. The degree of staining of the cloth was very significantly reduced following the cleaning process.

Example 3

[0063] The fabric to be cleaned comprised a soiled cloth of mercerised cotton stained with city street dirt in an aqueous transport medium. This pre soiled fabric sample was placed in an apparatus according to the invention with 75 g (air dry mass) of polymer particles comprising cylindrical chips of Nylon 6,6 polymer, with average dimensions of 4 mm in length and 4 mm in diameter. The pre-soiled fabric sample was wetted with tap water before commencement of cleaning to give a substrate to water ratio of 1:2. The apparatus was operated on the cleaning cycle for 30 minutes to a maximum of 70 °C with a cooling stage at the end of the cycle, then the cycle for removal of the nylon chips was operated for 5 minutes. Once this was complete, the cleaned fabric was removed from the apparatus and dried flat. A significant reduction in numbers of dirt particles was observed after the cleaning process had taken place.

Example 4

[0064] The fabrics to be cleaned comprised soiled cloths (cotton and polyester stained with coffee, soil, boot polish, ball point pen, lipstick, tomato ketchup and grass). Each pre-soiled fabric sample was placed in an apparatus according to the invention with 75 g (air dry mass) of the polymer particles (cylindrical nylon chips comprising nylon 6,6 polymer, with average dimensions of 4 mm in length and 4 mm in diameter). Each pre-soiled fabric sample was wetted with mains or tap water before cleaning commenced to give a substrate to water ratio of 1:1. The apparatus was operated on the cleaning cycle for 30 minutes at a maximum temperature of 70°C with a cooling stage at the end of the cycle, then the cycle for removal of the nylon chips was operated for 5 minutes. Once this was complete, the cleaned fabric was removed from the apparatus and dried flat. In each case, the degree of staining of the fabric was significantly reduced.

Example 5

[0065] The fabric to be cleaned comprised a soiled cloth (cotton stained with city street dirt in an aqueous transport medium). This pre-soiled fabric sample was placed in an apparatus according to the invention with 75 g (air dry mass) of the polymer particles (cylindrical nylon chips comprising nylon 6,6 polymer, with average dimensions of 4 mm in length and 4 mm in diameter). The pre-soiled fabric sample was wetted with mains or tap water before cleaning commenced to give a substrate to water ratio of 1:2. The apparatus was operated on the cleaning cycle for 30 minutes to a maximum temperature of 70°C with a cooling stage at the end of the cycle, then the cycle for removal of the nylon chips was operated for 5 minutes. Once this was complete, the cleaned fabric was removed from the apparatus and dried flat. The amount of removal was very significant was measured by the change in colour strength values between the fabric before and after cleaning.

Example 6

[0066] The fabric to be cleaned comprised a large soiled cloth (cotton stained with boot polish, soil, coffee and tomato ketchup). This pre-soiled fabric sample was placed in an apparatus according to the invention with 500 g (air dry mass) of the polymer particles (cylindrical nylon chips comprising nylon 6,6 polymer, with average dimensions of 4 mm in length and 4 mm in diameter). The pre-soiled fabric sample was wetted with mains or tap water before cleaning commenced to give a substrate to water ratio of 1:0.2. The apparatus was operated on the cleaning cycle for 30 minutes to a maximum temperature of 70°C with a cooling stage at the end of the cycle, then the cycle for removal of the nylon chips was operated for 5 minutes. Once this was complete, the cleaned fabric was removed from the apparatus and dried. The degree of staining of the fabric was significantly reduced.

Example 7

[0067] The fabric to be scoured comprised a greige cotton cloth. This greige fabric sample was placed in an apparatus according to the invention with 75 g (air dry mass) of the polymer particles (cylindrical nylon chips comprising nylon 6,6 polymer, with average dimensions of 4 mm in length and 4 mm in diameter). The greige fabric sample was wetted with mains or tap water before cleaning commenced to give a substrate to water ratio of 1:2. The apparatus was operated on the cleaning cycle for 30 minutes to a maximum temperature of 70°C with a cooling stage at the end of the cycle, then the cycle for removal of the nylon chips was operated for 5 minutes. Once this was complete, the cleaned fabric was removed from the apparatus and dried flat. The difference in colour between conventionally scoured fabric and the fabric cleaned using the novel process was shown by the change in colour strength values between the fabrics to be very significant.

Example 8

[0068] Further experiments were carried out in order to determine the efficiency of removal of cleaning material from the substrates after treatment with the cleaning material. The tests were carried out using polyester/cotton shirts, since these provided more testing substrates than cloths, due to the potential for retention of cleaning materials in crevices and pockets.

Experiment A

[0069] A polyester/cotton shirt wetted with mains or tap water to give a substrate to water ratio of 1:2 was loaded into an apparatus according to the invention containing 75 g (air dry mass) of polymer particles (cylindrical nylon chips comprising nylon 6,6 polymer, with average dimensions of 4 mm in length and 4 mm in diameter). The apparatus was operated on the cleaning cycle for 2 minutes to ensure that the shirt was thoroughly covered with chips. During this cycle both the inner rotatably mounted cylindrical cage and outer rotatably mounted cylindrical drum were rotated together, causing thorough mixing of the shirt and chips. The shirt with chips still attached was carefully removed from the machine and weighed as a whole. The mass of the shirt was then deducted from the recorded weight to give the mass of chips, which was then converted to a numerical figure showing the approximate number of chips.

Experiment B

[0070] A polyester/cotton shirt wetted with mains or tap water to give a substrate to water ratio of 1:2 was loaded into an apparatus according to the invention containing 75 g (air dry mass) of polymer particles (cylindrical nylon chips comprising nylon 6,6 polymer, with average dimensions of 4 mm in length and 4 mm in diameter). The apparatus was

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operated on the cleaning cycle for 2 minutes to ensure that the shirt was thoroughly covered with chips. During this cycle both the inner rotatably mounted cylindrical cage and outer rotatably mounted cylindrical drum were rotated together, causing thorough mixing of the shirt and chips. The cycle for removal of the nylon chips was then operated for cycles of 3 and 5 minutes. In the course of these cycles, the outer rotatably mounted cylindrical drum was kept stationary, while the inner rotatably mounted cylindrical cage containing the shirt was rotated with frequent changes of direction. The shirt was carefully removed from the machine without shaking and the chips were removed and counted. In addition, the number of chips in the pocket of the shirt was also counted.

[0071] The results of these tests are set out in Tables 4, 5 and 6.

Table 4 Number of Chips attached to Shirt after Two Minute Wash Cycle

Trial	Number of Beads
1	29000
2	23000
3	27000
4	37000
5	33000
Average	29800

Table 5 Number of Chips attached to Shirt after Two Minute Wash Cycle and Three Minute Chip Removal Cycle

Trial	Number of Beads	Number of Beads in Pocket
1	247	1
2	269	0
3	112	0
4	167	0
5	133	0
Average	186	0

Table 6 Number of Chips attached to Shirt after Two Minute Wash Cycle and Five Minute Chip Removal Cycle

Trial	Number of Beads
1	6
2	11
3	3
4	38
5	17
Average	15

[0072] From the above data, the percentage removal of chips from the shirt between the end of the wash cycle and the end of the chip removal cycle may be calculated. The values used for the calculation are the average number of beads after two minutes washing and the average number of beads remaining after the chip removal cycle, and the value is calculated from the following formula:

$$\text{Percentage removal} = \frac{\text{Number of beads after wash} - \text{Number of beads after separation}}{\text{Number of beads after separation}} \times 100$$

[0073] Using this formula, it was calculated that the percentage removal by means of the three minute chip removal cycle was 99.38% while the percentage removal via the five minute chip removal cycle was 99.95%.

[0074] From further observations, it appears that the majority of the chip removal occurs within the first few seconds of the cycle and, whilst extended tumbling improves the efficacy, there seems to be little value in extending the cycle beyond five minutes. The present process achieves a satisfactory level of performance, with good removal even from the shirt pocket.

Claims

1. An apparatus (1) for use in the cleaning of soiled substrates, said apparatus comprising a casing (2) which contains a rotatably mounted cylindrical cage (5) concentrically located within a rotatably mounted cylindrical drum (8) having a greater diameter than said cage, wherein said cage and said drum are concentrically located within a stationary cylindrical drum having a greater diameter than said rotatably mounted drum, wherein said casing includes access means (3), allowing access to the interior of said cylindrical cage, and wherein said rotatably mounted cylindrical cage and said rotatably mounted cylindrical drum are adapted to rotate independently.
2. An apparatus (1) as claimed in claim 1 wherein said access means (3) may be closed so as to provide a substantially sealed system.
3. An apparatus (1) as claimed in claim 1 or 2 wherein said stationary cylindrical drum, said rotatably mounted cylindrical cage (5) and rotatably mounted cylindrical drum (8) are mounted such that their axes are horizontal within said casing.
4. An apparatus (1) as claimed in claim 1, 2 or 3 wherein said rotatably mounted cylindrical cage (5) comprises a plurality of perforations (6) in its cylindrical side walls, thereby allowing for ingress and egress of fluids and solid particulate cleaning material.
5. An apparatus (1) as claimed in any one of claims 1 to 4 wherein said rotatably mounted cylindrical drum (8) comprises a plurality of perforations in its cylindrical side walls, thereby allowing for ingress and egress of fluids but preventing the ingress or egress of solid particulate cleaning material.
6. An apparatus (1) as claimed in any preceding claim wherein said rotatably mounted cylindrical cage (5) has a capacity in the region of 50-500 litres.
7. An apparatus (1) as claimed in any preceding claim wherein rotation of said rotatably mounted cylindrical cage (5) and said rotatably mounted cylindrical drum (8) is effected by use of drive means, wherein operation of said drive means is optionally effected by control means.
8. An apparatus (1) as claimed in any preceding claim which comprises means for the circulation of solid particulate cleaning material.
9. An apparatus (1) as claimed in claim 8 wherein the inner surface of the cylindrical side walls of said rotatably mounted cylindrical drum (8) comprises a multiplicity of spaced apart circulation paddles (11) to serve as circulation means.
10. An apparatus (1) as claimed in any preceding claim wherein said apparatus additionally comprises separation means adapted to facilitate controlled flow of solid particulate material between said rotatably mounted cylindrical cage (5) and said rotatably mounted cylindrical drum (8), wherein said separation means optionally comprises a plurality of reservoir baffles (10) which are fixedly mounted between the cylindrical walls of said cage and said drum.
11. An apparatus (1) as claimed in any preceding claim which comprises suction means (12, 14, 15) to facilitate the removal of residual solid particulate material at the conclusion of a cleaning operation.

12. An apparatus (1) as claimed in any preceding claim which additionally comprises recirculation means, wherein said recirculation means optionally comprises ducting (17, 18, 19) connecting suction means (12) and said rotatably mounted cylindrical drum (8), said ducting comprises separating means and purification means and said separating means comprises a cyclone (20) and said purification means comprises a filter (21).
13. A method for cleaning a soiled substrate (7), said method comprising the treatment of the moistened substrate with a formulation comprising solid particulate cleaning material (9), said formulation being free of organic solvents, wherein said method is carried out in an apparatus (1) according to any preceding claim, and wherein said solid particulate cleaning material is re-usable in further cleaning procedures according to the method.
14. A method as claimed in claim 13, said method comprising the steps of:
- (a) loading at least one soiled substrate into an apparatus (1) as claimed in any one of claims 1 to 12 via the access means (3), said apparatus containing a solid particulate cleaning material (9) which is free of organic solvents located in at least one of the rotatably mounted cylindrical cage (5) and the rotatably mounted cylindrical drum (8);
 - (b) closing the access means so as to provide a substantially sealed system;
 - (c) operating the apparatus for a first cycle, wherein said rotatably mounted cylindrical cage and said rotatably mounted cylindrical drum are both caused to rotate in the same direction (A, B), wherein said first cycle comprises a wash cycle;
 - (d) operating the apparatus for a second cycle, wherein said rotatably mounted cylindrical cage continues to rotate in the same direction (A), but said rotatably mounted cylindrical drum (i) is caused to initially cease rotation and (ii) subsequently is subjected to incremental movements in the opposite direction (C) to the cage, whereby the solid particulate cleaning material is retained between successive pairs of reservoir baffles (10) until removal of the material from the cage has been completed, wherein said second cycle comprises a cycle for removal of said solid particulate cleaning material from said at least one substrate;
 - (e) removing the cleaned at least one substrate from the apparatus; and
 - (f) removing any remaining solid particulate cleaning material.
15. A method as claimed in claim 13 or 14 for the cleaning of at least one textile garment (7), wherein said solid particulate cleaning material (9) comprises a multiplicity of polymeric particles, and wherein said solid particulate cleaning material optionally comprises at least one cleaning material, and said textile garment is moistened by wetting with water prior to commencing cleaning operations.

Patentansprüche

1. Vorrichtung (1) zur Verwendung bei der Reinigung verschmutzter Substrate, wobei die genannte Vorrichtung ein Gehäuse (2) umfasst, das einen drehbar angebrachten zylindrischen Käfig (5) aufweist, der konzentrisch in einer drehbar angebrachten zylindrischen Trommel (8) mit einem größeren Durchmesser als der genannte Käfig angeordnet ist, wobei der genannte Käfig und die genannte Trommel konzentrisch in einer stationären zylindrischen Trommel angeordnet sind, die einen größeren Durchmesser aufweist als die genannte drehbar angebrachte Trommel, wobei das genannte Gehäuse eine Zugangseinrichtung (3) aufweist, die einen Zugang in das Innere des genannten zylindrischen Käfigs ermöglicht, und wobei der genannte drehbar angebrachte zylindrische Käfig und die genannte drehbar angebrachte zylindrische Trommel sich unabhängig voneinander drehen können.
2. Vorrichtung (1) nach Anspruch 1, wobei die genannte Zugangseinrichtung (3) geschlossen werden kann, um ein im Wesentlichen geschlossenes System bereitzustellen.
3. Vorrichtung (1) nach Anspruch 1 oder 2, wobei die genannte stationäre zylindrische Trommel, der genannte drehbar angebrachte zylindrische Käfig (5) und die genannte drehbar angebrachte zylindrische Trommel (8) so angebracht sind, dass ihre Achsen horizontal in dem genannten Gehäuse sind.
4. Vorrichtung (1) nach Anspruch 2, 2 oder 3, wobei der genannte drehbar angebrachte zylindrische Käfig (5) eine Mehrzahl von Perforationen (6) in dessen zylindrischen Seitenwänden umfasst, wodurch das Eintreten und Austreten von Fluiden und festem, teilchenförmigem Reinigungsmaterial ermöglicht wird.
5. Vorrichtung (1) nach einem der Ansprüche 1 bis 4, wobei die genannte drehbar angebrachte zylindrische Trommel

(8) eine Mehrzahl von Perforationen in ihren zylindrischen Seitenwänden umfasst, wodurch das Eintreten und Austreten von Fluiden ermöglicht, jedoch das Eintreten und Austreten von festem, teilchenförmigem Reinigungsmaterial verhindert wird.

- 5 6. Vorrichtung (1) nach einem der vorstehenden Ansprüche, wobei der genannte drehbar angebrachte zylindrische Käfig (5) eine Kapazität im Bereich von 50 bis 500 Litern aufweist.
7. Vorrichtung (1) nach einem der vorstehenden Ansprüche, wobei die Rotation des genannten drehbar angebrachten zylindrischen Käfigs (5) und der genannten drehbar angebrachten zylindrischen Trommel (8) unter Verwendung
10 einer Antriebseinrichtung bewirkt wird, wobei der Betrieb der genannten Antriebseinrichtung optional durch eine Steuereinrichtung bewirkt wird.
8. Vorrichtung (1) nach einem der vorstehenden Ansprüche, wobei diese eine Einrichtung für die Zirkulation des festen, teilchenförmigen Reinigungsmaterials umfasst.
15
9. Vorrichtung (1) nach Anspruch 8, wobei die innere Oberfläche der zylindrischen Seitenwände der genannten drehbar angebrachten zylindrischen Trommel (8) eine Mehrzahl von mit Zwischenabständen angeordneten Zirkulations-
20 schaufeln (11) umfasst, die als Zirkulationseinrichtung dienen.
10. Vorrichtung (1) nach einem der vorstehenden Ansprüche, wobei die genannte Vorrichtung zusätzlich eine Trenn-
25 einrichtung umfasst, um die geregelte Strömung von festem, teilchenförmigem Material zwischen dem genannten drehbar angebrachten zylindrischen Käfig (5) und der genannten drehbar angebrachten zylindrischen Trommel (8) zu erleichtern, wobei die genannte Trenneinrichtung optional eine Mehrzahl von Speichereinbauten (10) umfasst, die fest zwischen den zylindrischen Wänden des genannten Käfigs und der genannten Trommel angebracht sind.
11. Vorrichtung (1) nach einem der vorstehenden Ansprüche, wobei diese eine Saugeinrichtung (12, 14, 15) umfasst, um die Entfernung von Resten von festem, teilchenförmigem Material bei Abschluss des Reinigungsvorgangs zu erleichtern.
- 30 12. Vorrichtung (1) nach einem der vorstehenden Ansprüche, wobei diese zusätzlich eine Rezirkulationseinrichtung umfasst, wobei die genannte Rezirkulationseinrichtung optional eine Leitungsführung (17, 18, 19) umfasst, welche die Saugeinrichtung (12) und die genannte drehbar angebrachte zylindrische Trommel (8) verbindet, wobei die genannte Leitungsführung eine Trenneinrichtung und eine Klärungseinrichtung umfasst, und wobei die genannte Trenneinrichtung einen Zyklon (20) umfasst, und wobei die genannte Kläreinrichtung einen Filter (21) umfasst.
- 35 13. Verfahren zum Reinigen eines verschmutzten Substrats (7), wobei das genannte Verfahren die Behandlung des angefeuchteten Substrats mit einer Zusammensetzung umfasst, welche festes, teilchenförmiges Reinigungsmaterial (9) umfasst, wobei die genannte Zusammensetzung frei ist von organischen Lösungsmitteln, wobei das genannte Verfahren ausgeführt wird in einer Vorrichtung (1) nach einem der vorstehenden Ansprüche, und wobei das genannte
40 feste, teilchenförmige Reinigungsmaterial in weiteren Reinigungsprozeduren gemäß dem Verfahren wiederverwendet werden kann.
14. Verfahren nach Anspruch 13, wobei das genannte Verfahren die folgenden Schritte umfasst:
45 (a) das Laden mindestens eines verschmutzten Substrats in eine Vorrichtung (1) nach einem der Ansprüche 1 bis 12 über die Zugangseinrichtung (3), wobei die genannte Vorrichtung ein festes, teilchenförmiges Reinigungsmaterial (9) aufweist, das frei ist von organischen Lösungsmitteln, wobei es sich zumindest in dem drehbar angebrachten zylindrischen Käfig (5) oder in der drehbar angebrachten zylindrischen Trommel (8) befindet;
50 (b) das Schließen der Zugangseinrichtung, so dass ein im Wesentlichen geschlossenes System vorgesehen wird;
(c) das Betreiben der Vorrichtung über einen ersten Zyklus, wobei bewirkt wird, dass sich sowohl der genannte drehbar angebrachte zylindrische Käfig als auch die genannte drehbar angebrachte zylindrische Trommel in die gleiche Richtung (A, B) drehen, wobei der genannte erste Zyklus einen Spülzyklus umfasst;
55 (d) das Betreiben der Vorrichtung über einen zweiten Zyklus, wobei sich der genannte drehbar angebrachte zylindrische Käfig weiter in die gleiche Richtung (A) dreht, wobei für die genannte drehbar angebrachte zylindrische Trommel aber (i) bewirkt wird, dass sie zuerst die Rotation einstellt und (ii) danach inkrementellen Bewegungen in die entgegengesetzte Richtung (C) zu dem Käfig ausgesetzt wird, wodurch das feste, teilchenförmige Reinigungsmaterial zwischen aufeinanderfolgenden Paaren von Speichereinbauten (10) gehalten wird,

bis die Entfernung des Materials aus dem Käfig abgeschlossen ist, wobei der genannte zweite Zyklus einen Zyklus zur Entfernung des genannten festen, teilchenförmigen Reinigungsmaterials von dem genannten mindestens einen Substrat umfasst;

(e) das Entfernen des gereinigten mindestens einen Substrats von der Vorrichtung; und

(f) das Entfernen von jeglichem verbliebenem festem, teilchenförmigem Reinigungsmaterial.

15. Verfahren nach Anspruch 13 oder 14 zum Reinigen mindestens eines textilen Kleidungsstücks (7), wobei das genannte feste, teilchenförmige Reinigungsmaterial (9) eine Mehrzahl von polymeren Teilchen umfasst, und wobei das genannte feste, teilchenförmige Reinigungsmaterial optional mindestens ein Reinigungsmaterial umfasst, und wobei das genannte textile Kleidungsstück durch Benetzung mit Wasser vor Beginn der Reinigungsoperationen befeuchtet wird.

Revendications

1. Appareil (1) destiné à être utilisé dans le nettoyage de substrats souillés, ledit appareil comprenant un boîtier (2) qui contient une cage cylindrique montée en rotation (5) située de façon concentrique à l'intérieur d'un tambour cylindrique monté en rotation (8) ayant un diamètre plus grand que ladite cage, dans lequel ladite cage et ledit tambour sont situés de façon concentrique au sein d'un tambour cylindrique fixe ayant un plus grand diamètre que ledit tambour monté en rotation, dans lequel ledit boîtier comprend des moyens d'accès (3), permettant l'accès à l'intérieur de ladite cage cylindrique, et dans lequel ladite cage cylindrique montée en rotation et ledit tambour cylindrique monté en rotation sont conçus pour tourner de façon indépendante.
2. Appareil (1) selon la revendication 1, dans lequel lesdits moyens d'accès (3) peuvent être fermés de manière à fournir un système sensiblement étanche.
3. Appareil (1) selon la revendication 1 ou 2, dans lequel ledit tambour cylindrique fixe, ladite cage cylindrique montée en rotation (5) et le tambour cylindrique monté en rotation (8) sont montés de sorte que leurs axes sont horizontaux à l'intérieur dudit boîtier.
4. Appareil (1) selon la revendication 1, 2 ou 3, dans lequel ladite cage cylindrique montée en rotation (5) comprend une pluralité de perforations (6) dans ses parois latérales cylindriques, ce qui permet l'entrée et la sortie de fluides et d'un matériau de nettoyage à particules solides.
5. Appareil (1) selon l'une quelconque des revendications 1 à 4, dans lequel ledit tambour cylindrique monté en rotation (8) comprend une pluralité de perforations dans ses parois latérales cylindriques, ce qui permet l'entrée et la sortie de fluides mais empêche l'entrée ou la sortie d'un matériau de nettoyage à particules solides.
6. Appareil (1) selon l'une quelconque des revendications précédentes, dans lequel ladite cage cylindrique montée en rotation (5) a une capacité de l'ordre de 50 à 500 litres.
7. Appareil (1) selon l'une quelconque des revendications précédentes, dans lequel la rotation de ladite cage cylindrique montée en rotation (5) et dudit tambour cylindrique monté en rotation (8) est effectuée par l'utilisation de moyens d'entraînement, dans lequel le fonctionnement desdits moyens d'entraînement est réalisé par des moyens de commande.
8. Appareil (1) selon l'une quelconque des revendications précédentes, qui comprend des moyens pour la circulation du matériau de nettoyage à particules solides.
9. Appareil (1) selon la revendication 8, dans lequel la surface interne des parois latérales cylindriques dudit tambour cylindrique monté en rotation (8) comprend une multiplicité d'aubes de circulation espacées (11) pour servir de moyens de circulation.
10. Appareil (1) selon l'une quelconque des revendications précédentes, dans lequel ledit appareil comprend en outre des moyens de séparation conçus pour faciliter le débit modulé du matériau à particules solides entre ladite cage cylindrique montée en rotation (5) et ledit tambour cylindrique monté en rotation (8), dans lequel lesdits moyens de séparation comprennent éventuellement une pluralité de chicanes de réservoir (10) qui sont montées de manière fixe entre les parois cylindriques de ladite cage et dudit tambour.

11. Appareil (1) selon l'une quelconque des revendications précédentes, qui comprend des moyens d'aspiration (12, 14, 15) destinés à faciliter l'enlèvement du matériau à particules solides résiduel à la fin d'une opération de nettoyage.

12. Appareil (1) selon l'une quelconque des revendications précédentes, qui comprend en outre des moyens de recirculation, dans lequel lesdits moyens de recirculation éventuellement comprennent une canalisation (17, 18, 19) reliant des moyens d'aspiration (12) et ledit tambour cylindrique monté en rotation (8), ladite canalisation comprend des moyens de séparation et des moyens de purification et lesdits moyens de séparation comprennent un cyclone (20) et lesdits moyens de purification comprennent un filtre (21).

13. Procédé de nettoyage d'un substrat souillé (7), ledit procédé comprenant l'étape consistant à traiter le substrat imprégné avec une formulation comprenant un matériau de nettoyage à particules solides (9), ladite formulation étant exempte de solvants organiques, dans lequel ledit procédé est effectué dans un appareil (1) selon l'une quelconque des revendications précédentes, et dans lequel ledit matériau de nettoyage à particules solides est réutilisable dans d'autres procédures de nettoyage selon le procédé.

14. Procédé selon la revendication 13, ledit procédé comprenant les étapes consistant à :

(a) charger au moins un substrat souillé dans un appareil (1) selon l'une quelconque des revendications 1 à 12 par l'intermédiaire des moyens d'accès (3), ledit appareil contenant un matériau de nettoyage à particules solides (9) qui est exempt de solvants organiques situé dans la cage cylindrique montée en rotation (5) et/ou le tambour cylindrique monté en rotation (8) ;

(b) fermer les moyens d'accès de sorte à fournir un système sensiblement étanche ;

(c) faire fonctionner l'appareil pendant un premier cycle, dans lequel ladite cage cylindrique montée en rotation et ledit tambour cylindrique monté en rotation sont tous deux entraînés en rotation dans le même sens (A, B), dans lequel ledit premier cycle comprend un cycle de lavage ;

(d) faire fonctionner l'appareil pendant un second cycle, dans lequel ladite cage cylindrique montée en rotation continue à tourner dans le même sens (A), mais ledit tambour cylindrique monté en rotation (i) est amené tout d'abord à cesser sa rotation et (ii) subséquemment est soumis à des mouvements incrémentaux dans l'autre sens (C) vers la cage, de sorte que le matériau de nettoyage à particules solides est retenu entre des paires successives de chicanes de réservoir (10) jusqu'à ce que le retrait du matériau de la cage ait été achevé, dans lequel ledit second cycle comprend un cycle pour le retrait dudit matériau de nettoyage à particules solides dudit au moins un substrat ;

(e) retirer l'au moins un substrat nettoyé de l'appareil ; et

(f) retirer tout matériau de nettoyage à particules solides restant.

15. Procédé selon la revendication 13 ou 14, pour le nettoyage d'au moins un vêtement en tissu (7), dans lequel ledit matériau de nettoyage à particules solides (9) comprend une multiplicité de particules de polymère, et dans lequel ledit matériau de nettoyage à particules solides comprend éventuellement au moins un matériau de nettoyage, et ledit vêtement en tissu est humidifié par un mouillage avec de l'eau avant le début des opérations de nettoyage.

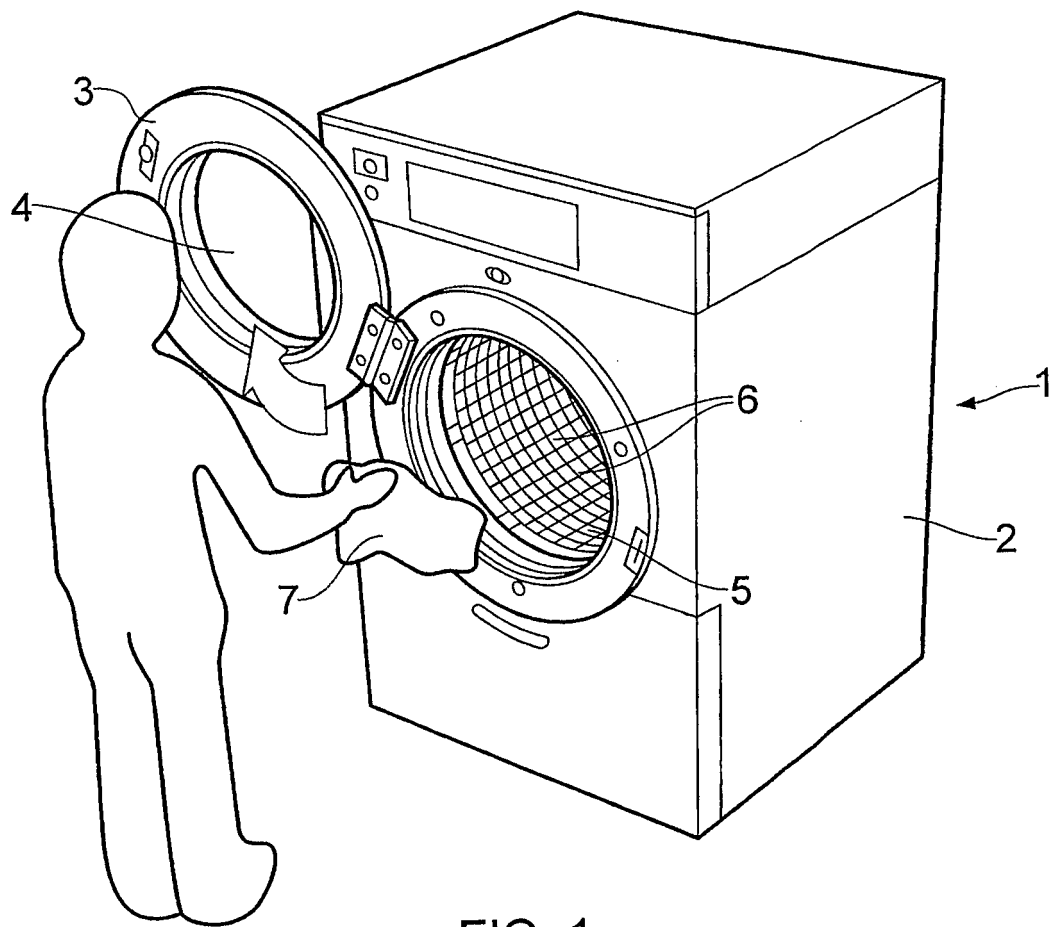


FIG. 1

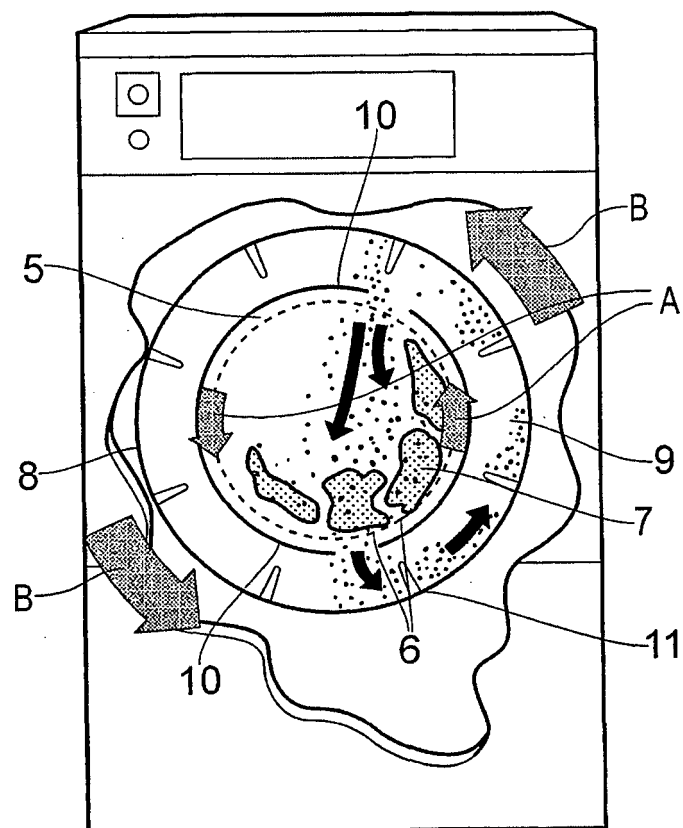


FIG. 2

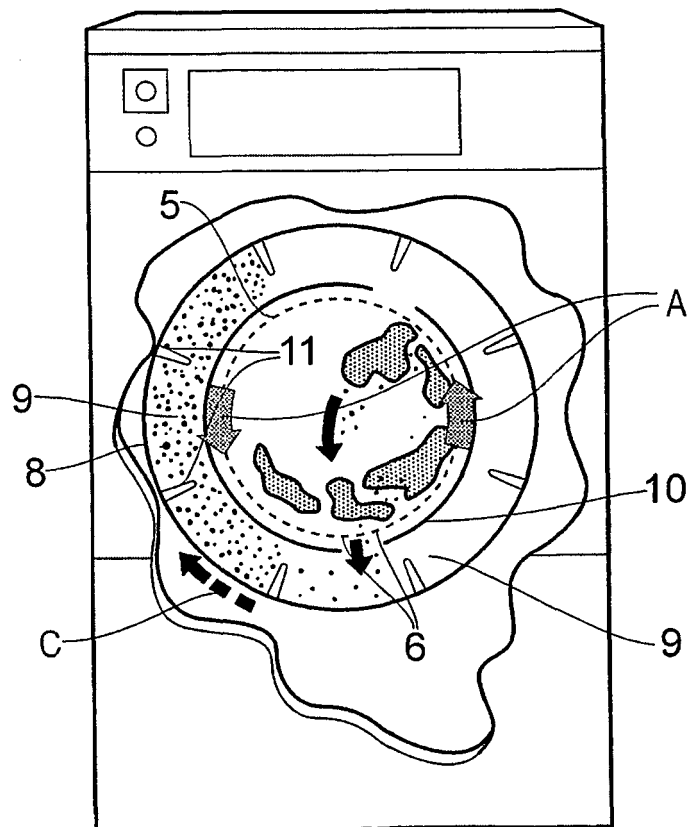


FIG. 3

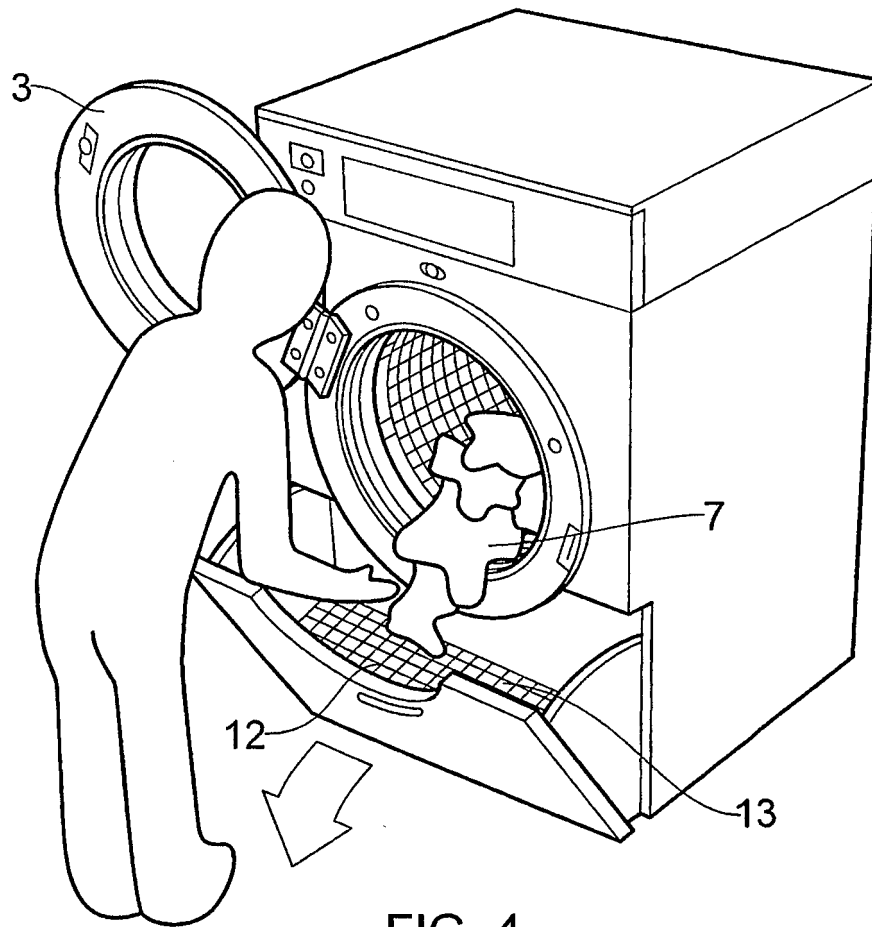


FIG. 4

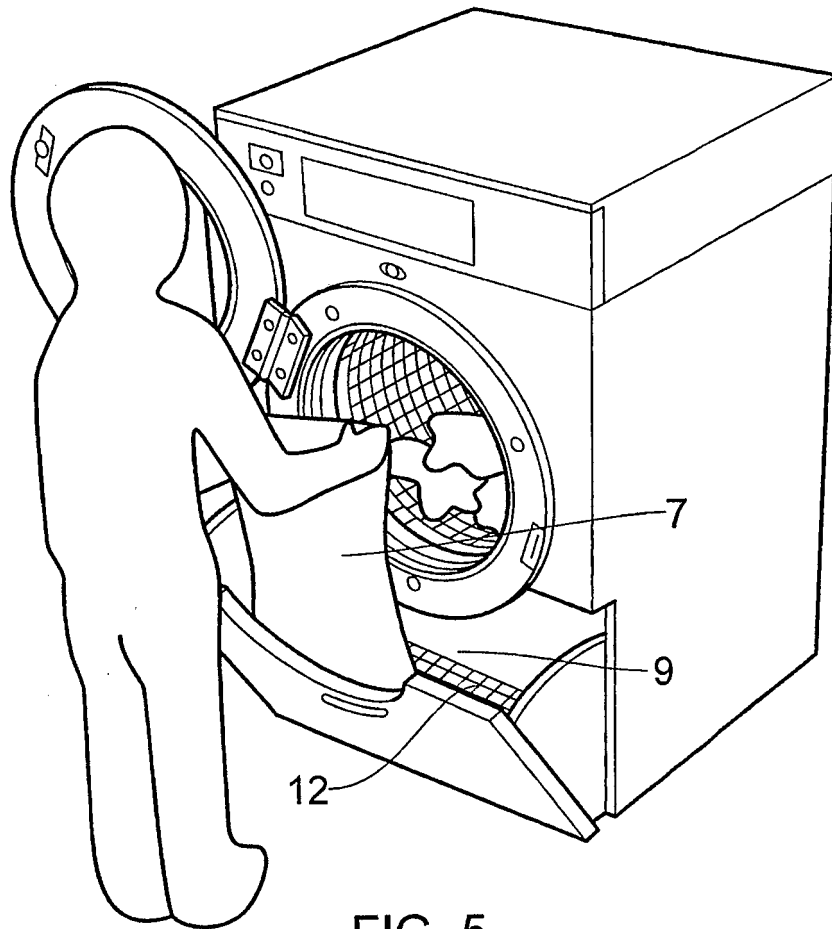


FIG. 5

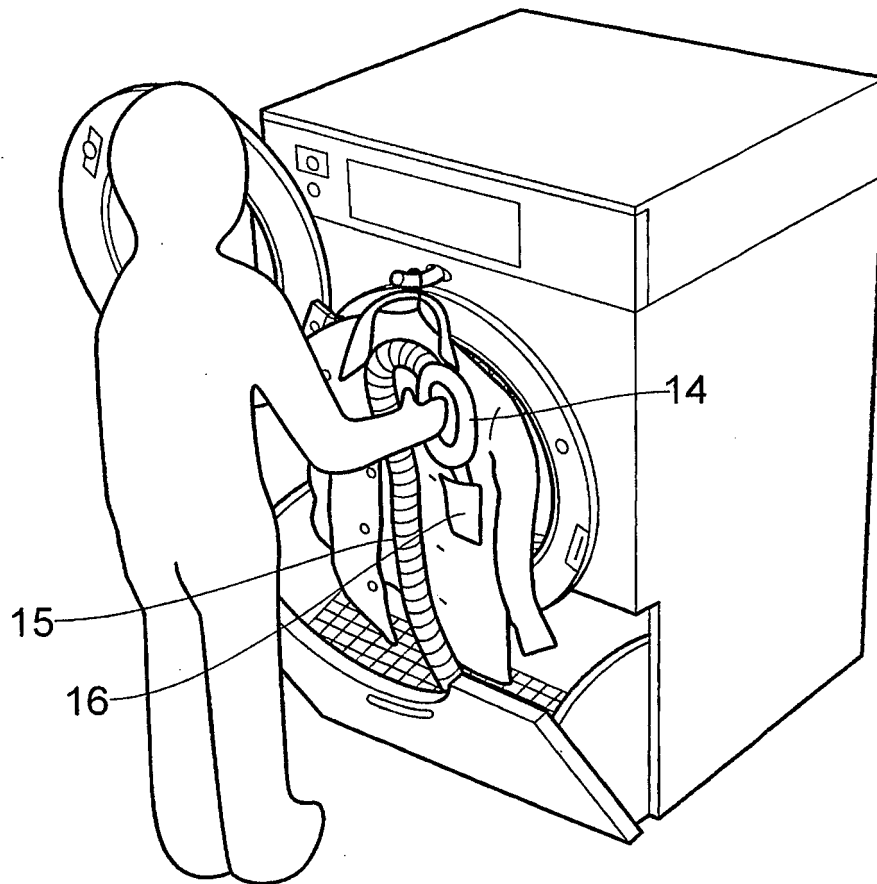


FIG. 6

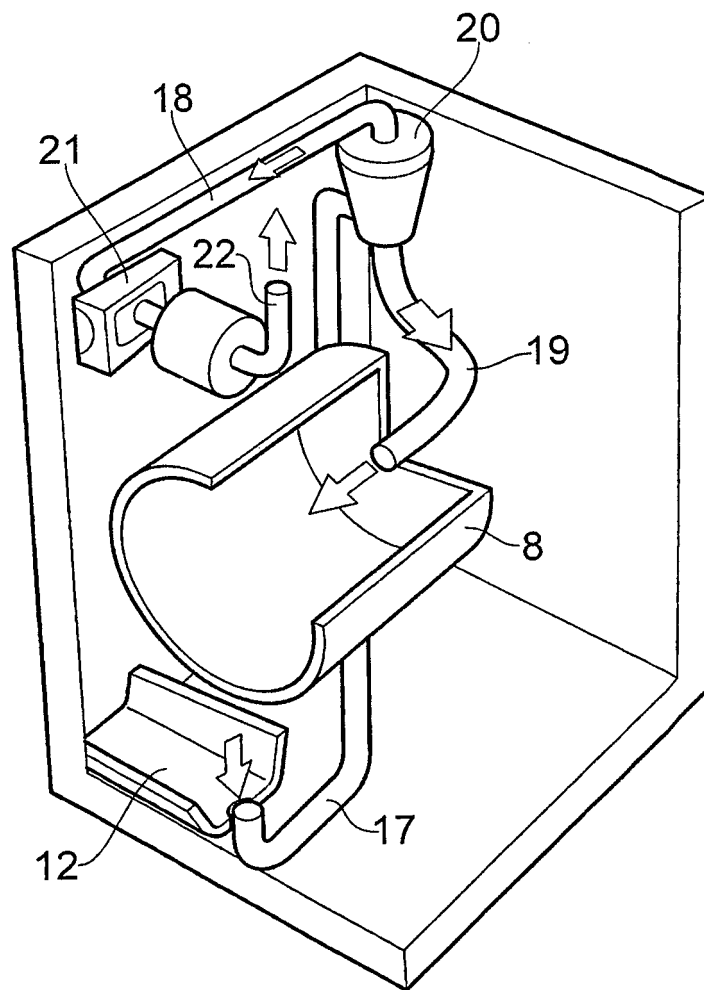


FIG. 7

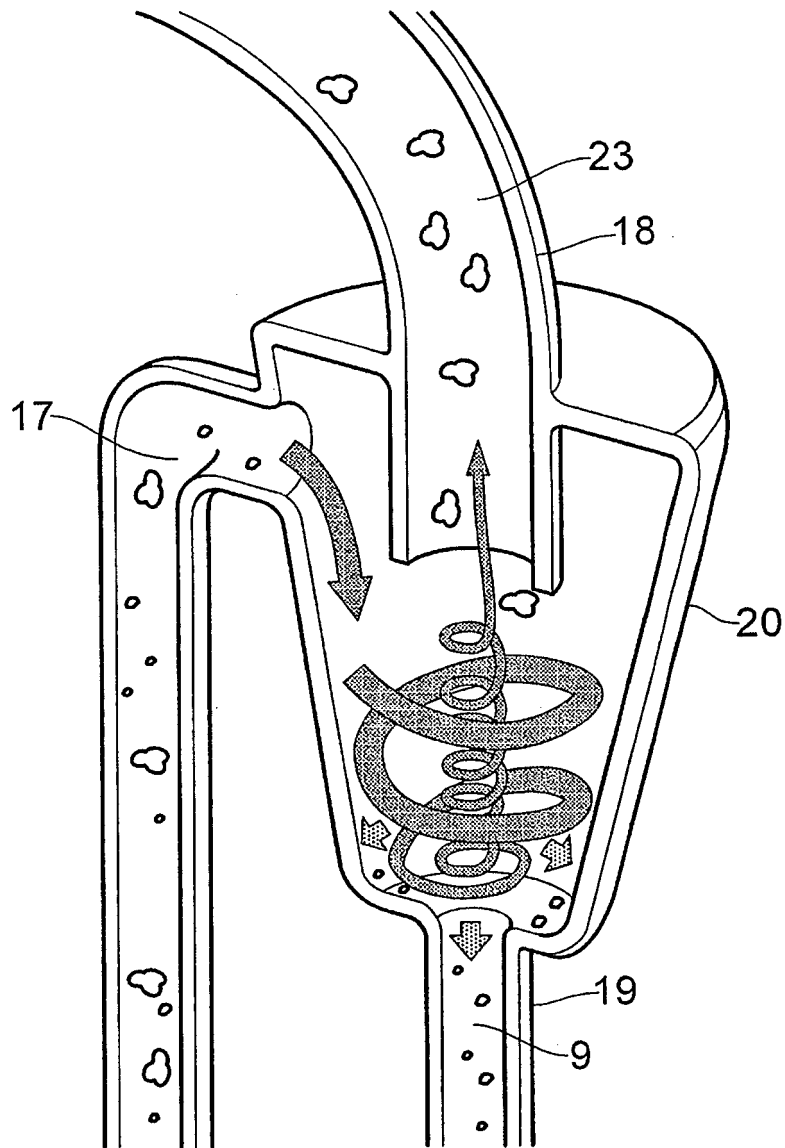


FIG. 8

REFERENCES CITED IN THE DESCRIPTION

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