

POROUS CLEANING MATERIAL

FIELD OF THE INVENTION

This invention relates to a wet cleaning apparatus comprising a porous cleaning material and an underpressure generator arranged to apply suction to the porous cleaning material. The invention further concerns use of such a porous cleaning material, with the use comprising arranging an underpressure generator to apply suction to the porous cleaning material.

The wet cleaning apparatus can be used, for example, for cleaning a floor, an indoor surface, or a window.

BACKGROUND OF THE INVENTION

Wet cleaning apparatuses, for example wet mopping devices, are known which remove water from a surface to be cleaned. Such wet cleaning apparatuses can also apply cleaning liquid, e.g. water, to the surface to be cleaned, and then remove the liquid, e.g. with a suitable cloth.

Some wet cleaning apparatuses have powered pick-up functionality for removing the water from the surface to be cleaned. Wet vacuum cleaners, for instance, may pick up liquid by generating sufficient airspeed (e.g. at least 10 m/s) and/or brushpower to exert enough shear force on liquid droplets to cause them to enter the device. Typical power consumption values for such wet vacuum cleaners are relatively high, for example in the order of several hundred watts.

Certain wet cleaning apparatuses make use of a porous layer that covers dirt inlet(s) in which an underpressure is provided by an underpressure generator, e.g. a pump. When the porous layer is dry, the porous layer may be regarded as being in an “air transport state” in which air is transported through each of the dry pores of the porous layer. A “liquid transport state” corresponds to liquid, e.g. water, being transported through the (wetted) pores of the porous layer. When there is no longer a feed of liquid to the pores, a “fluid block state” may be adopted. The “fluid block state” corresponds to the state at which the surface tension of the (residual) liquid retained in the wetted pores of the porous layer prevents fluid transport through the pores. In the latter state, a surface or barrier is created at the boundary between air

and liquid, e.g. water. This barrier can assist to maintain the underpressure between the porous layer and the underpressure generator.

Maintenance of the underpressure in this manner can mean that significantly less energy is consumed to pick up liquid from the surface to be cleaned compared to, for example, wet vacuum cleaners of the type described above.

SUMMARY OF THE INVENTION

Various challenges have been encountered relating to the above-mentioned porous layer used to maintain the underpressure. It would be desirable for the porous layer to itself contact the surface to be cleaned, so that the porous layer fulfils the function of a surface interaction layer as well as maintaining the underpressure. However, identifying porous layers capable of fulfilling both of these functions has proven challenging in practice. Porous layers, such as densely woven cloths, well-suited for maintaining the underpressure and picking up liquids from the surface to be cleaned, as well as loosening stains, have been found to be disadvantageous when coarse dirt, such as sand, is present on the surface to be cleaned. If, for instance, a particle of sand is caught in-between the surface to be cleaned and such a porous layer, the particle can experience high normal forces towards the surface to be cleaned, since it is squeezed between the relatively dense porous layer and the surface to be cleaned. This can lead to highly undesirable scratching of the surface to be cleaned.

This surface scratching issue can in principle be alleviated by providing the porous layer with projections, such as tufts, since the projections can provide spaces therebetween for accommodating the coarse dirt. By providing such spaces in the porous layer for receiving the coarse dirt, the coarse dirt may be less prone to being squeezed between the porous layer and the surface to be cleaned.

However, adding such projections can risk diminishing the liquid pick-up performance of the porous layer. The inventors have identified that the poorer liquid pick-up performance of such projections-comprising porous layers can be due to pores, e.g. micropores, of the porous layer not reaching the surface to be cleaned. This may be applicable to, for example, projections in the form of open tufts, since the (cut) fibers constituting such open tufts may define a capillary path that is less capable of carrying liquid to pores defined in a main body, e.g. chamois material, of the porous layer. This is thought to be due to spaces between such open tufts being poorly defined and hence the size of such spaces being uncontrolled. This, in turn, may impair the capability of the porous layer to pick up liquid from the surface to be cleaned.

The invention is defined by the claims.

According to examples in accordance with an aspect of the invention, there is provided a wet cleaning apparatus comprising: a porous cleaning material that includes a backing member comprising a back side and a projections-comprising side, the projections-comprising side comprising projections that project from the backing member so that at least some of the projections are contactable with a surface to be cleaned, the projections comprising fibers assembled so that movement of the fibers relative to each other, within each of the projections, is constrained, wherein capillary paths extend from the projections to reach the back side of the backing member, the capillary paths being at least partly defined by spaces between the fibers whose movement relative to each other is constrained; and an underpressure generator arranged to apply suction to the back side of the backing member.

Implicit in the projections each projecting from the backing member is that points at which the projections join to the backing member are spatially separated from each other.

Thus, coarse dirt, e.g. sand, may be accommodated in spaces between the projections, thereby alleviating the risk of scratching of the surface to be cleaned.

Moreover, since the capillary paths are at least partly defined by the spaces between the fibers whose movement relative to each other is constrained within each projection, and the capillary paths extend from the projections to reach the back side of the backing member, effective liquid pick-up from the surface to be cleaned can be maintained.

It is noted, for the avoidance of any doubt, that the term “constrained” in relation to movement of the fibers within each projection should not be regarded as eliminating any movement of the fibers. Rather, the term “constrained” is intended to convey that the fibers’ movement relative to each other is confined to that allowed by the manner in which the fibers are assembled, e.g. twisted, woven and/or knitted.

The fibers can be regarded as being more constrained than, for example, a scenario in which projections in the form of cut fibers project from the backing member.

The projections-comprising porous cleaning material can have further benefits, including, for example, decreased motion resistance of the porous cleaning layer across the surface to be cleaned. A chamois-type porous layer has the tendency to create a relatively high friction force with the surface to be cleaned, which can be heavily dependent on the contact surface area of the chamois with the surface to be cleaned. Liquid in the chamois may also be continuously removed from the surface to be cleaned, which may result in a relatively thin liquid layer between the chamois and the surface to be cleaned, resulting in relatively high

viscous friction. A flat surface of the chamois can cause it to stick to the surface to be cleaned like a suction cup.

Both of these properties of the chamois-type porous layer can be counteracted by the projections-comprising porous cleaning material. In the latter, the contact area with the surface to be cleaned may be reduced significantly, with paths being provided for air to move in between the projections-comprising porous cleaning material and the surface to be cleaned, thereby assisting to minimize or prevent the above-described suction-cup phenomenon.

It is also noted that the chamois-type porous layer may be less effective in following contours of uneven surfaces, such as floors comprising uneven tiles, seams, etc. The projections can better accommodate such unevenness of the surface to be cleaned, noting that individual projections can enter recesses, dislocations etc. in the surface to be cleaned and can remove dirty liquid therefrom as well.

Furthermore, inclusion of the projections, e.g. flexible projections, in the porous cleaning material can, in certain embodiments, obviate the requirement for an additional cleaning material to be employed for applying cleaning liquid to the surface to be cleaned. Since both liquid pick-up and cleaning liquid wetting functions can be provided using one and the same porous cleaning material, manufacture of the wet cleaning apparatus can be made simpler and lower cost.

The projections-comprising porous cleaning material can be constructed in various ways. For example, the porous cleaning material can have a structure in which groups of densely packed fibers are surrounded by pockets with a relatively low density of fibers. Alternatively, the porous cleaning material can have a knitted structure, with liquid transport being provided through the yarn, as well as open pockets of air being provided both in the backing member, as well as in between ridge-type projections that make contact with the surface to be cleaned.

In more general terms, the backing member may comprise a backing fabric, such as a woven or knitted backing fabric. Such a backing member may be relatively straightforward to manufacture and can provide a suitable porous structure for maintaining the underpressure behind the back side of the backing member.

In some embodiments, the backing member comprises a porous layer in addition to a layer comprising the projections-comprising side. In such embodiments, the back side of the backing member can be provided by the porous layer.

For example, the backing member comprises the porous layer arranged on a layer in the form of the backing fabric, e.g. on the woven or knitted backing fabric, with the back side of the backing member being provided by the porous layer.

Such a porous layer can assist to maintain the underpressure at the back side of the backing member, particularly in embodiments in which the backing fabric comprises relatively large holes (as well as the spaces between fibers that at least partly define the capillary paths).

As briefly mentioned above, the projections can include, e.g. can be defined by, ridges that project from the backing member.

The pitch of the ridges, in other words the spacing between centers of adjacent ridges measured in a direction perpendicular to the extension of the ridges, can be, for example, 1 to 5 mm, such as about 2 mm.

Such a pitch can be suitable for accommodating coarse dirt, e.g. sand, between the ridges.

As an alternative or in addition to the projections comprising ridges, the projections can comprise tufts, e.g. microfiber tufts, that project from the backing member. Such tufts can provide the projections' contribution to the capillary paths via defined spacing between fibers and/or yarns constituting each of the tufts.

The fibers can be assembled in any suitable manner in order to constrain movement between the fibers within each of the projections. In some embodiments, the projections comprise fibers assembled, at least in part, by twisting the fibers. In such embodiments, spaces between the twisted fibers can at least partly define the capillary paths.

Alternatively or additionally, the projections can comprise fibers assembled, at least in part, by weaving the fibers and/or yarns formed from the fibers. In such embodiments, the spaces between the woven fibers, the spaces between the woven yarns, and/or the spaces between the fibers, e.g. twisted fibers, of the yarns can at least partly define the capillary paths.

Alternatively or additionally, the projections can comprise fibers assembled, at least in part, by knitting the fibers and/or yarns formed from the fibers. In such embodiments, the spaces between the knitted fibers, the spaces between the knitted yarns, and/or the spaces between the fibers, e.g. twisted fibers, of the yarns can at least partly define the capillary paths.

In at least some embodiments, the projections comprise uncut fibers. In such embodiments, the fibers can be in the form of loops that extend from and return to the backing member.

Such a loop can constrain the fibers, e.g. relative to cut fibers in which no such loop is provided, and the spaces defined by such loops can at least partly define the capillary paths.

5 In some embodiments, the projections comprise plied yarns formed by twisting yarns, with the capillary paths being at least partly defined by spaces between the fibers of the twisted yarns. The twisting of the yarns can assist to keep the fibers present in each of the plied yarns together, thus providing well-defined capillary paths/channels from the backing member to the extremities, in other words tips, of the plied yarns.

10 In such embodiments, the backing member can comprise a woven structure formed by weaving or knitting said plied yarns. For example, the backing member comprises the woven structure and the above-mentioned porous layer arranged on the woven structure, with the back side of the backing member being provided by the porous layer.

In some embodiments, the projections comprise plied yarns formed by twisting two or more singles yarns, with the capillary paths being at least partly defined by spaces
15 between the singles yarns.

In such embodiments, the twisting of the singles yarns assists to keep the fibers present in each of the plied yarns together, thus providing well-defined capillary paths/channels from the backing member to the extremities, in other words tips, of the plied yarns.

20 In some embodiments, the projections comprise uncut twisted microfiber tufts. Such uncut twisted microfiber tufts have been found to be particularly effective in terms of providing relatively well-defined capillary paths that extend from the extremities, in other words tips, of the tufts.

It is noted that “terry knitting” is a term used for the processing of knitting uncut twisted tufts.

25 In some embodiments, the backing member comprises a woven structure formed by weaving or knitting the uncut twisted microfiber tufts.

This can assist to ensure that the capillary paths extend from the extremities of the plied yarns, e.g. twisted microfiber tufts, constituting the projections to, or at least towards, the back side of the backing member.

30 More generally, at least part of the backing member and the projections can be formed from a common material, for example from a common fibrous material. Forming at least part of the backing member and the projections from such a common fibrous material in this manner can assist to ensure that the capillary paths extend continuously from the

extremities of the projections along the projections and through the backing member to, or at least towards, the back side of the backing member.

Forming the projections, e.g. tufts, and at least part of the backing member from the same fibers can be particularly beneficial in terms of water transport within the porous cleaning material, since the common fibers can mean that there is intimate liquid connection between the backing member and the projections, without liquid-air interfaces between the projections and the backing member.

In some embodiments, the backing member and the projections each comprise polyester fibers and/or polyamide fibers. Such polyester fibers and/or polyamide fibers can constitute the common fibrous material that forms the backing member and the projections.

The wettability properties of polyester and polyamide, e.g. nylon, particularly following plasma treatment, can make such fibers especially suitable for picking up aqueous cleaning liquid from the surface to be cleaned.

In some embodiments, the wet cleaning apparatus comprises a cleaner head in which a dirt inlet structure is defined, with the dirt inlet structure being arranged to apply the suction generated by the underpressure generator to the back side of the backing member.

A liquid pick-up region of the porous cleaning material may be delimited by sealing attachment of the porous cleaning material around the dirt inlet structure.

The sealing attachment of the cleaning material layer around the dirt inlet structure, may assist to maintain the underpressure in the dirt inlet structure with or without the flow being applied by the underpressure generator.

In some embodiments, the cleaner head comprises a support substrate. The support substrate may, for example, be regarded as a main body of the cleaner head.

The support substrate may, for instance, be a pliable support substrate. Such a pliable support substrate can assist the cleaner head to follow contours on the surface to be cleaned. Alternatively or additionally, the pliability of the pliable support substrate may assist cleaning of the cleaner head after use, for example involving wringing liquid from the cleaner head and/or washing the cleaner head in the user's washing machine.

In embodiments in which the support substrate is a pliable support substrate, the support substrate may be formed from any suitable pliable material. In some embodiments, the pliable material forming the pliable support substrate comprises a polymeric material and/or elastomeric material.

In embodiments in which the cleaner head comprises the support substrate, e.g. the pliable support substrate, the dirt inlet structure may be recessed into and/or embossed on

a bottom surface of the support substrate, which bottom surface faces, in use, the surface to be cleaned.

The underpressure generator may be configured to provide a pressure difference between an inside of the wet cleaning apparatus and atmospheric pressure for drawing fluid
5 through the porous cleaning material, with the pressure difference being in a range of 3000 Pa to 13500 Pa.

Alternatively or additionally, the underpressure generator may be configured to generate a flow through the porous cleaning material that is at most 2000 cm³/minute.

In some embodiments, the underpressure generator is configured to supply the
10 suction by providing a flow through the porous cleaning material in the range of 15 to 2000 cm³/minute, more preferably 80 to 750 cm³/minute, even more preferably 100 to 300 cm³/minute, and most preferably 150 to 300 cm³/minute.

Such a flow, i.e. flow rate, may capitalize on the underpressure-maintaining capability of the porous cleaning material, and may ensure sufficient liquid pick-up whilst
15 limiting energy consumption.

The underpressure generator may, for example, comprise a positive displacement pump, such as a peristaltic pump.

Such a positive displacement pump can assist to maintain the underpressure in the dirt inlet structure after the underpressure generator has been deactivated, e.g. switched off,
20 because the pump design inherently restricts backflow from the pump outlet. This, in turn, may alleviate problematic liquid release from the porous cleaning material, for instance following cleaning of the surface to be cleaned and/or during stowing of the wet cleaning apparatus in a storage area after use.

The wet cleaning apparatus may include a dirty liquid collection tank. In such
25 embodiments, the underpressure generator may be arranged to draw liquid from the back side of the backing member to the dirty liquid collection tank.

In some embodiments, the wet cleaning apparatus comprises a cleaning liquid supply for supplying cleaning liquid for delivery towards the surface to be cleaned.

Such a cleaning liquid supply may, for example, comprise a cleaning liquid
30 reservoir and a delivery arrangement, e.g. a delivery arrangement comprising a pump, for transporting the cleaning liquid towards the surface to be cleaned.

The cleaning liquid supply may be configured to provide a continuous delivery of the cleaning liquid towards the surface to be cleaned. Such continuous delivery may, for

instance, be provided at the same time as the underpressure generator is applying suction to the back side of the backing member.

The cleaning liquid supply and the underpressure generator may, for instance, be configured such that the flow of the cleaning liquid delivered towards the surface to be cleaned is equal to or lower than the flow provided by the underpressure generator. This may assist to ensure that the surface to be cleaned does not become excessively wet with the cleaning liquid. For example, the flow of cleaning liquid may be in the range of 20 to 100 cm³/minute, and the flow provided by the underpressure generator may be in the range of 40 to 2000 cm³/minute, more preferably 80 to 750 cm³/minute, even more preferably 100 to 300 cm³/minute, and most preferably 150 to 300 cm³/minute.

More generally, the wet cleaning apparatus may comprise, for example, a wet mopping device, a window cleaner, a sweeper, or a wet vacuum cleaner, such as canister-type, stick type, or upright type wet vacuum cleaner. The wet cleaning apparatus may in some examples comprise a robotic wet vacuum cleaner or a robotic wet mopping device configured to autonomously move the cleaner head on the surface to be cleaned, such as the surface of a floor. Particular mention is made of a wet mopping device.

In a particular non-limiting example, the wet cleaning apparatus is a battery-powered (or battery-powerable) wet cleaning apparatus, such as a battery-powered (or battery-powerable) wet mopping device, in which the underpressure generator, e.g. pump, is powered (or powerable) by a battery electrically connected (or connectable) thereto. Particular mention is made of this example due to the power consumption-reducing effect which can be provided by the porous cleaning material to which the suction of the underpressure generator is applied.

According to another aspect there is provided a use of a porous cleaning material that includes a backing member comprising a back side and a projections-comprising side, the projections-comprising side comprising projections that project from the backing member so that at least some of the projections are contactable with a surface to be cleaned, the projections comprising fibers assembled so that movement of the fibers relative to each other, within each of the projections, is constrained, wherein capillary paths extend continuously from the projections to reach the back side of the backing member, the capillary paths being at least partly defined by spaces between the fibers whose movement relative to each other is constrained, and wherein the use comprises arranging an underpressure generator to apply suction to the back side of the backing member.

The porous cleaning material in this aspect can be a porous cleaning material according to any of the embodiments described herein, for example as described above in relation to the wet cleaning apparatus.

In some embodiments, the use further comprises operating the underpressure generator to apply the suction to the back side of the backing member.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example only, to the accompanying drawings, in which:

FIG. 1 schematically depicts a liquid transport state, intermediate regime and end regime sequence of a porous cleaning material when liquid and suction are applied thereto;

FIG. 2 schematically depicts a test arrangement for testing the behavior of the porous cleaning material when liquid and suction are applied thereto;

FIG. 3 provides a graph of underpressure vs time from data acquired using the test arrangement shown in FIG. 2;

FIG. 4 schematically depicts a wet cleaning apparatus, according to a comparative example, whose porous cleaning material comprises open tufts for contacting a surface to be cleaned;

FIG. 5 schematically depicts a wet cleaning apparatus according to an example of the present disclosure;

FIG. 5A schematically depicts a wet cleaning apparatus according to another example of the present disclosure;

FIG. 6A provides a photograph of a porous cleaning material comprising projections in the form of ridges;

FIG. 6B provides a magnified view of the porous cleaning material shown in FIG. 6A;

FIGs. 7A and 7B provide photographs of a porous cleaning material comprising projections in the form of plied yarns; and

FIGs. 8 to 10 provide photographs of further examples of a porous cleaning material comprising projections in the form of plied yarns.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The invention will be described with reference to the Figures.

It should be understood that the detailed description and specific examples, while indicating exemplary embodiments of the apparatus, systems and methods, are intended for purposes of illustration only and are not intended to limit the scope of the invention. These and other features, aspects, and advantages of the apparatus, systems and methods of the present invention will become better understood from the following description, appended claims, and accompanying drawings. It should be understood that the Figures are merely schematic and are not drawn to scale. It should also be understood that the same reference numerals are used throughout the Figures to indicate the same or similar parts.

Provided is a wet cleaning apparatus comprising a porous cleaning material. The porous cleaning material includes a backing member comprising a back side and a projections-comprising side. The projections-comprising side comprises projections that project from the backing member. An underpressure generator can be arranged to apply suction to the back side of the backing member.

Further provided is a use of such a porous cleaning material, which use comprises arranging an underpressure generator to apply suction to the back side of the backing member.

FIG. 1 schematically depicts a working principle of a wet cleaning apparatus 100 comprising an underpressure generator 102 and a porous cleaning material 104. The underpressure generator 102 is arranged to apply suction to a back side 106 of the porous cleaning material 104. The front side 108 of the porous cleaning material 104 can, in use, face the surface to be cleaned (not visible in FIG. 1).

The wet cleaning apparatus 100 can comprise a cleaner head 110 in which a dirt inlet structure 112 is defined, with the dirt inlet structure 112 being arranged to apply the suction generated by the underpressure generator 102 to the back side 106 of the porous cleaning material 104.

A liquid pick-up region of the porous cleaning material 104 may be delimited by sealing attachment of the porous cleaning material 104 around the dirt inlet structure 112.

The sealing attachment of the cleaning material layer 104 around the dirt inlet structure 112, may assist to maintain an underpressure in the dirt inlet structure 112 with or without the flow being applied by the underpressure generator 102 included in the wet cleaning apparatus 100.

The sealing attachment can be implemented in any suitable manner, such as by gluing or welding the porous cleaning material 104 around the dirt inlet structure 112, for example gluing and/or welding the porous cleaning material 104 around one or more tubes or channels that define the dirt inlet structure 112.

5 Still referring to FIG. 1, the cleaner head 110 can comprise a support substrate 114. The support substrate 114 may, for example, be regarded as a main body of the cleaner head 110.

The support substrate 114 may, for instance, be a pliable support substrate 114. Such a pliable support substrate 114 can assist the cleaner head 110 to follow contours on the
10 surface to be cleaned. Alternatively or additionally, the pliability of the pliable support substrate 114 may assist cleaning of the cleaner head 110 after use, for example involving wringing liquid from the cleaner head 110 and/or washing the cleaner head 110 in the user's washing machine.

Such a pliable support substrate 114 may be formed from any suitable pliable
15 material. For example, the pliable material forming the pliable support substrate 114 can comprise a polymeric material and/or elastomeric material.

Particular mention is made of silicone rubber and ethylene-vinyl acetate, in other words a copolymer of ethylene and vinyl acetate, for the pliable material.

Other polymeric and/or elastomeric materials, such as a polydiene, e.g.
20 polybutadiene, a thermoplastic elastomer, and so on, can also be contemplated for the pliable material.

Alternatively or additionally, the pliable material can be less than 50 Shore A, preferably less than 20 Shore A, most preferably less than 10 Shore A.

In a non-limiting example, the pliable material is 4 Shore A silicone rubber.

25 The pliable support substrate 114 can, for instance, be formed from a closed cell foam material, for example an ethylene-vinyl acetate closed cell foam material.

Such a closed cell foam material may facilitate an efficient (and inexpensive) production/assembly process for fabricating the cleaner head 110. Moreover, the closed cellular structure of the closed cell foam material can assist to retain liquid in the dirt inlet
30 structure 112.

When the cleaner head 110 comprises the support substrate 114, e.g. the pliable support substrate 114, the dirt inlet structure 112 may be recessed into and/or embossed on a bottom surface of the support substrate 114, which bottom surface faces, in use, the surface to be cleaned.

In the scenario that the dirt inlet structure 112 is recessed into the bottom surface of the support substrate 114, the dirt inlet structure 112 may comprise, e.g. be defined by, a groove defined in and extending across at least part of the bottom surface.

When the dirt inlet structure 112 is embossed on the bottom surface of the support substrate 114, the dirt inlet structure 112 may comprise, e.g. be defined by, an arrangement of protruding elements protruding from the bottom surface and extending across at least part of the bottom surface, with path(s) for the dirty liquid being defined between protruding elements of the arrangement of protruding elements.

As shown in FIG. 1, a dirt conduit 116 can fluidly connect the dirt inlet structure 112 to the underpressure generator 102. At least part of the dirt conduit 116 can be defined, for example, in a connector for connecting the cleaner head 110 to the underpressure generator 102.

FIG. 1 schematically depicts pores 118 of the porous cleaning material 104. When the porous cleaning material 104 is dry, the porous cleaning material 104 may be regarded as being in an “air transport state” in which air is transported through each of the dry pores 118 of the porous cleaning material 104. A “liquid transport state”, as shown in a) of FIG. 1, corresponds to liquid, e.g. water, being transported through all of the (wetted) pores 118 of the porous cleaning material 104 (but note that the (ample) liquid below the pores is not visible in a)). The end of the “liquid transport state” is shown in b) of FIG. 1, an intermediate regime is shown in c) of FIG. 1, and an end regime is shown in d) of FIG. 1.

The pores 118, e.g. micropores, may each have a different “breaking pressure.” This is represented in FIG. 1 by the number provided underneath each pore 118. For the sake of simplicity, each number is rounded to a single digit.

Taking as an illustrative example a porous cleaning material 104 in the form of a cloth made from fibers and yarns, which are woven together into a sheet of fabric, the pore sizes present in such a porous cleaning material 104 may be defined between all fibers and yarns, so the pore sizes present in the cloth are not fixed to exactly one size, but rather vary statistically. This variation is represented in FIG. 1 via the different numbers under each pore 118.

At start-up of the underpressure generator 102, e.g. pump, all liquid, e.g. water, is drawn from the surface to be cleaned, and the required pressure is the liquid transport pressure, in this example set at “1”. The underpressure in the dirt inlet structure 112 behind the porous cleaning material 104 is correspondingly “1”.

In b), the underpressure starts to rise. When all the liquid, e.g. water, has been removed from the surface to be cleaned, all pores 118 may be blocked via the surface tension of the residual liquid therein. In the depicted illustrative example, the underpressure generator 102 is a fixed flow pump, and hence continued operation of the pump may increase the underpressure. At a certain point, the underpressure in the dirt inlet structure 112 may rise to the level, such as “4”, of the breaking pressure of the “weakest” pores 118, and exceeding of the breaking pressure of these pores’ 118 means that air starts to be transported therethrough. Since the pressure in the dirt inlet structure 112 behind the porous cleaning material 104 may already be significant when these first pores 118 “break”, the air transported by these pores 118 at this point may be significant. Step c) in FIG. 1 can thus be regarded as schematically representing an intermediate regime.

In the intermediate regime, pores 118 may be getting blocked while other pores 118 are still transporting liquid from further regions (further away from the dirt inlet structure 112), hence creating more underpressure close to the dirt inlet structure 112. This can make the underpressure rise relatively slowly until all free liquid is gone. This may all be influenced by the pump rate and, in at least some examples, the properties of the dirt inlet structure 112, together with the flexibility of all elements, deforming when underpressure is applied.

This process may continue until the air transported is equal to the pump rate in this illustrative example, and the underpressure in the dirt inlet structure 112 behind the porous cleaning material 104 is lower than the breaking pressure of the remaining “unbroken” pores 118 having the lowest breaking pressure. Step d) in FIG. 1 can thus be regarded as schematically representing an end regime.

FIG. 2 schematically depicts an exemplary test arrangement 120 for testing the breaking pressure characteristics of the porous cleaning material 104. The porous cleaning material 104 is clamped between a clamping member 122 and a base plate 124. The clamping member 122 delimits holes for bolts 126, which bolts 126 are received in threaded holes in the base plate 124. Turning of the bolts 126 in the appropriate direction enables clamping/releasing of the porous cleaning material 104.

In this specific example, the clamping member 122 is an aluminium ring having a thickness of 10 mm, and the base plate 124 is made of poly (methyl methacrylate) having a thickness of 10 mm. The sample of the porous cleaning material 104 is a circular disk having a diameter of 140 mm. The sample is secured using eight bolts 126.

The dirt inlet structure 112 in this test arrangement 120 is provided in the form of a coarse mesh with a diameter of 80 mm. The dirt conduit 116 is partly defined by an opening of a transport duct 128 provided in the base plate 124.

5 The test arrangement 120 comprises an underpressure generator 102 for generating an underpressure in the dirt inlet structure 112, and a pressure sensor 130, e.g. a pressure gauge, arranged to measure the pressure in the dirt inlet structure 112.

The pressure sensor 130 in this specific example comprises a pressure gauge in combination with a data acquisition unit (LabQuest® 2) to enable monitoring of the pressure as a function of time.

10 The underpressure generator 102 in this specific example is in the form of a peristaltic pump or a syringe pump, e.g. a 250 mL syringe pump. The peristaltic pump can provide a pulsed water flow. The syringe pump was found to permit more precise measurements than the peristaltic pump.

15 The test arrangement 120 also comprises a pressure line filter 132 in the form of a chamber arranged to prevent liquid from entering the pressure sensor line 134 connecting the pressure line filter 132 with the pressure sensor 130. Downstream of the pressure line filter 132 and the underpressure generator 102 is a collection reservoir 136 for collecting the liquid pumped through the porous cleaning material 104.

20 The testing procedure comprises clamping the sample of the porous cleaning material 104 between the clamping member 122 and the base plate 124, and then setting the underpressure generator 102 to deliver a flow rate of 100 cm³/minute. The pressure line filter 132 is checked to ensure that it is empty, the pressure gauge of the pressure sensor 130 is zeroed and reconnected before each measurement. 25 cm³ of water is then poured onto the sample of the porous cleaning material 104, leaving a layer of water on the porous cleaning material 104
25 having a depth of approximately 4 mm. A flushing run is then implemented by starting the underpressure generator 102 such that the water is pulled through the sample of the porous cleaning material 104. Following the flushing run, the underpressure generator 102 is stopped and 25 cm³ of water is poured onto the sample of the porous cleaning material 104, and a measurement run is implemented by triggering the data acquisition unit to start the data
30 acquisition and starting the underpressure generator 102.

A typical graph of underpressure vs time from the data acquisition is provided in FIG. 3, together with schematic diagrams of the porous cleaning material 104. Initially, the above-described “liquid transport state” 138 is adopted in which the liquid 140, in this example water, is transported through the (pre-wetted) pore 118. The recorded “transport pressure” in

this case corresponds to the pressure difference required to transport the liquid 140 through the porous cleaning material 104 and the dirt inlet structure 112.

The governing equation describing the “liquid transport state” 138 may be the following Poiseuille equation:

$$\Delta P = \frac{8\eta L \phi}{\pi r^4}$$

where ΔP is the pressure difference across the pore 118; η is the dynamic viscosity of the liquid; L is the length of the pore 118; ϕ is the volumetric flow rate; and r is the radius of the pore 118.

Assuming, for instance, a pore diameter of 20 μm , with the pore 118 extending across a porous cleaning material 104 having a thickness of 0.8 mm, with an estimated
10 volumetric flow rate of about $4.96 \times 10^{-14} \text{ m}^3/\text{s}$ per pore 118 (from a typical fluid flow of 100 $\text{cm}^3/\text{minute}$), and with η_{water} being $1 \times 10^{-3} \text{ Pa}\cdot\text{s}$, $\Delta P = 10.1 \text{ Pa}$.

Subsequently to the “liquid transport state” 138, the intermediate regime 142 is adopted in which almost all of the liquid 140 has been removed from the surface of the sample of the porous cleaning material 104, such that most of the pores 118 are in the above-described
15 “fluid block state” in which the surface tension of the (residual) liquid 140 retained in the wetted pore(s) 118 of the porous cleaning material 104 prevents air 144 from being transported through the pore 118. An ever decreasing number of pores 118 may be in the “liquid transport state” in the intermediate regime 142. The “fluid block state” allows a significantly higher underpressure, so during the intermediate regime 142 the underpressure increases relatively
20 rapidly, as shown.

The governing equation describing the “fluid block state” may be the following Droplet dP equation:

$$P_i - P_o = \frac{2T}{R}$$

where P_i and P_o are the inside and outside pressures, and R is the fluid drop radius, as
25 schematically depicted in FIG. 3. T is the surface tension.

Assuming, for instance, that R is 10 μm for a typical 20 μm diameter pore 118, and T_{water} is 0.073 N/m, $P_i - P_o = \Delta P = 14600 \text{ Pa}$.

The ΔP of 14600 Pa from the above Droplet dP equation may be increased to 18000 Pa when detergent is added to the water. Whilst water surface tension decreases when
30 detergent is added ($T_{\text{soapy water}}$ is 0.045 N/m.), two surfaces in the bubble over the pore 118 are created: the inside and the outside of the bubble. Thus, the breaking pressure in the case of detergent being added to the water may be approximately double that of a single-layer surface:

$$P_i - P_o = \frac{4T}{R}$$

Following the intermediate regime 142, the end regime 146 is adopted in which all free water has been removed from the surface of the porous cleaning material 104, and all the pores 118 are initially in the “fluid block state”. Since the underpressure generator 102 continues drawing water through the porous cleaning material 104, hence increasing the underpressure, this may cause some of the fluid blocks to break such that air 144 is transported through the respective pores 118 in an “air transport state”. The associated ingress of air may come to an equilibrium in the end regime 146 in which the applied flow results in an underpressure which causes no more fluid blocks to break. The latter corresponds to the “breaking pressure” of the porous cleaning material 104 being investigated.

The governing equation describing the “air transport state” may be the Poiseuille equation provided above for the “liquid transport state”. Assuming, for instance, a pore diameter of 20 μm , with the pore 118 extending across a porous cleaning material 104 having a thickness of 0.8 mm, with an estimated volumetric flow rate of about $4.96 \cdot 10^{-14} \text{ m}^3/\text{s}$ per pore 118 (from a typical fluid flow of 100 $\text{cm}^3/\text{minute}$), and with η_{air} being $18.1 \cdot 10^{-6} \text{ Pa} \cdot \text{s}$, $\Delta P = 0.18 \text{ Pa}$.

Overall, the air transport pressure (e.g. 0.18 Pa) and the water transport pressure (e.g. 10.1 Pa) may both be significantly smaller, e.g. negligible, in comparison to the surface tension-derived pressure difference (e.g. 14600 Pa).

The porous cleaning material 104 may accordingly be selected to provide a relatively large difference between breaking pressure and water transport pressure. The significant advantage of this is that the porous cleaning material 104 can be “pre-tensioned” by the underpressure generator 102. A wetted porous cleaning material 104, e.g. pick-up pad, can be set to a pressure of, for example, 14600 Pa. When this state is reached, no more power may be needed. Whenever a droplet of liquid, e.g. water, is added to the porous cleaning material 104, the air-liquid surface disappears and suddenly the function of transporting the liquid can be fulfilled at a pressure difference of, for example, 10 Pa.

Thus, the wet cleaning apparatus 100 can be highly energy-efficient and effective. Liquid, e.g. water, may only be transported at the position where it is fed to the porous cleaning material 104. Once no liquid is provided for transportation, the wet cleaning apparatus 100 can return to its “pre-tensioned” state.

The pore size, in other words pore diameter, of the pores 118 of the porous cleaning material 104 may be selected in order to balance a relatively high underpressure with a relatively low resistance to transport of liquid through the porous cleaning material 104.

Achieving this balance may not, however, represent the only consideration in terms of properties of the porous cleaning material 104. It would be desirable for the porous cleaning material 104 to itself contact the surface to be cleaned, so that the porous cleaning material 104 additionally fulfils the function of a surface interaction layer. Porous cleaning materials 104, such as densely woven cloths, well-suited for maintaining the underpressure and picking up liquids from the surface to be cleaned, as well as loosening stains, have been found to be disadvantageous when coarse dirt, such as sand, is present on the surface to be cleaned.

If, for instance, a particle of sand is caught in-between the surface to be cleaned and the porous cleaning material 104, the particle can experience high normal forces towards the surface to be cleaned, since it is squeezed between the relatively dense porous cleaning material 104 and the surface to be cleaned. This can lead to highly undesirable scratching of the surface to be cleaned.

Referring now to FIG. 4, this surface scratching issue can in principle be alleviated by providing the porous cleaning layer 104 with projections 148, such as tufts, since the projections 148 can provide spaces therebetween for accommodating the coarse dirt. By providing such spaces in the porous cleaning material 104 for receiving the coarse dirt, the coarse dirt may be less prone to being squeezed between the porous cleaning material 104 and the surface to be cleaned 150. The risk of scratching of the surface to be cleaned 150 can correspondingly be reduced.

However, adding such projections 148 can risk diminishing the liquid pick-up performance of the porous cleaning material 104. The inventors have identified that the poorer liquid pick-up performance of such projections-comprising porous cleaning materials 104 can be due to pores 118, e.g. micropores, of the porous cleaning material 104 not reaching the surface to be cleaned 150. This may apply to, for example, projections 148 in the form of open tufts, since the (cut) fibers constituting such open tufts may define a capillary path that is less capable of carrying liquid to pores 118 defined in a main body 151, e.g. chamois material, of the porous cleaning material 104. This is thought to be due to spaces between such open tufts 148 being poorly defined and hence the size of such spaces being uncontrolled. This may impair the capability of the porous cleaning material 104 to pick up liquid from the surface to be cleaned 150.

Referring now to FIG. 5, the present disclosure accordingly proposes the use of a porous cleaning material 152 that includes a backing member 154 comprising a back side 156 and a projections-comprising side 158, with the projections-comprising side 158 comprising projections 160, for example flexible projections 160, that project from the backing member 154 so that at least some of the projections 160 are contactable with the surface to be cleaned 150, and with the projections 160 comprising fibers assembled so that movement of the fibers relative to each other, within each of the projections 160, is constrained.

It is noted that it may not only be extremities 162 of the projections 160 that can contact the surface to be cleaned 150, but other parts, e.g. along the length, of the projections 160 can contact the surface to be cleaned 150.

Capillary paths 164 extend from the projections to reach the back side 156 of the backing member 154, with the capillary paths 164 being at least partly defined by spaces between the fibers whose movement relative to each other is constrained. For example, the capillary paths 164 extend continuously from extremities 162 of the projections 160 along the projections 160 and through the backing member 154 to reach the back side 156 of the backing member 154.

Implicit in the projections 160 each projecting from the backing member 154 is that points at which the projections 160 join the backing member 154 are spatially separated from each other.

Thus, coarse dirt, e.g. sand, may be accommodated in spaces 166 between the projections 160, thereby alleviating the risk of scratching of the surface to be cleaned 150.

Moreover, since the capillary paths 164 are at least partly defined by the spaces between fibers whose movement relative to each other is constrained within each projection 160, and the capillary paths 164 extend to reach the back side 156 of the backing member 154, effective liquid pick-up from the surface to be cleaned 150 can be maintained.

In other words, the working principle of the porous cleaning layer 104, e.g. chamois material, as described above can extend through the projections 160, e.g. flexible projections 160, to the surface to be cleaned 150. Liquid pick-up from the surface to be cleaned 150, e.g. floor, can be equally effective as for the porous cleaning material 104 without projections, e.g. a chamois material, but with further benefits, including the above-described scratch reduction advantage.

It is also noted that the projections 160 can better accommodate unevenness of the surface to be cleaned 150, noting that individual projections 160 can enter recesses, dislocations etc. in the surface to be cleaned 150 and can remove dirty liquid therefrom as well.

Such benefits can further include decreased motion resistance of the porous cleaning layer 152 across the surface to be cleaned 150. A chamois-type porous cleaning material 104 has the tendency to create a relatively high friction force with the surface to be cleaned 150, which can be heavily dependent on the contact surface area of the chamois with the surface to be cleaned 150. Liquid in the chamois may be continuously removed from the surface to be cleaned 150, which may consistently result in a relatively thin liquid layer between the chamois and the surface to be cleaned 150, resulting in relatively high viscous friction. A flat surface of the chamois can cause it to stick to the surface to be cleaned 150 like a suction cup.

Both of these properties of the chamois-type porous cleaning material 104 can be counteracted by the projections-comprising porous cleaning material 152. In the latter, the contact area with the surface to be cleaned 150 may be reduced significantly, with paths being provided for air to move in between the projections-comprising porous cleaning material 152 and the surface to be cleaned 150, thereby assisting to minimize or prevent the above-described suction-cup phenomenon.

In addition, inclusion of the projections 160, e.g. flexible projections 160, in the porous cleaning material 152 can, in certain embodiments, obviate the requirement for an additional cleaning material to be employed for applying cleaning liquid to the surface to be cleaned 150. Since both liquid pick-up and cleaning liquid wetting functions can be provided using one and the same porous cleaning material 152, manufacture of the wet cleaning apparatus 100 can be made simpler and lower cost.

The projections-comprising porous cleaning material 152 can be constructed in various ways in order to provide the continuous capillary paths 164. For example, the porous cleaning material 152 can have a structure in which groups of densely packed fibers are surrounded by pockets with a relatively low density of fibers. Alternatively, and referring to FIGs. 6A and 6B, the backing member 154 can include a knitted structure, with liquid transport being provided through the yarn, as well as open pockets of air being provided both in the backing member 154, as well as in between ridge-type projections 160 that make contact with the surface to be cleaned 150.

In more general terms, the backing member 154 may comprise a backing fabric, such as a woven or knitted backing fabric. Such a backing member 154 may be relatively straightforward to manufacture and can provide a suitable porous structure for transporting liquid to, or at least towards, the back side 156 of the backing member 154.

In some embodiments, such as shown in FIG. 5A, the backing member 154 comprises a porous layer 154A in addition to a layer 154B comprising the projections-comprising side 158. In such embodiments, the back side 156 of the backing member 154 can be provided by the porous layer 154A.

5 For example, the porous layer 154A can be arranged on a layer 154B in the form of a backing fabric, with the back side 156 of the backing member 154 being provided by the porous layer.

Such a porous layer can assist to maintain the underpressure at the back side 156 of the backing member 154, particularly in embodiments in which the backing fabric
10 comprises relatively large holes (as well as the spaces between fibers that at least partly define the capillary paths).

As briefly mentioned above, and still referring to FIGs. 6A and 6B, the projections 160 can include, e.g. can be defined by, ridges that project from the backing member 154. In such embodiments, the spaces 166 can take the form of furrows defined
15 between the ridges.

The pitch of the ridges, in other words the spacing between centers of adjacent ridges measured in a direction perpendicular to the extension of the ridges, can be, for example, 1 to 5 mm, such as about 2 mm. Such a pitch can be suitable for accommodating coarse dirt, e.g. sand, between the ridges.

20 As an alternative or in addition to the projections 160 comprising ridges, the projections 160 can comprise tufts, e.g. microfiber tufts, that project from the backing member 154. Such tufts can provide the projections' 160 contribution to the capillary paths via defined spacing between fibers and/or yarns constituting each of the tufts.

More generally, the fibers can be assembled in any suitable manner in order to
25 constrain movement between the fibers within each of the projections 160. In some embodiments, the projections 160 comprise fibers assembled, at least in part, by twisting the fibers. In such embodiments, spaces between the twisted fibers can at least partly define the capillary paths 164.

Alternatively or additionally, the projections 160 can comprise fibers
30 assembled, at least in part, by weaving the fibers and/or yarns formed from the fibers. In such embodiments, the spaces between the woven fibers, the spaces between the woven yarns, and/or the spaces between the fibers, e.g. twisted fibers, of the yarns can at least partly define the capillary paths 164.

Alternatively or additionally, the projections 160 can comprise fibers assembled, at least in part, by knitting the fibers and/or yarns formed from the fibers. In such embodiments, the spaces between the knitted fibers, the spaces between the knitted yarns, and/or the spaces between the fibers, e.g. twisted fibers, of the yarns can at least partly define the capillary paths 164.

In at least some embodiments, the projections 160 comprise uncut fibers. In such embodiments, the fibers can be in the form of loops that extend from and return to the backing member 154.

Such a loop can constrain the fibers, e.g. relative to cut fibers in which no such loop is provided (see FIG. 4), and the spaces defined by such loops can at least partly define the capillary paths 164.

In some embodiments, the projections 160 comprise plied yarns formed by twisting yarns, with the capillary paths 164 being at least partly defined by spaces between the fibers of the twisted yarns. The twisting of the yarns can assist to keep the fibers present in each of the plied yarns together, thus providing well-defined capillary paths 164 from the backing member 154 to the extremities 162, in other words tips, of the plied yarns.

In such embodiments, the backing member 154 can comprise a woven structure formed by weaving or knitting said plied yarns. For example, the backing member 154 comprises the woven structure and the porous layer 154A arranged on the woven structure, with the back side 156 of the backing member 154 being provided by the porous layer 154A.

In some embodiments, such as that shown in FIGs. 7A and 7B, the projections 160 comprise plied yarns formed by twisting two or more singles yarns, with the capillary paths 164 being at least partly defined by spaces between the singles yarns.

In some embodiments, and referring to FIGs. 7A and 8 to 10, the projections 160 comprise uncut twisted microfiber tufts. Such uncut twisted microfiber tufts have been found to be particularly effective in terms of providing relatively well-defined capillary paths 164 that extend from the extremities 162, in other words tips, of the tufts.

It is noted that “terry knitting” is a term used for the processing of knitting uncut twisted tufts.

It is also noted that a terry knitted fabric (as shown in FIG. 8) sometimes has relatively large holes in its knitted backing. In such instances, an extra layer in the form of the above-mentioned porous layer 154A can then be added for allowing a suitable underpressure to be provided at the back side 156, for example an underpressure in the range of 3000 to 13500 Pa.

In more general terms, and irrespective of the precise manner in which the porous cleaning material 152 is constructed, the pressure difference between an inside of the wet cleaning apparatus 100 and atmospheric pressure for drawing fluid through the porous cleaning material 152 may be in a range of 3000 Pa to 13500 Pa.

5 The pressure difference can be directly and positively verified in a given wet cleaning apparatus 100 by, for example, drilling a hole in a tube of the wet cleaning apparatus 100 which is fluidly connected with the dirt inlet structure 112 and using the hole to couple to a pneumatic pressure sensor itself having a tube with a membrane covering an end thereof; the sensor being thus connected using an airtight connection. The sensor may be arranged to avoid
10 disturbing the flow, hence the skilled person will arrange the sensor to avoid, for instance, creating a bypass flow. No flow may be towards or from the sensor: only pressure is transmitted. In this way, the flow of the appliance may never be compromised (hence may remain at the set level in spite of the sensor installation).

 The pressure sensor is connected between the porous cleaning material 152 and
15 the underpressure generator 102 and as close to the porous cleaning material 152 as possible, to minimise the influence of other factors, such as flow resistance etc., on the sensed pressure difference.

 The sensing element/ membrane of the pressure sensor/gauge is ideally arranged/positioned in the pressure sensor so that the sensing element can be placed directly
20 (without the requirement for connecting tubes) in the tube, or in a cavity behind the porous cleaning material 152.

 By positioning the membrane of the pressure sensor, in other words membrane pressure gauge, with the membrane positioned at, in other words in line with, the wall of the tube (or exposed to the cavity), measurement errors may be minimized, as will be appreciated
25 by a person skilled in the art.

 It is noted that air bubbles inside narrow tubes may generate resistance (capillary/surface tension effects), and hence may influence the measurement. Hence the skilled person will further appreciate that care is also to be taken that air bubbles (water-air surfaces) do not unduly influence the pressure difference measurement.

30 It is further noted that a column of water present between the pressure sensor and the porous cleaning material 152 should be deducted from the measurement result (if such a column of water is present during the measurement), to compensate for the static pressure generated by the column of water.

Once the pressure sensor is arranged as described above, it may be ascertained that maintenance of the underpressure is due to the porous cleaning material 152 and not some other element, such as a valve. Any such element that influences the underpressure that is presented to the porous cleaning material 152 should be rendered inoperable for the purpose of performing the measurement.

Component(s) that dispense cleaning liquid (should the wet cleaning apparatus 100 be configured to deliver cleaning liquid) is/are disengaged when performing the pressure difference measurement.

The wet cleaning apparatus 100 is turned on (in the desired setting), so that the pick-up system comprising the underpressure generator 102 is activated. Recording of data from the pressure sensor is started.

The pick-up area of the cleaner head 110 is suspended in a layer of water, at max. 5 mm depth.

The pick-up area is then lifted from the water without tilting it in any way (so that the cleaner head 110 remains in a cleaning position, as if it were positioned to clean the floor), so that the water is no longer touching the porous cleaning material 152. At this point, “free water” will be removed from the porous cleaning material 152, all pores 118 will go into their “blocked state”, and the breaking pressure is determinable. The measurement result will resemble the graph shown in FIG. 3, once again noting that an equilibrium is established in the end regime 146 in which the applied flow results in an underpressure which causes no more fluid blocks to break.

The breaking pressure obtained from this measurement result, referring to the end regime 146, is the “pressure difference between the inside of the wet cleaning apparatus 100 and atmospheric pressure for drawing fluid through the porous cleaning material 152.” It is verified from the measurement result whether or not the 3000 Pa to 13500 Pa range is satisfied.

It is noted that the porous cleaning material 152 may be arranged to contact liquid on the surface to be cleaned 150, as previously described. Thus, the porous cleaning material 152 may be defined from the projections-comprising side 158 of the porous cleaning material 152 exposible to liquid on the surface to be cleaned 150 to the back side 156 exposed to the dirt inlet structure 112.

In some embodiments, and as best shown in FIG. 6A, the backing member 154 may comprise a woven structure formed by weaving or knitting the plied yarns, e.g. twisted microfiber tufts. This can assist to ensure that the capillary paths extend from the extremities

162 of the plied yarns, e.g. twisted microfiber tufts, constituting the projections 160 to the back side 156 of the backing member 154.

The woven structure shown in FIG. 6A can risk being too “open” for allowing a suitable underpressure to be provided at the back side 156. In such a scenario, an extra layer
5 in the form of the above-mentioned porous layer 154A can be added for allowing a suitable underpressure to be achieved.

More generally, at least part of the backing member 154 and the projections 160 can be formed from a common fibrous material. Forming at least part of the backing member 154 and the projections 160 from such a common fibrous material in this manner can assist to
10 ensure that the capillary paths 164 extend continuously from the extremities 162 of the projections 160 along the projections 160 and through the backing member 154 to, or at least towards, the back side 156 of the backing member 154.

Forming the projections 160, e.g. tufts, and at least part of the backing member 154 from the same fibers can be particularly beneficial in terms of water transport within the
15 porous cleaning material 152, since the common fibers can mean that there is intimate liquid connection between the backing member 154 and the projections 160, without liquid-air interfaces between the projections 160 and the backing member 154.

In some embodiments, the backing member 154 and the projections 160 each comprise polyester fibers and/or polyamide fibers. Such polyester fibers and/or polyamide
20 fibers can constitute the common fibrous material that forms the backing member 154 and the projections 160.

The wettability properties of polyester and polyamide, e.g. nylon, particularly following plasma treatment, can make such fibers especially suitable for picking up aqueous cleaning liquid from the surface to be cleaned 150.

25 The use of the porous cleaning material 152, and the wet cleaning apparatus 100 comprising the porous cleaning material 152 and the underpressure generator 102 can be employed in, for example, floor cleaners, e.g. wet mopping devices, in surface treatment applications, and potentially in medical applications, for example in medical applications in which the porous cleaning material 152 is arranged to continuously receive bodily fluids from
30 the skin, e.g. via soft fine fibers included in the porous cleaning material 152.

Variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality.

The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

If the term "adapted to" is used in the claims or description, it is noted the term "adapted to" is intended to be equivalent to the term "configured to".

5 Any reference signs in the claims should not be construed as limiting the scope.

CLAIMS

1. A wet cleaning apparatus (100) comprising:
a porous cleaning material (152) that includes a backing member (154) comprising a back side (156) and a projections-comprising side (158), the projections-comprising side comprising projections (160) that project from the backing member so that at least some of the projections are contactable with a surface to be cleaned (150), the projections (160) comprising fibers assembled so that movement of the fibers relative to each other, within each of the projections, is constrained, wherein capillary paths (164) extend from the projections to reach the back side of the backing member, the capillary paths being at least partly defined by spaces between the fibers whose movement relative to each other is constrained; and
an underpressure generator (102) arranged to apply suction to the back side of the backing member.
2. The wet cleaning apparatus (100) according to claim 1, wherein the projections (160) comprise tufts and/or ridges that project from the backing member (154).
3. The wet cleaning apparatus (100) according to claim 1 or claim 2, wherein the fibers are assembled, at least in part, by twisting the fibers.
4. The wet cleaning apparatus (100) according to any one of claims 1 to 3, wherein the fibers are assembled, at least in part, by weaving the fibers and/or weaving yarns formed from the fibers.
5. The wet cleaning apparatus (100) according to any one of claims 1 to 4, wherein the fibers are assembled, at least in part, by knitting the fibers and/or knitting yarns formed from the fibers.
6. The wet cleaning apparatus (100) according to any one of claims 1 to 5, wherein the fibers comprise uncut fibers.
7. The wet cleaning apparatus (100) according to any one of claims 1 to 6, wherein the projections (160) comprise plied yarns formed by twisting yarns, the capillary paths (164)

being at least partly defined by spaces between the fibers of the twisted yarns; optionally wherein the backing member (154) comprises a woven structure formed by weaving or knitting said plied yarns.

5 8. The wet cleaning apparatus (100) according to any one of claims 1 to 7, wherein the projections (160) comprise uncut twisted microfiber tufts.

9. The wet cleaning apparatus (100) according to any one of claims 1 to 8, wherein at least part of the backing member (154) and the projections (160) are formed from a common
10 fibrous material.

10. The wet cleaning apparatus (100) according to any one of claims 1 to 9, wherein the backing member (154) and the projections (160) each comprise polyester fibers and/or polyamide fibers.

15 11. The wet cleaning apparatus (100) according to any one of claims 1 to 10, wherein the backing member (154) comprises a porous layer (154A) in addition to a layer (154B) comprising the projections-comprising side (158), the back side (156) of the backing member being provided by the porous layer.

20 12. The wet cleaning apparatus (100) according to any one of claims 1 to 11, wherein the backing member (154) comprises a backing fabric; optionally wherein the backing fabric is a woven or knitted backing fabric.

25 13. The wet cleaning apparatus (100) according to any one of claims 1 to 12, comprising a cleaner head (110) in which a dirt inlet structure (112) is defined, the dirt inlet structure being arranged to apply the suction generated by the underpressure generator (102) to the back side (156) of the backing member (154).

30 14. The wet cleaning apparatus (100) according to any one of claims 1 to 13, wherein the underpressure generator (102) is configured to generate a flow through the porous cleaning material (152) that is at most 2000 cm³/minute; and/or wherein the underpressure generator is configured to provide a pressure difference between an inside of the wet cleaning

apparatus and atmospheric pressure for drawing fluid through the porous cleaning material, with the pressure difference being in a range of 3000 Pa to 13500 Pa.

15. Use of a porous cleaning material (152) that includes a backing member (154)
5 comprising a back side (156) and a projections-comprising side (158), the projections-
comprising side comprising projections (160) that project from the backing member so that at
least some of the projections are contactable with a surface to be cleaned (150), the projections
(160) comprising fibers assembled so that movement of the fibers relative to each other, within
each of the projections, is constrained, wherein capillary paths (164) extend from the
10 projections to reach the back side of the backing member, the capillary paths being at least
partly defined by spaces between the fibers whose movement relative to each other is
constrained, and wherein the use comprises arranging an underpressure generator (102) to
apply suction to the back side of the backing member.