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(54) **CLEANING DEVICE FOR CLEANING A SURFACE COMPRISING A BRUSH AND A SQUEEGEE ELEMENT**

(75) Inventors: **Johannes Tseard Van Der Kooi**, Hurdegaryp (NL); **Britt Roumen**, Groningen (NL)

(73) Assignee: **KONINKLIJKE PHILIPS N.V.**, EINDHOVEN (NL)

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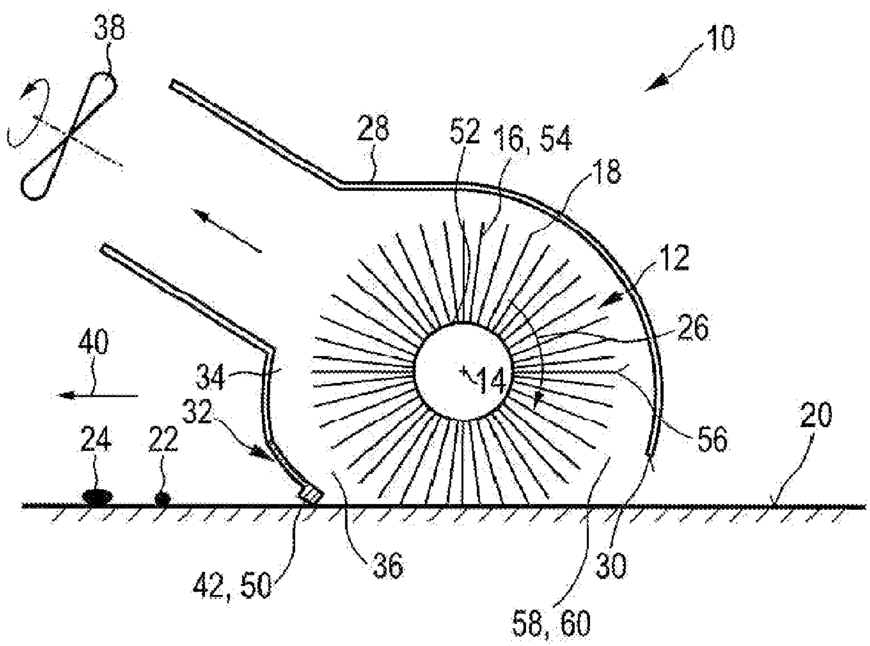
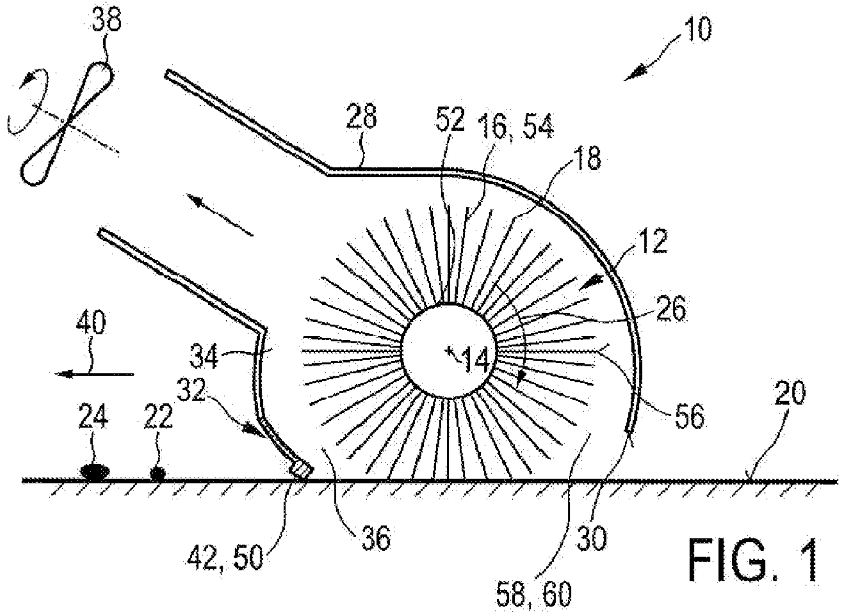
(57) **ABSTRACT**

The present invention relates to a cleaning device for cleaning a surface (**20**), comprising: —a nozzle arrangement (**10**) that comprises i) a brush (**12**) rotatable about a brush axis (**14**), said brush (**12**) being provided with flexible brush elements (**16**) having tip portions (**18**) for contacting the surface to be cleaned (**20**) and picking up dirt particles (**22**) and liquid (**24**) from the surface (**20**) during a pick-up period when the brush elements (**16**) contact the surface (**20**) during the rotation of the brush (**12**), wherein a linear mass density of a plurality of the brush elements (**16**) is, at least at the tip portions (**18**), lower than 150 g per 10 km, and ii) a single squeegee element (**32**) for pushing or wiping dirt particles (**22**) and liquid (**24**) across or off the surface to be cleaned (**20**) during movement of the cleaning device (**100**), said squeegee element (**32**) being spaced apart from the brush (**12**) and extending substantially along a longitudinal direction (**48**) being substantially parallel to the brush axis (**14**), wherein a suction area (**34**) is defined within the nozzle arrangement (**10**) between the squeegee element (**32**) and the brush (**12**), —a drive means for driving the brush (**12**) in rotation, wherein the drive means are adapted to realize a centrifugal acceleration at the tip portions (**18**) which is, in particular during a dirt release period when the brush elements (**16**) are free from contact to the surface (**20**) during rotation of the brush (**12**), at least 3,000 m/s 2, and —a vacuum aggregate (**38**) for generating an under-pressure in the suction area (**34**) for ingesting dirt particles (**22**) and liquid (**24**).




38
10
28
52
16, 54
18
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42, 50
36
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58, 60

FIG. 1

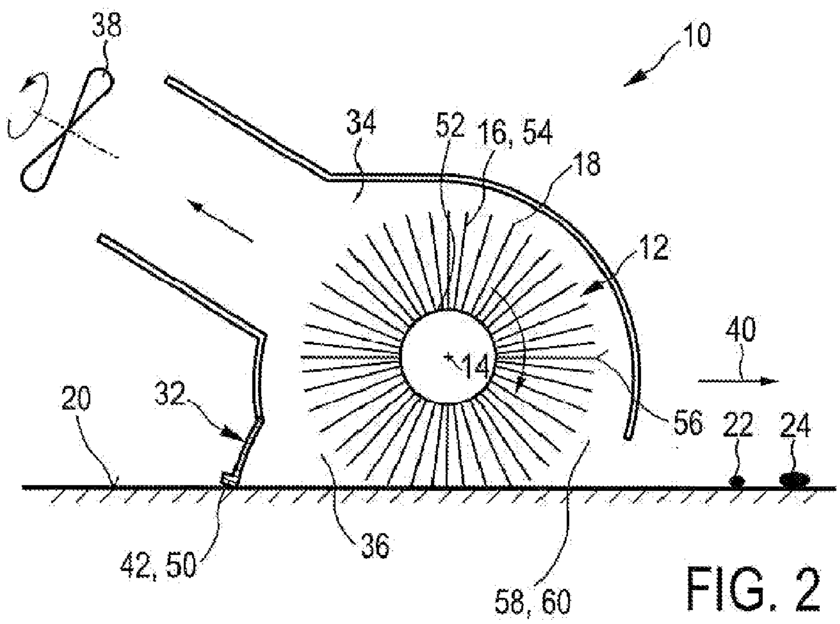
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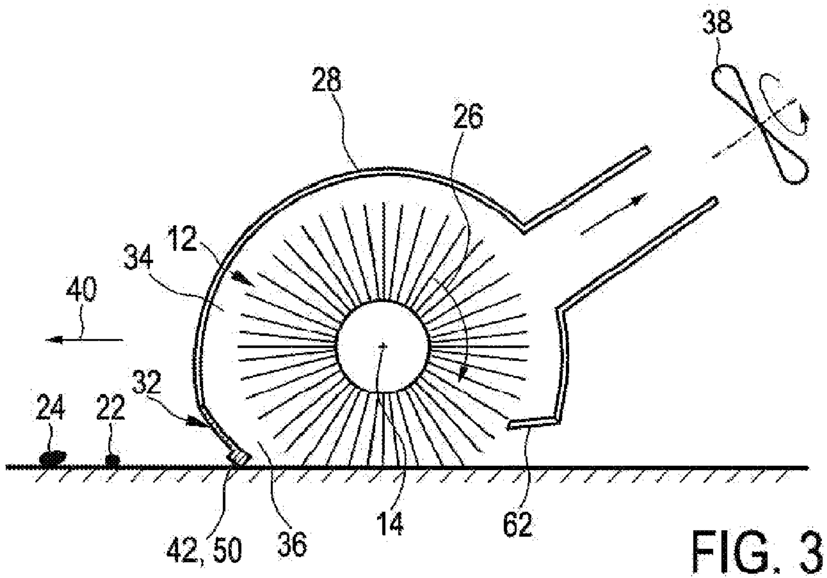
FIG. 2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42, 50
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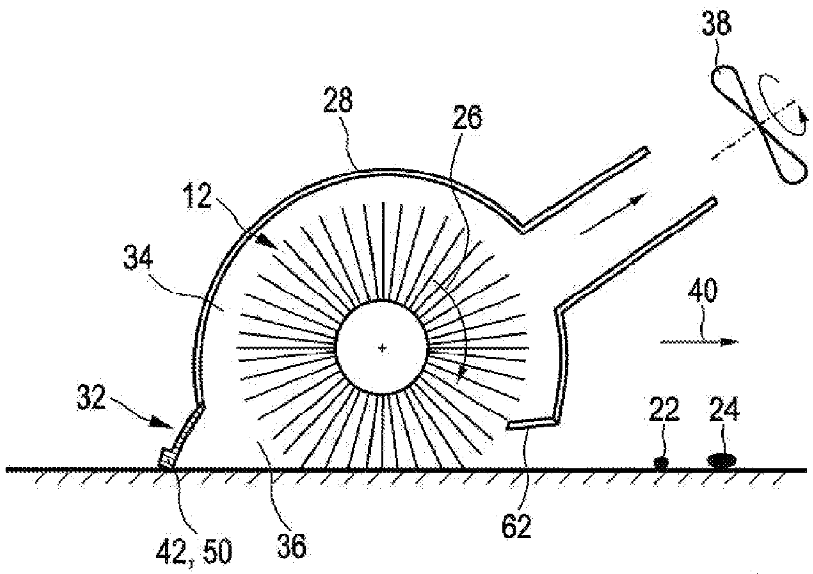
14
62

FIG. 3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42, 50
36
62

FIG. 4

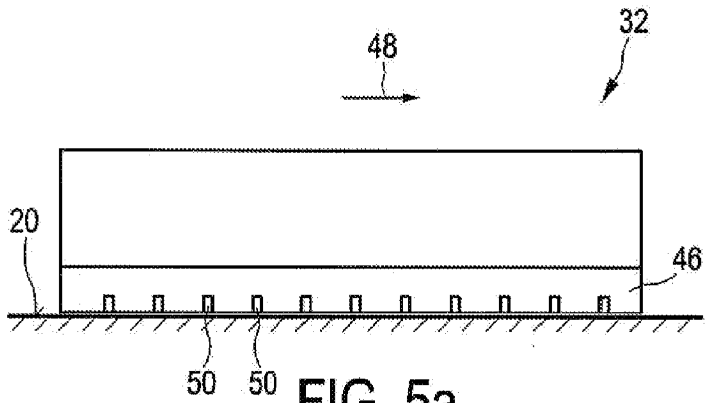


FIG. 5a

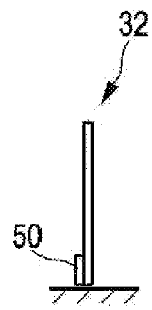


FIG. 5b

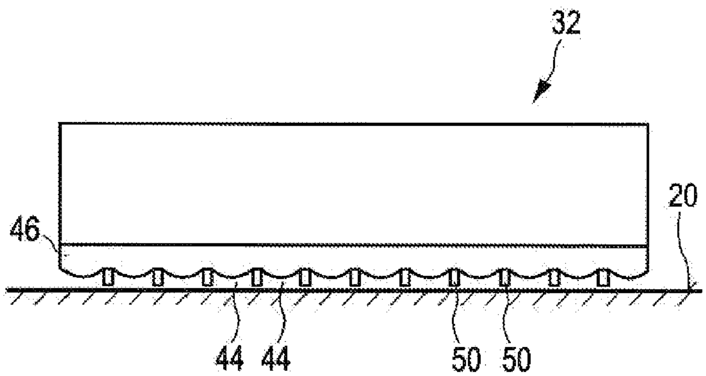


FIG. 6a

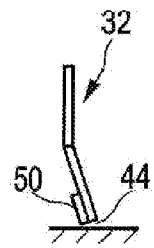
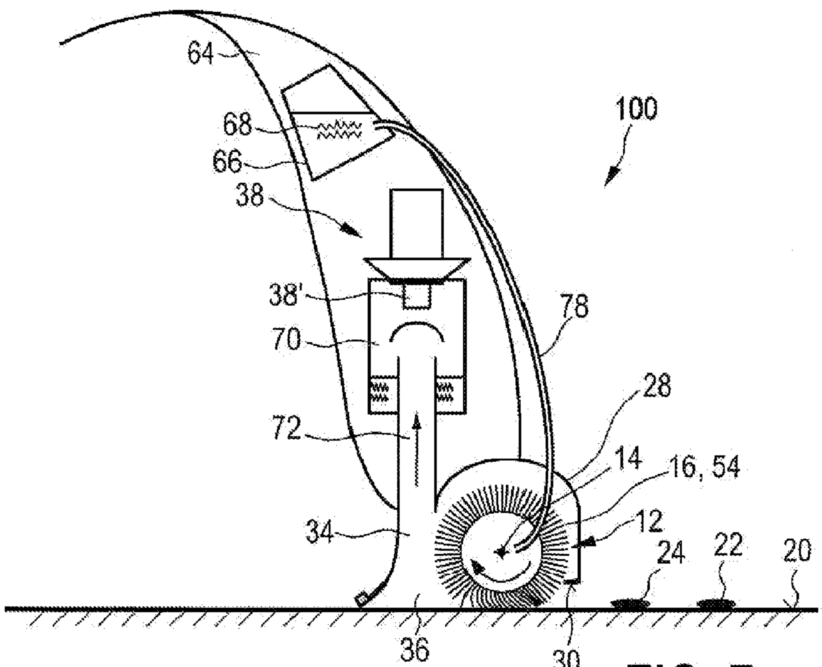


FIG. 6b


64
68
66
38
38'
70
72
34
36
100
78
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14
16, 54
12
24
22
20
30

FIG. 7

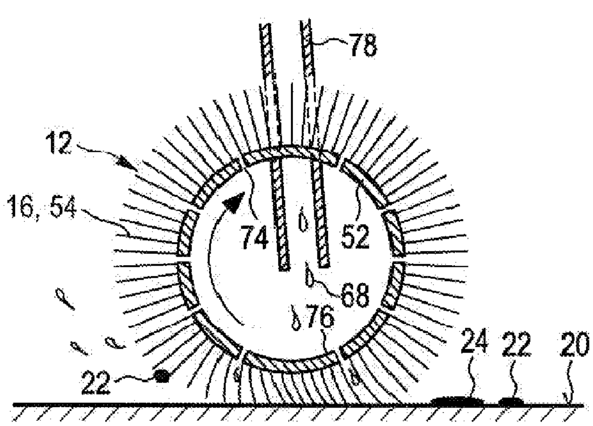
78
12
16, 54
74
52
68
76
22
24
22
20

FIG. 8

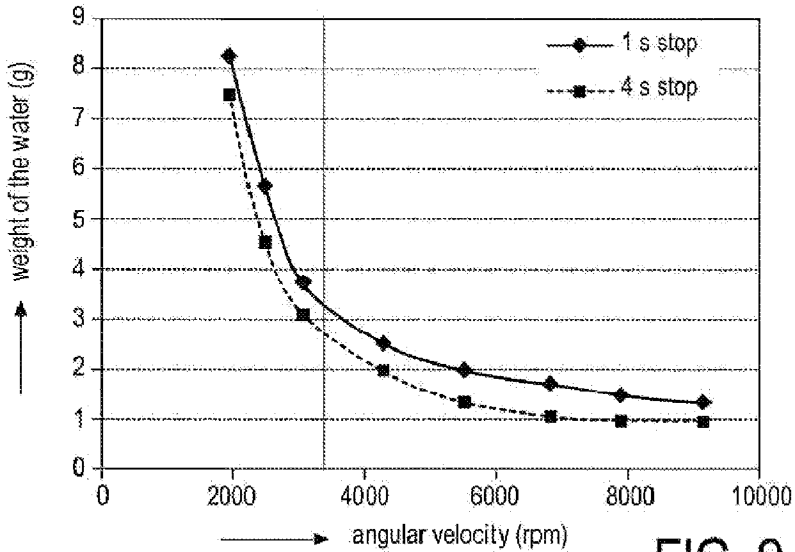
9
8
7
6
5
4
3
2
1
0
weight of the water (g)
1 s stop
4 s stop
0
2000
4000
6000
8000
10000
angular velocity (rpm)

FIG. 9

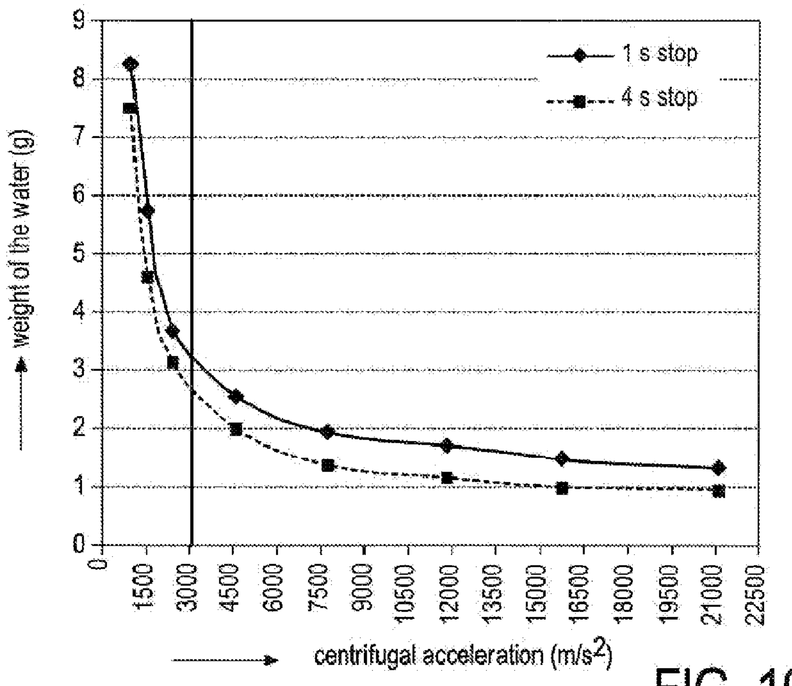
9
8
7
6
5
4
3
2
1
0
weight of the water (g)
1 s stop
4 s stop
0
1500
3000
4500
6000
7500
9000
10500
12000
13500
15000
16500
18000
19500
21000
22500
centrifugal acceleration (m/s2)

FIG. 10

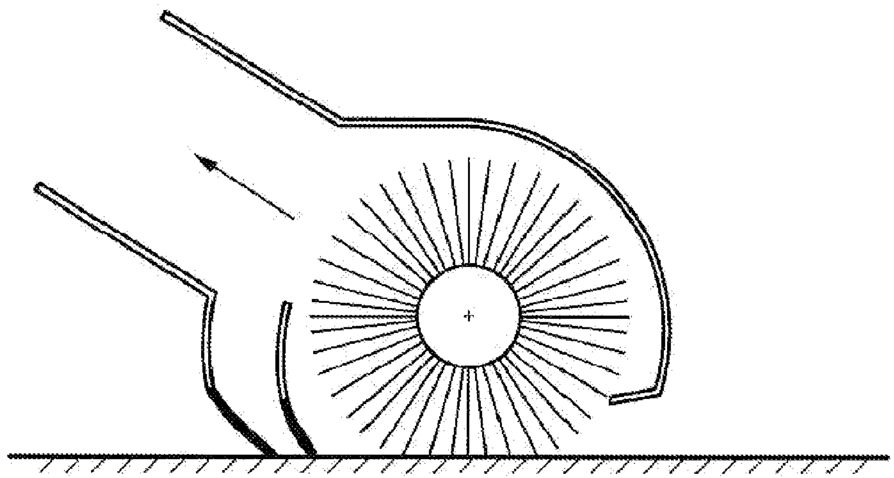

FIG. 11
(state of the art)

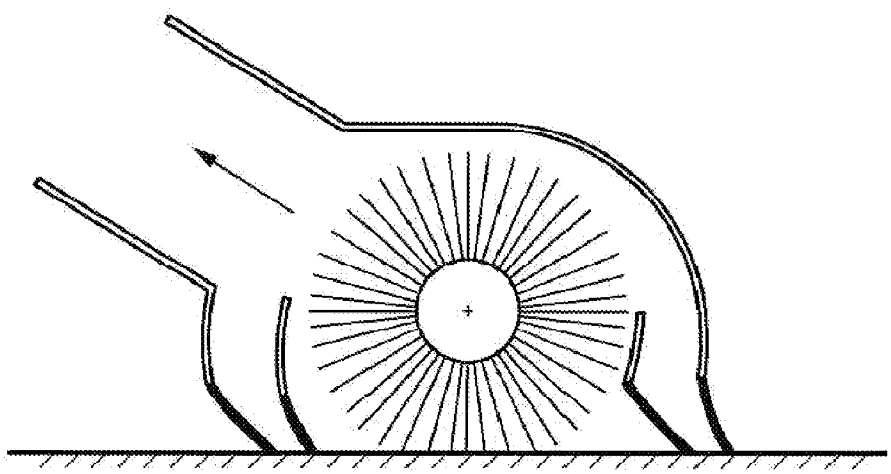

FIG. 12
(state of the art)

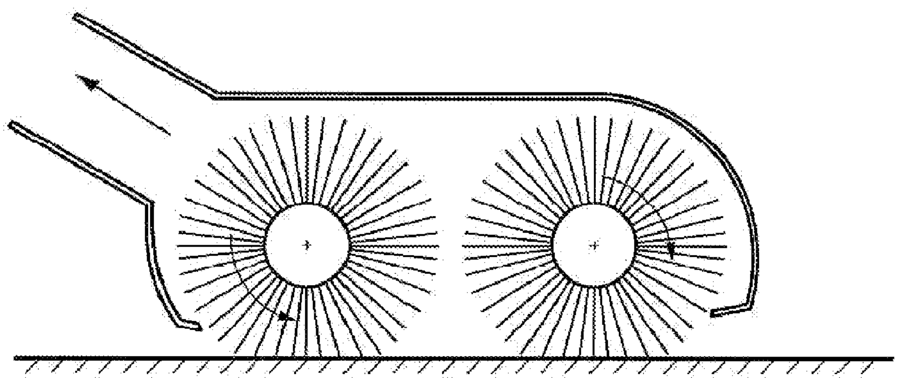

FIG. 13
(state of the art)

CLEANING DEVICE FOR CLEANING A SURFACE COMPRISING A BRUSH AND A SQUEEGEE ELEMENT

FIELD OF THE INVENTION

[0001] The present invention relates to a cleaning device for cleaning a surface. Further, the present invention relates to a nozzle arrangement for such a cleaning device.

BACKGROUND OF THE INVENTION

[0002] Hard floor cleaning these days is done by first vacuuming the floor, followed by mopping it. Vacuuming removes the coarse dirt, while mopping removes the stains. From the state of the art many appliances, especially targeting the professional cleaning sector, are known that claim to vacuum and mop in one go. Appliances for the professional cleaning sector are usually specialized for big areas and perfectly flat floors. They rely on hard brushes and suction power to get water and dirt from the floor. Appliances for home use often use a combination of a hard brush and a squeegee nozzle. Like the appliances for the professional cleaning sector these products use the brush to remove stains from the floor and the squeegee in combination with an under-pressure to lift the dirt from the floor.

[0003] Said squeegee elements are usually realized by a flexible rubber lip that is attached to the bottom of the cleaning device and merely glides over the surface to be cleaned thereby pushing or wiping dirt particles and liquid across or off the surface to be cleaned. An under-pressure, usually generated by a vacuum aggregate, is used to ingest the collected dirt particles and liquid.

[0004] A squeegee device for a vacuum cleaner system is, for example, known from EP 0 576 174 A1. A sweeper that uses an above-mentioned combination of a brush and a squeegee is, for example, known from U.S. Pat. No. 7,665,172 B1. The power floor sweeper described therein comprises a foot assembly with a motor driven primary agitator and a pair of edge agitators coupled to wheels such that manual propulsion of the sweeper rotates the wheels and thereby the edge agitators. The sweeper, however, does not include a vacuum source and is therefore not able to pick-up water from the floor to be cleaned. The performance on drying the floor is thus rather low.

[0005] Another vacuum cleaner that is known from the prior art and also uses a combination of a rotating brush and a squeegee is known from U.S. Pat. No. 4,864,682 A. This vacuum cleaner comprises a self-adjusting wiper strip assembly that automatically adjusts for the type of floor surface on which the vacuum cleaner is being used. The assembly used therein requires a high suction power in order to receive a satisfactory cleaning result. The brush which is used in this vacuum cleaner is an agitator (also denoted as adjutator) with stiff brush hairs to agitate the floor, e.g. a carpet. These stiff hairs show a rather good scrubbing effect, which enable to use the brush particularly for removing stains. However, the performance on drying the floor is rather low, since such an agitator is not able to lift liquid from the floor.

[0006] Vacuum and mop in one go devices known from the prior art often use brush elements that are actively spayed with water or a cleaning rinse in order to improve the removal of stains. Such devices usually use a double squeegee element having two squeegees that are arranged on one side of the brush, as this is exemplarily shown in the attached FIG. **11**. An additional vacuum source generates a suction in a channel between said double squeegee arrangement in order to remove the cleaning water from the floor again.

[0007] However, in order to remove the actively sprayed cleaning water from the floor again these devices always have to be moved in a forward direction in which the brush is, seen in the direction of the device movement, located in front of the double squeegee arrangement. Moving the device in an opposite backward direction would leave the floor wet, since the cleaning water which is dispersed with the brush is not removed from the squeegees in this backward stroke.

[0008] To get a good cleaning result in a forward as well as in a backward stroke of the device known cleaning devices are therefore provided with a double squeegee nozzle at both sides of the brush. Such an arrangement is exemplarily shown in the attached FIG. **12**. Even though such double squeegee arrangements on both sides of the brush show good cleaning results, the nozzle of these devices become fairly bulky. This again results in a non-satisfying, limited work capability. Especially in household appliances where often narrow corners need to be cleaned, such bulky nozzles are, due to their limited liberty of action, disadvantages and uncomfortable to use.

[0009] Besides that, the use of double squeegee arrangements as shown in the attached FIGS. **11** and **12** has several further disadvantages. Due to the constant contact of the squeegees with the floor during the movement of the device, such double squeegees may generate a high scratch load to the floor. Especially when the double squeegee arrangements are used on each side of the brush, this will lead to an increased risk of inducing scratches on the floor. Furthermore, such squeegee arrangements include the disadvantage that they are not open for coarse dirt like e.g. hairs or peanuts, since coarse dirt is often entangled within the squeegees or is pushed away from the squeegees, and is thus not able to enter the suction inlet. Apart from that such double squeegee nozzles are hard to clean and do not have the ability to clean themselves.

[0010] In order to overcome these disadvantages other devices known in the art use two separate brushes that are arranged in parallel to each other (schematically shown in attached FIG. **13**). A cleaning device of this kind is exemplarily known from U.S. Pat. No. 1,694,937. Said document discloses a floor scrubbing machine, which is capable of picking up dirt from a floor by two cylindrical floor brushes disposed parallel and close together. These brushes rotate at high speeds, one running clockwise and the other one counterclockwise. In this way, the adjacent peripheries travelling together with a sufficiently high velocity to project the dirt vertically upwards with a considerable force in the form of a substantially flat jet. A wiper or a squeegee is applied in addition to the brushes in order to dry the floor. Due to the two separate brushes and the additional squeegees the nozzle becomes also according to this solution fairly bulky, which again ends up in a non-satisfying liberty of action for the consumer.

SUMMARY OF THE INVENTION

[0011] It is an object of the present invention to provide an improved cleaning device that shows, compared to the state of the art, an improved cleaning performance and has at the same time a nozzle of small size in order to guarantee a high liberty of action.

[0012] This object is achieved by a cleaning device for cleaning a surface that comprises:

[0013] a nozzle arrangement that comprises

[0014] i) a brush rotatable about a brush axis, said brush being provided with flexible brush elements having tip portions for contacting the surface to be cleaned and picking up dirt particles and liquid from the surface during a pick-up period when the brush elements contact the surface during the rotation of the brush, wherein a linear mass density of a plurality of the brush elements is, at least at the tip portions, lower than 150 g per 10 km, and

[0015] ii) a single squeegee element for pushing or wiping dirt particles and liquid across or off the surface to be cleaned during movement of the cleaning device, said squeegee element being spaced apart from the brush and extending substantially along a longitudinal direction being substantially parallel to the brush axis, wherein a suction area is defined within the nozzle arrangement between the squeegee element and the brush,

[0016] a drive means for driving the brush in rotation, wherein the drive means are adapted to realize a centrifugal acceleration at the tip portions which is, in particular during a dirt release period when the brush elements are free from contact to the surface during rotation of the brush, at least 3,000 m/s^2, and

[0017] a vacuum aggregate for generating an under-pressure in the suction area for ingesting dirt particles and liquid.

[0018] The above-mentioned object is furthermore, according to a second aspect of the present invention, achieved by a corresponding nozzle arrangement for use in a cleaning device as mentioned before.

[0019] Preferred embodiments of the invention are defined in the dependent claims. It shall be understood that the claimed nozzle arrangement has similar and/or identical preferred embodiments as the claimed cleaning device and as defined in the dependent claims.

[0020] The present invention is based on the idea that by choosing a special combination of the density parameters of the brush elements and a realized centrifugal acceleration at the tip portions of the brush elements during their rotation the disadvantages of the above-mentioned double squeegee and double brush cleaning solutions can be overcome by applying only one single squeegee element. In contrast to the cleaning devices known from the prior art the nozzle arrangement of the presented cleaning device comprises only a single squeegee element and preferably only one primary brush. Because of having only one brush and one squeegee element, the nozzle thus becomes less bulky and shows an improved maneuverability.

[0021] The cleaning device, therefore, enables to clean also narrow surfaces in an efficient way. Due to the chosen parameters, i.e. the linear mass density of the flexible brush elements with an upper limit of 150 g per 10 km and a centrifugal acceleration at the tip portions of the brush elements with a lower limit of 3,000 m/s^2, which acceleration is realized by the drive means, it is possible to realize excellent cleaning results, wherein the surface to be cleaned is practically freed of particles and dried in one go.

[0022] In contrast to brushes used according to the prior art, which are only used for stain removal, a soft brush with flexible brush elements as presented here also has the ability to pick up water from the floor. Thus, a second squeegee element is no longer needed. Using the above-mentioned parameters concerning the linear mass density and the centrifugal acceleration of the brush elements has also shown to result in very good stain removing properties. Due to the flexible micro-fiber hairs that are preferably used as brush elements, dirt particles and liquid can be picked-up from the floor when the brush elements/microfiber hairs contact the floor during the rotation of the brush. The ability to also pick-up liquid with a brush is mainly caused by capillary and/or other adhesive forces that occur due to the chosen linear mass density of the brush elements and the occurring high speeds with which the brush is driven. Due to the very thin microfiber hairs the brush is also open for coarse dirt.

[0023] During the brush rotation the brush elements contact the floor with their tip portions and pick-up the dirt particles and the liquid from the floor during a pick-up period in which the said tip portions contact the floor. In the dirt release period, in which the brush elements are inside a nozzle housing and free from contact to the surface the centrifugal acceleration of the tip portions of the brush elements becomes so high that the occurring centrifugal forces that appear to the dirt and liquid particles within the micro fiber hairs become stronger than the adhesive forces with which the dirt and liquid particles are repressed from the brush elements. The dirt and liquid particles are thus automatically released in the dirt release period when the brush elements are during their rotation inside the nozzle housing free from contact to the surface. Besides the centrifugal forces as mentioned, other acceleration forces can be present, particularly acceleration forces which are due to deformation of the flexible brush elements. Such deformations may exemplarily occur when the flexible brush elements contact the floor during rotation or encounter liquid or dirt particles.

[0024] The occurring accelerations at the tip portions of the brush elements cause the dirt particles and liquid droplets to be automatically released from the brush, when the brush elements loose contact from the floor during their rotation. Since not all dirt particles and liquid droplets may be directly ingested by the vacuum aggregate, a small amount of dirt and liquid will be flung back onto the surface in the area where the brush elements loose the contact from the surface. However, this effect of re-spraying the surface is overcome by the squeegee element which collects this re-sprayed liquid and dirt by acting as kind of wiper, so that remaining liquid and dirt may then be ingested due to the applied under-pressure. The squeegee therefore ensures that the remaining liquid and dirt is not leaving the suction area again without being ingested by the vacuum aggregate. It therefore kind of closes the suction area for dirt and liquid on one side of the nozzle housing. Due to the chosen combination of a brush, which is, besides dirt, also able to pick-up liquid, with a single squeegee element for pushing or wiping dirt and liquid across or off the surface to be cleaned, it is thus possible to almost free the surface from dirt particles as well as from liquid. This results in improved cleaning properties and, at the same time, in a size reduction of the nozzle.

[0025] By reducing the number of squeegees to only a single squeegee element, not only the size of the housing can be reduced, making the nozzle less bulky, but also scratching of the floor, which might be caused by the squeegees, can be significantly reduced. Besides that, a single squeegee element is much easier to clean.

[0026] Due to the presented arrangement where the squeegee element is being spaced apart from the brush and extends substantially along a longitudinal direction which is preferably parallel to the brush axis, the brush and the single squeegee together form a suction area. This suction area is an area of under-pressure that is used for ingesting the dirt and liquid particles which have been collected by either the squeegee element or the brush. Said under-pressure is preferably generated by a vacuum aggregate that is in any way connected to the suction area.

[0027] The brush is preferably arranged at one side of the housing of the nozzle, whereas the squeegee element is arranged on another side of the housing, parallel to the brush, so that the brush and the squeegee element appear to be behind each other, when seen in the intended direction of the movement of the device. The squeegee and the brush are thereto arranged on a bottom-side of the nozzle housing, which during use of the device faces the surface to be cleaned, and at least partly protrude from the nozzle housing on this bottom side. When moving the device the squeegee element glides over the surface to be cleaned and thereby pushes or wipes dirt particles and liquid across or off the floor, while the brush, during its rotation, at same time picks-up dirt and liquid particles from the surface. In this way a suction inlet is created in between the brush and the squeegee element, which during use of the cleaning device, faces the surface to be cleaned. This suction inlet opens into the suction area, in which the above-mentioned under-pressure is created.

[0028] Applying this under-pressure the dirt and liquid particles picked-up by the squeegee and the brush are ingested and sucked away from the floor. The brush and the squeegee element are therefore at all times kept clean, so that there is no risk of distributing dirt over the surface to be cleaned. In other words, this results in a kind of self-cleaning of the brush and the squeegee.

[0029] The brush elements may be made of a plastic material wherein polyester and nylon are suitable examples. In any case, the linear mass density of a plurality of the brush elements is, at least at the tip portions, lower than 150 g per 10 km. This ensures that, at least the tip portions, the brush elements are flexible enough to undergo a bending effect and are able to pick-up dirt particles and liquid droplets from the surface to be cleaned.

[0030] Furthermore, the extend of wear and tear of the brush elements appears to be acceptable within this linear mass density range. It is to be noted that the linear mass density as mentioned, i.e. the linear mass density in grams per 10 km, is also denoted as Dtex value.

[0031] The experiments carried out by the applicant have proven that a Dtex value in the above-mentioned range appears to be technically possible and that good cleaning results can be obtained therewith. However, it has shown that cleaning results can be further improved by applying brush elements with an even lower upper limit of the Dtex value, such as a Dtex value of 125, 50, 20 or even 5 (in g/km).

[0032] With values in the latter order, it is ensured that cleaning results are excellent, water pick-up is optimal, wear is minimal and power consumption and heat generation on the surface to be cleaned are sufficiently low. It is also to be noted that the minimum value of 3,000 m/s^2 in respect of the acceleration which is prevailing at the tip portion at least during a dirt release period when the brush elements are free from contact to the surface during the rotation of the brush, is also supported by results of experiments which have been performed in the context of the present invention. These experiments have shown that cleaning performances of the device according to the present invention improve with an increase of the angular velocity of the brush, which implies an increase of the acceleration at the tip portions of the brush elements during rotation.

[0033] According to an embodiment of the present invention, the drive means are adapted to realize a centrifugal acceleration at the tip portions of at least 7,000 m/s^2 and more preferably a centrifugal acceleration of 12,000 m/s^2. When the drive means are adapted to realize centrifugal accelerations of the brush elements in the above-mentioned ranges, it is likely for the liquid droplets adhering to the brush elements to be expelled as a mist of droplets during a phase in which the brush elements are free from contact to the surface to be cleaned.

[0034] The combination of the linear mass density of the brush elements and the acceleration at the tips of the brush elements is a combination which yields optimal cleaning performance of the rotatable brush, wherein practically all dirt particles and spilled liquid encountered by the brush are picked-up by the brush elements and expelled at a position inside the nozzle housing. Naturally, effective pick-up of particles and liquid is advantageous when it comes to cleaning, wherein both a dirt removal and a drying process are realized at the same time. An effective subsequent expelling process is advantageous in view of the fact that a re-introduction of dirt and/or liquid to the surface to be cleaned is avoided. With the brush according to the present invention in combination with the above-mentioned squeegee element and the operating parameters which are realized by the drive means, it is possible to catch particles into droplets making the particles effectively larger, which enables for an easier filtering.

[0035] The combination of the above-mentioned parameters concerning the linear mass density and the realized centrifugal acceleration at the tip portions of the brush elements is not found on the basis of knowledge of the prior art. The prior art is not even concerned with the possibility of having an autonomous, optimal functioning of only one rotatable brush which is used for cleaning a surface and is also able to lift dirt and liquid, and thus being able to reduce the number of required squeegee elements by still realizing the same or even improving the cleaning properties.

[0036] When at least one rotatable brush is provided and operated as described by the present invention, it is ensured that liquid can be effectively removed from a surface to be cleaned, and that the same goes for dirt particles, which may be caught by the brush elements of the brush and/or be taken along with liquid. The cleaning process which is performed on one side of the nozzle housing by a rotatable brush brushing the surface and on the other side by a squeegee element constantly contacting the surface and thereby wiping the surface, is especially suitable to be applied on hard surfaces. Examples of hard surfaces are hard floors, windows, walls, table tops, plates of hard material, sidewalls, etc.

[0037] According to a preferred embodiment of the present invention, the under-pressure generated by the vacuum aggregate is in a range of 3 to 70 mbar, preferably in a range of 4 to 50 mbar, most preferably in a range of 5 to 30 mbar. State of the art vacuum cleaners need to apply higher under-pressures in order to receive acceptable cleaning results. However, due to the above mentioned properties of the brush, very good cleaning results may already be realized in the above-mentioned pressure ranges. Thus, also smaller vacuum aggregates may be used. This increases the freedom in the selection of the vacuum pump.

[0038] According to a further preferred embodiment of the present invention, the brush axis and/or the longitudinal direction of the squeegee element is arranged transverse, preferably perpendicular to the intended direction of movement of the cleaning device. During the movement of the device the brush and the squeegee are therefore able to encounter dirt and liquid particles along their complete longitudinal sides. By arranging the brush axis and the squeegee element parallel to each other, a perfect collaboration of the brush and the squeegee element is established for picking-up dirt and liquid particles from the floor. A suction area of under-pressure is defined in between the squeegee element and the brush, which also substantially extends parallel to the brush axis.

[0039] In a further preferred embodiment of the present invention, said squeegee element comprises switching means for switching the squeegee element to a closed position, in which the squeegee element is adapted to push or wipe dirt particles and liquid across or off the surface to be cleaned, when the cleaning device is moved on the surface in a forward direction in which the squeegee element is, seen in the direction of movement of the cleaning device, located behind the brush, and for switching the squeegee element to an open position in which dirt particles and liquid from the floor can enter the suction area through an opening between the squeegee element and the surface to be cleaned, when the cleaning device is moved on the surface in a backward direction in which the squeegee element is, seen in the direction of movement of the cleaning device, located in front of the brush.

[0040] The ability to switch the squeegee element from an open to a close position depending on the movement direction of the cleaning device enables a good cleaning result in a forward as well as in a backward stroke of the nozzle. The open configuration is in order to allow the dirt to enter when the squeegee approaches dirt and liquid on the floor before the brush. And in the closed position the squeegee closes the gap to the floor, or in other words wipes or glides over the floor, when the brush approaches the dirt or liquid on the floor before the squeegee.

[0041] In order to guarantee this switching mode the squeegee element is preferably realized by a flexible rubber lip that, depending on the movement direction of the cleaning device, is adapted to flex about the longitudinal direction of said rubber lip. This rubber lip preferably comprises at least one stud which is arranged near the lower end of the rubber lip, where the rubber lip is intended to touch the surface to be cleaned. Said at least one stud is being adapted to at least partly lift the rubber lip from the surface, when the cleaning device is moved on the surface in a backward direction, in which the rubber lip is, seen in the direction of movement of the cleaning device, located in front of the brush. Due to this lifting of the rubber lip in a backward stroke of the nozzle, in which the squeegee element approaches dirt on the floor before the brush, coarse dirt may enter the nozzle also in a backward stroke through the opening created between the squeegee element and the surface to be cleaned. When moving the cleaning device on the surface in the opposite, forward direction said stud is free from contact to the floor, leaving the rubber lip freely glide over the floor in order to pick-up dirt and water particles from said floor.

[0042] According to a further embodiment, the nozzle arrangement comprises a housing that at least partly surrounds the brush, wherein the squeegee element is attached to said housing. In this arrangement the brush is at least partly surrounded by the nozzle housing and protrudes at least partially from a bottom side of said nozzle housing, which, during use of the device, faces the surface to be cleaned, so that the brush elements contact said surface outside of the housing during the rotation of the brush. The squeegee element is preferably also attached to said bottom side of the housing in order to contact the surface to be cleaned when the nozzle is moved over said surface. During the use of the device the suction area, in which the above-mentioned under-pressure is applied, is defined in the space between the brush, said housing, the squeegee element and the surface to be cleaned, wherein the suction inlet is arranged between the squeegee element and the brush.

[0043] According to a further preferred embodiment, the cleaning device comprises positioning means for positioning the brush axis at a distance to the surface to be cleaned that is smaller than the radius of the brush with fully outstretched brush elements to realize an indentation of the brush part contacting the surface during operation, which indentation is in a range from 2% to 12% of the brush diameter.

[0044] As a result, the brush elements are bent when the brush is in contact with the surface. Hence, as soon as the brush elements come into contact with a surface during rotation of the brush, the appearance of the brush elements changes from an outstretched appearance to a bent appearance, and as soon as the brush elements loose contact with the surface during rotation of the brush, the appearance of the brush elements changes from a bent appearance to an outstretched appearance.

[0045] A practical range for an indentation of the brush is arranged from 2% to 12% of a diameter of the brush relating to a fully outstretched condition of the brush elements. In practical situations, the diameter of the brush as mentioned can be determined by performing an appropriate measurement, for example, by using a high-speed camera or a stroboscope which is operated at the frequency of a rotation of the brush.

[0046] A deformation of the brush elements, or, to say it more accurately, a speed at which deformation can take place, is also influenced by the linear mass density of the brush elements. Furthermore, the linear mass density of the brush elements influences the power which is needed for rotating the brush. When the linear mass density of the brush elements is relatively low, the flexibility is relatively high, and the power needed for causing the brush elements to bend when they come into contact with the surface to be cleaned is relatively low. This also means that a friction power which is generated between the brush elements and the surface is low, whereby heating of the surface and associated damage of the surface are prevented. Other advantageous effects of a relatively low linear mass density of the brush elements are a relatively high resistance to wear, a relatively small chance of damage by sharp objects or the like, and the capability to follow the surface in such a way that contact is maintained even when a substantial unevenness in the surface is encountered.

[0047] When brush elements come into contact with a dirt particle or liquid, or, in case an indentation of the brush with respect to the surface is set, the brush elements are bent. As soon as the brush elements with the dirt particles and liquid adhering thereto loose contact with the surface, the brush elements are straightened out, wherein especially the tip portions of the brush elements are moved with a relatively high acceleration. As a result the centrifugal acceleration at the top portions of the brush elements is increased. Hence, the liquid droplets and dirt particles adhering to the brush elements are launched from the brush elements, as it were, as the acceleration forces are higher than the adhesive forces, as this has been mentioned according to the embodiment above. The values of the acceleration forces are determined by various factors, including the deformation and the linear mass density as mentioned, but also by the speed at which the brush is driven.

[0048] A factor which may play an additional role in the cleaning function of the rotatable brush is a packing density of the brush elements. When the packing density is large enough, capillary effects may occur between the brush elements, which enhance fast removal of liquid from the surface to be cleaned. According to an embodiment of the present invention the packing density of the brush elements is at least 30 tufts of brush elements per cm^2, wherein a number of brush elements per tuft is at least 500.

[0049] Arranging the brush elements in tufts forms additional capillary channels, thereby increasing the capillary forces of the brush for picking-up dirt particles and liquid droplets from the surface to be cleaned.

[0050] According to a further preferred embodiment, the linear mass density of a majority of a total number of the brush elements is, at least at the tip portions, lower than 20 g per 10 km. An important advantage of such a low Dtex value is that wear and tear of the brush elements are minimal. In this case the brush elements can be classified as very soft and flexible, contrary to many situations known from the art.

[0051] In order to realize the above-mentioned centrifugal accelerations at the tips of the brush elements the drive means are, according to an embodiment of the present invention, adapted to realize an angular velocity of the brush which is in a range of 3,000 to 15,000 revolutions per minute, more preferably in a range of 5,000 to 8,000 revolutions per minute, during operation of the device. Experiments of the applicant have shown that optimal cleaning results can be obtained, when the brush is driven at an angular velocity which is at least 6,000 revolutions per minute.

[0052] However, the desired centrifugal accelerations at the tip portions of the brush elements do not only depend on the angular velocity, respectively on the frequency of the brush, but also on the radius, respectively on the diameter of the brush. It is therefore, according to a further embodiment of the invention, preferred that the brush has a diameter which is in a range of 10 to 100 mm, more preferably in a range of 20 to 80 mm, most preferably in range of 35 to 50 mm, when the brush elements are in a fully outstretched condition, and wherein the length of the brush elements is in a range of 1 to 20 mm, preferably in a range of 8 to 12 mm, when the brush elements are in a fully outstretched condition.

[0053] As it has been mentioned above, the presented cleaning device has the ability to realize extremely good cleaning results. These cleaning results can be even improved by actively wetting the surface to be cleaned. This is especially advantageous in case of stain removal. The liquid used in the process of enhancing adherence of dirt particles to the brush elements may be provided in various ways. In a first place, the rotatable brush and the flexible brush elements may be wetted by a liquid which is present on the surface to be cleaned. An example of such a liquid is water, or a mixture of water and soap. Alternatively, a liquid may be provided to the flexible brush elements by actively supplying the cleansing liquid to the brush, for example, by oozing the liquid onto the brush, or by injecting the liquid into a hollow core element of the brush.

[0054] According to an embodiment, it is therefore preferred that the cleaning device comprises means for supplying a liquid to the brush at a rate which is lower than 6 ml per minute per cm of a width of the brush in which the brush axis is extending. It appears that it is not necessary for the supply of liquid to take place at a higher rate, and that the above-mentioned rate suffices for the liquid to fulfill a function as a carrying/transporting means for dirt particles. Thus, the ability of removing stains from the surface to be cleaned can be significantly improved. An advantage of only using a little liquid is that it is possible to treat delicate surfaces, even surfaces which are indicated as being sensitive to a liquid such as water. Furthermore, at a given size of a reservoir containing the liquid to be supplied to the brush, an autonomy time is longer, i.e. it takes more time before the reservoir is empty and needs to be filled again.

[0055] It has to be noted that, instead of using an intentionally chosen and actively supplied liquid, it is also possible to use a spilled liquid, i.e. a liquid which is to be removed from the surface to be cleaned. Examples are spilled coffee, milk, tea, or the like. This is possible in view of the fact that the brush elements, as mentioned before, are capable of removing the liquid from the surface to be cleaned, and that the liquid can be removed from the brush elements under the influence of centrifugal forces as described in the foregoing. The above-mentioned effect of re-spraying the surface in the area between the brush and the squeegee is overcome by the squeegee element which collects this re-sprayed liquid and dirt by acting as kind of wiper, so that remaining liquid and dirt may then be ingested due to the applied under-pressure. The squeegee thus ensures that the remaining liquid and dirt is not leaving the suction area again without being ingested by the vacuum aggregate. It therefore kind of closes the suction area for dirt and liquid on one side of the nozzle housing. The combination of the selected brush with the squeegee thus results in a very good cleaning and drying effect.

[0056] According to a further preferred embodiment, the cleaning device further comprises means for generating an air-flow on a brush side facing away from the squeegee element, in an area where the brush contacts the surface to be cleaned during operation of the device. Said air flow mainly has the function to counteract the air flow which is produced during the rotation of the brush. Due to the high speeds with which the brush is driven turbulent air streams may be generated outside the nozzle housing which could force dirt particles and liquid droplets present on the surface to blow away from the area where the brush elements, during rotation, first contact the floor.

[0057] In order to avoid such a disadvantageous effect, means for generating an air flow in an area where the brush contacts the surface to be cleaned may be applied, such that the air flow caused by the brushes is compensated. The generated counter-air flow is thereto preferably inwardly directed to generate a suction effect which forces the dirt particles and the liquid droplets to either directly enter the nozzle in front of the brush or to be encountered by the brush and then picked-up by the brush as explained above. A possibility to implement such an air flow generation is to arrange a small opening between the nozzle housing and the brush at a front side of the brush, where the brush elements leave the nozzle housing during rotation. In this way a second suction inlet is created at the front of the nozzle.

[0058] According to a further embodiment of the present invention, the cleaning device comprises a deflector for contacting the brush at a location, seen in direction of rotation, before the location where the brush contacts the surface to be cleaned during rotation. In this way the brush elements are pressed together by the deflector, whereby air, which is during the operation of the device always present in the space between the brush elements, will be pushed out of said space. In the area between the deflector and the surface to be cleaned, the brush elements will be straightened out again and moved apart from each other in order to increase the area between the brush elements. This abrupt increase of the space between the brush elements generates an additional under-pressure in the area where the brush elements first contact the surface to be cleaned. The additional under-pressure generates an additional suction effect with which air and thereby also dirt and liquid particles are sucked into the brush. Since the air is sucked into the brush close to the position where the brush is pressed together by the surface to be cleaned, the above-mentioned, unwanted turbulent air stream, which is caused by the rotation of the brush and its contact with the surface to be cleaned, is efficiently compensated for.

[0059] The deflector furthermore prevents droplets of water or cleaning liquid from falling back on the already cleaned surface. In an optimal case the deflector is arranged to sufficiently contact the brush in order to being able to guarantee the above-mentioned functions. In an implementation the deflector can, for example, be a simple part of the nozzle housing that protrudes towards the inside of the housing and thereby contacts the brush elements during the rotation of the brush. The deflector itself may either be realized by a stiff part of the nozzle housing or by a flexible element which is attached to the nozzle housing and is able to at least partly flex when it comes into contact with the brush elements.

[0060] According to a further preferred embodiment, the brush is a spiraled brush having tufts arranged on the periphery of the brush in a spiral-like pattern. Such a spiraled configuration of the tufts significantly reduces the suction power needed. In general, in this context, it is advantageous if the tufts are arranged in rows with intermediate spacing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0061] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter. In the following drawings

[0062] FIG. **1** shows a schematic cross-section of a first embodiment of a nozzle arrangement of a cleaning device according to the present invention, in a first working position;

[0063] FIG. **2** shows a schematic cross-section of the first embodiment of the nozzle arrangement shown in FIG. **1** in a second working position;

[0064] FIG. **3** shows a schematic cross-section of a second embodiment of the nozzle arrangement of the cleaning device according to the present invention, in a first working position;

[0065] FIG. **4** shows a schematic cross-section of the second embodiment of the nozzle arrangement shown in FIG. **3** in a second working position;

[0066] FIG. **5** shows a schematic top view (FIG. **5***a*) and a schematic cross-section (FIG. **5***b*) of a squeegee element of the cleaning device according to the present invention in a first working position;

[0067] FIG. **6** shows a schematic top view (FIG. **6***a*) and a schematic cross-section (FIG. **6***b*) of the squeegee element shown in FIG. **5** in a second working position;

[0068] FIG. **7** shows a schematic cross-section of the cleaning device according to the present invention in its entirety;

[0069] FIG. **8** shows a schematic cross-section of an embodiment of a brush of the cleaning device;

[0070] FIG. **9** shows a graph which serves for illustrating a relation between an angular velocity of a brush and a self-cleaning capacity of said brush;

[0071] FIG. **10** shows a graph which serves for illustrating a relation between a centrifugal acceleration of a brush and a self-cleaning capacity of said brush;

[0072] FIG. **11** shows a schematic cross-section of a first example of a nozzle arrangement according to the state of the art;

[0073] FIG. **12** shows a schematic cross-section of a second example of a nozzle arrangement according to the state of the art; and

[0074] FIG. **13** shows a schematic cross-section of a third example of a nozzle arrangement according to the state of the art.

DETAILED DESCRIPTION OF EMBODIMENTS

[0075] FIGS. **1** and **2** show a schematic cross-section of a first embodiment of a nozzle arrangement **10** of a cleaning device **100** according to the present invention. In FIG. **1** the nozzle arrangement **10** is shown in a first working position, whereas in FIG. **2** the nozzle arrangement **10** is shown in a second working position. The nozzle arrangement **10** comprises a brush **12** that is rotatable about a brush axis **14**. Said brush **12** is provided with flexible brush elements **16** which are preferably realized by thin microfiber hairs. The flexible brush elements **16** comprise tip portions **18** which are adapted to contact a surface to be cleaned **20** during the rotation of the brush **12** and to pick-up dirt particles **22** and liquid **24** from said surface **20** during a pick-up period when the brush elements **16** contact the surface **20**.

[0076] A linear mass density of a plurality, preferably of a majority of the brush elements **16** is, at least at their tip portions **18**, chosen to be lower than 150 g/10 km. Further, the nozzle arrangement **10** comprises a drive means, e.g. a motor (not shown), for driving the brush **12** in a predetermined direction of rotation **26**. Said drive means are adapted to realize a centrifugal acceleration at the tip portions **18** of the brush elements **16** which is, in particular during a dirt release period when the brush elements **16** are free from contact to the surface **20** during the rotation of the brush **12**, at least 3,000 m/s^2.

[0077] The brush **12** is at least partly surrounded by a nozzle housing **28**. The arrangement of the brush **12** within the nozzle housing **28** is preferably chosen such that the brush **12** at least partially protrudes from a bottom side **30** of the nozzle housing **28**, which, during use of the device **100**, faces the surface to be cleaned **20**.

[0078] Also attached to said bottom side **30** of the nozzle housing **28** is a squeegee element **32**. This squeegee element **32** is arranged such that it contacts the surface to be cleaned **20** during the use of the device **100**. The squeegee **32** is used as a kind of wiping element for pushing or wiping dirt particles **22** and liquids **24** across or off the surface **20** when the cleaning device **100** is moved. Said squeegee **32** is preferably spaced apart from the brush **12** and extends substantially parallel to the brush axis **14**. The nozzle housing **28**, the squeegee **32** and the brush **12** together define a suction area **34** which is located within the nozzle housing **28**. It is to be noted that the suction area **34**, in the meaning of the present invention, not only denotes the area between the brush **12**, the squeegee **32** and the nozzle housing **28**, but also denotes the space between the brush elements **16** for the time during the rotation of the brush **12** in which the brush elements **16** are inside the nozzle housing, as well as it denotes an area that is defined between the squeegee **32** and the brush **12**. The latter area will be in the following also denoted as suction inlet **36** which opens into the suction area **34**.

[0079] By means of a vacuum aggregate **38**, which is in these figures only shown in a schematic way, an under-pressure is generated in the suction area for ingesting dirt particles **22** and liquid **24** that have been encountered and collected by the brush **12** and the squeegee **32**. According to the present invention said under-pressure preferably ranges between 3 and 70 mbar, more preferably between 4 and 50 mbar, most preferably between 5 and 30 mbar. This under-pressure is, compared to regular vacuum cleaners which apply an under-pressure of around 70 mbar, quite low. However, due to the above mentioned properties of the brush **12**, very good cleaning results may already be realized in the above-mentioned pressure ranges. Thus, also smaller vacuum aggregates **38** may be used. This increases the freedom in the selection of the vacuum pump.

[0080] The main gist of the present invention is that by applying the above-mentioned parameters concerning the linear mass density of the brush elements **16** and by realizing a centrifugal acceleration at the tip portions **18** of the brush elements **16** in the above-mentioned range, very good cleaning results and stain removal properties can be achieved by equipping the nozzle **10** with only a single brush **12** and a single squeegee element **32**.

[0081] In contrast to nozzle arrangements known from the prior art, which need to be equipped with at least two squeegees, one at each side of the brush, or which need to be equipped with two brushes that rotate counterclockwise, in order to receive good cleaning results, the presented solution results in a very space-saving nozzle size. The very good cleaning properties that can be achieved with the presented solution mainly rely on the brush **12**, which is due to the above-mentioned operating parameters, in contrast to hard brushes used in prior art solutions, not only able to pick-up dirt particles **22** from the surface to be cleaned **20**, but also to pick-up liquid **24** from the surface to be cleaned **20**.

[0082] Due to the ability of the brush **12** to also pick-up water **24** a double squeegee solution as this is exemplarily shown in FIGS. **11** and **12** is no longer necessary. This mainly relies on the fact that water is not only picked-up from the floor due to the generated under-pressure, but also actively lifted from the floor by means of the brush **12**. Even if the nozzle is moved across the surface in a backward stroke as shown in FIG. **1** water **24** and dirt particles **22** that remain on the surface **20** after passing the squeegee **32** and the suction inlet **36**, i.e. water and dirt which were not directly ingested from the surface **20** by the under-pressure applied in the suction area **34** at the suction inlet **36**, is then encountered by the brush **12** and lifted thereby. A backward stroke in this meaning denotes a movement of the nozzle arrangement **10** in an intended movement direction **40**, in which the squeegee element **32** encounters dirt and liquid particles **22**, **24** present on the surface **20** before they are encountered by the brush **12**. This situation is exemplarily shown in FIG. **1**.

[0083] In case the brush **12** is actively sprayed with water, which is in practice often done to improve the removal of stains in the surface **20**, such a backward stroke would leave behind the cleaning liquid on the surface if the brush **12** was not able to also pick-up the sprayed water again. In this case an additional squeegee would have to be used in order to guarantee the water removal from the floor **20**. However, this is due to the presented properties of the brush **12**, the speed with which the brush **12** is driven and the combination with the squeegee **32** not necessary according to the present invention.

[0084] In order to guarantee a good cleaning result in the backward stroke (shown in FIG. **1**) as well as in a forward stroke (shown in FIG. **2**) the squeegee element **32** preferably comprises switching means **42** for switching squeegee **32** from an open to a closed position and vice versa, depending on the direction of movement **40** of the nozzle **10** with respect to the surface **20**. If the nozzle is moved in a forward stroke (shown in FIG. **2**) where the squeegee element **32** is, seen in the direction of movement **40** of the cleaning device **100**, located behind the brush, the squeegee is arranged in a closed position. In this closed position the squeegee **32** is adapted to push or wipe dirt particles **22** and liquid **24** across or off the surface **20** by more or less gliding over the surface **20**. In such a forward stroke the squeegee **32** then acts as a kind of wiper that collects the remaining water from the surface **20**, which has not been lifted or has been sprayed back from the brush **12** to the surface **20**. The remaining water which is collected by the squeegee **32** can then be ingested by means of the applied under-pressure within the suction area **34**.

[0085] On the other hand, the squeegee **32** is arranged in its open position when the nozzle **10** is moved in a backward stroke (shown in FIG. **1**), in which the squeegee **32** is, seen in the direction of movement **40**, located in front of the brush **12**, so that it would encounter the dirt particles **22** and the liquid **24** on the surface **20** before they would be encountered by the brush **12**. In this backward stroke the switching elements **42** switch the squeegee **32** to its open position, wherein dirt particles and liquid from the surface **20** can enter the suction area **34** through an opening in between the squeegee **32** and the surface to be cleaned **20**. In this way, dirt particles **22** and liquid **24** are also able to enter the suction area **34** at the position of the suction inlet **36** and encounter the brush **12** with which they are picked-up from the surface **20**.

[0086] If the squeegee **32** would not be switched to said open position only very small dirt particles **22** would be able to reach the suction inlet **36**, while most of the dirt and liquid would be entangled by the squeegee **32** and pushed across the surface **20** without being able to enter the suction area **34**. This would of course result in a poor cleaning and drying effect.

[0087] In order to guarantee this direction-dependent switching of the squeegee element **32**, the squeegee **32** preferably comprises a flexible rubber lip **46** that, depending on the movement direction **40** of the cleaning device **100**, is adapted to flex about a longitudinal direction of said rubber lip **46**. An enlarged schematic view of the squeegee **32** is shown in FIGS. **5** and **6**. FIG. **5** shows the squeegee **32** in its closed position, whereas FIG. **6** shows a situation of the squeegee **32** in its open position.

[0088] Studs **50** that are arranged near the lower end of the rubber lip **46** where the squeegee **32** is intended to touch the surface **20**, are adapted to at least partly lift the rubber lip **46** from the surface **20**, when the cleaning device is moved on the surface **20** in a backward direction **40** (as shown in FIG. **1**), in which the rubber lip is, seen in the direction of movement **40** located in front of the brush **12**. In this case the rubber lip **46** is lifted, which is mainly due to the natural friction which occurs between the surface **20** and the studs **50**, which act as a kind of stopper that decelerates the rubber lip **46** and forces it to flip over the studs **50**. The squeegee **32** is thereby forced to glide on the studs **50**, wherein the rubber lip is lifted by the studs and openings **44** occur in the space between the rubber lip **46** and the surface **20** (see FIGS. **6***a* and *b*).

[0089] FIGS. **3** and **4**, which show a second embodiment of the nozzle arrangement **10**, illustrate that the positions of the squeegee **32** and the brush **12** can be, compared to the first embodiment (shown in FIGS. **1** and **2**), interchanged without leaving the scope of the present invention. The squeegee **32** is in this case, with respect to the brush axis **14**, arranged at the other side of the nozzle housing **28**. In this case, the squeegee element **32** of course has to be in an open position when the nozzle **10** is moved in a forward stroke as shown in FIG. **3**, where the nozzle is moved in a direction **40** in which the squeegee **32** is, seen in the direction of movement **40**, located in front of the brush **12**. Otherwise, the liquid **24** and dirt particles **22** would again not be able to enter the suction area **34**, respectively the suction inlet **36**.

[0090] On the other hand, the squeegee **32** needs to be in its closed position when the nozzle is according to this embodiment moved in a backward stroke as shown in FIG. **4**, where the brush **12** is, seen in movement direction **40**, located in front of the squeegee **32** and encounters the dirt and liquid particles **22**, **24** first. The squeegee **32** in this case again acts as a wiper that glides over the surface **20** and collects the remaining dirt and liquid particles **22**, **24** on the surface **20**.

[0091] By comparing the first embodiment shown in FIGS. **1** and **2** with the second embodiment shown in FIGS. **3** and **4** it is to be noted that the rest of the arrangement, i.e. the properties of the brush as well as the properties of the nozzle housing **28** remain the same. Even the direction of rotation **26** of the brush **12** needs to remain the same, since the direction of rotation **26** of the brush **12** needs to be directed such that the brush element **16** enter the nozzle housing **28** on the side of the nozzle housing **28** on which also the squeegee **32** is arranged. Otherwise, this would not enable the above-mentioned interaction of the brush **12** and the squeegee element **32**.

[0092] The properties of the brush **12**, however, remain the same. The brush **12** preferably has a diameter which is in a range of 20 to 80 mm, and the driving means may be capable of rotating the brush **12** at an angular velocity which is at least 6,000 revolutions per minute. A width of the brush **12**, i.e. a dimension of the brush **12** in a direction in which the rotation axis **14** of the brush **12** is extending, may be in an order of 25 cm, for example.

[0093] On an exterior surface of a core element **52** of the brush **12**, tufts **54** are provided. Each tuft **54** comprises hundreds of fiber elements, which are referred to as brush elements **16**. For example, the brush elements **16** are made of polyester with a diameter in an order of about 10 micrometers, and with a Dtex value which is lower than 150 g per 10 km. A packing density of the brush elements **16** may be at least 30 tufts **54** per cm^2 on the exterior surface of the core element **52** of the brush **12**.

[0094] The brush elements **16** may be rather chaotically arranged, i.e. not at fixed mutual distances. Furthermore, it is mentioned that an exterior surface **56** of the brush elements **16** may be uneven, which enhances the capability of the brush elements **16** to catch liquid droplets **24** and dirt particles **22**. In particular, the brush elements **16** may be so-called microfibers, which do not have a smooth and more or less circular circumference, but which have a rugged and more or less star-shaped circumference with notches and grooves instead. The brush elements **16** do not need to be identical, as long as it is true that the linear mass density of a majority of a total number of the brush elements **16** of the brush **12** meets the requirement of being lower than 150 g per 10 km, at least at tip portions **18**.

[0095] By means of the rotating brush **12**, in particular by means of the brush elements **16** of the rotating brush **12**, dirt particles **22** and liquid **24** are picked up from the surface **20**, and are transported to a collecting position inside the cleaning device **100**. Due to the rotation of the brush **12**, a moment occurs at which a first contact with the surface **20** is realized at a first position. The extent of contact is increased until the brush elements **16** are bent in such a way that the tip portions **18** of the brush elements **16** are in contact with the surface **20**. The tip portions **18** as mentioned slide across the surface **20** and encounter dirt particles **22** and liquid **24** in the process, wherein an encounter may lead to a situation in which a quantity of liquid **24** and/or a dirt particles **22** are moved away from the surface **20** to be cleaned and are taken along by the brush elements **16** on the basis of adhesion forces. In the process, the brush elements **16** may act more or less like a whip for catching and dragging particles **22**, **24**, which is force-closed and capable of holding on to a particle **22**, **24** on the basis of a functioning which is comparable to the functioning of a band brake. Furthermore, the liquid **24** which is picked up may pull a bit of liquid with it, wherein a line of liquid is left in the air, which is moving away from the surface **20**. The occurring accelerations at the tip portions **18** of the brush elements **16** cause the dirt particles **22** and liquid droplets **24** to be automatically released from the brush **12**, when the brush elements loose contact from the floor **20** during their rotation. Since not all dirt particles **22** and liquid droplets **24** may be directly ingested by the vacuum aggregate **38**, a small amount of dirt and liquid will be flung back onto the surface **20** in the area where the brush elements **16** loose the contact from the surface **20**. However, this effect of re-spraying the surface **20** is overcome by the squeegee element **32** which collects this re-sprayed liquid and dirt by acting as kind of wiper, so that the remaining liquid **24** and dirt **22** may then be ingested due to the applied under-pressure. The liquid **24** and dirt **22** does therefore not leave the suction area **34** again without being ingested.

[0096] Due to the chosen technical parameters the brush elements **16** have a gentle scrubbing effect on the surface **20**, which contributes to counteracting adhesion of liquid **24** and dirt particles **22** to the surface **20**.

[0097] As the brush **12** rotates, the movement of the brush elements **16** over the surface **20** continues until a moment occurs at which contact is eventually lost. When there is no longer a situation of contact, the brush elements **16** are urged to assume an original, outstretched condition under the influence of centrifugal forces which are acting on the brush elements **16** as a result of the rotation of the brush **12**. As the brush elements **16** are bent at the time that there is an urge to assume the outstretched condition again, an additional, outstretching acceleration is present at the tip portions **18** of the brush elements **16**, wherein the brush elements **16** swish from the bent condition to the outstretched condition, wherein the movement of the brush elements **16** is comparable to a whip which is swished. The acceleration at the tip portions **18** at the time the brush elements **16** have almost assumed the outstretched condition again meets a requirement of being at least 3,000 m/sec^2.

[0098] Under the influence of the forces acting at the tip portions **18** of the brush elements **16** during the movement as described, the quantities of dirt particles **22** and liquid **24** are expelled from the brush elements **16**, as these forces are considerably higher than the adhesion forces. Hence, the liquid **24** and the dirt particles **22** are forced to fly away in a direction which faces away from the surface **20**. The most part of the liquid **24** and the dirt particles **22** is then ingested by the vacuum aggregate. By means of the squeegee element **32** and the under-pressure generated in the suction area **34**, as explained above, it is ensured that also the remaining part of the liquid **24** and the dirt **22**, that is sprayed back from the brush **12** to the surface **20**, is collected and then also ingested.

[0099] Under the influence of the acceleration, the liquid **24** may be expelled in small droplets. This is advantageous for further separation processes such as performed by the vacuum fan aggregate **38**, in particular the centrifugal fan of the vacuum aggregate **38**, which serves as a rotatable air-dirt separator. It is noted that suction forces such as the forces exerted by the centrifugal fan do not play a role in the above-described process of picking up liquid and dirt by means of brush elements **16**. However, these suction forces are necessary for picking up the dirt and liquid that has been collected by the squeegee.

[0100] Besides the functioning of each of the brush elements **16**, as described in the foregoing, another effect which contributes to the process of picking up dirt particles **22** and liquid **24** may occur, namely a capillary effect between the brush elements **16**. In this respect, the brush **12** with the brush elements **16** is comparable to a brush **12** which is dipped in a quantity of paint, wherein paint is absorbed by the brush **12** on the basis of capillary forces.

[0101] It appears from the foregoing that the brush **12** according to the present invention has the following properties:

- **[0102]** the soft tufts **54** with the flexible brush elements **16** will be stretched out by centrifugal forces during the contact-free part of a revolution of the brush **12**;
- **[0103]** it is possible to have a perfect fit between the brush **12** and the surface **20** to be cleaned, since the soft tufts **54** will bend whenever they touch the surface **20**, and straighten out whenever possible under the influence of centrifugal forces;
- **[0104]** the brush **12** constantly cleans itself, due to sufficiently high acceleration forces, which ensures a constant cleaning result;
- **[0105]** heat generation between the surface **20** and the brush **12** is minimal, because of a very low bending stiffness of the tufts **54**;
- **[0106]** a very even pick-up of liquid from the surface **20** and a very even overall cleaning result can be realized, even if creases or dents are present in the surface **20**, on the basis of the fact that the liquid **24** is picked up by the tufts **54** and not by an airflow as in many conventional devices; and
- **[0107]** dirt **22** is removed from the surface **20** in a gentle yet effective way, by means of the tufts **54**, wherein a most efficient use of energy can be realized on the basis of the low stiffness of the brush elements **16**.

[0108] On the basis of the relatively low value of the linear mass density, it may be so that the brush elements **16** have very low bending stiffness, and, when packed in tufts **54**, are not capable of remaining in their original shape. In conventional brushes, the brush elements spring back once released. However, the brush elements **16** having the very low bending stiffness as mentioned will not do that, since the elastic forces are so small that they cannot exceed internal friction forces which are present between the individual brush elements **16**. Hence, the tufts **54** will remain crushed after deformation, and will only stretch out when the brush **12** is rotating.

[0109] In comparison with conventional devices comprising hard brushes for contacting a surface to be cleaned, the brush **12** which is used according to the present invention is capable of realizing cleaning results which are significantly better, due to the working principle according to which brush elements **16** are used for picking up liquid **24** and dirt **22** and taking the liquid **24** and the dirt **22** away from the surface **20** to be cleaned, wherein the liquid **24** and the dirt **22** are flung away by the brush elements **16** before they contact the surface **20** again in a next round.

[0110] As a result of the fact that the brush **12** is indented by the surface **20** to be cleaned, the brush **12** acts as a kind of gear pump which pumps air from the inside of the nozzle housing **28** to the outside. This is an effect which is disadvantageous, as dirt particles **22** are blown away and droplets of liquid **24** are formed at positions where they are out of reach from the brush **12** and can fall down at unexpected moments during a cleaning process.

[0111] In order to compensate for the pumping effect as mentioned, it is proposed to have means for generating an airflow in an area where the brush **12** contacts the surface **20**, which airflow is used to compensate for the airflow generated by the brush **12**.

[0112] These means can be realized in various ways. A first implementation possibility is shown in the first embodiment which is shown in FIGS. **1** and **2**, where a small opening **58** is arranged between nozzle housing **28** and the brush **12** at a position where the brush elements **16** leave the nozzle housing **28** during the rotation of the brush **12**. This opening **58** realizes a further suction inlet **60** to the suction area **34** which applies an under-pressure (due to the described under-pressure in the suction area **34**) in the area where the brush elements **16** first contact the surface **20**. This under-pressure generates an airflow that counteracts the unwanted turbulent airstream that is generated in front of the brush **12** due to its rotation during use.

[0113] A second possibility to counteract the unwanted turbulent airstream in front of the brush **12**, is to equip the brush **12** with tufts **54** of brush elements **16** which are arranged in rows on the brush **12**, so that the necessary suction power will be significantly reduced.

[0114] Furthermore, it is possible to use a deflector **62** for indenting the brush **12** at a position, seen in rotation direction **26**, before the brush **12** contacts the surface **20**, as this is exemplary shown in second embodiment which is shown in FIGS. **3** and **4**. The deflector **62** has the function to press the brush elements **16** together by deflecting them. In this way air, which is present in the space between the brush elements **16**, is pushed out of said space. When the brush elements **16** are, after leaving the deflector **62**, moved apart from each other again, the space in between the brush elements **16** increases so that air will be sucked into the brush **12**, wherein an under-pressure is created that sucks in dirt **22** and liquid particles **24**. This again compensates for the air blow that is generated by the rotating brush **12**. Examples of deflectors as mentioned are found in PCT/IB2009/054333 and PCT/IB2009/054334, both in the name of Applicant.

[0115] The airflow which needs to be compensated can be calculated, using the following equation:

$$\Phi_c=\pi*f*W*F*(D*I-I^2)$$

in which:

Φ_c=airflow which needs to be compensated for (m^3/s)

f=brush frequency (Hz)

W=width of the brush **12** (m)

F=brush compensation factor (–)

D=diameter of the brush **12** (m)

I=indentation of the brush **12** by the surface **20** (m)

[0116] In a practical example, f=133 Hz, W=0.25 m, D=0.044 m, and I=0.003 m. In respect of the brush compensation factor, it is noted that this factor is determined on the basis of experiments with a brush having features as mentioned above, and is found to be 0.4. With the values as mentioned, the following compensation flow is found:

$$\Phi_c=\pi*133*0.25*0.4*(0.044*0.003-0.003^2)=0.005015\ m^3/s$$

[0117] Hence, in this example, it is advantageous to have a compensating airflow of about 5 liters per second. Such an airflow can very well be realized in practice with one of the implementation possibilities exemplarily mentioned above, so that the disadvantageous pumping effect of the brush **12** can actually be dispensed with.

[0118] FIG. **7** provides a view of the cleaning device **100** according to the present invention in its entirety. According to this schematic arrangement the cleaning device **100** comprises a nozzle housing **28** in which the brush **12** is rotatably mounted on the brush axis **14**. A drive means, which can be realized be a regular motor, such as e.g. an electro motor (not shown), is preferably connected to or even located on the brush axis **14** for the purpose of driving the brush **12** in rotation. It is noted that the motor may also be located at any other suitable position within the cleaning device **100**.

[0119] In the nozzle housing **28**, means such as wheels (not shown) are arranged for keeping the rotation axis **14** of the brush **12** at a predetermined distance from the surface **20** to be cleaned, wherein the distance is chosen such that the brush **12** is indented. Preferably, the range of the indentation is from 2% to 12% of a diameter of the brush **12** relating to a fully outstretched condition of the brush elements **16**. Hence, when the diameter is in an order of 50 mm, the range of the indentation can be from 1 to 6 mm.

[0120] As already explained above, the squeegee element **32** is spaced apart from the brush **12** and attached to the bottom side **30** of the nozzle housing **28**. It extends substantially parallel to the brush axis **14**, thereby defining a suction area **34** within the nozzle housing **28** in between the squeegee element **32** and the brush **12**, which suction area **34** has a suction inlet **36** which is located at the bottom side **30** of the nozzle housing **28** facing the surface **20** to be cleaned.

[0121] Besides the nozzle housing **28**, the brush **12** and the squeegee element **32**, the cleaning device **100** is preferably provided with the following components:

[0122] a handle **64** which allows for easy manipulation of the cleaning device **100** by a user;

[0123] a reservoir **66** for containing a cleansing liquid **68** such as water;

[0124] a debris collecting container **70** for receiving liquid **24** and dirt particles **22** picked up from the surface **20** to be cleaned;

[0125] a flow channel in the form of, for example, a hollow tube **72**, connecting the debris collecting container **70** to the suction area **34**, which suction area **34** constitutes the suction inlet **36** on the bottom side **30** of the nozzle **10**. It has to be noted that, in the meaning of the present invention the flow channel including the hollow tube **72** may also be denoted as suction area **34** in which the above mentioned under-pressure is applied by the vacuum aggregate **38**; and

[0126] the vacuum fan aggregate **38** comprising a centrifugal fan **38'**, arranged at a side of the debris collecting chamber **70** which is opposite to the side where the tube **72** is arranged.

[0127] For sake of completeness, it is noted that within the scope of the present invention, other and/or additional constructional details are possible. For example, an element may be provided for deflecting the debris **22**, **24** that is flung upwards, so that the debris **22**, **24** first undergoes a deflection before it eventually reaches the debris collecting chamber **70**. Also, the vacuum fan aggregate **38** may be arranged at another side of the debris collecting chamber **70** than the side which is opposite to the side where the tube **72** is arranged.

[0128] According to an embodiment, which is shown in FIG. **8**, the brush **12** comprises a core element **52**. This core element **52** is in the form of a hollow tube provided with a number of channels **74** extending through a wall **76** of the core element **52**. For the purpose of transporting cleansing fluid **68** from the reservoir **66** to the inside of the hollow core element **52** of the brush **12**, e.g. a flexible tube **78** may be provided that leads into the inside of the core element **52**.

[0129] According to this embodiment cleansing fluid **68** may be supplied to the hollow core element **52**, wherein, during the rotation of the brush **12**, the liquid **68** leaves the hollow core element **52** via the channels **74**, and wets the brush elements **16**. In this way the liquid **68** also drizzles or falls on the surface **20** to be cleaned. Thus, the surface **20** to be cleaned becomes wet with the cleansing liquid **68**. This especially enhances the adherence of the dirt particles **22** to the brush elements **16** and, therefore improves the ability to remove stains from the surface **20** to be cleaned.

[0130] According to the present invention, the rate at which the liquid **68** is supplied to the hollow core element **52** can be quite low, wherein a maximum rate can be 6 ml per minute per cm of the width of the brush **12**, for example.

[0131] However, it is to be noted that the feature of actively supplying water **68** to the surface **20** to be cleaned using hollow channels **74** within the brush **12** is not a necessary feature. Alternatively, a cleansing liquid could be supplied by spraying the brush **12** from outside or by simply immersing the brush **12** in cleansing water before the use. Instead of using an intentionally chosen liquid, it is also possible to use a liquid that has been already spilled, i.e. a liquid that needs to be removed from the surface **20** to be cleaned.

[0132] The pick-up of the cleansing water **68** from the floor is, as already mentioned above, either done by the squeegee element **32** which collects the water by acting as a kind of wiper transporting liquid to the suction area **34** where it is ingested due to the under-pressure generated by the vacuum aggregate **38**, or the water is directly picked-up from the floor by the brush **12**. In comparison with conventional devices comprising hard brushes that are not able to pick-up water, the brush **12** used according to the present invention is capable of picking-up water. The realized cleaning results are thus significantly better.

[0133] The technical parameters regarding the brush **12**, the brush elements **16** and the drive means result from experiments which have been performed in the context of the present invention.

[0134] In the following, one of the experiments and the results of the experiment will be described. The tested brushes were equipped with different types of fiber materials used for the brush elements **16**, including relatively thick fibers and relatively thin fibers. Furthermore, the packing density as well as the Dtex values have been varied. The particulars of the various brushes are given in the following table.

	packing density (# tufts/cm^2)	fibers per tuft	Dtex value (g/10 km)	fiber material	fiber length (mm)	fiber appearance
brush 1	160	9	113.5	nylon	10	springy, straight
brush 2	25	35	31.0	nylon	11	fairly hard, curled
brush 3	40	90	16.1	—	11	very soft, twined
brush 4	50	798	0.8	polyester	11	very soft, twined

[0135] The experiment includes rotating the brush under similar conditions and assessing cleaning results, wear, and power to the surface **20** subjected to treatment with the brush **12**. This provides an indication of heat generation on the surface **20**. The outcome of the experiment is reflected in the following table, wherein a mark **5** is used for indicating the best results, and lower marks are used for indicating poorer results.

	stain removal	water pick-up	wear	power to the surface
Brush 1	5	3	3	3
Brush 2	5	3	1	4
Brush 3	5	4	4	5
Brush 4	5	5	5	5

[0136] Among other things, the experiment proves that it is possible to have brush elements **16** with a linear mass density in a range of 100 to 150 g per 10 km, and to obtain useful cleaning results, although it appears that the water pick-up, the wear behavior and the power consumption are not so good. It is concluded that an appropriate limit value for the linear mass density is 150 g per 10 km. However, it is clear that with a much lower linear mass density, the cleaning results and all other results are very good. Therefore, it is preferred to apply lower limit values, such as 125 g per 10 km, 50 g per 10 km, 20 g per 10 km, or even 5 g per 10 km. With values in the latter order, it is ensured that cleaning results are excellent, water pick-up is optimal, wear is minimal, and power consumption and heat generation on the surface **20** are sufficiently low.

[0137] It is noted that the minimum value of 3,000 m/sec^2 in respect of the acceleration which is prevailing at tips **18** of the brush elements **16** during some time per revolution of the brush **12**, in particular some time during a dirt release period, in which there is no contact between the brush elements **16** and the surface **20**, is supported by results of experiments which have been performed in the context of the present invention.

[0138] In the following, one of the experiments and the results of the experiment will be described. The following conditions are applicable to the experiment:

[0139] 1) A brush **12** having a diameter of 46 mm, a width of approximately 12 cm, and polyester brush elements **16** with a linear mass density of about 0.8 g per 10 km, arranged in tufts **54** of about 800 brush elements **16**, with approximately 50 tufts **54** per cm^2, is mounted on a motor shaft.

[0140] 2) The weight of the assembly of the brush **12** and the motor is determined.

[0141] 3) The power supply of the motor is connected to a timer for stopping the motor after a period of operation of 1 second or a period of operation of 4 seconds.

[0142] 4) The brush **12** is immersed in water, so that the brush **12** is completely saturated with the water. It is noted that the brush **12** which is used appears to be capable of absorbing a total weight of water of approximately 70 g.

[0143] 5) The brush **12** is rotated at an angular velocity of 1,950 revolutions per minute, and is stopped after 1 second or 4 seconds.

[0144] 6) The weight of the assembly of the brush **12** and the motor is determined, and the difference with respect to the dry weight, which is determined under step 2), is calculated.

[0145] 7) Steps 4) to 6) are repeated for other values of the angular velocity, in particular the values as indicated in the following table, which further contains values of the weight of the water still present in the brush **12** at the stops after 1 second and 4 seconds, and values of the associated centrifugal acceleration, which can be calculated according to the following equation:

$$a=(2*\pi*f)^2*R$$

in which:

a=centrifugal acceleration (m/s^2)

f=brush frequency (Hz)

R=radius of the brush **12** (m)

angular velocity (rpm)	weight of water present after 1 s (g)	weight of water present after 4 s (g)	centrifugal acceleration (m/s^2)
1,950	8.27	7.50	959
2,480	5.70	4.57	1,551

-continued

angular velocity (rpm)	weight of water present after 1 s (g)	weight of water present after 4 s (g)	centrifugal acceleration (m/s^2)
3,080	3.70	3.11	2,393
4,280	2.52	1.97	4,620
5,540	1.95	1.35	7,741
6,830	1.72	1.14	11,765
7,910	1.48	1.00	15,780
9,140	1.34	0.94	21,069

[0146] The relation which is found between the angular velocity and the weight of the water for the two different stops is depicted in the graph of FIG. **9**, and the relation which is found between the centrifugal acceleration and the weight of the water for the two different stops is depicted in the graph of FIG. **10**, wherein the weight of the water is indicated at the vertical axis of each of the graphs. It appears from the graph of FIG. **9** that the release of water by the brush **12** strongly decreases, when the angular velocity is lower than about 4,000 rpm. Also, it seems to be rather stable at angular velocities which are higher than 6,000 rpm to 7,000 rpm.

[0147] A transition in the release of water by the brush **12** can be found at an angular velocity of 3,500 rpm, which corresponds to a centrifugal acceleration of 3,090 m/s^2. For sake of illustration of this fact, the graphs of FIGS. **9** and **10** contain a vertical line indicating the values of 3,500 rpm and 3,090 m/s^2, respectively.

[0148] On the basis of the results of the experiment as explained in the foregoing, it may be concluded that a value of 3,000 m/s^2 in respect of an acceleration at tips **18** of the brush elements **16** during a contact-free period is a realistic minimum value as far as the self-cleaning capacity of brush elements **16** which meet the requirement of having a linear mass density which is lower than 150 g per 10 km, at least at tip portions **18**, is concerned. A proper performance of the self-cleaning function is important for obtaining good cleaning results, as has already been explained in the foregoing.

[0149] For sake of completeness, it is noted that in the cleaning device **100** according to the present invention, the centrifugal acceleration may be lower than 3,000 m/s^2. The reason is that the acceleration which occurs at tips **18** of the brush elements **16** when the brush elements **16** are straightened out can be expected to be higher than the normal centrifugal acceleration. The experiment shows that a minimum value of 3,000 m/s^2 is valid in respect of an acceleration, which is the normal, centrifugal acceleration in the case of the experiment, and which can be the higher acceleration which is caused by the specific behavior of the brush elements **16** when the dirt pick-up period has passed and there is room for straightening out in an actual cleaning device **100** according to the present invention, which leaves a possibility for the normal, centrifugal acceleration during the other periods of the rotation (e.g. the dirt pick-up period) to be lower.

[0150] Even though a single brush is, according to the present invention, preferred, it is clear that also further brushes may be used without leaving the scope of the present invention.

[0151] It will be clear to a person skilled in the art that the scope of the present invention is not limited to the examples discussed in the foregoing, but that several amendments and modifications thereof are possible without deviating from the scope of the present invention as defined in the attached claims. While the present invention has been illustrated and described in detail in the figures and the description, such illustration and description are to be considered illustrative or exemplary only, and not restrictive. The present invention is not limited to the disclosed embodiments.

[0152] For sake of clarity, it is noted that a fully outstretched condition of the brush elements **16** is a condition in which the brush elements **16** are fully extending in a radial direction with respect to a rotation axis **14** of the brush **12**, wherein there is no bent tip portion in the brush elements **16**. This condition can be realized when the brush **12** is rotating at a normal operative speed, which is a speed at which the acceleration of 3,000 m/sec^2 at the tips **18** of the brush elements **16** can be realized. It is possible for only a portion of the brush elements **16** of a brush **12** to be in the fully outstretched condition, while another portion is not, due to obstructions which are encountered by the brush elements **16**. Normally, the diameter D of the brush **12** is determined with all of the brush elements **16** in the fully outstretched condition.

[0153] The tip portions **18** of the brush elements **16** are outer portions of the brush elements **16** as seen in the radial direction, i.e. portions which are the most remote from the rotation axis **14**. In particular, the tip portions **18** are the portions which are used for picking up dirt particles **22** and liquid, and which are made to slide along the surface **20** to be cleaned. In case the brush **12** is indented with respect to the surface **20**, a length of the tip portion is approximately the same as the indentation.

[0154] The present invention can be summarized as follows. By applying the above-mentioned parameters concerning the linear mass density of the brush elements and by realizing a centrifugal acceleration at the tip portions of the brush elements in the above-mentioned range, very good cleaning results and stain removal properties can be achieved by equipping the nozzle with only a single brush and a single squeegee element.

[0155] In contrast to nozzle arrangements known from the prior art, which need to be equipped with at least two squeegees, one at each side of the brush, or which need to be equipped with two brushes that rotate counterclockwise, in order to receive good cleaning results, the presented solution results in a very space-saving nozzle size. The very good cleaning properties that can be achieved with the presented solution mainly rely on the brush, which is due to the above-mentioned operating parameters, in contrast to hard brushes used in prior art solutions, not only able to pick-up dirt particles from the surface, but also to pick-up liquid from the surface to be cleaned.

[0156] Due to the ability of the brush to also pick-up water a double squeegee solution is no longer necessary. Because of having only a single squeegee element and only one brush, the nozzle becomes less bulky. Due to the reduced number of squeegees (only one) scratching is significantly reduced. The proposed nozzle arrangement is, at least at the brush side, open for coarse dirt. The brush and the squeegee together form a channel. Due to the spraying of the brush, the suction area, and therefore also the squeegee, are constantly cleaned. All over all, very good cleaning results can be achieved with a very small, but highly effective nozzle having only one squeegee and preferably only one brush.

[0157] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments. Other 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.

[0158] 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. A single element or other unit may fulfill the functions of several items recited in the claims. 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.

[0159] Any reference signs in the claims should not be construed as limiting the scope.

1-15. (canceled)

16. A nozzle arrangement for a hard floor cleaning device, comprising:

a single rotary brush rotatable about a brush axis, said brush being provided with flexible brush elements having tip portions for contacting the surface to be cleaned and picking up dirt particles and liquid from the surface during a pick-up period when the brush elements contact the surface during the rotation of the brush, wherein a linear mass density of a plurality of the brush elements is, at least at the tip portions, lower than 150 g per 10 km, and

a single squeegee element for pushing or wiping dirt particles and liquid across or off the surface to be cleaned during movement of the cleaning device, said squeegee element being spaced apart from the brush and extending substantially along a longitudinal direction being substantially parallel to the brush axis, wherein a suction area is defined within the nozzle arrangement between the squeegee element and the brush, and

a drive means for driving the brush in rotation, wherein the drive means are adapted to realize a centrifugal acceleration at the tip portions which is, in particular during a dirt release period when the brush elements are free from contact to the surface during rotation of the brush, at least 3,000 m/s^2.

17. The nozzle arrangement as claimed in claim **1**, wherein the brush axis and/or the longitudinal direction of the squeegee element is arranged transverse, preferably perpendicular to the intended direction of movement of the cleaning device.

18. The nozzle arrangement as claimed in claim **1**, wherein said squeegee element comprises switching means for switching the squeegee element to a closed position, in which the squeegee element is adapted to push or wipe dirt particles and liquid across or off the surface to be cleaned, when the cleaning device is moved on the surface in a forward direction, in which the squeegee element is, seen in the direction of movement of the cleaning device, located behind the brush, and for switching the squeegee element to an open position, in which dirt particles and liquid from the surface to be cleaned can enter the suction area through an opening between the squeegee element and said surface, when the cleaning device is moved on the surface in a backward direction, in which the squeegee element is, seen in the direction of movement of the cleaning device, located in front of the brush.

19. The nozzle arrangement as claimed in claim **1**, wherein the nozzle arrangement comprises a nozzle housing that at least partly surrounds the brush and wherein the squeegee element is attached to said housing.

20. The nozzle arrangement as claimed in claim **1**, further comprising positioning means for positioning the brush axis at a distance to the surface to be cleaned that is smaller than the radius of the brush with fully outstretched brush elements to realize an indentation of the brush part contacting the surface during operation, which indentation is in a range from 2% to 12% of the brush diameter.

21. The nozzle arrangement as claimed in claim **1**, wherein a packing density of the brush elements is at least 30 tufts of brush elements per cm^2, and wherein a number of brush elements per tuft is at least 500.

22. The nozzle arrangement as claimed in claim **1**, wherein a linear mass density of a majority of a total number of the brush elements is, at least at the tip portions, lower than 20 g per 10 km.

23. The nozzle arrangement as claimed in claim **1**, wherein the drive means are adapted to realize an angular velocity of the brush which is in a range of 3,000 to 15,000 revolutions per minute, more preferably in a range of 5,000 to 8,000 revolutions per minute, during operation of the device.

24. The nozzle arrangement as claimed in claim **1**, wherein the brush has a diameter which is in a range of 10 to 100 mm, more preferably in a range of 20 to 80 mm, most preferably in a range of 35 to 50 mm, when the brush elements are in a fully outstretched condition, and wherein the length of the brush elements is in a range of Ito 20 mm, preferably in a range of 8 to 12 mm, when the brush elements are in a fully outstretched condition.

25. The nozzle arrangement as claimed in claim **1**, comprising means for supplying a liquid to the brush at a rate which is lower than 6 ml per minute per cm of a width of the brush in which the brush axis is extending.

26. The nozzle arrangement as claimed in claim **1**, comprising means for generating an airflow on a brush's side facing away from the squeegee element, in an area where the brush contacts the surface to be cleaned during operation of the device.

27. The nozzle arrangement as claimed in claim **1**, comprising a deflector for contacting the brush at a location, seen in direction of rotation, before the location where the brush contacts the surface to be cleaned during rotation.

28. The nozzle arrangement as claimed in claim **1**, wherein the brush is a spiraled brush having tufts arranged on the periphery of the brush in a spiral-like pattern.

29. Hard floor cleaning device for cleaning a surface comprising:

the nozzle arrangement as claimed in claim **1**, and

a vacuum aggregate for generating an under-pressure in the suction area for ingesting dirt particles and liquid.

30. The hard floor cleaning device as claimed in claim **14**, wherein said under-pressure generated by the vacuum aggregate is in a range of 3 to 70 mbar, preferably in a range of 4 to 50 mbar, most preferably in a range of 5 to 30 mbar.

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