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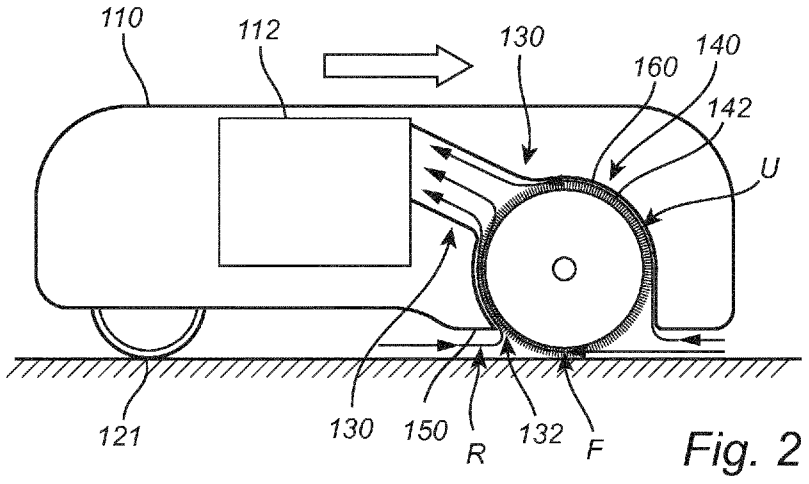

Fig. 2

(57) Abstract: An autonomous cleaning robot (100) is disclosed, comprising a body (110), a driving means (120) configured to move the robot in a forward direction over a surface being cleaned, a suction opening (132) arranged at an underside of the body, and a roller (140) arranged at the underside of the body and in front of the suction opening, relative the forward direction. The roller is configured to define a front air passageway (F) at the surface, and comprises bristles (142) arranged to form a front air barrier restricting an air flow in the front air passageway. The front air barrier is configured to be substantially uniform over an entire turn of the roller, wherein the bristles are further arranged to direct the air flow towards a particle (P) passing by the roller, and further into the suction opening.

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VACUUM CLEANER BRUSH ROLL

Technical field of the invention

The present inventive concept relates to the field of vacuum cleaners, and in particular to autonomous vacuum cleaner robots, and especially for household use.

Background of the invention

Autonomous vacuum cleaner robots are a type of cleaning devices that navigate across a floor surface while removing dirt, such as dust, debris and other particles, from the floor surface. The robot typically comprises a chassis provided with wheels and a brush roller that is rotated for the purpose of brushing the dust and particles towards a suction opening, from which the dust and particles are conveyed through a suction channel to an interior of the robot by means of a suction airflow.

It is desirable to provide an airflow that is sufficiently strong to ensure that dust and particles are caught by the flow and transported into the suction opening. It is at the same time desirable to provide a power efficient robot, both in term of energy consumption and noise level. Thus, a trade-off generally has to be made between dust pick-up and power efficiency.

Summary of the invention

In view of the above, it is an object of the present inventive concept to provide a technology that addresses the above concerns. This and other objects, which will become apparent in the following, are accomplished by an autonomous cleaning robot as defined in the independent claim. Preferable embodiments are defined in the dependent claims.

Thus, according to an aspect, an autonomous cleaning robot is provided, comprising a body, a driving means configured to move the robot in a forward direction over a surface being cleaned, a suction opening arranged at an underside of the body, and a roller arranged at the underside of the body and in front of the suction opening, relative the forward direction. The

roller may be configured to define a front air passageway at the surface, and comprise bristles arranged to form an air barrier restricting an air flow in the front air passageway. The air barrier may be substantially uniform over an entire turn of the roller, and the bristles may be arranged to direct the air flow towards a particle passing by the roller, and further into the suction opening.

The present inventive concept involves the realisation that it is desirable to direct as much as possible of the airflow in the front air passageway towards the surface to be cleaned, since the dust pick-up generally tends to increase with increasing flow and/or speed of the air that passes over the surface. The present inventive concept is associated with several advantages – firstly, the bristles are arranged to form an air barrier that restricts the airflow in the front air passageway. This allows for a general reduction in power consumption and noise, since the fan that generates the suction airflow can operate on a reduced power level. Secondly, the bristles are arranged to direct the air flow towards a particle passing by the roller. This may for example be achieved by the bristles being bent or pushed aside by the particle as the roller passes over the particle, such that a gap or passage is formed in the barrier, allowing for a local flow passageway to be formed at the location of the particle, through which the airflow may be concentrated and passing with a relatively high speed that facilitates transport of the particle towards an interior of the robot.

The bristles may be arranged to form an air barrier that is substantially uniform over an entire turn of the roller. This may for example be achieved by distributing the bristles uniformly over the envelope surface of the roller, or at least such that the number of bristles pointing towards the surface is substantially constant during the entire turn of the roller. A uniform barrier allows for the performance of the robot, and the suction conditions under which it operates, to be constant while the roller is rotated. Advantageously, this allows for a smooth operation and reduced noise – especially compared to prior art rollers comprising bristle rows and/or rubber vanes that tend to whip the surface during the rotation.

A consequence of increasing the distribution density of the bristles, i.e., the number of bristles per unit area, is that the roller may be operated at a

reduced speed while maintaining the same number of bristles passing the surface for a given time period. This allows for a reduced power consumption and noise level.

By “air barrier”, which also may be referred to as a “sealing”, is meant a feature that prevents a substantial amount of air from passing towards the suction channel, but does not require an air tight seal. The air barrier may be characterised by the flow resistance in the air passageway through which the air passes on its way to the suction channel. The flow resistance may, in turn, be defined by the density by which the bristles are arranged on the roller, the length of the bristles, and any gap between the bristles and the surface to be cleaned. Increasing the density of the bristles, i.e., the number of bristles per unit area of a core of the roller, may increase the flow resistance experienced by air passing between the bristles. Further, reducing the length of the bristles may result in a narrower passageway and hence an increased flow resistance, while introducing a gap between the roller and for example the surface to be cleaned may reduce the flow resistance. Thus, it is desirable to use a larger number of shorter bristles that are arranged to engage the surface such that no additional gap is formed that may impair the barrier function of the roller. The term “restricting an airflow” therefore refers to the bristle’s capability of forming an air barrier, or seal, with an adjacent surface, such as the floor surface, during operation of the robot – preferably by engaging the surface such that most of the air passing through the front air passageway has to pass through the roller, i.e., between the bristles.

By the bristles being arranged to “direct the airflow towards a particle” is understood a capability to focus at least some of the airflow in the front air passageway towards the particle. A particle may interact with the roller in several ways depending, inter alia, on the size of the particle in relation to the spacing and length of the bristles. Preferably, the particle is sufficiently large, relative the length of the bristles and the spacing of neighbouring bristles, to push or bend them away from each other, thereby forming a local passageway in which an airflow may be passed to entrap the particle. Further, the particle is sufficiently small to fit in the front air passageway, i.e., to be pushed into the bristles and further towards the suction opening.

Generally, this requires the particle to be of a size that does not exceed the length of the bristles and/or the spacing between a core of the roller and the floor surface.

A device as described in the context of the present disclosure is often referred to as an autonomous cleaning robot due to the fact that the device can automatically move around on a work surface according to, for example, a predetermined or randomised pattern. The device may generally be used to clean the surface from dust, debris, gravel, sand, hair, and other particles.

As already mentioned, the bristles may be arranged in a non-uniform manner over an envelope surface of the roller. The bristles may for example be arranged to cover only a part of a length portion facing the surface as the roller is rotated. Preferably, the bristles are arranged to form an air barrier that extends along a substantial part of the length portion facing the surface. Thus, according to an embodiment, the bristles may be distributed such that the number of bristles pointing towards the surface are distributed over a length portion of the roller that corresponds to at least 50%, such as at least 75%, of a total length of the roller so as to provide an increased sealing and less noise.

Alternatively, the bristles may be uniformly distributed over the entire envelope surface of the roller or substantially the entire envelope surface of the roller.

The bristles, which may be formed as short hairs or whiskers, may be fastened to a core of the roller such that they stand substantially upright from the surface of the core, pointing in a radial direction of the roller. Preferably, the bristles have a length of 3-15 mm, such as 3-10 mm or 3-7 mm. In a specific example, the bristles may have a length of 5.5 mm. Further, the bristles may be arranged with a density of 1 000-20 000 bristles per cm^2, such as 10 000-18 000 or 12 000-17 000 per cm^2. In two specific examples, the bristles may have a density of 2 000 per cm^2 (for harder brush rolls) and 13 200 per cm^2 (for softer brush rolls), or a mix of lower and higher density bristles. The bristles may further have a diameter of 0.03-0.15 mm, such as for example 0.05 mm. In some examples, the core (i.e. the roller without the

bristles) may have a diameter in the interval of 8-40 mm, such as for example 15-25 mm.

According to an embodiment, the robot may further comprise a sealing edge arranged behind the suction opening, relative the forward direction. The sealing edge may be arranged spaced from the surface to define a rear air passageway between the surface and the sealing edge. Thus, the air that is sucked into the robot and forms the suction air flow may take at least two different ways – either the front air passageway through the roller, or the rear air passageway behind the roller. Preferably, the flow resistance is higher in the rear air passageway than in the front air passageway to force the air to pass through the front air passageway and thereby increase dust-pickup. This may be achieved by reducing the clearance between the sealing edge and the surface to be cleaned. In case the robot is operating mainly during its forward motion, the clearance between the sealing edge and the surface may be even further reduced.

According to an embodiment, the robot may further comprise a roller housing with an inner surface that is arranged to partly surround the roller, along a portion of the roller facing away from the surface being cleaned, to form an upper air passageway with the roller. Thus, the air that is sucked into the robot may take at least three different ways, i.e., the front air passageway, the rear air passageway, and the upper air passageway. Preferably, the flow resistance in the upper air passageway is higher than in the front air passageway so as to force most of the air to pass through the latter. This may be accomplished by reducing a distance between the inner surface and the roller, and further by increasing the length of the upper air passageway by increasing the circumferential distance of the roller over which the inner surface extends.

According to an embodiment, the roller is rotatable such that a portion of its envelope surface facing the surface to be cleaned is moved towards the suction opening. Put differently, the roller may be rotatable in the same direction as the rotation of the wheels of the robot when the robot is moving in the forward direction. Preferably, the roller is rotated at a speed allowing it to

brush dust and particles towards the suction opening, rather than merely rolling over them.

Brief description of the drawings

The above, as well as additional objects, features and advantages of the present inventive concept, will be better understood through the following illustrative and non-limiting detailed description of embodiments. Reference will be made to the appended drawings, on which:

figure 1 illustrates a top view of an autonomous cleaning robot according to an embodiment;

figure 2 is a cross section of an autonomous cleaning robot according to an embodiment;

figure 3 is a cross section of a roller of an autonomous cleaning robot according to an embodiment; and

figure 4 is a perspective view of a roller of an autonomous cleaning robot according to an embodiment.

Like reference numerals are used for like elements on the drawings. Unless otherwise indicated, the drawings are schematic and generally not to scale.

Detailed description of embodiments

Figure 1 is a top view of an autonomous cleaning robot 100 for household use according to an embodiment, comprising a body 110, a driving means 120, 121, a suction opening (not shown), a suction unit 112 and a roller 140. The body 110 may form a chassis having an outer cover for protecting and enclosing functional units, such as control electronics, dust box and fan unit, arranged in the interior of the robot. Further, the chassis may provide support for the driving means 120, which in the present example is represented by two driving wheels 120 and a support wheel 121 arranged at the underside of the chassis. The driving of the drive wheels 120 may be performed by separate motors for improved navigation and movement control.

The roller 140 may be arranged at the underside of the chassis, and such that it engages a surface of the floor during operation. Preferably, the

roller 140 is arranged in the front third of the body, as seen in the forward direction. The roller 140 may comprise a core and a plurality of bristles, which will be described in more detail in connection with the following figures.

During operation, the robot 100 may move autonomously over the surface to be cleaned, and preferably in a forward direction indicated by the arrows in figures 1 and 2. When moving in the forward direction, debris, dust and other particles may be engaged by the bristles of the roller 140 and sucked into the interior of the robot 100 by means of an airflow that is passing over the surface. The roller 140 may preferably rotate in the same direction as the wheels 120, and with a speed that allows the bristles to brush the particles towards the suction opening 132 in the body 110 of the robot 100.

Figure 2 is a cross section of a cleaning robot 100 according to an embodiment, which may be similarly configured as the cleaning robot discussed in connection with figure 1. Thus, the robot 100 may comprise a body, or chassis 110, accommodating a suction unit 112 for generating a suction airflow and filtering out dust and particles from the same. The suction airflow passes through the suction opening 132 and into the suction channel 130, leading into the interior of the robot 100. The suction opening 132 may be arranged at least slightly behind the roller 140 as seen in the forward travel direction indicated by the arrow.

In connection with the suction opening 132, and at the underside of the chassis 110, the roller 140 may be arranged for facilitating transport of dust and particles into the suction channel 130. The roller 140 may comprise an air impermeable core 144, which may be substantially cylindrical, onto which a plurality of bristles 142 may be attached. The bristles 142 may be attached with one end to the core such that the other end points away from the core 144, along a radial direction of the roller 140. The bristles may be arranged to form an air barrier that restricts the air flow in a front air passageway F between the core 144 and the surface. Preferably, the roller 140 is arranged to engage the floor surface during operation, such that the air in the front air passageway passes through the bristles 142 on its way towards the suction channel 130. By arranging the bristles 142 sufficiently dense in terms of number of bristles per unit area, a sealing against the surface may be

accomplished that prevents a substantial amount of air from passing through the front air passageway F.

The chassis 110 may further comprise a sealing edge 150 arranged at the underside of the chassis 110 and behind the suction opening 132, relative the forward direction. The sealing edge 150 may be provided to reduce a clearance between the chassis 110 and the surface and thereby define a rear air passageway R for the air entering the suction opening 132 and passing towards the suction channel 130. Preferably, the clearance between the chassis 110 and the surface is smaller behind the roller 140 than in front of the roller 140, to provide a flow resistance in the rear air passageway R that is higher than in the front air passageway F. The clearance behind the roller 140 may for example be 0-7 mm. In an example, the sealing edge 150 is arranged to abut the surface to provide a flow resistance in the rear air passageway R that is higher than in the front air passageway F and hence force most of the air passing into the interior of the robot 100 to pass through the front air passageway F rather than the rear air passageway R.

A further air passageway may be defined at the upper side of the roller 140. This air passageway may hence be referred to as an upper air passageway U, and may be defined between an inner surface of a roller housing 160. The flow resistance along the upper air passageway U may be increased by increasing the length of the passageway and/or reducing a spacing between the inner surface and the roller 140. It is advantageous to use an upper air passageway that has a higher flow resistance than the front air passageway F, which allows it to restrict most of the airflow to the front air passageway F and thereby force the flowing air towards the surface to be cleaned.

Figure 3 is a cross section of a roller according to an embodiment, which may be similarly configured as the embodiments discussed above in connection with figures 1 and 2. The roller 140 may comprise a substantially cylindrical core 144 that can be mounted in the chassis such that it is rotatable around its length axis A, and spaced apart from the floor surface during operation. Further, the roller 140 comprises a plurality of bristles 142 arranged in a protruding manner on the air impermeable core 144. The

bristles may be distributed such that the number of bristles that for a given point in time are directed towards the surface is constant. Further, as illustrated in the present figure, the bristles 142 may be evenly distributed along the length axis A of the core 144 such that the number of bristles pointing towards the surface are distributed along the entire length of the roller 140. In the present example, the bristles may be formed of nylon, polypropylene or hair.

The bristles 142 may be arranged such that they give way for a particle P passing under the roller 140. More specifically, the bristles 142 may be bent or pushed aside by the particle P such that an opening is formed in the barrier, allowing a flow of air to be directed towards the particle P and further into the suction opening. As indicated in the present figure, the particle P is small enough to pass through the gap defined by the clearance between the core 144 and the surface, and large enough to bend the bristles 142 to the side to create a local airflow through the barrier.

Figure 4 is a perspective view of a roller 140 according to an embodiment, which may be similar to the embodiments described with reference to figures 1 to 3. In the present example, the bristles 142 are distributed substantially uniformly over the entire roller 140, with the exception of one or several helical regions 146 wound around the length axis A of the roller 140. The helical region 146 forms a local gap in the air barrier, which due to the helical arrangement moves along the length axis A as the roller 140 rotates. The gap may for example be provided in order to provide a slight increase in the air flow through the front air channel. It may be desired to increase the air flow depending on the characteristics of the surface and to reduce the friction generating vacuum between the robot and surface.

The person skilled in the art is by no means limited to the example embodiments described above. On the contrary, many modifications and variations are possible within the scope of the appended claims. Additionally, variations to the disclosed examples can be understood and effected by the skilled person in practising the claimed inventive concept, from the study of the drawings, the disclosure, and the appended 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.

CLAIMS

1. An autonomous cleaning robot (100), comprising:

a body (110);

a driving means (120) configured to move the robot in a forward direction over a surface being cleaned;

a suction opening (132) arranged at an underside of the body; and

a roller (140) arranged at the underside of the body and in front of the suction opening, relative the forward direction;

wherein:

the roller is configured to define a front air passageway (F) at the surface; and

the roller comprises bristles (142) arranged to form a front air barrier restricting an air flow in the front air passageway, the front air barrier being configured to be substantially uniform over an entire turn of the roller, wherein the bristles are further arranged to direct the air flow towards a particle (P) passing by the roller, and further into the suction opening.

2. The autonomous cleaning robot according to claim 1, wherein the bristles are distributed such that the number of bristles pointing towards the surface are distributed over a length portion of the roller corresponding to at least 50% of a total length of the roller.

3. The autonomous cleaning robot according to claim 1, wherein the bristles are uniformly distributed over substantially the entire envelope surface of the roller.

4. The autonomous cleaning robot according to any of the preceding claims, wherein the bristles are arranged with a density of 1 000-20 000 bristles per cm^2, such as 10 000-18 000 bristles per cm^2, such as 12 000-17 000 bristles per cm^2.

5. The autonomous cleaning robot according to any of the preceding claims, further comprising a sealing edge (150) arranged behind the suction opening, relative the forward direction, and configured to be spaced from the surface so as to define a rear air passageway between the surface and the sealing edge.

6. The autonomous cleaning robot according to claim 5, wherein the sealing edge is arranged such that a flow resistance of the rear air passageway is higher than a flow resistance of the front air passageway.

7. The autonomous cleaning robot according to claim 5 or 6, wherein a clearance between the surface and the sealing edge is smaller than, or equal to, a clearance between the surface and the body in front of the suction opening, relative the forward direction.

8. The autonomous cleaning robot according to claim 7, wherein the clearance between the sealing edge and the surface is 0-7 mm.

9. The autonomous cleaning robot according to any of the preceding claims, further comprising a roller housing (160) having an inner surface, wherein the inner surface is arranged to partly surround the roller, along a portion of the roller facing away from the surface being cleaned, to form an upper air passageway with the roller, the upper air passageway having a higher flow resistance than the front air passageway.

10. The autonomous cleaning robot according to any one of the preceding claims, wherein the roller is rotatable such that a portion of its envelope surface facing the surface to be cleaned is moved towards the suction opening.

11. The autonomous cleaning robot according to any of the preceding claims, wherein:

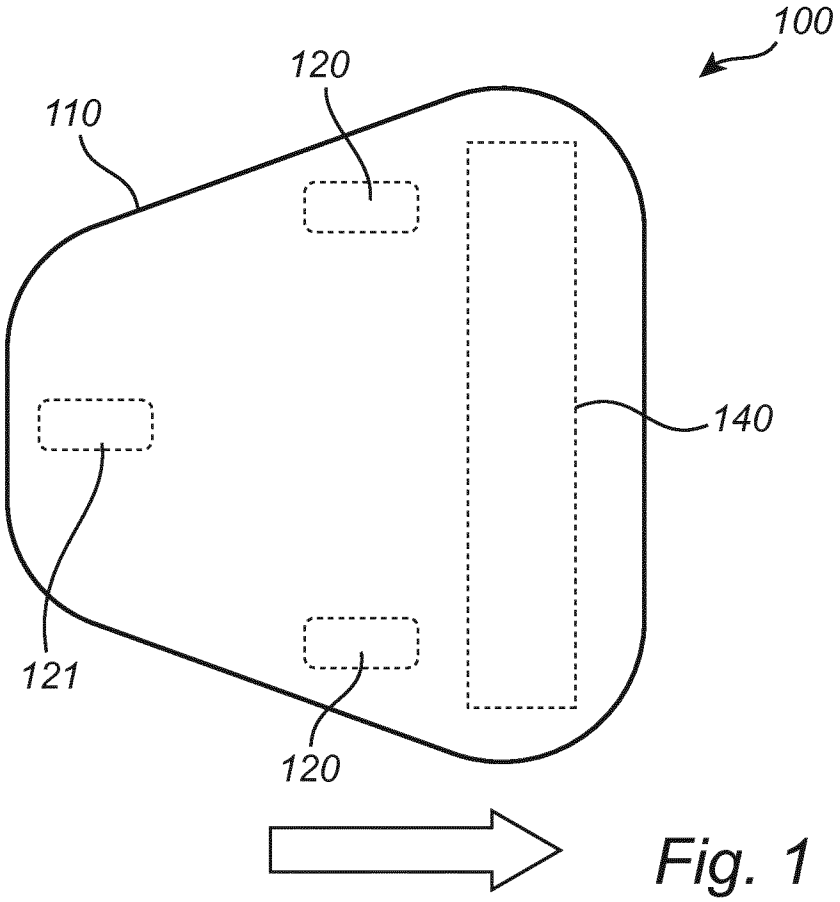
the bristles protrude from a surface of a core of the roller,

the core has a diameter in the range of 8-40 mm, such as 15-25 mm, and

the bristles have a length in the range of 3-15 mm, such as 3-10 mm, such as 3-7 mm.

12. The autonomous cleaning robot according to any of the preceding claims, wherein the roller is arranged in the front third of the body, as seen in the forward direction.

13. An autonomous vacuum cleaning robot for household use according to any of the preceding claims.


100
120
110
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121
120

Fig. 1

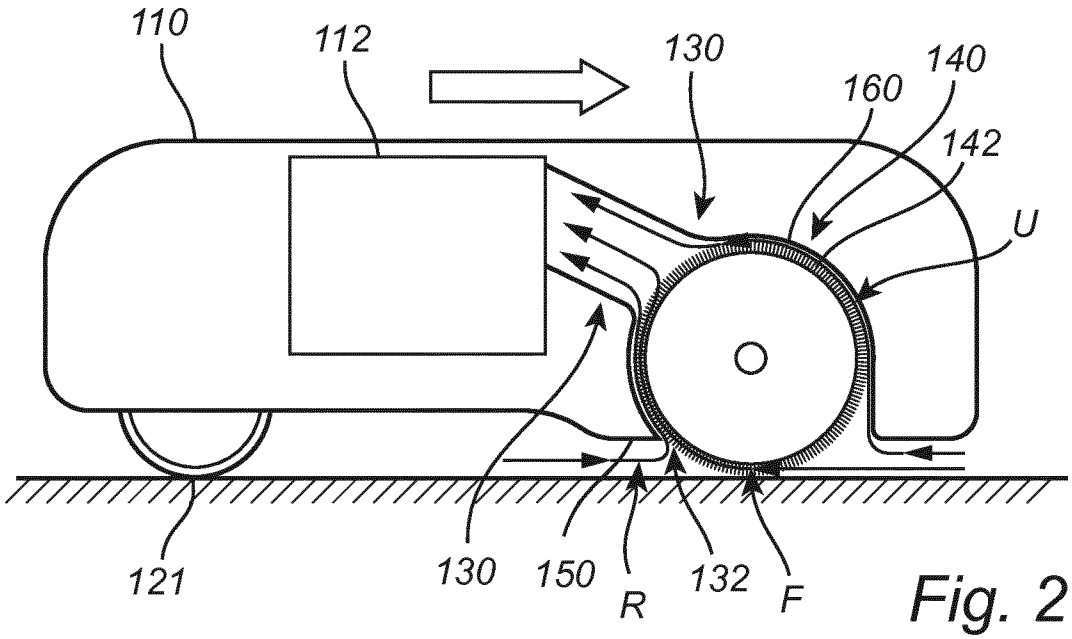
110
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Fig. 2

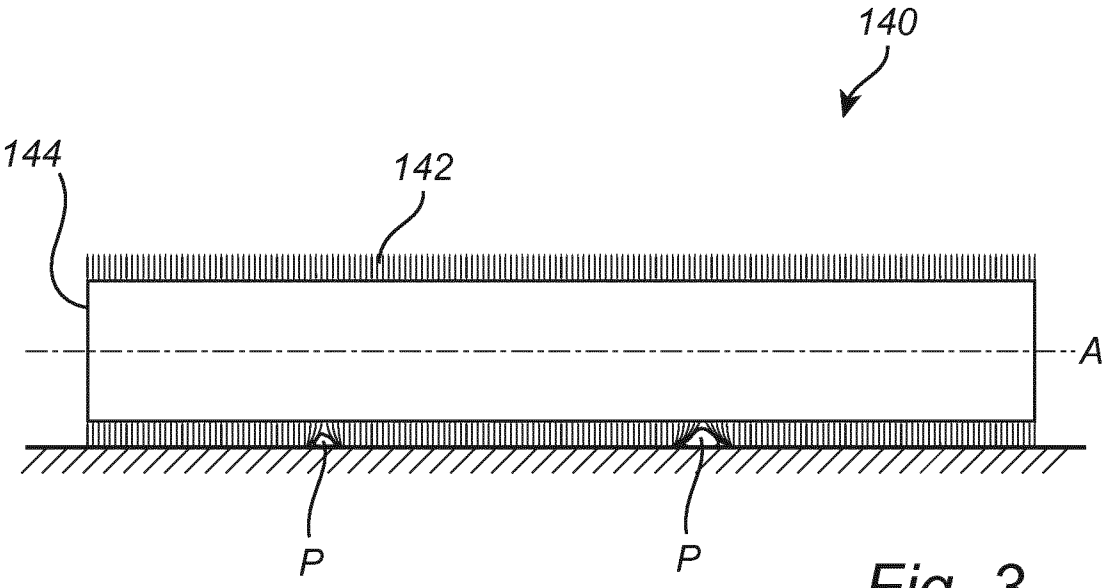

Fig. 3

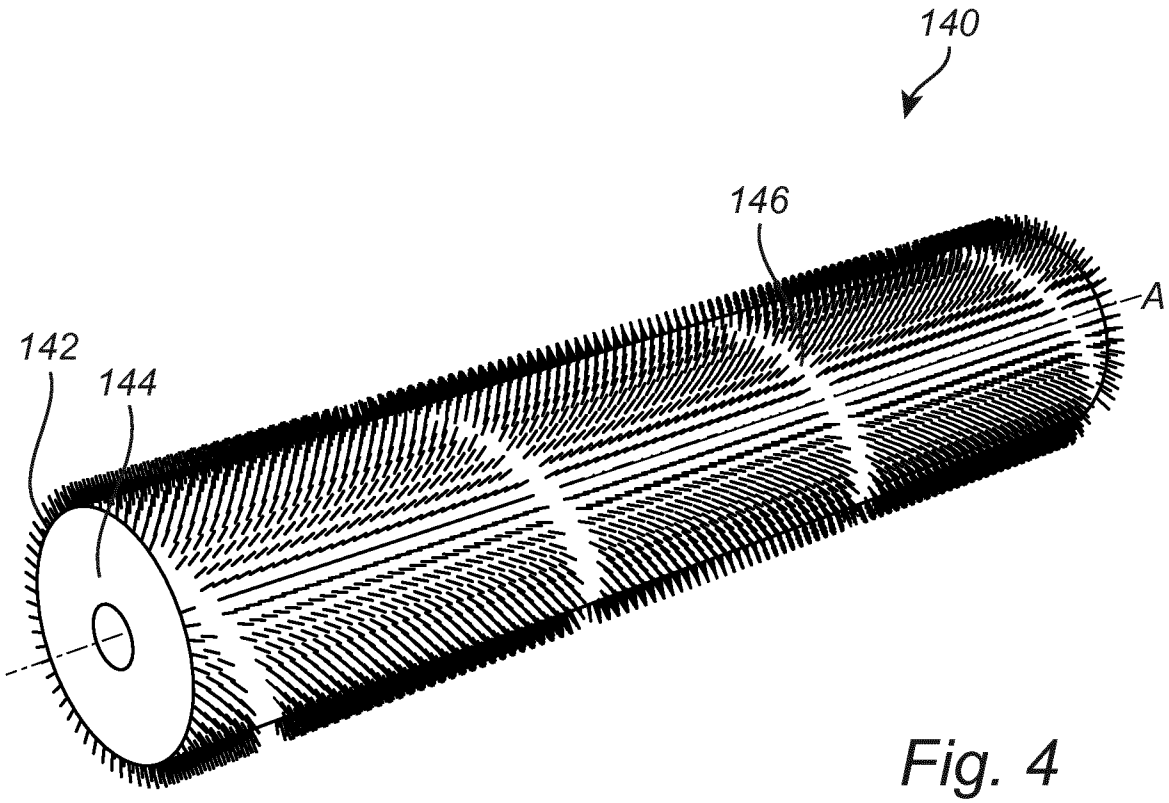

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/073503

A. CLASSIFICATION OF SUBJECT MATTER
INV. A47L9/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A47L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2017/070492 A1 (SHARKNINJA OPERATING LLC [US]) 27 April 2017 (2017-04-27) paragraphs [0028], [0050]; claims 1,4,5,8,11,16-19; figures 2,4,5,6	1-13
X	GB 2 550 180 A (LUPE TECH LTD [GB]) 15 November 2017 (2017-11-15) page 5, lines 10,11; claims 1-8,10,11,13,14,30; figures 4,6,7,8,9 page 9, lines 1-16 page 11, line 19 - page 12, line 6	1-13
A	US 10 271 699 B2 (BEIJING XIAOMI MOBILE SOFTWARE CO LTD [CN] ET AL.) 30 April 2019 (2019-04-30) column 7, lines 28-45; figures 1,2,11,13 column 8, lines 11-20,38-50 column 9, lines 14-23	1-13

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 May 2020	19/05/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Laurim, Jana

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

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