

Description

Title: BRAKE PAD

Technical field

[1] This disclosure lies within the field of brake pads.

5 Prior art

[2] Typically, vehicle braking systems comprise a brake pad which, during braking, presses against a rotating element, thus braking the vehicle. In particular, in rail vehicles such as trains, trams, or subways, braking is achieved using a shoe brake, also called a tread brake or a TBU (Trailer Brake Unit). In this type of brake, the brake pad, also called the wear plate or shoe, presses against a
10 radially outer surface of a moving wheel of the railway vehicle during braking.

[3] The pad of the shoe brake comprises a lining made of friction material. One face of this lining which comes into contact with the wheel during braking, called the friction face, is gradually worn down by abrasion, as is the wheel itself. This generates particles. Since these particles are pollutants, their release into the environment should be limited. For that purpose, the lining is conventionally
15 equipped with a particle collection groove that is fully open on the friction face and extends across almost the entire width of the pad, as described in FR 3087238 A1. This groove is fluidly connected to a negative-pressure source capable of suctioning in the collected particles.

[4] Wear on the friction face allows the pad to fit closely against the shape of the vehicle's wheel. In particular, beyond a certain level of wear, the radius of curvature of the pad matches the radius of
20 curvature of the wheel. Once such a level of wear is reached, the opening of the collection groove on the friction face is therefore completely sealed off by the wheel during braking. This limits the loss of collected particles and therefore improves the suction efficiency.

[5] It is well known that the diameter of the wheel varies over its service life, due to wear and successive reprofiling. In particular, the diameter of a new wheel can be between 50 mm and 150
25 mm larger than the diameter of the same wheel when worn. Furthermore, the lateral position of the wheel relative to the brake pad is specific to each wagon-bogie combination. As a result, it is difficult to design a brake pad that fits perfectly against the shape of the wheel when it is first placed in service. This means that during braking phases, the collection groove is not completely sealed off prior to reaching a minimum level of wear on the friction face. Particles generated during braking phases
30 during contact between the lining and the wheel can therefore escape and pollute the environment.

[6] To overcome this disadvantage, it has been proposed to equip the brake pad with shorter collection grooves. However, reducing the groove size also decreases the efficiency of particle collection within the groove, since a large proportion of the particles are not trapped.

[7] There is therefore a need to design a brake pad capable of collecting and suctioning in most of
35 the particles formed by abrasion during braking phases, while reducing the risk of leakage of the collected particles when the pad does not fit perfectly against the shape of the wheel.

Summary

[8] To this end, a brake pad is proposed, the pad comprising a lining made of friction material and having a friction face intended to come into contact with a rotating element, a leading edge, and a trailing edge, the lining being provided with at least one main collection groove, the pad further comprising at least one suction hole intended to be in fluid communication with the at least one main
5 collection groove, the at least one suction hole also being intended to be connected to a negative-pressure source, wherein the at least one main collection groove comprises a first portion that is open on the friction face and a second portion that is covered by friction material of the friction face.

[9] Because the second portion of the at least one main collection groove is covered by friction material, this second portion of the at least one main collection groove is open on the friction face
10 only after the friction material covering it has been completely worn away by abrasion of the pad in contact with the rotating element during braking phases. In particular, the second portion of the at least one main collection groove is initially buried in the lining. As the friction face of the pad is worn down by contact with the rotating element, the second portion of the main collection groove is exposed and is now open on the friction face. This prevents the second portion of the main collection
15 groove from being open on the friction face before the pad's level of wear is sufficient for the rotating element to seal off the second portion of the at least one main collection groove during braking. This thus reduces the risk of escape, by particles resulting from wear of the pad and rotating element and collected in the at least one main collection groove, through the second portion of the main collection groove before the particles are suctioned by the negative-pressure source. In other words, the at
20 least one main collection groove becomes sealed off earlier than in pads of the prior art. The efficiency of the collection and suctioning of these particles is thus improved, since fewer particles are lost than if the main collection groove were initially completely open to the friction face.

[10] To summarize, the second portion of the groove is covered by friction material of the friction face, which is intended to be rubbed off as the pad wears.

25 **[11]** In the present case, a groove (or groove portion) is an empty volume having a (circumferential) width, a depth at least three times the width, and a length at least five times the width.

[12] The first and second portions of the groove have the same width. Thus, no change in cross-section disrupts the flow of fluid between the first and second portions of the groove. The first and second portions of the groove are directly contiguous and in fluid communication. They form a
30 virtually inseparable unit once the pad has worn down.

[13] In this text, when it is stated that any groove becomes "sealed," this is understood to mean that the groove is closed off by the rotating element when the pad comes into contact with it.

[14] The pad is, for example, a wear plate (or shoe) of a shoe brake (or tread brake, or T.B.U.) of a rail vehicle. Alternatively, the pad may be a brake pad for a road vehicle, or for a stationary machine
35 with a rotor such as a wind turbine, or for an industrial machine.

[15] The pad may further comprise a lining carrier which is shaped to be connected to a brake head, for example via a pin configured to pass through at least one hole provided in the lining carrier. The

lining carrier may be connected to a face of the lining, called the mounting face. The mounting face may be opposite the friction face in a direction substantially perpendicular to the friction face.

[16] The lining carrier may comprise a plate, for example made of metal.

5 **[17]** The depthwise direction of the at least one main collection groove may extend between the friction face and the mounting face. The main collection groove is preferably a blind groove closed off at an end that is opposite, along the direction connecting the friction and mounting faces, to its opening on the friction face.

10 **[18]** The rotating element is, for example, a wheel of a rail vehicle. The rotating element may alternatively be a brake disc. According to one example, the rotating element rotates about an axis of rotation that is substantially perpendicular to a radial direction of the rotating element.

15 **[19]** A radially outer surface of the wheel may have a substantially frustoconical shape. In particular, the diameter of the wheel may gradually increase between an axially inner face and an axially outer face of the wheel. The rotating element may comprise a flange projecting radially from the axially inner face of the wheel. The truncated cone shape and/or the flange reduce the risk of vehicle derailment.

[20] In this text, "axial" is understood to mean in a direction substantially parallel to the axis of rotation of the rotating element, while "radial" is understood to mean any direction substantially perpendicular to the axis of rotation of the rotating element.

20 **[21]** The wheel wears down progressively during the vehicle's travels. The diameter of a new wheel is therefore greater than the diameter of the same wheel when worn.

[22] When the pad is included in a braking system for a rail vehicle, it is configured so that, during braking, it bears against the rotating element in the radial direction of that rotating element.

25 **[23]** In this text, the "leading edge" of the pad means the edge of the pad that is first seen by a specific imaginary point on the rotating element as it rotates about its axis of rotation. Similarly, the "trailing edge" of the pad is understood to be the edge of the pad that is last seen by the specific imaginary point on the rotating element as it rotates about its axis of rotation.

30 **[24]** The suction hole is, for example, a hole passing through the lining between an edge or face thereof and a portion of the at least one main collection groove. Alternatively, the suction hole is, for example, a hole passing through the lining between an edge thereof and a portion of a groove fluidly connected to the at least one main collection groove. In some cases, where several main collection grooves are provided, a respective suction hole is provided for each main collection groove. In other cases, a single suction hole may be provided for the suction of particles from several main collection grooves which are fluidly interconnected.

35 **[25]** The negative-pressure source is, for example, a particle suction system. Communication means, such as a pneumatic hose, may connect the negative-pressure source to the suction hole.

[26] According to one aspect, the friction face may comprise a chamfered edge extending between the leading edge and the trailing edge, the second portion of the at least one main collection groove being located at least partially beneath the chamfered edge.

5 **[27]** The chamfered edge is, for example, located facing the flange of the rotating element. Contact between this chamfered edge and the rotating element generally occurs later than contact between the rest of the pad and the rotating element. Therefore, wear of the chamfered edge begins later than wear of the rest of the pad when the friction face comes into contact with the rotating element. Because the second portion of the at least one main collection groove is located at least partially beneath the chamfered edge, particles collected in the main collection groove are prevented from
10 escaping across the chamfered edge, which is not yet in contact with the rotating element when other parts of the pad are already in contact with that rotating element. At the same time, due to the presence of the second portion, the collection groove extends over a larger surface area.

[28] In one example, the entire second portion of the at least one collection groove is located beneath the chamfered edge.

15 **[29]** The chamfered edge may connect the leading and trailing edges. For example, the chamfered edge may be substantially perpendicular to each of the leading and trailing edges. The leading and trailing edges may, for example, be substantially parallel to each other.

[30] According to one aspect, the lining may comprise a first main collection groove located near the leading edge and a second main collection groove located near the trailing edge.

20 **[31]** In this text, “near the leading/trailing edge” is understood to mean located at a distance from the leading/trailing edge that is less than or equal to 20% of the distance separating the leading and trailing edges, preferably less than or equal to 10% of the distance separating the leading and trailing edges.

25 **[32]** The presence of the first and second main collection grooves near the leading and trailing edges of the pad lining makes it possible, regardless of the direction of rotation of the rotating element, to collect particles resulting from abrasion of the lining and of the rotating element, in at least one collection groove. Suction of the polluting particles is therefore possible regardless of the direction of rotation of the rotating element.

30 **[33]** According to one aspect, the lengthwise dimension of the first main collection groove may extend substantially parallel to the leading edge, and the lengthwise dimension of the second main collection groove may extend substantially parallel to the trailing edge. The first and second collection grooves may thus be respectively adjacent to the leading and trailing edges along their entire length. The lengthwise dimension of each collection groove is understood here to be the dimension of that groove that lies within the plane of the friction face of the lining.

35 **[34]** According to one aspect, the depthwise dimension of the first main collection groove may not be parallel to the leading edge, and the depthwise dimension of the second main collection groove may not be parallel to the trailing edge.

[35] Indeed, in some cases, the first collection groove may not be parallel to the leading edge of the lining along its entire depthwise dimension, and/or the second collection groove may not be parallel to the trailing edge of the lining along its entire depthwise dimension (depthwise dimension being understood here as the dimension of the first and second collection grooves extending from the friction face to the mounting face of the lining). This may occur even when the first collection groove is substantially parallel to the leading edge and/or the second collection groove is substantially parallel to the trailing edge, along their entire lengthwise dimension (understood here, as indicated above, as the dimension of the first and second grooves contained within the plane of the friction face). In this manner, the portions of the lining between the leading edge and the first collection groove, and/or between the trailing edge and the second collection groove, gradually increase between the friction face and the mounting face, thereby reducing stresses on the lining and thus the risk of breakage in these portions. In one non-limiting example, it is possible for the first and second collection grooves not to be parallel to the leading and trailing edges along their entire depthwise dimension when the leading and/or trailing edges are inclined between the friction face and the mounting face of the lining.

[36] According to one aspect, the pad may further comprise a secondary collection groove located between the first and second main collection grooves, the secondary collection groove being at least partially open on the friction face.

[37] The presence of the first and second main collection grooves, and of the secondary collection groove, has the advantage of ensuring that, regardless of the radius of curvature of the lining's friction face, the contact of the lining's friction face with the wheel during braking phases occurs while facing one of the collection grooves. A greater amount of polluting particles emitted by abrasion of the pad and wheel can thus be collected in the collection grooves. Moreover, as indicated above, the presence of the first and second main collection grooves near the leading and trailing edges, respectively, ensures the collection of polluting particles regardless of the wheel's direction of rotation.

[38] The secondary collection groove may be located in a central position on the lining. A "central position" is understood here to mean a position located approximately equidistant from the leading and trailing edges of the lining. Alternatively, the secondary collection groove could be closer to one among the leading or trailing edges of the lining than to the other.

[39] The secondary collection groove may extend substantially parallel to the first and second main collection grooves, but this is not a limitation. For example, the secondary collection groove could be substantially parallel to only one of the two main collection grooves. In another example, the secondary collection groove may extend in a direction that is not parallel to the first or second main collection grooves.

[40] According to one aspect, the secondary collection groove may comprise a first portion that is open on the friction face and a second portion that is covered by friction material of the friction face.

[41] As with the main collection grooves, due to the second portion being covered by friction material, this second portion of the secondary collection groove is open to the friction face only after the friction

material that covers it has been completely worn away by abrasion of the pad in contact with the rotating element during braking phases. In particular, the second portion of the secondary collection groove is initially buried in the lining. As the friction face of the brake pad is worn down by contact with the rotating element, the second portion of the secondary collection groove is exposed and
5 becomes open on the friction face. This prevents the second portion of the secondary collection groove from being open on the friction face before the level of wear of the pad becomes sufficient for the rotating element to seal it off during braking. This thus reduces the risk that particles, originating from wear of the brake pad and rotating element and collected in the secondary collection groove, will escape through the second portion of the groove before being suctioned in by the negative-
10 pressure source. In other words, the secondary collection groove becomes sealed off more quickly. The efficiency of the collection and suctioning of the polluting particles is thus improved, since fewer particles are lost than if the secondary collection groove were initially fully open on the friction face.

[42] The second portion of the secondary collection groove may be entirely beneath the chamfered edge. Alternatively, part of the second portion of the secondary collection groove may be buried in
15 the friction material of the lining's friction face, with the remainder of the second portion of the secondary collection groove being buried beneath the chamfered edge. At a certain level of lining wear, the buried second portion of the secondary collection groove can be exposed, i.e., be open on the lining's friction face.

[43] In some cases, the secondary collection groove is fully open on the lining's friction face even
20 when the pad is new. In such cases, advantageously the secondary collection groove is shorter, for example, no part of it extends into the chamfered edge.

[44] Of course, the lining may comprise a plurality of secondary collection grooves as described herein.

[45] According to one aspect, the secondary collection groove is fluidly connected to the first main
25 collection groove and to the second main collection groove.

[46] According to one example, channels may be provided within the lining, fluidly connecting the secondary collection groove to the first main collection groove and to the second main collection groove. Alternatively, the secondary collection groove may extend so as to be directly connected to the first main collection groove and to the second main collection groove.

[47] According to one aspect, the pad further comprises a first transverse collection groove fluidly
30 connecting the first main collection groove to the secondary collection groove, and a second transverse collection groove fluidly connecting the second main collection groove to the secondary collection groove.

[48] By means of these transverse collection grooves, the entire length of the lining between the first
35 main collection groove and the second main collection groove can be traversed by at least one collection groove, thereby increasing the amount of polluting particles resulting from abrasion of the lining and wheel that are collected in the collection grooves. This reduces the amount of polluting particles released into the environment.

5 **[49]** According to one aspect, the first transverse collection groove is at least partially open on the friction face and extends obliquely between the first main collection groove and the secondary collection groove, and the second transverse collection groove is at least partially open on the friction face and extends obliquely between the second main collection groove and the secondary collection groove.

10 **[50]** In this text, when it is stated that the transverse collection grooves extend “obliquely,” it is understood that they form a non-zero, non-right angle with each of the grooves that they connect. In the current case, the first transverse collection groove forms a non-zero, non-right angle with the first main collection groove and the secondary collection groove, while the second transverse collection groove also forms a non-zero, non-right angle with the second main collection groove and the secondary collection groove.

[51] The fact that the first and second transverse collection grooves extend obliquely allows the radially outer surface of the wheel to wear evenly during braking, without generating areas of excess thickness on this radially outer surface, as will be described in more detail below.

15 **[52]** The first transverse collection groove may extend between one end of the first main collection groove, located next to the axially outer edge of the lining, and one end of the secondary collection groove, located next to the chamfered edge.

20 **[53]** The second transverse collection groove may extend between one end of the second main collection groove, located next to the axially outer edge of the lining, and the end of the secondary collection groove, located next to the chamfered edge.

[54] The first and second transverse collection grooves may be open on the friction face along their entire length. However, it is possible to have buried portions in each of the first and second transverse collection grooves.

25 **[55]** According to one aspect, the pad comprises a single suction hole with its mouth being in one among the secondary collection groove, the first main collection groove, and the second main collection groove.

30 **[56]** Thus, from a single suction hole, it is possible to suction in the particles collected in the secondary collection groove, first main collection groove, and second main collection groove. Manufacture of the pad is thereby facilitated. Moreover, the overall size of the assembly formed by the negative-pressure source, the communication means, and the pad is reduced.

[57] According to one non-limiting example, the suction hole is arranged at one end of one of the main collection grooves or of the secondary collection groove. This thus concentrates the suction of particles at that end. According to one example, the mouth of the suction hole is at the end of the secondary collection groove that is next to the axially outer edge of the lining.

35 **[58]** The suction hole is arranged, for example, in the pad lining so as to fluidly connect one of the collection grooves to the external environment.

[59] According to another example, an individual suction hole may be provided for each of the main collection grooves and for the secondary collection groove. This configuration is particularly useful when the main and secondary collection grooves are not fluidly interconnected, but it could also be used when all the collection grooves are fluidly interconnected. According to one non-limiting
5 example, the individual suction hole is located at one end of the respective collection groove, thus concentrating the particle suction at that end.

[60] In some cases, the lining may further comprise at least one orifice that passes through the chamfered edge. Each orifice may open into one of the main collection grooves or into the secondary collection groove. A flow of air can thus enter the collection grooves through the orifice. By the action
10 of the negative-pressure source, this flow then circulates through the collection grooves until it reaches the suction hole and the pneumatic hose, thereby allowing the particles collected in the lining's collection grooves to be evacuated. Due to this or these orifices, the particle suction performance is independent of the lining's level of wear.

Brief description of drawings

[61] Other features, details and advantages will become apparent from the detailed description below, and from an analysis of the accompanying drawings, in which:

Fig. 1

[62] [Fig. 1] shows a schematic perspective view of a braking system according to one exemplary embodiment.

Fig. 2

[63] [Fig. 2] shows a schematic side view of a brake assembly of the braking system of FIG. 1.

Fig. 3

[64] [Fig. 3] shows a schematic front view of details of the braking system of FIG. 1.

Fig. 4A

[65] [Fig. 4A] shows a schematic side view of a rotating element and a brake pad of the braking system of FIG. 1, in a first configuration.

Fig. 4B

[66] [Fig. 4B] shows a schematic side view of a rotating element and a brake pad of the braking system of FIG. 1, in a second configuration.

Fig. 5A

[67] [Fig. 5A] shows a schematic perspective view of a brake pad of the braking system of FIG. 1, according to a first exemplary embodiment.

Fig. 5B

[68] [Fig. 5B] shows a schematic cross-section view of the pad of FIG. 5A.

Fig. 6

[69] [Fig. 6] shows a schematic perspective view of a brake pad in the braking system of FIG. 1, according to a second exemplary embodiment.

Fig. 7

5 [70] [Fig. 7] shows a schematic perspective view of a brake pad in the braking system of FIG. 1, according to a third exemplary embodiment.

Fig. 8

[71] [Fig. 8] presents a table schematically showing an area of contact of the friction face for different types of brake pads, including the pads in the examples of FIGS. 5A to 7, for a first level of wear of
10 these pads according to whether a rotating element of the braking system in FIG. 1 is new or worn.

Fig. 9

[72] [Fig. 9] presents the table of FIG. 8 for a higher level of brake pad wear than in FIG. 8.

Fig. 10

[73] [Fig. 10] presents the table of FIGS. 8 and 9 for a higher level of brake pad wear than in FIG. 9.

15 **Fig. 11**

[74] [Fig. 11] presents the table of FIGS. 8, 9 and 10 for a higher level of brake pad wear than in FIG. 8.

Fig. 12

[75] [Fig. 12] shows a graph representing, for the case where the rotating element of the braking
20 system is new, an evolution in the cumulative efficiency of the particle suction as a function of the pad service life for the types of pads presented in FIGS. 8 to 11.

Fig. 13

[76] [Fig. 13] shows a graph representing, for the case where the rotating element of the braking
25 system is worn, an evolution in the cumulative efficiency of the particle suction as a function of the pad service life for the types of pads presented in FIGS. 8 to 11.

Description of embodiments

[77] FIG. 1 shows an example of a braking system 10 for a vehicle, in particular a rail vehicle (train, tram, subway, etc.). The braking system 10 comprises a rotating element 12 and a brake assembly 14.

30 [78] The rotating element 12 corresponds to a part of the vehicle that causes translational movements of the vehicle by means of a rotational movement of this element 12 about an axis of rotation. In the case here, the rotating element 12 is a wheel of the vehicle, configured to rotate about an axis of rotation A.

[79] Advantageously, a radially outer surface 16 of the wheel 12 has a substantially frustoconical shape. In particular, the diameter of the wheel 12 gradually increases between an axially inner face 13A and an axially outer face 13B of the wheel 12. In this text, the axial direction corresponds to any direction substantially parallel to the axis of rotation A, and the radial direction corresponds to any direction substantially perpendicular to the axis of rotation A. Such a frustoconical shape of the radially outer surface 16 makes it possible to ensure that the wheel 12 is self-centering during the vehicle's translational movement, and limits the risk of derailment on curves in its path.

[80] As can be seen in FIG. 1, the wheel 12 may also comprise a flange 17 projecting radially from the axially inner face 13A of the wheel 12. Such a flange 17 also reduces the risk of derailment of the vehicle.

[81] When the vehicle is moving, the wheel 12, and in particular its radially outer surface 16, is gradually worn down. The diameter of the new wheel 12 therefore differs from the diameter of the worn wheel 12. Generally, the diameter of the new wheel 12 is larger than the diameter of the worn wheel 12. For example, the diameter of the new wheel 12 may be between 50 mm and 150 mm larger than the diameter of the same wheel 12 when worn. According to one non-limiting example, the diameter of the new wheel 12 is 860 mm, while the diameter of the worn wheel 12 is 790 mm.

[82] The brake assembly 14 comprises a brake pad 18, also called a wear plate or shoe. The pad 18 comprises a lining 20 made of friction material. The lining 20 comprises a first face, called the friction face 22A, arranged radially facing the radially outer surface 16 of the wheel. The friction face 22A is substantially curved. When the brake pad is new, the friction face 22A has a radius of curvature R1 (FIGS. 4A and 4B).

[83] As will be detailed below, the friction face 22A is intended to come into contact with a portion of the radially outer surface 16 of the wheel 12 during the vehicle's braking phases. Generally, when the pad 18 is new, the radius of curvature R1 of the friction face 22A is different from a radius of curvature R2 of the portion of the radially outer surface 16 of the wheel 12 which the friction face 22A bears against during braking phases. Therefore, when the pad 18 is new, the entire friction face 22A is not in contact with the radially outer surface 16. When the radius of curvature R1 of the friction face 22A is greater than radius of curvature R2, as illustrated in FIG. 4A, only a central portion of the friction face 22A is in contact with the radially outer surface 16, the ends of the friction face 22A being at a distance from the radially outer surface 16. Conversely, when the radius of curvature R1 of the friction face 22A is less than radius of curvature R2, as illustrated in FIG. 4B, the central portion of the friction face 22A is at a distance from the radially outer surface 16, while the ends of the friction face 22A bear against the radially outer surface 16.

[84] In the following, the radius of curvature R1 of the friction face 22A is considered to be greater than radius of curvature R2, although this is not a limitation.

[85] The lining 20 comprises a second face 22B, called the mounting face, that is opposite the friction face 22A. In particular, the friction face 22A and the mounting face 22B are opposite one another in the axial direction.

[86] The lining 20 further comprises an axially inner edge 22C, an axially outer edge 22D, a leading edge 22E, and a trailing edge 22F. The edges 22C, 22D, 22E, and 22F extend substantially radially between the friction face 22A and the mounting face 22B.

5 **[87]** The axially inner edge 22C and the axially outer edge are opposite in the axial direction. These edges 22C and 22D interconnect the leading edge 22E and the trailing edge 22F.

[88] As can be seen in FIG. 3, the axially inner edge 22C is axially facing the flange 17 when the pad 18 is in contact with the wheel 12. As can be seen from this figure, the axially inner edge 22C may be chamfered.

10 **[89]** The leading edge 22E and the trailing edge 22F are defined in relation to the direction of rotation of the wheel 12. In the example in FIG. 1, it is assumed that the wheel 12 is rotating in a direction R about the axis A. The leading edge 22E corresponds to the edge of the lining 20 that is seen first by a specific imaginary point P on the wheel 12 as it rotates about its axis of rotation A in direction R, while the trailing edge 22F corresponds to the edge of the lining 20 that is seen last by the specific point P as the wheel 12 rotates about its axis of rotation A in direction R. Of course, the direction of
15 rotation R could be opposite to what is indicated in FIG. 1, which would reverse the position of the leading edge 22E and trailing edge 22F.

[90] As will be described in more detail below, the lining 20 comprises at least one particle collection groove.

20 **[91]** The brake assembly 14 may further comprise a lining carrier 24, visible in particular in FIG. 2. The lining carrier 24 may comprise a plate, for example made of metal. The lining carrier 24 is connected, directly or indirectly, to the mounting face 22B of the lining 20.

[92] The brake assembly 14 may also be equipped with a brake head 28. The brake head 28 is connected to the lining carrier 24. In particular, as can be seen in FIG. 2, the brake head 28 may comprise a pin 30 shaped to pass through at least one orifice provided in the lining carrier 24. Thus,
25 by means of this pin 30, the pad 18 is secured to the brake head 28.

[93] The brake assembly 14 is configured to move the brake head 28, and therefore the pad 18, substantially radially. During the vehicle's braking phases, the brake assembly 14 is configured to move the pad 18 in a direction that brings it closer to the wheel 12, until the friction face 22A and the radially outer surface 16 of the wheel 12 come into contact, as can be seen in FIG. 3. Once the
30 braking phase is over, the brake assembly 14 is configured to move the pad 18 in a direction that distances it from the wheel 12, so that contact ceases between the friction face 22A and the radially outer surface 16 of the wheel 12. Indeed, outside of braking phases, the brake pad 18 and the wheel 12 are apart from each other, as illustrated in FIG. 1.

35 **[94]** When the friction face 22A of the pad 18 and the radially outer surface 16 of the wheel 12 come into contact during braking phases, the wheel 12 is in the process of rotating about axis A. A friction force is thus produced between the friction face 22A and the radially outer surface 16, causing wear on both the lining 20 of the brake pad 18 and on the radially outer surface 16 of the wheel 12. Particles, which are usually polluting particles, are thus formed by the abrasion of the friction material of the

lining 20 and the wheel 12. During this wear, the friction face 22A of the lining 20 is reshaped to fit against the radially outer surface 16 of the wheel 12. The initial radius of curvature R1 of the friction face 22A therefore changes progressively, due to wear of the lining 20.

5 **[95]** In the following, the term “break-in period” refers to the period in the service life of the pad 18 during which less than 90% of the friction face 22A is in contact with the wheel 12 when the vehicle is braking.

10 **[96]** As indicated above, the lining 20 comprises at least one particle collection groove. Each collection groove is at least partially open on the friction face 22A, as will be detailed below. Each collection groove extends depthwise between the friction face 22A and the mounting face 22B. Each collection groove is preferably blind at an end that is opposite its opening on the friction face 22A. Furthermore, each collection groove is shaped to collect the polluting particles resulting from wear of the lining 20 and wheel 12, thereby preventing these particles from being released into the environment.

15 **[97]** Several particular possible shapes for the at least one particle collection groove will now be described with reference to FIGS. 5A to 7. Of course, this is not an exhaustive list of these shapes.

[98] In FIG. 5A, the lining 20 comprises a first main collection groove 30 and a second main collection groove 32.

20 **[99]** The first main collection groove 30 is arranged near the leading edge 22E. For example, the first main collection groove 30 is substantially parallel to the leading edge 22E. The second main collection groove 32 is arranged near the trailing edge 22F. For example, the second main collection groove 32 is substantially parallel to the trailing edge 22F. As stated above, “near the leading/trailing edge” is understood to mean “at a distance from the leading/trailing edge that is less than or equal to 20% of the distance between the leading and trailing edges, preferably less than or equal to 10% of the distance between the leading and trailing edges.”

25 **[100]** The presence of the main collection grooves 30, 32 near the leading edge 22E and trailing edge 22F makes it possible to ensure the collection of polluting particles, regardless of the direction of rotation of the wheel 12.

30 **[101]** As shown in FIG. 5B, each main collection groove 30, 32 comprises a first portion 34 that is open on the friction face 22A and a second portion 36 that is covered by friction material of the friction face 22A. The second portion 36 of each groove 30, 32 is therefore buried in the lining when the brake pad 18 is new or only slightly worn. As will be explained in detail below, once the brake pad 18 reaches a certain level of wear, the second portion 36 of each groove 30, 32 is uncovered, i.e. it is also open on the friction face 22A.

35 **[102]** In the non-limiting example of FIGS. 5A and 5B, the second portion 36 of each main collection groove 30, 32 is located beneath the chamfered edge 22C, but this is not limiting. For example, alternatively, part of the second portion 36 could be buried under the friction material of the friction face 22A, with the remainder of the second portion 36 being buried under the chamfered edge 22C.

[103] The lining 20 of the pad 18 according to the example in FIG. 6 comprises the first and second main collection grooves 30, 32, and a secondary collection groove 38.

[104] The secondary collection groove 38 is located between the first main collection groove 30 and the second main collection groove 32. In one non-limiting example, the secondary collection groove 38 is situated in a central position of the lining. As indicated above, "central position" is understood here to mean a position located approximately equidistant between the leading edge 22E and trailing edge 22F of the lining 20. Of course, the secondary collection groove 38 could be closer to one among the leading edge 22E or trailing edge 22F than to the other.

[105] In FIG. 6, the secondary collection groove 38 extends substantially parallel to the main collection grooves 30, 32, but this is not a limitation. For example, the secondary collection groove could be substantially parallel to only one of the two grooves 30, 32, or could extend in a direction that is not parallel to the main collection grooves 30, 32.

[106] The secondary collection groove 38 may comprise a first portion that is open on the friction face 22A, similar to the first portion 34 of the main collection grooves 30, 32. Collection groove 38 may further comprise a second portion covered by friction material, similar to second portion 36 of the main collection grooves 30, 32. The second portion of the secondary collection groove 38 may be located entirely beneath the chamfered edge 22C. Alternatively, part of the second portion of the secondary collection groove 38 may be buried under the friction material of the friction face 22A, the remainder of the second portion of the secondary collection groove 38 being buried under the chamfered edge 22C. As with the second portion 36 of the main collection grooves 30, 32, at a certain level of wear on the pad 18, the second portion of the secondary collection groove 38 is uncovered, i.e., it also is open on the friction face 22A. This will be explained in more detail below.

[107] In some cases, the secondary collection groove 38 is fully open on the friction face 22A even when the pad 18 is new. In such cases, the secondary collection groove 38 advantageously is shorter; for example, it has no portion extending into the chamfered edge 22C.

[108] It should be noted that although in FIG. 6 only one secondary collection groove 38 is shown, the lining 20 could comprise a plurality of secondary collection grooves 38 as described above.

[109] The presence of the main collection grooves 30, 32 and the secondary collection groove 38 offers the advantage of ensuring that, regardless of the radius of curvature of the friction face 22A of the brake pad, the contact of the friction face 22A with the wheel 12 during braking occurs while facing one of the grooves 30, 32, or 38. A greater amount of polluting particles emitted by the abrasion of the brake pad 18 and wheel 12 can thus be collected in the grooves 30, 32, or 38. Moreover, as previously stated, the presence of the main collection grooves 30, 32 near the leading edge 22E and trailing edge 22F makes it possible to ensure the collection of polluting particles regardless of the direction of rotation of the wheel 12.

[110] In certain cases, the secondary collection groove 38 is fluidly connected to the first main collection groove 30 and to the second main collection groove 32. For this purpose, in the non-limiting

example of FIG. 7, a first transverse collection groove 40 and a second transverse collection groove 42 are provided in the lining 20.

5 [111] The first transverse collection groove 40 fluidly connects the first main collection groove 30 and the secondary collection groove 38. In the non-limiting example of FIG. 7, the first transverse collection groove 40 extends between one end of the first main collection groove 30, located next to the axially outer edge 22D of the lining 20, and one end of the secondary collection groove 38, located next to the chamfered edge 22C. The first transverse collection groove 40 thus extends obliquely between the first main collection groove 30 and the secondary collection groove 38.

10 [112] The second transverse collection groove 42 fluidly connects the second main collection groove 32 and the secondary collection groove 38. In the non-limiting example of FIG. 7, the second transverse collection groove 42 extends between one end of the second main collection groove 32, located next to the axially outer edge 22D of the lining 20, and the end of the secondary collection groove 38 located next to the chamfered edge 22C. The second transverse collection groove 42 thus extends obliquely between the second main collection groove 32 and the secondary collection
15 groove 38.

[113] The first transverse collection groove 40 and the second transverse collection groove 42 are advantageously open on the friction face 22A. In the non-limiting example of FIG. 7, the first and second transverse collection grooves 40, 42 are open along their entire length on the friction face 22A. However, it is possible to provide buried portions in each of the first and second transverse
20 collection grooves 40, 42.

[114] Due to the presence of the transverse collection grooves 40, 42, the entire length of the lining 20 between the main collection grooves 30, 32 is traversed by at least one particle collection groove. This increases the surface area of the lining that is occupied by collection grooves, thereby increasing the amount of polluting particles collected in the grooves and thus not released into the environment.

25 [115] The fact that the first and second transverse collection grooves 40, 42 extend obliquely is also advantageous. In particular, as mentioned above, during braking phases, the radially outer surface 16 of the wheel 12 wears concurrently with the wear of the lining 20. The portion of the radially outer surface 16 of the wheel 12 that is directly facing one of the collection grooves at any given moment during braking is not wearing at that moment. Indeed, each collection groove forms a recess in the
30 friction face 22A. Each collection groove therefore prevents friction forces from occurring between the friction face 22A and the radially outer surface 16 of the wheel 12. If the transverse collection grooves 40, 42 connected the main collection grooves 30, 32 and the secondary collection groove 38 in a direction tangential to the portion of the radially outer surface 16 that is in contact with the lining 20 during braking phases, an annular portion of the radially outer surface 16 of the wheel 12
35 would never be in contact with the friction material of the friction face 22A. Eventually, the radially outer surface 16 of the wheel 12 would have an excess thickness in this annular portion relative to the rest of the radially outer surface 16 of the wheel 12. Such excess thickness can damage the rail on which the wheel 12 travels, and/or can cause the vehicle to derail. In the current case, due to the oblique transverse collection grooves 40, 42, it is ensured that the contact time with any portion of

the radially outer surface 16 of the wheel 12 is negligible compared to the time such a portion is in contact with the friction material of the lining 20. The wheel 12 is thus worn uniformly, which prevents the formation of areas of excess thickness on its radially outer surface 16.

5 **[116]** In order to suction in the polluting particles collected in each groove 30, 32, 38, 40, 42, the pad 18 further comprises at least one suction hole, not visible in the figures. This suction hole is arranged in the lining 20 of the pad 18 so as to fluidly connect one of the collection grooves 30, 32, 38, 40, 42 to the external environment.

10 **[117]** In one example, an individual suction hole may be provided for each of the main collection grooves 30, 32 and for the secondary collection groove 38. This configuration is implemented in particular when the main 30, 32 and secondary 38 collection grooves are not fluidly connected, as is the case in the embodiments shown in FIGS. 5A and 6. Advantageously, but without this being a limitation, the individual suction hole is arranged at an end of the respective collection groove 30, 32, 38, thereby concentrating the suction of particles at that end.

15 **[118]** In another example, the pad 18 comprises a single suction hole with its mouth being in one of the main collection grooves 30, 32 or in the secondary collection groove 38. This configuration is particularly useful when the main collection grooves 30, 32 and the secondary collection groove 38 are fluidly connected, as in the example shown in FIG. 7. Advantageously, but without this being a limitation, the suction hole is arranged at an end of one of the main collection grooves 30, 32 or of the secondary collection groove 38. This thus concentrates the suction of particles at that end. In
20 one example, the mouth of the suction hole is at the end of the secondary collection groove 38 that is next to the axially outer edge 22D of the lining 20.

25 **[119]** Each suction hole is intended to be connected to a negative-pressure source (not shown). The negative-pressure source is, for example, a particle suction system. Connection means 44, visible in FIG. 1, may connect the negative-pressure source to the corresponding suction hole. The particles collected in the collection grooves 30, 32, 38, 40, 42 can thus be suctioned. The connection means 44 comprise, for example, a pneumatic hose.

30 **[120]** As can be seen in FIGS. 5A, 6 and 7, the lining 20 may further comprise at least one orifice 46 which passes through the chamfered edge 22C. In particular, each orifice 46 passes through the chamfered edge 22C and leads to one of the main collection grooves 30, 32 or to the secondary collection groove 38. A flow of air can thus enter the grooves 30, 32, or 38 through the orifice 46. By the action of the negative-pressure source, this flow then circulates through the collection grooves until it reaches the suction hole and the hose 44, thereby allowing the particles collected in the collection grooves of the lining 20 to be evacuated. Due to this or these orifices 46, the particle suction performance is independent of the level of wear of the lining 20.

35 **[121]** As indicated above, the friction face 22A is substantially curved. However, the radius of curvature R1 of the friction face 22A when the pad 18 is new is generally different from the radius of curvature R2 of the portion of the radially outer surface 16 which the friction face 22A bears against during braking phases, whether the wheel is new or worn. The surface area of the friction face 22A

that comes into contact with the wheel 12 during braking phases increases as the lining wears, which, as indicated above, causes the friction face 22A to gradually fit against the shape of the wheel.

[122] FIGS. 8 to 11 schematically show the area of contact of the friction face 22A of the pad 18 against the wheel 12 during braking phases, for four different levels of wear of the friction face 22A as a function of:

- the type of grooves arranged in the lining 20; and
- whether the wheel 12 is new or worn.

[123] As indicated above, we assume here that the radius of curvature R1 of the friction face 22A is greater than the radius of curvature R2 of the portion of the wheel 12 which the pad 18 bears against during braking phases. Therefore, as long as the friction face 22A does not match the shape of this portion of the wheel 12, the central portion of the friction face 22A bears against the wheel while its ends remain free.

[124] Each of these figures includes a table that has five rows X and three columns Y. The table in each FIG. 8 to 11 thus includes fifteen cells XY.

[125] Each row X corresponds to a type of pad 18 analyzed according to the type of grooves arranged in the lining 20. The column Y=A represents the type of pad 18 studied. Also, as shown in cells 1A to 5A:

- row X=1 corresponds to prior art pads that comprise two grooves at the ends which extend across almost the entire width of the pad 18 and that are fully open on the friction face starting from the very beginning of the service life of the pad 18;
- row X=2 corresponds to prior art pads that comprise two grooves at the ends which are shorter than in the example of row 1 and that are fully open on the friction face starting from the very beginning of the service life of the pad 18;
- row X=3 corresponds to pads as described above with reference to FIGS. 5A and 5B (i.e., pads comprising the two main collection grooves 30, 32);
- row X=4 corresponds to pads as described above with reference to FIG. 6 (i.e., pads comprising the two main collection grooves 30, 32 and the secondary collection groove 38); and
- row X=5 corresponds to pads as described above with reference to FIG. 7 (i.e., pads comprising the two main collection grooves 30, 32 and the secondary collection groove 38 which are interconnected by transverse collection grooves 40, 42).

[126] Column Y=N shows, for each of these types of pads 18, the area of contact of the friction face 22A with the wheel 12 during the vehicle's braking phases when the wheel 12 is new. Column Y=U shows, for each of these types of pads 18, the area of contact of the friction face 22A with the wheel 12 during the vehicle's braking phases when the wheel 12 is worn.

[127] The differences between FIGS. 8, 9, 10, and 11 are due to the fact that in each of these figures, the level of wear on the friction face 22A is different, this level of wear increasing from FIG. 8 to FIG. 11.

- [128]** Columns Y=N and Y=U in FIG. 8 represent the area of contact of the friction face 22A that bears against the radially outer surface 16 of the new (Y=N) or worn (Y=U) wheel as of the first contact of the pad 18 with the wheel 12. In other words, in FIG. 8, the friction face 22A is not worn before the contact between the friction face 22A and the wheel 12.
- 5 **[129]** FIGS. 9, 10, and 11 represent the area of contact of the friction face 22A on the radially outer surface 16 of the new (Y=N) or worn (Y=U) wheel at different levels of wear of the friction face 22A. The level of wear of the friction face 22A increases between FIG. 9 and FIG. 11, with FIG. 10 corresponding to the friction face 22A having an intermediate level of wear between that of FIG. 9 and that of FIG. 11.
- 10 **[130]** In these FIGS. 8 to 11, the hatched areas correspond to the areas of the friction face 22 where the polluting particles generated during braking can be collected in the collection grooves for suctioning when the wheel 12 rotates in a first direction. The unhatched areas correspond to the areas of the friction face 22 where the polluting particles generated during braking are mostly released into the environment and are therefore not suctioned in when the wheel 12 rotates in this
- 15 first direction. It should be noted that if the wheel 12 were rotating in a second direction, opposite to the first, the hatched and unhatched areas would be reversed in comparison to those in FIGS. 8 to 11.
- [131]** Reference is now made to FIG. 8, which, as indicated above, corresponds to the first contact of a new pad with the wheel 12.
- 20 **[132]** As can be seen in cells 1N, 2N, 1U, and 2U, during this first contact, the pads with grooves according to the prior art have an area of contact of the friction face 22A with the new (cells 1N and 2N) or worn (cells 1U and 2U) wheel 12 that does not include any portion of the collection grooves. Therefore, the polluting particles generated during this first contact are mostly, if not entirely, released into the environment.
- 25 **[133]** In the case of the pad 18 shown in FIGS. 5A and 5B, the area of contact of the friction face 22A with the new (cell 3N) or worn (cell 3U) wheel 12 is similar to that of the pads of the prior art. Indeed, the area of contact of the friction face 22A with the wheel 12 does not include any portion of the main collection grooves 30, 32. Therefore, the polluting particles generated during this initial contact are mostly, if not entirely, released into the environment.
- 30 **[134]** The situation is different for pads 18 with collection grooves arranged according to the examples in FIGS. 6 and 7 described above. In these examples, secondary collection grooves 38 are provided. As indicated above, such secondary collection grooves 38 are arranged on a central portion of the friction face 22A. Thus, during the initial contact of the friction face with the wheel 12, a portion of the secondary collection groove 38 is within the area of contact of the friction face 22A
- 35 on the new (cells 4N and 5N) or worn (cells 4U and 5U) wheel 12. This portion of the collection groove 38 is thus sealed off by the radially outer surface 16 of the wheel 12. This allows the collection, in the secondary collection groove 38, of polluting particles generated by the portion of the area of contact of the friction face 22A that is located in front of the sealed-off portion of the secondary

collection groove 38 (relative to the directions of rotation R of the wheel). This portion of the area of contact, from which the generated particles can be collected in the secondary collection groove 38, is indicated by hatching in cells 4N, 5N, 4U, and 5U.

5 [135] It should be noted, however, that the area of contact of the friction face 22A with the wheel 12 does not include the entire secondary collection groove 38, due to the frustoconical shape of the radially outer surface of the wheel 12. Therefore, negative pressure is not established uniformly in the secondary collection groove 38 during this initial contact, since ambient air is able access it through the unsealed portion of the groove 38. In the example shown in FIG. 7, ambient air is also able to access the sealed portion of the groove 38 through the main collection grooves 30, 32 and
10 the transverse grooves 40, 42, with which the secondary collection groove 38 is fluidly connected. Therefore, some of the polluting particles collected in the secondary collection groove 38 are ultimately released into the environment before being suctioned in. For example, when a portion of the sealed groove, in this case the secondary collection groove 38, is not sealed, the percentage of particles collected in that groove that are ultimately suctioned in may be between 30% and 60%, or
15 between 35% and 50%. For example, this percentage may be approximately 40%.

[136] Reference is now made to FIG. 9, in which the level of wear of the friction face 22A is greater than that shown in FIG. 8.

[137] In the case of pads having grooves according to the prior art, the area of contact of the friction face 22A with the new wheel 12 (cells 1N and 2N) now comprises a portion of the collection grooves
20 which are arranged at the ends of these pads according to the prior art. This portion of the collection grooves is therefore sealed off by the radially outer surface 16 of the wheel 12. This allows collecting, from the collection grooves in the ends of the pad, polluting particles generated by the portion of the area of contact of the friction face 22A that is located in front of the portion of sealed-off collection grooves, in the direction of rotation R of the wheel. This portion of the area of contact corresponds
25 to the hatched area in cells 1N and 2N. However, as explained above for cells 4N, 5N, 4U, and 5U in FIG. 8, since the collection grooves at the ends of these pads are not completely sealed off in the prior art, negative pressure is not established uniformly in these grooves, and some of the collected particles are ultimately released into the environment through the unsealed portion of the grooves. The percentage of collected particles that are ultimately suctioned in may therefore be between 30%
30 and 60%, or between 35% and 50%. For example, this percentage may be substantially equal to 40%.

[138] It should be noted that with the level of level shown in FIG. 9, when the pads according to the prior art come into contact with a worn wheel, the intended collection grooves are not included in the area of contact between the friction face 22A and the wheel 12 (see cells 1U and 2U). Therefore, at
35 this level of wear on the friction face 22A and when the wheel is worn, the polluting particles generated by abrasion of the friction face 22A and wheel are largely, if not entirely, released into the environment.

[139] In the case of the pad 18 according to FIGS. 5A and 5B, the area of contact between the friction face 22A and the new (cell 3N) or worn (cell 3U) wheel 12 is similar to that of the pads of the prior

art. Thus, in the case of the new wheel, a portion of the area of contact of the friction face 22A comprises a portion of the main collection grooves 30, 32, which makes it possible to collect particles originating from the hatched area of cell 3N. However, not all of the main collection groove 30, 32 is sealed off by the wheel 12. Therefore, negative pressure is not established uniformly in these grooves
5 30, 32, and consequently, some of the collected particles are ultimately released into the environment through the unsealed off portion of the grooves 30, 32. The percentage of collected particles that is ultimately suctioned in may thus be between 30% and 60%, or between 35% and 50%. For example, this percentage may be substantially equal to 40%. In the case of the worn wheel, the area of contact of the friction face 22A does not comprise any portion of the main collection grooves 30, 32. As a
10 result, the polluting particles generated by abrasion of the friction face 22A and worn wheel are largely, if not entirely, released into the environment.

[140] For the example in FIG. 6, the situation is the same as for the level of wear in FIG. 8, but since the area of contact between the friction face 22A and the wheel 12, whether new or worn, is larger, the portion of the secondary collection groove 38 that is sealed off by the radially outer surface 16 of
15 the wheel 12 is also larger. This allows more polluting particles to be collected in the secondary collection groove 38. As in the previous cases, the collected polluting particles originate from the portion of the area of contact of the friction face 22A that is located in front of the sealed-off portion of the secondary collection groove 38, in the direction of rotation R of the wheel (hatched area in FIGS. 4N and 4U). However, the secondary collection groove 38 is not completely sealed off, so the
20 negative pressure inside is not uniform. This results in the percentage of collected particles actually suctioned in being within the ranges indicated above (30% to 60%, or 35% to 50%, for example 40%).

[141] For the example in FIG. 7, when the friction face 22A comes into contact with the worn wheel 12, the situation concerning the level of wear of the friction face 22A in FIG. 9 is similar to the situation with the level of wear in FIG. 8, but with a larger area of contact (see cell 5U). A larger portion of the
25 secondary collection groove 38 is thus sealed off. The portion of the area of contact of the friction face 22A from which the generated particles can be collected in the groove 38 is therefore larger (see the hatched area in cell 5U). The total amount of particles collected in the secondary collection groove 38 is therefore greater than that shown in FIG. 8. However, since the secondary collection groove 38 is still not completely sealed off, the percentage of particles collected in the groove 38 that
30 is actually suctioned in falls within the ranges indicated above (30% to 60%, or 35% to 50%, for example 40%).

[142] In the case of contact between the pad in FIG. 7 and the new wheel, the area of contact is also larger at the level of wear in FIG. 9 than in FIG. 8. As can be seen in cell 5N, the area of contact now comprises not only a portion of the secondary collection groove 38, but also a portion of the main
35 collection grooves 30, 32 and a portion of the transverse collection grooves 40, 42. The portion of the area of contact of the friction face 22A for which the generated particles can be collected in the grooves 30, 32, 38, 40, 42 is therefore larger and corresponds to the hatched area in cell 5N. However, since it is still the case that none of the grooves 30, 32, 38, 40, 42 are completely sealed

off, the percentage of particles collected in groove 38 that are actually suctioned in falls within the ranges indicated above (30% to 60%, or 35% to 50%, for example 40%).

[143] Reference is now made to FIG. 10, in which the level of wear of the friction face 22A is greater than in FIG. 9.

5 **[144]** In the case of the prior art pads in row X=1 of the table (corresponding to those comprising two grooves at the ends which extend over almost the entire width of the pad), the area of contact between the friction face 22A and the new wheel 12 is such that the grooves in the pad ends are completely sealed off except for their end located at the chamfered edge of the pad. Particles from the entire hatched area in cell 1N can therefore be collected in the grooves at the pad ends, but some
10 are released into the environment through the unsealed end before being suctioned in. The percentage of particles collected in the grooves at the pad ends that are actually suctioned in is therefore within the ranges indicated above (30% to 60%, or 35% to 50%, for example 40%).

[145] When the wheel is worn, the area of contact of the prior art pads in row X=1 still does not include the collection grooves at the pad ends (cell 1U). Therefore, at this level of wear on the friction
15 face 22A and when the wheel is worn, the polluting particles generated by abrasion of the friction face 22A and wheel are mostly, if not entirely, released into the environment.

[146] In the case of the prior art pads in row X=2 of the table (corresponding to those comprising two grooves, shorter than those in row X=1), the area of contact between the friction face 22A and the wheel comprises the entirety of the grooves at the pad ends (cell 2N). The grooves are thus at
20 a uniform negative pressure, and there is very little risk of leakage of the particles collected in the grooves. When the collection grooves are completely sealed off, the percentage of particles collected in the grooves that are actually suctioned in is between 80% and 100%. For example, the percentage of particles collected in the grooves that are actually suctioned in is 90%.

[147] When the wheel is worn, the area of contact of the prior art brake pads in row X=2 still does
25 not include the collection grooves at the pad ends (cell 2U). Therefore, at this level of wear of the friction face 22A and when the wheel is worn, the polluting particles generated by abrasion of the friction face 22A and wheel are largely, if not entirely, released into the environment.

[148] In the examples in FIGS. 5A to 7, when the friction face 22A makes contact with the new wheel, the entire first portion 34 of the main collection grooves 30, 32, and possibly the secondary groove
30 38, as well the entirety of the transverse collection grooves 40, 42, are sealed off by the wheel (cells 3N, 4N, and 5N). It should be noted that at the level of wear shown in FIG. 10, the second portion 36 of the grooves, which comprises a buried portion, has not yet been exposed. Thus, all grooves 30, 32, 38, 40, 42 are at a uniform negative pressure, and the risk of leakage of particles collected in the grooves 30, 32, 38, 40, 42 is greatly reduced. As indicated above, when the grooves are completely
35 sealed off, the percentage of particles collected in the grooves that are actually suctioned in is between 80% and 100%. For example, the percentage of particles collected in the grooves that are actually suctioned in is 90%.

[149] For the example in FIG. 5A, when the friction face 22A makes contact with the worn wheel, the area of contact of the friction face 22A still does not include the collection grooves 30, 32 (cell 3U). Therefore, at this level of wear on the friction face 22A and when the wheel is worn, the polluting particles generated by abrasion of the friction face 22A and wheel 12 are largely, if not entirely, released into the environment.

[150] For the example in FIG. 6, when the friction face 22A makes contact with the worn wheel, the area of contact of the friction face 22A is similar to that at the level of wear in FIG. 9, but with a larger area of contact (see cell 4U). This therefore seals off a larger portion of the secondary collection groove 38. The portion of the area of contact of the friction face 22A from which generated particles can be collected in groove 38 is therefore larger (see the hatched area in cell 4U). The total amount of particles collected in the secondary collection groove 38 is therefore greater than that in FIG. 9. However, since the secondary collection groove 38 is still not completely sealed off, the proportion of particles collected in the groove 38 that are actually suctioned in falls within the ranges indicated above (30% to 60%, or 35% to 50%, for example 40%).

[151] For the example in FIG. 7, when the friction face makes contact with the worn wheel, the area of contact of the friction face 22A comprises not only the secondary collection groove 38, but also the transverse collection surfaces 40, 42 (cell 5U). However, the main collection grooves 30, 32, which are fluidly connected to the transverse collection grooves 40, 42 and the secondary groove 38, are not included in this area of contact. Therefore, although the main collection groove 38 and the transverse collection grooves 40, 42 are completely sealed off, ambient air is able to enter these grooves via the unsealed main collection grooves 30, 32. Negative pressure is therefore not established uniformly in grooves 38, 40, and 42, and some of the collected particles may thus escape through the main collection grooves 30 and 32. Consequently, the percentage of particles collected in groove 38 that are actually suctioned in falls within the ranges indicated above (30% to 60%, or 35% to 50%, for example 40%).

[152] Reference is now made to FIG. 11, in which the level of wear of the friction face 22A is greater than that in FIG. 10. At this level of wear, whether the wheel is new or worn and for all types of brake pads presented in rows X=1 to X=5, the collection grooves provided in the lining are completely sealed off by the wheel 12 during braking phases. Indeed, at this level of wear, the friction face 22A already fits perfectly against the shape of the wheel 12. Particles from the entire friction surface 22A can therefore be collected in the collection grooves. Since the grooves are completely sealed off, the percentage of collected particles actually suctioned in is between 80% and 100%. For example, the percentage of particles collected in the grooves that are actually suctioned in is 90%.

[153] The graph in FIG. 12 shows, for the case where the wheel 12 is new, the evolution in the cumulative particle suctioning efficiency (y axis) as a function of the wear rate of the pad 18, in particular its lining 20 (x axis). The graph in FIG. 13 shows this same evolution but for the case where the wheel 12 is worn.

[154] In these two graphs, curve 50 represents this evolution for the pads of the prior art in row X=1 in the tables of FIGS. 8 to 11. Curve 52 represents this evolution for the pads of the prior art in row

X=2 in the tables of FIGS. 8 to 11. Curve 54 represents this evolution for the pads according to the example in FIG. 5A. Curve 56 represents this evolution for the pads according to the example in FIG. 6. Curve 58 represents this evolution for the pads according to the example in FIG. 7.

5 **[155]** From the graph in FIG. 12, it can be deduced that the linings 20 with buried grooves, such as those in the examples in FIGS. 5A to 7, are very effective at the beginning of the service life of the lining 20 when the wheel 12 is new. Indeed, until 10% of the service life of the lining 20, the suction efficiency increases very rapidly, reaching 70%. Then, between 10% and 30% of the service life of the lining 20, the suction efficiency continues to increase, but more slowly, to reach 75%. Beyond 30% of the service life of the lining, the suction efficiency is maintained at around 75%. In the graph
10 in FIG. 12, curves 54, 56, and 58 are coincident, which shows that all the examples in FIGS. 5A to 7 have similar efficiencies.

[156] From the graph in FIG. 12, it can also be deduced that the use of short grooves such as those of the prior art in row X=2 in FIGS. 8 to 11 has, at the beginning of the lining's service life and when the wheel is new, a particle suction efficiency similar to that of the linings 20 with buried grooves in
15 FIGS. 5A to 8. Indeed, until 10% of the lining's service life, curve 52 follows the trend of curves 54, 56, and 58, and reaches 70% efficiency. However, beyond 10% of the lining's service life, the suction efficiency decreases compared to the linings 20 having buried grooves. This is due to the fact that the short grooves of the prior art have a constant size throughout their service life. These short grooves may be similar in size to the first portion 34 of the grooves having buried portions of FIGS.
20 5A to 7. Therefore, as long as the lining with short grooves according to the prior art has not worn down on the portion of the lining which does not include grooves, the suction efficiency is the same as in the linings 20 having buried grooves. However, once wear begins on these ungrooved portions, in the case of the pad with short grooves according to the prior art, the particles generated by wear of this portion are neither collected nor suctioned in (since, as indicated in this prior art case, pad
25 wear does not change the size of the collection grooves). Conversely, in the case of the linings 20 having buried grooves, wear of the pad 18 leads to exposing the second portions 36 of the grooves with buried portions. Thus, in the linings 20 according to FIGS. 5A to 7, the size of the collection grooves increases during wear of the pad 18, which allows collecting more particles as the lining wears. These reasons explain why the suction efficiency decreases beyond 10% of the service life
30 of pads having short grooves according to the prior art, while it continues to increase for the pads with buried grooves of FIGS. 5A to 7.

[157] Finally, the graph in FIG. 12 shows that when the wheel is new, the use of a pad of the prior art having long grooves, such as those in row X=1 of FIGS. 8 to 11, is more efficient than the use of short grooves such as those in row X=2 of FIGS. 8 to 11, beyond 70% of the service life of the lining.
35 Indeed, prior to 70% of the service life of the lining, the ends of the long grooves of the prior art are not sealed off during braking phases, which allows the particles collected in the grooves to escape. Conversely, in the short grooves of the prior art, the grooves become sealed off more quickly. However, as explained above, beyond 10% of the service life of the lining, the worn surface area of the lining increases, but the short grooves of the prior art do not increase in size, resulting in a

significant release of particles into the environment. In the case of the long grooves of the prior art, these grooves are not sealed off prior to 70% of the service life of the lining. However, beyond 70% of the service life of the lining, the ends of these long grooves begin to be sealed off by the wheel during braking phases, thus increasing suction efficiency.

5 **[158]** From the graph in FIG. 13, it can be deduced that, when the wheel is worn, the linings comprising at least the main collection grooves 30, 32 and the secondary collection groove 38, such as the examples in FIGS. 6 and 7, have a higher suction efficiency compared to the linings lacking a secondary collection groove 38. Moreover, for the initial 30% of the service life of the lining, the lining 20 comprising transverse collection grooves 40, 42 which connect the main collection grooves 30,
10 32 to the secondary collection groove 38 has the best efficiency among the different types of lining analyzed. Beyond 30% of the service life of the lining, the suction efficiency is similar for the lining according to the example in FIG. 6 and for the lining 20 according to the example in FIG. 7.

15 **[159]** This disclosure is not limited to the examples of brake pads that are described above, which are merely illustrative, but encompasses all variations conceivable to a person skilled in the art within the context of the protection sought. For example, according to one variation, not shown, the friction face of the pad lining could have two different radii of curvature. For example, the friction face could have a smaller first radius of curvature in the center and a larger second radius of curvature at the ends. This reduces the break-in period.

Claims

- [Claim 1]** A brake pad (18), the pad (18) comprising a lining (20) made of friction material and having a friction face (22A) intended to come into contact with a rotating element (12), a leading edge (22E), and a trailing edge (22F), the lining being provided with at least one main collection groove (30, 32), the pad (18) further comprising at least one suction hole intended to be in fluid communication with the at least one main collection groove (30, 32), the at least one suction hole also being intended to be connected to a negative-pressure source, wherein the at least one main collection groove (30, 32) comprises a first portion (34) that is open on the friction face and a second portion (36) that is covered by friction material of the friction face (22A).
- 5
- [Claim 2]** Brake pad (18) according to claim 1, wherein the friction face (22A) comprises a chamfered edge (22C) extending between the leading edge (22E) and the trailing edge (22F), the second portion (36) of the at least one main collection groove (30, 32) being located at least partially beneath the chamfered edge (22C).
- 10
- [Claim 3]** Brake pad (18) according to claim 1 or 2, wherein the lining (20) comprises a first main collection groove (30) located near the leading edge (22E) and a second main collection groove (32) located near the trailing edge (22F).
- 15
- [Claim 4]** Brake pad (18) according to claim 3, wherein the lengthwise dimension of the first main collection groove (30) extends substantially parallel to the leading edge (22E), and the lengthwise dimension of the second main collection groove (32) extends substantially parallel to the trailing edge (22F).
- 20
- [Claim 5]** Brake pad (18) according to claim 3 or 4, further comprising a secondary collection groove (38) located between the first main collection groove (30) and the second main collection groove (32), the at least one secondary collection groove (38) being at least partially open on the friction face (22A).
- 25
- [Claim 6]** Brake pad (18) according to claim 5, wherein the secondary collection groove (38) comprises a first portion that is open on the friction face (22A) and a second portion that is covered by friction material of the friction face (22A).
- [Claim 7]** Brake pad (18) according to any one of claims 5 to 7, wherein the secondary collection groove (38) is fluidly connected to the first main collection groove (30) and to the second main collection groove (32).
- 30
- [Claim 8]** Brake pad (18) according to any one of claims 5 to 8, further comprising a first transverse collection groove (40) fluidly connecting the first main collection groove (30) to the secondary collection groove (38), and a second transverse collection groove (42) fluidly connecting the second main collection groove (32) to the secondary collection groove (38).
- 35
- [Claim 9]** Brake pad (18) according to claim 8, wherein the first transverse collection groove (40) is at least partially open on the friction face (22A) and extends obliquely between the first main collection groove (30) and the secondary collection groove (38), and the second transverse collection

groove (42) is at least partially open on the friction face (22A) and extends obliquely between the second main collection groove (32) and the secondary collection groove (38).

[Claim 10] Brake pad (18) according to any one of claims 7 to 9, comprising a single suction hole with its mouth being in one among the secondary collection groove, the first main collection
5 groove, and the second main collection groove.

[Claim 11] Brake pad (18) according to any one of claims 3 to 10, wherein the depthwise dimension of the first main collection groove (30) is not parallel to the leading edge (22E), and the depthwise dimension of the second main collection groove (32) is not parallel to the trailing edge (22F).