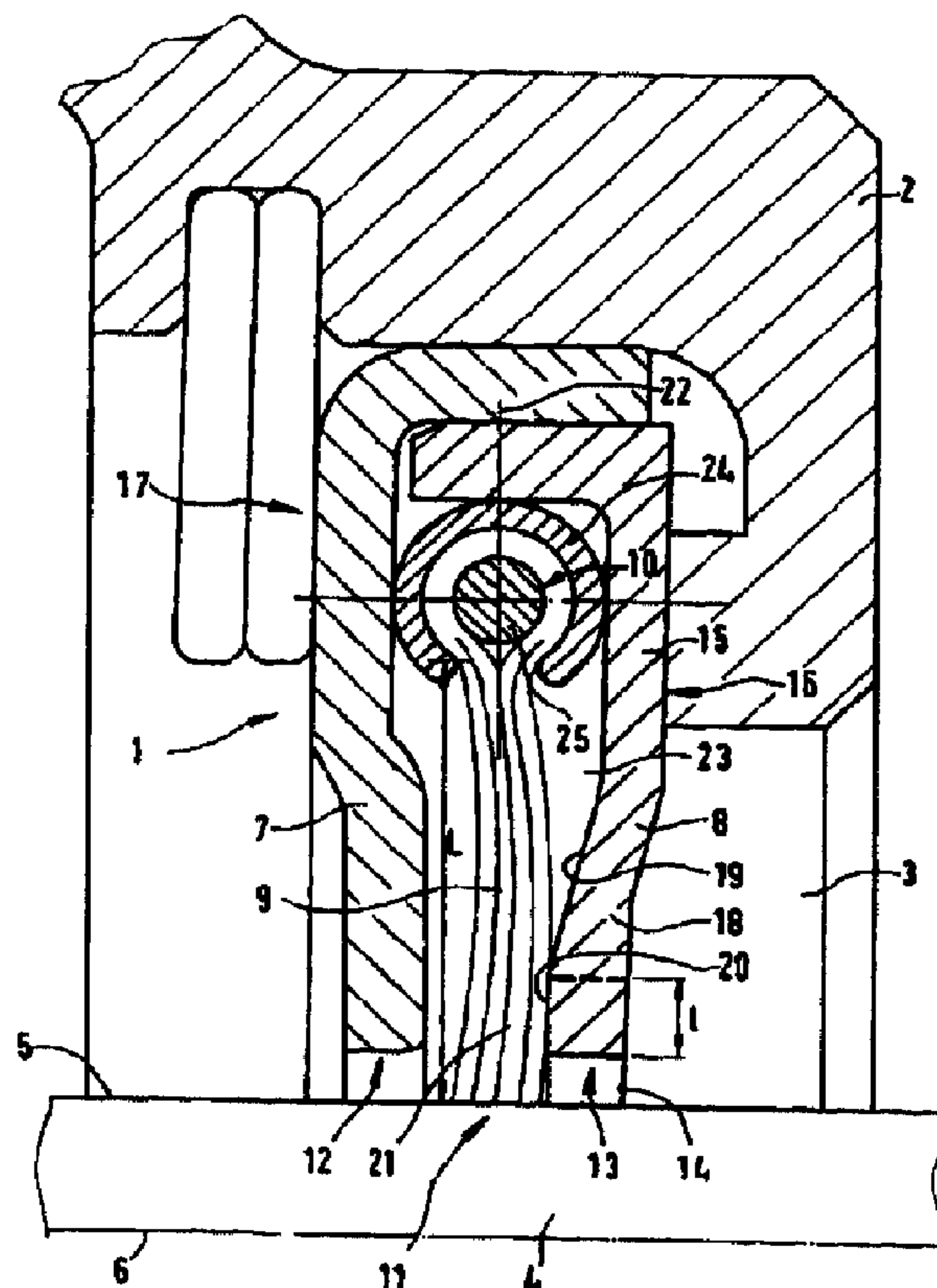




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(57) Abrégé/Abstract:

The invention relates to a brush-hair seal for sealing a rotor against an enclosure having a bore for the rotor to extend therethrough and comprising a front plate and a bearing plate affixed thereto. A multitude of brush hair is maintained between the front plate and the bearing plate in such a way that the hair free ends emerge above an inner edge of the bearing plate, thus touching a rotor surface. The bearing plate inner edge is not very far from the surface, and the bearing plate prevents said hair from completely bending back. Said bearing plate (8) is designed in such a way that the hair (9) must take their bearing by their free ends (21) on a bearing segment (20), while the resting length extends at a distance from the bearing plate (8).



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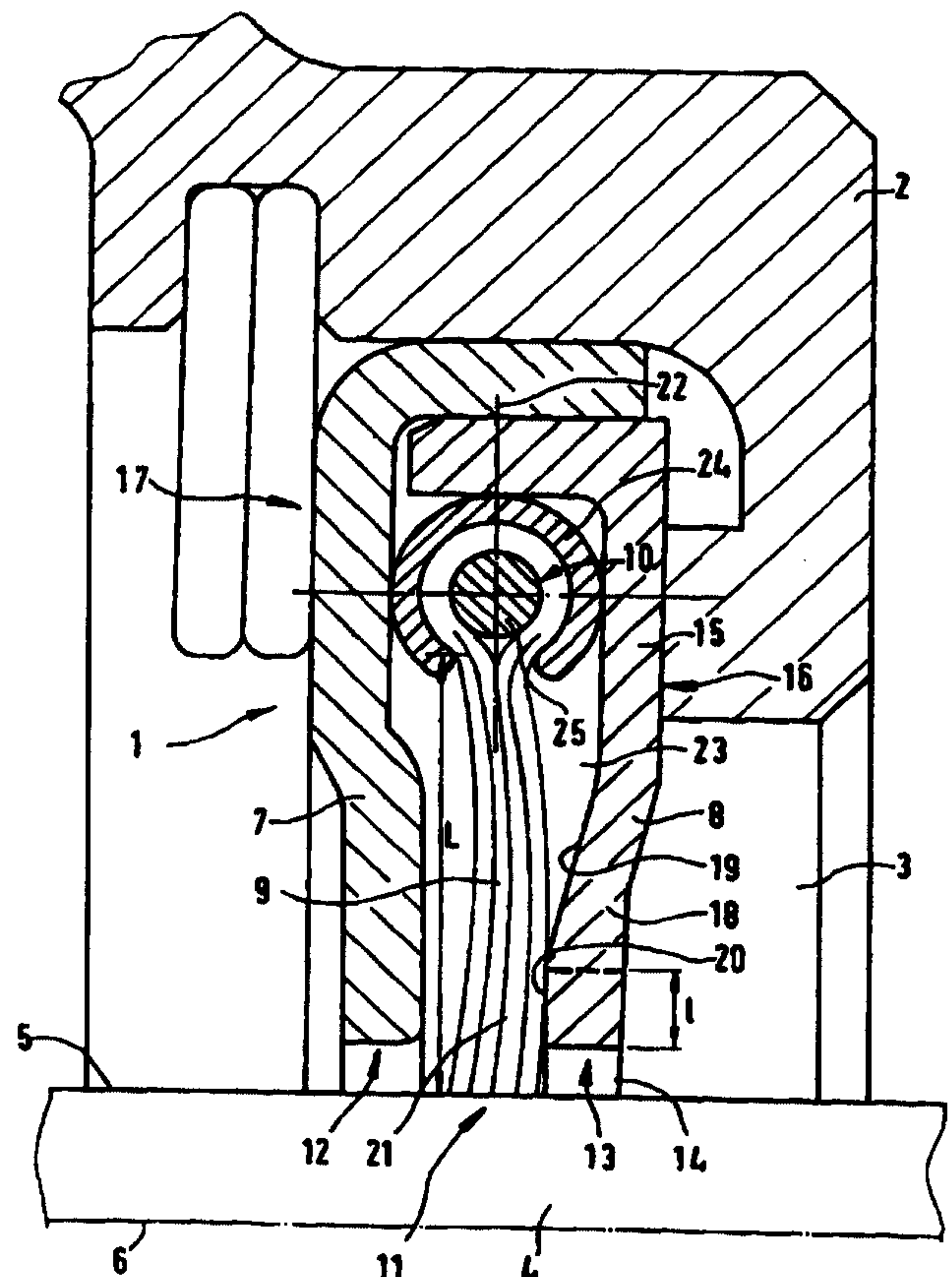
(54) Bezeichnung: BÜRSTENDICHTUNG

(57) Abstract

The invention relates to a brush-hair seal for sealing a rotor against an enclosure having a bore for the rotor to extend therethrough and comprising a front plate and a bearing plate affixed thereto. A multitude of brush hair is maintained between the front plate and the bearing plate in such a way that the hair free ends emerge above an inner edge of the bearing plate, thus touching a rotor surface. The bearing plate inner edge is not very far from the surface, and the bearing plate prevents said hair from completely bending back. Said bearing plate (8) is designed in such a way that the hair (9) must take their bearing by their free ends (21) on a bearing segment (20), while the resting length extends at a distance from the bearing plate (8).

(57) Zusammenfassung

Bürstendichtung zum Abdichten eines Rotors gegen ein Gehäuse mit einer Bohrung, durch das sich der Rotor erstreckt, mit einer Frontplatte und einer Stützplatte, die an dem Gehäuse angebracht sind und zwischen denen eine Vielzahl von Borsten so gehalten sind, daß sie mit ihren freien Enden über eine Innenkante der Stützplatte vorstehen und eine Oberfläche des Rotors berühren, wobei die Innenkante der Stützplatte einen geringen Abstand zu der Oberfläche aufweist und die Stützplatte die Borsten gegen eine Durchbiegung stützt, wobei die Stützplatte (8) so ausgebildet ist, daß die Borsten (9) mit ihren Endabschnitten (21) an einem Stützabschnitt (20) der Stützplatte (8) abzustützen sind und sich über ihre restliche Länge (L-l) mit Abstand zur Stützplatte (8) erstrecken.



BRUSH SEAL

The invention is directed to a brush seal.

Such brush seals are utilized, for example, in gas turbines in order to seal the interspace between a housing and a rotor rotating at a comparatively high speed against leakage. In general, this ensues in the presence of hot, pressurized gas. Since no satisfactory sealing effect can be achieved under these conditions with simple rubber ring seals, numerous, different brush seals have been developed. Given these seals, the ends of the bristles that are combined to form a dense bristle packet project beyond the inside edge of an inside bore of the supporting plate and thus seal an interspace - to be kept optimally small - between the inside edge of the supporting plate and the rotor surface. This interspace is always present, since the dimensions of the seal, of the housing and of the rotor can change due to thermal stresses or, respectively, expansions or the like, and a minimum play between the supporting plate and the rotor dare not be downwardly transgressed for safety reasons.

When a great difference pressure is adjacent at the seal, then the supporting plate arranged at the low-pressure side supports the bristles to prevent sagging toward the low-pressure side in a direction proceeding parallel to the rotor axis. A sagging of the bristles is opposed because this reduces their length and, thus, opens the interspace between the inside edge of the supporting plate and the rotor surface, which leads to an increase of leakage. A sagging of the projecting bristle ends, however, cannot be avoided.

What is meant above and below by an axial direction is a direction proceeding parallel to the longitudinal axis of the rotor, and what is meant by a radial direction or, respectively, plane is a direction proceeding or, respectively, a plane extending perpendicular to the longitudinal axis thereof.

WO-A-86/05252 discloses a brush seal with a multitude of bristles in a holder for sealing two spaces differing in pressure, whereby the bristles are

directed at an angle β of 5° through 45° by setting means for improving the sealing effect toward the side of the higher pressure. When a difference pressure is adjacent, the bristles are pressed against the sealing surface from the side of higher pressure, which, on the one hand, leads to a dependable sealing effect and, on the other hand, however, leads to considerable wear of the bristles.

DE 3907 614 A1 discloses a brush seal wherein the bristles are clamped in a slotted tube that is clamped between two support ring [sic] joined to form a housing, whereby the inside edge of the of the support ring at the high-pressure side comprises a greater spacing from the surface of a rotor than the inside edge of the support ring at the low-pressure side. A special design of the support ring at the low-pressure side adapted to the bristles is not disclosed, nor is a setting of the bristles.

EP 0 778 431 A1 discloses a brush sea; wherein a support element arranged between the bristles -- which are not set relative to the radial direction -- and the low-pressure side is fashioned such that a chamber is present between the bristles and the support element, this chamber being supplied with fluid, whose pressure is higher than that at the low-pressure side, in order to increase the restoring force.

EP 0 617 216 A1 discloses a brush seal means with a support plate comprising a recess, the bristles being placed against the free end section thereof after being charged with pressure.

Given a brush seal disclosed by EP 0 453 315, the entire supporting plate serves as supporting surface against which the bristles - except for their projecting ends - lie over their entire, remaining length. For improving the sealing effect, the inside edge of an inside bore of the supporting plate is provided with an erodible material layer in order to lengthen the supporting surface and support the bristles close to their tips and to simultaneously reduce the interspace between the supporting plate and the rotor.

What proves disadvantageous given this seal, however, particularly given a differential pressure adjacent thereto, is that the bristles can deflect radially outward given an excursion of the rotor that, for example, can occur

due to thermal stresses or, respectively, expansions, but remain in this position even after return of the rotor into the central position as a consequence of arrow dynamic effects. As a result of the lateral deflection of the bristles, the interspace between the supporting plate and the rotor is opened, so that the leakage noticeably increases. It is known that the bristles thereby adhere to the supporting plate and move back into their original position only after being completely relieved, i.e. a differential pressure of approximately zero, and close or, respectively, seal the interspaces.

The invention has an object of improving a brush seal of the species initially cited such that a good sealing effect is also achieved given high difference pressures and excursions of the rotor.

The invention provides a brush seal received in a bore of a housing for forming a seal between the bore and a rotor extending therethrough, the seal comprising a front panel and a supporting plate being spaced apart, each of the front panel and supporting plate having a bore with an annular inside edge, the supporting plate having an inside surface facing the front panel, the inside surface having an annular supporting surface adjacent the inside edge extending in a radial plane relative to a longitudinal axis of the rotor, the inside surface of the plate having an inward section inclined relative to the radial plane, a plurality of bristles being held between the front panel and the supporting plate to be inclined to the radial plane with a free end of the bristles extending inwardly beyond the inside edge of the supporting plate and the bristles being supported on the supporting section with an interspace between the remaining length of the bristles and the inside surface of the plate.

Deriving therefrom is the advantage that the brushes only have their end sections supported at the supporting surface, as a result whereof their flexibility is noticeably increased even given high difference pressures. Since the bristles exhibit their maximum flexibility in their end section remote from

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the clamping location and, moreover, are continuously excited to vibrations by the flowing leakage air, the bristles follow the rotor motion, i.e. they are laterally outwardly pressed given the excursion thereof and return into their original position immediately after the return of the rotor in to the central position. Moreover, the flowing leakage air forms an air pillow in the interspace between the bristles and the supporting plate, this reducing the friction between the bristles and the supporting surface and opposing an adhesion of the bristles to the supporting plate.

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The bristles are inclined toward the supporting plate relative to a radial plane, i.e. a plane proceeding radially relative to the longitudinal rotor axis, so that a defined seating of the end sections of the bristles at the supporting section can be achieved. The bristles preferably slant at an angle of approximately 6° .

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In another preferred development, the supporting plate, proceeding from the clamping region of the bristles, extends with an axial spacing from the bristles and, adjoining the inside edge of an inside bore in the supporting plate, comprises a region slanting toward the bristles at whose inner lateral surface a supporting section is fashioned at which the end sections of the bristles are to be supported.

It is advantageous that the length of the end sections of the bristles to be supported at the supporting section amounts to at most one-fourth of their total length, since the bristles exhibit their maximum flexibility in these end sections remote from the clamping region, so that the bristles, despite seating against the supporting section, immediately spring back here into their original position after a deflection motion.

It is also advantageous that the inside edge of the front panel comprises a greater spacing from the surface of the rotor than the inside edge of the supporting plate. Although only a small interspace likewise exists between the inside edge of the front panel and the surface of the rotor, greater manufacturing tolerances can be allowed. As a result thereof, what is referred to as the "blow down" effect is minimized, and no increased wear of the bristles occurs. Moreover, the bristles are thereby protected against damage during mounting/demounting and are also protected against damage due to air turbulence.

The bristles are preferably clamped at one side between the front panel and the supporting plate, so that they can be held in a simple way with different attack or, respectively, inclination angles relative to a radial plane between the front panel and the supporting plate.

It is expedient to arrange a clamp member in the clamping region between the bristles and the front panel as well as the supporting plate, the bristle packet wound around a core wire being clamped in said clamp member.

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The invention is explained in greater detail below with reference to a drawing (Figure 1) that shows a schematic cross-sectional view of an exemplary embodiment of the inventive brush seal.

5 Figure 1 shows a brush seal referenced 1 overall that is clamped in a housing 2. A rotor 4, whose surface is referenced 5 and whose longitudinal axis is referenced 6, extends through a bore 3 in the housing 2. The brush seal 1 essentially comprises a front panel 7, a supporting plate 8 and a plurality of densely packed bristles 9 that are firmly clamped between
10 the front panel 7 and the supporting plate 8, being clamped in 10. Given a difference pressure adjacent at the brush seal 1, the front panel 7 is arranged at the high-pressure side and the supporting plate 8 is arranged at the low-pressure side. The bristles 9 clamped at one side extend between the front panel 7 and the supporting plate 8 and have their free ends 11

remote from the clamping location 10 projecting beyond the inside edges 12 or, respectively 13 of the front panel 7 and the supporting plate 8. The ends 11 of the bristles 9 touch the surface 5 of the rotor and thus seal an annular interspace between the inside edge 12 of the supporting plate 8 and the surface 5 of the rotor 4.

The front panel 7 and the supporting plate 8 each respectively comprise an inside bore coaxial with the longitudinal axis 6 of the rotor 4, so that their inside edges 12 or, respectively, 13 are spaced from the surface 5 of the rotor 4. The inside edge 12 of the front panel 7, too, has only comparatively slight play relative to the rotor surface 6. The bristles 9, which can be composed of various materials familiar to a person skilled in the art, are thereby protected against damage during handling and during air turbulence during operation.

In the present exemplary embodiment, the supporting plate 8 comprises a first section 15 extending in a radial plane relative to the rotor axis 6 whose outside surface 16 is parallel to an outside surface 17 of the front panel 7 for an exactly fitting attachment of the brush seal to the housing 2. The front panel 7 and the supporting plate 8 also respectively comprise a rectangularly inwardly angled-off section that, however, are of no significance here and are only mentioned for the sake of completeness.

A region 18 of the supporting plate 8 adjoining the inside edge 13 of the supporting plate 8 is slanted toward the brushes 9, whereby a supporting surface 20 at which the bristles 9 have their end sections 21 supported is fashioned at the inside 19 thereof. As can be seen at the clamping location 10, the bristles 9 or, respectively, the bristle packet is wound over a core wire 25 and is clamped with a clamp member 24 fashioned as slotted tube that has the cross-sectional shape of an open ring C-tube. The bristles 9 in this exemplary embodiment are slanted toward the supporting plate 8 with reference to a radial plane 22. The angle amounts to approximately 6° . In this way, a defined seating of the end sections 21 of the bristles 9 at the supporting surface 20 of the supporting plate 8 can be achieved. This measure, however, is no compulsory since the end sections 21 can also be

initially pressed against the supporting surface 20 by the difference pressure. The pressing power of the brushes 9 at the supporting section 20 can thus be reduced given extremely high difference pressures.

5 The radial length l of the supporting surface 20 of the supporting plate 8 amounts to approximately one-fifth of the free (overall) length L of the bristles 9, so that the bristles 9 have a great region of their length L extending at a distance from the inside surface 19 of the supporting plate 8 upon formation of an interspace 23.

10 Since the bristles 9 are most flexible at their end sections 21 remote from the clamping location 10 and, moreover, are constantly caused to vibrate by the leakage air flowing in the interspace 23, the bristles 9 laterally deflect given an excursion of the rotor 4 from its central position but, together with the rotor 4, immediately return into their original position given the elimination of the cause such as, for example, thermal stresses, effecting the
15 excursion of the rotor 4. Due to an air cushion forming in the interspace 23, over and above this, the friction between the end sections 21 of the bristles 9 and the supporting section 20 of the supporting plate 8 is reduced. As a result thereof, a good sealing effect of the brush seal 1 is assured even given
20 an adjacent differential pressure and excursions of the rotor, so that no significant rise in the leakage occurs.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A brush seal received in a bore of a housing for forming a seal between the bore and a rotor extending therethrough, said seal comprising a front panel and a supporting plate being spaced apart, each of said front panel and supporting plate having a bore with a annular inside edge, said supporting plate having an inside surface facing the front panel, said inside surface having an annular supporting surface adjacent the inside edge extending in a radial plane relative to a longitudinal axis of the rotor, said inside surface of the plate having an inward section inclined relative to the radial plane, a plurality of bristles being held between the front panel and the supporting plate to be inclined to the radial plane with a free end of the bristles extending inwardly beyond the inside edge of the supporting plate and the bristles being supported on the supporting section with an interspace between the remaining length of the bristles and the inside surface of said plate.
2. A brush seal according to claim 1, wherein the bristles are inclined at an angle approximate six degrees (6°) to the supporting surface.
3. A brush seal according to claim 1 or 2, wherein the supporting surface has a radial length equal to or less than approximately one-fourth of the bristle length.
4. A brush seal according to claim 1, 2 or 3, wherein the supporting surface has a radial length of approximately two millimeters.

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5. A brush seal according to any one of claims 1 to 4, wherein the inside edge of the front panel has a greater spacing from the surface of the rotor than the inside edge of the supporting plate.
6. A brush seal according to any one of claims 1 to 5, wherein the bristles are held in the seal by being clamped between the front panel and the supporting plate.
7. A brush seal according to any one of claims 1 to 6, which includes a clamp member, said clamp member being attached to the bristles and being clamped between the front panel and the supporting plate.
8. A brush seal according to claim 7, wherein the clamp member is a slotted annular tube.

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FIG. 1

