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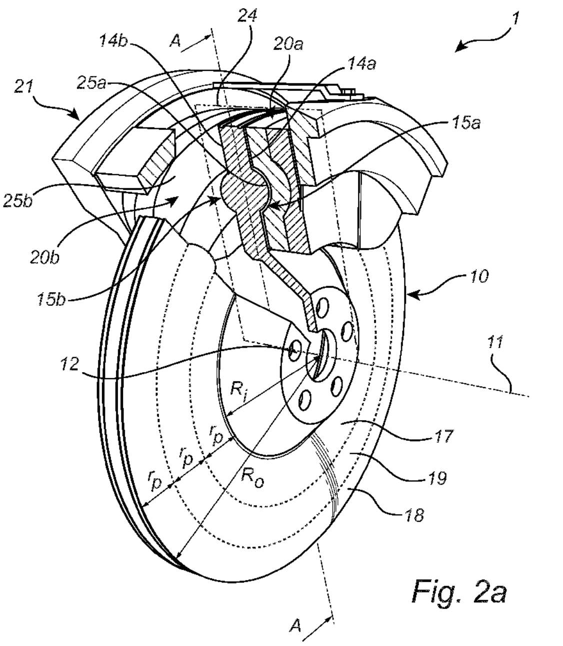

Fig. 2a

(57) Abstract: A brake disc (10) for arrangement in a vehicle to rotate around a rotational axis (11). First and second annular braking surfaces (15a-b) extend radially between an inner braking surface radius (R_i) and an outer braking surface radius (R_o). Each of the first and second braking surfaces has an annular proximal portion (17), an annular distal portion (18), and an annular central portion (19). At least one of the first and second braking surfaces is structured to protrude from a base plane (16a, 16b) perpendicular to the rotational axis (11) to exhibit a surface profile cross-section (14a, 14b) with a plane (24) including the rotational axis (11). A protrusion distance ($h_a(r)$, $h_b(r)$) from the base plane (24) to the surface profile cross-section (14a, 14b) varies with radial distance (r) from the rotational axis (11) in such a way that a central portion distance ($d_{central}$) is longer than each of a proximal portion distance ($d_{proximal}$) and a distal portion distance (d_distal).

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Structured brake disc

TECHNICAL FIELD

The invention relates to a brake disc for arrangement in a vehicle to allow reduction of a speed of the vehicle by pressing first and second brake pads against the brake disc resulting in frictional interaction between first and second brake pad surfaces and corresponding first and second annular braking surfaces. The invention further relates to a brake pad for use with the brake disc according to the invention, a braking system and a vehicle.

The invention can be applied in heavy-duty vehicles, such as trucks, buses and construction equipment. Although the invention will be described with respect to a truck, the invention is not restricted to this particular vehicle, but may also be used in other vehicles such as buses and construction equipment.

BACKGROUND

Disc brakes are commonly used in various vehicles to provide for efficient and reliable braking.

In an effort to improve the braking performance of a disc brake system, US 3 750 788 discloses a brake disc with a serrated cross-sectional shape forming teeth having a relatively low height, to increase friction for a given braking force used for pressing brake pads against the brake disc.

There appears to be room for improvement of the brake disc and braking system according to US 3 750 788, in particular concerning the management of the heat generated during braking.

SUMMARY

An object of the invention is to provide for improved braking, in particular concerning management of the heat generated during braking.

According to a first aspect of the invention, this object is achieved by the brake disc according to claim 1.

Studies have shown that the temperature resulting from braking is not the same across the contact area between the brake disc and the brake pad, but that the temperature may be higher in the central annular portion of the braking surfaces than in the proximal annular portion and the distal annular portion of the braking surfaces, in particular during severe operating conditions. The expansion-contraction cycling resulting from this temperature gradient has been found to increase the risk of brake disc cracks and may also lead to an increased risk of noise and vibrations from the braking system.

The present invention is based upon the realization that by increasing the surface area more in the central portion than in the proximal and distal portions in accordance with embodiments of the present invention, the build-up of stress and the resulting fatigue damage on the brake disc can be reduced, whereby the risk of formation of radial brake disc cracks can consequently be reduced. This in turn provides for an increased utilization of a vehicle equipped with a braking system including the brake disc.

Embodiments of the present invention thus provide for a reduced radial temperature gradient between the central portion and at least one of the proximal and distal portions, which in turn reduces the risk of radial cracks in the brake disc. In addition, the increased contact area between brake disc and brake pad provides for a lower maximum temperature for a given braking torque.

According to various embodiments, the above-mentioned central portion distance may be at least five percent longer than the proximal and distal portion distances.

The difference between the central portion distance and the proximal and distal portion distances can be achieved in various ways. For example, the average amplitude of protrusion distance variations may be greater in the central portion than in the proximal and distal portions and/or the wavelength of protrusion distance variations may be shorter in the central portion than in the proximal and distal portions.

The protrusion distance may advantageously vary continuously with radial distance from the rotational axis, which reduces the risk of excessive wear on the brake disc and/or brake pads, and reduces the requirement on the mounting tolerance of the brake pads in relation to the surface structure of the brake disc.

According to embodiments, the protrusion distance may vary between a minimum protrusion distance and a maximum protrusion distance, a difference between the minimum protrusion distance and the maximum protrusion distance being at least 5 percent of a width of the braking surface.

According to embodiments, the difference between the minimum protrusion distance and the maximum protrusion distance may be at least 6 mm. In embodiments where there is enough space to accommodate a somewhat thicker brake disc, the above-mentioned difference may be considerably greater, such as at least 20 mm. The larger this difference can be made, the more the size of the interfacing surfaces between brake pad and brake disc is increased. This in turn provides for a more efficient heat dissipation.

According to various embodiments, the central portion maximum protrusion distance may be greater than the distal protrusion distance. Such a configuration may facilitate exchange of brake pads.

In these embodiments, the central portion maximum protrusion distance may be greater than each of the proximal protrusion distance and the distal protrusion distance, such that the surface profile cross-section has a generally convex shape.

According to other embodiments, the central portion maximum protrusion distance may be less than each of the proximal protrusion distance and the distal protrusion distance, such that the surface profile cross-section has a generally concave shape.

According to various embodiments, the protrusion distance as a function of radial distance from the rotational axis may exhibit a plurality of local extrema. For instance, the surface profile cross-section may exhibit a generally sinusoidal variation with radial distance from the rotational axis of the brake disc. Hereby, the surface area of the braking surfaces of the brake disc can be increased even further, providing for even more efficient heat dissipation from the brake disc.

According to a second aspect of the invention, the above-mentioned object is achieved by the brake pad according to claim 14.

According to embodiments, the brake pad may comprise a friction member and a structured coating on the friction member. The structured coating may be applied to the friction member to achieve a surface profile cross-section of the brake pad surface that may be a scaled inverse of the surface profile cross-section of the brake disc surface of the brake disc according to embodiments of the present invention. In particular, the surface profile cross-section of the brake pad surface may be scaled to exhibit smaller amplitudes than the surface profile cross-section of the brake disc. After an initial wear-in period, the surface profile cross-sections of the brake pad and the brake disc may fit perfectly with each other.

According to one example, the structured coating may be provided in the form of a so-called “green coat”. It should, however, be noted that any other suitable material or substance may be used. It should also be noted that the surface profile of the friction member may be different from the surface profile provided by the structured coating.

According to embodiments of the present invention, there is provided a braking system for a vehicle, comprising a brake disc according to embodiments of the first aspect of the present invention; first and second brake pads according to embodiments of the second aspect of the present invention; and an actuator for reducing the distance between the first and second brake pads to pressing the brake disc between the first and second brake pads.

Each of the first and second brake pads may be made of a brake pad material being less wear resistant than a brake disc material of the brake disc. Further, each of the first and second braking surfaces may lack a coating being harder than the brake disc material.

Moreover, the braking system according to embodiments of the present invention may advantageously be comprised in a vehicle for allowing controlled reduction of the speed of the vehicle.

In summary, the present invention thus relates to a brake disc for arrangement in a vehicle to rotate around a rotational axis. First and second annular braking surfaces extend radially between an inner braking surface radius and an outer braking surface radius. Each of the first and second braking surfaces has an annular proximal portion, an annular distal portion, and an annular central portion. At least one of the first and second braking surfaces is structured to protrude from a base plane perpendicular to the rotational axis to exhibit a surface profile cross-section with a plane including the rotational axis. A protrusion distance from the base plane to the surface profile cross-section varies with radial distance from the rotational axis in such a way that a central portion distance is longer than each of a proximal portion distance and a distal portion distance.

Further advantages and advantageous features of the invention are disclosed in the following description and in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, below follows a more detailed description of embodiments of the invention cited as examples.

In the drawings:

Figs 1a-b schematically illustrate an example temperature distribution during braking and a possible resulting failure mode for a conventional brake disc;

Fig. 2a is a partly cut-out perspective view of a braking system according to a first embodiment of the present invention;

Fig. 2b is a cross-section view of the braking system in fig 2a;

Fig 2c is a diagram schematically showing the distances along the proximal, central and distal portions of the braking surface cross-section for the brake disc configuration in fig 2a and fig 2b.

Fig. 2d is a partly cut-out perspective view of the braking system according to a second embodiment of the present invention;

Fig 3 is a partial cross-section view of a braking system according to a third embodiment of the present invention;

Fig 4a is a partial cross-section view of a braking system according to a fourth embodiment of the present invention; and

Fig 4b is a partial cross-section view of a braking system according to a fifth embodiment of the present invention.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS OF THE INVENTION

To illustrate advantages of the braking system according to the present invention, the concept of “thermal localization” and an important related failure mode will be briefly explained below with reference to figs 1a-b.

Fig 1a shows the result of a simulation of the temperature on a brake disc surface of a prior art brake disc 31 resulting from application of the brake (“Simulation of Thermal Stresses in a Brake Disc” by Asim Rashid, Licentiate Thesis No. 1603, LIU-TEK-LIC-2013:37). As is schematically shown in fig 1a, application of the brake results in a hot band 32 in the central portion of the braking surface where the temperature is as high as in excess of 600°C. In the proximal and distal portions, the temperature is well below 400°C.

The repeated engagement and disengagement of the braking system may eventually result in the formation of radial cracks 34 in the brake disc 31 as is schematically shown in fig 1b. By reducing the maximum temperature in the hot band 32 through embodiments of the present invention, the formation or radial cracks may be prevented, or at least considerably delayed, resulting in an improved utilization of the vehicle comprising the braking system.

Fig 2a is a partly cut-out perspective view of a braking system 1 according to a first embodiment of the present invention, comprising a brake disc 10, first 20a and second 20b brake pads, and a braking actuator arrangement 21. In the braking system 1 according to the present first embodiment, the brake disc 10 is attachable to a rotatable member of a vehicle by means of mounting holes 12 (only one of the mounting holes is indicated by a reference numeral for ease of drawing) so that the brake disc 10 rotates around a rotational axis 11 of the brake disc 10 when the vehicle is moving.

To reduce the speed of the vehicle, the braking actuator arrangement 21 can be controlled to move the first 20a and second 20b brake pads towards each other to press the brake disc 10 between the first 20a and second 20b brake pads. This results in frictional interaction between the first 25a and second 25b brake pad surfaces and corresponding first 15a and second 15b annular braking surfaces on opposite sides of the brake disc 10.

As is shown in fig 2a, each of the first 15a and second 15b annular braking surfaces extends radially between an inner braking surface radius R_i and an outer braking surface radius R_o in relation to the rotational axis 11. As is also schematically indicated for the first braking surface 15a in fig 1a, each of the braking surfaces has an annular proximal portion 17, an annular distal portion 18, and an annular central portion 19 between the proximal portion 17 and the distal portion 18. The proximal portion 17, the distal portion 18, and the central portion 19 have the same widths r_p as indicated in fig 2a.

To efficiently address the hot band issue explained above with reference to figs 1a-b, the increase in braking surface area may be made the greatest in the central portion 19 of the braking surfaces 15a-b, where the temperature is the highest. This will contribute to reducing the radial temperature differential across the braking surfaces 15a-b, and thereby reduce the problem of radial cracks discussed further above.

In the braking system of fig 1a, the surface profile cross-sections of the braking surfaces 15a-b are thus substantially planar in the proximal 17 and distal 18 portions, and each exhibits a “bulge” in the central portion 19. The corresponding braking surfaces 25a-b of the brake pads 20a-b conform to the shapes of the braking surfaces 15a-b. This provides for an increased heat dissipating area of the brake disc 10 where the temperature is the highest during braking. This contributes to reducing the radial temperature differential across the braking surfaces 15a-b, and thereby reducing the problem of radial cracks discussed further above. In addition, the structured braking surfaces contribute to reduce the maximum temperature due to the increased contact area between the braking surfaces 15a-b of the brake disc 10 and the corresponding braking surface 25a-b of the respective brake pads 20a-b.

The configuration of the braking surfaces 15a-b of the brake disc 10 will now be described in greater detail with reference to the cross-section view in fig 2b. Referring to fig 2b, each of the first 15a and the second 15b braking surfaces of the brake disc 10 is structured to protrude from a respective base plane 16a-b (perpendicular to the rotational axis 11) to exhibit a surface profile cross-section with a plane 24 including the rotational axis 11. As can be seen in fig 2b, each of the surface profile cross-sections of the first 15a and second 15b braking surfaces exhibits a respective protrusion distance $h_a(r)$ and $h_b(r)$ along a normal to the respective base planes 16a-b. Each of the protrusion distances $h_a(r)$, $h_b(r)$ varies with radial distance from the rotational axis 11 in such a way that the central portion distance $d_{central}$ along the surface profile cross-section in the central portion 19 is longer than the proximal portion distance $d_{proximal}$ along the surface profile cross-section in the proximal portion 17 and the distal portion distance d_{distal} along the surface profile cross-section in the distal portion 18. This relation is schematically illustrated in the diagram of fig 2c.

In addition, each of the protrusion distances $h_a(r)$, $h_b(r)$ varies with radial distance from the rotational axis 11 in such a way that the central portion average protrusion distance in the central portion 19 is greater than the proximal average protrusion distance in the proximal portion 17 and the distal average protrusion distance in the distal portion 18.

As is also indicated in fig 2b, each of the brake pads 20a-b comprises a friction member 22a-b and a backplate 23a-b for attachment of the brake pads 20a-b to the braking actuator arrangement 21. Each of the backplates 23a-b has a generally planar mounting side 26a-b for attachment to the braking actuator arrangement 21, and a friction member side 27a-b to which the friction member 22a-b is fixed. To provide for an increased service life of the brake pads 20a-b, the friction member side 27a-b of the backplate 22a-b is curved to substantially follow the braking surface profile 25a-b of the brake pad 20a-b.

To illustrate that embodiments of the present invention are equally useful regardless of the overall configuration of the brake disc, fig 2d schematically shows a second embodiment of the braking system according to the present invention, which differs from the braking system in figs 2a-b in that the brake disc is attachable to a rotating member of a vehicle by splines 29 rather than by the mounting holes 12 shown in figs 2a-b.

So far, a brake disc 10 having a relatively simple macroscopically convex surface profile cross-section has been described with reference to figs 2a-d. Several other surface profile cross-sections are possible and may be advantageous as can readily be realized by one of ordinary skill in the relevant art, based on the present disclosure. Some examples of advantageous braking surface profile cross-sections, as well as brake pad configurations will be described below with reference to figs 3 and figs 4a-b.

Referring first to fig 3, schematically showing a partial cross-section of a third embodiment of the braking system according to the invention, the heat-dissipating surface area of the braking surfaces 15a-b of the brake disc 10 has been further increased by superimposing a smaller scale, here sinusoidal, variation on the large scale generally convex variation in protrusion distance. In this third embodiment, the small scale variation of the braking surface cross-section of the brake pads 20a-b has been achieved by providing a structured coating 36a-b on the generally concave friction members 22a-b.

Fig 4a schematically shows a partial cross-section of a fourth embodiment of the braking system according to the invention. As can be seen in fig 4a, a smaller scale protrusion distance variation with substantially constant wavelength and varying amplitude has been superimposed on generally planar braking surfaces. The amplitude is greater in the central portion 19 than in the proximal portion 17 and the distal portion 18 of the braking surface 15a-b.

Alternatively, as in the fifth embodiment schematically shown in fig 4b, a smaller scale protrusion distance variation with substantially constant amplitude and varying wavelength may be superimposed on generally planar braking surfaces. The wavelength is here shorter in the central portion 19 than in the proximal portion 17 and the distal portion 18 of the braking surface 15a-b.

Due to the variations in amplitude and/or wavelength, the central portion distance $d_{central}$ along the surface profile cross-section in the central portion 19 is longer than the proximal portion distance $d_{proximal}$ along the surface profile cross-section in the proximal portion 17 and the distal portion distance d_{distal} along the surface profile cross-section in the distal portion 18.

It is to be understood that the present invention is not limited to the embodiments described above and illustrated in the drawings; rather, the skilled person will recognize that many, combinations, changes and modifications may be made within the scope of the appended claims.

CLAIMS

1. A brake disc (10) for arrangement in a vehicle to rotate around a rotational axis (11) of said brake disc (10) when said vehicle is moving, and to allow reduction of a speed of said vehicle by pressing first (20a) and second (20b) brake pads against said brake disc (10) resulting in frictional interaction between first (25a) and second (25b) brake pad surfaces and corresponding first (15a) and second (15b) annular braking surfaces on opposite sides of said brake disc (10), each extending radially between an inner braking surface radius (R_i) and an outer braking surface radius (R_o) of said brake disc (10) in relation to said rotational axis (11), wherein each of said first (15a) and second (15b) braking surfaces has an annular proximal portion (17), an annular distal portion (18) further away from said rotational axis (11) than said proximal portion (17), and an annular central portion (19) between said proximal portion (17) and said distal portion (18), said proximal portion (17), distal portion (18), and central portion (19) having equal widths (r_p), wherein at least one of said first (15a) and second (15b) braking surfaces is structured to protrude from a base plane (16a, 16b) perpendicular to said rotational axis (11) to exhibit a surface profile cross-section (14a, 14b) with a plane (24) including said rotational axis (11), wherein a protrusion distance ($h_a(r)$, $h_b(r)$) along a normal to said base plane (16a, 16b) from said base plane (16a, 16b) to said surface profile cross-section (14a, 14b) varies with radial distance (r) from said rotational axis (11), **characterized in that** a central portion distance ($d_{central}$) along said surface profile cross-section (14a, 14b) in said central portion (19) is longer than each of a proximal portion distance ($d_{proximal}$) along said surface profile cross-section (14a, 14b) in said proximal portion (17) and a distal portion distance (d_{distal}) along said surface profile cross-section (14a, 14b) in said distal portion (18).

2. The brake disc (10) according to claim 1, **characterized in that** said central portion distance ($d_{central}$) is at least five percent longer than at least one of said proximal portion distance ($d_{proximal}$) and said distal portion distance (d_{distal}).

3. The brake disc (10) according to claim 1 or 2, **characterized in that** said protrusion distance ($h_a(r)$, $h_b(r)$) as a function of radial distance (r) from said rotational axis (11) exhibits a first number of local extrema in said central portion (19), a second number of local extrema in said proximal portion (17) and a third number of local extrema in said distal portion (18), said first number being greater than each of said second number and said third number.

4. The brake disc (10) according to any one of the preceding claims, **characterized in that** said protrusion distance ($h_a(r)$, $h_b(r)$) varies continuously with radial distance (r) from said rotational axis (11).

5. The brake disc (10) according to any one of the preceding claims, **characterized in that** said protrusion distance ($h_a(r)$, $h_b(r)$) varies between a minimum protrusion distance ($h_{a,min}$, $h_{b,min}$) and a maximum protrusion distance ($h_{a,max}$, $h_{b,max}$), a difference between said minimum protrusion distance ($h_{a,min}$, $h_{b,min}$) and said maximum protrusion distance ($h_{a,max}$, $h_{b,max}$) being at least 5 percent of a width (R_o-R_i) of said braking surface (15a, 15b).

6. The brake disc (10) according to any one of the preceding claims, **characterized in that** a central portion average protrusion distance in said central portion (19) is different from each of a proximal average protrusion distance in said proximal portion (17) and a distal average protrusion distance in said distal portion (18).

7. The brake disc (10) according to claim 6, **characterized in that** said central portion average protrusion distance is greater than said distal protrusion distance.

8. The brake disc (10) according to claim 7, **characterized in that** said central portion average protrusion distance is greater than each of said proximal portion average protrusion distance and said distal average protrusion distance, such that said surface profile cross-section has a generally convex shape.

9. The brake disc (10) according to claim 6, **characterized in that** said central portion average protrusion distance is less than each of said proximal portion protrusion distance and said distal portion average protrusion distance, such that said surface profile cross-section has a generally concave shape.

10. The brake disc (10) according to any one of the preceding claims, **characterized in that** said protrusion distance ($h_a(r)$, $h_b(r)$) as a function of radial distance (r) from said rotational axis (11) exhibits a plurality of local extrema.

11. The brake disc (10) according to any one of the preceding claims, **characterized in that** each of said first (15a) and second (15b) braking surfaces is structured in such a way that the central portion distance ($d_{central}$) along said surface profile cross-section (14a, 14b)

in said central portion (19) is longer than each of the proximal portion distance ($d_{proximal}$) along said surface profile cross-section (14a, 14b) in said proximal portion (17) and the distal portion distance (d_{distal}) along said surface profile cross-section (14a, 14b) in said distal portion (18).

12. A brake pad (20a, 20b) for use together with the brake disc (10) according to any one of the preceding claims, **characterized in that** said brake pad (20a, 20b) is structured to at least partly conform to the at least one structured braking surface (15a, 15b) of the brake disc (10) according to any one of the preceding claims.

13. The brake pad (20a, 20b) according to claim 12, **characterized in that** said brake pad (20a, 20b) comprises a friction member (22a, 22b) and a structured coating (36a, 36b) on said friction member (22a, 22b).

14. The brake pad (20a, 20b) according to claim 12 or 13, **characterized in that** said brake pad (20a, 20b) comprises a friction member (22a, 22b) and a backplate (23a, 23b) having a generally planar mounting side (26a, 26b) for attachment of said brake pad (20a, 20b) to a braking actuator arrangement (21), and a friction member side (27a, 27b) to which said friction member (22a, 22b) is fixed, wherein the friction member side (27a, 27b) of said backplate (22a, 22b) is structured to substantially follow a braking surface profile (25a, 25b) of said brake pad (20a, 20b).

15. A braking system (1) for a vehicle, **characterized by** the brake disc (10) according to any one of claims 1 to 11 and the brake pad (20a, 20b) according to any one of claims 12 to 14.

16. A vehicle, **characterized by** the braking system (1) according to claim 15.

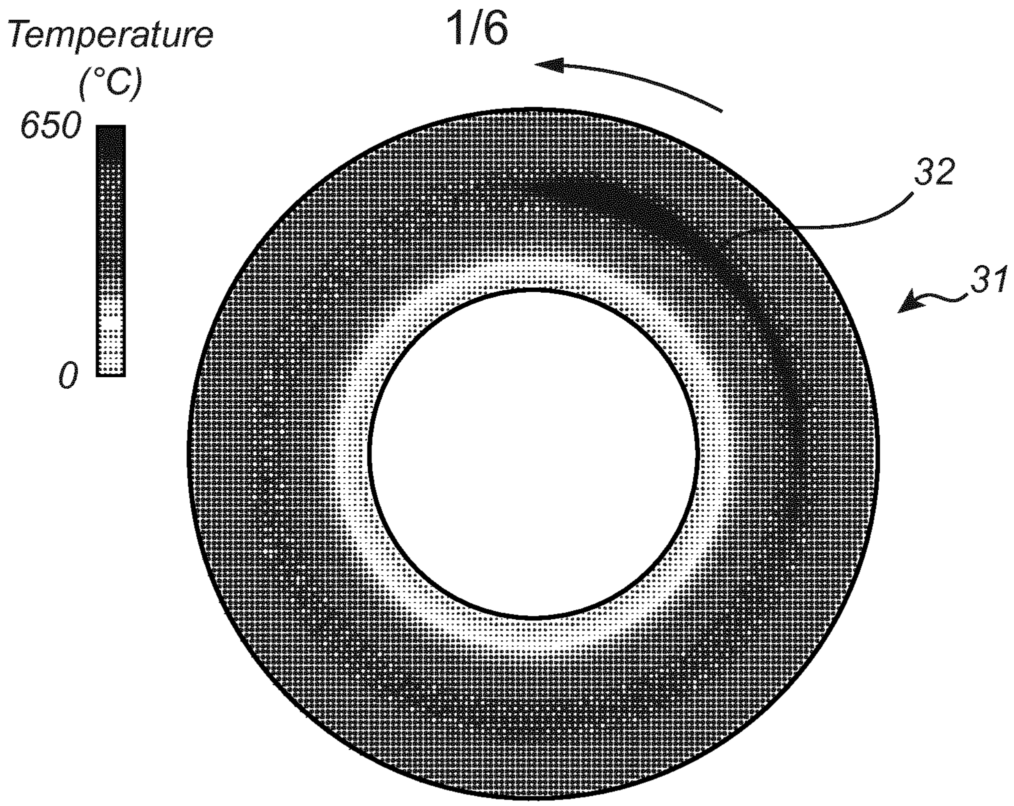


Fig. 1a

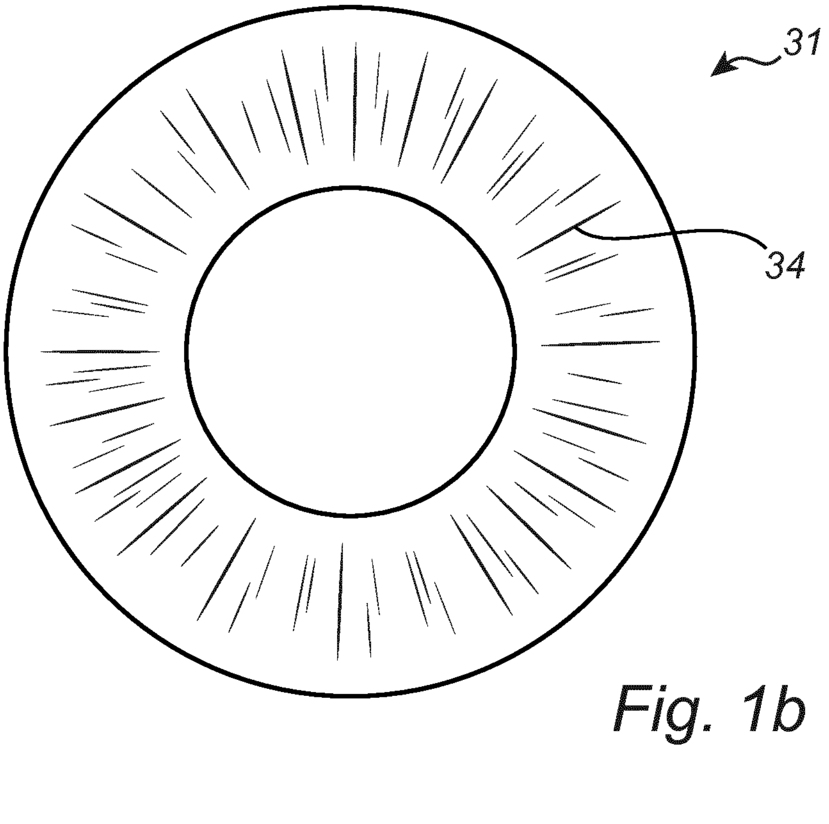
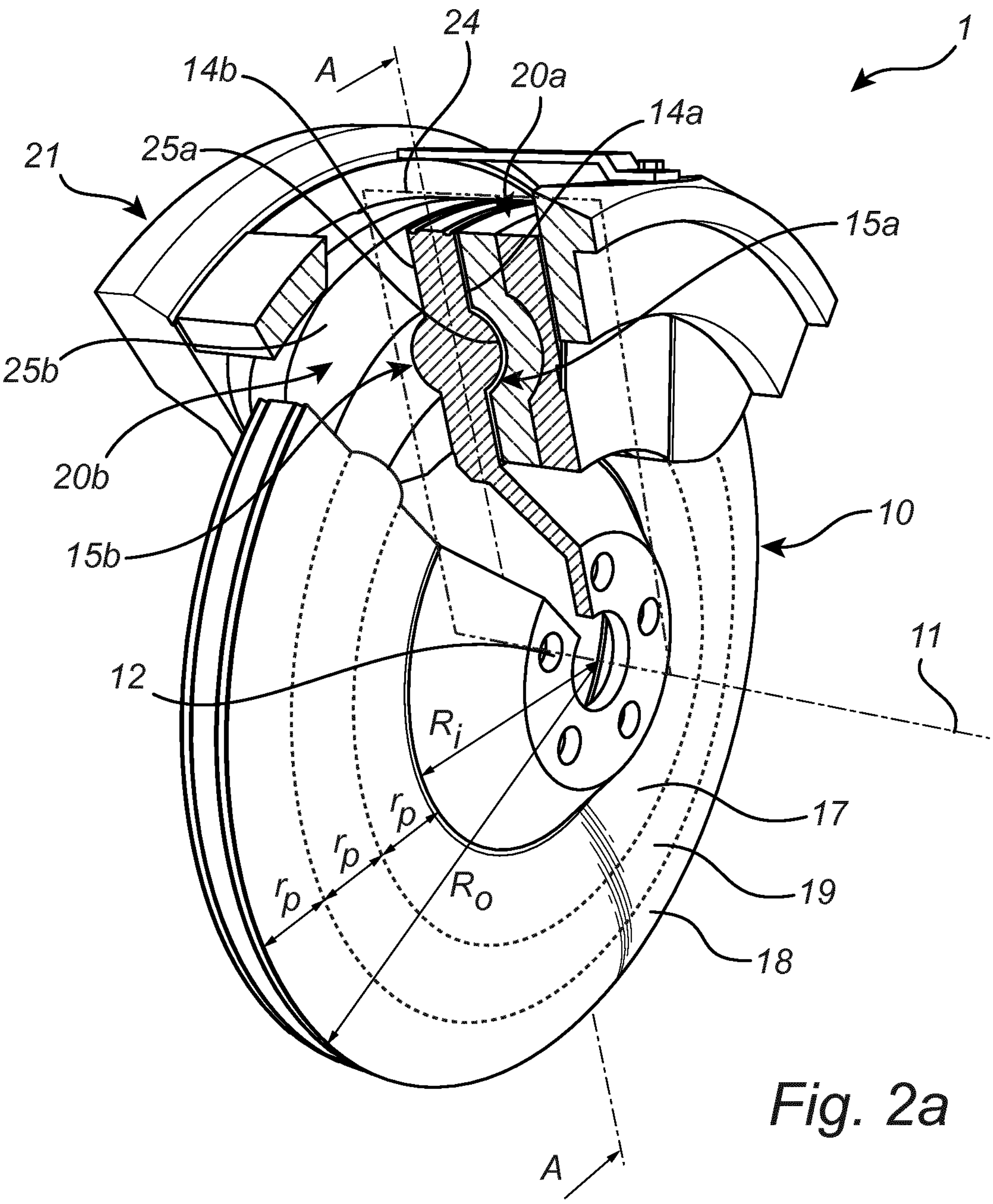


Fig. 1b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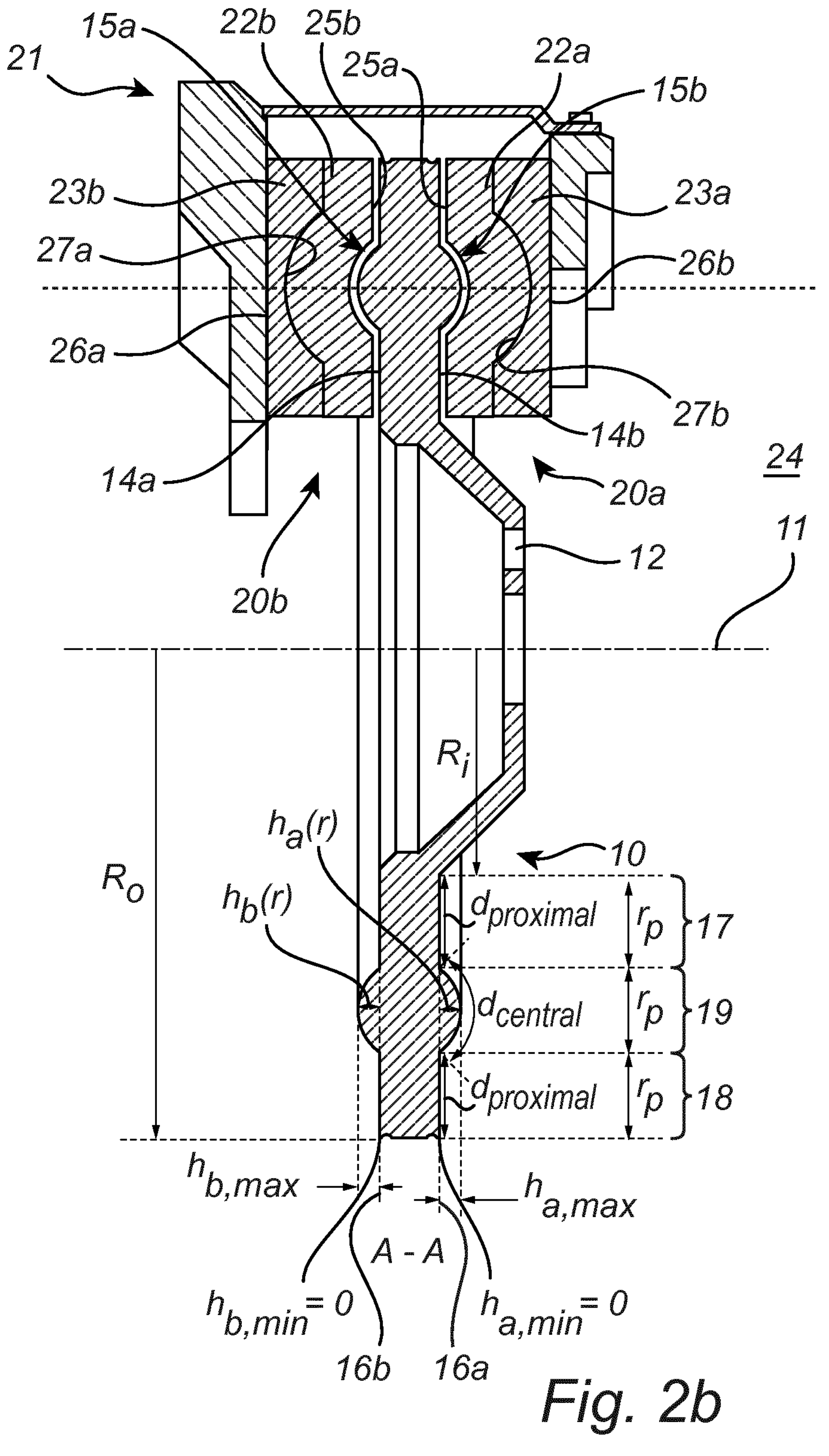
24
A
14b
20a
14a
21
25a
15a
25b
20b
15b
10
12
11
R_i
r_p
r_p
r_p
R_o
17
19
18
A

Fig. 2a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22b
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25a
22a
15b
23b
23a
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26a
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20b
11
12
R_i
$h_a(r)$
10
R_o
$h_b(r)$
$d_{proximal}$
r_p
17
$d_{central}$
r_p
19
$d_{proximal}$
r_p
18
$h_{b,max}$
$h_{a,max}$
A - A
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$h_{a,min} = 0$
16b
16a

Fig. 2b

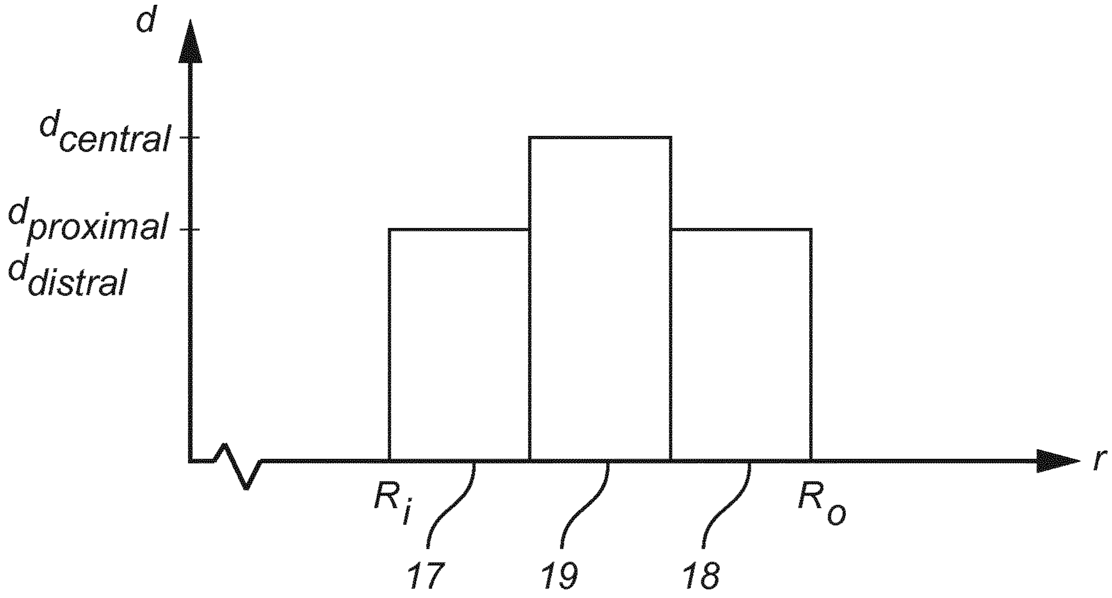

Fig. 2c

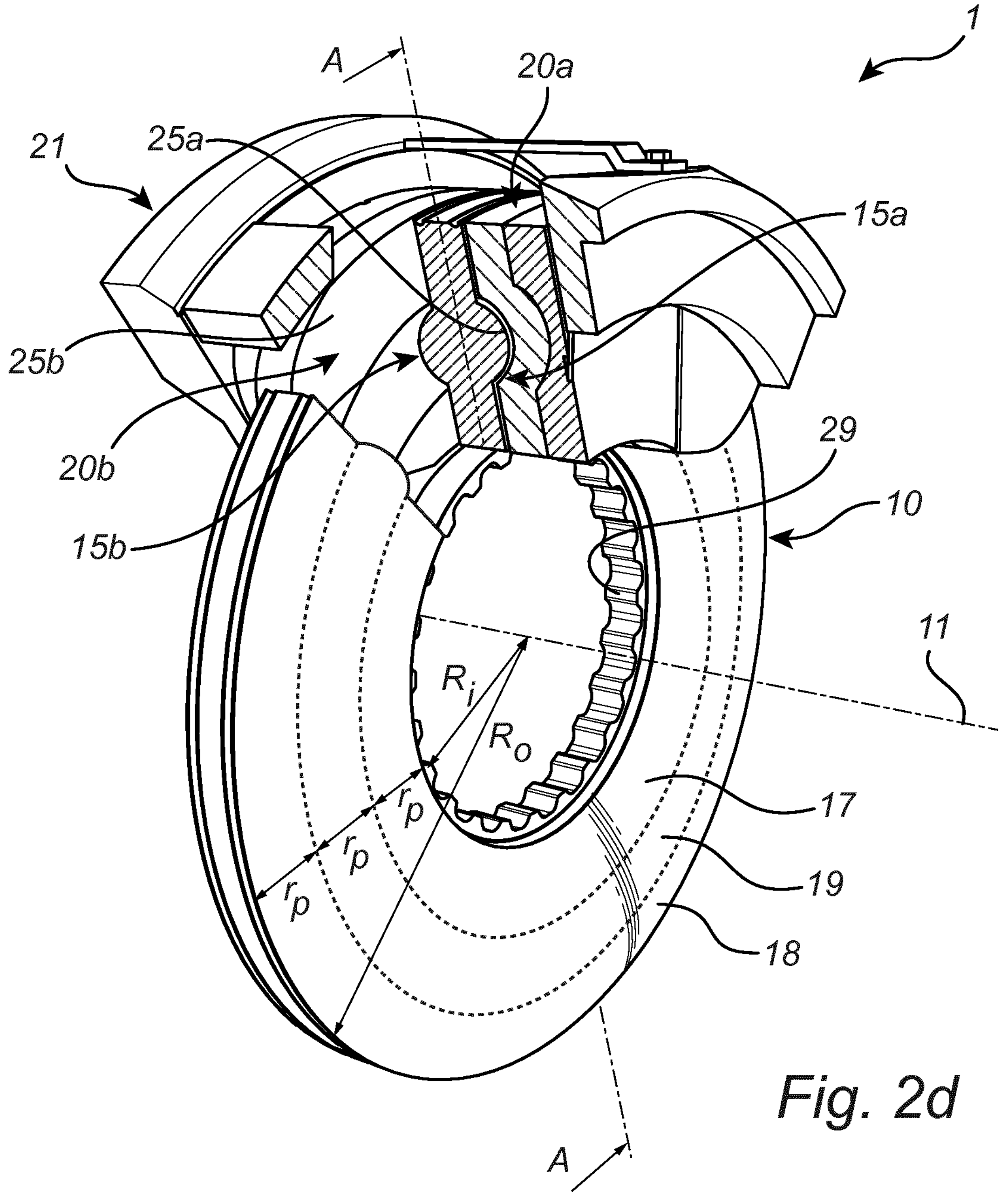

Fig. 2d

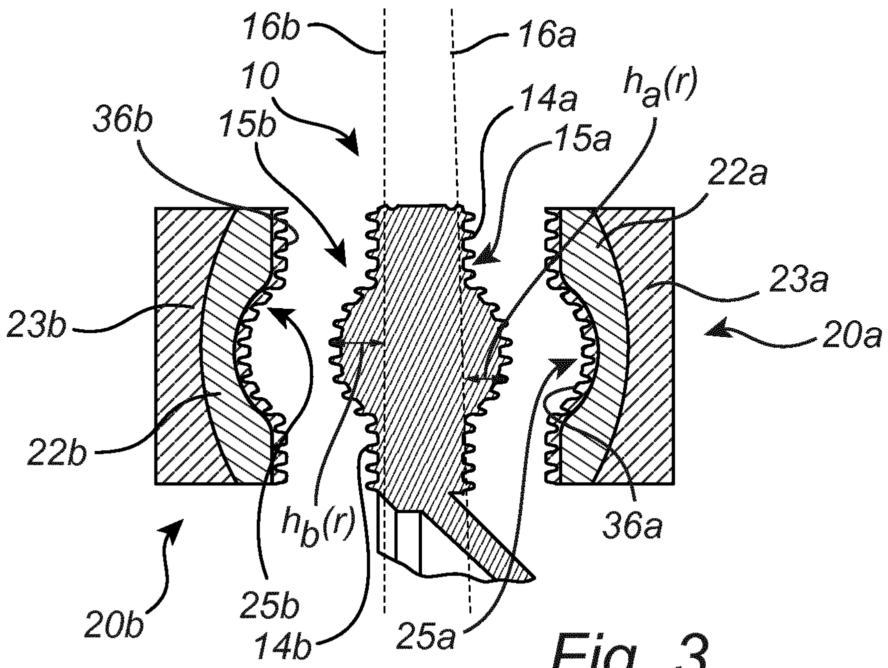

Fig. 3

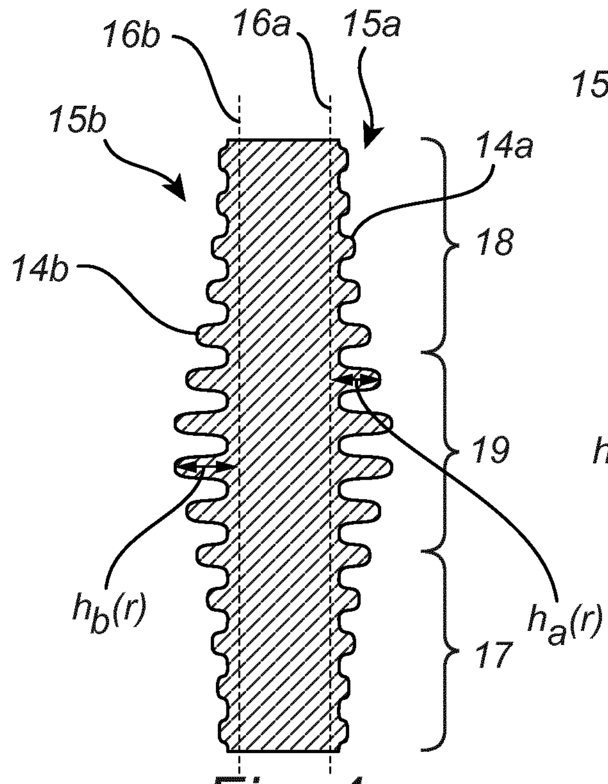

Fig. 4a

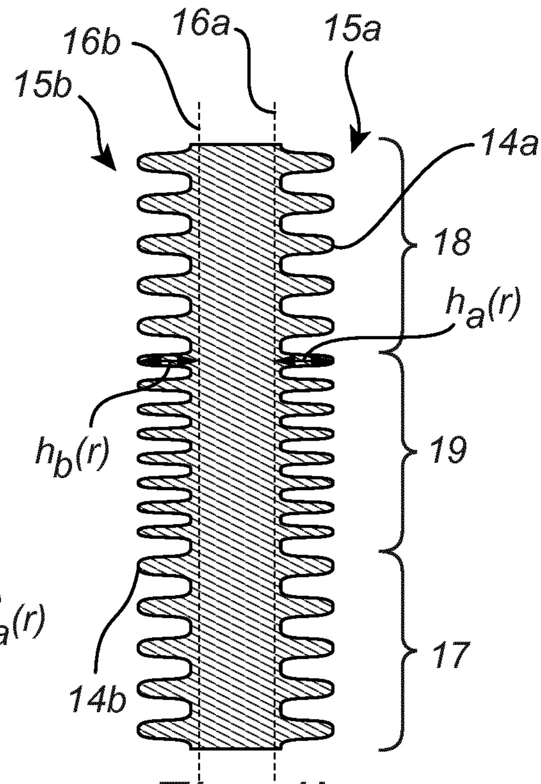

Fig. 4b

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/058554

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16D65/12 F16D65/092 F16D65/18
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16D

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP H01 124433 U (.) 24 August 1989 (1989-08-24)	1,2,4-9, 11,12, 14-16
Y	the whole document	3,10,13
Y	US 3 750 788 A (HEINEMANN R) 7 August 1973 (1973-08-07) cited in the application abstract	3,10,13
X	EP 0 039 641 A1 (DBA SA [FR]) 11 November 1981 (1981-11-11)	1,2,4-9, 11,12, 14-16
A	page 3, line 12 - line 23; figure 3	3,10,13
A	JP S60 99337 U (.) 6 July 1985 (1985-07-06) figure 2	1-16

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 December 2016	20/12/2016

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

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 295 636 A (FRED ADAMS) 3 January 1967 (1967-01-03) page 1, line 64 - page 2, line 44; figures	1-16
A	DE 26 11 078 A1 (WEBERLING PAUL) 22 September 1977 (1977-09-22) page 4, paragraph 4 page 7, last paragraph - page 9, last paragraph; figures	3,10,13

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/058554

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