(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 February 2016 (04.02.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/016043 A1

(51) International Patent Classification:
F16D 65/12 (2006.01)

(21) International Application Number:
PCT/EP2015/066623

(22) International Filing Date:
21 July 2015 (21.07.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
14178823.2 28 July 2014 (28.07.2014) EP

(71) Applicants: **BREMBO SGL CARBON CERAMIC BRAKES S.P.A.** [IT/IT]; Viale Europa 2, I-24040 Stezzano (BG) (IT). **FRENI BREMBO - S.P.A.** [IT/IT]; Via Brembo 25, I-24035 Curno (BG) (IT).

(72) Inventors: **BONFANTI, Roberto**; c/o FRENI BREMBO - S.P.A., Via Brembo 25, I-24035 Curno (BG) (IT). **PIAVANI, Riccardo**; c/o FRENI BREMBO - S.P.A., Via Brembo 25, I-24035 Curno (BG) (IT). **MILESI, Andrea**; c/o FRENI BREMBO - S.P.A., Via Brembo 25, I-24035 Curno (BG) (IT). **TIRONI, Giovanni Mario**; c/o FRENI BREMBO - S.P.A., Via Brembo 25, I-24035 Curno (BG) (IT).

(74) Agent: **BRASCA, Marco**; c/o PGA S.R.L., Via Mascheroni 31, 20145 Milano (IT).

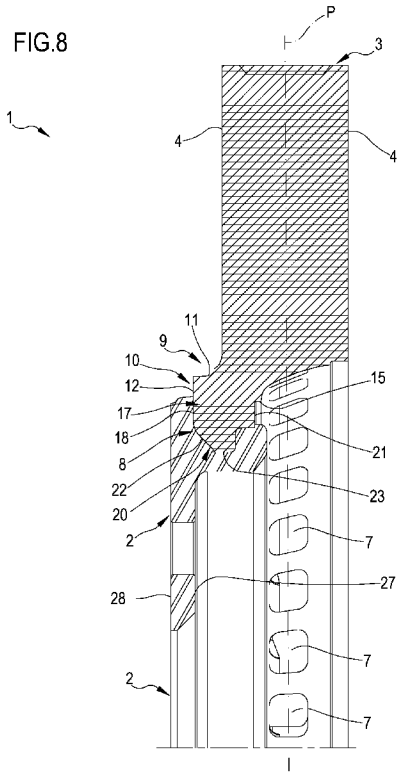
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,

[Continued on next page]

(54) Title: DISC FOR DISC BRAKES AND PROCESS FOR MANUFACTURING THE SAME

FIG.8



(57) Abstract: Disc for disc brakes comprising a metallic bell (2) and a radially external band (3) in composite material comprising carbon fibers. The bell (2) is co-casted on the radially external band (3). The radially external band (3) presents side braking surfaces (4) suitable to cooperate with brake calipers to exert a braking action on a vehicle. The radially external band (3) is shaped to form a plurality of protrusions (8) of composite material, which protrusions (8) are placed around a symmetry axis. In a radial plane, a terminal portion (20) of each protrusion (8) juts radially inwards and tapers towards the symmetry axis and the co-casted bell (2) incorporates the terminal portions (20).

WO 2016/016043 A1

TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

TITLE

"Disc for disc brakes and process for manufacturing the same"

DESCRIPTION

Field of the art

The present invention relates to a disc for disc brakes, to a process for manufacturing such disc and to a braking system comprising such disc. The invention is in particular related to disc brakes provided with a braking band made of composite material comprising ceramic material reinforced with carbon fibers. The invention is preferably related to disc brakes for motor vehicles, such as high performance cars. A disc brake comprises a bell, configured to be connected to an arm of a vehicle to rotate integral with a wheel rim, and an external band provided with side braking surfaces suitable to cooperate with brake calipers of the vehicle to exert a braking action on the same.

State of the art

Document DE102009013358A illustrates a brake disc for vehicles. The disc has a friction ring with an opening and a cup that is molded at the friction ring, where the cup is made of aluminum and/or the friction ring is made of ceramic e.g. carbon/silicon carbon composite material. The friction ring is provided with two ring elements whose front ends are connected with each other by bars that project into the opening where ends of the bars are molded into a flange of the cup.

Document EP1117943 discloses a method for producing brake disks consisting of ceramic parts with metal hubs. At least one ceramic part is placed in a diecasting mould and is joined to melted metals by casting under pressure, in order to obtain a rotationally symmetrical body. Said body contains at least one ceramic (composite) segment that is symmetrical to the axis of rotation of the metal body and projects beyond at least one surface of the metal body that is perpendicular to said axis.

Object of the invention

The Applicant has observed that the disc manufactured by co-casting of the prior art, while providing a simpler and cheaper product (since the number of working steps is lowered, the parts of the assembly are less being absent the mounting

hardware such as bolts, mounting of bell and braking band need not to be performed) cannot grant performance and safety of the traditional discs made of assembled parts.

The Applicant observed that the critical area of the prior art co-cast discs is the interface area between friction disc or discs and the metal bell or drum, i.e. the zones of connection between said friction disc or discs and the metal bell.

These areas are critical for the making process, because of the interaction between the metal of the bell and composite friction disc. The Applicant observed that, during cooling of the melted metal, the thermal shrinkage of the same tends to make the bell depart from the originally matching shape of the radially external band.

The same areas are also critical during the working life cycle of the brake disc equipping a vehicle. Indeed, the Applicant observed that such areas presents a very high level of local stresses due to the transmission of the braking torque from the radially external band to the bell and then to the vehicle and of thermal stresses due to energy dissipation occurring during braking.

In such context, the Applicant has set the objective of improving reliability and performance of the co-cast composite brakes discs and of improving the manufacturing process of the same in terms of reduction of manufacturing steps and simplification of each step.

In particular, one objective is to optimize the coupling zones between the bell and the external braking band both during co-casting and during working of the finished and installed brake disc.

Summary of the invention

The Applicant has found that such objectives can be obtained by means of a particular design of the protrusions in composite material which belong to the external braking band and which are configured to link said band to the inner metal bell.

More specifically, according to one aspect, the present invention relates to a disc for disc brakes, comprising a metallic bell and a radially external band extending around a symmetry axis, said radially external band presenting side braking surfaces suitable to cooperate with brake calipers to exert a braking action on a vehicle, said radially external band being of a composite material comprising

carbon fibers; wherein at least part of the metallic bell is co-casted on the radially external band; wherein the radially external band presents a plurality of protrusions of said composite material; wherein said protrusions are placed around the symmetry axis; wherein, in a radial plane, a terminal portion of each protrusion juts radially inwards and tapers towards the symmetry axis; wherein the bell incorporates at least the terminal portions of said protrusions.

According to a different aspect, the present invention relates to a process for manufacturing a disc for disc brakes, comprising: producing a radially external band in composite material comprising carbon fibers; wherein the radially external band is shaped to form a plurality of protrusions of said composite material; wherein said protrusions are placed around the symmetry axis and jut radially inwards; wherein, in a radial plane, each protrusion tapers towards the symmetry axis; inserting said radially external band in a mold cavity; introducing a melted metal in the mold cavity to form at least part of a bell of the disc co-casted with the external band; wherein the melted metal partly surrounds said protrusions provided on the radially external band.

According to a different aspect, the present invention relates to a radially external band presenting side braking surfaces suitable to cooperate with brake calipers to exert a braking action on a vehicle, said radially external band being in composite material comprising carbon fibers; wherein the radially external band presents a plurality of protrusions of said composite material; wherein said protrusions are placed around the symmetry axis; wherein, in a radial plane, a terminal portion of each protrusion juts radially inwards and tapers towards the symmetry axis; wherein the bell incorporates at least the terminal portions of said protrusions.

In other words, a plurality of said protrusions protrude like teeth from an inner radial edge of the radially external band and the metal material of the bell partly surrounds said teeth and lies also between said protrusions. Said protrusions are preferably equally spaced along a circumferential direction around a symmetry axis of the disc (which is the axis around which the disc rotates with the wheel).

Please note that a radial plane is a plane extending radially from the symmetry axis wherein said symmetry axis lies on said plane.

The Applicant verified that the tapering portion of the protrusions made of composite material, around which the metal of the bell is clung, assures an

intimate and safe connection between the metal co-casted bell and the external friction band.

In particular, the Applicant verified that said geometric solution improves the interaction between the composite material and the melted metal during casting and the following cooling and solidification in terms of wettability, shrinkage of the melted metal and stresses.

The Applicant also verified that the tapering portion according to the invention allows to transmit high braking torques from the band to the bell avoiding at the same time the generation of dangerous local stresses.

The Applicant also verified that the tapering portion according to the invention allows to limit the local stresses due to the thermal shock both in the external band (in particular while braking) and in the inner metal bell (during cooling after braking).

Further, the Applicant verified that the claimed structure allows to make the production process of the composite external band, of the bell and of the overall disc easier and cheaper.

The present invention, in at least one of the aforesaid aspects, can have one or more of the preferred characteristics that are described hereinbelow.

Preferably, said composite material comprises ceramic material reinforced with carbon fibers.

Preferably, the metal of the bell is aluminum alloy.

Preferably, the whole metallic bell is co-casted on the external band.

In one aspect, a ratio between a maximum axial dimension and a minimum axial dimension of the terminal portion of each protrusion is comprised between about 1,5 and about 2,5, preferably between about and about 1,8 and about 2,2.

In one aspect, a ratio between a minimum axial dimension and a radial dimension of the terminal portion of each protrusion is comprised between about 0,8 and about 1,2, preferably between about and about 0,9 and about 1,1.

Preferably, the maximum axial dimension is comprised between about 10mm and about 20mm. Preferably, the radial dimension is comprised between about 5mm and about 10mm.

The axial dimensions are measured in a radial plane and parallel to the symmetry axis of the disc.

In one aspect, said terminal portion presents a first side surface substantially perpendicular to the symmetry axis (parallel to the side braking surfaces of the radially external band) and a second slanted side surface axially opposite to the first side surface. Preferably, said slanted side surface delimits with a plane parallel to the side braking surfaces of the radially external band an angle comprised between about 40° and between about 50°. In one aspect, said terminal portion presents a radially inner surface shaped like a tubular sector. Preferably, the metal of the bell lies in contact with the first side surface, with the second slanted side surface and with the radially inner surface. In one aspect, the radially external band presents an inner tubular surface facing the symmetry axis and delimiting with each of the first side surfaces of the terminal portions a corner, wherein the metal of the bell lies in said corner.

In one aspect, said protrusion presents opposite lateral surfaces substantially perpendicular to a circumferential direction (wherein the circumferential direction is the tangential direction). Preferably, the lateral surfaces of each protrusion converge towards the symmetry axis. Preferably, the lateral surfaces lies on radial planes. Preferably, each protrusion extends circumferentially along an arc comprised between about 6°and about 15°, preferably between about 8° and about 12°. Preferably, the metal of the bell lies in contact with said opposite lateral surfaces. In other words, the lateral surfaces of adjacent protrusions delimit a seat for the metal of the bell. The metal of the bell exchanges forces (due to the braking torque) with the protrusions mainly through said lateral surfaces lying on radial planes and this structure contributes to avoid concentration of local stresses.

In one aspect, the protrusions are axially offset with respect to a median plane of the side braking surfaces. The median plane is a plane of symmetry of the side braking surfaces and is parallel to the side braking surfaces. In one aspect, the protrusions protrude axially from at least one of the side braking surfaces. In one aspect, each protrusion comprises an axial portion jutting out axially from a side of the radially external band. In one aspect, the slanted side surface connects each terminal portion to a respective axial portion. In one aspect, the metal of the bell lies in contact with said axial portion. In one aspect, the radially external band presents an outer tubular surface facing the symmetry axis and an annular surface connecting said inner and said outer tubular surfaces, wherein said protrusions are formed on said surfaces.

In one aspect, the radially external band comprises an annular body placed at a radially inner edge of the radially external band, wherein said protrusions are formed on said annular body. In one aspect, the annular body is axially offset with respect to the median plane of the side braking surfaces.

In one aspect, the annular body protrudes axially and radially from a main body of the radially external band carrying the side braking surfaces. In one aspect, the annular body presents the outer tubular surface, the annular surface and the inner tubular surface and carries the protrusions. In one aspect, the terminal portion of each protrusion protrudes radially from the inner tubular surface. In one aspect, the axial portion of each protrusion protrudes axially from the annular surface. In one aspect, the axial portion of each protrusion protrudes radially from the outer tubular surface.

In one aspect, the radially external band comprises two opposite annular members connected to each other and each carrying one of the side braking surfaces, wherein the protrusions are shaped at a radially inner edge of one annular member only. In one aspect, cooling channels are formed between said two opposite annular members. In one aspect, the protrusions are axially shifted apart with respect to said cooling channels. In one aspect, the protrusions are shaped at the radially inner edges of both annular members. In one aspect, the bell is connected to radially inner edge of one annular member only. In one aspect, the bell is connected to radially inner edges of both annular members.

In one aspect, the radially external band is produced by: mixing raw material carbon fiber reinforced polymer (CFRP); molding the carbon fiber reinforced polymer; adding the ceramic material by pyrolysis and infiltration into the carbon fiber reinforced polymer.

In one aspect, after co-casting of the metal bell, the rough co-casted bell is subjected to machining.

According to a further different aspect, the present invention relates to a braking system comprising at least a disc according to one or more of the previous aspects and preferably manufactured according to a process for making a disc according to one or more of the previous aspects.

Brief description of the drawings

Further characteristics and advantages will be more evident from the detailed description of a preferred but not exclusive embodiment of a disc for disc brakes in accordance with the present invention.

Such description will be set forth hereinbelow with reference to the enclosed drawings, provided only for exemplifying and hence non-limiting purposes, in which:

- figure 1 shows a perspective view of a disc for disc brakes according to the present invention;
- figure 2 shows a perspective view of a sectioned part of an element of the disc of figure 1;
- figure 3 is an enlarged view of a portion of the sectioned part of figure 2;
- figure 4 shows a different perspective view of the sectioned part of figure 2;
- figure 5 is a plan view of a portion of the element of figures 2 to 4;
- figure 6 is a sectioned and an enlarged view of a particular of the element of figures 2 to 5;
- figure 7 shows a sectioned half-portion of the disc of figure 1 in a step of the manufacturing process according to the present invention; and
- figure 8 shows the sectioned half-portion of figure 7 in a different step of the manufacturing process.

Detailed description of a preferred embodiment of the invention

With reference to figure 1, reference number 1 indicates a disc for disc brakes for vehicle wheels in accordance with the present invention.

The disc 1 comprises a bell or cup 2 configured to be connected by bolts to the hub of a vehicle wheel and a radially external band 3 or ring presenting side braking surfaces 4 suitable to cooperate with brake calipers (not shown) to exert a braking action on the vehicle. The radially external band 3 presents a central hole configured to accommodate the bell 2.

The radially external band 3 comprises two opposite annular members 5 which surround the bell 2, are placed axially side by side and are connected to each other by means of spacing walls 6. Said spacing walls 6, together with the annular members 5, delimit inside the radially external band 3 a plurality of cooling

channels 7 which extend substantially radially. Each of the annular members 5 carries one of the side braking surfaces 4.

The bell 2 is made of aluminum alloy and the radially external band 3 is made of carbo-ceramic composite material, i.e. ceramic material reinforced with carbon fibers. The radially external band 3 is manufactured, according to a process known per-se, by molding a mix of carbon fiber reinforced polymer and then adding, by pyrolysis and infiltration, ceramic material into the carbon fiber reinforced polymer. Before pyrolysis and infiltration, the radial external band 3 is drilled to make ventilation holes.

According to the present invention, the radially external band 3 is shaped to present a plurality of protrusions 8 jutting out from a radially inner edge 9 of the radially external band 3 towards a symmetry axis “X-X” of the disc 1 (which is the axis of rotation of the disc 1 and the wheel). The protrusions 8 delimit a central passage of the radially external band 3. Such protrusions 8 are made in one piece with the overall radially external band 3 during the molding process.

According to the embodiment shown in the attached figures, an annular body 10 is placed at the radially inner edge 9 of the radially external band 3. Said annular body 10 is coaxial to the symmetry axis “X-X” and is made in one piece with the annular members 5. As well shown in figures 2, 4 and 6 to 8, the annular body 10 is integral with one of the two annular members 5 and is axially offset with respect to a median plane “P” of said annular members 5. The annular body is also axially offset with respect to the mouths of the cooling channels 7 which opens radially inwards towards the symmetry axis “X-X” (see figure 4) and are in fluid communication with the ventilation holes. In particular, said annular body 10 protrudes axially and radially from the annular member 5 which is attached to.

Said annular body 10 presents a circumferential surface 11 facing radially outwards, i.e. opposite to the symmetry axis “X-X”, and joined to the respective braking surface 4. An annular surface 12 parallel to the braking surfaces 4 develops from said circumferential surface 11. The annular body 10 further defines a circular step comprising an outer tubular surface 13, coaxial with the symmetry axis “X-X” and departing from the annular surface 12, a further annular surface 14 departing from the outer tubular surface 13 and parallel to the braking surface 4 and an inner tubular surface 15 departing from the further annular surface 14 and coaxial with the symmetry axis “X-X”. The annular surface 12 develops

uninterrupted around the symmetry axis “X-X”. The outer tubular surface 13 and the further annular surface 14 are each made of a succession of portions divided by the protrusions 8 as explained more in details further on. The inner tubular surface 15 comprises an uninterrupted portion and a succession of portions divided by the protrusions 8. The annular surface 12 and the outer tubular surface 13 delimit between them a succession of arched and sharp edges. The outer tubular surface 13 and the further annular surface 14 delimit between them a succession of arched and recessed corners. The further annular surface 14 and the inner tubular surface 15 delimit between them a succession of arched and sharp edges. The annular body 10 further presents another annular surface 16 axially opposite with respect to said further annular surface 14 and parallel to the same. Said another annular surface 16 is place close to the mouths of the cooling channels 7 and faces the median plane “P” of the annular members 5.

Each protrusion 8 is shaped like a sort of tooth which develops from outer tubular surface 13, the further annular surface 14 and the inner tubular surface 15 and is made integral (in one piece) with the annular body 10 and with the overall radially external band 3. Each protrusion 8 comprises an axial portion 17 jutting out axially from a side of the radially external band 3, in particular from the further annular surface 14, and presents a front surface 18 developing from the annular surface 12 and flush with said annular surface 12. The front surface 18 is parallel to the side braking surfaces 4. Lateral surfaces 19 of said axial portion 17 (see figure 3) connects the front surface 18 with the further annular surface 14. Said lateral surfaces 19 lie in respective radial planes and therefore converge towards the symmetry axis “X-X”. Each protrusion 8 further comprises a terminal portion 20 (figures 3 and 6 to 8) jutting radially inwards towards the symmetry axis “X-X”. Said terminal portion 20 presents a first side surface 21 (figures 6 to 8) parallel to the braking surface 4 and facing the cited median plane “P”. Said first side surface 21 develops perpendicularly from the inner tubular surface 15. Said terminal portion 20 presents a second slanted side surface 22 axially opposite to the first side surface 21 and developing with no interruption from the front surface 18 of the axial portion 17. On moving towards the symmetry axis “X-X”, the second slanted side surface 22 moves closer to the first side surface 21 so that, in a radial plane, the terminal portion 20 tapers towards said symmetry axis “X-X”. The second slanted side surface 22 and the first side surface 21 of each protrusion 8 are

connected one to the other by a radially inner surface 23 shaped like a tubular sector and by two opposite lateral surfaces 24 (figure 3 and 6 to 8). Between the lateral surfaces 19 of the axial portion 17 and the lateral surfaces 24 of the terminal portion 20 and between the second slanted side surface 22 and the radially inner surface 23, a rim surface 25 is delimited which is substantially parallel to the braking surface 4. The lateral surfaces 19 of the axial portion 17 and the lateral surfaces 24 of the terminal portion 20 are placed on different and parallel radial planes.

By way of example, the terminal portion 20 of said protrusion 8 presents a radial dimension “a” of about 7mm, a maximum axial dimension “b” (measured at the inner tubular surface 15) of about 10mm, a minimum axial dimension “c” (measured at the radially inner surface 23) of about 5mm. An axial dimension “d” of the axial portion 17 of the protrusion 8 measured from the further annular surface 14 is about 8mm.

Said protrusions 8 are disposed in succession around the symmetry axis “X-X” and are equally spaced one from the other along the circumferential direction. In the illustrated embodiment, each of the eighteen protrusions 8 extends circumferentially along an arc “α” of about 10°. Two subsequent protrusions 8 delimit between them (between facing opposite lateral surfaces 19) a seat 26.

Once that the radially external band 3 with its protrusions 8 is ready, making of the bell 2 is performed by co-casting on said band 3 the aluminum alloy. To this aim, the radially external band 3 is placed in a cavity of a mold (insertion in shell) and melted aluminum is poured in the mold. The cavity of the mold is so shaped that the melted aluminum partly surrounds the protrusions 8 and enters the seats 26. In particular, the melted aluminum covers in part the annular surface 12, all the front surface 18 of each axial portion 17 of the protrusions 8, the first side surface 21, the second slanted surface 22 and the radially inner surface 23 and the lateral surfaces 24 of each terminal portion 20 of the protrusions 8. Further, the melted aluminum covers the inner tubular surface 15, the outer tubular surface 13, the further annular surface 14 and the lateral surfaces 19 of each axial portion 17 of the protrusions 8. Once solidified, the bell 2 presents radial lugs which are placed inside the seats 26 formed between the protrusions 8 of the radial external band 3. After solidification of aluminum, the disc 1 with the raw bell 2 (shown in figure 7) is extracted from the mold and sprue removal performed. Then the raw bell 2 is

drilled to make holes for the studs of the vehicle hub and for the shaft and machined to define the plane of coupling 27 with the vehicle hub and the axially opposite plane 28 (figure 8).

In a further embodiment, not shown, the annular body 10 and the protrusions 8 are provided on both the annular members and the bell 2 is joined to both said annular bodies 10.

In a further embodiment not shown, only the radially peripheral part of the metallic bell 2 which is in contact with the external band 3 is co-casted with said external band 3 while an inner part of the same bell 2 could be produced separately and then welded to said radially peripheral part.

CLAIMS

1. Disc for disc brakes, comprising a metallic bell (2) and a radially external band (3) extending around a symmetry axis (X-X), said radially external band (3) presenting side braking surfaces (4) suitable to cooperate with brake calipers to exert a braking action on a vehicle, said radially external band (3) being of a composite material comprising carbon fibers;

wherein at least part of the metallic bell (2) is co-casted on the radially external band (3);

wherein the radially external band (3) is shaped to form a plurality of protrusions (8) of said composite material placed around the symmetry axis (X-X);

wherein, in a radial plane, a terminal portion (20) of each protrusion (8) juts radially inwards and the co-casted bell (2) incorporates at least said terminal portions (20);

wherein, in a radial plane, each terminal portion (20) tapers towards the symmetry axis (X-X).

2. Disc according to the preceding claim, wherein said terminal portion (20) presents a first side surface (21) substantially perpendicular to the symmetry axis (X-X) and a second slanted side surface (22) axially opposite to the first side surface (21).

3. Disc according to one of the preceding claims, wherein said terminal portion (20) presents a radially inner surface (23) shaped like a tubular sector.

4. Disc according to the preceding claim when depending on claim 2, wherein the metal of the bell (2) lies in contact with the first side surface (21), with the second slanted side surface (22) and with the radially inner surface (23).

5. Disc according to the preceding claims 2 or 3 when depending on claim 2 or 4, wherein the radially external band (3) presents an inner tubular surface (15) facing the symmetry axis (X-X) and delimiting with each of the first side surfaces (21) of the terminal portions (20) a corner, wherein the metal of the bell (2) lies in said corner.

6. Disc according to one of the preceding claims, wherein each protrusion (8) presents two opposite lateral surfaces (19, 24) substantially perpendicular to a circumferential direction, wherein the lateral surfaces (19, 24) of each protrusion (8) converge towards the symmetry axis (X-X).

7. Disc according to the preceding claim, wherein the lateral surfaces (19, 24) lies on radial planes.

8. Disc according to the preceding claims 6 or 7, wherein the lateral surfaces (19) of adjacent protrusions (8) delimit a seat (26) for the metal of the bell (2), wherein the metal of the bell (2) lies in contact with said opposite lateral surfaces (19).

9. Disc according to one of the preceding claims, wherein each protrusion (8) comprises an axial portion (17) jutting out axially from a side of the radially external band (3).

10. Disc according to the preceding claim when depending on claims 2 to 8, wherein the slanted side surface (22) connects each terminal portion (20) to a respective axial portion (17).

11. Disc according to one of the preceding claims, wherein each protrusion (8) extends circumferentially along an arc (α) comprised between about 6° and about 15°, preferably between about 8° and about 12°.

12. Disc according to one of the preceding claims, wherein the protrusions (8) are axially offset with respect to a median plane of the side braking surfaces (4).

13. Disc according to one of the preceding claims, wherein the protrusions (8) protrude axially from at least one of the side braking surfaces (4).

14. Disc according to one of the preceding claims, wherein the radially external band (3) comprises two opposite annular members (5) connected to each other and each carrying one of the side braking surfaces (4), wherein the protrusions (8) are shaped at a radially inner edge (9) of one annular member (5) only.

15. Disc according to the preceding claim, wherein cooling channels (7) are formed between said two opposite annular members (5) and the protrusions (8) are axially shifted apart with respect to said cooling channels (7).

16. Disc according to one of the preceding claims, wherein the composite material comprises ceramic material reinforced with carbon fibers.

17. Disc according to one of the preceding claims, wherein the metal of the bell (2) is aluminum alloy.

18. Braking system comprising at least a disc according to one or more of the previous claims.

19. Process for manufacturing a disc for disc brakes, wherein preferably the disc (1) comprises the features of one or more of the preceding claims from 1 to 17, wherein the process comprises:

producing a radially external band (3) in composite material comprising carbon fibers; wherein the radially external band (3) is shaped to form a plurality of protrusions (8) of said composite material; wherein said protrusions (8) are placed around the symmetry axis (X-X) and jut radially inwards; wherein, in a radial plane, each protrusion (8) tapers towards the symmetry axis (X-X);

inserting said radially external band (3) in a mold cavity;

introducing a melted metal in the mold cavity to form at least part of a bell (2) of the disc (1) co-casted with the external band (3);

wherein the melted metal partly surrounds said protrusions (8) provided on the radially external band (3).

20. Process according to the preceding claim, wherein the radially external band (3) is produced by: mixing raw material carbon fiber reinforced polymer (CFRP); molding the carbon fiber reinforced polymer; adding the ceramic material by pyrolysis and infiltration into the carbon fiber reinforced polymer.

FIG.1

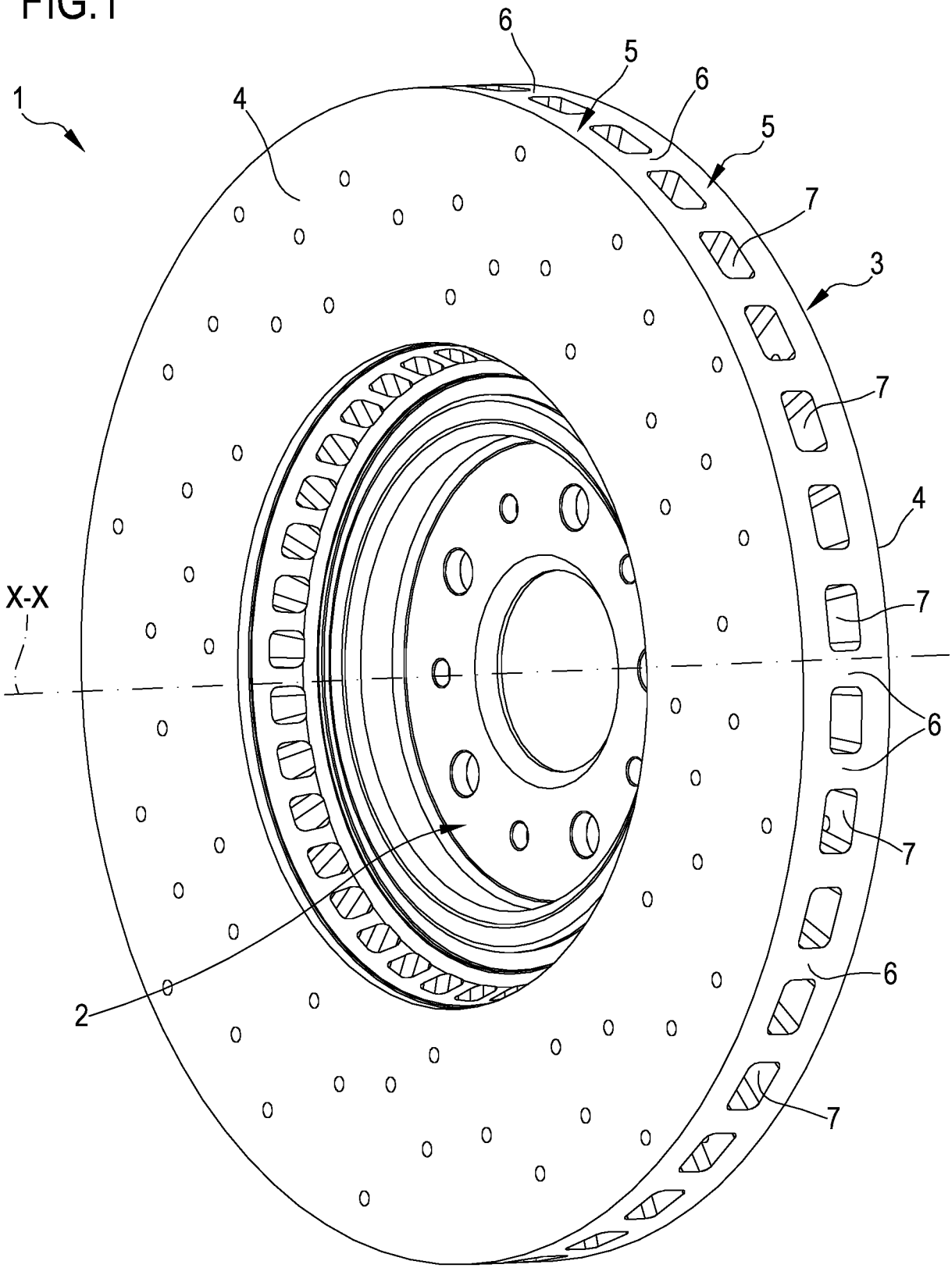
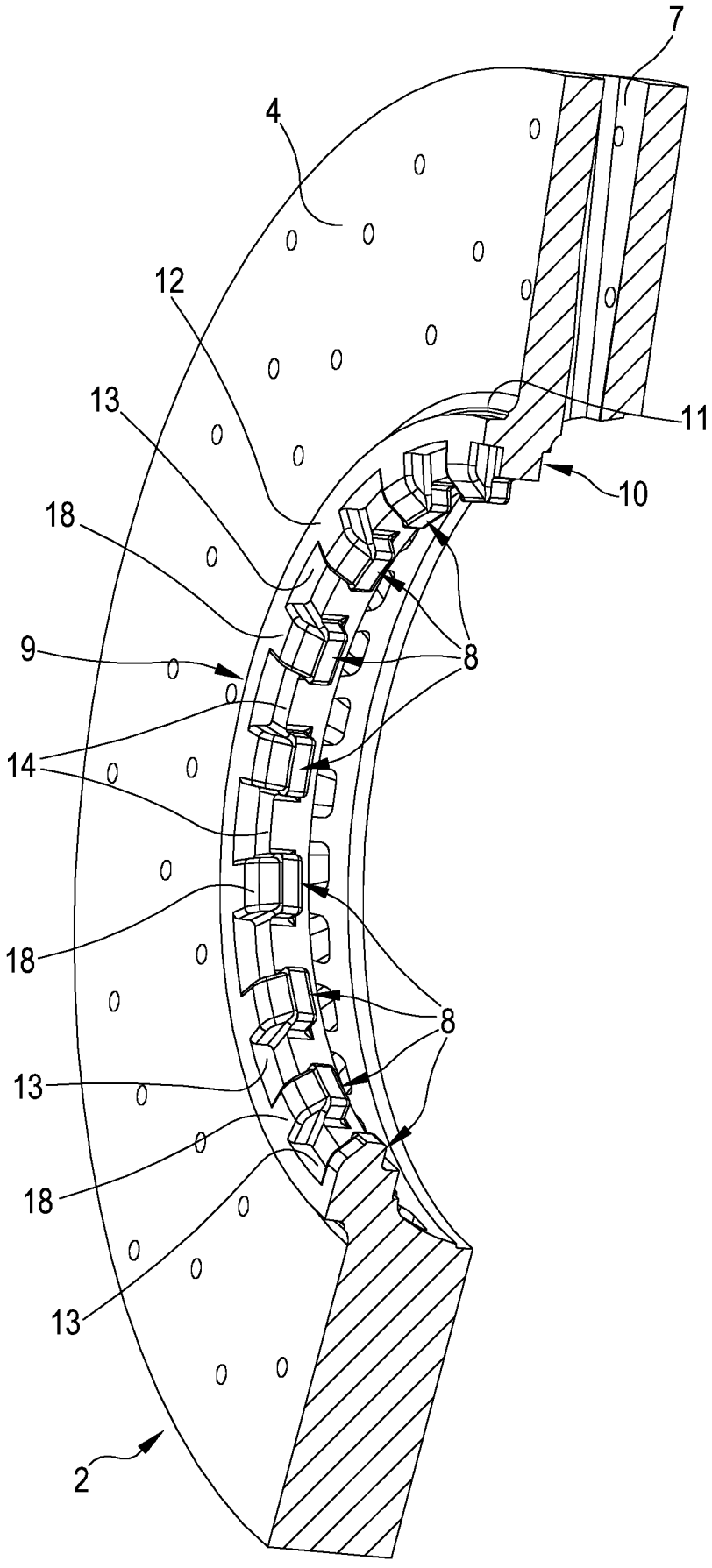


FIG.2



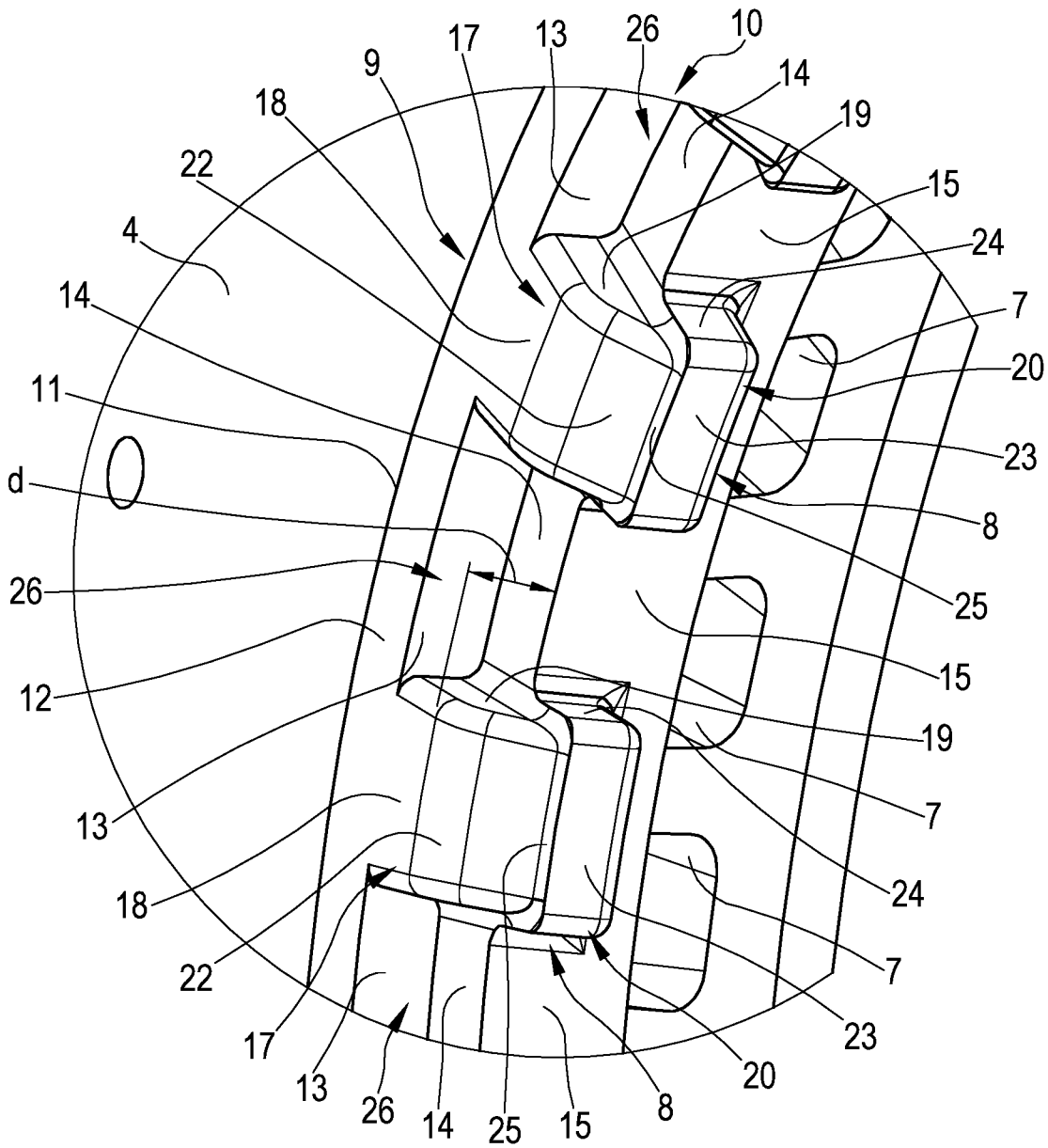
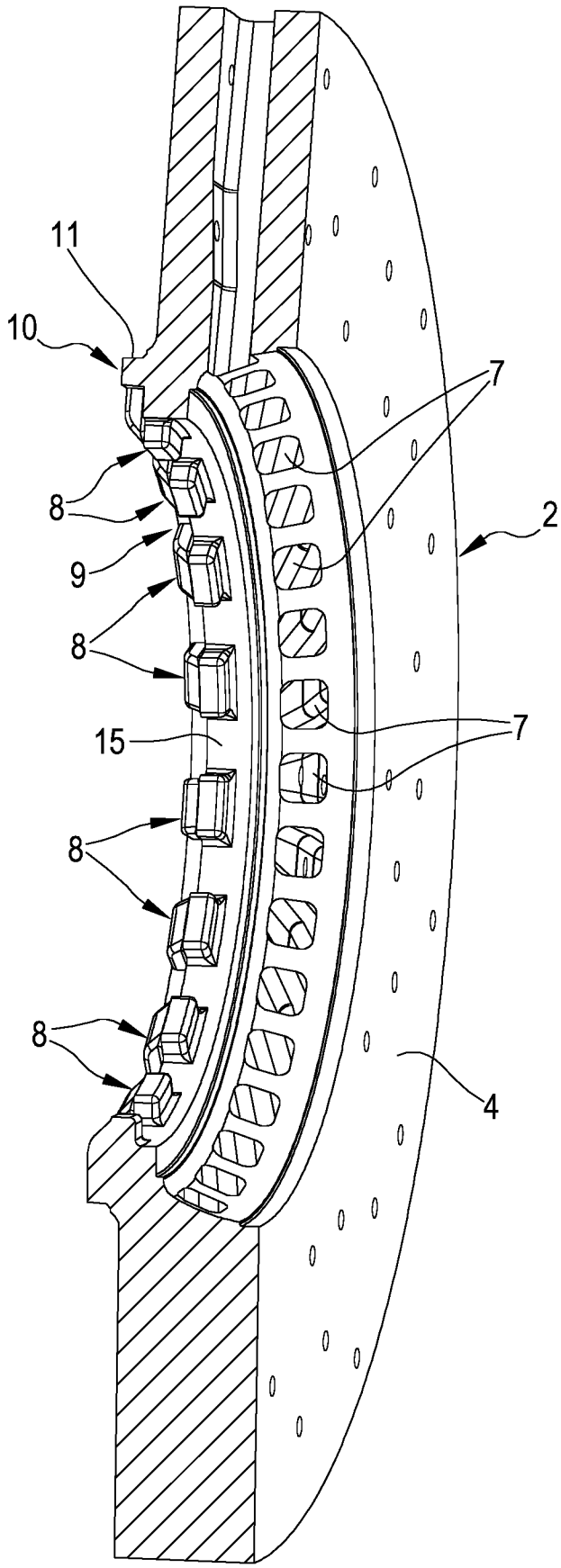

9
17
13
26
10
14
19
18
22
15
4
24
14
7
20
11
23
d
8
26
25
12
15
19
13
7
18
24
22
7
17
23
13
20
26
14
25
15
8

FIG.3

FIG.4



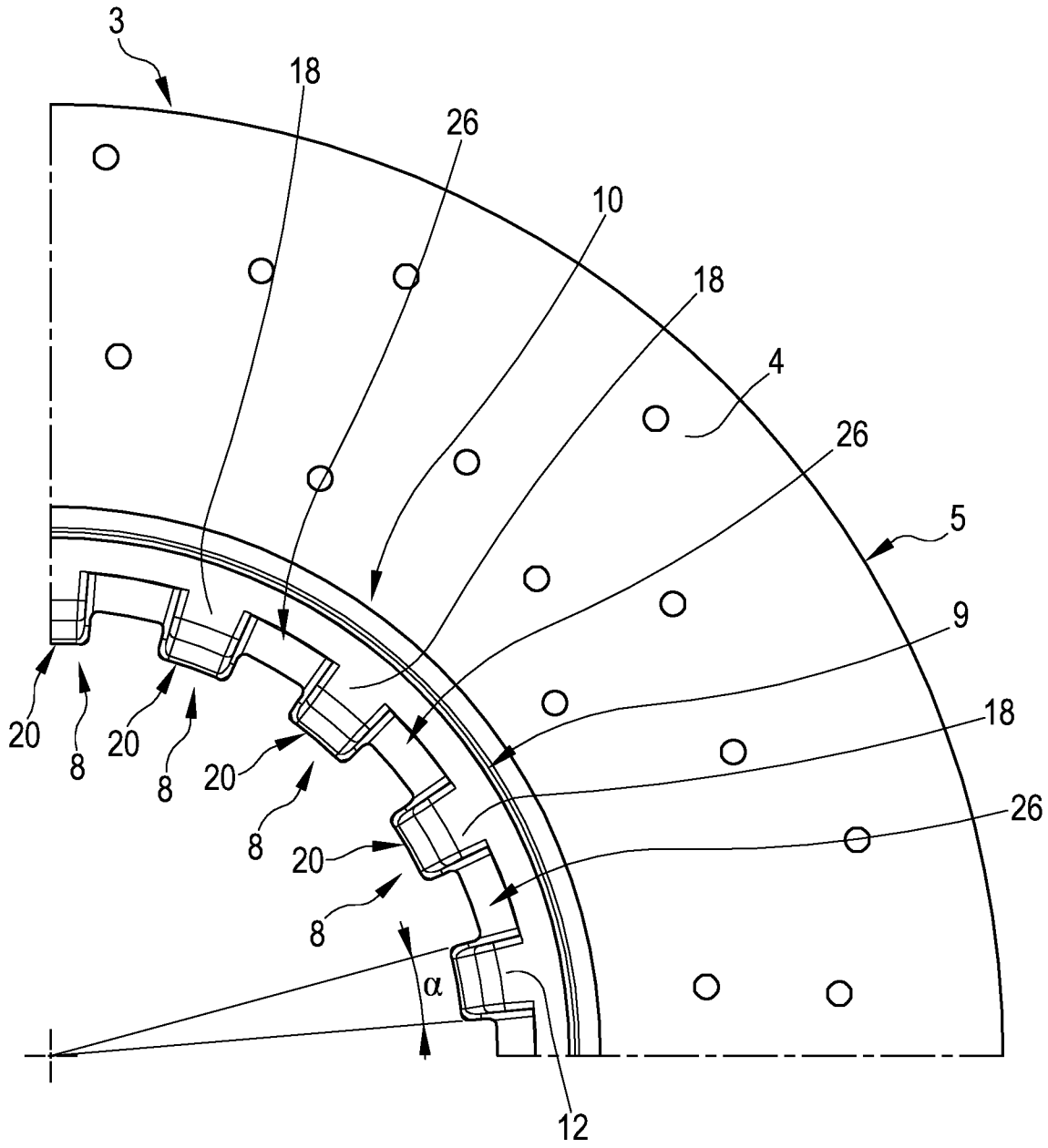


FIG.5

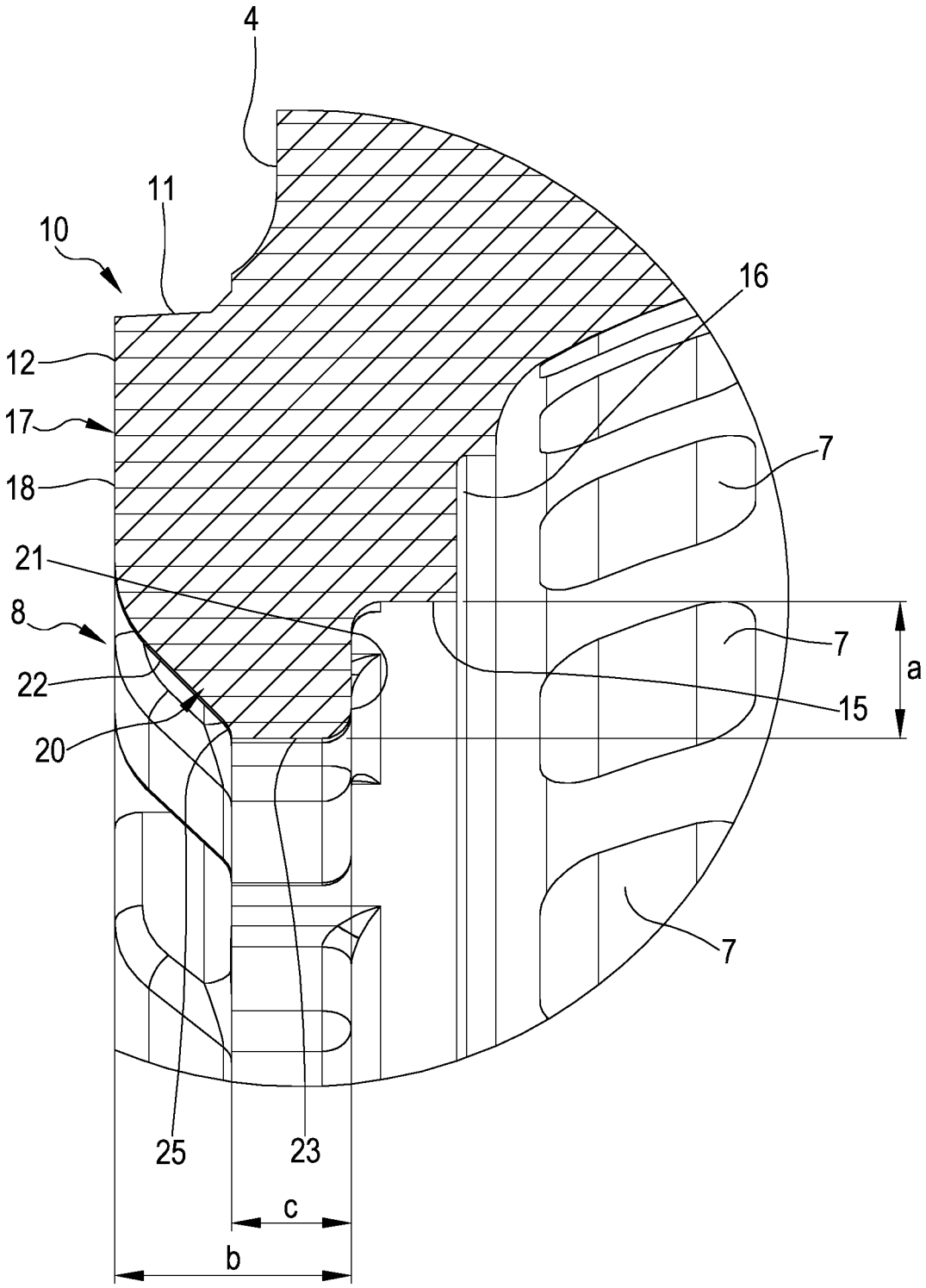


FIG.6

FIG.7

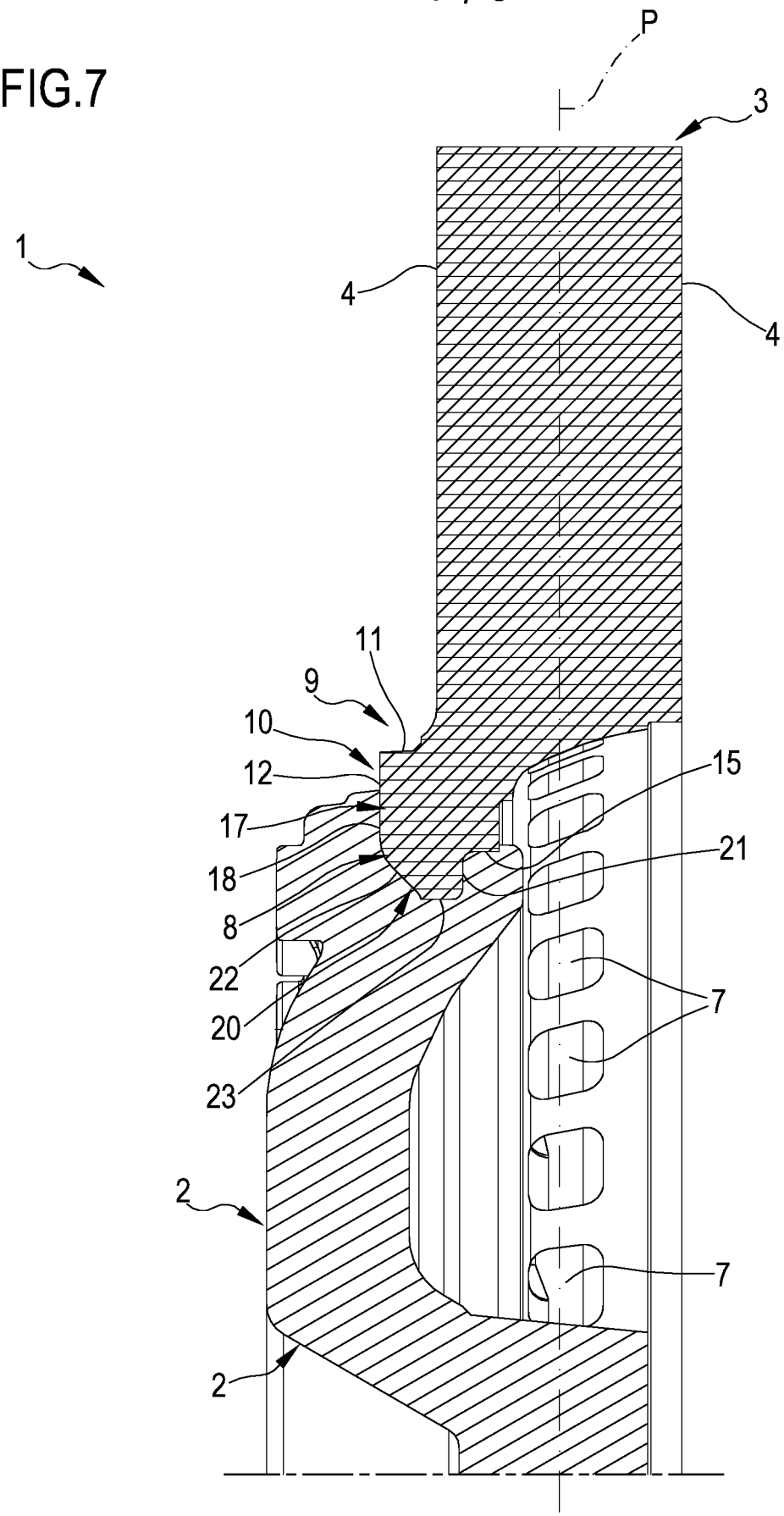
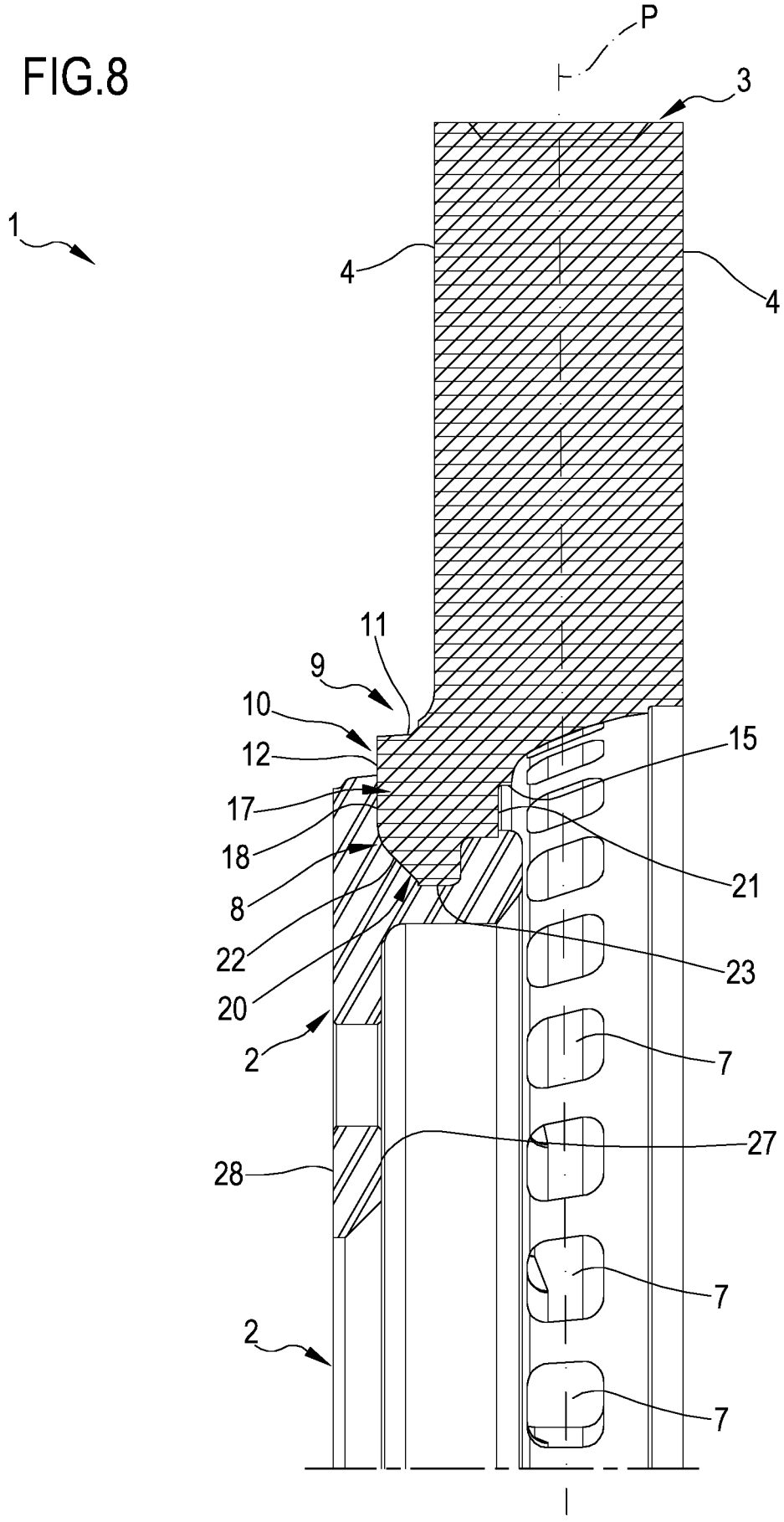


FIG.8



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/066623

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16D65/12
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 Y	US 6 152 270 A (GIORGETTI ALBERTO [IT]) 28 November 2000 (2000-11-28) column 1, line 62 - column 2, line 45; figures 1-3	1-15, 17-19 16
X	US 2013/037359 A1 (KIM YOON CHEOL [KR] ET AL) 14 February 2013 (2013-02-14) paragraphs [0010], [0011]; figures	1-3, 17-19
X Y A	DE 10 2009 013358 A1 (PORSCHE AG [DE]) 23 September 2010 (2010-09-23) cited in the application the whole document	19,20 16 1
A	WO 2006/046258 A1 (FRENI BREMBO SPA) 4 May 2006 (2006-05-04) paragraph [0033]; figure 9b	1,19

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

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 December 2015	15/12/2015

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

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2015/066623

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6152270 A	28-11-2000	DE 4436653 A1	20-04-1995
		FR 2711406 A3	28-04-1995
		IT MI930794 U1	18-04-1995
		JP 3016002 U	26-09-1995
		US 6152270 A	28-11-2000
US 2013037359 A1	14-02-2013	CN 102927169 A	13-02-2013
		DE 102011088029 A1	14-02-2013
		KR 20130017376 A	20-02-2013
		US 2013037359 A1	14-02-2013
DE 102009013358 A1	23-09-2010	NONE	
WO 2006046258 A1	04-05-2006	CN 101052820 A	10-10-2007
		EP 1805430 A1	11-07-2007
		EP 2275702 A2	19-01-2011
		JP 4897693 B2	14-03-2012
		JP 2008518175 A	29-05-2008
		US 2007246314 A1	25-10-2007
		WO 2006046258 A1	04-05-2006