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(71) Applicant: **BREMBO S.P.A.** [IT/IT]; Via Brembo, 25,
I-24035 Curno, Bergamo (IT).

(72) Inventors: **CARMINATI, Fabiano**; c/o BREMBO
S.p.A., Via Brembo, 25, I-24035 Curno, Bergamo (IT).
BRESCIANI, Francesco Andrea; c/o BREMBO S.p.A.,
Via Brembo, 25, I-24030 Curno, Bergamo (IT).

(74) Agent: **CRIPPA, Paolo Ernesto** et al.; c/o JACOBACCI
& PARTNERS S.p.A., Via Senato, 8, I-20121 Milano (IT).

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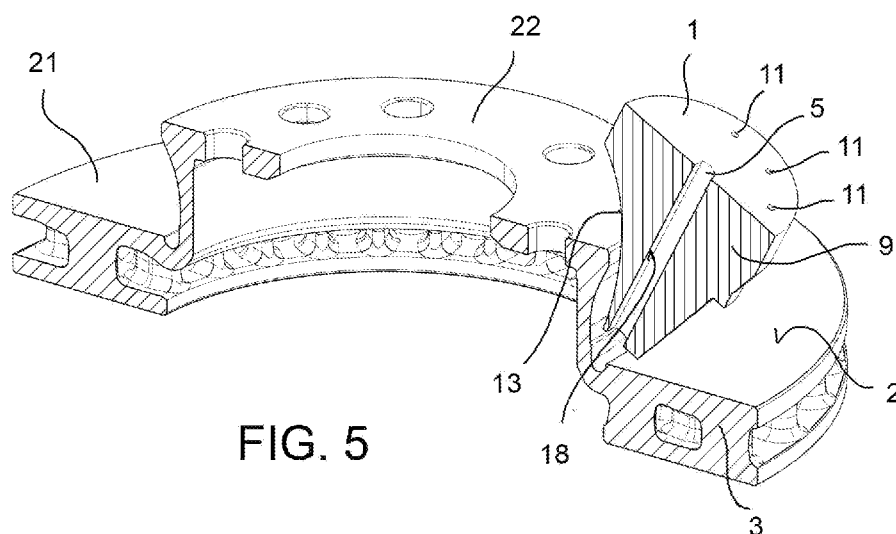


FIG. 5

(57) Abstract: Deposition nozzle for coating a surface of a piece The present invention relates to a deposition nozzle (1) for coating a surface (2) of a piece (3) by means of the heat treatment of additive material, in particular powder material (4), and/or for thermally treating the surface (2) of said piece (3), comprising - a radiation conduit (5) connectable to a laser device (6) to generate a focused laser beam (7) through a laser focusing device (8), said focused laser beam (7) being directed along a predetermined direction defining a nozzle axis (L-L); wherein - said deposition nozzle (1) comprises a nozzle body (9); said nozzle body (9) is initially axisymmetric-in shape with respect to said nozzle axis (L-L); - said nozzle body (9) has an elongated shape toward a nozzle radiation mouth (10); - said deposition nozzle (1) further comprises a plurality of powder feeding conduits (11) having extension along powder feeding directions (D-D) converging toward said nozzle axis (L-L); and wherein - said nozzle body (9) comprises a nozzle recess (13) which makes said nozzle body (9) dissymmetric; - said nozzle recess (13) affects an arc extending about said nozzle axis (L-L) by less than 180 DEG, preferably between 140 DEG and 160 DEG; - said nozzle recess (13) tapers the elongated shape of the nozzle body (9) locally narrowing the nozzle body (9) toward said nozzle radiation mouth (10); - said plurality of powder feeding conduits (11) being arranged entirely in the part of nozzle body (9) not affected by said nozzle recess (13).

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Deposition nozzle for coating a surface of a piece
DESCRIPTION

[0001]. Field of the invention

[0002]. The present invention relates to a deposition nozzle for coating a surface of a piece, and to an assembly comprising said deposition nozzle and said piece, e.g., a braking band of a disc brake disc.

[0003]. Background art

[0004]. In a disc brake, the brake caliper is generally arranged straddling the outer peripheral margin of a brake disc, adapted to rotate about a rotation axis (A-A) defining an axial direction (X-X). In a disc brake, there are defined a radial direction (R-R) substantially orthogonal to said axial direction (X-X), and a circumferential direction (C-C), orthogonal to both said axial direction (X-X) and said radial direction (R-R), as well as a tangential direction (T-T) locally, or rather punctually, i.e., in an intersection point of an axial and a radial direction, orthogonal to both said axial direction (X-X) and said radial direction (R-R).

[0005]. As is known, discs for a disc brake comprise a bell adapted to associate the disc with a hub of a vehicle, from which an annular portion extends, referred to as a braking band, intended to cooperate with brake pads of a caliper. In the case of discs of ventilated type, the braking band is obtained by two facing plates connected to each other by means of connection elements, e.g., in the form of pins or fins. The outer surfaces of the two plates define opposite braking surfaces, while the inner surfaces, together

with the pins or fins, delimit ventilation channels for cooling the disc, which channels are crossed by air according to a centrifugal direction during the rotary motion of the disc itself.

[0006]. Said braking band is intended to cooperate with disc brake calipers adapted to apply a braking action to the vehicle by applying, by means of the aforesaid pads, friction to the opposite surfaces of the two plates, referred to as braking surfaces.

[0007]. It is known that during the operation of the brakes, the friction between the pads of brake calipers and the braking surfaces of the braking band generates particulate matter.

[0008]. In particular, the automotive braking systems generate the aforementioned particulate matter, resulting in damage to health. Based on these assumptions, the Euro 7 exhaust gas standard (European Community standard) introduces restrictions to the amount of the allowed emitted particulate matter.

[0009]. Currently, to solve this drawback, it is known to coat the braking band of the disc by means of laser cladding technology: the powder to be coated is conveyed directly into the focus of the laser beam, where it melts in contact with air and reaches the molten surface of the brake disc. Argon, as an inert shielding gas, also passes through the nozzle so that the melting zone is substantially surrounded by this shielding gas.

[0010]. The metal powder is thus applied in layers to the base material with which it melts without creating pinholes or cracks.

[0011]. At this stage, the metal powder generates a high-strength welding joint with the surface. After cooling, a metal layer that

can be subjected to mechanical machining is formed.

[0012]. The special feature of this technique is that several identical or even different metal layers can be purposefully superimposed.

[0013]. The laser cladding process not only ensures less particulate matter, but also less wear of the braking band.

[0014]. Example of laser cladding technologies are: LMD (Laser Metal Deposition), EHLA (Extreme High-speed Laser Material Deposition).

[0015]. Examples of devices for applying these technologies to surfaces are disclosed in the following documents.

[0016]. WO2023152014A1 discloses a laser deposition welding method for producing coating layers on opposite surfaces of a component. In particular, on each surface, an additive material, in particular an additive powder material, is directed onto each surface along a processing trajectory, in particular a spiral-shaped processing trajectory, where the additive material and the component are heated along the processing trajectory by means of a laser beam so that the additive material connects to the component upon impacting against the surface of the component, and coating layers are simultaneously produced on the opposite surfaces of the component.

[0017]. WO2021156317A1 discloses a material depositing unit comprising a radiating unit, a powder discharging device, having seven powder discharging units, and a powder dividing unit, having seven powder channels, where the individual powder channels are connected to the individual powder channels by means of an

interchangeable connection element, where all the powder discharging units have an interchangeable powder discharging element, where the powder discharging element is elongated in shape and is arranged at least partially inside the corresponding powder discharging unit.

[0018]. WO2023116983A1 discloses an apparatus for coating a piece; said apparatus has the following components: a laser device for generating a laser beam with a laser focus; a nozzle for feeding powder; and an advancement actuator system for advancing the laser device and the powder nozzle.

[0019]. The laser device is designed to thermally treat the powder material provided by a powder nozzle to coat a surface of a piece and/or thermally treat this surface.

[0020]. The equipment further comprises:

[0021]. - a measuring device for detecting the coordinates of a point on a surface to be coated;

[0022]. - an adjustment device for adjusting the laser focus and the powder nozzle with respect to each other.

[0023]. US2006065650A1 discloses a compact coaxial nozzle useful in laser welding operations in which the piece to be welded has a narrow or confined geometry.

[0024]. The nozzle is generally conical in shape and ends with a relatively small tip.

[0025]. The nozzle includes a central opening for laser discharge.

[0026]. The conical shape allows the movement of the nozzle in narrow areas.

[0027]. The nozzle includes a cooling jacket to provide coolant to

the nozzle.

[0028]. The nozzle also includes a powder mixing chamber which provides good mixing of the powder filling material with a coaxial discharge about the laser.

[0029]. Finally, the nozzle provides for the passage of inert gas from an upper inlet, through passages, out of an annular discharge.

[0030]. The annular discharge is also arranged coaxially about the central laser.

[0031]. Moreover, the annular discharge provides the inert gas mixing to minimize turbulent flow problems associated with limiting plates.

[0032]. **US2009095214A1** discloses a laser device for applying a coating to a part comprising a laser which can generate laser light, which is adapted to heat the coating and the part. Said device has a main body which defines a laser light channel adapted to transmit the laser light to the part, a coating channel adapted to transmit the coating to the part, and a vacuum channel and nozzle having an outlet.

[0033]. The nozzle comprises a dispensing port at one end of the laser light channel, a coating port at one end of the coating channel, and a vacuum port at one end of the vacuum channel, where the vacuum port is positioned adjacent to the dispensing port. In operation, the vacuum port creates a vacuum, pulling the coating toward the piece.

[0034]. **US2015298258A1** discloses a powder supply device for a laser powder welding device.

[0035]. The powder supply device has a nozzle head which tapers along a longitudinal axis of the powder supply device in the direction of a first end. A cavity which tapers toward the first end of the nozzle head is arranged radially about the longitudinal axis inside the nozzle head. The cavity leads to an annular opening at the first end for the discharge of a powder.

[0036]. The powder supply device has a plurality of powder supply lines extending through a second end of the nozzle head, which is opposite to the first nozzle head, in the direction toward the cavity to direct the powder from a powder reservoir into the cavity.

[0037]. WO9520458A1 discloses a laser metal powder coating apparatus which includes a removable conical nozzle having a central opening through which the laser beam and the metal powder exit from the apparatus.

[0038]. The opening extends up to the front surface of the nozzle which is close to the piece.

[0039]. The axial passages in the tapered nozzle wall extend backward from the front surface and are arranged in a series centered about the opening.

[0040]. The inert gas flows through these axial passages to cool the nozzle and form an oxidation screen in the liquid metal pool.

[0041]. Water is circulated through a water jacket between the openings to cool the apparatus.

[0042]. The metal powder for the coating is dispensed to a conical passage at the inlets thereof and exits through the opening.

[0043]. However, these known solutions do not allow solving a

particular need, as will be explained below.

[0044]. By holding the nozzle in a vertical position (laser beam perpendicular to the piece to be treated, e.g., to the braking band), it is not possible to coat the undercuts, e.g., the undercut between the braking band and the brake disc bell, or portions of the braking band close to the brake disc bell, such as the groove (or gully) at the junction between the bell and the disc braking band present in some discs, for example (see Figure 14 regarding a solution of the prior art).

[0045]. This problem arises because of the size of the nozzle body itself, which abuts against the disc bell when held in a vertical position. It is necessary to tilt the nozzle at an extreme inclination angle in order to direct the laser into the undercut to also coat these portions of the disc.

[0046]. The technologies used today exhibit a reduction in efficiency and quality of the coating made in the undercut portion between bell and disc braking band when made by tilting the nozzle as previously described.

[0047]. The main problems identifiable from this solution in Figure 14 are:

[0048]. - loss of efficiency and quality due to the need to tilt, or tilt at a high angle, the process powder distribution unit to process specific parts or components during the laser cladding operation;

[0049]. - inability to process specific parts or components using laser cladding techniques due to the geometry of the part or

component to be processed;

[0050]. - longer overall processing cycle time.

[0051]. Solution

[0052]. It is the object of the present invention to provide a deposition nozzle which also allows processing zones close to the undercuts to be treated with greater precision and speed.

[0053]. This and other objects and advantages are achieved by a deposition nozzle according to claim 1 as well as by a deposition nozzle and piece-to-be-treated assembly according to claim 10.

[0054]. Some advantageous embodiments are the subject of the dependent claims.

[0055]. From the discussion of this solution, it was found that the suggested solution allows obtaining a reduction of the gun nozzle section and in particular a non-axisymmetric nozzle.

[0056]. In particular, a recess is made in the nozzle to reduce the inclination angle at which the gun needs to be tilted when coating the undercut zone, e.g., an undercut between bell and braking band.

[0057]. Unlike the currently known nozzles (free from recess), which must be tilted at inclination angles between 25 and 35 degrees, as a function of the specific geometry of the bell (cylindrical or with a "C"-shaped section, as depicted in the accompanying Figures 1, 2 and 4, 5) and the degree of precision chosen to coat the critical zones, in order to reach the undercut/grooves between the bell and braking band of the brake disc, by virtue of the suggested solution the inclination angle of

the nozzle can be reduced between 13 and 20 degrees with respect to the direction orthogonal to the flat surface to be treated.

[0058]. By virtue of the suggested solution, it is possible to obtain several advantages, including:

[0059]. - improving the efficiency and overall quality of a layer deposited by laser cladding techniques in operations which would otherwise need to tilt the process powder distribution unit to be performed;

[0060]. - improving the efficiency and overall quality of a layer deposited by laser cladding techniques in operations that would otherwise require to tilt the process powder distribution unit at an extreme angle to be performed thus reducing the required angle;

[0061]. - allowing the possibility to process parts or components which would otherwise be impossible to process with a standard process powder distribution unit.

[0062]. By virtue of the suggested solution, the technology is applicable:

[0063]. - in brake discs which could hinder the use of laser cladding techniques;

[0064]. - in zones close to the bell for the connection with the brake disc hub near the inner diameter of the friction ring (car on the outside);

[0065]. - in zones close to the bell for the connection with the brake disc hub with undercut (e.g., application on commercial vehicles).

[0066]. Figures

[0067]. Further features and advantages of the device, the disc brake, and the vehicle will become apparent from the following description of preferred embodiments thereof, given by way of non-limiting indication, with reference to the accompanying drawings, in which:

[0068]. - figure 1 depicts an axonometric view of an assembly comprising a piece, in this case a brake disc comprising a ventilated braking band connected in one piece to a bell, or portion for the connection of the brake disc with a support, or hub, of a vehicle, and a deposition nozzle placed close to the bell and oriented so as to treat the connection channel between the braking surface, or surface to be treated, of the braking band and the bell;

[0069]. - figure 2 shows a side view of the assembly in figure 1, in which the deposition nozzle is viewed from the side and the recess thereof is highlighted;

[0070]. - figure 3 diagrammatically depicts a side view of the cladding process performed with the deposition nozzle of the present invention while performing a treatment on a surface to be treated of a piece;

[0071]. - figure 4 shows a side view of the assembly in figure 1, in which the deposition nozzle is shown frontally;

[0072]. - figure 5 depicts an axonometric view sectioned on a plane passing through the axial A-A and radial R-R directions of the brake disc passing through the nozzle axis L-L of the assembly in figure 1;

[0073]. - figure 6 depicts an axonometric view of the deposition

nozzle of the present invention;

[0074]. - figures 7 to 9 depict top, side, and bottom views of the deposition nozzle in figure 6;

[0075]. -figure 10 shows an axonometric view sectioned according to the plane passing through the nozzle axis and defined by letters A-A in figure 9 of the deposition nozzle in figure 6;

[0076]. - figure 11 shows an axonometric view sectioned according to the plane passing through the nozzle axis and defined by letters B-B in figure 9 of the deposition nozzle in figure 6;

[0077]. -figure 12 shows an axonometric view sectioned according to the plane passing through the nozzle axis and defined by letters C-C in figure 9 of the deposition nozzle in figure 6;

[0078]. - figure 13 shows a very diagrammatic side view of a disc surface treatment system;

[0079]. - figure 14 shows a deposition nozzle and piece-to-be-treated assembly according to the prior art;

[0080]. figure 15 shows a deposition nozzle and piece-to-be-treated assembly according to the invention.

[0081]. Description of some preferred embodiments

[0082]. According to a general embodiment, a deposition nozzle 1 for coating a surface 2 of a piece 3 by means of the heat treatment of additive material, in particular powder material 4, and/or for thermally treating the surface 2 of said piece 3.

[0083]. Said deposition nozzle 1 comprises a radiation conduit 5 connectable to a laser device 6 to generate a focused laser beam 7 through a laser focusing device 8, said focused laser beam 7 being

directed along a predetermined direction defining a nozzle axis L-L.

[0084]. Said deposition nozzle 1 comprises a nozzle body 9; said nozzle body 9 is initially axisymmetric in shape with respect to said nozzle axis L-L.

[0085]. Said nozzle body 9 has an elongated shape toward a nozzle radiation mouth 10.

[0086]. Said deposition nozzle 1 further comprises a plurality of powder feeding conduits 11 having extension along powder feeding directions D-D converging toward said nozzle axis L-L.

[0087]. Advantageously, said nozzle body 9 comprises a nozzle recess 13, which makes said nozzle body 9 dissymmetric.

[0088]. Said nozzle recess 13 affects an arc extending about said nozzle axis L-L by less than 180 DEG, preferably between 140 DEG and 160 DEG.

[0089]. Said nozzle recess 13 tapers the elongated shape of the nozzle body 9 locally narrowing the nozzle body 9 toward said nozzle radiation mouth 10.

[0090]. Said plurality of powder feeding conduits 11 being arranged entirely in the part of nozzle body 9 not affected by said nozzle recess 13.

[0091]. According to a constructional variant, said nozzle recess 13 is given by the intersection between a ball and said nozzle body 9 when still axisymmetric.

[0092]. According to a constructional variant, said nozzle recess 13 is obtained by the subtraction of a ball portion from said nozzle body 9 when still axisymmetric.

[0093]. According to a constructional variant, said nozzle body 9 comprises a first proximal cylindrical nozzle portion 14, a first intermediate conical portion 15, a second intermediate cylindrical portion 16, and a second distal conical portion 17.

[0094]. According to a constructional variant, said nozzle recess 13 affects said first intermediate conical portion 15, said second intermediate cylindrical portion 16, and said second distal conical portion 17.

[0095]. According to a constructional variant, said nozzle body 9 comprises a first proximal cylindrical nozzle portion 14 distally connected to a first intermediate conical portion 15 distally connected to a second intermediate cylindrical portion 16 distally connected to a second distal conical portion 17.

[0096]. Said nozzle recess 13 affects said first intermediate conical portion 15, said second intermediate cylindrical portion 16, and said second distal conical portion 17.

[0097]. According to a constructional variant, said powder feeding conduits 11 converge in a single point of intersection 12 of the powder feeding directions, placed on said nozzle axis L- L.

[0098]. According to a constructional variant, said plurality of powder feeding conduits 11 is distributed so as to have the powder feeding conduits 11 equally spaced apart from each other and mutually converging.

[0099]. According to a constructional variant, said radiation conduit 5 has cylinder-shaped radiation conduit walls 18.

[00100]. According to a constructional variant, said radiation

conduit 5 delimits a passage in the shape of a right cylinder.

[00101]. According to a constructional variant, said nozzle radiation 10 is delimited by a circumference-shaped periphery.

[00102]. According to a constructional variant, said nozzle radiation mouth 10 is orthogonal to said nozzle axis L-L.

[00103]. According to a constructional variant, said powder feeding conduits 11 are distributed in said nozzle body 9 in an arc extending about said nozzle axis L-L with a width of less than 200 DEG.

[00104]. According to a constructional variant, said powder feeding conduits 11 delimit a cylindrical passage with rectilinear extension along a straight powder feeding direction D-D.

[00105]. The present invention also relates to a deposition nozzle 1 and piece-to-be-treated assembly, comprising

[00106]. - a feeding nozzle 1 according to any one of the previous embodiments described;

[00107]. - and where said piece 3 is a braking band of a disc brake disc.

[00108]. A treatment process possible with this deposition nozzle is described below.

[00109]. For example, there is described the laser cladding process on a surface to be treated 2 of a braking band 3 of a brake disc 21 for a disc brake, where the treatment is taken close to the bell 22 or portion for the connection of the brake disc to the vehicle hub (see figures 1, 2, 4, 5 and 15).

[00110]. A laser beam, e.g., surrounded by a shielding gas, is

focused into the deposition nozzle 1. The process powder 20 is fed into the powder feeding conduits 11. Usually the deposition nozzle is cooled with fluid, e.g., water.

[00111]. As mentioned, the laser beam 19 is directed along a direction defined by the nozzle axis L-L and focuses on a point, in which point the melting and thus the process activation occur, which point is preferably close to or coinciding with the intersection point of the powder feeding directions D-D. At this point, the surface to be treated 2 of the piece 3 is heated, e.g., melts, and creates a bonding zone, to which the cladding layer obtained by activating the powder with the laser, e.g., by melting the powder at least partially, is bonded (Figure 3).

[00112]. The nozzle body 9, by virtue of the nozzle recess 13, is very close to the bell 22 and allows having a very small angle 23, for example between 13 DEG and 20 DEG, between the direction given by the extension of the nozzle axis L-L and the normal to the surface to be treated 2, e.g., the axial direction A-A of the brake disc 21 even when the laser beam 19 is directed to the connection portion between the braking band 3 and the bell 22, i.e., the undercut given by the connection channel.

[00113]. LIST OF REFERENCE SIGNS

	1	deposition nozzle
	2	surface to be treated
	3	piece, e.g., braking band of a disc brake disc
5	4	powder material
	5	radiation conduit
	6	laser device
	7	focused laser beam
	8	laser focusing device
10	9	nozzle body
	10	nozzle radiation mouth
	11	powder feeding conduits
	12	single point of intersection of the powder feeding directions
	13	nozzle recess
15	14	first proximal cylindrical nozzle portion
	15	first intermediate conical portion
	16	second intermediate cylindrical portion
	17	second distal conical portion
	18	radiation conduit walls
20	X-X	rotation axis
	A-A	axial direction
	R-R	radial direction
	C-C	circumferential direction
	T-T	tangential direction
25	L-L	nozzle axis
	D-D	powder feeding direction
	ANG	arc of extension of the recess about the nozzle axis

CLAIMS

1. A deposition nozzle (1) for coating a surface (2) of a piece (3) by means of the heat treatment of additive material, in particular powder material (4), and/or for thermally treating the surface (2) of said piece (3), comprising
- a radiation conduit (5) connectable to a laser device (6) to generate a focused laser beam (7) through a laser focusing device (8), said focused laser beam (7) being directed along a predetermined direction defining a nozzle axis (L-L);
- wherein
- said deposition nozzle (1) comprises a nozzle body (9); said nozzle body (9) is initially axisymmetric-in shape with respect to said nozzle axis (L-L);
 - said nozzle body (9) has an elongated shape toward a nozzle radiation mouth (10);
 - said deposition nozzle (1) further comprises a plurality of powder feeding conduits (11) having extension along powder feeding directions (D-D) converging toward said nozzle axis (L-L);
- characterized in that
- said nozzle body (9) comprises a nozzle recess (13) which makes said nozzle body (9) dissymmetric;
 - said nozzle recess (13) affects an arc (ANG) extending about said nozzle axis (L-L) by less than 180 DEG, preferably between 140 DEG and 160 DEG;
 - said nozzle recess (13) tapers the elongated shape of the nozzle body (9) locally narrowing the nozzle body (9) toward said nozzle

radiation mouth (10);

- said plurality of powder feeding conduits (11) being arranged entirely in the part of nozzle body (9) not affected by said nozzle recess (13).

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2. A deposition nozzle (1) according to claim 1, wherein said nozzle recess (13) is given by the intersection between a ball and said nozzle body (9) when still axisymmetric;

or wherein

10 said nozzle recess (13) is obtained by the subtraction of a ball portion from said nozzle body (9) when still axisymmetric.

3. A deposition nozzle (1) according to claim 1 or 2, wherein said nozzle body (9) comprises a first proximal cylindrical nozzle portion (14), a first intermediate conical portion (15), a second intermediate cylindrical portion (16), and a second distal conical portion (17);

and wherein

20 said nozzle recess (13) affects said first intermediate conical portion (15), said second intermediate cylindrical portion (16), and said second distal conical portion (17);

or wherein

25 said nozzle body (9) comprises a first proximal cylindrical nozzle portion (14) distally connected to a first intermediate conical portion (15) distally connected to a second intermediate cylindrical

portion (16) distally connected to a second distal conical portion (17);

and wherein

said nozzle recess (13) affects said first intermediate conical portion (15), said second intermediate cylindrical portion (16), and said second distal conical portion (17).

4. A deposition nozzle (1) according to any one of the preceding claims, wherein

said powder feeding conduits (11) converge in a single point of intersection (12) of the powder feeding directions, placed on said nozzle axis (L-L)

and/or wherein

said plurality of powder feeding conduits (11) is distributed so as to have the powder feeding conduits (11) equally spaced apart from each other and mutually converging.

5. A deposition nozzle (1) according to any one of the preceding claims, wherein

said radiation conduit (5) has cylinder-shaped radiation conduit walls (18).

6. A deposition nozzle (1) according to the preceding claim, wherein said radiation conduit (5) delimits a passage in the shape of a right cylinder.

7. A deposition nozzle (1) according to any one of the preceding claims, wherein

said nozzle radiation mouth (10) is delimited by a circumference-shaped periphery;

and/or wherein

said nozzle radiation mouth (10) is orthogonal to said nozzle axis (L-L).

8. A deposition nozzle (1) according to any one of the preceding claims, wherein

said powder feeding conduits (11) are distributed in said nozzle body (9) in an arc extending about said nozzle axis (L-L) with a width of less than 200 DEG.

9. A deposition nozzle (1) according to any one of the preceding claims, wherein

said powder feeding conduits (11) delimit a cylindrical passage with rectilinear extension along a straight powder feeding direction (D-D).

10. A deposition nozzle (1) and piece-to-be-treated assembly, comprising

- a feeding nozzle (1) according to any one of the preceding claims;

and wherein

said piece (3) is a braking band of a disc brake disc.

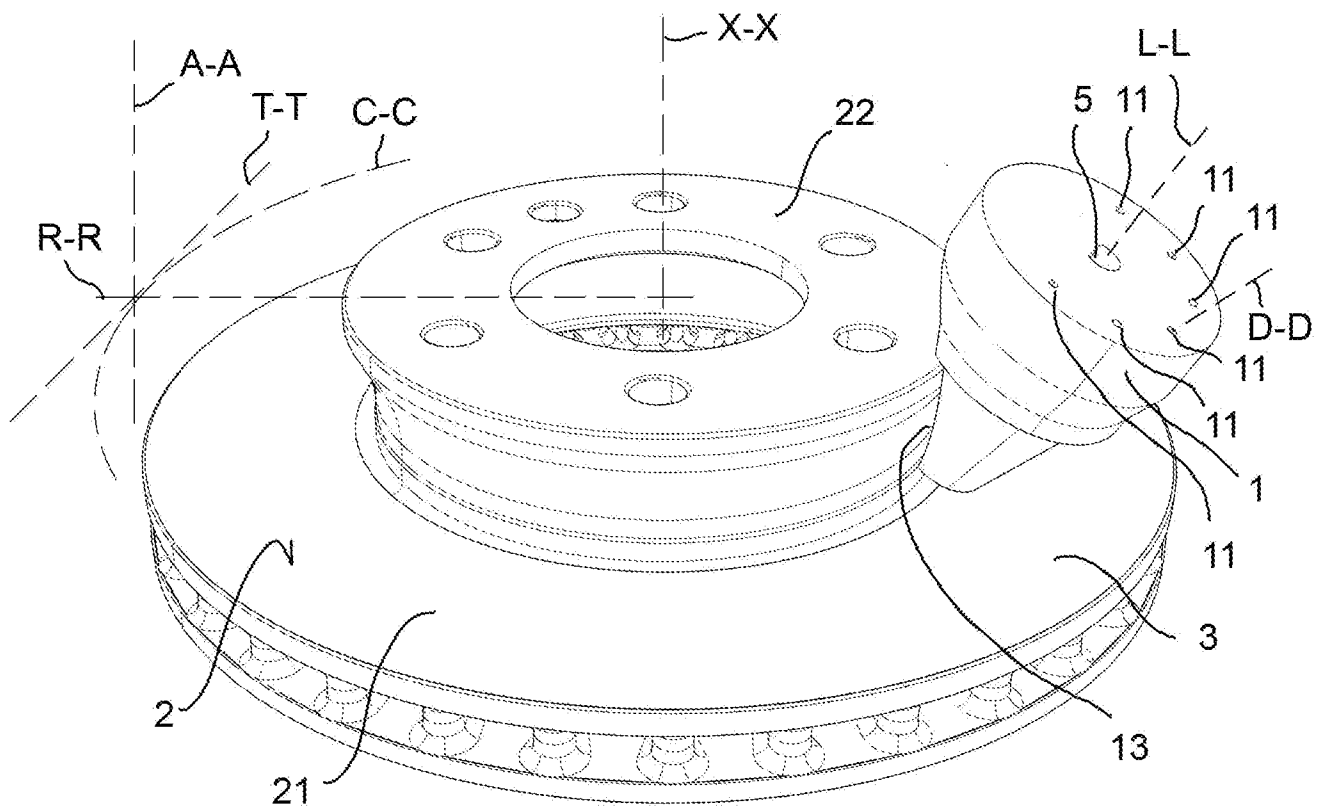


FIG. 1

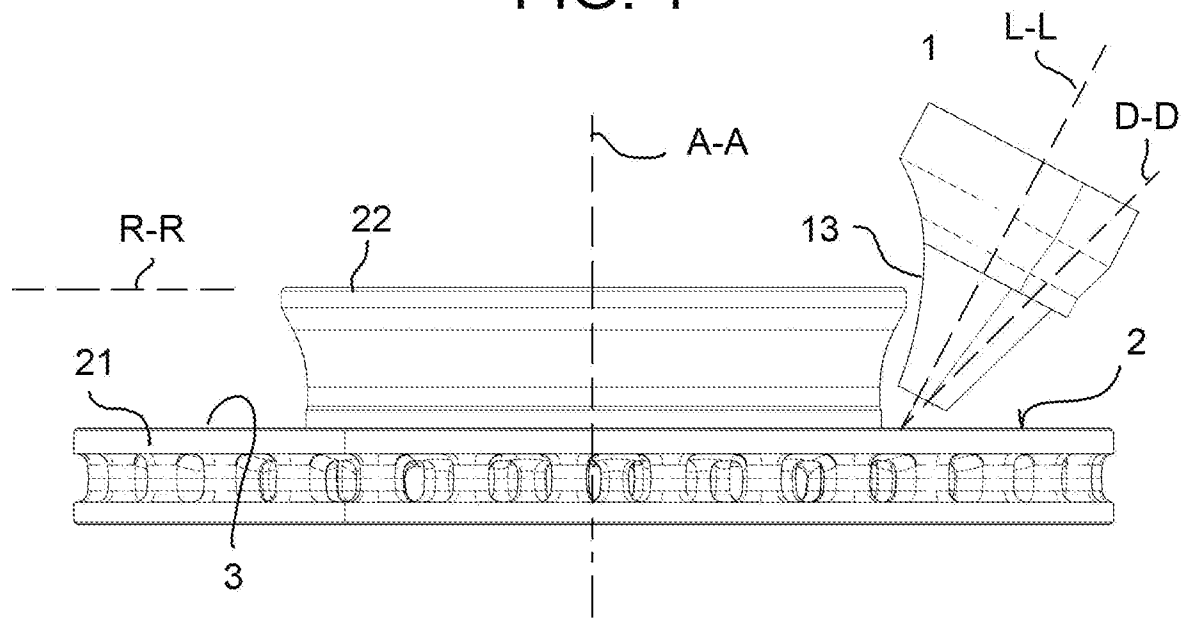


FIG. 2

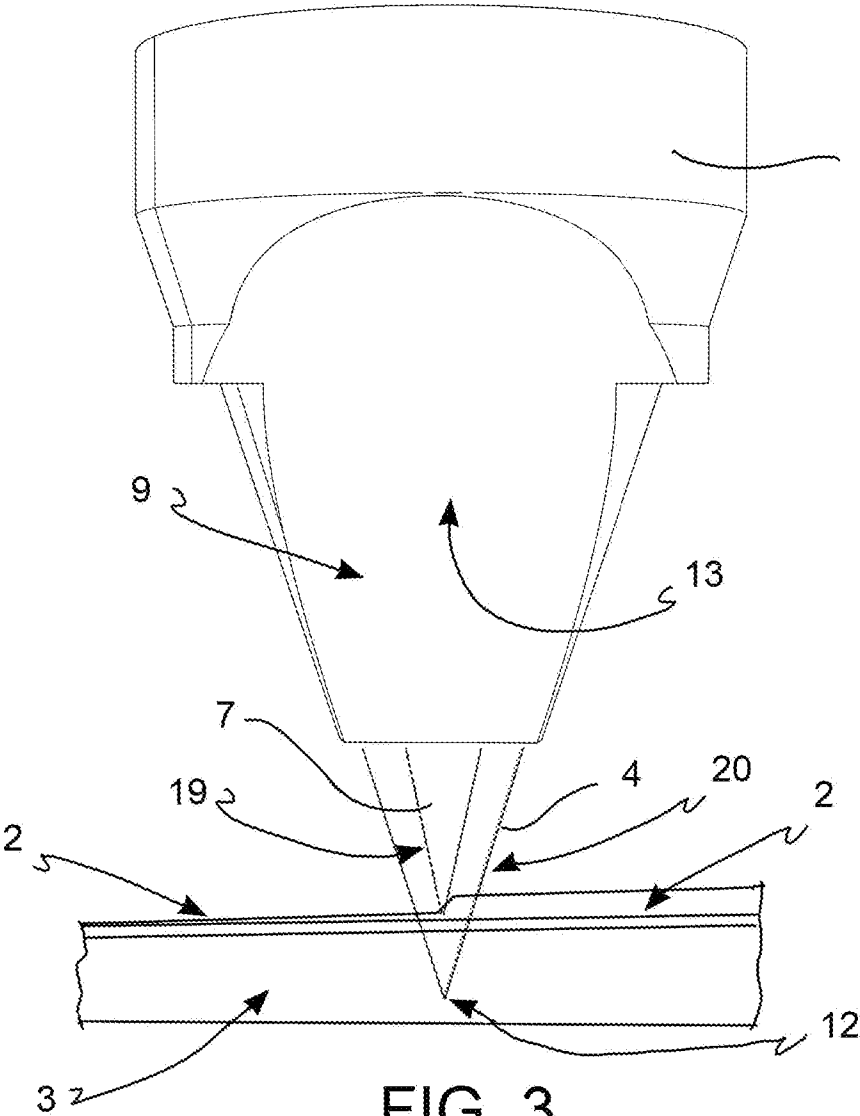


FIG. 3

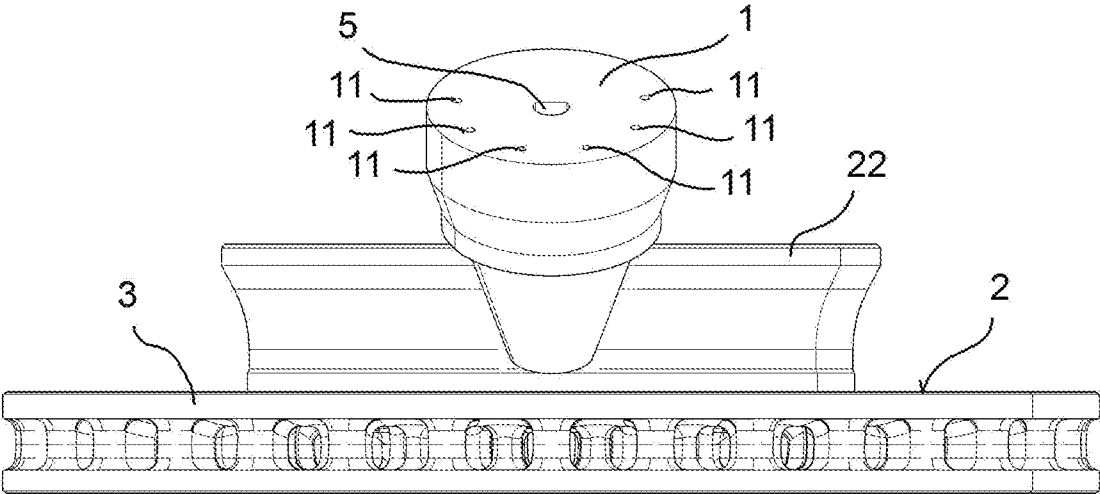


FIG. 4

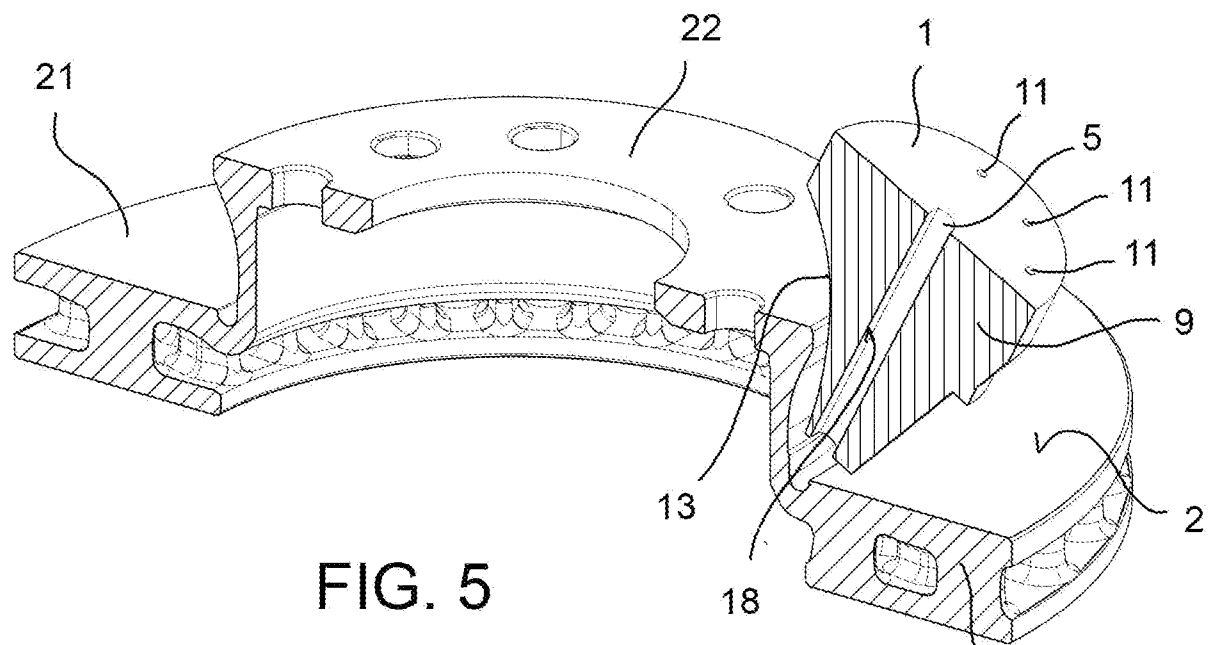


FIG. 5

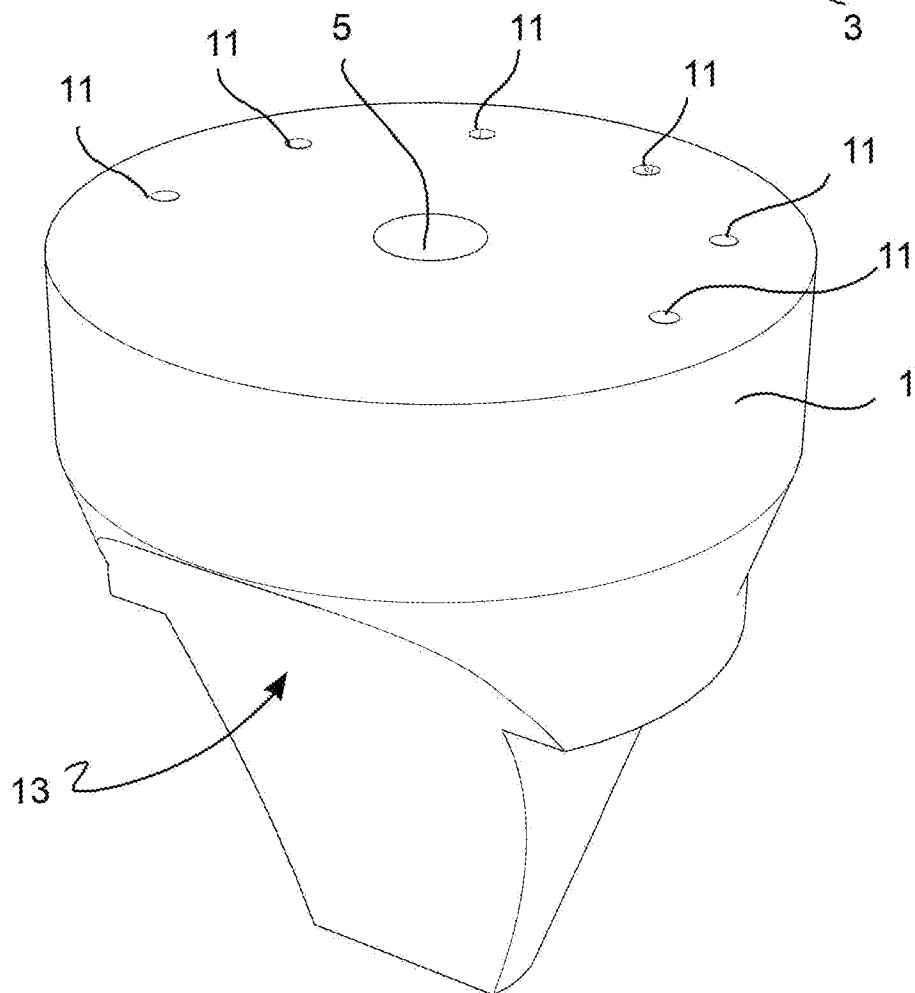
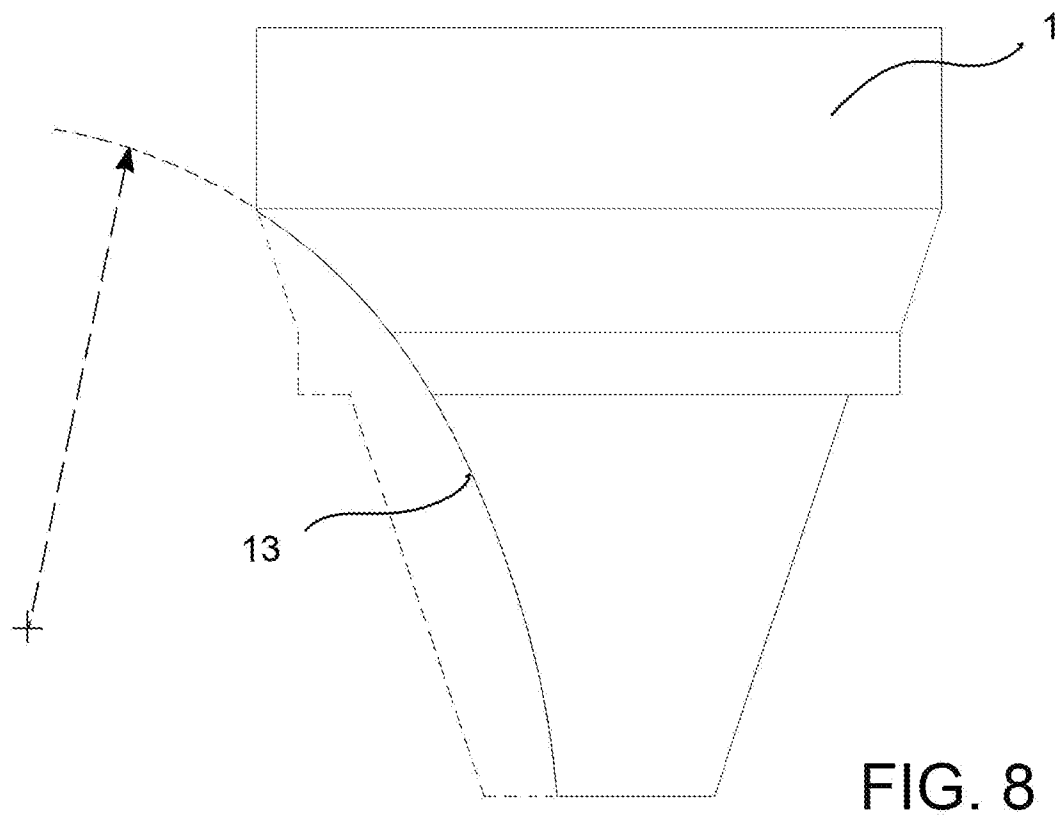
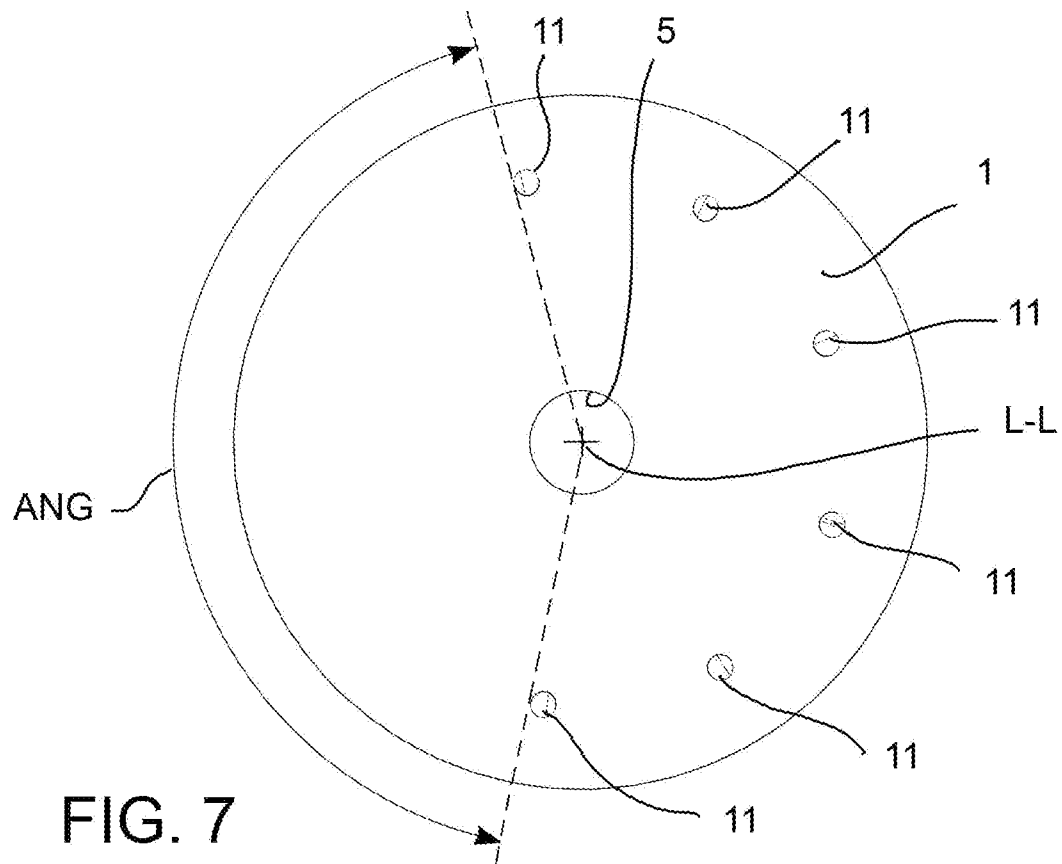


FIG. 6



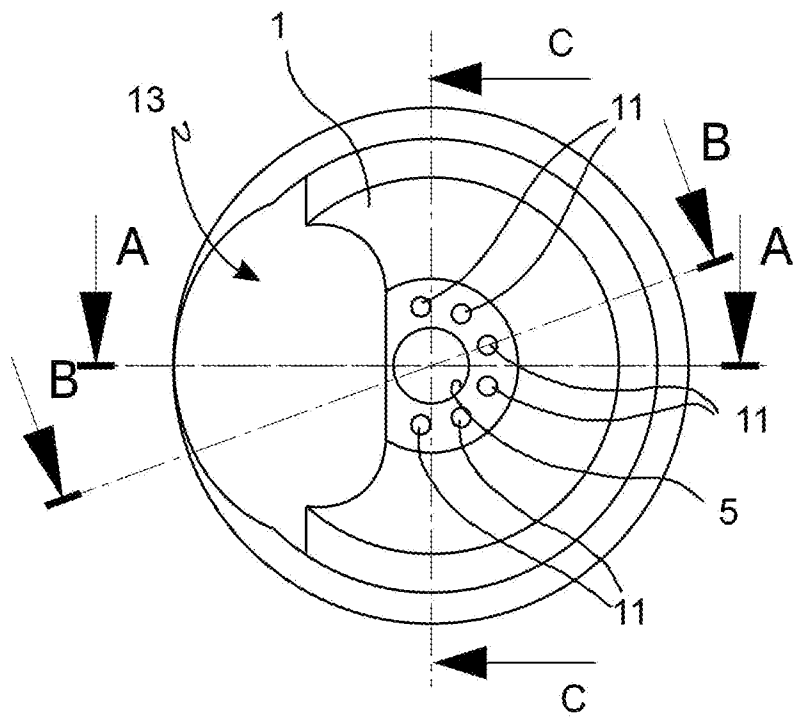


FIG. 9

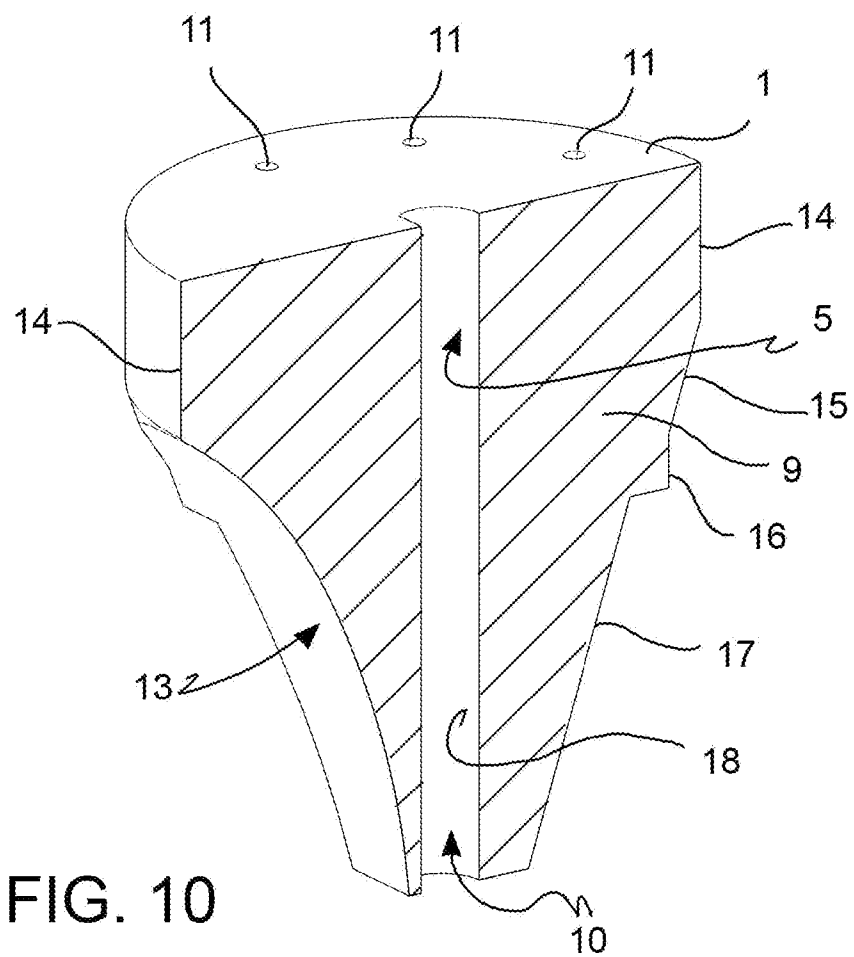


FIG. 10

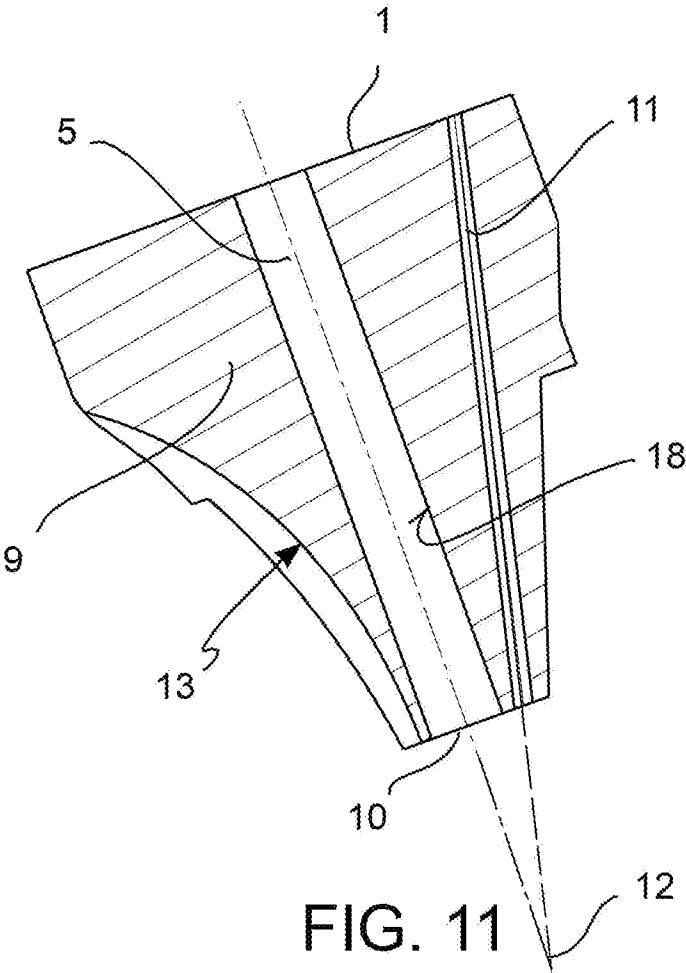


FIG. 11

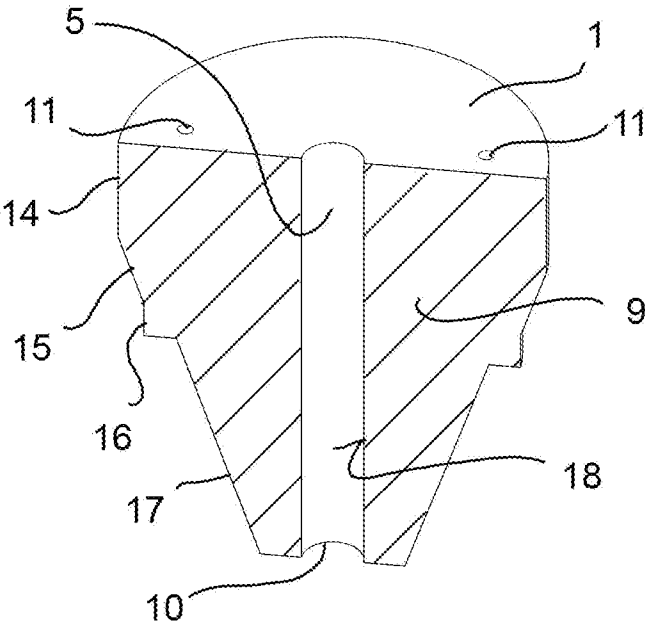


FIG. 12

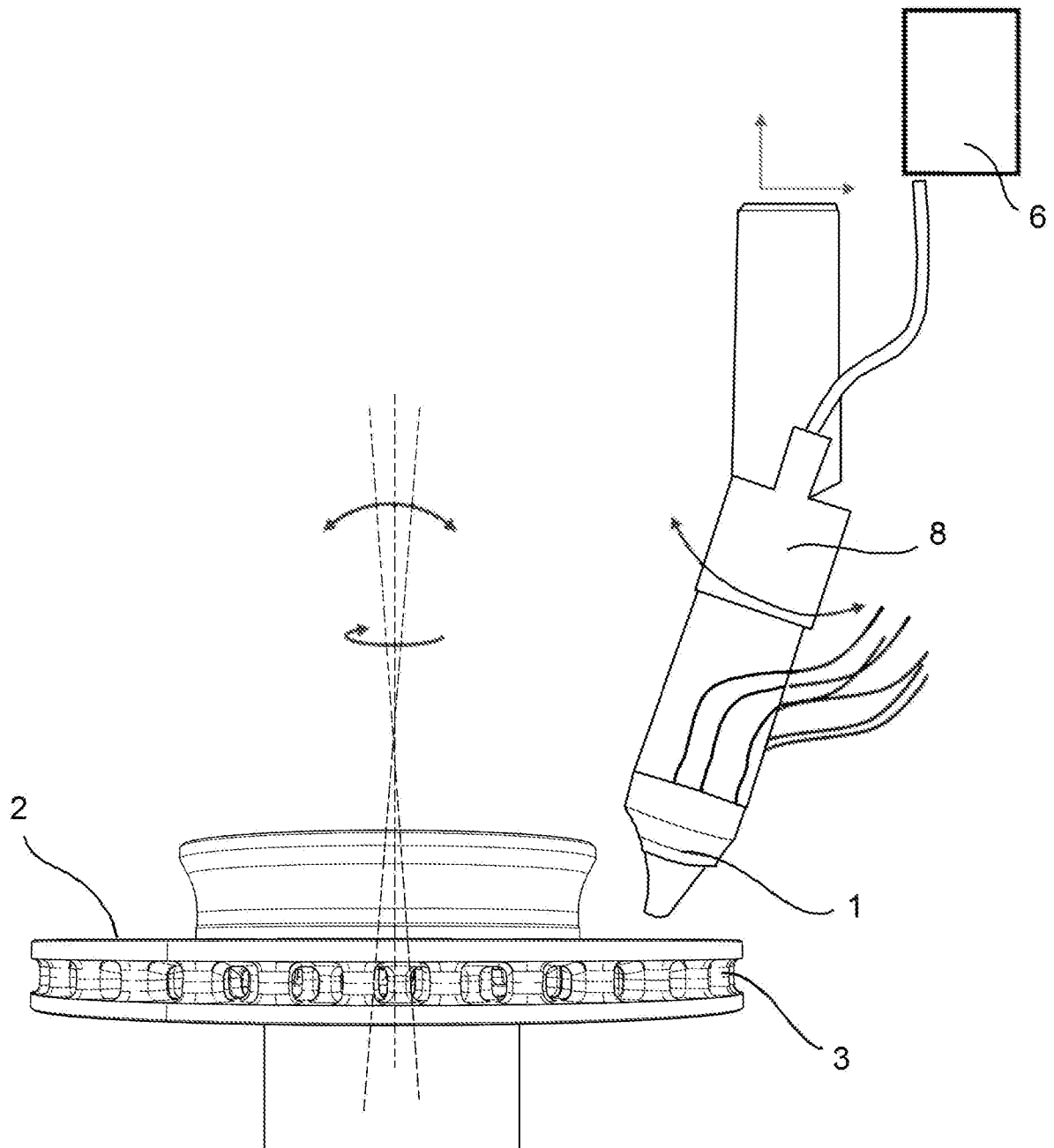


FIG. 13

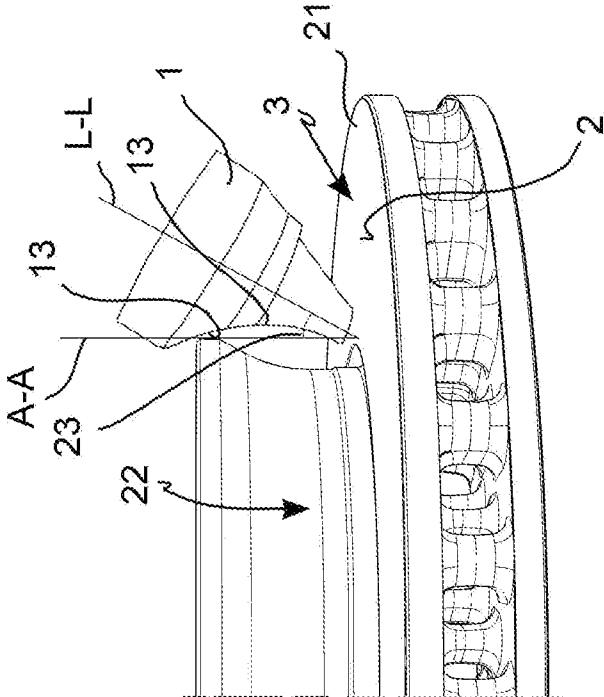


FIG. 15

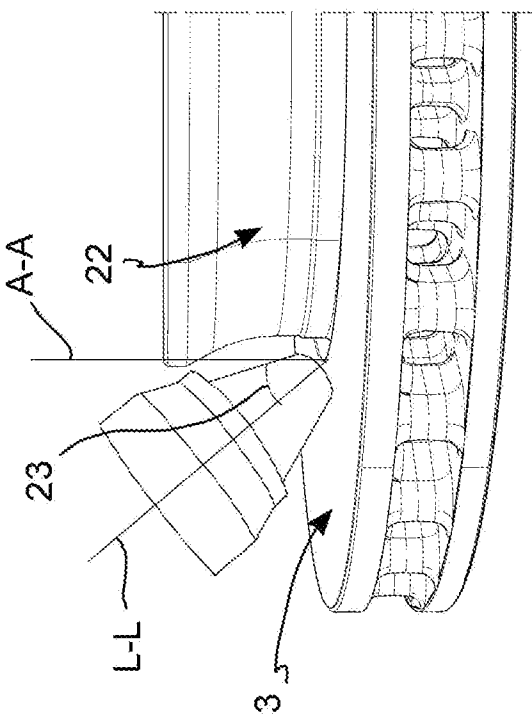


FIG. 14
(Prior art)

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2024/060874

A. CLASSIFICATION OF SUBJECT MATTER

INV. B23K26/14 B05B7/22 B05D3/02 B22F10/00 F16D65/12
B23K26/34 B23K101/00

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)

B23K

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 3 045 294 A1 (ROLLS ROYCE CORP [US]) 20 July 2016 (2016-07-20)	1,3-7,9
Y	paragraphs [0001], [0014], [0016], [0017], [0023], [0024]; figures 1-4 -----	2,8,10
Y	US 2018/050421 A1 (MARCHIONE THIERRY [US] ET AL) 22 February 2018 (2018-02-22) paragraphs [0001], [0035] -----	2,8
Y	WO 2023/161088 A1 (TRUMPF LASER & SYSTEMTECHNIK GMBH [DE]) 31 August 2023 (2023-08-31) page 17, line 9 - page 21, line 31; figures 1,3 -----	10
A	JP 5 389822 B2 (AIR LIQUIDE) 15 January 2014 (2014-01-15) figure 3 -----	1-10

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Further documents are listed in the continuation of Box C.

☒

See patent family annex.

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Date of the actual completion of the international search

15 January 2025

Date of mailing of the international search report

06/02/2025

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Schloth, Patrick

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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