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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
13 August 2020 (13.08.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/162823 A2

(51) International Patent Classification:
B23K 26/14 (2014.01) ***B23K 26/38*** (2014.01)

(21) International Application Number:
PCT/SE2020/050119

(22) International Filing Date:
07 February 2020 (07.02.2020)

(25) Filing Language: Swedish

(26) Publication Language: English

(30) Priority Data:
1950144-4 08 February 2019 (08.02.2019) SE

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(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, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, 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, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, 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, 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,

(54) Title: LASER NOZZLE, INSET FOR A LASER NOZZLE, LASER CUTTING DEVICE AND METHODS OF LASER CUTTING

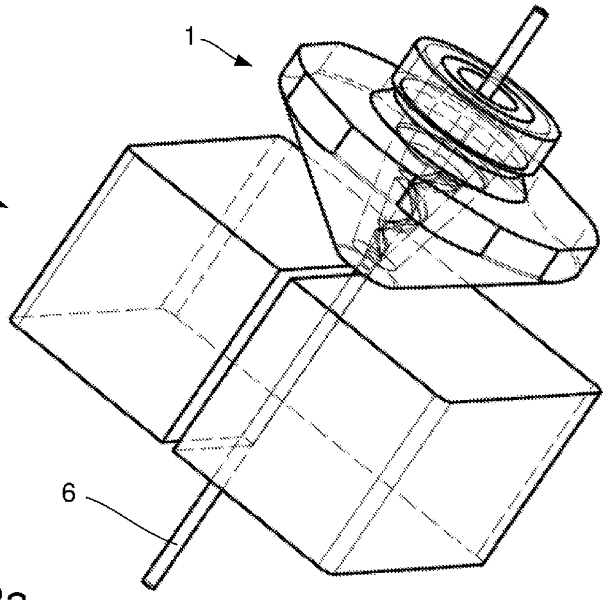

Fig 2a

(57) Abstract: This document discloses a laser nozzle (1) for gas-assisted cutting by means of a laser beam (6), comprising an inlet (12), an outlet (13), and a channel (14) extending between the inlet (12) and outlet (13) for the laser beam (6) and cutting gas. The channel (14) has a central axis (Z). The channel (14) has a first portion (141) with an inwardly facing surface (112). The laser nozzle comprises a substantially helical blade (16) which extends radially inwardly from the inwardly facing surface (112) and extends over at least 300 degrees around the central axis (Z) and along the inwardly facing surface. The document also discloses an inset for a laser nozzle, a laser cutting device and methods of laser cutting.

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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:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

LASER NOZZLE, INSET FOR A LASER NOZZLE, LASER CUTTING DEVICE AND METHODS OF LASER CUTTING

Technical Field

This document discloses a laser nozzle for use in a laser cutting head in a laser cutting machine. The document furthermore discloses an inset for a laser nozzle. It also discloses a laser cutting device.

The document also discloses a method for laser cutting.

The devices and methods disclosed in the document are used in particular but not exclusively in laser cutting of substances of metal, such as steel, and in particular for laser cutting of substances in the form of plates, tubes or bars.

Background

It is known that in laser cutting, cutting gas is used to flush out, by means of a nozzle concentric with the laser beam, the molten or vaporized material from the hole, recess or cut formed by the laser beam.

Depending on the type of material and the desired cutting speed, the cutting gas may for example consist of oxygen, nitrogen, helium, argon, carbon dioxide or combinations thereof. The cutting gas may thus be inert or reactive.

For many applications, inert gases such as nitrogen or helium are desirable since they reduce the effect, such as oxidation, on the material being cut. To achieve high cutting speeds, a cutting gas which reacts exothermically, such as oxygen gas, is selected. In such an exothermic reaction, to a great extent oxide coatings may occur on and around the cut surfaces. Such oxide coatings can have a negative effect on subsequent surface treatment or joining. It is therefore desirable to use inert cutting gas.

The nozzle comprises a channel which extends between an inlet and an outlet and may taper in the direction towards the outlet. The laser beam may be focused through the channel and outlet, and cutting gas may be conducted under high pressure through the channel and outlet.

It is known that a higher laser power allows cutting of thicker material. It is also known to increase the pressure of the cutting gas when cutting thicker material.

CN103056522A discloses an approach for improving the cutting speed by bringing the cutting gas to form an eddy. The rotational movement of the eddy is created by means of a set of radially short, oblique wings on the inwardly facing conical surface of the nozzle.

There remains however a further desire to enable cutting of thicker material and/or to enable higher cutting speeds, while retaining the quality of the recess, hole or cut produced, for a specific laser power.

Summary

One object is to create a laser nozzle which allows a higher cutting speed and/or cutting of thicker material for a specific laser power.

The invention is defined by the attached independent claims. Embodiments arise from the dependent claims, the description which follows and the attached drawings.

According to a first aspect, a laser nozzle is produced for gas-assisted cutting by means of a laser beam. The laser nozzle comprises an inlet, an outlet, and a channel extending between the inlet and outlet for the laser beam and cutting gas, which channel has a central axis. The channel has a first portion with an inwardly facing surface. The laser nozzle comprises a substantially helical blade which extends radially inwardly from the inwardly facing surface and extends over at least 120 degrees around the central axis and along the inwardly facing surface.

The term "gas-assisted" means that gas is blown through the nozzle and down into the recess, hole or cut formed by the laser beam with the aim of removing vaporized or molten material.

The term "extends radially inward" means that the blade extends inwardly from the inwardly facing surface, but not necessarily that the blade extends perpendicularly to the central axis. For example, viewed in a plane containing the central axis, the blade may slope upward or downward from the inwardly facing surface.

The blade may be formed by a continuous blade. One or more blades may be used. For example, 2 to 4 blades each with an extension of around 120 degrees may be used.

The term "substantially helical" means that the blade follows a path along the inwardly facing surface of the channel and along the central axis. The width, thickness (in direction Z) and slope of the path may vary.

By giving the blade a longer extent viewed around the central axis, a clear eddy movement is achieved, which in turn creates an improved removal of material which has been vaporized or melted by the laser beam. The improved removal of material may allow higher cutting speeds to be achieved for a given material thickness and laser power. Alternatively, for a given cutting speed and laser power, a greater material thickness may be cut.

The laser nozzle may have a maximum nominal beam diameter, i.e. a maximum beam diameter for which the nozzle is intended to be used. The beam has a beam radius at each point along a central axis of the laser nozzle, wherein the inwardly facing surface has an outer radius at each point along the central axis, and wherein the blade has a radial extent amounting to 50-105% of a difference between said outer radius and said beam radius, preferably 50-99%, 60-90% or 80-90%.

The term "outer radius" means a radius from the central axis to the inwardly facing surface.

By allowing the blade to extend almost up to the laser beam, a larger part of the gas flowing through the nozzle is forced to eddy.

The blade may extend around the central axis and for at least 150 degrees along the inwardly facing surface, preferably at least 180 degrees, at least 200 degrees, at least 270 degrees, at least 360 degrees, at least 500 degrees, at least 540 degrees, at least 700 degrees, at least 720 degrees, at least 900 degrees, at least 1000 degrees or at least 1080 degrees.

By allowing the blade to extend further, it is possible to influence a larger part of the gas flowing through the nozzle and thereby achieve an improved eddy. The upper limit for the extent of the blade is formed by the space available and the desired pitch.

The blade may have a pitch amounting to 2-7 mm/turn, preferably 3-6 mm/turn, 4-6 mm/turn, or most preferably 4, 4.5, 5, 5.5 or 6 mm/turn. The pitch may be constituted by the given value ± 5%, preferably ± 1% or ± 0.5%.

The laser nozzle may have a maximum nominal beam diameter, i.e. a maximum beam diameter for which the nozzle is designed to be used, wherein the outlet has no opening or has an opening which is smaller than said nominal beam diameter.

The term "the outlet has no opening" means that the outlet, when produced, may be produced such that it has no opening at all, but that this is formed as soon as the nozzle is mounted on the laser head and the laser is activated.

By producing and supplying the laser nozzle with an opening which is smaller than the laser beam to be directed through the opening, and allowing the laser beam to cut away material around the opening, it is possible to achieve a perfect match between the laser beam, the opening and the recess, hole or track which the laser beam creates in the workpiece. Thus a larger part of the gas flowing through the laser nozzle can be conducted into the recess, hole or track which the laser beam forms in the workpiece.

Said opening may amount to 0-99% of said nominal beam diameter, preferably 30-99%, 50-80% or 60-70%.

The inwardly facing surface may have a cross-sectional area which diminishes along the central axis in the direction towards the outlet.

Preferably, the cross-sectional area - apart from the blade - is substantially circular. For example, the cross-sectional area may be approximately conical or frustoconical. As another non-limitative alternative, viewed in a plane containing the central axis, a casing surface may be bent, for example following a curve.

By producing a conical surface, the flow speed may be increased in the direction towards the outlet of the laser nozzle.

Alternatively, the inwardly facing surface may have a cross-sectional area which is constant along the central axis.

The channel may have a second portion which has an inward conical surface and is situated downstream of said first portion, wherein a cone angle of said second inward conical surface is greater than a cone angle of said first portion.

Said inlet, outlet, channel and blade may be integral with, i.e. formed in, the nozzle.

According to a first embodiment, the entire laser nozzle including blade may thus be integral, i.e. formed of one material piece.

According to another aspect, an inset is produced for a laser nozzle for gas-assisted cutting by means of a laser beam, comprising an inlet, an outlet, and a channel extending between the inlet and outlet for the laser beam and cutting gas, which channel has a central axis, wherein the channel has a first portion with an inwardly facing surface. The inset comprises a substantially helical blade which extends radially inwardly from the inwardly facing surface and extends over at least 120 degrees around the central axis and along the inwardly facing surface.

According to another embodiment, the channel and blade may be formed from a separate material piece and as a separate part which is mounted, e.g. by axial insertion, in a corresponding recess in the laser nozzle. This may help simplify production and reduce costs. For example, wearing parts of the laser nozzle may be formed in the inset and be exchangeable. As a further alternative, different nozzle variants may be created by producing a single nozzle but with different insets, for example in different materials and with different pitch.

The inset may be separably arranged in the laser nozzle.

According to a third aspect, a laser cutting device is created for cutting by means of a gas-assisted laser beam, comprising a laser source for generating the laser beam, a cutting gas inlet, and a laser nozzle as described above, wherein the laser source is arranged such that the laser beam extends along a central axis of the channel and out through the outlet, and wherein the cutting gas inlet is connected to the channel for supplying cutting gas through the channel to the outlet.

According to a fourth aspect, a method is created for gas-assisted laser cutting, comprising supplying a laser beam and a cutting gas through a laser nozzle, which laser nozzle comprises an inlet, an outlet, and a channel extending between the inlet and outlet for the laser beam and cutting gas, which channel has a central axis, wherein the channel has a first portion with an inwardly facing surface. The method comprises forming an eddy, and more specifically forming the eddy using a substantially helical blade which extends radially inwardly from the inwardly facing surface and extends over at least 300 degrees around the central axis and along the conical surface.

Before the start of said laser cutting, the outlet may have an opening diameter which is smaller than the diameter of the laser beam, wherein the method comprises allowing the laser beam to cut away an edge portion of the outlet.

According to a fifth aspect, a laser nozzle is produced for gas-assisted cutting by means of a laser beam, comprising an inlet, an outlet, and a channel extending between the inlet and outlet for the laser beam and cutting gas, which channel has a central axis, wherein the channel has a first portion with an inward conical surface. The nozzle has no opening or has a nominal beam diameter, defined as a maximum diameter of a laser beam for which the nozzle is suitable, and the outlet has an opening which is smaller than said nominal beam diameter.

According to a sixth aspect, a method is created for gas-assisted laser cutting, comprising supplying a laser beam and a cutting gas through a laser nozzle, wherein the laser nozzle comprises an inlet, an outlet, and a channel extending between the inlet and outlet for the laser beam and cutting gas, which channel has a central axis, wherein the channel has a first portion with an inward conical surface. The method comprises bringing the cutting gas to form an eddy by means of at least one blade on the conical surface. The method furthermore comprises that, before said laser cutting begins, the outlet has no opening or has an opening diameter which is smaller than a diameter of the laser beam, and that the laser beam is allowed to cut away an edge portion of the outlet.

According to a seventh aspect, a method is created for producing a laser nozzle for gas-assisted cutting by means of a laser beam. The produced laser nozzle comprises an inlet, an outlet, and a channel extending between the inlet and outlet for the laser beam and cutting gas, which channel has a central axis. The channel has a first portion with an inwardly facing surface. According to the method, the outlet is formed such that, before the nozzle is first used, the outlet has no opening or has an opening diameter which is smaller than a diameter of the laser beam, and that the laser beam is allowed to cut away an edge portion of the outlet to form the opening.

Brief Description of the Drawings

Fig. 1 diagrammatically shows a laser cutting device.

Figs. 2a-2d show a first variant of a laser nozzle.

Figs. 3a-3d show a second variant of a laser nozzle.

Figs. 4a-4d show a third variant of a laser nozzle.

Detailed Description

Figure 1 shows a laser cutting device 7 which comprises a holder 71 for a workpiece and a cutting head holder 72.

The holder 7 is arranged to carry a workpiece such as a plate, a bar, a tube or another part, which may be made of metal, preferably steel or aluminium.

The cutting head may comprise a laser source 3 and a laser cutting head 2. The cutting head may also comprise a focusing device 23. A cutting gas source 4 is connected to the laser cutting head 2.

The laser beam emitted by the laser head may, but need not, be focused by means of the focusing device 23, which may be integrated with the laser source or the laser head or be formed as a part arranged between the laser source 3 and laser head 2.

The laser beam extends along a beam axis which may coincide with a central axis Z of the laser head.

The laser head 2 contains a chamber 22 which has a connection 21 for cutting gas, to which the cutting gas source 4 is connected.

The laser head has an inlet 24 for the laser beam and an outlet 25 for the laser beam.

A laser nozzle 1 is arranged at the outlet 25. The laser nozzle 1 is formed as a body 11 with an inlet 12, an outlet 13 and a channel 14 extending in between. The laser nozzle 1 may be mounted on the laser head outlet 25, for example by means of a screw joint or bayonet fitting. In the example shown, the laser nozzle has a threaded portion 15 at its inlet 12 which engages in a corresponding threaded portion on the outlet of the laser head 2.

The body 11 may be formed as a substantially cylindrical or conical part with a length amounting to around 1-5 cm, preferably 1-3 cm. In the example shown, the body has a substantially vertical conical form, the bottom surface periphery of which has been modified to make it easier to grip when the nozzle 1 is screwed in and out of engagement with the laser head 2.

The channel 14 may have an inward surface 112 which is approximately cylindrical or approximately conical.

An approximately helical or spiral blade 16 extends along at least a portion 141 of the channel 14. The blade extends over at least 300 degrees around the central axis Z. For example, the blade may extend over at least 360 degrees (i.e. one turn) along the surface, preferably at least 500 degrees, at least 540 degrees, at least 700 degrees, at least 720 degrees (i.e. two turns), at least 900 degrees, at least 1000 degrees or at least 1080 degrees (i.e. three turns).

At the central axis Z, a beam path is shown, the diameter of which corresponds approximately to a maximum diameter of a laser beam for which the nozzle is suitable.

It is clear that the diameter of the beam path may be fixed or diminishing, where it may rather be suitable to use a focused laser beam.

The beam path is defined by a radially inner edge of the blade.

The laser beam has the approximate form of a cylinder or cone with a radius RL from the central axis Z. In the case where the laser beam has a conical form, the radius RL varies along the central axis Z and may be expressed as RL(Z).

The wall has a radius RA which, in the case of a conical wall, varies along the central axis Z and may be expressed as RA(Z).

In the case that both the wall and the laser beam are cylindrical, the radial extent of the blade may be expressed as RA-RL.

In the case that both the wall and the laser beam are conical, the radial extent of the blade may be expressed as RA(Z)-RL(Z).

In the case that the wall is cylindrical and the laser beam conical, the radial extent of the blade may be expressed as RA-RL(Z).

In the case that the wall is conical and the laser beam cylindrical, the radial extent of the blade may be expressed as RA(Z)-RL.

The blade 16 thus extends radially inwardly from the wall towards the beam path at a distance which is at least 70% of the difference RA-RL, preferably at least 80%, at least 90%, at least 95% or at least 99%.

The outlet 13 from the laser nozzle 1 may be adapted to a greatest nominal beam diameter at the outlet.

A second portion 142 may be present at the outlet downstream of the first portion 141. This second portion may have an inward conical surface which is formed such that a cone angle of said second inward conical surface 142 is greater than a cone angle of said first portion 141.

According to one embodiment, the outlet may have a size, typically the diameter, which is sufficiently large for the laser beam to be able to extend out through the outlet without influencing this or being influenced thereby.

According to the embodiment shown in the figures however, the outlet 13 has a diameter which is smaller than a nominal beam diameter at the outlet. This means that, when the laser beam is activated for the first time after assembly, the outlet is cut away by the laser beam so that the outlet has a diameter which is precisely adapted to the laser beam.

Preferably, the initial diameter of the outlet may be 30-95% of a nominal maximum beam diameter, preferably 50-90%, or 60-80%.

According to one embodiment, the laser nozzle - including blade - may be made from one material piece, or from two or more material pieces which are permanently joined together. For example, two material pieces may be joined along a plane which contains the central axis Z.

According to another embodiment, which is shown in the figures, the laser nozzle 1 may have an inset 17 in which flanges are formed. The inset may be fixedly or separably arranged in the laser nozzle 1.

The inset 17 may have a radially outward form which is approximately cylindrical or approximately conical, and an inward form which is correspondingly approximately cylindrical or approximately conical, with the blade as described above.

The inset may be received in a recess in the nozzle 1, the shape of which may correspond to the outer form of the inset 17.

The inset 17 may extend all the way to the outlet 12 so that the edge 111 which is cut away forms part of the inset. Alternatively, the outlet 111 may be formed by the nozzle so that the part 111 which is cut away forms part of the nozzle 1.

It is clear that the laser nozzle 1 or inset 17 may be provided with one, two or more blades, which may form one, two or more helical parallel channels through the nozzle.

According to one embodiment, n blades (wherein $2 \leq n \leq 4$) each with an extension of up to $360/n \pm 20$ degrees may be placed such that together they extend all the way along the inwardly facing surface.

When the nozzle 1 is used, it is mounted in the known fashion, wherein the cutting gas and laser beam are attached. Due to the shape of the blade, an improved eddying of cutting gas occurs which extends downward into the recess, hole or cut formed by the laser beam, and thereby allows more effective removal of vaporized material.

By forming the opening 13 with a diameter which is smaller than the nominal beam diameter, it is ensured that the diameter 13 of the opening matches the recess, hole or cut formed by the laser beam, and hence the quantity of cutting gas which does not penetrate therein is minimized.

Alternatively, the nozzle 1 or inset 17 may be produced without an opening or with a very small opening, wherein the laser is allowed to create the opening when it is first started after mounting of the nozzle/inset on the laser head. On such start-up, it may be desirable to start the laser with a lower power than for normal cutting, and/or to apply the cutting gas with a lower pressure than usual, and then to increase the laser power and/or cutting gas pressure when the opening is formed.

Furthermore, the outlet of the nozzle or inset may be formed with thinner material in the region where the opening is expected to be formed.

Figures 2a-2d show an embodiment of a laser nozzle 1 in which the blade 16 extends approximately over 1.75 turns, i.e. around 630 degrees, around the central axis Z.

Figures 3a-3d show an embodiment of a laser nozzle 1 in which the blade 16 extends approximately over 1.5 turns, i.e. around 540 degrees, around the central axis Z.

Figures 4a-4d show an embodiment of a laser nozzle 1 in which the blade 16 extends approximately over 1.25 turns, i.e. around 450 degrees, around the central axis Z.

Since the blade 16 extends over the same axial length along the central axis Z, the blade 16 has a different pitch in the different embodiments.

An inner wall may be arranged on the radially inner part of the blade, which extends axially along part of the nozzle and divides the part of the channel in which the blade is situated from the part of the channel in which the laser beam runs. The inner wall may have a substantially conical or cylindrical form.

A laser nozzle 1 or inset 17 as described above may be formed in a number of different ways. A first such way may be by 3D printing (additive manufacturing). Another such way may be to form the blade 16 itself and the conical or cylindrical body as separate parts which are fixed to each other. A further such way is by casting with a core which is removed after the material has been introduced. Yet another such way is to produce a nozzle or inset in two parts which are joined together along a plane containing the central axis Z.

CLAIMS

1. Laser nozzle (1) for gas-assisted cutting by means of a laser beam (6), comprising:

an inlet (12),

an outlet (13), and

a channel (14) extending between the inlet (12) and outlet (13) for the laser beam (6) and cutting gas, which channel (14) has a central axis (Z),

wherein the channel (14) has a first portion (141) with an inwardly facing surface (112),

characterized by

a substantially helical blade (16) which extends radially inwardly from the inwardly facing surface (112) and extends over at least 120 degrees around the central axis (Z) and along the inwardly facing surface.

2. Laser nozzle according to Claim 1, wherein the laser nozzle has a maximum nominal beam diameter (RL, RL(Z)), i.e. a maximum beam diameter for which the nozzle (1) is intended to be used,

wherein the beam (6) has a beam radius (RL, RL(Z)) at each point along a central axis (Z) of the laser nozzle,

wherein the inwardly facing surface (112) has an outer radius (RA, RA(Z)) at each point along the central axis (Z), and

wherein the blade (16) has a radial extent amounting to 50-105% of a difference between said outer radius (RA, RA(Z)) and said beam radius (RL, RL(Z)), preferably 50-99%, 60-90% or 80-90%.

3. Laser nozzle according to Claim 1 or 2, wherein the blade (16) extends around the central axis (Z) and for at least 150 degrees along the inwardly facing surface (112), preferably at least 180 degrees, at least 200 degrees, at least 270 degrees, at least 360 degrees, at least 500 degrees, at least 540 degrees, at least 700 degrees, at least 720 degrees, at least 900 degrees, at least 1000 degrees or at least 1080 degrees.

4. Laser nozzle according to any of the preceding claims, wherein the blade (16) has a pitch amounting to 2-7 mm/turn, preferably 3-6 mm/turn, 4-6 mm/turn, or most preferably 3, 3.5, 4, 4.5 or 5 mm/turn.

5. Laser nozzle according to any of the preceding claims, wherein the laser nozzle (1) has a maximum nominal beam diameter, i.e. a maximum beam diameter for which the nozzle is designed to be used, and wherein the outlet (13) has no opening or has an opening which is smaller than said nominal beam diameter.

6. Laser nozzle according to Claim 5, wherein said opening is 0-99% of said nominal beam diameter, preferably 30-99%, 50-80% or 60-70%.

7. Laser nozzle according to any of the preceding claims, wherein the inwardly facing surface (112) has a cross-sectional area which diminishes along the central axis (Z) in the direction towards the outlet (13).

8. Laser nozzle according to any of Claims 1-6, wherein the inwardly facing surface (112) has a cross-sectional area which is constant along the central axis (Z).

9. Laser nozzle according to any of the preceding claims, wherein the channel (14) has a second portion (142) which has an inward conical surface and is situated downstream of said first portion, wherein a cone angle of said second inward conical surface is greater than a cone angle of said first portion.

10. Laser nozzle according to any of the preceding claims, wherein said inlet (12), outlet (13), channel (14) and blade (16) are integral with the nozzle (1).

11. Laser nozzle according to any of the preceding claims, furthermore comprising an inner wall which divides a part of the channel in which the blade is active from a part of the channel in which the laser beam runs.

12. Inset (17) for a laser nozzle for gas-assisted cutting by means of a laser beam (6), comprising:

an inlet (12),

an outlet (13), and

a channel (14) extending between the inlet and outlet for the laser beam (6) and cutting gas, which channel has a central axis (Z),

wherein the channel (14) has a first portion (141) with an inwardly facing surface (112), and

a substantially helical blade (16) which extends radially inwardly from the inwardly facing surface (112) and extends over at least 120 degrees around the central axis (Z) and along the inwardly facing surface (112).

13. Inset according to Claim 12, furthermore comprising an inner wall which divides a part of the channel in which the blade is active from a part of the channel in which the laser beam runs.

14. Laser nozzle (1) comprising an inset (17) according to Claim 12 or 13 which is separably arranged in the laser nozzle (1).

15. Laser cutting device for cutting by means of a gas-assisted laser beam, comprising:

a laser source (3) for generating the laser beam (6),

a cutting gas inlet (21), and

a laser nozzle (1) according to any of Claims 1-11 or 14,

wherein the laser source (3) is arranged such that the laser beam (6) extends along the central axis (Z) of the channel (14) and out through the outlet (13), and wherein the cutting gas inlet (21) is connected to the channel (14) for supplying cutting gas through the channel (14) to the outlet (13).

16. Method for gas-assisted laser cutting, comprising:

supplying a laser beam (6) and a cutting gas through a laser nozzle (1) comprising:

an inlet (12),

an outlet (13), and

a channel (14) extending between the inlet (12) and outlet (13) for the laser beam and cutting gas, which channel has a central axis (Z),

wherein the channel (14) has a first portion (141) with an inwardly facing surface (112),

characterized by

forming an eddy by means of a substantially helical blade (16) which extends radially inwardly from the inwardly facing surface (112) and extends over at least 120 degrees around the central axis (Z) and along the conical surface.

17. Method according to Claim 16, wherein, before the start of said laser cutting, the outlet (13) has no opening or has an opening diameter which is smaller than the diameter of the laser beam (6), and wherein the laser beam (6) is allowed to cut away an edge portion (111) of the outlet (13) so that the outlet has a diameter corresponding to said diameter of the laser beam (6).

18. Laser nozzle for gas-assisted cutting by means of a laser beam (6), comprising:

an inlet (12),

an outlet (13), and

a channel (14) extending between the inlet (12) and outlet for the laser beam and cutting gas, which channel has a central axis (Z),

wherein the channel (14) has a first portion (141) with an inward conical surface (112), characterized in that

the nozzle (1) has a nominal beam diameter, defined as a maximum diameter of a laser beam for which the nozzle (1) is suitable, and wherein the outlet (13) has no opening or has an opening which is smaller than said nominal beam diameter.

19. Method for gas-assisted laser cutting, comprising:

supplying a laser beam (6) and a cutting gas through a laser nozzle (1) comprising:

an inlet (12),

an outlet (13), and

a channel (14) extending between the inlet (12) and outlet (13) for the laser beam (6) and cutting gas, which channel has a central axis (Z),

wherein the channel (14) has a first portion (141) with an inward conical surface (112),

bringing the cutting gas to form an eddy by means of a blade on the conical surface,

characterized in that

before said laser cutting begins, the outlet (13) has no opening or has an opening diameter which is smaller than a diameter of the laser beam (6), and

that the laser beam (6) is allowed to cut away an edge portion (111) of the outlet (13).

20. Method for producing a laser nozzle or an inset for a laser nozzle for gas-assisted cutting by means of a laser beam (6), which laser nozzle or inset comprises:

an inlet (12),

an outlet (13), and

a channel (14) extending between the inlet (12) and outlet for the laser beam and cutting gas, which channel has a central axis (Z),

wherein the channel (14) has a first portion (141) with an inward conical surface (112), wherein the method is characterized in that

the nozzle (1) or inset is formed to have a nominal beam diameter, defined as a maximum diameter of a laser beam for which the nozzle (1) or inset is suitable,

the outlet (13) is formed such that, before said laser cutting begins, the outlet has no opening or has an opening diameter which is smaller than a diameter of the laser beam (6), and

the laser beam (6) is allowed to cut away an edge portion (111) of the outlet (13) to form the opening.

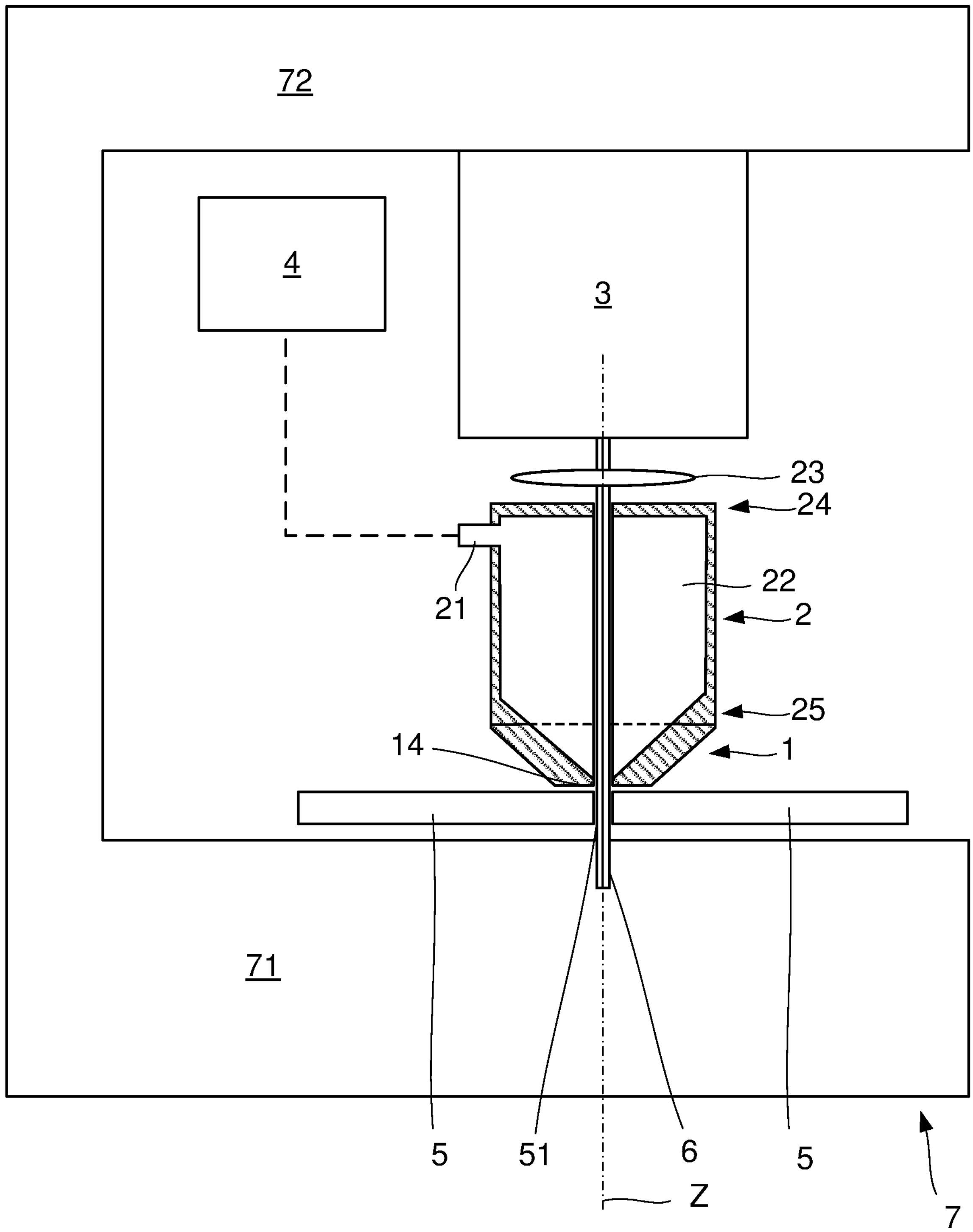

Fig 1

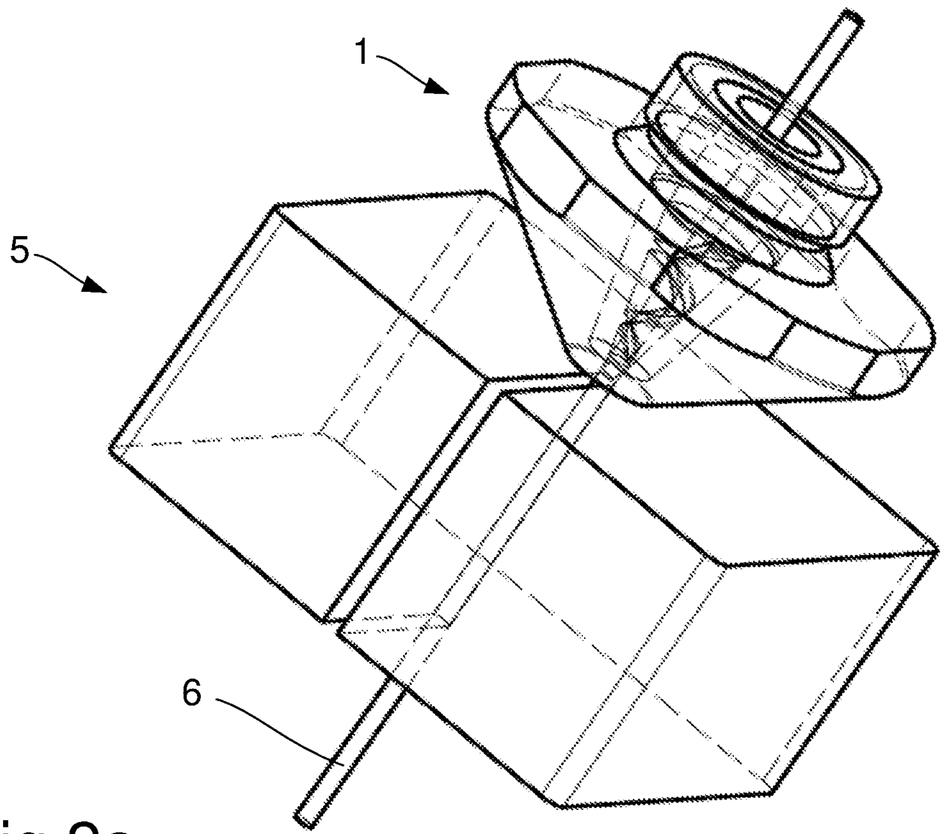

Fig 2a

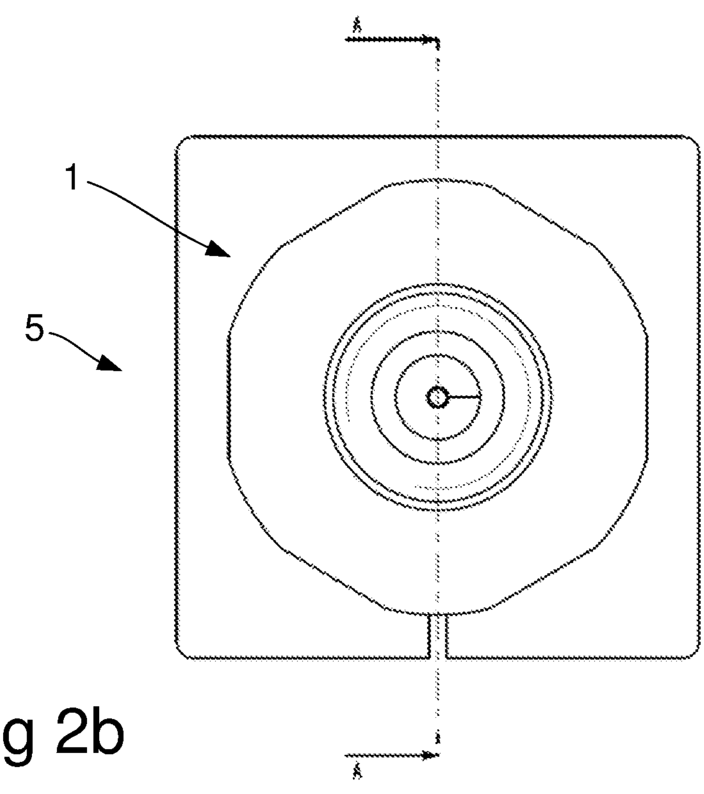

Fig 2b

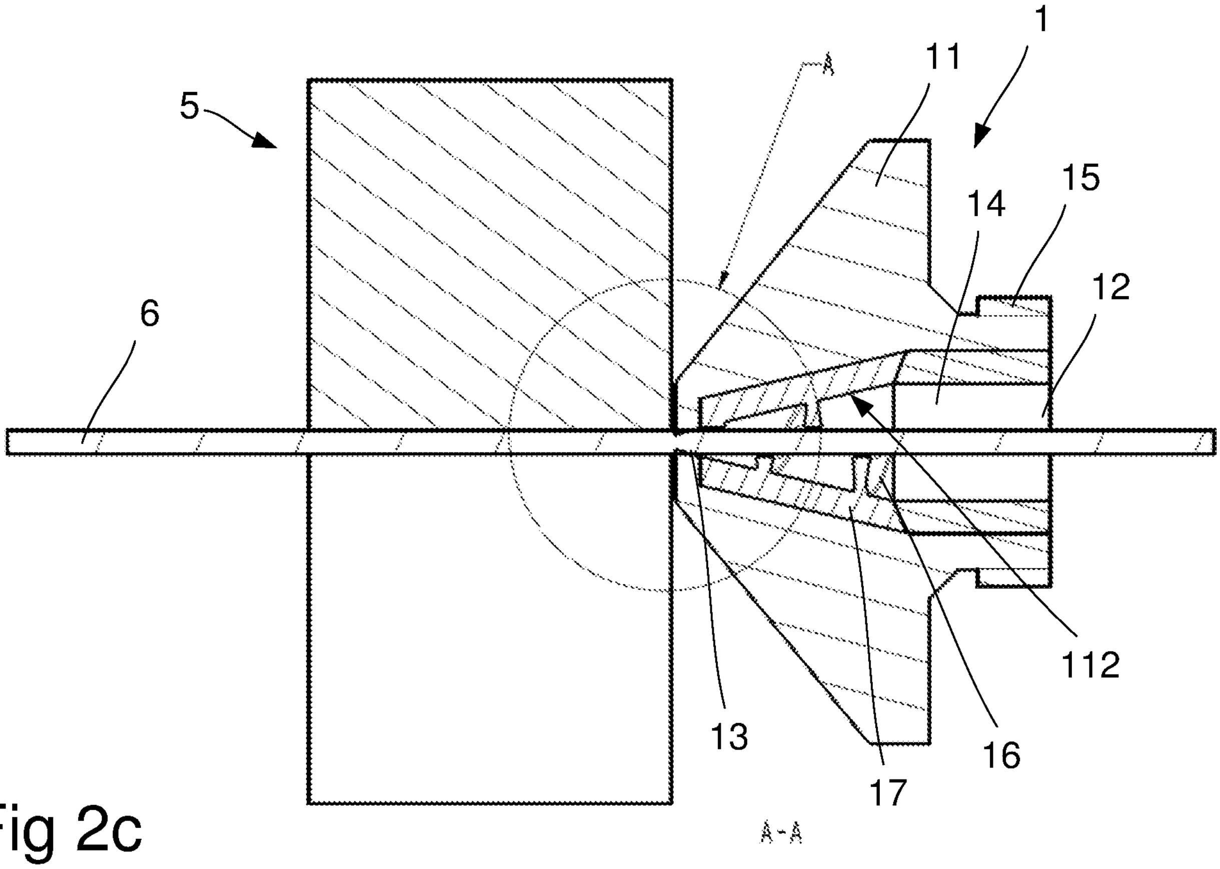

Fig 2c

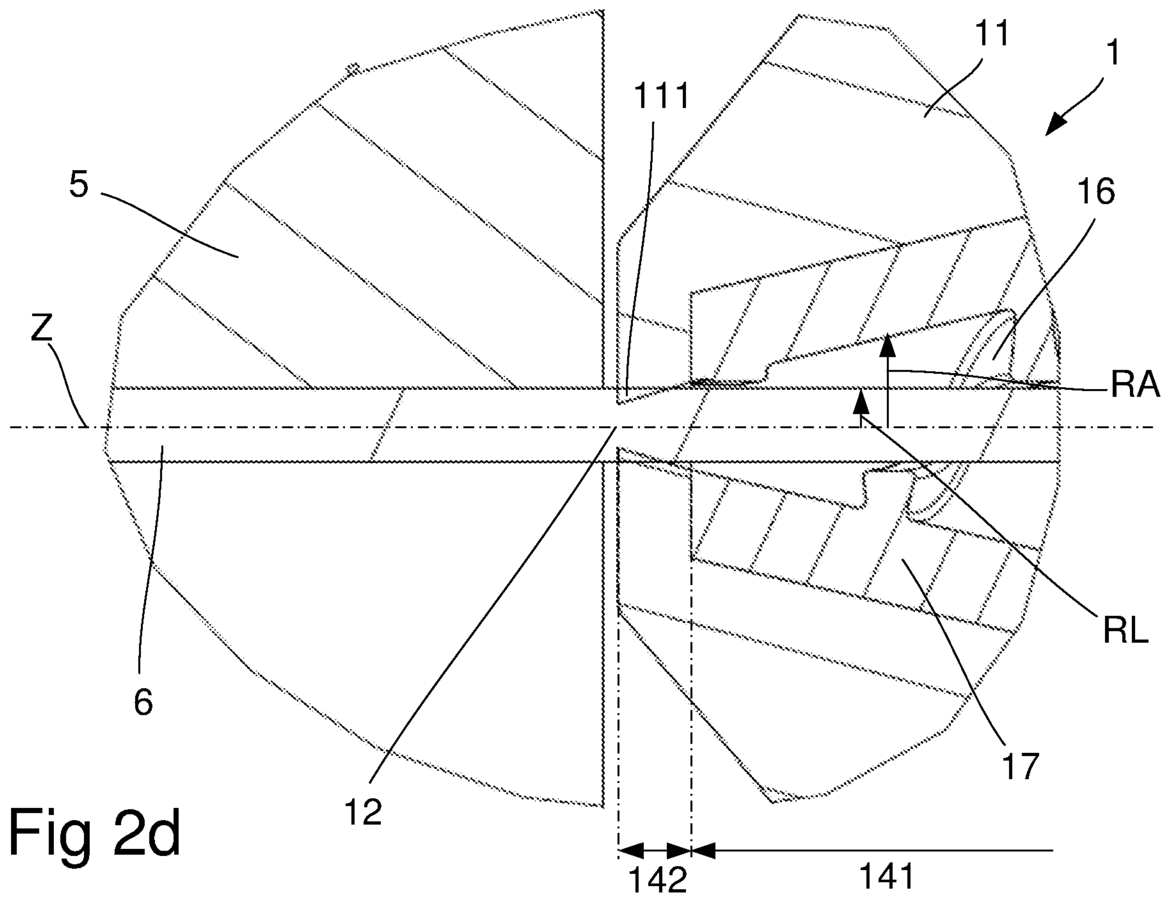

Fig 2d

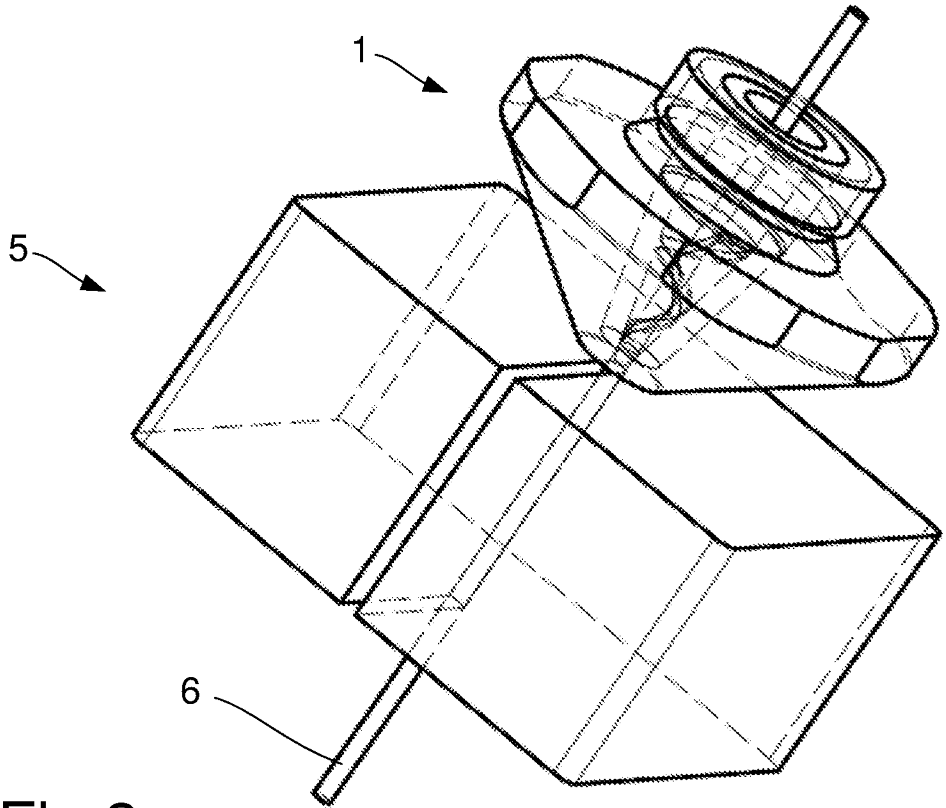

Fig 3a

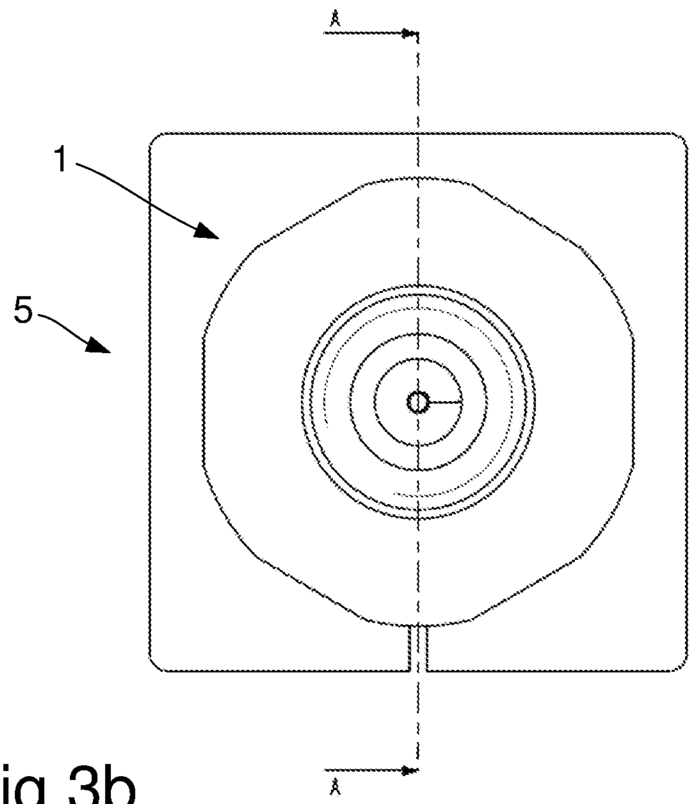

Fig 3b

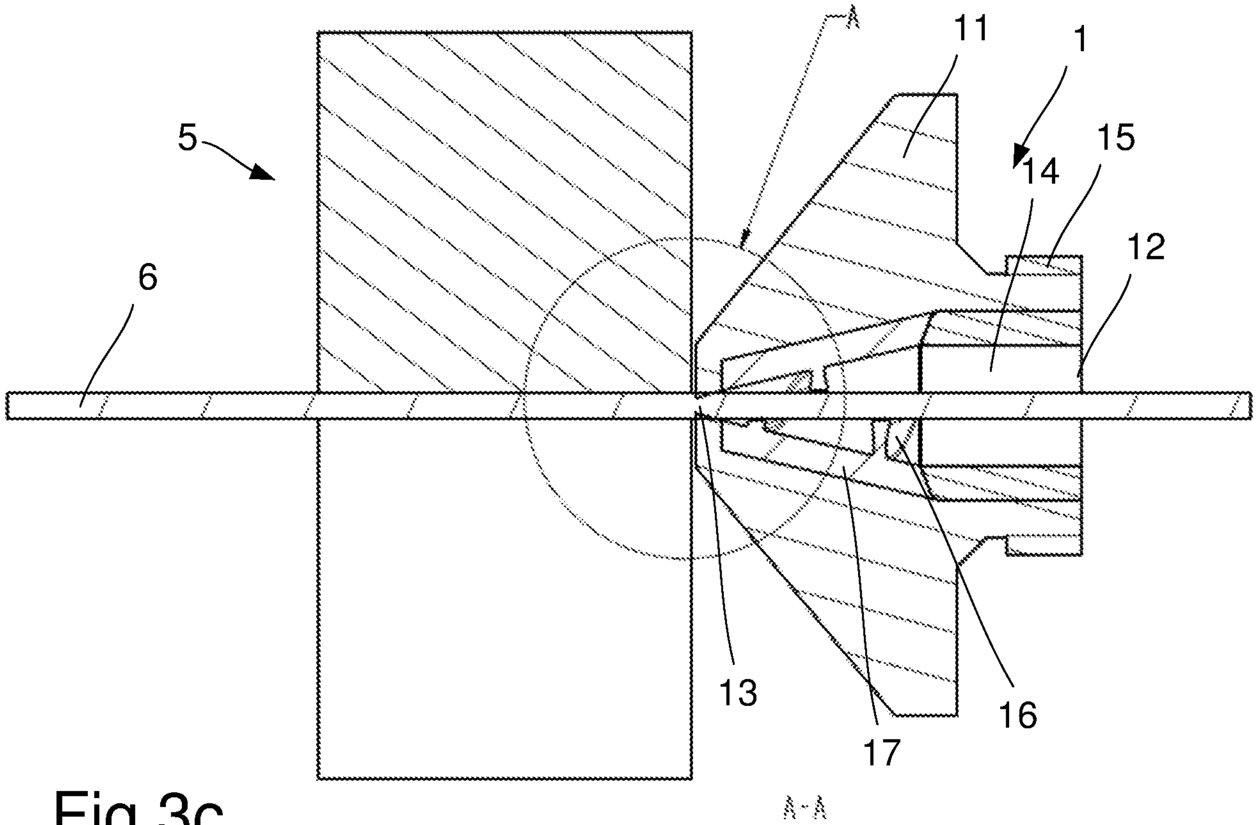

Fig 3c

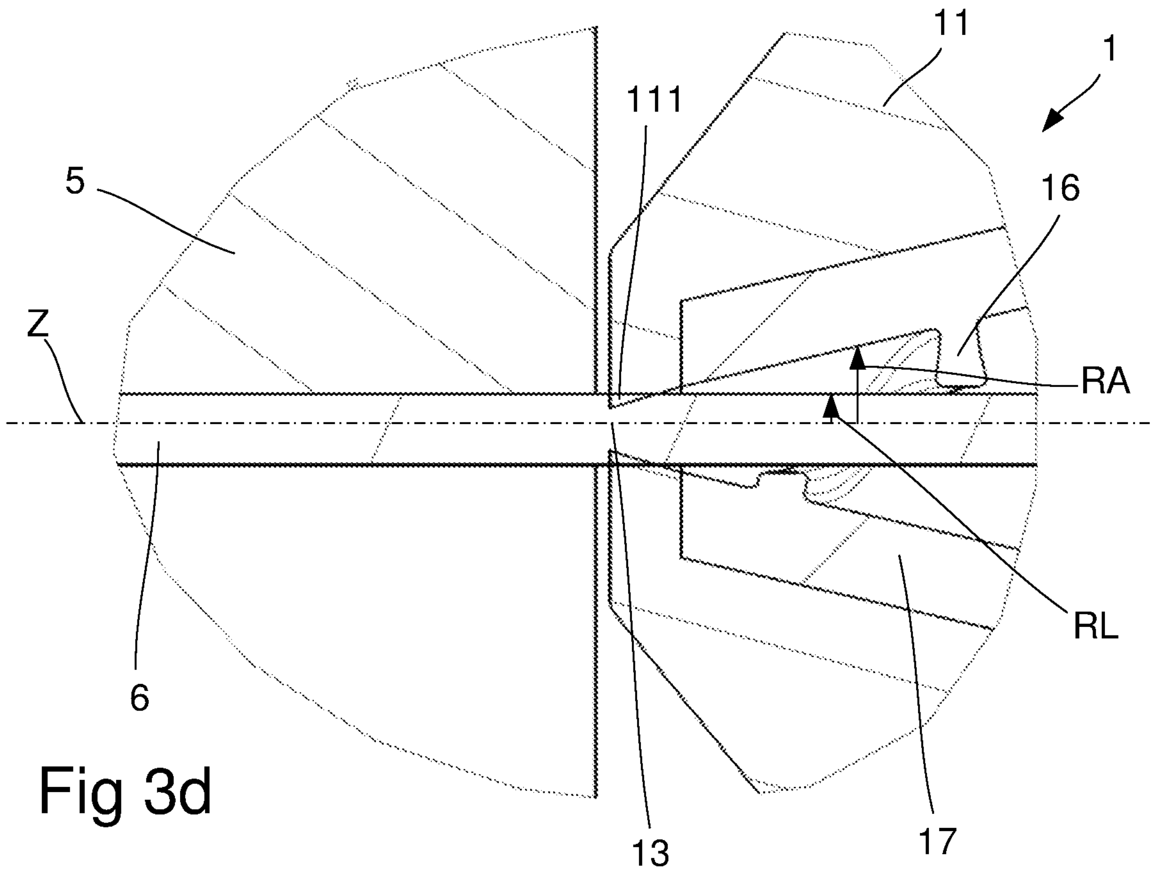

Fig 3d

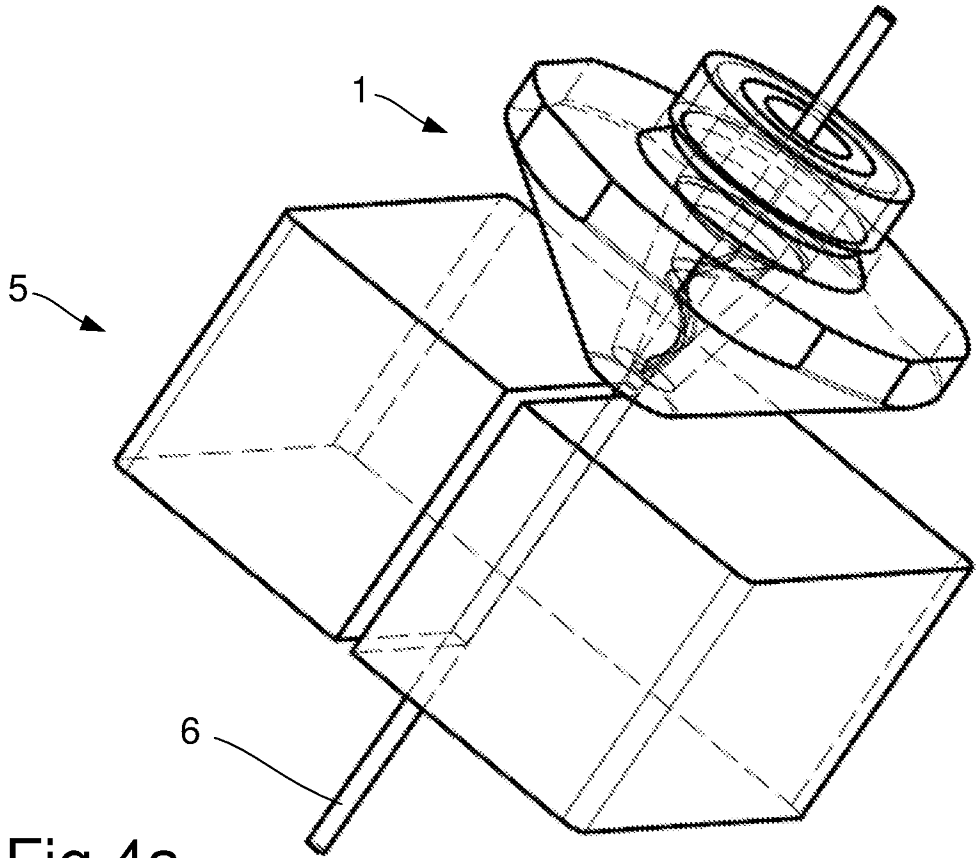

Fig 4a

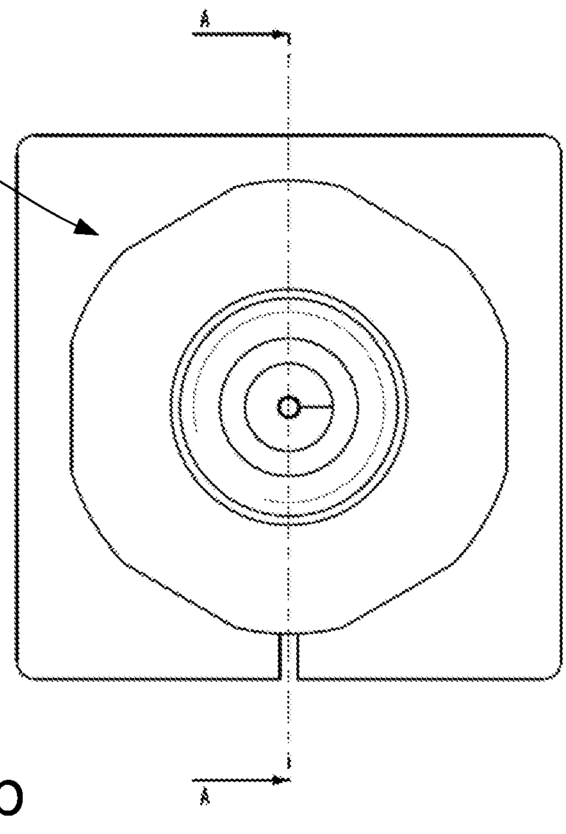

Fig 4b

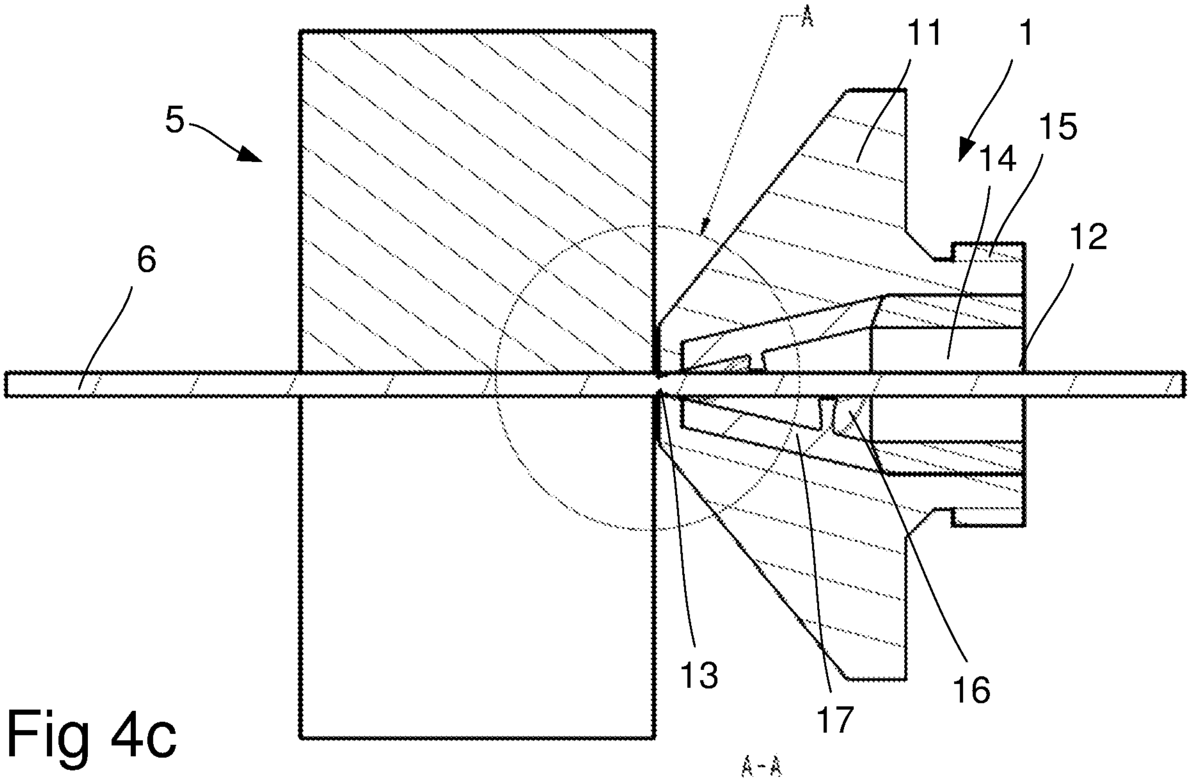

Fig 4c

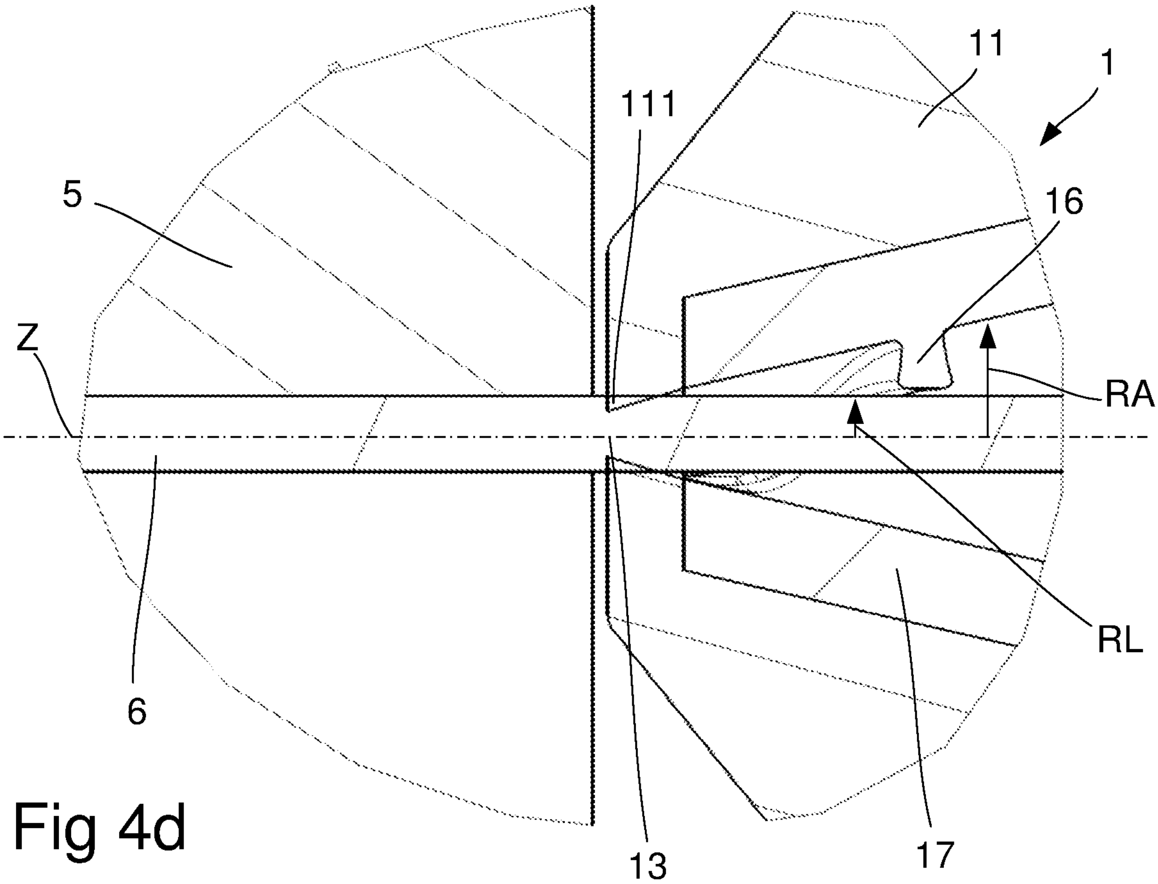

Fig 4d