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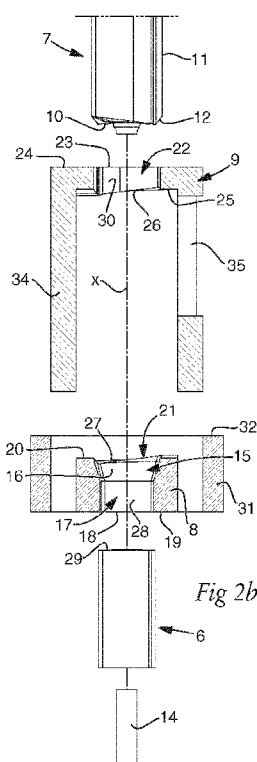
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(54) Title: A METHOD OF AND A DEVICE FOR THE COMPACTION OF A POWDER INTO A CUTTING INSERT GREEN BODY



(57) Abstract: A device for manufacturing a cutting insert green body (1) by compacting a powder, said device comprising a first punch (6), a second punch (7) having a punch edge that has a curvature around the circumference of the punch edge (12) that is at least partially non-perpendicular with a pressing axis (x) of the device, a first die part (8), a second die part (9), and wherein, when the first and second die parts (8, 9) are joined to each other in connection to filling of powder into the die, one (9) of said first and second die parts is on top of the other (8) and, when the device is in a position ready for filling of powder into the die, the device presents a cavity defined by the lower die part (8), a punch (6) introduced therein and the upper die part (9). An opening (23) in an upper end surface (24) of the upper die part (9) is exposed for enabling filling of powder into said cavity through said opening (23).

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A method of and a device for the compaction of a powder into a cutting insert green body

TECHNICAL FIELD

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The present invention relates to a method for the compaction of a powder into a cutting insert green body. It also relates to a device for the compaction of a powder into a cutting insert green body, as well as a cutting insert produced from a cutting insert green body produced by means of said device.

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The invention relates to the technical field in which cutting inserts, preferably to be used for the machining of metal by milling, drilling or turning or by similar chip forming methods, are produced from a powder which is compacted into a green body and then subjected to a sintering process in which the compacted green body is further densified. Typically, the sintered body is then provided with a suitable wear resistant coating, such as a carbide, nitride, carbonitride, oxide, or boride with any suitable contemporary technique, such as physical vapour deposition or chemical vapour deposition.

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20 BACKGROUND OF THE INVENTION

In connection to the compacting of a powder to a green body during production of cutting inserts, the powder is introduced into a cavity defined by a die. Normally, the die comprises an upper opening through which the powder is introduced into said cavity and through which, during a subsequent pressing step, an upper punch is introduced into the die. Typically, there is also provided a lower punch which is able of sliding through a tunnel, often referred to as a bore or pressing bore, in the die and which will form at least part of a bottom of said die cavity and by means of which the green body formed upon compaction of the powder is ejected from the surrounding die. From the upper opening of the die there is provided a punch tunnel, also often referred to as a bore or pressing bore, in which the upper punch is able to move downwards for the purpose of contacting the powder and subjecting it to a

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compacting pressure. In other words, the punch tunnels contribute to the definition of the die cavity provided for receipt of the powder, and the punches are provided for the purpose of compacting a powder received in said cavity.

- 5 After compaction of the powder into a green body, the upper punch is retracted out of the die, and the green body is ejected by a motion of the lower punch relative to the die (either of these components could be the one which is moving). Accordingly, the green body is ejected through the tunnel in which the upper punch was moving downwards into the die during the pressing step.

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- Typically, the material of the green body is of such nature that it will expand when the compacting pressure from the punches is relieved and when it is ejected and released from the surrounding die. In order to enable the green body to expand radially when it is ejected from the cavity in which it has been compacted, the tunnel
15 is widened slightly above the level to which the upper punch is forwarded during compaction. It could be said that the cavity is provided with a release portion having a certain inclination angle of the inner wall of the die relative a centre axis of the cavity. The inclination angle (possibly also referred to as the release angle) as well as the length (in the vertical direction) of the release portion is adapted to the expected
20 (radial) expansion of the green body upon ejection thereof.

- Typically, for positive inserts the cavity has a cross section that narrows as seen from the release portion to the remaining (lower) part of the cavity. Upon compaction of the powder, a lower edge of the upper punch, which is defined by the intersection of
25 a lateral surface and a bottom surface thereof, is not allowed to come into contact with the inner peripheral surface of the die, since such contact might result in damages on both die and punch. Therefore, the punch is only forwarded to a level at which there will be a small gap between said punch edge and the inner peripheral surface of the die. During compaction of the powder, the latter will to some extent
30 leak out and to some extent be extruded out through said gap and into the release portion. The leakage will result in gathering of loose powder in the release portion and the extrusion and/or leakage will result in a residual edge being formed on the

green body along the upper edge thereof, which needs to be treated, i.e. at least partly removed, before the subsequent sintering of the green body. Such treatment is time-consuming and contributes to unwanted production costs. The loose powder gathered as a result of said leakage, on the other hand, results in unwanted loss of material and will have a negative influence on the surface finish of the compacted body as the latter is ejected out of the die, especially if the radius of the edge of compacted body is very small and thereby sensitive to interaction with loose powder. Further negative effects of powder leakage and extrusion may also be an unwanted effect on the shape of the upper edge of the green body or a lower density, i.e. a generation of porosity, in the region of the upper edge of the green body.

The present applicant has considered a solution, to the above-mentioned problem, according to which the die is subdivided into an upper part and a lower part, and wherein the die cavity that will define the geometry of the green body in the final compaction position of the punches is housed in the lower die part. During compaction, the upper punch is advanced through the upper die part and into the lower die part. The parting plane between the upper and lower die parts is just slightly above the level to which the edge of the upper punch is advanced in the final compaction position thereof. During filling of the die with powder, the upper die and the upper punch is held in a retracted position above an upper opening in the lower die part. The parting plane is generally flat and a powder-filling device is permitted to slide on an upper surface of the lower die part to and from a position on top of said upper opening. Typically, the powder is filled to the same level in the die as the upper surface of the lower die. After filling of powder, the upper die is joined with the lower die, and compaction is performed by means of the lower punch and the upper punch. When the compacted green body is subsequently to be displaced out of the die, the upper die part is removed from the lower die part before said displacement of the green body. Thanks to this principle solution and design of the die, the release portion into which powder may leak and form a residual edge during compaction can be kept very small.

Preferably, the length of the release portion, i.e. the distance in the direction of the pressing axis from the punch edge (in its final compaction position) to an edge that defines the upper opening in the upper surface of the lower die part should be generally the same all around the circumference of the punch. Therefore, in an application in which the punch edge of the upper punch is partly non-perpendicular to the pressing axis of the upper punch, said edge that defines the upper opening in the upper surface of the lower die part should be correspondingly partly non-perpendicular. If, for example, the punch edge has a wave-like extension, i.e. a varying position in the direction of the pressing axis around the circumference of the punch, the edge that defines the upper opening in the upper surface of the lower die part should have a corresponding wave-like extension. As a result thereof, the upper surface of the lower die will not be planar, and will not allow a powder-filling device having a generally plane bottom surface to be slid to a position on top of the upper opening in the lower die part and fill the lower die part with powder to the level of the edge that defines said upper opening. There is also a risk of having powder escaping to the upper surface of the lower die part in connection to such a filling.

THE OBJECT OF THE INVENTION

The object of the invention is to present a method and device that solve the above-mentioned problem regarding the generation of an unwanted residual edge and the problem of how to achieve an efficient and reliable powder-filling procedure in the case when the punch edge, and the adjacent edge that defines an opening in a surface of the relevant die part, are at least partly non-perpendicular to the pressing axis.

SUMMARY OF THE INVENTION

The object of the invention is achieved by means of a method of compacting a powder into a cutting insert green body, comprising the steps of:

- providing a compaction device comprising
 - a first punch,

- 5 -a second punch that presents an abutment surface for abutment with the powder to be compacted, and an outer peripheral surface, and a punch edge at the intersection between the abutment surface and the outer peripheral surface, wherein the punch edge extends with a predetermined curvature around the circumference of the second punch,
- 10 -a first die part, presenting a chamber having an inner peripheral surface which corresponds to a peripheral surface of a cutting insert green body to be compacted in said first die part, a bore for receiving said first punch, said bore extending from an opening in a first end surface of the first die to said chamber, and an opening region extending with an expanding cross-section from said chamber to an opposite second end surface of the first die part and defining an opening in said opposite second end surface,
- 15 -a second die part, presenting a bore for receiving said second punch, said bore extending from an opening in a first end surface of the second die part to a second end surface thereof, thereby defining an opening in said second end surface,
- 20 -wherein an edge that defines said opening in the second end surface of the first die part extends with a curvature corresponding to said curvature of the punch edge,
- 25 -arranging the second end surface of the first die part and the second end surface of the second die part contiguously such that said opening in the second end surface of the first die part meets said opening of the second end surface of the second die part,
- positioning the device such that one of said first and second die parts is contiguously arranged above the other die part,
- 30 -arranging said first end surface of the one of the die parts being arranged above the other die part such that it extends rectilinearly in at least one direction,
- introducing one of said punches into the bore of the one of the die parts being arranged below the other die part,
- said method being characterized in that
- said predetermined curvature of the punch edge of the second punch is at least partly non-perpendicular to a pressing axis of the device and that the edge of the opening in

the second end surface of the first die part presents a corresponding curvature with regard to said pressing axis, and that the method comprises the further step of -filling powder into a cavity defined by the one of the first and second die parts being arranged below the other die part, the punch introduced therein and the one of the
5 first and second die parts being arranged above the other die part by introducing the powder through the opening in the first end surface of the one of the first and second die parts being arranged above the other die part.

A punch edge with a curvature partly non-perpendicular to the pressing axis may be referred to as a punch edge following a line around the circumference of the punch
10 that has a certain curvature, for example a predetermined wave-shape, such that, for different angular positions along said line, the position of the punch edge in the direction of the pressing axis differs. Preferably, the pressing axis of the second punch is parallel to, preferably coinciding with, a longitudinal centre axis of the
15 second punch. Since the edge that defines the opening in the second end surface of the first die part has a corresponding curvature, parts of said edge will define an irregularity (curvature) of said second end surface that makes the latter unsuitable for the purpose of advancing a powder-filling device by way of sliding to and from a position on top of said opening in the second surface of the first die in those cases
20 when the first die part forms the lower die part. If the first die part forms the upper die part, the second surface of the second die will pose a corresponding problem. The present invention presents a solution that avoids using a surface presenting such an irregularity that reflects the curvature of the punch edge as the base for a powder-filling device that is used for filling powder into the die. Instead, a surface which
25 does not need to reflect the curvature of the punch edge may be used as such a base for a powder filling device. The term “contiguously” as used above and hereinafter does not necessarily mean that there is direct physical contact between parts joined to each other. However, preferably, joined surfaces that are contiguously arranged in relation to each other are also in bearing direct contact with each other in order to
30 imply stability to the device.

According to one embodiment, the method of the invention comprises the further step of compacting the powder introduced into said cavity by advancing the other of said first and second punches through the bore of the one of the die parts being arranged above the other die part towards said chamber to a final compacting position. Advancing a punch into the upper die part through the opening in the first end surface thereof will be necessary in order to compact the powder housed in said cavity, regardless of which of the first and second die part that is positioned on top of the other. If the first die part is the die part being arranged above the other die part, the first punch is advanced downwards into the latter through the opening in the first end surface thereof. If the second die part is the die part being arranged above the other die part, the second punch is advanced downwards into the latter through the first end surface thereof.

According to yet an embodiment, the method of the invention comprises the step of compacting the powder introduced into said cavity by advancing the second punch through the second die part until the punch edge is at a distance from said inner peripheral surface of said chamber of the first die part so short that an edge of the compacted green body will be formed in the region in which said punch edge is adjacent to said inner peripheral surface.

Preferably, the second punch is advanced until the distance between the punch edge and the inner peripheral surface of the chamber in the first die part is equal to or less than 50 μm , preferably equal to or less than 30 μm . Even more preferably, the maximum distance is equal to or less than 10 μm or equal to or less than 5 μm . The distance between the punch edge and the inner peripheral surface of the chamber may differ along the circumference of the second punch. It is, however, preferred that it is relatively constant around said circumference. The smaller the distance between punch edge and peripheral surface, the better suppression of the generation of a residual edge on the compacted green body as a result of powder leaking out through the gap between punch edge and inner peripheral chamber surface. However, the punch edge must not be in contact with the inner peripheral surface of said

chamber, since such contact may damage the edge and/or the inner peripheral surface.

According to one embodiment, the method of the invention further comprises the steps of exposing the compacted cutting insert green body by retracting the first die part from the second die part (relative motion between said parts; anyone could be the moving one), and displacing the compacted green body out of the first die part through the opening in the second end surface thereof. Even though the invention may be applied in connection to die designs according to which the first die is subdivided into two or more parts that have a parting plane non-perpendicular to the pressing axis and permit separation from each other in a direction perpendicular to the pressing axis for the purpose of closing the cavity before filling or exposing the compacted green body, the invention is particularly suitable for a die design according to which the compacted green body is displaced through said opening in the second end surface of the first die part. The correspondence between the curvature of the punch edge (and edge of the green body) and the curvature of the edge of the opening in the second end surface of the first die part enables a very short and constant release portion in the opening region that extends from said chamber to the edge that defines the opening in the second end surface of the first die part.

According to one embodiment of the invention, the method thereof comprises the step of providing a region around said opening in the second surface of the second die part with a curvature corresponding to the curvature of the edge that defines the opening in the second end surface of the first die part, such that the second surface of the second die part will be in a sealing relation with said edge of the first die part when the first and second die parts are joined. Thereby, powder is prevented from leaking into any space between the second surface of the first die part and the opposing second end surface of the second die part, or even leaking out of the die.

According to one embodiment, the method of the invention comprises the step of providing a powder-filling device and positioning it on top of said opening in the first end surface of the one of the first and second die parts being arranged above the

other die part or removing it from said position by permitting it to slide on said first end surface of the one of the first and second die parts being arranged above the other die part in said direction in which said surface extends rectilinearly.

- 5 According to yet another embodiment, the compacted cutting insert green body has the shape of a positive cutting insert, and the inner peripheral surface of said chamber in the first die part has a corresponding shape, with a cross section cross wise to the pressing axis that increases towards the opening in the second end surface of the first die part.
- 10 The object of the invention is also achieved by means of a device for manufacturing a cutting insert green body by compacting a powder, said device comprising:
- a first punch,
 - a second punch that presents an abutment surface for abutment with the powder to be compacted, and an outer peripheral surface, and a punch edge at the intersection
 - 15 between the abutment surface and the outer peripheral surface, wherein the punch edge presents a predetermined curvature around the circumference of the second punch,
 - a first die part, presenting a chamber having an inner peripheral surface which corresponds to a peripheral surface of a cutting insert green body to be compacted in
 - 20 said first die part, a bore for receiving said first punch, said bore extending from an opening in a first end surface of the first die part to said chamber, and an opening region extending with an expanding cross-section from said chamber to an opposite second end surface of the first die part and defining an opening in said opposite second end surface,
 - 25 -a second die part, presenting a second bore for receiving said second punch, said bore extending from a an opening in the first end surface of the second die part to a second end surface thereof, thereby defining an opening in said second end surface,
 - wherein an edge that defines said opening in the second end surface of the first die part has a curvature corresponding to the predetermined curvature of said punch edge
 - 30 of the second punch,
 - the second end surface of the first die part being adapted to be arranged contiguously in relation to the second surface of the second die part such that said

opening in the second end surface of the first die part meets said opening in the second end surface of the second die part,

- wherein, when the first and second die parts are arranged contiguously in relation to each other in connection to filling of powder into the die, one of said first and second

5 die parts is arranged above the other die part,

-wherein said first end surface of the one of the first and second die parts being arranged above the other die part extends rectilinearly in at least in one direction, said device being characterized in that

-said predetermined curvature is at least partly non-perpendicular to a pressing axis

10 of the device and that the edge of the opening in the second end surface of the first die part presents a corresponding curvature with regard to said pressing axis, and that

-when the device is in a position ready for filling of powder into the die, it presents a cavity defined by the one of the first and second die parts being arranged below the other die part, a punch introduced therein and the one of the first and second die parts

15 being arranged above the other die part. Thereby, the opening in the first end surface of the one of the first and second die parts being arranged above the other die part is exposed for enabling filling of powder into said cavity through said opening.

Since the first end surface of the one of the first and second die parts being arranged

20 above the other die part extends rectilinearly in at least one direction, said first end surface can be used for advancing a powder-filling device to and from a powder filling position on top of the opening therein by means of a sliding motion in the direction in which the first end surface extends rectilinearly. The punch that is introduced into the one of the first and second die parts being arranged below the

25 other die part and contributes to the definition of said cavity when the device is in a position ready for filling of powder is the punch associated to the die part that forms the lower die part. Thus if the one of the first and second die parts being arranged below the other die part is the first die part, the punch introduced therein, from below, is the first punch. If the one of the first and second die parts being arranged

30 below the other die part is the second die part, the punch introduced therein, from below, is the second punch.

According to one embodiment of the device of the invention the first end surface of the upper die part is flat. Thereby, a powder-filling device is not restricted to slide along a specific direction on said first end surface of the one of the first and second die parts being arranged above the other die part, but can be slid in any direction thereon to or from the opening in said first end surface.

Preferably, the first surface of the one of the first and second die parts being arranged above the other die part extends in a plane perpendicular to the pressing axis. Preferably, the pressing axis extends in a vertical direction.

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According to one embodiment the device comprises a powder-filling device, arranged to slide on said first end surface of the one of the first and second die parts being arranged above the other die part in said least one direction in which the first end surface extends rectilinearly, to and from a powder-filling position on top of said opening in the first end surface of the one of the first and second die parts being arranged above the other die part.

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According to one embodiment the second punch is arranged so as to be advanced through the second die part to a final compaction position at which the punch edge is at a distance so short from the inner peripheral surface of said chamber of the first die part that, upon compaction of a powder introduced into said cavity, an edge of the compacted green body will be formed in the region in which said punch edge is adjacent to said inner peripheral surface. The punch is however arranged so as not to contact the inner peripheral surface of the chamber of the first die with its punch edge, but to leave a small gap to the latter. Preferably, said edge of the compacted green body corresponds to the cutting edge of a cutting insert produced from said compacted green body.

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According to one embodiment, the second punch is arranged to be advanced until the distance between the punch edge and the inner peripheral surface of said chamber is equal to or less than 50 μm , preferably equal to or less than 30 μm , even more

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preferably equal to or less than 10 μm , or even more preferably equal to or less than 5 μm .

Preferably, when the second punch is in its final compaction position, the distance L
5 in the direction of the pressing axis from the level of the punch edge to the level of
the edge that defines the opening in the second surface of the first die part is within
the range of 1-500 μm , preferably within the range of 100-300 μm . The lower limit is
dependent on the depth of the chamber, i.e. the height of the green body to be
compacted. Preferably $L \geq 10 \mu\text{m}$, and it may be preferred that $L \geq 50 \mu\text{m}$. The green
10 body will expand once the second punch (and possibly also the second die) is
retracted from the green body, and it is desired that the green body does not expand
beyond the edge that defines the opening of first die. Therefore, said distance must
not be too short, and is related to the height of the green body and the expected
expansion of the latter. The upper limit is chosen with regard to the fact that it is
15 desired that the release portion along which the green body is taken out of the first
die should be as short as possible in order to minimize the upcoming of damages on
the green body caused by contact between the green body and the inner peripheral
surface of in the region of the opening in the second end surface in the first die part
and/or by loose powder and residual edge remain on the inner peripheral surface of
20 the opening region of the first die part. Preferably, the distance between said levels is
constant around the circumferences of the second punch and said opening in the
second end surface of the first die part.

According to one embodiment of the device of the invention, a region around said
25 opening in the second end surface of the second die part has a curvature
corresponding to the curvature of the edge that defines the opening in the second
surface of the first die part, such that the second surface of the second die part will be
in sealing relation with said edge of the opening in the second end surface of the first
die part when the first and second die parts are contiguously arranged.

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According to another embodiment, when the first and second die parts are
contiguously arranged, the second surface of the second die part overlaps the opening

in the second surface of the first part, thereby forming an overlapping rim around said opening in the second end surface of the first die part. The width of the rim is dependent of the angle of the inner periphery of the chamber of the first die part and the angle of the inner periphery in the before-mentioned opening region of the first die part (that forms a release portion for the green body), as well as the distance in the direction of the pressing axis between the level of the punch edge of the second punch and the level of the edge that defines the opening in the second end surface in the first die part (when the second punch is in its final compaction position), and the width of the second punch. Preferably, at least in the region of the opening in the second end surface of the second die part the bore therein is of a dimension (width) such that there is only a very small gap between the inner periphery of the bore in the second die part and the outer peripheral surface of the second punch. The bore in the second die part may thereby contribute to a guiding and lateral positioning of the second punch.

According to one embodiment of the device of the invention, the die comprises an outer die part that at least partially laterally encloses the first and second die parts when those are joined, and wherein the outer die part has an upper surface that, at least partially (at the conceived path of a powder-filling device), coincides with the first surface of the one of the first and second die parts being arranged above the other die part when the latter is joined with said other die part and the device is in a position ready for filling of powder into said cavity. The outer die part may be connected to, and form a single unit with, the one of the first and second die parts being arranged below the other die part. The outer die part may also be regarded as a table, providing a further support surface for a powder filling-device. Thanks to the provision of its upper surface such that it at least partially coincides with the first end surface of the one of the first and second die parts being arranged above the other die part, sliding of and positioning of a powder-filling device on said upper surface is enabled.

According to yet another embodiment of the device of the invention, said one of the first and second die parts being arranged above the other die part presents an

extension that laterally overlaps the one of the first and second die parts being arranged below the other die part when the first and second die parts are joined, wherein said extension comprises a lateral opening which is exposed when the one of the first and second die parts being arranged above the other die part is retracted from the position in which it is joined with said other die part, such that a compacted green body, which is exposed as a result of said retraction of the one of the first and second die parts being arranged above the other die part and a displacement of the green body out of the first die part in the direction of the pressing axis, is laterally exposed through said opening. The extension may comprise one or more shanks extending downwards from the upper die part, or a sleeve extending downwards from the one of the first and second die parts being arranged above the other die part. Preferably, said lower extension of the upper die part is connected to an actuator arranged to displace the one of the first and second die parts being arranged above the other die part in the direction of the pressing axis. In this embodiment, the actuator for displacing the one of the first and second die parts being arranged above the other die part is thus arranged below the die.

Alternatively, the die part forming the one of the first and second die parts being arranged above the other die part presents an upper extension which extends above said first surface of the upper die part. Preferably, said upper extension of the one of the first and second die parts being arranged above the other die part is connected to an actuator arranged to displace the one of the first and second die parts being arranged above the other die part in the direction of the pressing axis. In such an alternative embodiment, the actuator for displacing the one of the first and second die parts being arranged above the other die part is thus arranged above the die. The upper extension must enable the powder-filling device to slide to and from its powder-filling position on the one of the first and second die parts being arranged above the other die part.

According to one embodiment of the device of the invention, the cutting insert green body to be compressed has the shape of a positive cutting insert, and the inner peripheral surface of said chamber in the first die part has a corresponding shape,

with a cross section cross wise to the pressing axis that increases towards the opening in the second surface of the first die part. A positive cutting insert may be referred to as a cutting insert the cross section of which increases from a first end thereof to second end thereof, wherein said second end carries a cutting edge of the cutting insert. According to alternative embodiments of the invention, the cutting insert, and thereby the inner peripheral surface of said chamber of the first die part, may define a double positive cutting insert, i.e. a shape that has a waist between its opposite ends, such that the first die part must be subdivided in subparts that are separable in a direction cross-wise to the pressing axis in order to enable exposal of the compacted green body and removal thereof from the die.

According to one embodiment the second die part is one of the first and second die parts being arranged above the other die part. Thereby, after removal of the second die part from the first die part, the compacted green body is exposed as it is displaced upwards relative the first die part. Such displacement of the compacted green body relative the first die part may be achieved either by displacing the first die part downwards by the action of an actuator connected thereto and/or displacing the compacted green body upwards by the action of the lower (first) punch, which is in its turn connected to an actuator for the displacement thereof in the direction of the pressing axis.

According to an alternative embodiment, the first die part is the one of the first and second die parts being arranged above the other die part. Displacement of the compacted green part out of the first die part is then achieved either by displacing the first die part upwards by the action of an actuator connected thereto and/or by displacing the compacted green body downwards by displacing the upper punch, the lower (second) punch and the lower die part downwards by the action of actuators connected thereto. Which solution is chosen is a matter of design within the expected knowledge of the person skilled in the art.

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The present invention also refers to a cutting insert, characterized in that it is formed from a green body produced in a device according to the invention and/or by means

of a method according to the invention. Likewise, the invention also refers to a cutting insert green body produced in a device according to the invention or by means of a method according to the invention.

- 5 Further features and advantages of the present invention will be presented in the following detailed description of exemplifying embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

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Hereinafter, embodiments of the present invention will be described in detail with reference to the annexed drawing, on which:

- Fig. 1a-1b is a representation of a cutting insert the shape of which corresponds to a
15 shape of a cutting insert green body to be produced in a device and by means of a method according to the present invention,

Fig. 2a is a perspective cross section of a first embodiment of a device according to the invention,

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Fig. 2b is an exploded side view of a cross section of the embodiment shown in fig. 2a,

- Figs. 3a-3g is a series of figures showing the succeeding steps of the method
25 according to an embodiment of the present invention for compacting a cutting insert green body by means of the abovementioned first embodiment of a compaction device according to the present invention, as seen in cross-section,

- Fig. 4a is a perspective cross section of a second embodiment of the device according
30 to the invention,

Fig. 4b is an exploded side view of a cross section of the embodiment shown in fig. 4a,

Figs. 5a-5f is a series of figures showing the succeeding steps of the method
5 according to an embodiment of the present invention for compacting a cutting insert green body by means of the abovementioned second embodiment of a compaction device according to the present invention, as seen in cross-section, and

Fig. 6 is an enlarged representation of a detail of the an inventive device showing
10 some essential parts of the device in a final compaction position of a second punch.

DETAILED DESCRIPTION OF THE INVENTION

15 Fig. 1a and 1b show a cutting insert green body 1 which could be produced by compaction of a powder by means of a device and a method according to the present invention. Typically, the cutting insert green body 1 is subjected to edge treatment and grinding followed by a sintering process in which it is further densified. In most cases, the sintered body is then provided with a suitable wear resistant coating, such
20 as a carbide, nitride, carbonitride, oxide, or boride with any suitable contemporary technique, such as physical vapour deposition or chemical vapour deposition. The cutting insert is used for the machining of metal by milling, drilling or turning or by similar chip forming methods. The shape of the cutting insert corresponds to the shape of the compacted green body 1 from which it has been produced. What is
25 hereby stated regarding the shape of the cutting insert green body 1 shown in figs. 1a and 1b is therefore also valid for the shape of a cutting insert produced from said green body.

The cutting insert green body 1 shown in figs. 1a and 1b has the shape of a positive
30 cutting insert, presenting an increasing cross section from a first end 2 thereof, to a second end 3 thereof. At the second end 3 of the green body 1 the latter presents a cutting edge 4 which runs around the circumference of the green body 1. The cutting

edge 4 is defined by an intersection of the surface of the second end 3 and a peripheral surface 5 of the green body 1. The edge 4 has a curvature that is at least partly non-perpendicular to an axis x corresponding to the pressing axis that has been applied during the compaction of a powder into said green body 1. Partly non-perpendicular is hereby referred to as having a curvature, such that, for different angular positions around said axis x along said cutting edge around the circumference of the green body 1, the position of the cutting edge in the direction of the pressing axis differs.

Fig. 2 shows a first embodiment of a device according to the present invention for producing a cutting insert green body like the green body 1 shown in figs. 1a and 1b. The device defines a press tool that comprises a first punch 6, a second punch 7, a first die part 8 and a second die part 9. It should be understood that parts of the device that are to be displaced during the operation of the device may be connected to actuators provided for that purpose. Such actuators, and the specific connection of said parts thereto, are not shown in the drawing, since it is regarded as ordinary design measures to be taken by a person skilled in the art.

The second punch 7 presents an abutment surface 10 for abutment with the powder to be compacted, and an outer peripheral surface 11, and a punch edge 12 at the intersection between the abutment surface 10 and the outer peripheral surface 11, wherein the punch edge 12 presents a predetermined curvature corresponding to the curvature of the abovementioned cutting edge of the green body 1. Accordingly, the punch edge 12 presents a curvature that is at least partly non-perpendicular to the pressing axis x in the sense that it has a curvature, such that, for different angular positions along said cutting edge around the circumference of the green body 1, the position of the cutting edge in the direction of the pressing axis differs.

The second punch 7 also presents a centre bore 13 extending in the longitudinal direction of punch 7, i.e. parallel with the pressing axis x, for the purpose of receiving a core pin 14. It should however be understood that the provision of a core

pin and bores like the bore 13 in the second punch 7 is optional and not critical to the present invention.

The first die part 8 presents a chamber 15, with an inner peripheral surface 16 which
5 has a geometry that corresponds to the geometry of the peripheral surface 5 of the cutting insert green body 1 to be compacted in said first die part 8. Furthermore, the first die part 8 presents a bore 17 for receiving said first punch 6, said bore 17 extending from an opening 18 in a first end surface 19 of the first die part 8 to said chamber 15, and an opening region extending with an expanding cross-section from
10 said chamber 15 to an opposite second end surface 20 of the first die part 8 and defining an opening 21 in said opposite second end surface 20.

The second die part 9 presents a bore 22 for receiving said second punch 7. The bore 22 extends from an opening 23 in a first end surface 24 of the second die part 9 to a
15 second end surface 25 thereof, thereby defining an opening 26 in said second end surface 25.

An edge 27 that defines said opening 21 in the second end surface 20 of the first die part 8 has a curvature corresponding to the predetermined curvature of the
20 abovementioned punch edge 12 of the second punch 7 in the sense that it has a corresponding curvature around the circumference of the opening 21 that it defines as has the punch edge 12 around the circumference of the second punch 7. Curvature may be referred to as a variation of the position for each incremental part of the edge 27 in the direction of the pressing axis x.

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Fig. 2a shows a first embodiment of the press tool of the present invention in a position ready for filling of powder into a cavity defined therein. The second end surface 20 of the first die part 8 is contiguously arranged in relation to the second end surface 25 of the second die part 9 such that said opening 21 in the second end
30 surface 20 of the first die part 8 meets said opening 26 in the second end surface 25 of the second die part 9.

When the first and second die parts 8, 9 are contiguously arranged in relation to each other in connection to the filling of powder into the die, one of said first and second die parts 8, 9 is above the other, thereby defining an upper die part having its first end surface turned upwards. In the first embodiment shown in figs. 2-3, the second die part 9 is above the first die part 8. The first end surface 24 of the second die part 9 thus forms an upper surface of the die and the opening 23 defines an upper opening of the die, through which a powder to be compacted may be introduced into said cavity, which is defined by the inner peripheral surface 16 of said chamber 15 of the first die part 8, an inner peripheral surface 28 of the bore 17 of the first die part 8, an end surface 29 of the first punch 6 introduced into said bore 17, and an inner peripheral surface 30 of the bore 22 in the second die part 9.

The first end surface 24 of the second die part 9 is essentially flat and extends in a plane perpendicular to the pressing axis x. Preferably, the pressing axis x is vertical, and thus said plane is preferably horizontal.

The die further comprises an outer die part 31 that laterally encloses the first and second die parts 8, 9 when those are joined. The outer die part 31 may be connected to, and form a unit together with, the lower die part. The outer die part 31 has an upper surface 32 that coincides with the first surface 24 of the second die part 9 when the latter is joined with the first die part 8 and the device is in a position ready for filling of powder into said cavity. The outer die part 31 may be provided primarily for the purpose of defining a table on which a powder-filling device may be positioned during operation of the device. However, it may also have possible further function, such as stabilizing function, and may therefore be referred to as a die part, such as when being connected to the lower die part.

The second die part 9, presents an extension 34 that laterally overlaps the first die part 8 when the first and second die parts are joined and that comprises a lateral opening 35 which is exposed when the first and second die parts 8, 9 are retracted from each other, such that a compacted green body, which is exposed as a result of said retraction and a displacement of the green body out of the first die part 8 in the

direction of the pressing axis x, is laterally exposed through said opening 35 (see in particular fig. 3g). The extension 34 is in its turn connected to an actuator, not shown, located below the first die part 8. Other alternative solutions are of course feasible. According to one such alternative solution, not shown on drawing but
5 within the scope of the present invention, the die part forming the upper die part presents an upper extension which extends above said first surface of the upper die part. Such an upper extension is connected to an actuator provided for the displacement thereof located above the die.

10 Figs. 3a-3g show essential steps of an embodiment of the method of the invention applied by means of the above-disclosed first embodiment of the device according to the present invention.

Fig. 3a shows the device of the invention in a position ready for filling powder into
15 the previously mentioned die cavity defined by the aforementioned peripheral surfaces 16, 28 and 30 and the end surface 29 of the first punch 6. The second punch 7 is retracted to a position above the first surface 24 of the second die part 9, leaving room for a powder-filling device 33 to be positioned on top of the opening 23 in the first end surface 24 of the second die part 9. The powder-filling device 33 may be
20 regarded as forming part of the device of the invention. A further table 36 that laterally surrounds the outer die part 31 and has an upper surface in alignment with the upper surface 32 of the outer die part 31 is also shown and forms an optional part of the device.

25 Fig. 3b shows a subsequent step in which the powder-filling device 33 is positioned on top of the opening 23 in the first end surface 24 of the second die part and executes the filling operation. In order to move the powder-filling device 33 from the laterally retracted position shown in fig. 3a to the position on top of said opening 23 shown in fig. 3b, the powder-filling device 33 is slid on the first end surface of the
30 upper die part, i.e. the first end surface 24 of the second die part 9, and here also on the upper surface 32 of the outer die part 31 and the upper surface of the surrounding table 36. The first punch 6 is in a position inside the bore 17 of the first die part 8,

but somewhat retracted in relation to the chamber 15 therein in order to enable receipt of a sufficient amount of powder in the cavity thereby defined in the die.

Fig. 3c shows a subsequent compaction step in which the second punch 7, is being
5 displaced downwards into the bore 22 in the second die part 9. The first punch 6 is displaced upwards through the bore 17 towards the chamber 15 in the first die part 8. Preferably, but not necessarily, the displacements of the first punch 6 and the second punch 7 are simultaneous.

10 Fig. 3d shows the device in a final compaction position, in which the chamber 15 that defines the geometry of the cutting insert green body 1 to be formed is now defined by the inner peripheral surface 16 of the chamber 15 of the first die part, the upper
end surface 29 of the first punch 6 and the abutment surface 10 of the second punch 7. Here, the method according to the invention comprises the step of
15 compacting the powder introduced into said cavity by advancing the second punch 7 through the second die part 9 until the punch edge 12 is at a distance from said inner peripheral surface 16 of said chamber 15 of the first die part 8 so short that an edge, corresponding to a cutting edge of the cutting insert, of the compacted green body 1 will be formed in the region in which said punch edge 12 is adjacent to said inner
20 peripheral surface 16.

Reference is now being made to fig. 6 that shows a detail of the device in an enlarged scale in a position corresponding to the one shown in fig. 3d. In the final compaction position, the second punch 7 protrudes with the punch edge 12 a distance L into the
25 first die part 8, such that the distance g between the punch edge 12 and the inner peripheral surface 16 of the chamber 15 is equal to or less than 10 μm , or even more preferably equal to or less than 5 μm (anywhere around the circumference of the second punch 7). Since the edge 27 defining the opening 21 in the second end surface 20 of the first die part 8 has a curvature corresponding to the curvature of the
30 punch edge 12, the distance between the punch edge 12 and said edge 27 is more or less the same all around the circumference of the second punch 7. The distance L in the direction of the pressing axis x from the level of the punch edge 12 to the level of

the edge 27 that defines the opening 21 in the second surface 20 of the first die part 8 is within the range of 1-500 μm , preferably within the range of 100-300 μm . Preferably, $L \geq 10 \mu\text{m}$, and, depending on the geometry and size of the compacted body to be formed $L \geq 50 \mu\text{m}$. Powder is to a high degree prevented from escaping through the gap g between the punch edge 12 and the inner peripheral surface 16 of the chamber 15 and there will be a very limited space in which escaped loose powder can be gathered. Thereby, the invention results in an advantageous suppression of any formation of a residual edge on the cutting insert green body 1, and a promotion of a production of a cutting insert with a cutting edge with a very small radius.

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From the level of the punch edge 12 to the level of the edge 27 defining the opening 21 in the second end surface 20 of the first die part 8, the inner peripheral surface 37 of the first die part 8 has an inclination angle α relative the pressing axis x which depends on the inclination angle of the inner peripheral surface 16 of the chamber 15. Preferably, the inclination angle α is the same for the inner peripheral surface 16 of the chamber 15 and the inner peripheral surface 37 of the opening region as seen at any cross section around in the circumference of the chamber 15. The inclination angle α may vary around the circumference of the inner peripheral surface 37 of the opening region and the inner peripheral surface 16 of chamber.

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A region around the opening 26 in the second end surface 25 of the second die part 9 has a shape, i.e. a curvature around the circumference of said opening 26, corresponding to the curvature of the edge 27 that defines the opening 21 in the second surface 20 of the first die part 8, such that the second surface 25 of the second die part 9 will be in sealing relation with said edge 27 of the opening 21 in the second end surface 20 of the first die part 8 when the first and second die parts 8, 9 are joined. Thereby, powder is prevented from escaping into any possible space between the second surfaces 20, 25 of the first and second die parts 8, 9.

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When the first and second die parts 8, 9 are contiguously arranged in relation to each other, the second surface 25 of the second die part 9 overlaps the opening 21 in the second end surface 20 of the first die part 8, thereby forming an overlapping rim 38

around said opening 21 in said second end surface 20 of the first die part 8. The size of the rim 38 may vary around the circumference of the opening 21 in the second end surface 20 of the first die part 8, depending on the geometry of the cutting insert green body 1 to be compacted and the geometry of said opening 21. The size of the rim 38 thus depends on the distance L that the punch edge 12 of the second punch 7 projects into the first die part 8, the inclination angle α and the gap k between the outer peripheral surface 11 of the second punch 7 and an inner peripheral surface 30 of the bore 22 in the second die part 9.

- 10 Fig. 3e shows a subsequent step in which the first and second die parts 8, 9 are separated from each other. In this particular embodiment, separation is achieved by means of retraction of the second die part 9 from the first die part 8. However, it should be understood that this is a relative displacement, and that the separation could as well be achieved by a displacement of the first die part 8 or both die parts.
- 15 This is only a matter of connecting the respective part to an actuator, and thereby making displacement thereof possible.

Fig. 3f shows a subsequent step in which the first punch 6 and the second punch 7 are displaced in the direction of the pressing axis x relative the first die part 8 such that the compacted cutting insert green body 1 is displaced out of the first die part 8 through the opening 21 in the second end surface 20 of the first die part 8 and is exposed and laterally accessible through the opening 35 in the extension 34 of the second die part 9.

- 25 Fig. 3g shows a further step according to which the punch that forms the upper punch, here the second punch 7, is further retracted as well as the core pin 14, such that the exposed cutting insert green body 1 is only supported by an upper end surface of the lower punch, here the first punch 6. The exposed cutting insert green body 1 can now get gripped by a device 39 for the removal of the green body 1 from the die. The removal device 39 may be any kind of robot or the like.
- 30

Fig. 4 shows an alternative embodiment which differs from the first embodiment in the sense that the first die part 108 is positioned above the second die part 109, thereby defining an upper die part having its first end surface 119 turned upwards. The first punch 106 and the second punch 107 are identical to the ones disclosed with reference to the first embodiment. Thus, the second punch 107 has an abutment surface 110, a peripheral surface 111 and a punch edge 112. The first die part 108 presents a chamber 115 with an inner peripheral surface 116, a bore 117 extending from the chamber 115 to an opening 118 in a first end surface 119, an opening region extending from the chamber 115 to an opening 121 in an opposite second end surface 120, said opening being defined by an edge 127. The second die part 109 presents a bore 122 which extends from an opening 123 in first end surface 124 to an opening 126 in an opposite second end surface 125. What has previously been stated regarding the provision of the corresponding surfaces, openings, bores, extensions and actuators of the first embodiment is also valid for these surfaces, openings, bores, extensions and actuators in the second embodiment.

The embodiment in fig. 4 further differs from the one shown in figs. 2 and 3 in that it is the first die part 108 that comprises an extension 134 corresponding to the extension 34 carried by the second die part 9 in the first embodiment. Accordingly, also here it is the upper die part that presents said extension. However, it should be mentioned that, as an alternative to the design presented in both the abovementioned embodiments, the extension may be provided on the lower die part, provided that the upper die part is designed such that it still enables the filling of powder into the latter from a position on top thereof and removal of the compacted green body by, for example, a robot. The provision of extensions that connect the respective moving part with an actuator is a matter of choice with regard to the requested functionality, and may be varied widely within the scope of the present invention.

When the die is in a position ready for filling of powder, the second end surface 120 of the first die part 108 is contiguously arranged in relation to the second end surface 125 of the second die part 109 such that the opening 121 in the first die part 108 meets the opening 126 in the second die part 109. A cavity is defined by inner

peripheral surfaces 116, 128, 130 of the above-mentioned bores and chamber and the abutment surface 110 of the second punch 107, which projects from below into the bore provided in the second die part 109. The first end surface 119 of the first die part 108 forms a flat upper surface in which the abovementioned opening 118 is provided. An outer die part 131, that may or may not be directly connected to the lower die part, surrounds the first and second die parts 108, 109 laterally and presents an upper surface 132 which coincides with and is in alignment with the first end surface 119 of the first die part 108. A powder-filling device 133 is provided for the purpose of filling powder into said cavity through said opening 118 in the first end surface 119 of the first die part 108 from a position on top of said opening 118. The powder-filling device 133 reaches its operative position above the opening 118 by sliding on the first end surface 119 of the first die part 108 and on the upper surface 132 of the outer die part 131.

Figs. 5a-5f show essential steps of an embodiment of the method of the invention applied by means of the above-disclosed second embodiment of the device according to the present invention.

Fig. 5a shows the device in a position ready for filling of powder into the cavity defined by the inner peripheral surfaces 116, 128, 130 of the chamber 115, the bore 117 and the bore 122 and the abutment surface 110 of the second punch 107. A further table 136 that laterally surrounds the outer die part 131 and has an upper surface in alignment with the upper surface 132 of the outer die part 131 is also shown and forms an optional part of the device. The powder-filling device 133 is located on the upper surface of the table 136 and is ready for sliding on that surface and the upper surface 132 of the outer die part 131 and the first end surface 119 of the first die part 108 to a position on top of said opening 118 in said first end surface 119. The first punch 106 is retracted from the first end surface 119 of the first die part 108 in order to enable the positioning of the powder-filling device 133 on top of said opening.

Fig. 5b shows a subsequent step in which the powder-filling device 133 fills the abovementioned cavity with powder. The second punch 107 is in a position inside the bore 122 of the second die part 109, but somewhat retracted in relation to the chamber 115 therein in order to enable receipt of a sufficient amount of powder in the cavity thereby defined in the die. As an alternative, the second punch 107 could be in its final compaction position already at this stage, provided that the cavity defined by the die is yet large enough to accommodate the required amount of powder.

Fig. 5c shows a subsequent compaction step in which the first punch 106, is being displaced downwards into the bore 117 in the first die part 108. The second punch 107 is displaced upwards through the bore 122 in the second die part 109 towards the chamber 115 in the first die part 108. Preferably, but not necessarily, the displacements of the first punch 106 and the second punch 107 are simultaneous.

Fig. 5d shows the device in a final compaction position, in which the chamber 115 that defines the geometry of the cutting insert green body 1 to be formed is now defined by the inner peripheral surface 116 of the chamber 115 of the first die part, the end surface 129 of the first punch 106 and the abutment surface 110 of the second punch 107. Likewise to the first embodiment disclosed with reference to fig. 3a-3g, the method according to the second embodiment of the invention comprises the step of compacting the powder introduced into said cavity by advancing the second punch 107 through the second die 109 and predetermined distance into the first die part 108 such that the punch edge 112 is at a distance from said inner peripheral surface 116 of said chamber 115 of the first die part 108 so short that an edge, corresponding to a cutting edge of the cutting insert, of the compacted green body 1 will be formed in the region in which said punch edge 112 is adjacent to said inner peripheral surface 116. In the region corresponding to the region shown in fig. 6, the second embodiment preferably presents the same features as the first embodiment. However, fig. 6 would have to be turned upside down to fully reflect the second embodiment presented in figs. 4-5.

Fig. 5f shows a subsequent step in which the first die part 108 is retracted upwards relative the lower die part 109 in order to displace the compacted cutting insert green body 1 out of the first die part 108. A lateral opening 135 in the extension 134 of the first die part 108 makes the cutting insert green body accessible from a lateral
5 position.

Fig. 5g shows a further step in which the first punch 106 is retracted upwards from the compacted cutting insert green body 1 and the core pin 114 is retracted downwards from said body 1 in order to enable removal of the compacted green
10 body 1 from the die by means of a device 139 for the removal of the green body 1 from the die. The compacted green body 1 is thus only supported by the abutment surface 110 of the second punch 107 when being gripped by said device 139.

It should be understood that the above description of the invention is only by way of
15 example and that the scope of protection is defined by the patent claims, and that alternative embodiments obvious to the person skilled in the art are included in the claimed scope of protection. Accordingly, the invention also includes solutions in which any of the abovementioned first and second die parts are further subdivided into two or more subparts. Furthermore, the first and second parts, though it is
20 preferred in connection to the present invention, need not be separated from each other by displacement thereof in the direction of the pressing axis. If any such die part is subdivided into two or more subparts, such a die part may be removed from the other die part by separation of such subparts and displacement thereof in another direction than the pressing axis, such as in a direction perpendicular to the pressing
25 axis. There may also be further punches, and subdivision of the abovementioned punches into several punches. Also the number of core pins is a matter of choice for the person skilled in the, as well as the connection of the respective die parts, punches and core pins to actuators for the displacement thereof.

PATENT CLAIMS

1. A method of compacting a powder into a cutting insert green body (1),
5 comprising the steps of:
-providing a compaction device comprising
 -a first punch (6; 106),
 -a second punch (7; 107) that presents an abutment surface (10; 110)
for abutment with the powder to be compacted, and an outer peripheral
10 surface (11; 111), and a punch edge (12; 112) at the intersection
between the abutment surface (10; 110) and the outer peripheral surface
(11; 111), wherein the punch edge (12; 112) presents a predetermined
curvature around the circumference of the second punch (107),
 -a first die part (8; 108) presenting a chamber (15; 115) having an inner
15 peripheral surface (16; 116) which corresponds to a peripheral surface
(5) of a cutting insert green body (1) to be compacted in said first die
part (8; 108), a bore (17; 117) for receiving said first punch (6; 106),
said bore (17; 117) extending from an opening (18; 118) in a first end
surface (19; 119) of the first die part (8; 108) to said chamber (15;
20 115), and an opening region extending with an expanding cross-section
from said chamber (15; 115) to an opposite second end surface (20;
120) of the first die part (8; 108) and defining an opening (21; 121) in
said opposite second end surface (20; 120),
 -a second die part (9; 109), presenting a bore (22; 122) for receiving
25 said second punch (7; 107), said bore (22; 122) extending from an
opening (23; 123) in a first end surface (24; 124) of the second die part
(9; 109) to a second end surface (25; 125) thereof, thereby defining an
opening (26; 126) in said second end surface (25; 125),
 -wherein an edge (27; 127) that defines said opening (21; 121) in the
30 second end surface (20; 120) of the first die part (8; 108) has a
curvature corresponding to the predetermined curvature of said punch
edge (12; 112) of the second punch (7; 107),

-arranging the second end surface (20; 120) of the first die part (8; 108) and the second end surface (25; 125) of the second die part (9; 109) contiguously such that said opening (21; 121) in the second end surface (20; 120) of the first die part (8; 108) meets said opening (26; 126) of the second end surface (25; 125) of the second die part (9; 109),
 -positioning the device such that one (9; 108) of said first and second die parts is contiguously arranged above the other die part (8; 109),
 -arranging said first end surface (24; 119) of the one of the die parts (8; 9; 108; 109) being arranged above the other die part such that it extends rectilinearly in at least one direction,
 -introducing one (6; 107) of said punches into the bore (17; 122) of the one of the die parts (8; 9; 108; 109) being arranged below the other die part, said method being **characterized in that**
 -said predetermined curvature of the punch edge (12; 112) of the second punch (7; 107) is at least partly non-perpendicular to a pressing axis (x) of the device and that the edge of the opening in the second end surface of the first die part (8; 108) presents a corresponding curvature with regard to said pressing axis (x), and that the method comprises the further step of
 -filling powder into a cavity defined by the one of the die parts (8; 9; 108; 109) being arranged below the other die part, the punch (6; 107) introduced therein and the one of the die parts (8; 9; 108; 109) being arranged above the other die part by introducing the powder through the opening (23; 118) in the first end surface (24; 119) of the one of the die parts (8; 9; 108; 109) being arranged above the other die part (8; 9; 108; 109) .

25

2. A method according to claim 1, **characterized in** that it comprises the further step of compacting the powder introduced into said cavity by advancing the other (7; 106) of said first and second punches (6, 7; 106, 107) through the opening (23; 118) in the first end surface (24; 119) of the one of the first and second die parts being arranged above the other die part (9; 108; 8; 109) towards said chamber (15; 115) to a final compacting position.

30

3. A method according to claim 1 or 2, **characterized in** that it comprises the step of compacting the powder introduced into said cavity by advancing the second punch (7; 107) through the second die part (9; 109) until the punch edge (12; 112) is at a distance from said inner peripheral surface (16; 116) of said chamber (15; 115) of the first die part (8; 108) so short that an edge of the compacted green body (1) will be formed in the region in which said punch edge (12; 112) is adjacent to said inner peripheral surface (16; 116).

4. A method according to claim 3, **characterized in** that the second punch (7; 107) is advanced until the distance (g) between the punch edge (12; 112) and the inner peripheral surface (16; 116) of the chamber (15; 115) in the first die part (8; 108) is equal to or less than 50 μm , preferably equal to or less than 30 μm , or even more preferably equal to or less than 10 μm , or even more preferably equal to or less than 5 μm .

5. A method according to any one of claims 1-4, **characterized in** that it further comprises the steps of exposing the compacted cutting insert green body (1) by retracting the first die part (8; 108) from the second die part (9; 109), and displacing the compacted green body (1) out of the first die part (8; 108) through the opening (21; 121) in the second end surface (20; 120) thereof.

6. A method according to any of claims 1-5, **characterized in** that it comprises the step of providing a region around said opening (26; 126) in the second end surface (25; 125) of the second die part (9; 109) with a curvature corresponding to the curvature of the edge (27; 127) that defines the opening (21; 121) in the second end surface (20; 120) of the first die part (8; 108), such that the second surface (25; 125) of the second die part (9; 109) will be in a sealing relation with said edge (27; 127) of the first die part (8; 108) when the first die part (8; 108) is contiguously arranged in relation to the second die part (9; 109).

7. A method according to anyone of claims 1-6, **characterized in** that it comprises the step of providing a powder-filling device (33; 133) and positioning it on top of

said opening (23; 118) in the first end surface (24; 119) of the upper die part (9; 108) or removing it from said position by permitting it to slide on said first end surface (24; 119) of the upper die part (9; 108) in said direction in which said surface (24; 119) extends rectilinearly.

5

8. A method according to any one of claims 1-7, **characterized in** that the compacted cutting insert green body (1) has the shape of a positive cutting insert, and that the inner peripheral surface (16; 116) of said chamber (15; 115) in the first die part (8; 108) has a corresponding shape, with a cross section cross wise to the pressing axis (x) that increases towards the opening (21; 121) in the second end surface (20; 120) of the first die part (8; 108).

9. A device for manufacturing a cutting insert green body (1) by compacting a powder, said device comprising:

15 -a first punch (6; 106),

-a second punch (7; 107) that presents an abutment surface (10; 110) for abutment with the powder to be compacted, and an outer peripheral surface (11; 111), and a punch edge (12; 112) at the intersection between the abutment surface (10; 110) and the outer peripheral surface (11; 111), wherein the punch edge (12; 112) presents a predetermined curvature around the circumference of the second punch (107),

20 -a first die part (8; 108), presenting a chamber (15; 115) having an inner peripheral surface (16; 116) which corresponds to a peripheral surface of a cutting insert green body (1) to be compacted in said first die part (8; 108), a bore (17; 117) for receiving said first punch (6; 106), said bore (17; 117) extending from an opening (18; 118) in a first end surface (19; 119) of the first die part (8; 108) to said chamber (15; 115), and an opening region extending with an expanding cross-section from said chamber (15; 115) to an opposite second end surface (20; 120) of the first die part (8; 108) and defining an opening (21; 121) in said opposite second end surface (20; 120),

25 -a second die part (9; 109), presenting a bore (22; 122) for receiving said second punch (7; 107), said bore (22; 122) extending from a an opening (23; 123) in the first end surface (24; 124) of the second die part (9; 109) to a second end surface (25;

- 125) of the second die part, thereby defining an opening (26; 126) in said second end surface (25; 125),
- wherein an edge (27; 127) that defines said opening (21; 121) in the second end surface (20; 120) of the first die part (8; 108) has a curvature corresponding to the predetermined curvature of said punch edge (12; 112) of the second punch (7; 107),
 - the second end surface (20; 120) of the first die part (8; 108) being adapted to be contiguously arranged in relation to the second surface (25; 125) of the second die part (9; 109) such that said opening (21; 121) in the second end surface (20; 120) of the first die part (8; 108) meets said opening (26; 126) in the second end surface (25; 125) of the second die part (9; 109),
 - wherein, when the first and second die parts (8, 9; 108, 109) are contiguously arranged to each other in connection to filling of powder into the die, one (9; 108) of said first and second die parts is arranged above the other (8; 109),
 - wherein said first end surface (24; 119) of the one of the die parts (8; 9; 108; 109) being arranged above the other die part extends rectilinearly in at least in one direction,
- said device being **characterized in** that
- said predetermined curvature is at least partly non-perpendicular to a pressing axis (x) of the device and that the edge (27; 127) of the opening in the second end surface (20; 120) of the first die part (8; 108) presents a corresponding curvature with regard to said pressing axis (x), and that
 - when the device is in a position ready for filling of powder into the die, it presents a cavity defined by the one of the die parts (8; 9; 108; 109) being arranged below the other die part, a punch (6; 107) introduced therein and the one of the die parts (8; 9; 108; 109) being arranged above the other die part

10. A device according to claim 9, **characterized in** that the first end surface (24; 119) of the one of the die parts (8; 9; 108; 109) being arranged above the other die part is flat.

11. A device according to any claim 9 or 10, **characterized in** that the first surface (24; 119) of the one of the die parts (8; 9; 108; 109) being arranged above the other die part (9; 108) extends in a plane perpendicular to the pressing axis (x).

5 12. A device according to any one of claims 9-11, **characterized in** that it comprises a powder-filling device, arranged to slide on said first surface (24; 119) of the one of the die parts (8; 9; 108; 109) being arranged above the other die part (9; 108) in said at least one direction in which the first surface (24; 119) extends rectilinearly, to and from a powder-filling position on top of said opening (23; 118) in the first surface
10 (24; 119) of the one of the die parts (8; 9; 108; 109) being arranged above the other die part (9; 108).

13. A device according to any one of claims 9-12, **characterized in** that the second punch (7; 107) is arranged so as to be advanced through the second die part (9; 109)
15 to a final compaction position at which the punch edge (12; 112) is at a distance so short from the inner peripheral surface (16; 116) of said chamber (15; 115) of the first die part (8; 108) that, upon compaction of a powder introduced into said cavity, an edge (4) of the compacted green body (1) will be formed in the region in which said punch edge (12; 112) is adjacent to said inner peripheral surface (16; 116).

20 14. A device according to claim 13, **characterized in** that the second punch (7; 107) is arranged to be advanced until the distance between the punch edge (12; 112) and the inner peripheral surface (16; 116) of said chamber (15; 115) is equal to or less than 50 μm , preferably equal to or less than 30 μm , even more preferably equal to or
25 less than 10 μm , or even more preferably equal to or less than 5 μm .

15. A device according to claim 13 or 14, **characterized in** that, when the second punch (7; 107) is in its final compaction position, the distance in the direction of the pressing axis (x) from the level of the punch edge (12; 112) to the level of the edge
30 (27; 127) that defines the opening (21; 121) in the second surface (20; 120) of the first die part (8; 108) is within the range of 10-500 μm , preferably within the range of 100-300 μm .

16. A device according to any one of claims 9-15, **characterized in** that a region around said opening (26; 126) in the second end surface (25; 125) of the second die part (9; 109) has a curvature corresponding to the curvature of the edge (27; 127) that defines the opening (21; 121) in the second end surface (20; 120) of the first die part (8; 108), such that the second end surface (25; 125) of the second die part (9; 109) will be in sealing relation with said edge (27; 127) of the opening (21; 121) in the second end surface (20; 120) of the first die part (8; 108) when the first and second die parts (8, 9; 108, 109) are contiguously arranged.

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17. A device according to any one of claims 9-16, **characterized in** that, when the first and second die parts (8, 9; 108, 109) are contiguously arranged, the second surface (25; 125) of the second die part (9; 109) overlaps the opening (21; 121) in the second end surface (20; 120) of the first die part (8; 108), thereby forming an overlapping rim (38) around said opening (21; 121) in said second end surface (20; 121) of the first die part (8; 108).

18. A device according to any one of claims 9-17, **characterized in** that the die comprises an outer die part (31; 131) that at least partially laterally encloses the first and second die parts (8, 9; 108, 109) when those are contiguously arranged, and that the outer die part (31; 131) has an upper surface (32; 132) that coincides with the first surface (24; 119) of the one of the die parts (8; 9; 108; 109) being arranged above the other die part when the latter is contiguously arranged in relation to the one of the die parts (8; 9; 108; 109) being arranged below the other die part and the device is in a position ready for filling of powder into said cavity.

19. A device according to any one of claims 9-18, **characterized in** that the one of the die parts (8; 9; 108; 109) being arranged above the other die part presents an extension (34; 134) that overlaps the lower die part (8; 109) when the first and second die parts (8, 9; 108, 109) are joined and that comprises a lateral opening (35; 135) which is exposed when the one of the die parts (8; 9; 108; 109) being arranged above the other die part (9; 108) is retracted from the position in which it is

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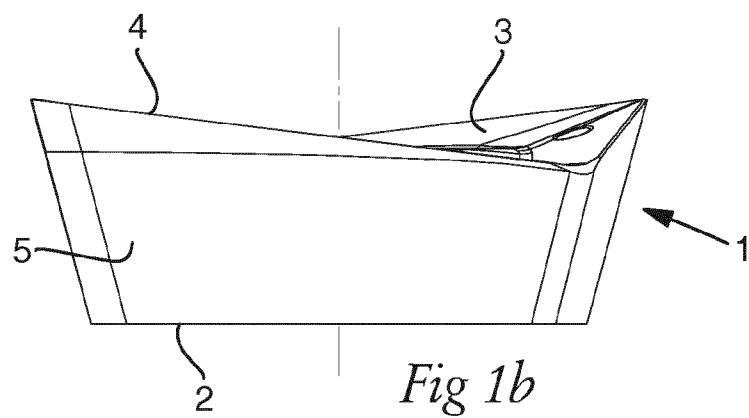
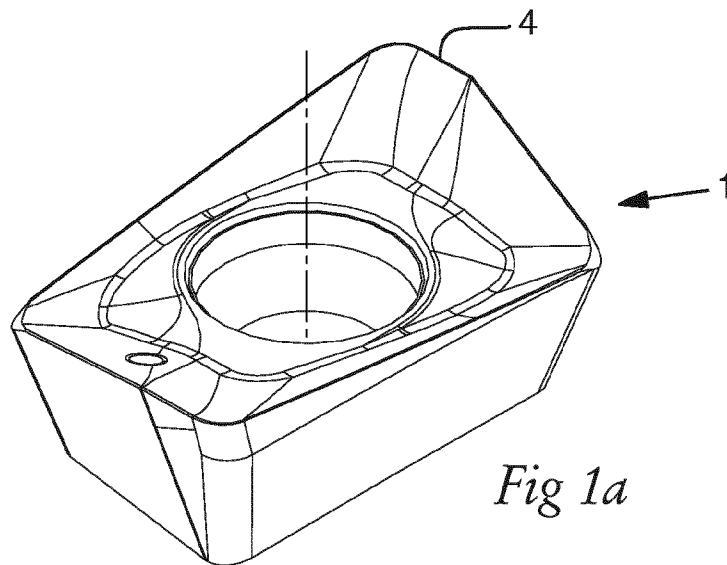
contiguously arranged in relation to the other die part, such that a compacted green body (1), which is exposed as a result of said retraction of the one of the die parts (8; 9; 108; 109) being arranged above the other die part and a displacement of the green body (1) out of the first die part (8; 108) in the direction of the pressing axis (x), is
5 laterally exposed through said opening (35; 135).

20. A device according to any one of claims 9-19, **characterized in** that the cutting insert green body (1) has the shape of a positive cutting insert, and that the inner peripheral surface (16; 116) of said chamber (15; 115) in the first die part (8; 108)
10 has a corresponding shape, with a cross section cross wise to the pressing axis (x) that increases towards the opening (21; 121) in the second surface (20; 120) of the first die part (8; 108).

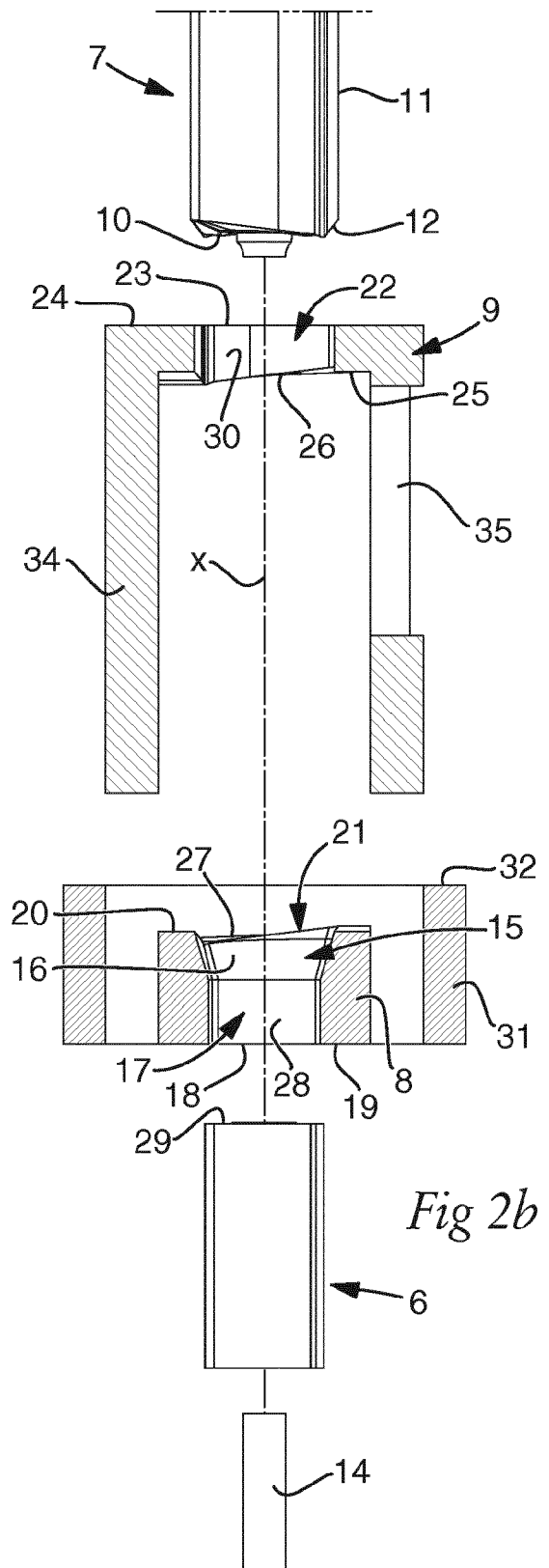
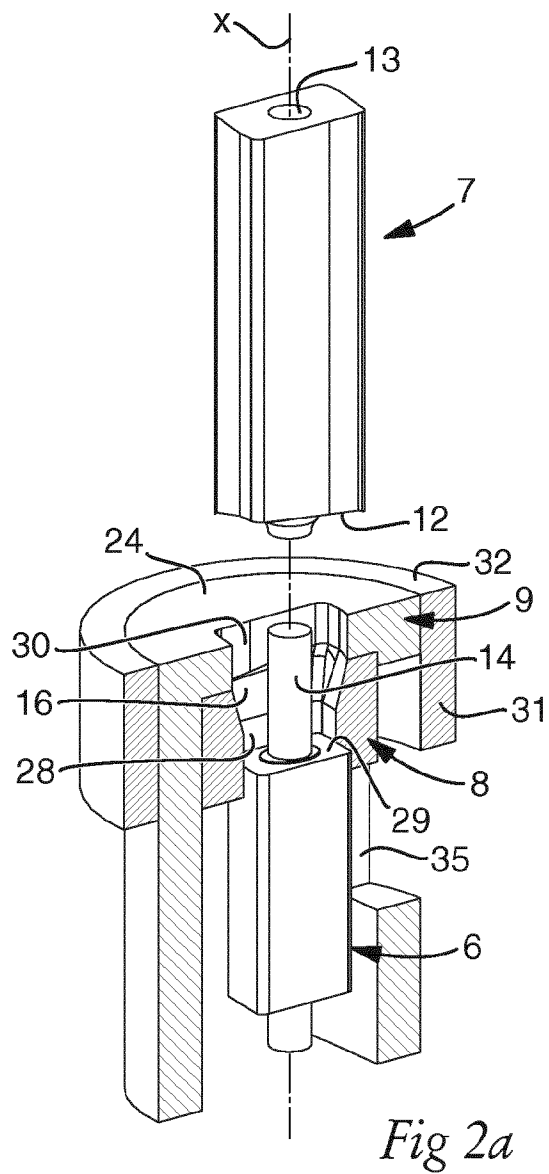
21. A device according to any one of claims 9-20, **characterized in** that the second
15 die part (9) is the one of the die parts (8; 9; 108; 109) being arranged above the other die part.

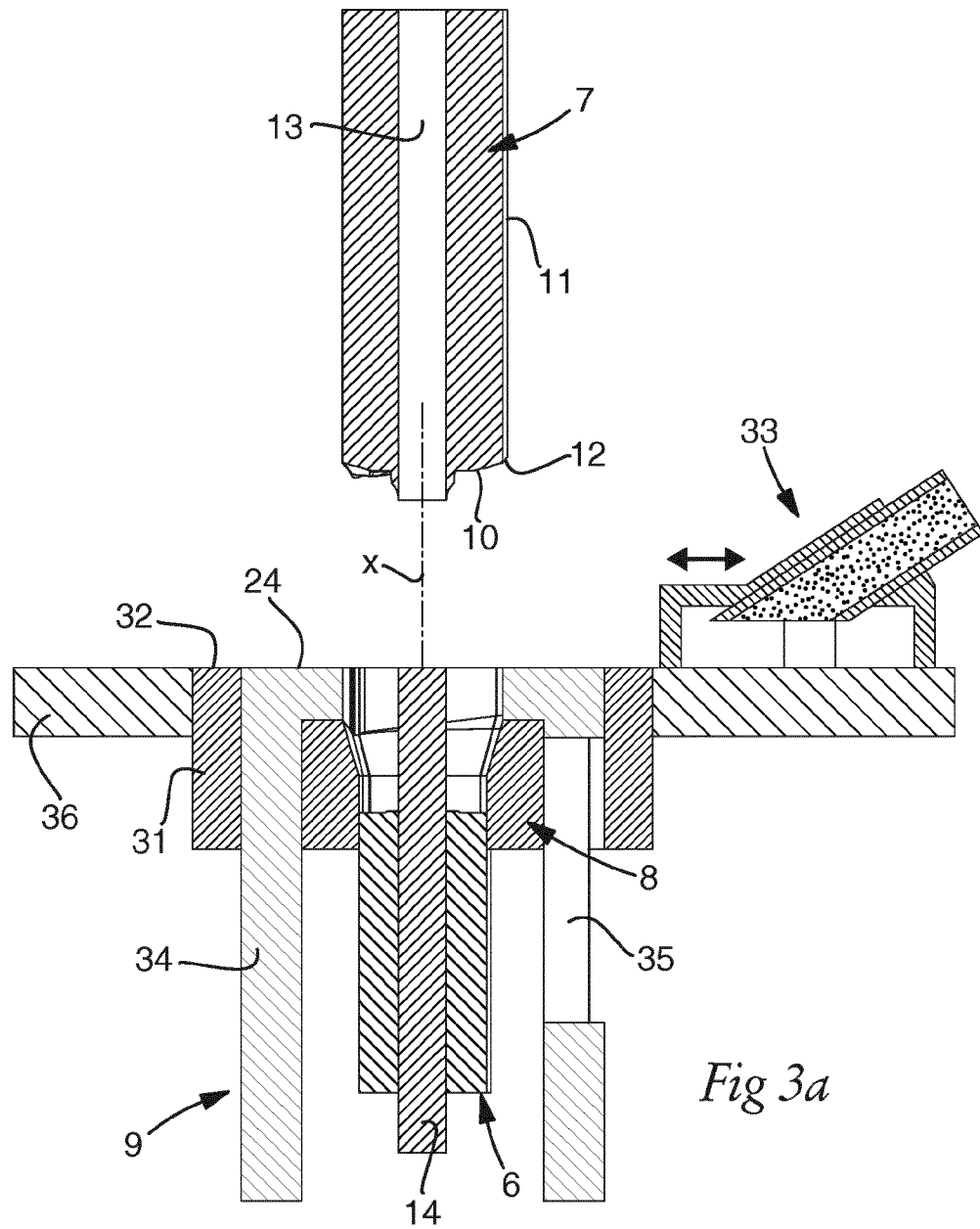
22. A device according to any one of claims 9-20, **characterized in** that the first die part (108) is the one of the die parts (8; 9; 108; 109) being arranged above the other
20 die part.

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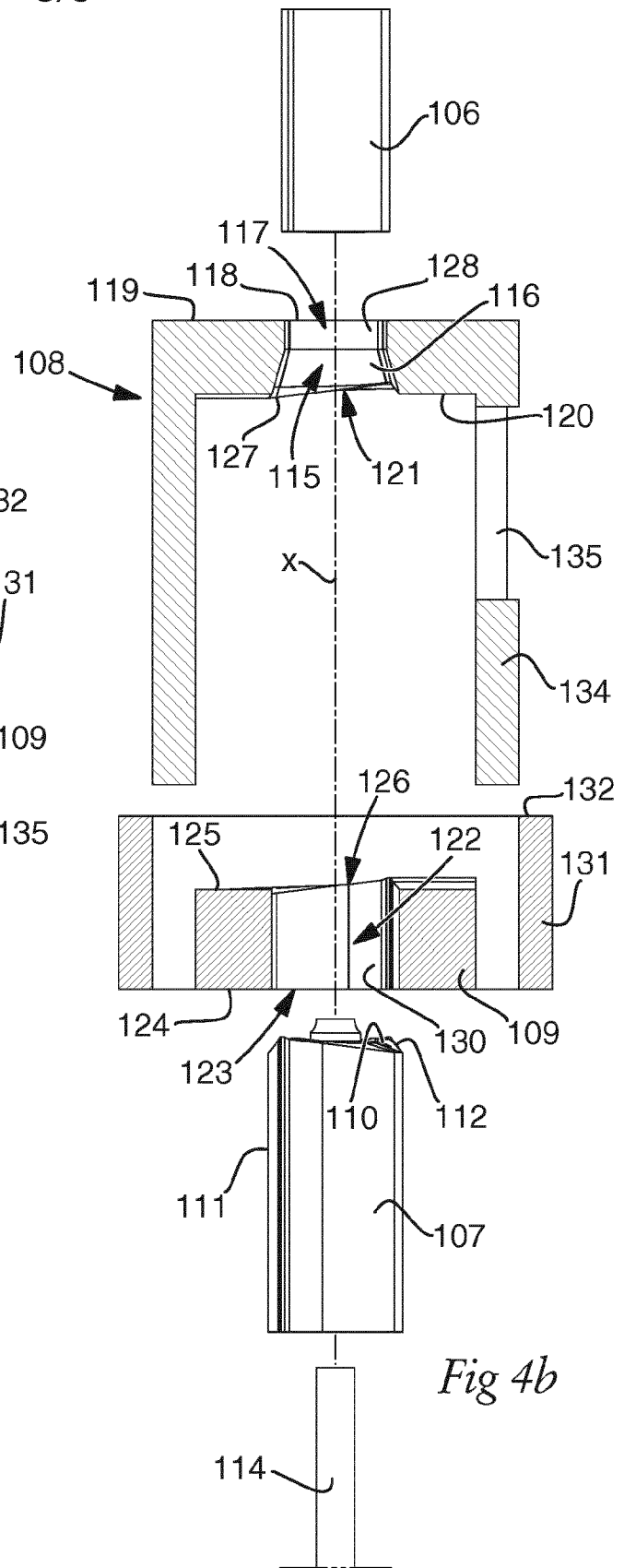
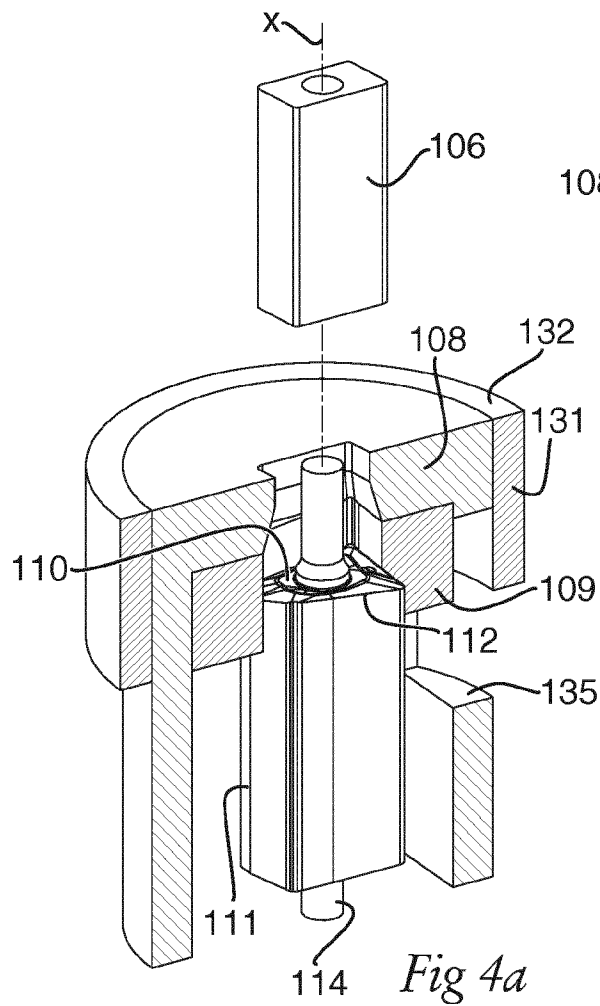


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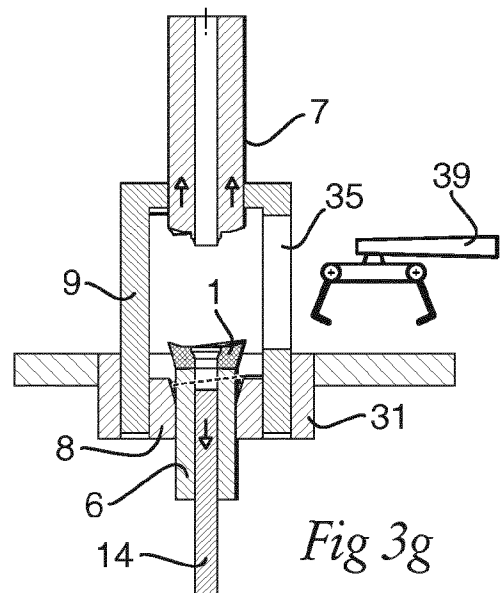
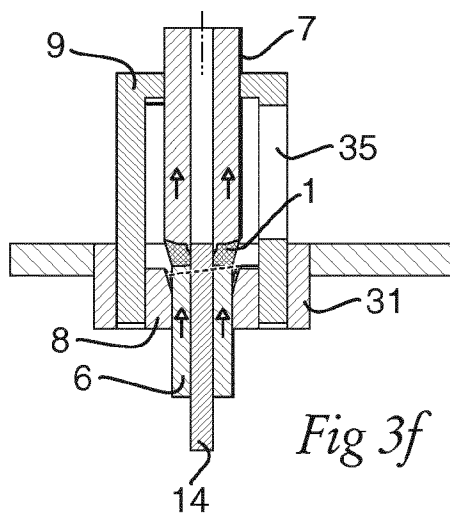
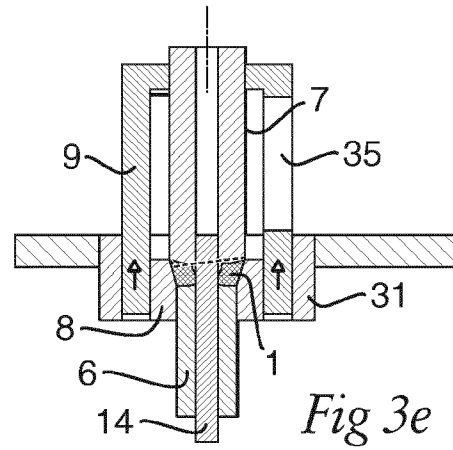
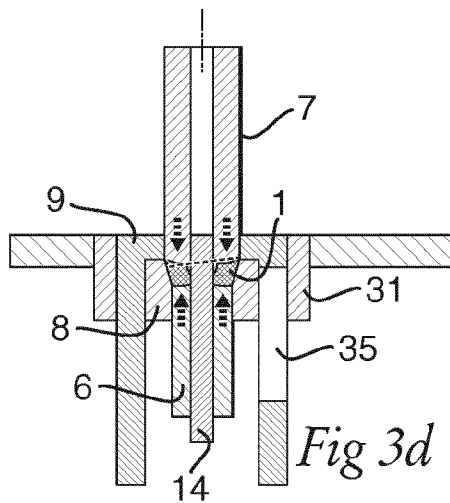
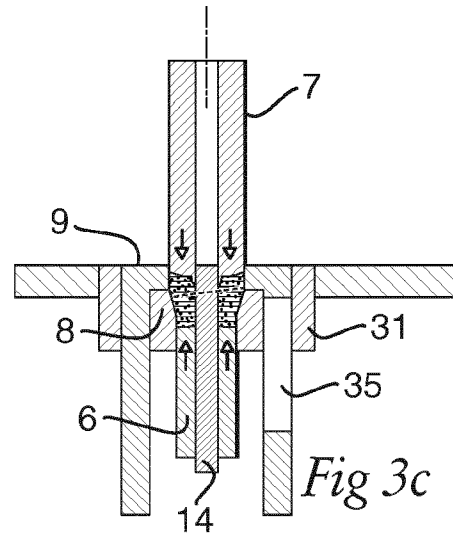
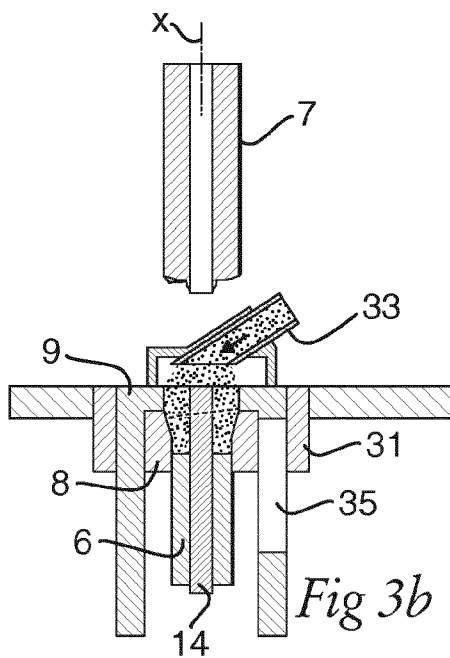




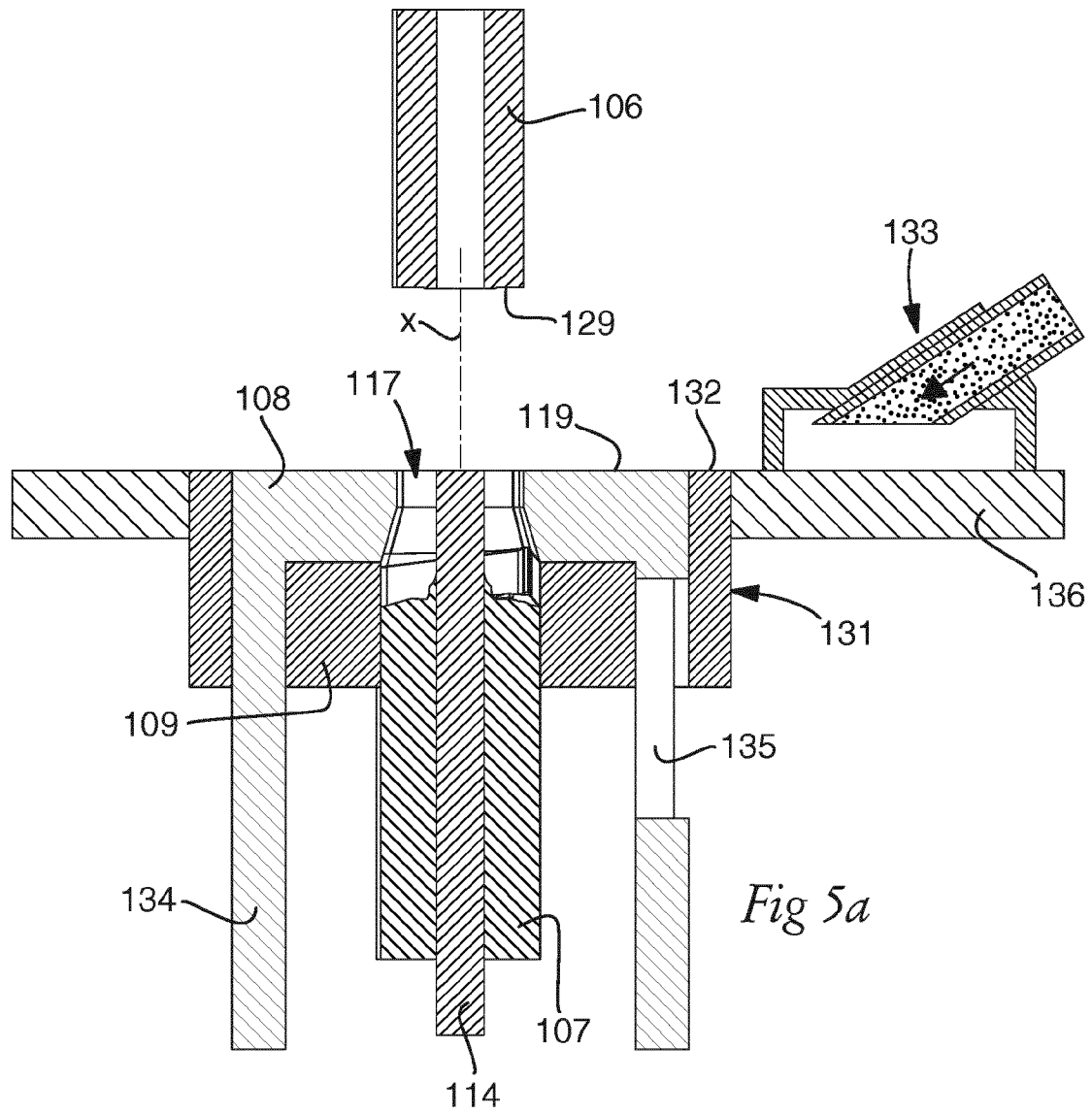
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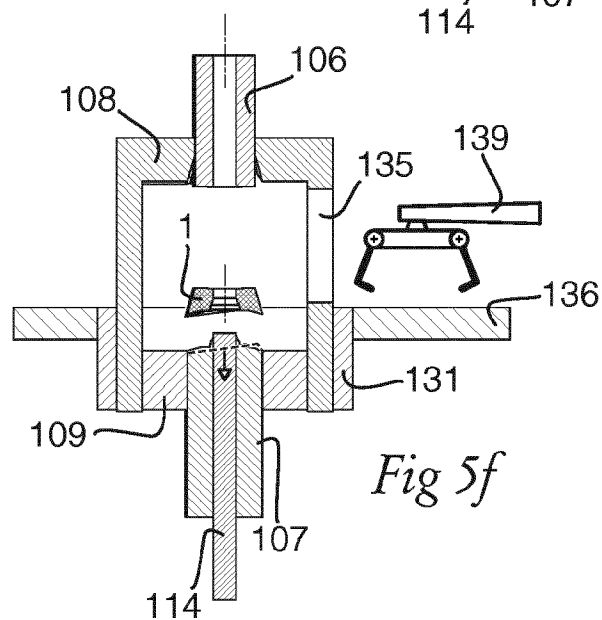
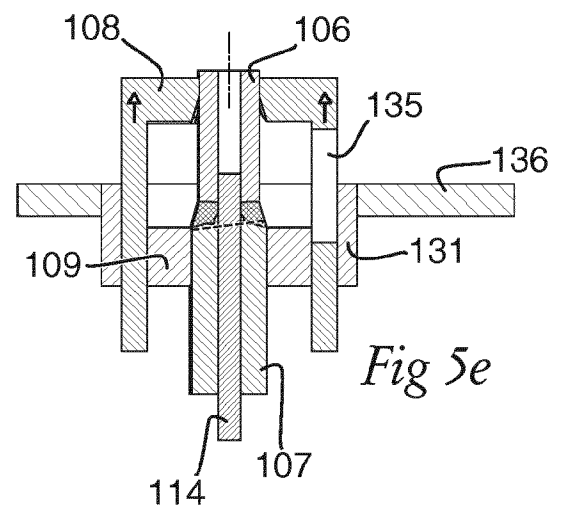
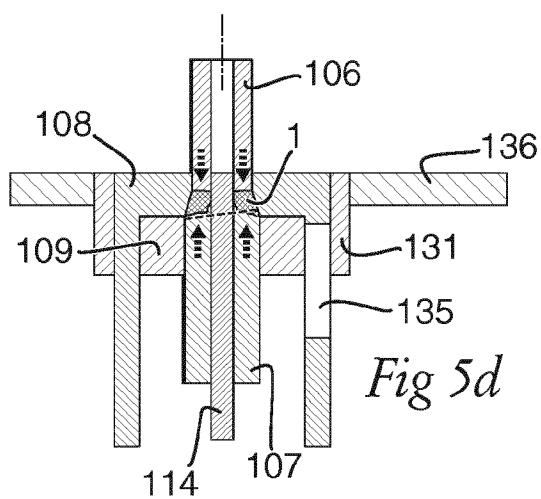
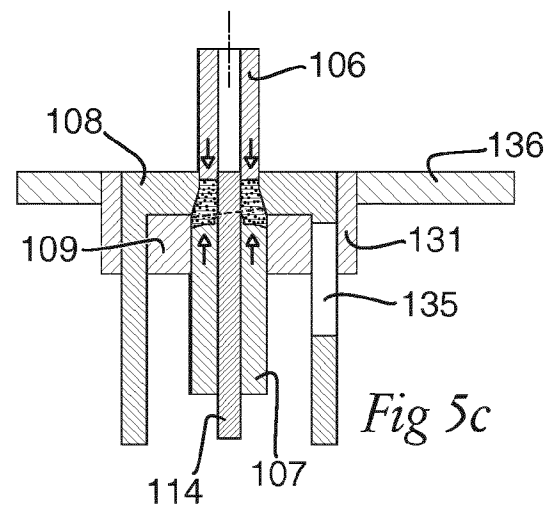
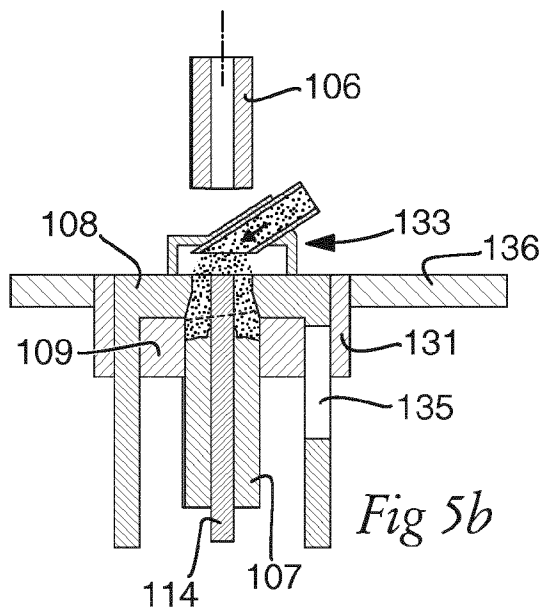
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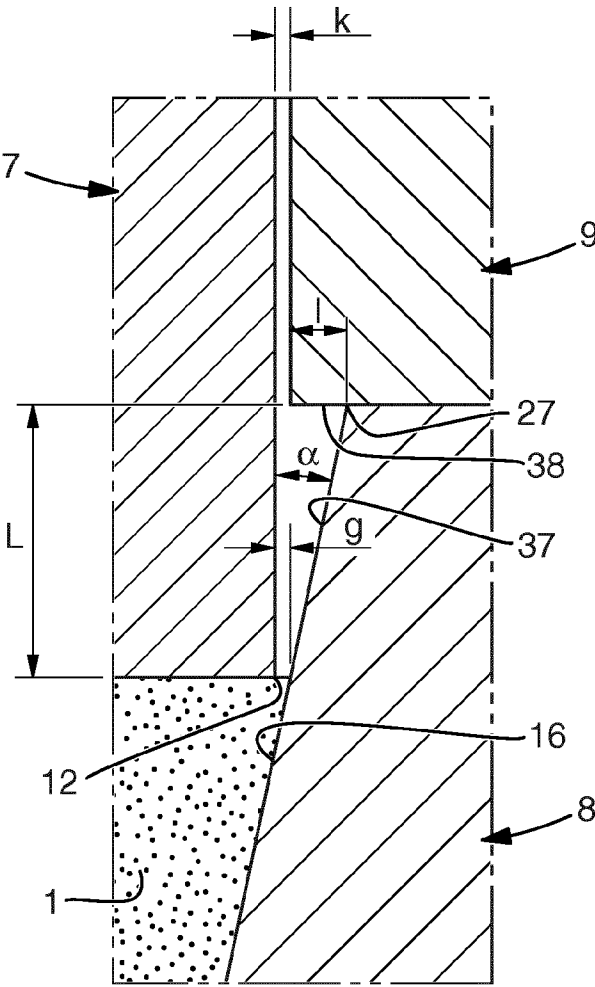


Fig 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/055879

A. CLASSIFICATION OF SUBJECT MATTER

INV. B22F3/00 B22F5/10 B30B11/02 B22F3/03 B30B15/02
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)

B22F B30B

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.
A	US 4 298 563 A (DESANTIS RAYMOND P ET AL) 3 November 1981 (1981-11-03) columns 7,9 figures 2, 8, 8a, 10 -----	1-22
A	US 4 906 294 A (VON HAAS RAINER [DE] ET AL) 6 March 1990 (1990-03-06) columns 3-5 figures 1, 3 -----	1-22



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"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

22 May 2015

Date of mailing of the international search report

12/06/2015

Name and mailing address of the ISA/

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Authorized officer

Forestier, Gilles

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/055879

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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