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(54) **PICK TOOL AND METHOD FOR MAKING SAME**

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Description

Background

[0001] Embodiments of the invention relate generally to pick tools comprising a superhard tip, particularly but not exclusively degrading hard or abrasive bodies, such as rock, asphalt, coal or concrete, for example, and to a method for making same.

[0002] Pick tools may be used for breaking, boring into or otherwise degrading structures or bodies, such as rock, asphalt, coal or concrete and may be used in applications such as mining, construction and road reconditioning. For example, in road reconditioning operations, a plurality of pick tools may be mounted on a rotatable drum and caused to break up road asphalt as the drum is rotated. A similar approach may be used to break up rock formations such as in coal mining. Some pick tools may comprise a working tip comprising synthetic diamond material, which is likely to have better abrasion resistance than working tips formed of cemented tungsten carbide material. However, synthetic and natural diamond material tends to be more brittle and less resistant to fracture than cemented carbide material and this tends to reduce its potential usefulness in pick operations. There is a need to provide a pick tool having longer working life.

[0003] United States patent application publication number 2008/0035383 discloses a high impact resistant tool having a superhard material bonded to a cemented metal carbide substrate, the cemented metal carbide substrate being bonded to a front end of a cemented metal carbide segment, which has a stem formed in the base end, the stem being press fit into a bore of a steel holder. The steel holder is rotationally fixed to a drum adapted to rotate about an axis. US 2009/0051211 discloses a similar superhard material mounted to a high impact resistant tool. US 5,150,636 also describes a bit designed to rotate about its longitudinal axis. US 2006/055229 describes a water spraying system for a bit designed to rotate about its longitudinal axis. Similarly, WO 2005/093214 describes a bit designed to rotate about its longitudinal axis.

Summary

[0004] Viewed from a first aspect, there is provided a pick tool (also referred to as a superhard pick tool) comprising an insert (also referred to as a pick insert) mounted in a steel holder, the insert comprising a superhard tip joined to a cemented carbide support body at an end of the support body, the support body comprising an insertion shank (also referred to simply as a shank); the steel holder having a bore configured to accommodate the insertion shank and comprising a shaft configured for mounting the steel holder onto a tool carrier; such as a pick driver apparatus; the volume of the cemented carbide support body being at least 15 cm^3 and comprising cemented carbide material having fracture toughness of at least 8 megapascals times square root metre ($MPa.m^{1/2}$) and at most 17 $MPa.m^{1/2}$; in which an inserted portion of the insertion shank is secured in the bore, the inserted portion having an axial length of at least 4 cm and at most 8.5 cm, and a mean diameter of at least 2 cm and at most 3.5 cm. The insertion shank may be shrink-fitted within the bore..

[0005] Viewed from a second aspect, there can be provided a method for making a pick tool, the method including providing an insert and a steel holder for the insert, the insert comprising a superhard tip joined to a cemented carbide support body having an insertion shank; the steel holder comprising a shaft for connection to a tool carrier, and provided with a bore for receiving the insertion shank; the insertion shank having a volume of at least 10 cm^3; and shrink fitting the insertion shank into the bore of the steel holder; in which the cemented carbide support body has a volume of at least 15 cm^3 and comprises cemented carbide material having a fracture toughness of at least 8 $MPa.m^{1/2}$ and at most 17 $MPa.m^{1/2}$; and in which an inserted portion of the insertion shank is secured in the bore, the inserted portion having an axial length of at least 4 cm and at most 8.5 cm, and a mean diameter of at least 2 cm and at most 3.5 cm.

[0006] Viewed from a third aspect, there can be provided a method of disassembling a pick tool as described above in the first aspect, the method including heating the steel holder to expand the bore and withdrawing the insertion shank from the bore.

Brief introduction to the drawings

[0007] Non-limiting example arrangements to illustrate the present disclosure are described hereafter with reference to the accompanying drawings, of which:

FIG 1A shows a schematic partially cut-away side view of an example of a pick tool.

FIG 1B shows a schematic side view of the pick insert of the example pick tool shown in FIG 1A.

FIG 1C shows a partially cut-away perspective view of the steel holder of the example pick tool shown in FIG 1A.

FIG 2 shows a schematic partially cut-away side view of an example of a pick tool.

FIG 3 shows a schematic partially cut-away side view of an example of a pick tool.

FIG 4 shows a schematic partially cut-away side view of an example of a pick tool, in which dimensions are in millimetres.

FIG 5 shows a schematic partially cut-away side view of an example of a pick tool, in which dimensions are in millimetres.

FIG 6 shows a schematic partially cut-away side view of an example of a pick tool, in which dimensions are in millimetres.

FIG 7 shows a schematic longitudinal cross section view of the example of a superhard tip and part of the support body of any one of the example pick tools shown in FIG 1A to FIG 6.

FIG 8 shows a schematic side view of an example of a superhard tip and part of the support body of any one of the example pick tools shown in FIG 1A to FIG 6, in which dimensions are in millimetres and angles are in degrees.

FIG 9 shows a schematic partially cut-away side view of an example of a pick tool mounted to a carrier body, in which only a portion of the pick tool is shown.

FIG 10 shows a schematic side view an example of a pick tool for a different carrier than that illustrated in FIG 9.

FIG 11 shows a schematic partially cut-away side view of an example of a pick tool, with a section of the steel holder in a worn-away condition.

[0008] The same reference numbers refer to the same general features in all drawings.

Detailed description

[0009] As used herein, "superhard" means a Vickers hardness of at least 25 GPa, and a superhard tool, insert or component means a tool, insert or component comprising a superhard material.

[0010] Synthetic and natural diamond, polycrystalline diamond (PCD), cubic boron nitride (cBN) and polycrystalline cBN (PCBN) material are examples of superhard materials. As used herein, synthetic diamond, which is also called man-made diamond, is diamond material that has been manufactured. As used herein, polycrystalline diamond (PCD) material comprises a mass (an aggregation of a plurality) of diamond grains, a substantial portion of which are directly inter-bonded with each other and in which the content of diamond is at least about 80 volume percent of the material. Interstices between the diamond grains may be at least partly filled with a binder material comprising a catalyst material for synthetic diamond, or they may be substantially empty. As used herein, a catalyst material for synthetic diamond is capable of promoting the growth of synthetic diamond grains and or the direct intergrowth of synthetic or natural diamond grains at a temperature and pressure at which synthetic or natural diamond is thermodynamically stable. Examples of catalyst materials for diamond are Fe, Ni, Co and Mn, and certain alloys including these. Bodies comprising PCD material may comprise at least a region from which catalyst material has been removed from the interstices, leaving interstitial voids between the diamond grains. As used herein, PCBN material comprises grains of cubic boron nitride (cBN) dispersed within a matrix comprising metal or ceramic material.

[0011] Other examples of superhard materials include certain composite materials comprising diamond or cBN grains held together by a matrix comprising ceramic material, such as silicon carbide (SiC), or cemented carbide material, such as Co-bonded WC material (for example, as described in United States patents numbers 5,453,105 or 6,919,040). For example, certain SiC-bonded diamond materials may comprise at least about 30 volume percent diamond grains dispersed in a SiC matrix (which may contain a minor amount of Si in a form other than SiC). Examples of SiC-bonded diamond materials are described in United States patents numbers 7,008,672; 6,709,747; 6,179,886; 6,447,852; and International Application publication number WO2009/013713). Example arrangements of pick tools for degrading hard or abrasive bodies or structures are described with reference to FIG 1A to FIG 6.

[0012] Examples of pick tools 100 comprise an insert 110 and a steel holder 120 for the insert 110. The insert 110 comprises a superhard tip 112 joined to a cemented carbide support body 114 comprising an insertion shank 118. In these examples, the insertion shanks 118 are generally cylindrical in shape and have a mean diameter D, the superhard tips 112 comprise respective PCD structures 111 bonded to cemented carbide substrates 113, which are joined to

respective support bodies 114 at respective interfaces 115 by means of braze material, and the support bodies 114 have generally frusto-conical portions 116 to which the superhard tips 112 are brazed. The steel holders 120 comprise shafts 122 for connection to a pick drum device (not shown), and bores 126 are configured for shrink-fitting the insertion shanks 118.

[0013] The steel holders 120 may be provided with respective insert receiver members 124 in which the bores 126 are formed.

[0014] At least a portion of the insertion shank 118 may be secured within the bore 126 by means of a shrink fit. As used herein, a shrink fit is a kind of interference fit between components achieved by a relative size change in at least one of the components (the shape may also change somewhat). This is usually achieved by heating or cooling one component before assembly and allowing it to return to the ambient temperature after assembly. Shrink-fitting is understood to be contrasted with press-fitting, in which a component is forced into a bore or recess within another component, which may involve generating substantial frictional stress between the components.

[0015] Shrink-fitting is likely to result in a region (not indicated) of the steel holder 120 adjacent the bore 126 being in a static state of circumferential tensile stress. In some examples of pick tools, a region within the steel holder adjacent the bore may be in a state of circumferential (or hoop) static tensile stress of at least about 300 MPa or at least about 350 MPa, and in some pick tools, the circumferential static tensile stress may be at most about 450 MPa or at most about 500 MPa. As used herein, the static stress state of a tool or element refers to the stress state of the tool or element under static conditions, such as may exist when the tool or element is not in use.

[0016] In some example pick tools, a portion 119 of the support body 114, including the frusto-conical portion 116, may protrude from the steel holder 120 and extend beyond a mouth 128 of the bore 126. In some examples, the diameter of the protruding portion 119 along the entire length of the protruding portion may be at most about 5% greater, or substantially no greater than the mean diameter D of the bore 126. In the examples illustrated in FIG 1A to FIG 6, the diameter of the protruding portion 119 does not substantially exceed that of the bore 126.

[0017] In one embodiment, a collar encloses at least part of a protruding portion of the cemented carbide support body, and in one embodiment the collar may be shrink-fitted onto the protruding portion. In one embodiment, the collar has lower hardness and abrasive wear resistance than cemented carbide, and in one embodiment the collar comprises steel. In one example, the collar is joined to the steel holder by means of brazing. The collar may provide support or protection for the cemented carbide support body.

[0018] With reference to the example pick tool variants shown in FIG 2 and FIG 4, a collar 130 encloses part of the protruding portion 119 of the support body 114. The collar 130 may enclose at least part of the protruding portion 119, and in one example the collar 130 may be shrink-fitted onto the protruding portion. The collar 130 may have lower hardness and abrasive wear resistance than cemented carbide and may comprise steel. In one embodiment, the collar 130 is joined to the steel holder 120 by means of brazing. The collar 130 may provide support or protection for the cemented carbide support body 114. The collar 130 may have various shapes, such as generally conical or generally rounded, and it may be substantially symmetrical or non-symmetrical. At least part of the outer surface of the collar 130 may be protected by means of a wear protective hard facing (not shown), for example a layer or sleeve comprising tungsten carbide. In particular, at least a part 127 of the outer surface of the steel holder 120 adjacent the mouth 128 of the bore 126, for example a surface region of the insert receiver member 124 extending up to 20 mm from the mouth 127, may be protected by means of a wear protective means (not shown). Examples of such means may be a layer or sleeve comprising tungsten carbide and / or grains of superhard material such as diamond or cBN. In one example embodiment, the collar 130 may have a protective hard facing disposed mainly or only on a side that would be exposed to greater wear in use.

[0019] With reference to FIG 3, a major portion of the insertion shank 118 is secured within the bore 126 of the steel holder 120 by means of a shrink fit. In this example, the insert receiver member 124 is provided with a seat 129 against which the insertion shank 118 of the support body 114 may be positioned. The seat 129 may be provided with a through-hole 1291 for facilitating extraction of the insert 112 or brazing the end of if the insertion shank 118 to the seat 129. For example, the through-hole 1291 of the seat 129 may have a diameter S of at least about 0.6 cm and at most about 2 cm. The insert receiver member 124 may have an outer dimension W, which may be about 4.8 cm. In general, the greater the diameter D of the insertion shank 118 of the support body 114, the thinner the wall of the insert receiver member 124 defining the bore 126 may need to be, since the external dimensions of the steel holder 120 may be constrained by the design of the pick apparatus (not shown) or the requirements of the pick operation. For example, the thicker the wall of the insert receiver member, the more robust the pick tool is likely to be in general, but as a trade-off, the energy requirement of the operation and wear of the steel are likely to be higher.

[0020] In the examples illustrated in FIG 1A, FIG 2 and FIG 4, the bore 126 may extend through the holder 120, providing a through-hole having a pair of opposite open ends (or mouths) 128. In these examples, least a portion of the insertion shank 118 may extend substantially through the insert receiver member 124.

[0021] In some examples of pick tools, the ratio of the volume of the cemented carbide support body to the volume of the superhard structure is at least about 30, at least about 40 or at least about 50. In some embodiments, the ratio of

the volume of the cemented carbide support body to the volume of the superhard structure is at most about 300, at most about 200 or at most about 150. In some embodiments, the volume of the superhard structure is at least about 200 mm^3 or at least about 300 mm^3. In some embodiments, the volume of the superhard structure is at most about 500 mm^3 or at most about 400 mm^3.

[0022] In some variants of pick holders, the length of the bore may be at least equal to its diameter. In one example, the diameter of the insertion shank and the bore may be about 2.5 cm and the length of the bore and the inserted portion of the insertion shank may be about 6 cm; and therefore the volume of the bore and the inserted portion of the insertion shank may be about 29 cm^3 and the area of contact between the internal peripheral surface of the bore and the insertion shank may be about 47 cm^2. In another example, the diameter of the insertion shank and the bore may be about 2 cm and the length of the bore and the inserted portion of the insertion shank may be about 8.3 cm; and therefore the volume of the bore and the inserted portion of the insertion shank may be about 26 cm^3 and the area of contact between the internal peripheral surface of the bore and the insertion shank may about 52 cm^2. In yet another example, the diameter of the insertion shank and the bore may be about 3.5 cm and the length of the bore and the inserted portion of the insertion shank may be about 6.9 cm; therefore the volume of the bore and the inserted portion of the insertion shank may be about 66 cm^3 and the area of contact between the internal peripheral surface of the bore and the insertion shank may be about 76 cm^2.

[0023] In some examples of pick tools, the insertion shank may not be substantially cylindrical and may exhibit any of various shapes when viewed in transverse cross section. For example, insertion shank may be generally elliptical, egg-shaped, wedge-shaped, square, rectangular, polygonal or semi-circular in shape; or the cross-sectional shape of the insertion shank may vary along its length.

[0024] In some examples, the shank may have a substantially cylindrical form and may have a diameter of at least about 15 mm, at least about 20 mm, at least about 25 mm or even at least 30 mm. In some embodiments, the shank has a diameter of at most about 20 mm, at most about 25 mm, at most about 30 mm, at most about 35 mm, or even at most about 40 mm. In some embodiments, the diameter of the shank varies by less than about 5 mm along its entire length, or the diameter is substantially invariant along its entire length.

[0025] The table below summarises certain example combinations of approximate dimensions that may be used with variants of pick tools disclosed herein. The dimensions relate to the length of the bore and the length of the inserted portion of the insertion shank, the mean diameter of the bore and of the inserted portion of the insertion shank, the minimum volume of the bore and the volume of the inserted portion of the insertion shank; and the area of contact between the peripheral internal wall of the bore and the corresponding surface of the inserted portion of the insertion shank.

	a	b	c	d	e	f	g
Bore length / depth L of insertion of shaft, cm	7.0	7.7	4.9	6.5	6	6.5	6.7
Bore / insertion shank diameter D, cm	2.0	2.0	2.5	2.5	2.5	3.0	3.5
Volume of bore / inserted portion of shaft, cm^3	22	24	24	32	29	46	64
Area of contact of bore and insertion shank, cm^2	44	48	38	51	47	61	73

[0026] In some embodiments, the support body comprises a cemented carbide material having fracture toughness of at most about 17 $MPa.m^{1/2}$, at most about 13 $MPa.m^{1/2}$, at most about 11 $MPa.m^{1/2}$ or even at most about 10 $MPa.m^{1/2}$. In some embodiments, the support body comprises a cemented carbide material having fracture toughness of at least about 8 $MPa.m^{1/2}$ or at least about 9 $MPa.m^{1/2}$. In some embodiments, the support body comprises a cemented carbide material having transverse rupture strength of at least about 2,100 MPa, at least about 2,300 MPa, at least about 2,700 MPa or even at least about 3,000 MPa.

[0027] In some embodiments, the support body comprises a cemented carbide material comprising grains of metal carbide having a mean size of at most about 8 microns or at most about 3 microns. In one embodiment, the support body comprises a cemented carbide material comprising grains of metal carbide having a mean size of at least about 0.1 microns.

[0028] In some embodiments, the support body comprises a cemented carbide material comprising at most about 13 weight percent, at most about 10 weight percent, at most about 7 weight percent, at most about 6 weight percent or even at most about 3 weight percent of metal binder material, such as cobalt (Co). In some embodiments, the support body comprises a cemented carbide material comprising at least about 1 weight percent, at least about 3 weight percent or at least about 6 weight percent of metal binder.

[0029] In some examples, the support body may consist essentially of, or consist of cemented carbide material.

[0030] In some examples of pick tools, the shrink-fitting of the components may be reversible and the steel holder and / or the insertion shank may be detached and reused, which may in effect reduce the cost of the pick tool and permit

extended use of the steel holder. This could be achieved by heating the steel holder in the vicinity of the bore to cause it to expand relative to the cemented carbide insertion shank, permitting the insertion shank to be removed from the bore.

[0031] A method for making a pick tool is provided, the method including providing a pick insert comprising a superhard tip joined to a cemented carbide support body at an end of the support body, the support body comprising a shank (insertion shank); providing a steel holder having a bore configured to accommodate the shank and comprising a shaft suitable for mounting the holder onto a tool carrier; and shrink-fitting the shank into the bore of the steel holder. The insertion shank may be shrink-fitted into the bore of the steel holder by heating at least the part of the steel holder including the bore to a temperature of about 350 degrees centigrade, inserting the shank into the bore of the heated holder and allowing the bore of the steel holder to cool and shrink, thereby holding the insertion shank in compression. In examples where the steel holder comprises a seat, the insertion shank may be inserted all the way into the bore so that the inserted end abuts the seat.

[0032] The interference between the insertion shank and the bore of the holder is the difference in size between them, which may be expressed as a percentage of the size. For example, in embodiments where the insertion shank (and the bore) has a generally circular cross section, the interference may be expressed as the difference in diameter as a percentage of the diameter. The dimension between the insertion shank and the bore would be expected to be selected depending at least on the diameter of the insertion shank, and may be at least about 0.002 percent of the diameter of the insertion shank. In one example, the diameter of the insertion shank is about 2.5 cm and the interference between the insertion shank and the bore is about 0.08 percent of the diameter of the insertion shank. The interference between the insertion shank and the bore may be at most about 0.3 percent of the diameter of the diameter of the insertion shank. If the interference is too great, the elastic limit of the steel material of the holder may be exceeded when the steel holder is shrink-fitted onto the onto the insertion shank, resulting in some plastic deformation of the steel adjacent the bore. If the interference is not high enough, then the shrink fit may not be sufficient for the insert to be held robustly by the holder in use.

[0033] In some versions of the method, the precise dimensions of the insertion shank and the bore may be selected such that after shrink-fitting the insertion shank into the bore, a region within the steel holder adjacent the bore is in a state of circumferential (or hoop) static tensile stress of at least about 300 MPa or at least about 350 MPa. In some embodiments, a region within the steel holder adjacent the bore is in a state of circumferential (or hoop) static tensile stress of at most about 450 MPa or at most about 500 MPa.

[0034] As a non-limiting example, a pick tool as disclosed may comprise a superhard tip as described in United States patent application publication numbers 2009/0051211; 2010/0065338; 2010/0065339 or 2010/0071964. With reference to FIG 7, an example of an insert for an embodiment of a pick tool as disclosed herein comprises a superhard tip 112 comprising a superhard structure 111 in the general form of a cap bonded to a cemented carbide substrate 113. The superhard tip 112 is joined to a frusto-conical portion 116 of a support body 114. The major part of the superhard structure 111 has a spherically blunted conical outer shape, having a rounded apex 1111 with a radius of curvature in a longitudinal plane, and a cone angle κ between an axis parallel to the longitudinal axis AL and conical portion 1112 of the outer surface of the superhard structure 111. The superhard structure 111 comprises a nose region 1113 and a skirt region 1114, which depends longitudinally and laterally away from the nose region 1113. In some versions of the example, the minimum longitudinal thickness of the skirt region 1114 may be at least about 1.3 mm or at least about 1.5 mm. In some versions of the example, the longitudinal thickness of the superhard cap 111 at the apex 1111 is at least about 4 mm or at least about 5 mm and at most about 7 mm or at most about 6 mm. In one version of the example, the longitudinal thickness of the superhard structure 111 at the apex 1111 is in the range from about 5.5 mm to 6 mm. In some versions of the example, the radius of curvature of the rounded apex 1111 is at least about 2 mm and at most about 3 mm. In some embodiments, the cone angle κ is at most 80 degrees or at most 70 degrees. In some versions of the example, the cone angle κ is at least 45 degrees or at least 50 degrees.

[0035] With reference to FIG 8, an example of an insert for an embodiment of a pick tool as disclosed comprises a superhard tip 112 comprising a superhard structure 111 bonded to a cemented carbide substrate 113. The superhard tip 112 is joined to a frusto-conical portion 116 of a support body 114. The radius of curvature R of the spherically blunted cone nose 1111 is about 2.25 mm and the cone angle κ is about 42 degrees.

[0036] With reference to FIG 9, a part of an example of a steel holder 120 for a pick tool as disclosed is attached to a base block 200 (carrier body) by means of an interlocking fastener mechanism 210 in which the shaft 122 of the steel holder 120 is locked within a bore formed within the carrier body 200. Part of the insertion shank 118 of an example pick tool is also shown. The shaft 122 may be releasibly connectable to the base block 200 welded or otherwise joined to the drum. The base block 200 and holder 120, more specifically the shaft 122, may be configured to permit releasable inter-engagement of the steel holder 120 and base block. The shaft 122 may be configured to interengage non-rotationally with a base block, and may be suitable for use with tool carriers disclosed in German patents numbers DE 101 61 713 B4 and DE 10 2004 057 302 A1, for example. The tool carrier, such as a base block, may be welded onto a component of a drive apparatus, such as a drum, for driving the superhard pick tool. FIG 10 shows a side view of a pick tool 100 for a different tool carrier than the example illustrated in FIG 9, the shaft 122 of the steel holder 120 being configured

differently. The pick tool 100 comprises an insert 110 with a superhard tip 112 joined to a portion 116 of a support body.

[0037] A method is provided for attaching a superhard pick tool to a tool carrier joined to a component for a drive apparatus, the method including joining a pick insert to a steel holder to form a pick tool, the steel holder comprising a shaft configured operable to attach the steel holder onto the tool carrier, the tool carrier comprising an engagement means configured to receive the shaft of the steel holder; and then attaching the superhard pick tool to the tool carrier. In one embodiment of the method, the tool carrier is welded onto a component of a drive apparatus, such as a drum, for driving the superhard pick tool.

[0038] In operation, the pick tool may be driven forward by a drive apparatus on which it is mounted, against a structure to be degraded and with the superhard tip at the leading end. For example, a plurality of pick tools may be mounted on a drum for asphalt degradation, as may be used to break up a road for resurfacing. The drum is connected to a vehicle and caused to rotate. As the drum is brought into proximity of the road surface, the pick tools are repeatedly impacted into the road as the drum rotates and the leading superhard tips thus break up the asphalt. A similar approach may be used to break up coal formations in coal mining.

[0039] With reference to FIG 11, the example pick tool illustrated in FIG 5 is shown schematically in a worn condition, in which a part 1201 of the steel holder 120 has been worn away in use to expose part of the surface of the insertion shaft 118 to which that part 1201 had been adjacent.

[0040] Although the example pick tool illustrated in FIG 11 is shown in a worn condition, some example pick tools may be provided with a cut-away portion 1201 prior to use. In this configuration, the insertion shank 118 is only partially surrounded by the bore 126 at a range of axial positions R along the length L of the insertion shank 118 (i.e. within the range R of axial positions, the insertion shank 118 is not entirely surrounded or enclosed by the steel holder 120).

[0041] When designing pick tools for highly abrasive operations such as asphalt, coal or potash degradation, it would be desirable to achieve a balance between the cost of the tool and its resistance to abrasive wear and fracture in use. Superhard materials such as synthetic diamond tend to be much more abrasion resistant but also much more costly than cemented carbide materials, which in turn tend to be much more abrasion resistant but much more costly than steel materials. One approach may be to minimise the amounts of diamond-containing and cemented carbide materials in the tool according to their relative costs and to configure components comprising these materials so as to achieve an acceptable tool life.

[0042] A cemented carbide support body having a relatively large volume of at least about 6 cm^3, at least about 10 cm^3 or at least about 15 cm^3 arranged behind the PCD tip in the direction of movement in use and extending relatively deeply into the steel holder seems to improve the working life of the tool to a surprising degree that is likely to justify additional cost of the carbide material.

[0043] While wishing not to be bound by a particular theory, the high density and relatively high mass of the carbide insertion shank, as well as its high stiffness may provide substantially improved support for the PCD tip by tending to resist deformation or bending of the tip when it is thrust against the structure being broken. The carbide insertion shank may be viewed as forming a spine-like structure extending relatively deeply into the steel holder. The elongate carbide insertion shank may also function as a stiffening spine extending into the steel holder and making it more robust.

[0044] It has been found that a superhard-tipped pick tool having the combination of a relatively large insertion shank and a shrink-fit connection of the insertion shank within the steel holder exhibits a extended working life in an asphalt degradation operation. If the volume of the inserted portion of the insertion shank is less than about 6 cm^3, less than about 15 cm^3, or even less than about 15 cm^3, there may be insufficient support for the superhard tip in operation; and if the interface area between the insertion shank and the bore is less than about 20 cm^2, the carbide support body may not be sufficiently robustly gripped by the steel holder into which it is shrink-fitted. If the diameter of the insertion shank is less than about 2 cm, it may not provide adequate support and robustness for the tool, which may break in particularly harsh operations, and / or the steel holder may wear excessively. If the length of the support body is less than about 4 cm, it may not provide sufficient support for the steel holder and / or the PCD tip, which may fracture prematurely.

[0045] In pick tools disclosed herein, in which the volume of the insertion shank and the bore as well as the area of contact between them are relatively high, shrink-fitting the insertion shank into the steel holder may have benefits over press-fitting. Considerably less force would be required to shrink fit the relatively large insertion shank than would be needed to press it into the bore. This may have the aspect that the insert can be held securely enough within the bore of the steel holder without the elastic limit of the steel material being substantially exceeded, thereby reducing plastic deformation of the steel holder. While wishing not to be bound by a particular theory, this may have the aspect that a region of the steel holder adjacent the bore may suffer less deformation and axial stress arising from the pressing force and friction between the insertion shank and the bore surface. The insertion shank may also have reduced residual stress components, which may result in greater resistance to fracture in use. As a trade-off, shrink-fitting may require somewhat more sophisticated equipment and procedure.

[0046] Shrink-fitting may permit reduced reliance on brazing to join the insert to the steel holder. This may be particularly useful where the superhard tip comprises synthetic or natural diamond, for example polycrystalline diamond, because of reduced thermal degradation of the tip as a result of brazing, which requires the use of high temperature (diamond,

particularly in PCD form, tends to have a relatively low thermal stability and to convert into graphite at high temperatures). Additionally, brazing may need to be carried out in a special furnace and a special atmosphere, which may not be required for shrink fitting.

[0047] Example pick tools are provided. The following clauses are offered as further descriptions of the disclosed pick tools.

1. A superhard pick tool (for brevity, also referred to as a pick tool) comprising an insert and a steel holder for the insert, the insert comprising a superhard tip joined to a cemented carbide support body having an insertion shank; the steel holder comprising a shaft for connection to a tool carrier and the steel holder provided with a bore configured for receiving the insertion shank; the volume of the cemented carbide support body being at least 6 cm^3, at least 10 cm^3 or at least 15 cm^3.

2. A pick tool comprising an insert and a steel holder for the insert, the insert comprising a superhard tip joined to a cemented carbide support body having an insertion shank; the steel holder comprising a shaft for connection to a tool carrier and the steel holder provided with a bore configured for receiving the insertion shank; an inserted portion of the insertion shank being secured in the bore; the inserted portion having an axial length and a mean diameter; the axial length being no less than the mean diameter.

3. The pick tool of clause 2, in which the axial length of the inserted portion is at least about 4 cm and at most about 8.5 cm.

4. The pick tool of clause 2 or clause 3, in which the mean diameter of the inserted portion is at least about 2 cm and at most about 3.5 cm.

[0048] A non-limiting example of a pick tool is described in more detail below.

[0049] A superhard tip comprising PCD integrally attached to a cobalt-cemented tungsten carbide (Co-WC) substrate as illustrated in FIG 8 was brazed to a support body. The PCD structure had a volume of about 382 mm^3. The support body was formed of Co-WC comprising about 13 weight percent Co and having a fracture toughness of about 16.3 $MPa.m^{1/2}$ and transverse rupture strength (TRS) of about 2,200 MPa. In another example, the support body was formed of Co-WC comprising about 8 weight percent Co and having a fracture toughness of about 14.6 $MPa.m^{1/2}$ and transverse rupture strength (TRS) of at about 2,800 MPa. The support body comprised a substantially cylindrical insertion shank and a frusto-conical end portion to which the PCD tip was brazed. The insertion shank had a surface finish in the range from about 0.04 microns Ra to about 0.5 microns Ra. The diameter of the insertion shank was 2.5 cm and its length was 6.7 cm.

[0050] A steel holder formed of 42Cr-Mo4 grade of steel and comprising an insertion receiver member with a bore was provided, the diameter of the bore being about 2.5 cm and its length being about 6.7 cm. An annular seat was provided at the bottom end of the bore. The insertion shank was shrink-fitted into the bore of the steel holder by heating the insertion receiver member of the steel holder in air to a temperature of about 350 degrees centigrade, inserting the shaft into the bore of the heated holder and allowing the insertion receiver member to shrink onto the insertion shank, thereby holding it in compression. The insertion shank was inserted all the way into the bore so that the inserted end abutted the annular seat. The volume of the inserted portion of the insertion shank was therefore about 33 cm^3 and the interface area between the insertion shank and the peripheral internal wall of the bore was about 53 cm^2. The interference between the insertion shank and the bore was about 0.02 mm and the static tensile hoop stress of the region of the steel holder adjacent the bore was estimated to be in the range from about 300 MPa to about 500 MPa.

[0051] Pick tools according to the present example have been tested in road reconditioning operations, in which they were mounted onto drums and used to degrade road asphalt. These were still in working condition after degrading at least about 20 km of road.

[0052] Various example embodiments of pick tools and methods for assembling and connecting them have been described above. Those skilled in the art will understand that changes and modifications may be made to those examples without departing from the scope of the claimed invention.

Claims

1. A pick tool (100) comprising an insert (110) mounted in a steel holder (120), the insert (110) comprising a superhard tip (112) joined to a cemented carbide support body (114) at an end of the support body (114), the support body (114) comprising an insertion shank (118); the steel holder (120) having a bore (126) configured to accommodate the insertion shank (118) and comprising a shaft (122) configured for mounting the steel holder (120) onto a tool carrier; **characterized by** the cemented carbide support body (114) having a volume of at least 15 cubic centimetres (cm^3) and comprising cemented carbide material having fracture toughness of at least 8 megapascals times square root metre ($MPa.m^{1/2}$) and at most 17 $MPa.m^{1/2}$; in which an inserted portion of the insertion shank (118) is secured

in the bore (126), the inserted portion having an axial length of at least 4 centimetres (cm) and at most 8.5 cm, and a mean diameter of at least 2 cm and at most 3.5 cm.

2. A pick tool as claimed in claim 1, in which the insertion shank (118) is shrink-fitted within the bore (126).

3. A pick tool as claimed in claim 1 or claim 2, in which the interference between the insertion shank (118) and the bore (126) is at least 0.002 per cent of the diameter of the insertion shank (118) and at most 0.3 per cent of the diameter of the insertion shank (118).

4. A pick tool as claimed in any of the preceding claims, in which the support body (114) comprises cemented carbide material comprising at most 10 weight per cent metal binder material.

5. A pick tool as claimed in any of the preceding claims, in which the support body (114) comprises cemented carbide material comprising grains of metal carbide having a mean size of at most 8 microns.

6. A pick tool as claimed in any one of the preceding claims, in which the ratio of the volume of the cemented carbide support body (114) to the volume of the superhard tip (112) is at least 30 and at most 300, and the volume of the superhard tip is at least 200 mm^3 and at most 500 mm^3.

7. A pick tool as claimed in any one of the preceding claims, in which a surface area of the insertion shank (118) abuts a corresponding inner side surface area of the bore (126), the surface area being at least 20 cm^2.

8. A pick tool as claimed in any one of the preceding claims, in which a portion of the insertion shank (118)is only partly surrounded by the bore (126) of the steel holder (120).

9. A pick tool as claimed in any one of the preceding claims, in which the steel holder (120) is provided with a seat for supporting an end of the cemented carbide support body(114), and the bore (126) communicates with the outside of the steel holder (120) through a passage provided through or adjacent the seat.

10. A pick tool as claimed in any one of the preceding claims, in which the superhard tip (112) comprises natural or synthetic diamond material or cBN-material.

11. A pick tool as claimed in any one of the preceding claims, in which the superhard tip (112) comprises a polycrystalline diamond (PCD) structure bonded to a cemented carbide substrate.

12. A pick tool as claimed in any one of the preceding claims, in which the superhard tip (112) comprises diamond grains dispersed in a cemented carbide matrix.

13. A pick tool as claimed in any one of the preceding claims, for pavement or road degradation, or for coal or potash mining.

14. A method of making a pick tool (100) as claimed in any one of the preceding claims, the method including providing an insert (110) and a steel holder (120) for the insert (110), the insert (110) comprising a superhard tip (112) joined to a cemented carbide support body (114) having an insertion shank (118); the steel holder (120) comprising a shaft (122) for connection to a tool carrier and the steel holder (120) provided with a bore for receiving the insertion shank (118); **characterized by** the insertion shank (118) having a volume of at least 10 cm^3; and shrink fitting the insertion shank (118) into the bore of the steel holder (120); in which the cemented carbide support body (114) has a volume of at least 15 cubic centimetres (cm^3) and comprises cemented carbide material having fracture toughness of at least 8 megapascals times square root metre ($MPa.m^{1/2}$) and at most 17 $MPa.m^{1/2}$; and in which an inserted portion of the insertion shank (118) is secured in the bore (126), the inserted portion having an axial length of at least 4 centimetres (cm) and at most 8.5 cm, and a mean diameter of at least 2 cm and at most 3.5 cm.

15. A method of disassembling a pick tool as claimed in any one of claims 1 to 13, the method including heating the steel holder (120) to expand the bore (126) and withdrawing the insertion shank (118) from the bore (126).

Patentansprüche

1. Meißelwerkzeug (100), das einen Einsatz (110) aufweist, der in einer Stahlhalterung (120) montiert ist, wobei der Einsatz (110) eine superharte Spitze (112) aufweist, die mit einem Hartmetallhaltekörper (114) an einem Ende des Haltekörpers (114) verbunden ist, wobei der Haltekörper (114) einen Einsatzschaft (118) aufweist; wobei die Stahlhalterung (120) eine Bohrung (126) hat, die konfiguriert ist, um den Einsatzschaft (118) aufzunehmen, und einen Schaft (122) aufweist, der konfiguriert ist, um die Stahlhalterung (120) auf einen Werkzeugträger zu montieren; **dadurch gekennzeichnet, dass** der Hartmetallhaltekörper (114) ein Volumen von mindestens 15 Kubikzentimetern (cm^3) hat und Hartmetallmaterial mit einer Bruchzähigkeit von mindestens 8 Megapascal-Quadratwurzelmeter ($MPa \cdot m^{1/2}$) und höchstens 17 $MPa \cdot m^{1/2}$ aufweist; wobei ein eingesetzter Abschnitt des Einsatzschafts (118) in der Bohrung (126) befestigt ist, wobei der eingesetzte Abschnitt eine axiale Länge von mindestens 4 Zentimetern (cm) und höchstens 8,5 cm und einen mittleren Durchmesser von mindestens 2 cm und höchstens 3,5 cm hat.

2. Meißelwerkzeug nach Anspruch 1, wobei der Einsatzschaft (118) in die Bohrung (126) schrumpfgepasst ist.

3. Meißelwerkzeug nach Anspruch 1 oder Anspruch 2, wobei das Übermaß zwischen dem Einsatzschaft (118) und der Bohrung (126) mindestens 0,002 Prozent des Durchmessers des Einsatzschafts (118) und höchstens 0,3 Prozent des Durchmessers des Einsatzschafts (118) ist.

4. Meißelwerkzeug nach einem der vorhergehenden Ansprüche, wobei der Haltekörper (114) Hartmetallmaterial aufweist, das höchstens 10 Gewichtsprozent Metallbindermaterial aufweist.

5. Meißelwerkzeug nach einem der vorhergehenden Ansprüche, wobei der Haltekörper (114) Hartmetallmaterial aufweist, das Körner aus Metallkarbid mit einer mittleren Größe von höchstens 8 Mikrometer aufweist.

6. Meißelwerkzeug nach einem der vorhergehenden Ansprüche, wobei das Verhältnis des Volumens des Hartmetallhaltekörpers (114) zu dem Volumen der superharten Spitze (112) mindestens 30 und höchstens 300 ist und das Volumen der superharten Spitze mindestens 200 mm^3 und höchstens 500 mm^3 ist.

7. Meißelwerkzeug nach einem der vorhergehenden Ansprüche, wobei ein Oberflächenbereich des Einsatzschafts (118) an einem korrespondierenden Innenseitenoberflächenbereich der Bohrung (126) anliegt, wobei der Oberflächenbereich mindestens 20 cm^2 hat.

8. Meißelwerkzeug nach einem der vorhergehenden Ansprüche, wobei ein Abschnitt des Einsatzschafts (118) nur teilweise von der Bohrung (126) der Stahlhalterung (120) umgeben ist.

9. Meißelwerkzeug nach einem der vorhergehenden Ansprüche, wobei die Stahlhalterung (120) mit einem Sitz zum Halten eines Endes des Hartmetallhaltekörpers (114) versehen ist und die Bohrung (126) durch einen Durchgang, der durch den Sitz oder benachbart zu ihm bereitgestellt ist, mit dem Äußeren der Stahlhalterung (120) in Verbindung steht.

10. Meißelwerkzeug nach einem der vorhergehenden Ansprüche, wobei die superharte Spitze (112) natürliches oder synthetisches Diamantmaterial oder cBN-Material aufweist.

11. Meißelwerkzeug nach einem der vorhergehenden Ansprüche, wobei die superharte Spitze (112) eine polykristalline Diamant- (PCD-) Struktur aufweist, die mit einem Hartmetallsubstrat verbunden ist.

12. Meißelwerkzeug nach einem der vorhergehenden Ansprüche, wobei die superharte Spitze (112) Diamantkörner aufweist, die in einer Hartmetallmatrix verteilt sind.

13. Meißelwerkzeug nach einem der vorhergehenden Ansprüche für Pflaster- oder Straßenabtragung oder für Kohle- oder Kalibergbau.

14. Verfahren zur Herstellung eines Meißelwerkzeugs (100) nach einem der vorhergehenden Ansprüche, wobei das Verfahren aufweist: Bereitstellen eines Einsatzes (110) und einer Stahlhalterung (120) für den Einsatz (110), wobei der Einsatz (110) eine superharte Spitze (112) aufweist, die mit einem Hartmetallhaltekörper (114) mit einem Einsatzschaft (118) verbunden ist; wobei die Stahlhalterung (120) einen Schaft (122) für die Verbindung mit einem Werkzeugträger aufweist und die Stahlhalterung (120) mit einer Bohrung zur Aufnahme des Einsatzschafts (118)

versehen ist; **dadurch gekennzeichnet, dass** der Einsatzschaft (118) ein Volumen von mindestens 10 cm^3 hat; und Schrumpfpassen des Einsatzschafts (118) in die Bohrung der Stahlhalterung (120); wobei der Hartmetallhaltekörper (114) ein Volumen von mindestens 15 Kubikzentimetern (cm^3) hat und Hartmetallmaterial mit einer Bruchzähigkeit von mindestens 8 Megapascal-Quadratwurzelmeter ($MPa \cdot m^{1/2}$) und höchstens 17 $MPa \cdot m^{1/2}$ aufweist; und wobei ein eingesetzter Abschnitt des Einsatzschafts (118) in der Bohrung (126) befestigt ist, wobei der eingesetzte Abschnitt eine axiale Länge von mindestens 4 Zentimetern (cm) und höchstens 8,5 cm und einen mittleren Durchmesser von mindestens 2 cm und höchstens 3,5 cm hat.

15. Verfahren zum Demontieren eines Meißelwerkzeugs nach einem der Ansprüche 1 bis 13, wobei das Verfahren ein Heizen der Stahlhalterung (120) zum Aufweiten der Bohrung (126) und ein Herausnehmen des Einsatzschafts (118) aus der Bohrung (126) aufweist.

Revendications

1. Outil de piochage (100) comprenant un insert (110) monté dans un support en acier (120), l'insert (110) comprenant une pointe super dure (112) jointe à un corps de support en carbure cémenté (114) au niveau d'une extrémité du corps de support (114), le corps de support (114) comprenant une tige d'insertion (118) ; le support en acier (120) ayant un alésage (126) configuré pour recevoir la tige d'insertion (118) et comprenant un arbre (122) configuré pour monter le support en acier (120) sur un porte-outil ; **caractérisé en ce que** le corps de support en carbure cémenté (114) a un volume d'au moins 15 centimètres cubes (cm^3) et comprend un matériau de carbure cémenté ayant une ténacité à la rupture d'au moins 8 mégapascals fois racine carrée de mètre ($MPa.m^{1/2}$) et d'au plus 17 $MPa.m^{1/2}$; où une partie insérée de la tige d'insertion (118) est fixée dans l'alésage (126), la partie insérée ayant une longueur axiale d'au moins 4 centimètres (cm) et d'au plus 8,5 cm, et un diamètre moyen d'au moins 2 cm et d'au plus 3,5 cm.

2. Outil de piochage tel que revendiqué dans la revendication 1, dans lequel la tige d'insertion (118) est ajustée par contraction dans l'alésage (126).

3. Outil de piochage tel que revendiqué dans la revendication 1 ou 2, dans lequel l'interférence entre la tige d'insertion (118) et l'alésage (126) est d'au moins 0,002 pour cent du diamètre de la tige d'insertion (118) et d'au plus 0,3 pour cent du diamètre de la tige d'insertion (118).

4. Outil de piochage tel que revendiqué dans l'une des revendications précédentes, dans lequel le corps de support (114) comprend un matériau de carbure cémenté comprenant au plus 10 % en poids de matériau liant métallique.

5. Outil de piochage tel que revendiqué dans l'une des revendications précédentes, dans lequel le corps de support (114) comprend un matériau de carbure cémenté comprenant des grains de carbure métallique ayant une taille moyenne d'au plus 8 microns.

6. Outil de piochage tel que revendiqué dans l'une quelconque des revendications précédentes, dans lequel le rapport du volume du corps de support en carbure cémenté (114) sur le volume de la pointe super dure (112) est d'au moins 30 et d'au plus 300, et le volume de la pointe super dure est d'au moins 200 mm^3 et d'au plus 500 mm^3.

7. Outil de piochage tel que revendiqué dans l'une quelconque des revendications précédentes, dans lequel une surface de la tige d'insertion (118) vient en butée contre une surface latérale interne correspondante de l'alésage (126), la surface étant d'au moins 20 cm^2.

8. Outil de piochage tel que revendiqué dans l'une quelconque des revendications précédentes, dans lequel une partie de la tige d'insertion (118) n'est que partiellement entourée par l'alésage (126) du support en acier (120).

9. Outil de piochage tel que revendiqué dans l'une quelconque des revendications précédentes, dans lequel le support en acier (120) est muni d'un siège pour supporter une extrémité du corps de support en carbure cémenté (114), et l'alésage (126) communique avec la partie externe du support en acier (120) à travers un passage prévu à travers le siège ou à proximité de celui-ci.

10. Outil de piochage tel que revendiqué dans l'une quelconque des revendications précédentes, dans lequel la pointe super dure (112) comprend un matériau de diamant naturel ou synthétique ou un matériau de nitrure de bore cubique cBN.

11. Outil de piochage tel que revendiqué dans l'une quelconque des revendications précédentes, dans lequel la pointe super dure (112) comprend une structure de diamant polycristallin (PCD) liée à un substrat de carbure cémenté.

12. Outil de piochage tel que revendiqué dans l'une quelconque des revendications précédentes, dans lequel la pointe super dure (112) comprend des grains de diamant dispersés dans une matrice de carbure cémenté.

13. Outil de piochage tel que revendiqué dans l'une quelconque des revendications précédentes, pour la dégradation de routes ou de chaussées, ou pour l'extraction de charbon ou de potasse.

14. Procédé de fabrication d'un outil de piochage (100) tel que revendiqué dans l'une quelconque des revendications précédentes, le procédé comportant le fait de fournir un insert (110) et un support en acier (120) pour l'insert (110), l'insert (110) comprenant une pointe super dure (112) jointe à un corps de support en carbure cémenté (114) ayant une tige d'insertion (118) ; le support en acier (120) comprenant un arbre (122) destiné à être relié à un porte-outil et le support en acier (120) étant muni d'un alésage pour recevoir la tige d'insertion (118) ; **caractérisé en ce que** la tige d'insertion (118) a un volume d'au moins 10 cm^3 ; et d'ajuster par contraction la tige d'insertion (118) dans l'alésage du support en acier (120) ; où le corps de support en carbure cémenté (114) a un volume d'au moins 15 centimètres cubes (cm^3) et comprend un matériau de carbure cémenté ayant une ténacité à la rupture d'au moins 8 mégapascals fois racine carrée de mètre ($MPa.m^{1/2}$) et d'au plus 17 $MPa.m^{1/2}$; et où une partie insérée de la tige d'insertion (118) est fixée dans l'alésage (126), la partie insérée ayant une longueur axiale d'au moins 4 centimètres (cm) et d'au plus 8,5 cm, et un diamètre moyen d'au moins 2 cm et d'au plus 3,5 cm.

15. Procédé de désassemblage d'un outil de piochage tel que revendiqué dans l'une quelconque des revendications 1 à 13, le procédé comportant le chauffage du support en acier (120) pour dilater l'alésage (126) et le retrait de la tige d'insertion (118) de l'alésage (126).

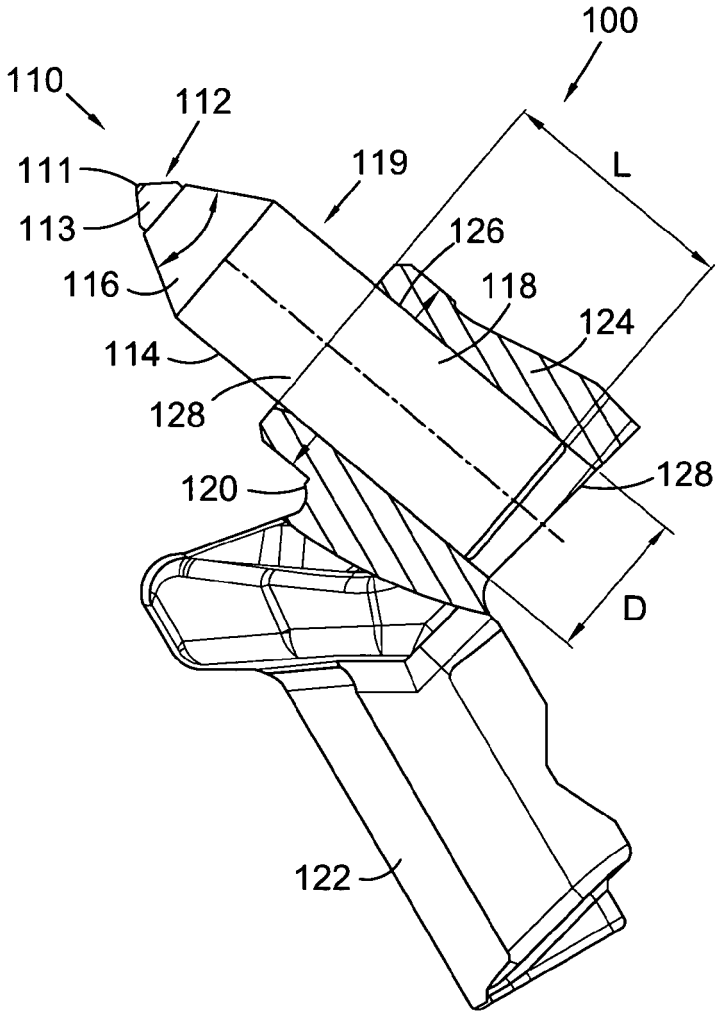


Fig. 1A

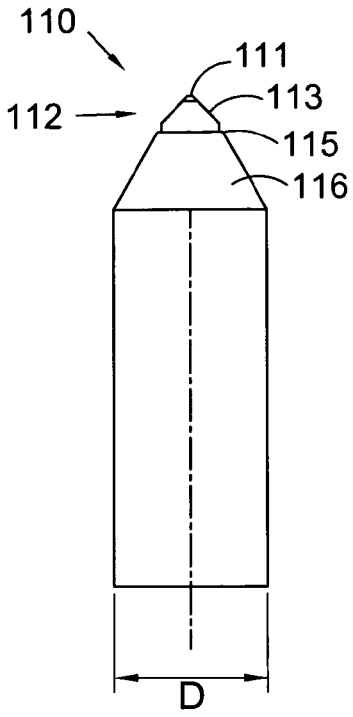


Fig. 1B

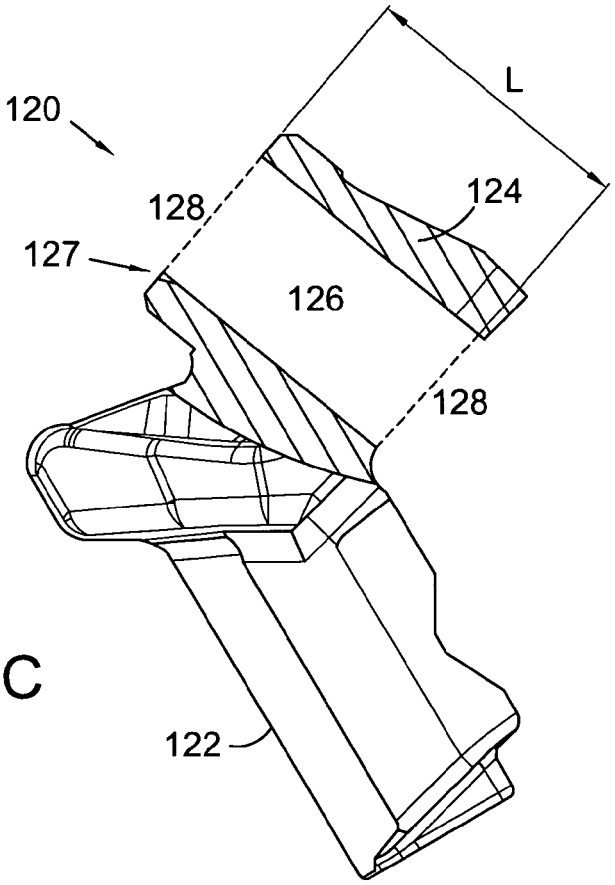


Fig. 1C

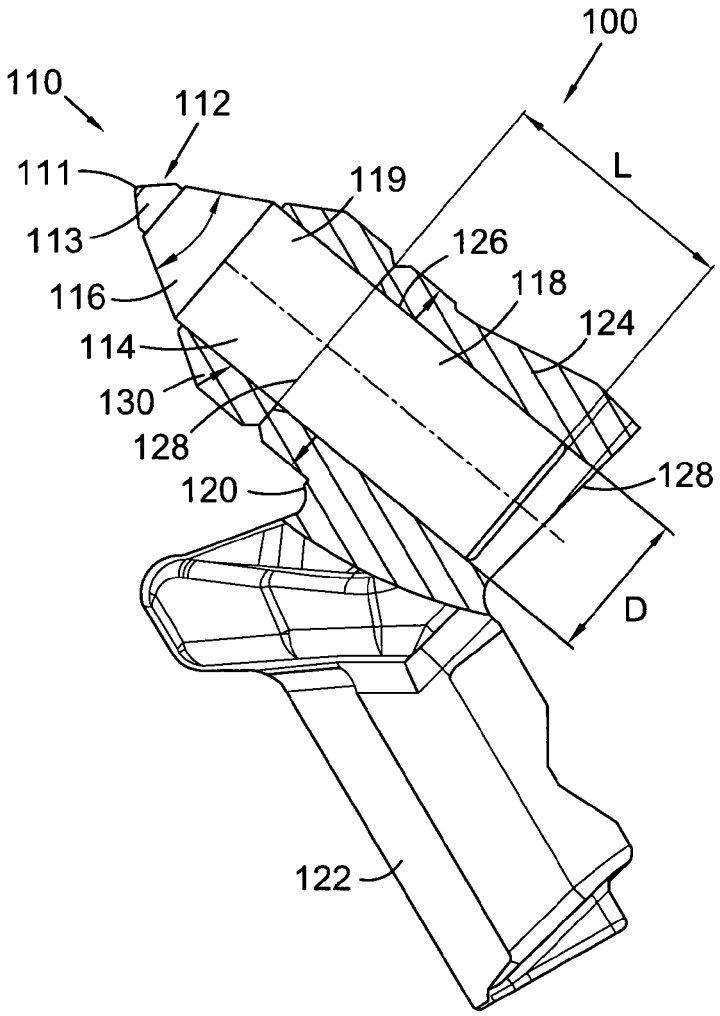

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Fig. 2

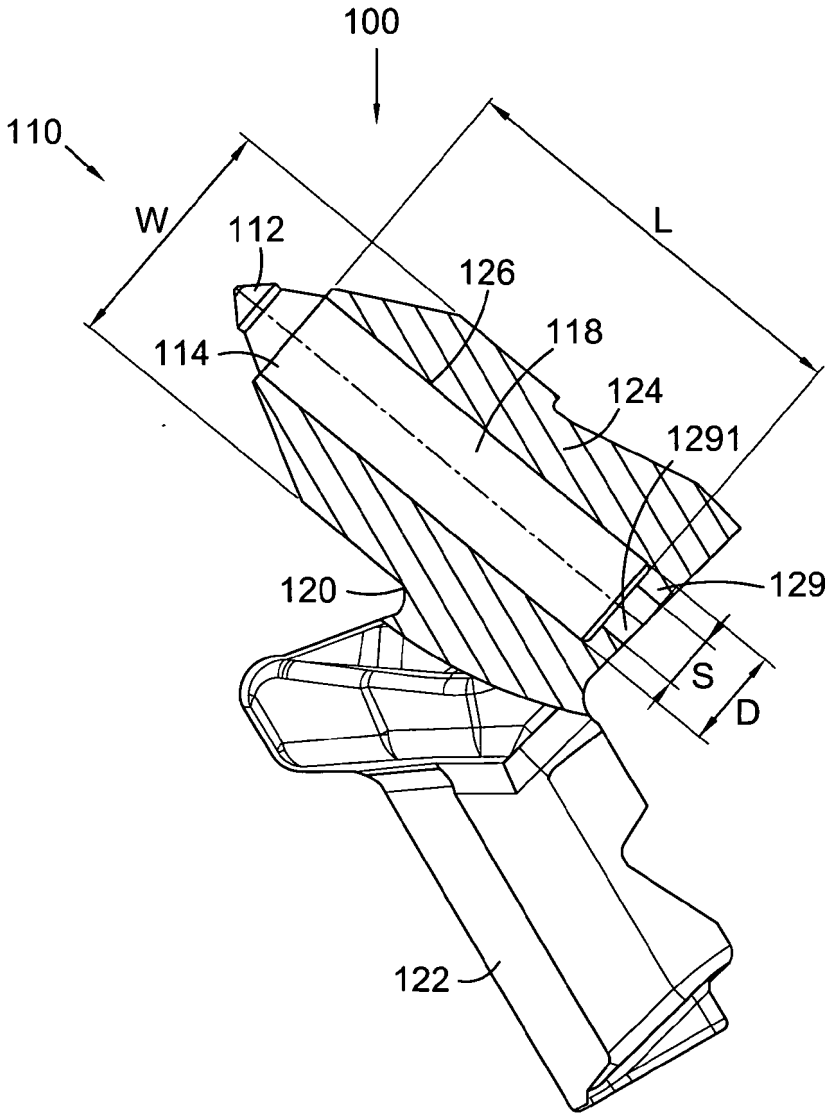


Fig. 3

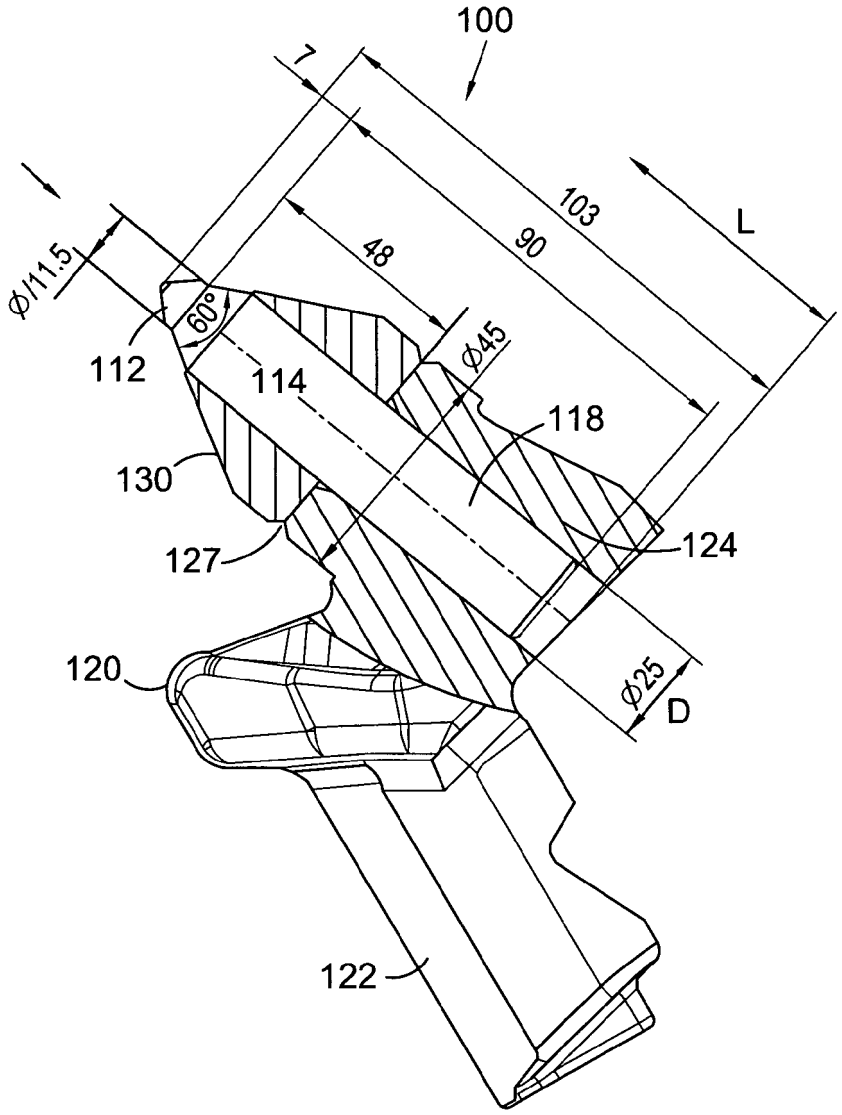


Fig. 4

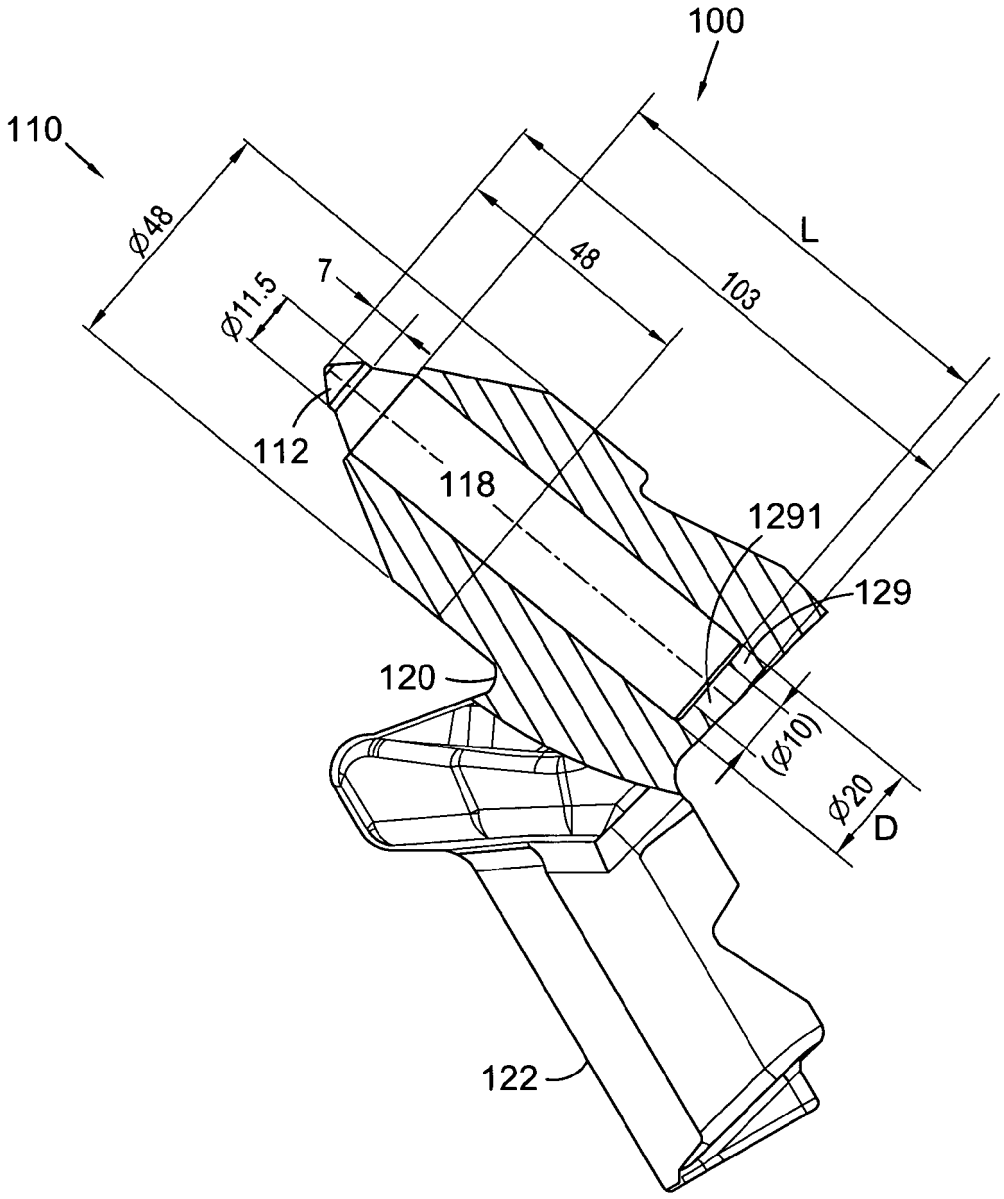


Fig. 5

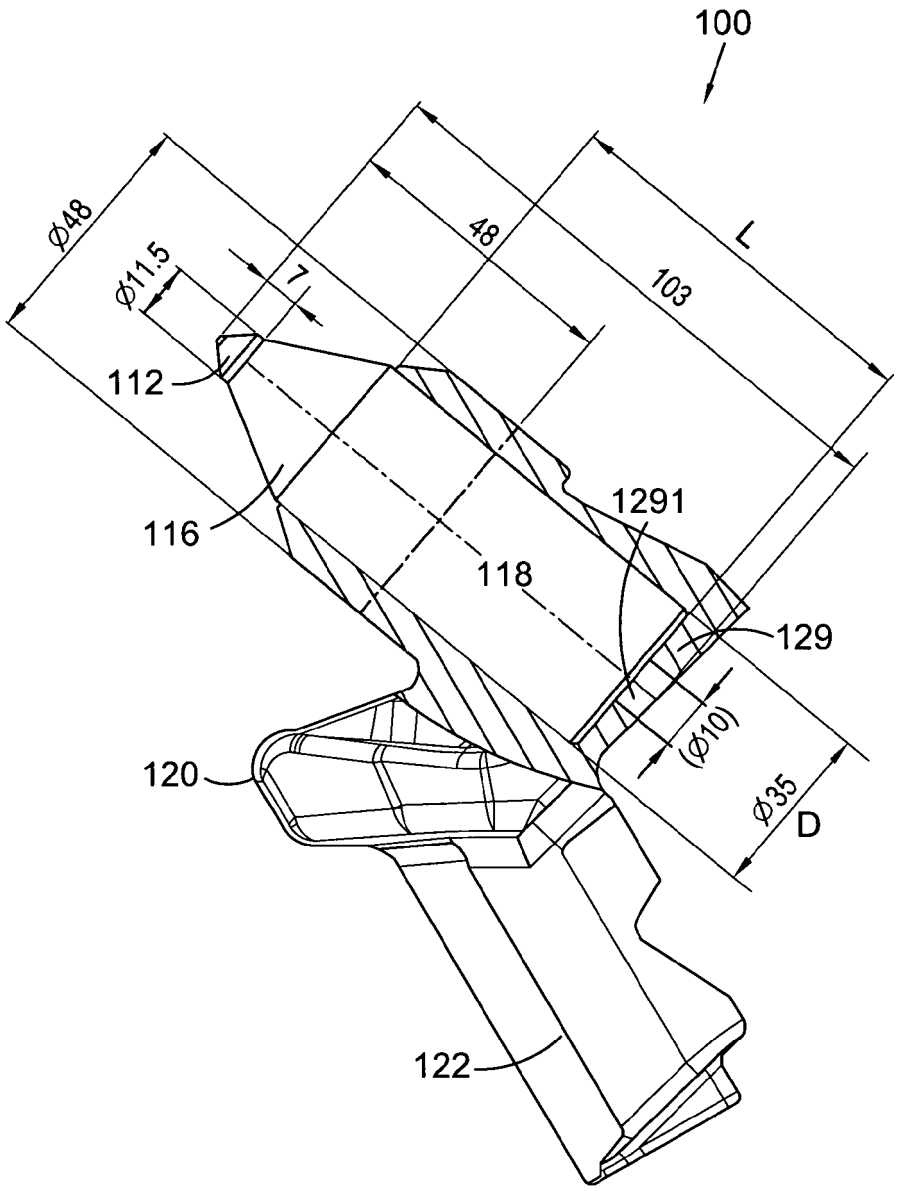


Fig. 6

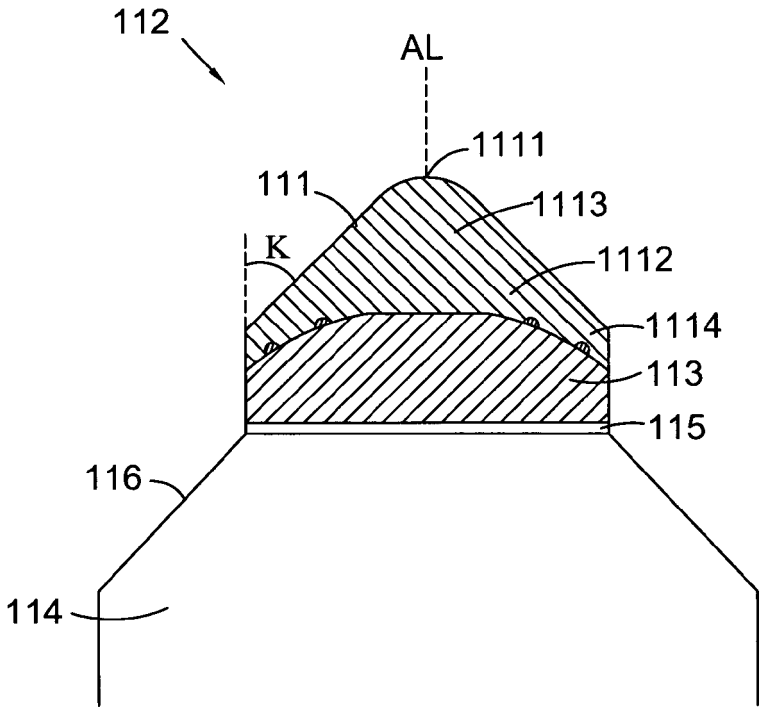

112
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Fig. 7

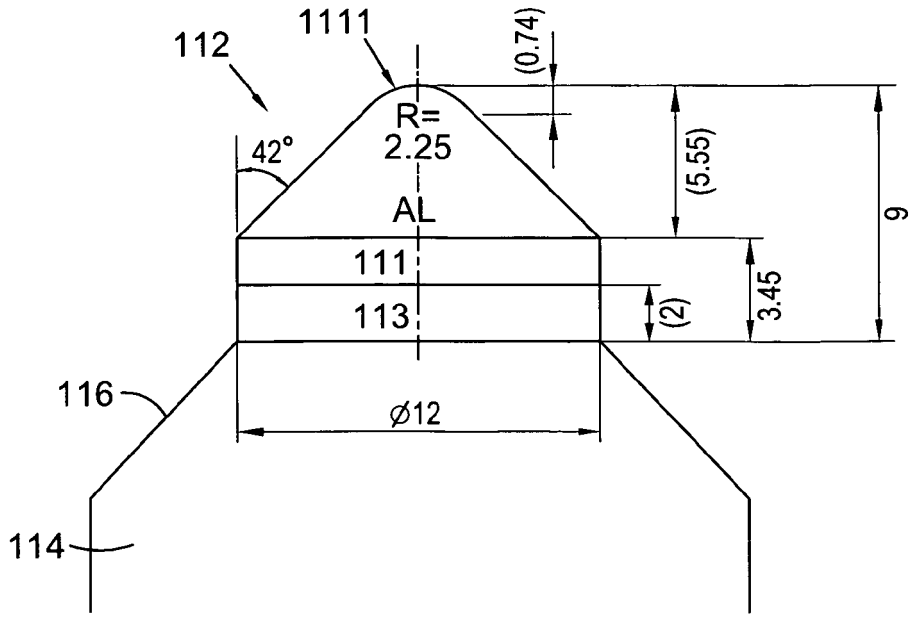

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Fig. 8

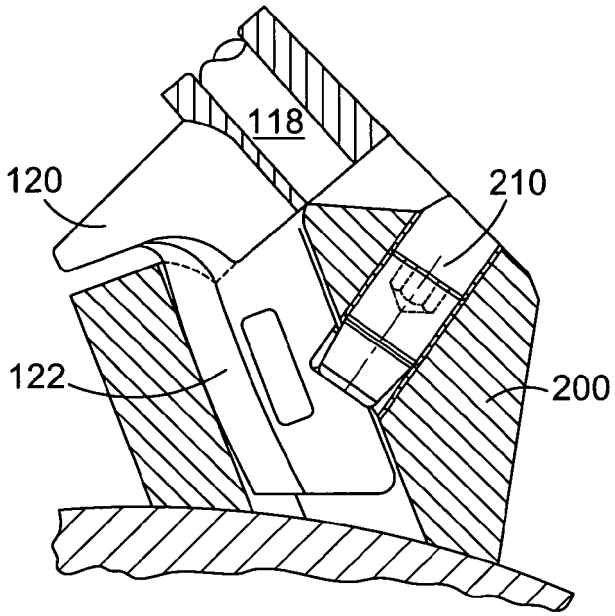


Fig. 9

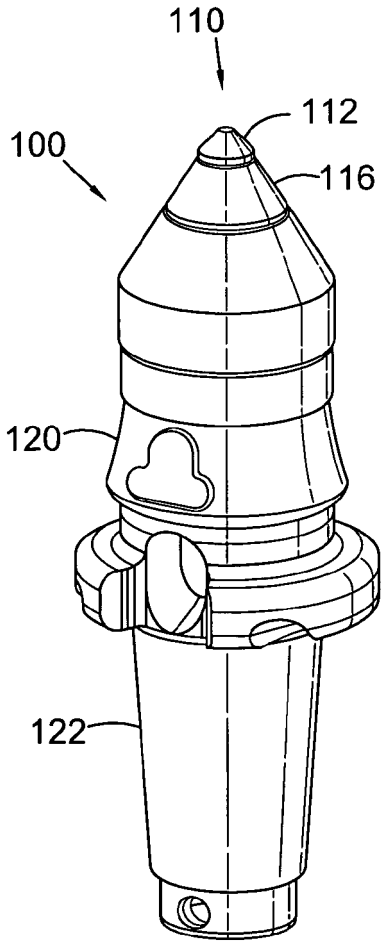


Fig. 10

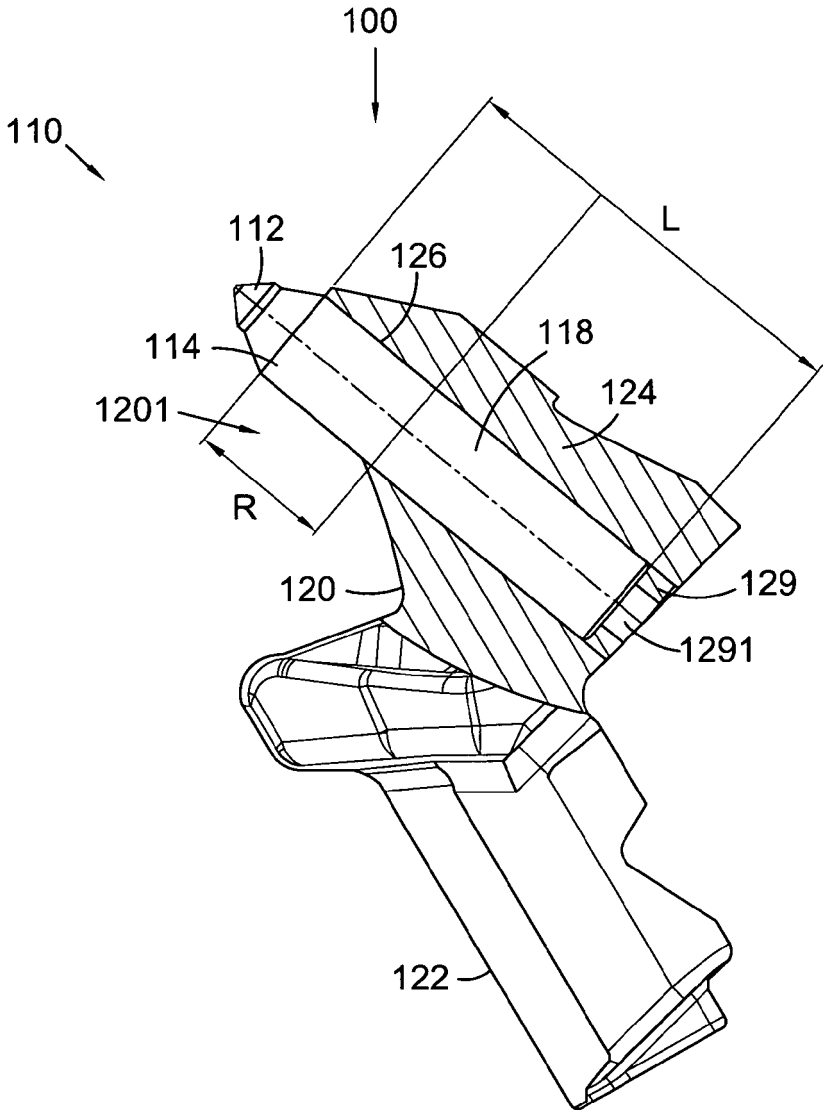


Fig. 11

REFERENCES CITED IN THE DESCRIPTION

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