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(54) MINING TOOL WITH ASYMMETRIC CUTTING INSERT

(57) A percussive drill bit for drilling a bore hole comprising a bit body having a front face surrounded by a gauge and a longitudinal bit central axis; and a plurality of gauge inserts embedded in the gauge; wherein the gauge inserts have a longitudinal insert central axis, a cylindrical shank portion; a working tip portion; an radially internal side located on the side nearest to the bit central axis and an radially external side on the side further from the bit central axis; characterized in that: the working tip portion of the gauge inserts have an asymmetric geometry wherein the volume of material on the radially external side is greater than the volume of material on the radially internal side.

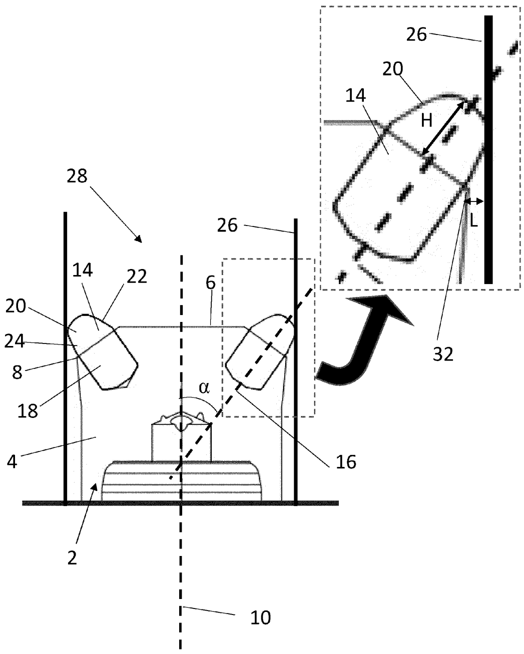

Fig 1

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Description

FIELD OF INVENTION

[0001] The present invention relates to an asymmetrically shaped cemented carbide inserts for percussive drilling applications.

BACKGROUND

[0002] Cemented carbide inserts are used in percussive drill bits. Front inserts are typically arranged in circumferential rows on the front face of the drill bit with a row of gauge inserts extending around them adjacent to the peripheral edge of the bit face. When the gauge inserts wear down below a certain level the steel of the drill bit becomes in contact with the rock being drilled, this is known as anti-taper. The issue with anti-taper is that because the carbide inserts have worn down to the same diameter as the steel drill bit body there is no or less space for the cuttings to be removed, this results in a reduced rate of penetration or the drill bit getting stuck in hole as it is not possible to remove the cuttings. Consequently, wear on the steel drill bit body is accelerated and the lifetime of the drill bit is decreased.

[0003] One possible way to delay the occurrence of anti-taper is to increase the protrusion height of the insert, however this will increase the likelihood of the inserts breaking.

[0004] Therefore, the problem to be solved is how to avoid or delay the occurrence of anti-taper to improve the lifetime of the drill bit whilst maintaining the rate of drilling and without increasing the risk of insert breakage.

SUMMARY OF THE INVENTION

[0005] According to a first aspect of the present invention it is an objective to provide a cemented carbide insert for mining or rock cutting applications comprising a percussive drill bit for drilling a bore hole (otherwise known as a drill hole) comprising a bit body having a front face surrounded by a gauge and a longitudinal bit central axis; and a plurality of gauge inserts embedded in the gauge; wherein the gauge inserts have a longitudinal insert central axis, a cylindrical shank portion; a working tip portion; an radially internal side located on the side nearest to the bit central axis and an radially external side located on the side furthest from the bit central axis; wherein the working tip portion of the gauge inserts have an asymmetric geometry; wherein the volume of material on the radially external side is greater than the volume of material on the radially internal side.

[0006] Advantageously, the increased volume of material on the radially external side of the gauge inserts, i.e., the surface of the inserts that is in contact with the rock in the bore hole means that the distance between the steel bit body and the wall of the bore hole is increased. Consequently, the drilling distance before steel contact is made is increased without increasing the bending motion of the inserts which would otherwise result in premature fracture and therefore failure of the inserts. This will therefore decrease the likelihood / delay the occurrence of anti-taper thereby increasing the lifetime of the drill bit. Furthermore, the space between the steel bit body and rock for allowing the drill cuttings to be removed is maintained for longer and therefore the higher drilling speed can be sustained for a greater drilling distance. Overall, this means that the service life of the drill bit is increased.

[0007] In some embodiments, there is a distance (L) between an outermost part of the bit body and a wall of the bore hole and wherein $L > 0.6$ mm. Advantageously, this provides sufficient space for the drill cuttings to be removed and delays the occurrence of anti-taper.

[0008] In some embodiments, the working tip portion of the gauge inserts has a height (H) and wherein L/H is > 0.15. Advantageously, this range will enable improved wear resistance and increased drilling capacity before steel contact with the rock being drilled occurs without adversely affecting the moment force on the gauge inserts which would increase the risk of premature fracture of the inserts.

[0009] In some embodiments the diameter of the gauge inserts is between 6-24 mm. Advantageously, this geometry range provides the balance between being small enough that there is sufficient space in the steel bit body to accommodate them and being large enough that they are sufficiently strong to avoid premature breakage. Inserts with this range of diameter size are suitable for both down-the-hole (DTH) and top hammer products.

[0010] In some embodiments there is a first angle (α) between the insert central axis of the gauge inserts and the bit central axis; wherein α is between 10-50°. Advantageously, this provides the balance between there being sufficient space between the wall of the bore hole and the steel drill bit body without increasing the angle so greatly that the risk of insert failure increases.

[0011] In some embodiments the working tip portion of the gauge inserts comprise between 5-60 % higher volume of material on their radially external side compared to the volume of material on their radially internal side. Advantageously, this delays the occurrence of anti-taper without decreasing the drilling rate of penetration.

[0012] In some embodiments the working tip portion of the gauge inserts have a ballistic geometry. Advantageously, this geometry provides increased drilling speed.

[0013] In some alternative embodiments the working tip portion of the gauge inserts has a domed geometry. Advantageously, this geometry provides improved wear resistance.

[0014] In some embodiments there a second angle (β) on the gauge inserts between the insert central axis and a tangent of the working tip portion of the gauge insert located at a point axially furthest from the bit central axis; wherein β is between 0-35°. Ideally, β should be as low as possible as this provides the most optimal geometry for delaying / reducing the occurrence of anti-taper without being reduced so much that it results in difficulties with pressing which would result in cracking issues.

[0015] In some embodiments, the cemented carbide used for the inserts comprises hard constituents in a metallic binder phase, wherein the metallic binder phase content in the cemented carbide is between 4 to 20 wt%. Advantageously, this provides an insert having sufficiently high hardness and toughness.

[0016] In some embodiments, the metallic binder phase of the cemented carbide inserts comprises at least 80wt% of one or more metallic elements selected from Co, Ni and Fe.

[0017] In some embodiments, the cemented carbide inserts further comprises gamma phase in a weight of between 0.8 - 10 wt%. Advantageously this provides a cemented carbide mining insert having improved wear resistance without increased brittleness. Therefore, the lifetime of the insert is increased. Further, it makes it easier to be able to use recycled carbide, that typically has higher gamma phase content that would be acceptable for cemented carbide grades that are commonly used for used mining or cutting applications.

[0018] In some embodiments the cemented carbide inserts further comprises Cr in such an amount that the mass ratio Cr/Co in the bulk is between 0.04-0.19. Advantageously, the presence of the chromium improves the plastic deformation of the cemented carbide, this enables higher compressive stresses to be introduced into the carbide when it is treated with a surface hardening treatment, such as tumbling. This increase in compressive stress provides an apparent hardness increase which improves the wear resistance of the cemented carbide, without reducing the toughness.

[0019] In some embodiments the cemented carbide inserts have a corrected CoM / wt% Co ratio between 0.70 - 0.81 and are substantially free of eta-phase wherein eta-phase is M_6C or $M_{12}C$ where M = (Co, W, Cr); wherein said corrected CoM / wt% Co ratio is calculated according to:

$$\text{Corrected CoM / wt\% Co} = (\text{magnetic-\% Co} + 1.13 * \text{wt\% Cr}) / \text{wt\% Co}$$

where magnetic-% Co is the weight percentage of magnetic Co and wt-% Co and wt-% Cr are the weight percentage of Co and Cr in the cemented carbide, respectively, which are measured according to the method defined in the description. Advantageously, when inserts having this special range of corrected CoM / wt% Co are subjected to static / low strain rate contact stress, which could be through a mechanical post-sintering treatment process such as high energy tumbling and / or through the actual drilling process, the material's strain hardening capacity will be enhanced. The material will also exhibit enhanced ultimate compressive strength (UCS), leading to the reduction of the risk of premature insert breakages in the rock drilling application. Additionally, it has been found that if the corrected CoM / wt% Co is in this range the wear properties of the insert are improved which also contributes to increasing the lifetime of the inserts when used in the field.

[0020] In some embodiments, the binder in the cemented carbide inserts has a gradient in concentration from one region of the insert to another region of the insert. Advantageously, this provides inserts having harder zones and tougher zones.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] A specific implementation of the present invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 shows a schematic drawing of a drill bit comprising asymmetrically shaped gauge inserts.

Figure 2 shows a side view of an asymmetric gauge insert having a ballistic geometry.

Figure 3 shows a side view schematic drawing of an asymmetric gauge insert having a domed geometry.

Figure 4 is a plot of the drilling rate of penetration (ROP) as a function of meters drilled comparing drill bits having symmetrical versus asymmetrical gauge inserts.

DETAILED DESCRIPTION

[0022] Figure 1 shows a percussive drill bit 2 for drilling a bore hole 28 comprising a bit body 4 having a front face 6 surrounded by a gauge 8 and a longitudinal bit central axis 10; a plurality of front inserts (not shown) are embedded in the front face and a plurality of gauge inserts 14 are embedded in the gauge 8. Inserts are otherwise known as buttons. The gauge inserts 14 have a longitudinal insert central axis 16, a cylindrical shank portion 18 that is secured by interference fit into sockets that have been drilled into the drill bit body 4; and a working tip portion 20 that protrudes from the steel bit body 4. The inserts, both front and gauge, are used for impacting and fracturing the rock being drilled. The front face inserts are arranged in one or more circumferential rows on the front face 6. The gauge inserts 14 extend around or adjacent to the peripheral edge of the drill bit 2. The gauge inserts 14 are in contact with a wall 26 of the bore hole 28.

[0023] The gauge inserts 8 have a radially internal side 22 located on the side nearest to the bit central axis 10 and a radially external side 24 located on the side furthest from the bit central axis 10. The working tip portion 20 of the gauge inserts 14 have an asymmetric geometry wherein the volume of material on the radially external side 24 is greater than the volume of material on the radially internal side 22. In other words, the side of the gauge insert 14 having the higher volume of material is positioned on the side that is in contact with the wall 26 of the bore hole 28.

[0024] An insert having asymmetric geometry is defined by when any one plane parallel to and passing through the insert central axis 16 divides the insert into two halves that are not mirror images. As opposed to an insert having symmetric geometry where there is symmetry across all planes parallel to and passing through the insert's central axis 16. If viewed from above and sectioned through a plane passing through the insert central axis 16, the half of the tip portion 20 that is radially further from the bit central axis 10 has a higher volume of material than the half of the tip portion 20 that is nearer to the bit central axis 10.

[0025] The enlargement shown on figure 1 shows that there is a distance (L) between an outermost part 32 of the steel bit body 4 and a wall 26 of the bore hole 2. L is for example > 0.6 mm or for example > 1.3 mm. The working tip portion 20 of the gauge inserts has a height (H). H is also equal to the height that the gauge inserts 14 protrudes from the gauge 8. L/H is for example >0.15 or for example > 0.2. Compared to a symmetrically shaped insert L is increased proportionately more for an asymmetrically shaped insert when the inserts have the same height (H). For drill bits 2 having the same diameter of the steel bit body 4 at its widest point and gauge inserts 14 having the same height H, the diameter to the peripheral edge of the gauge inserts 14 at their widest point is greater when the gauge inserts 14 have an asymmetric geometry compared to when they have a symmetric geometry, therefore the diameter wear internal is increased when asymmetric gauge inserts 14 are used.

[0026] In some embodiments the diameter of the gauge inserts 14 is between 6-24 mm, for example between 7-20 mm.

[0027] As shown in figure 1, there is a first angle (α) between the insert central axis 16 of the gauge inserts 14 and the bit central axis 10. For example, α is between 10-50° or for example α is between 25-45°.

[0028] Figure 2 shows that the working tip portion 20 of the gauge inserts 14 may have an asymmetric ballistic shape. This geometry may also be referred to as a distorted or off-centre or lop-sided or askew ballistic geometry or an asymmetric or distorted or off-centre or lop-sided or askew pointed geometry or an asymmetric or distorted or off-centre or lop-sided or askew peaked geometry.

[0029] Figure 3 shows that the working tip portion 20 of the gauge inserts 14 may have an asymmetric domed shape, also known as a domed shape. This geometry could also be referred to being a distorted or off-centre or lop-sided or askew dome geometry or an asymmetric or distorted or off-centre or lop-sided or askew spherical geometry.

[0030] The gauge inserts 14 could also have any other suitable asymmetric geometry, such as semi-ballistic.

[0031] In some embodiments, the working tip portion of the gauge inserts 14 comprise between 5-60%, for example between 10-40% more volume of material on their radially external side 24 compared to the volume of material on their radially internal side 22. The volume of material on the radially external side 24 is considered to be the material in the half of the working tip furthest from the bit central axis 10 and the volume of material on the radially internal side 22 is considered to be the material in the half of the working tip closest to the bit central axis 10.

[0032] As shown on figure 2, a second angle (β) on the gauge inserts 14 between the insert central axis 16 and a tangent of the working tip portion 20 of the gauge insert 14 located at a point 30 axially furthest from the bit central axis 10; wherein β is between 0-35. β is for example between 0-35° or for example between 3-25°.

[0033] In some embodiments, the cemented carbide used for the inserts 12, 14 comprises hard constituents in a metallic binder phase, and wherein the metallic binder phase content in the cemented carbide is between 4 to 20 wt%, for example between 5 to 15 wt%.

[0034] Typically, the hard constituents comprise at least 50 wt% WC and possibly other hard constituents common in the art of making cemented carbides. In one embodiment of the method, the cemented carbide mining insert contains a hard phase comprising at least 80 wt% WC, for example at least 90 wt%.

[0035] The metallic binder phase is for example selected from one or more of Fe, Co, and Ni. For example, the metallic binder phase of the cemented carbide inserts 12, 14 comprises at least 80wt% of one or more metallic elements selected from Co, Ni and Fe. The metallic binder of the cemented carbide can comprise other elements that are dissolved in the metallic binder during sintering, such as W and C originating from the WC. Depending on what other types of hard constituents that are present, also other elements can be dissolved in the binder.

[0036] In some embodiments, the mean WC grain size in the cemented carbide is between 0.8 - 18 μm, for example between 1.5 - 10 μm, for example between 1 - 5 μm.

[0037] In some embodiments, the cemented carbide inserts 12, 14 further comprise gamma phase in a weight of between 0.8 - 10 wt%, for example between 1 - 8 wt%. The gamma phase forming carbides or nitrides or carbonitrides added could be any of Ta, Nb, Ti, Zr, Hf.

[0038] In some embodiments, the cemented carbide inserts 12, 14 further comprises Cr in such an amount that the mass ratio Cr/Co in the bulk is 0.04-0.19, for example between 0.075 - 0.17.

[0039] In some embodiments, the cemented carbide inserts 12, 14 have a corrected CoM / wt% Co ratio between 0.70 - 0.81 and are substantially free of eta-phase wherein eta-phase is M_6C or $M_{12}C$ where M = (Co, W, Cr); wherein said corrected CoM / wt% Co ratio is calculated according to:

$$\text{Corrected CoM / wt\% Co} = (\text{magnetic-\% Co} + 1.13 * \text{wt\% Cr}) / \text{wt\% Co}$$

where magnetic-% Co is the weight percentage of magnetic Co and wt-% Co and wt-% Cr are the weight percentage of Co and Cr in the cemented carbide, respectively.

[0040] The corrected CoM / wt% Co of a sintered sample is measured and calculated by using commercially available Foerster Koerzimat CS 1.096 equipment. The sample is weighed and then put into the magnetic coil as described in the Koerzimat CS 1.096 V3.09 manual.

[0041] In a different embodiment, the binder in the cemented carbide inserts 12, 14 has a gradient in binder concentration from one region of the insert to another.

[0042] In some embodiments, the cemented carbide inserts 12, 14 are subjected to a post processing surface hardening and toughening treatment. For example, the sintered cemented carbide inserts are subjected to a tumbling treatment. For example, the sintered cemented carbide inserts are subjected to a high energy tumbling treatment (HET). HET is considered to be a tumbling process wherein post tumbling a homogenous cemented carbide mining insert has been deformation hardened such that $\Delta HV3\% \geq 9.72 - 0.00543*HV3_{bulk}$, wherein the $\Delta HV3\%$ is the percentage difference between the HV3 measurement at 0.3 mm from the surface compared the HV3 measurement in the bulk. HET could also be understood to mean a tumbling process that induces a hardness difference between 0.3 mm from the surface and the bulk of at least 20 HV3. HET could also be understood to mean that there is both a hardness and toughness increase induced from the surface to the bulk.

[0043] There are many different possible processes set ups that could be used to introduce HET, including the type of tumbler, the volume of media added (if any), the treatment time and the process set up, e.g., RPM for a centrifugal tumbler etc. Therefore, the most appropriate way to define HET is in terms of "any process set up that introduces a specific degree of deformation hardening in a homogenous cemented carbide mining insert consisting of WC-Co, having a mass of about 20g". In the present disclosure, HET is defined as a tumbling treatment that would introduce a hardness change, measured using HV3, after tumbling ($\Delta HV3\%$) of at least:

$$\Delta HV3\% = 9.72 - 0.00543*HV3bulk \qquad \text{(equation 1)}$$

Wherein:

$$\Delta HV3\% = 100*(HV30.3mm - HV3bulk)/HV3bulk \qquad \text{(equation 2)}$$

[0044] $HV3_{bulk}$ is an average of at least 10 indentation points measured in the innermost (centre) of the cemented carbide mining insert and $HV3_{0.3mm}$ is an average of at least 10 indentation points at 0.3mm below the tumbled surface of the cemented carbide mining insert. This is based on the measurements being made on a cemented carbide mining insert having homogenous properties. By "homogeneous properties" we mean that post sintering the hardness different is no more than 1% from the surface zone to the innermost bulk zone. The tumbling parameters used to achieve the deformation hardening described in equations (1) and (2) on a homogenous cemented carbide mining insert would be applied to cemented carbide bodies having a gradient property.

[0045] HET tumbling may typically be performed using an ERBA 120, having a disc size of about 600 mm, run at about 180 RPM if the tumbling operation is either performed without media or with media that is larger in size than the inserts being tumbled, or at about 240 RPM if the media used is smaller in size than the inserts being tumbled; Using a Rösler tumbler, having a disc size of about 350 mm, at about 280 RPM if the tumbling operation is either performed without media or with media that is larger in size than the inserts being tumbled, or at about 320 RPM if the media used is smaller in size than the inserts being tumbled. Typically, the parts are tumbled for at least 40-80 minutes.

[0046] In some embodiments, the HET is conducted at an elevated temperature of or above 100°C, for example at a temperature of or above 200°C, for example at a temperature of between 200°C and 450°C. In some embodiments, the inserts 12, 14 are pre-heated prior to the HET treatment. In some embodiments the HET is conducted in dry conditions. By "dry" conditions it is meant that no liquid is added to the process.

[0047] In one embodiment the difference between an average hardness at 0.3 mm below the surface of the rock drill insert and an average hardness in the bulk (i.e., the innermost part) of the rock drill insert is at least 20 HV3, for example at least 30 HV3, for example at least 40 HV3, wherein hardness is measured according to ISO EN6507.

EXAMPLES

Example 1 - Diameter of drill bit

[0048] Drill bits were tested in an underground mine in Sweden to compare the performance of symmetrical ballistic versus asymmetrical ballistic gauge inserts. In the tests the same bit bodies, the same number and distribution of inserts and the same insert diameters were used. The inserts used were all made from the same cemented carbide material, having a HV20 of 1440, Palmqvist Kic of 11 and D50 WC grain size measured using EBSD of 2.1 μm and were both subjected to the same HET treatment post sintering. The only difference was the geometry of the gauge inserts. Table 1 shows the diameter of the drill bit after drilling and the distance drilled.

Table 1: Drilling test results

Gauge insert geometry	Diameter of drill bit after drilling (mm)	Distance drilled (m)
Symmetrical (comparison)	44.59	86.4
Asymmetrical (invention)	45.89	91.7

[0049] It can be seen from table 1 that the diameter of the drill bit post drilling was greater for the bit with asymmetrical inserts, even after a higher drilling distance, compared to the bit with the symmetric inserts. This illustrates that the wear to the steel body is reduced when asymmetrical inserts are used.

Example 2 - Rate of penetration

[0050] Figure 4 shows the rate of penetration (ROP) drilling speed as a function of drilled meters. The solid line is the results for the symmetric inserts and the dashed line is the results for the asymmetric inserts. It can be seen that the initial drilling speed for the bit having the symmetrically shaped gauge inserts was higher. However, after about 37 m of drilling steel contact for the bit having the symmetrically shaped gauge inserts occurs and the rate of penetration significantly decreases (i.e. the steel of the drill bit body comes in contact with the wall of the bore hole) meaning that there is less space for the cuttings to be removed which adversely effects the rate of penetration. Whereas for the bit having the asymmetrically shaped gauge inserts no steel contact occurs (i.e., there is still cemented carbide in contact with the wall of the bore hole) and so sufficient space for removal of cutting is maintained and therefore a higher rate of penetration is achieved for longer.

Example 3 - Insert compression test

[0051] The insert compression test method involves compressing a drill bit insert having a 10 mm diameter between two plane-parallel hard counter surfaces, at a constant displacement rate, until the failure of the insert. A test fixture based on the ISO 4506:2017 (E) standard "Hardmetals - Compression test" was used, with cemented carbide anvils grade H6F from Hyperion having a hardness exceeding 2000 HV, while the test method itself was adapted to toughness testing of rock drill inserts. The fixture was fitted onto an Instron 5989 test frame.

[0052] The loading axis was identical with the axis of rotational symmetry of the inserts. The counter surfaces of the fixture fulfilled the degree of parallelism required in the ISO 4506:2017 (E) standard, i.e., a maximum deviation of 0.5 μm / mm. The tested inserts were loaded at a constant rate of crosshead displacement equal to 0.6 mm / min until failure, while recording the load-displacement curve. The compliance of the test rig and test fixture was subtracted from the measured load-displacement curve before test evaluation. Three inserts were tested per run. The counter surfaces were inspected for damage before each test. Insert failure was defined to take place when the measured load suddenly dropped by at least 1000 N. Subsequent inspection of tested inserts confirmed that this in all cases this coincided with the occurrence of a macroscopically visible crack. The material strength was characterized by means of the total absorbed deformation energy until fracture. The summary of insert crush strength (kN) and fracture energy in Joules (J), required to crush the samples is shown in table 2 below for the as sintered inserts:

Table 2: Insert compression test results for sintered inserts.

Insert geometry	Insert Crush strength (kN)	Fracture Energy at crush (J)
Symmetric ballistic	8.90	0.43
Asymmetric ballistic	18.72	0.99

[0053] Inserts from the same batch which were subjected to a high energy tumbling treatment were also analyzed using the insert compression test, the results are shown in table 3 below:

Table 3: Insert compression test results for insert post high energy tumbling

Insert geometry	Insert Crush strength (kN)	Fracture Energy at crush (J)
Symmetric ballistic	26.55	2.26
Asymmetric ballistic	35.0	3.30

[0054] It can be seen from tables 2 and 3 that the insert crush strength and fracture energy at crush of the asymmetric inserts is higher for the asymmetric inserts compared to the symmetric inserts, which will reduce the probability of insert breakages and thus increase the lifetime of the inserts.

Claims

1. A percussive drill bit (2) for drilling a bore hole (28) comprising a bit body (4) having a front face (6) surrounded by a gauge (8); a longitudinal bit central axis (10); and a plurality of gauge inserts (14) embedded in the gauge (8);

   wherein the gauge inserts (8) have a longitudinal insert central axis (16), a cylindrical shank portion (18); a working tip portion (20); a radially internal side (22) located on the side nearest to the bit central axis (10) and a radially external side (24) on the side further from the bit central axis (10);
   characterized in that:
   the working tip portion (20) of the gauge inserts (14) have an asymmetric geometry wherein the volume of material on the radially external side (24) is greater than the volume of material on the radially internal side (22).

2. The percussive drill bit (2) according to claim 1 wherein there is a distance (L) between an outermost part (32) of the bit body (4) and a wall (26) of the bore hole (28) and wherein $L > 0.6$ mm.

3. The percussive drill bit (2) according to claim 1 or claim 2 wherein the working tip portion (20) of the gauge inserts (14) has a height (H) and wherein L/H is >0.15.

4. The percussive drill bit (2) according to any of the previous claims wherein the diameter of the gauge inserts (14) is between 6-24 mm.

5. The percussive drill bit (2) according to any of the previous claims wherein there is a first angle (α) between the insert central axis (16) of the gauge inserts (14) and the bit central axis (10); wherein α is between 10-50°.

6. The percussive drill bit (2) according to any of the previous claims wherein the working tip portion (20) of the gauge inserts (14) comprise between 5-60 % more volume of material on their radially external side (24) compared to the volume of material on their radially internal side (22).

7. The percussive drill bit (2) according to any of the previous claims wherein the working tip portion (20) of the gauge inserts (14) has a ballistic geometry.

8. The percussive drill bit (2) according to any of claims 1-6 wherein the working tip portion (20) of the gauge inserts (14) has a domed geometry.

9. The percussive drill bit (2) according to any of the previous claims wherein there is a second angle (β) on the gauge inserts (14) between the insert central axis (16) and a tangent of the working tip portion (20) of the gauge insert (14)

located at the point axially furthest from the bit central axis (10); wherein β is between 0-35°.

10. The percussive drill bit (2) according to any of the previous claims wherein the cemented carbide used for the inserts (12, 14) comprises hard constituents in a metallic binder phase, and wherein the metallic binder phase content in the cemented carbide is between 4 to 20 wt%.

11. The percussive drill bit (2) according to claim 10 wherein the metallic binder phase of the cemented carbide inserts (12, 14) comprises at least 80wt% of one or more metallic elements selected from Co, Ni and Fe.

12. The percussive drill bit (2) according to claim 10 or 11 wherein the cemented carbide inserts (12, 14) further comprises gamma phase in a weight of between 0.8 - 10 wt%.

13. The percussive drill bit (2) according to any of claims 10 or 11 wherein the cemented carbide inserts (12, 14) further comprises Cr in such an amount that the mass ratio Cr/Co in the bulk is 0.04 - 0.19.

14. The percussive drill bit (2) according to claim 13 wherein the cemented carbide inserts (12, 14) have a corrected CoM / wt% Co ratio between 0.70 - 0.81 and are substantially free of eta-phase wherein eta-phase is M_6C or $M_{12}C$ where M = (Co, W, Cr); wherein said corrected CoM / wt% Co ratio is calculated according to:

$$\text{Corrected CoM / wt\% Co} = (\text{magnetic-\% Co} + 1.13 * \text{wt\% Cr}) / \text{wt\% Co}$$

where magnetic-% Co is the weight percentage of magnetic Co and wt-% Co and wt-% Cr are the weight percentage of Co and Cr in the cemented carbide, respectively, which are measured according to the method defined in the description.

15. The percussive drill (2) according to any of the previous claims wherein the binder in the cemented carbide inserts (12, 14) has a gradient in concentration from one region of the insert (12, 14) to another region of the insert (12, 14).

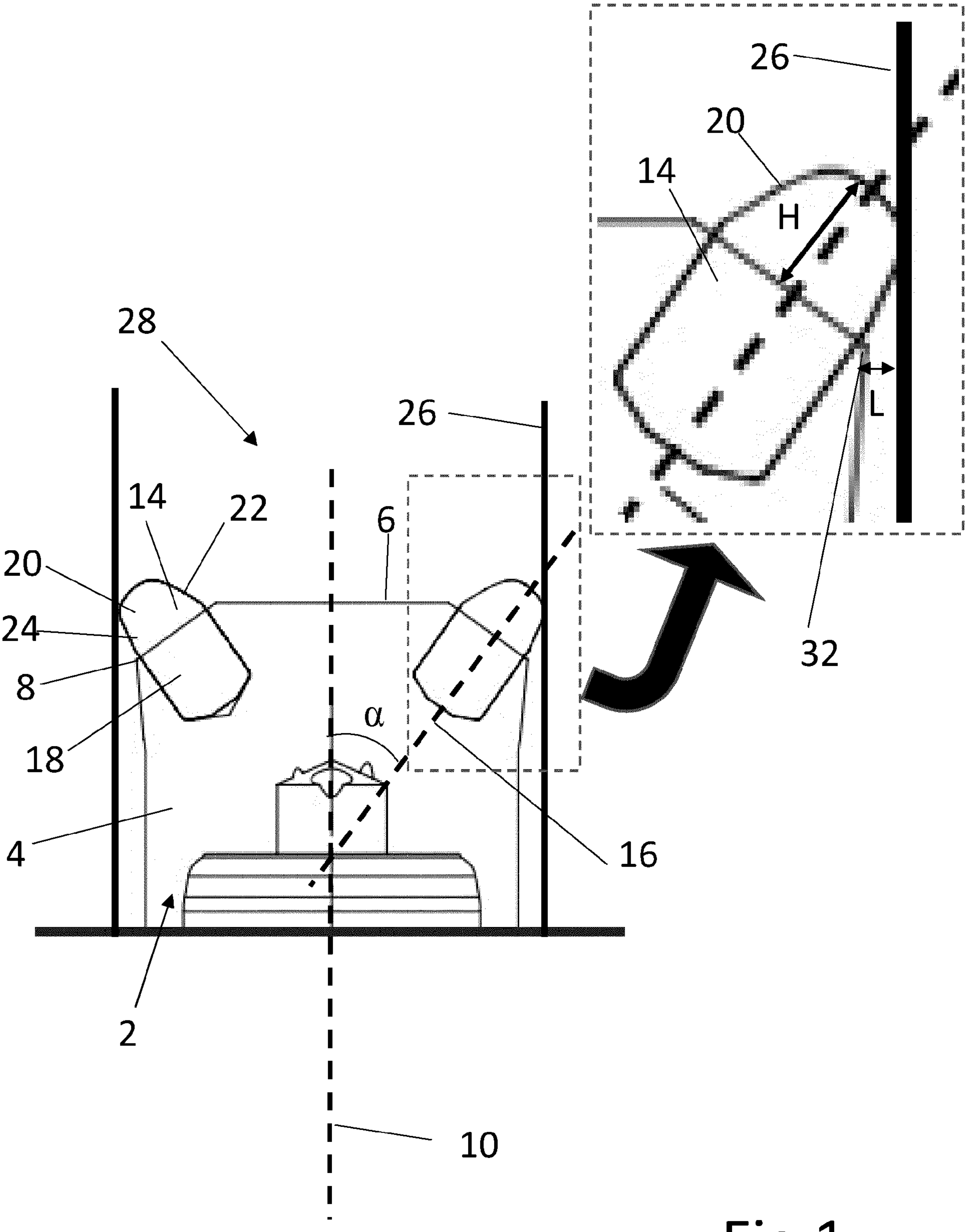

Fig 1

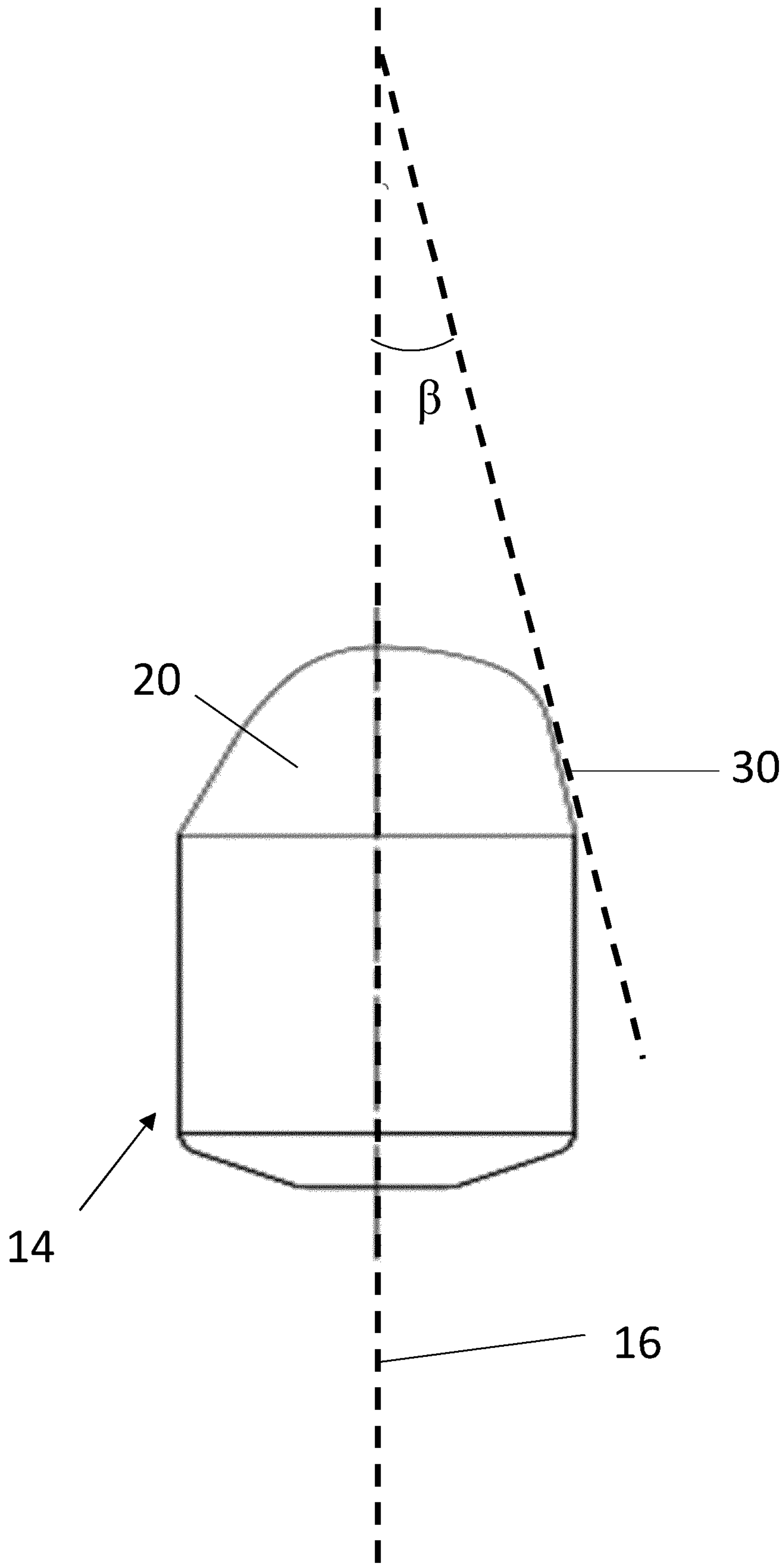

Fig 2

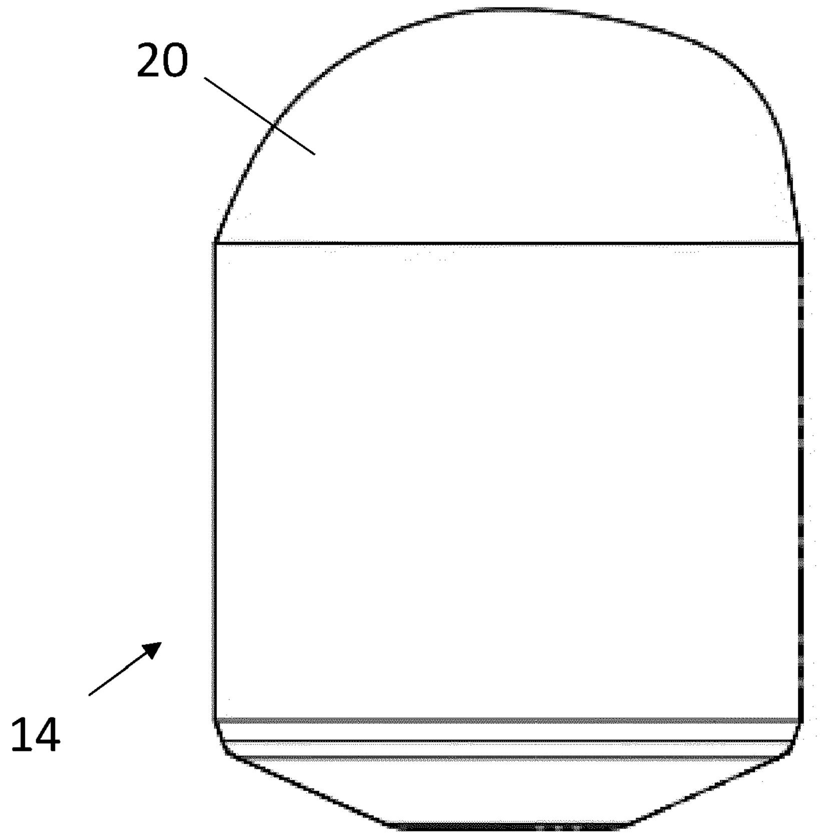

Fig 3

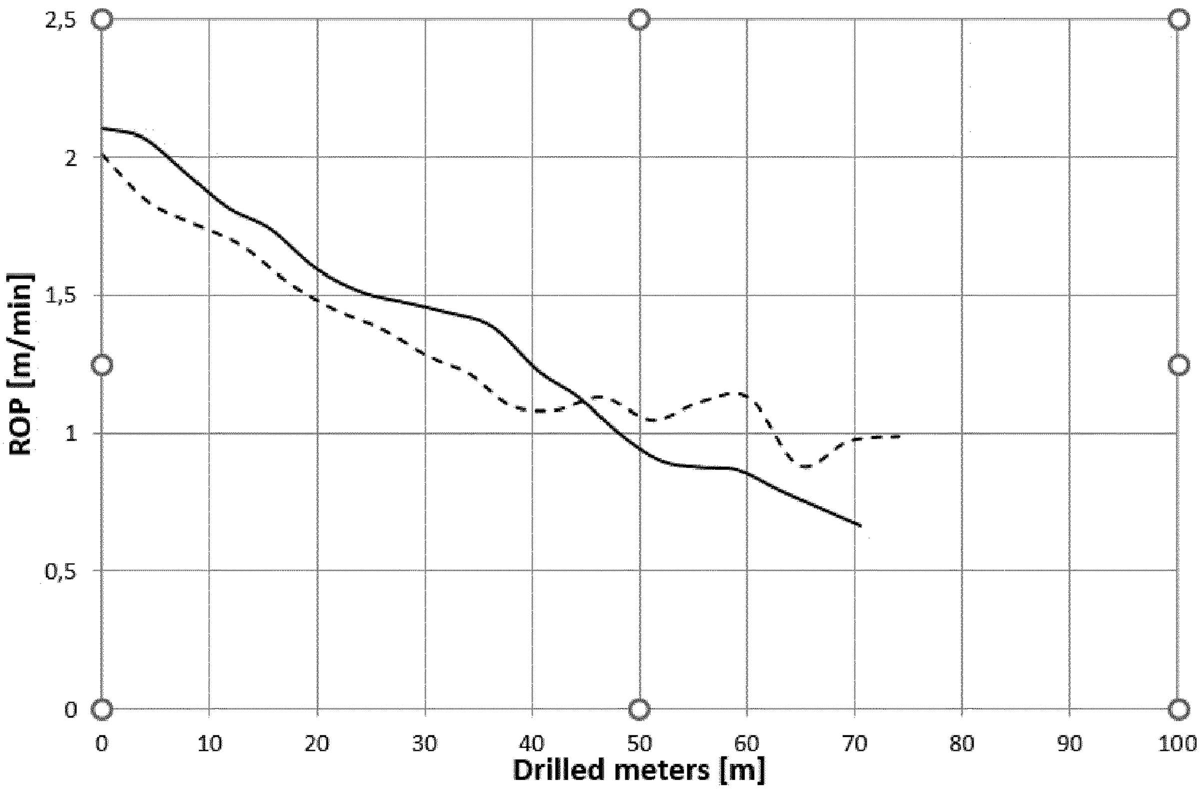
ROP [m/min]
2,5
2
1,5
1
0,5
0
0
10
20
30
40
50
60
70
80
90
100
Drilled meters [m]

Fig 4

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EUROPEAN SEARCH REPORT

Application Number
EP 23 19 9403

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The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	20 February 2024	Beran, Jiri

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