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(54) **CUTTING BIT USEFUL FOR IMPINGEMENT OF EARTH STRATA**

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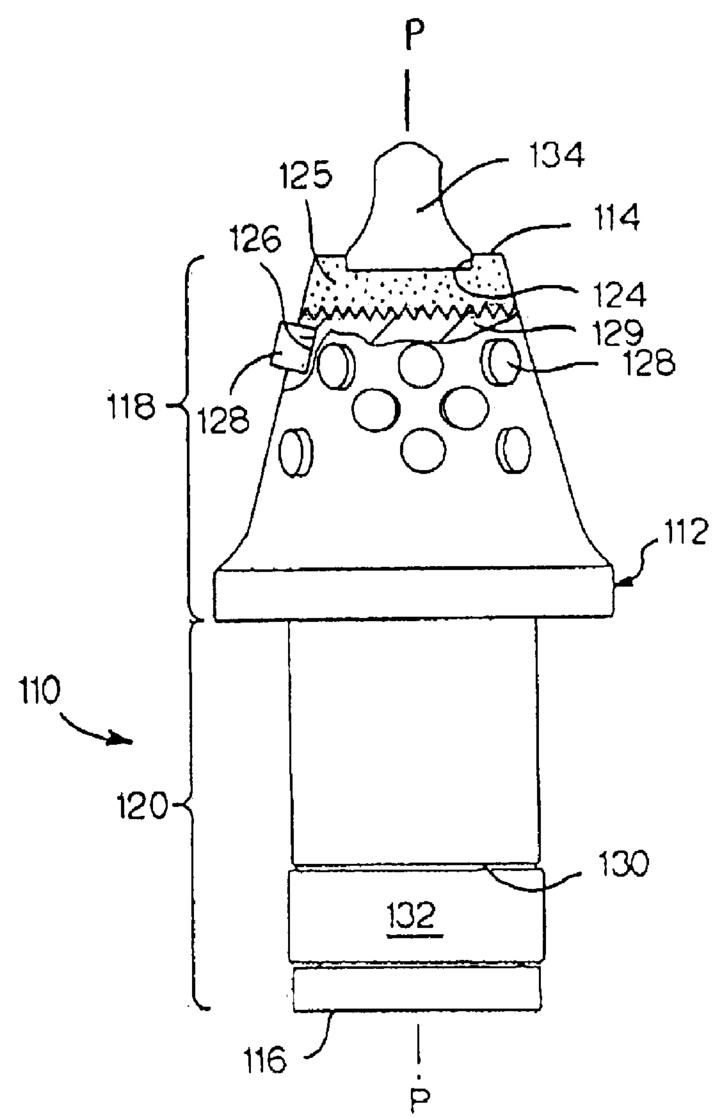
(57) **ABSTRACT**

A cutting bit for impinging earth strata wherein the cutting bit includes a highly wear-resistant elongate cutting bit body, which has an axial forward end and an axial rearward end, an enlarged dimension head portion at the axial forward end and a reduced dimension shank portion at the axial rearward end. The highly wear-resistant elongate cutting bit body has a maximum transverse dimension and a longitudinal axial length. The cutting bit includes a superhard insert, which is affixed to the head portion at the axial forward end of the cutting bit body. The cutting bit has a slimness ratio, which comprises the ratio of the maximum transverse dimension to the longitudinal axial length wherein the cutting bit exhibits a slimness ratio ranging between about 0.15 and about 0.60.



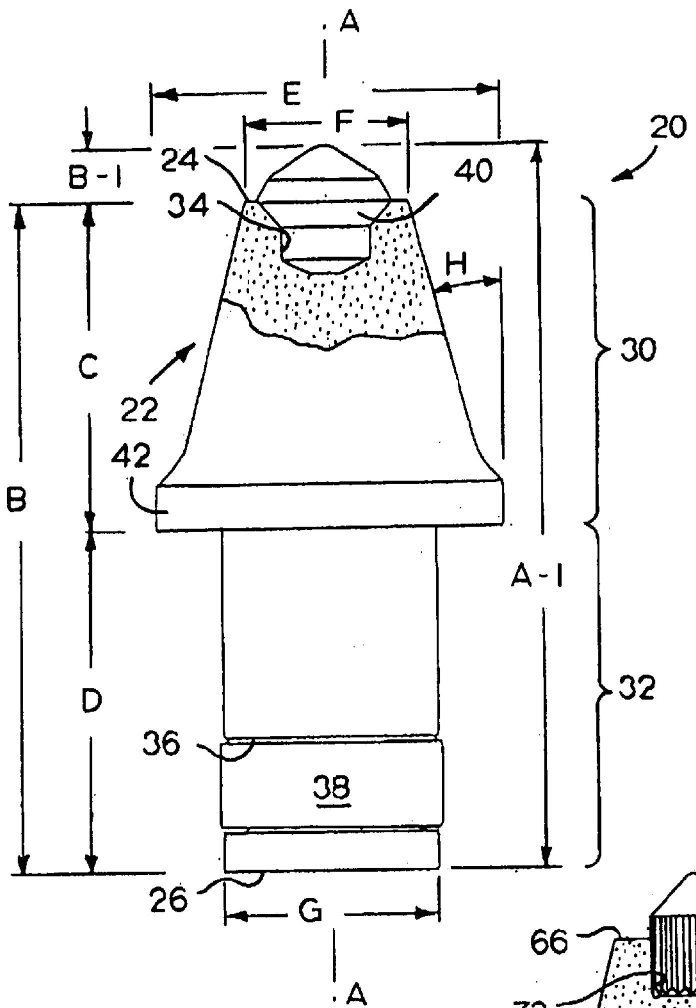


FIG. 1

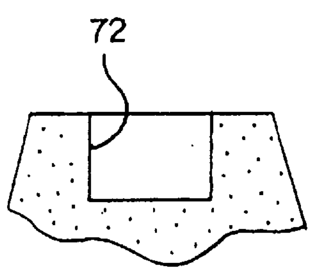


FIG. 2A

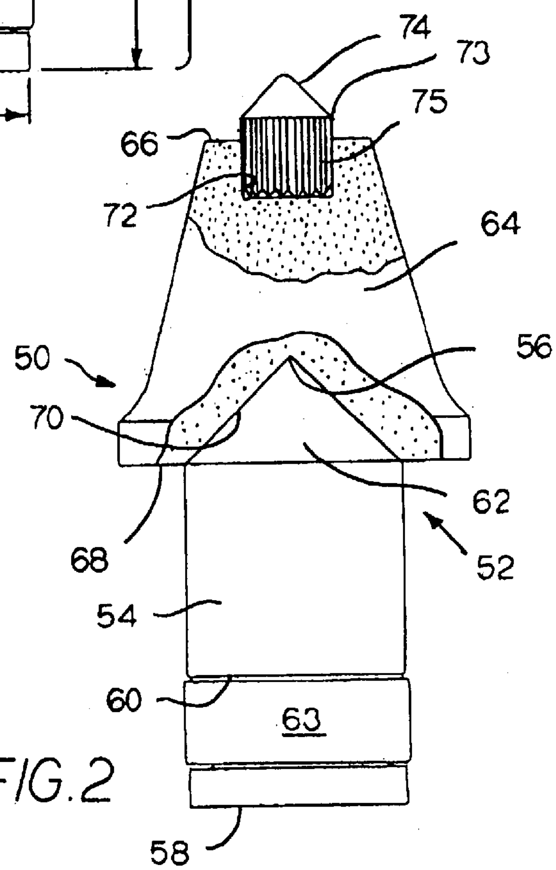


FIG. 2

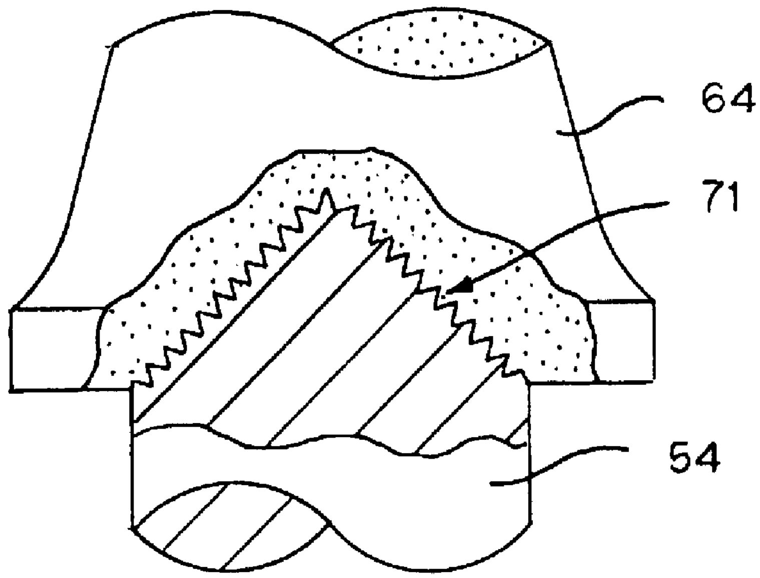


FIG. 2B

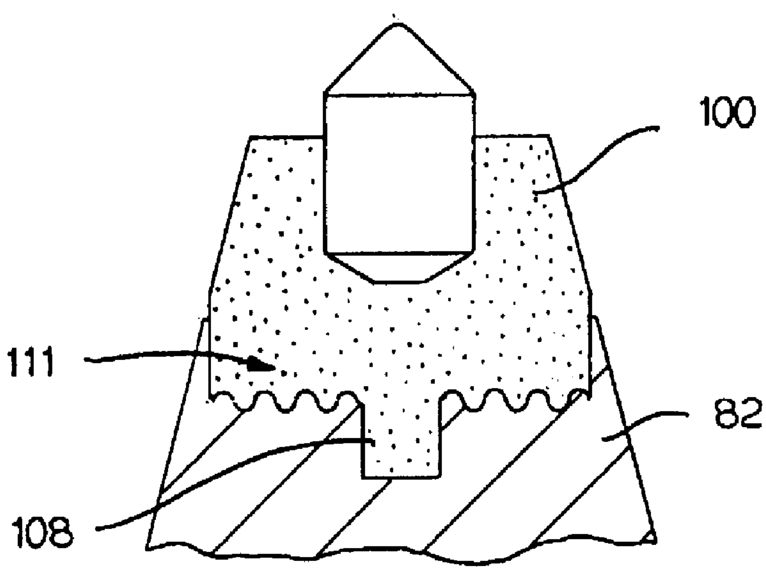


FIG. 3A

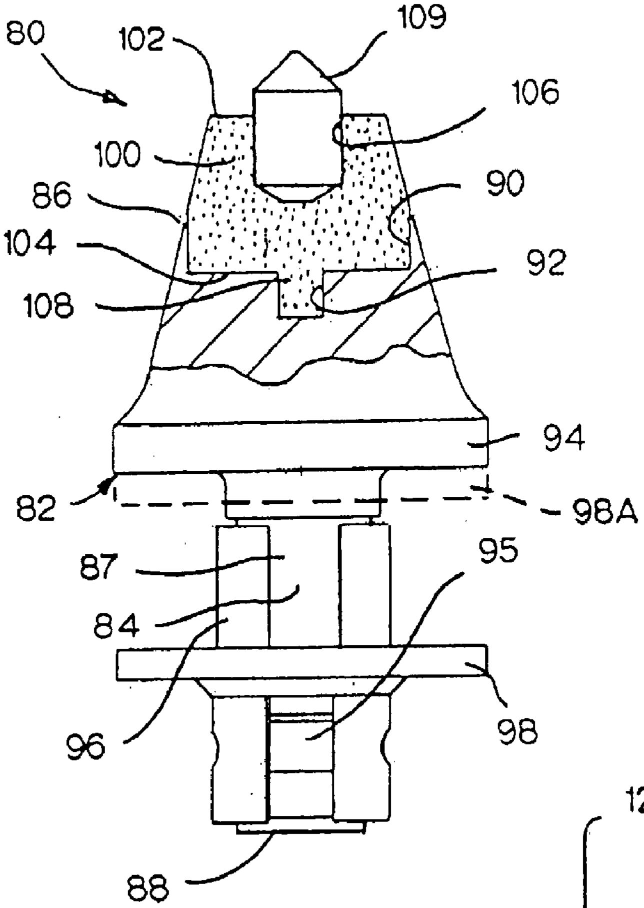

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FIG. 3

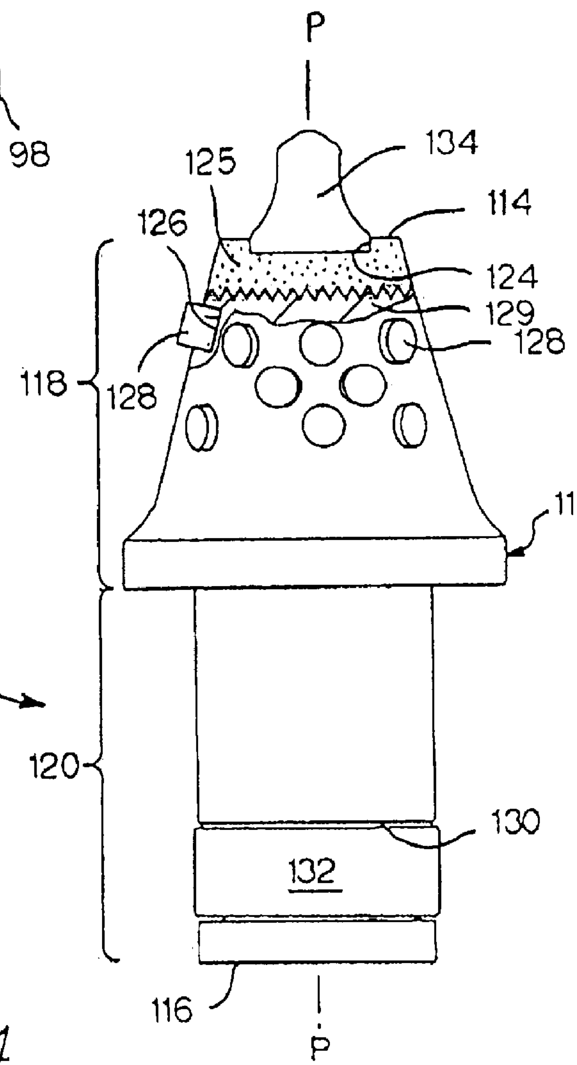
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FIG. 4

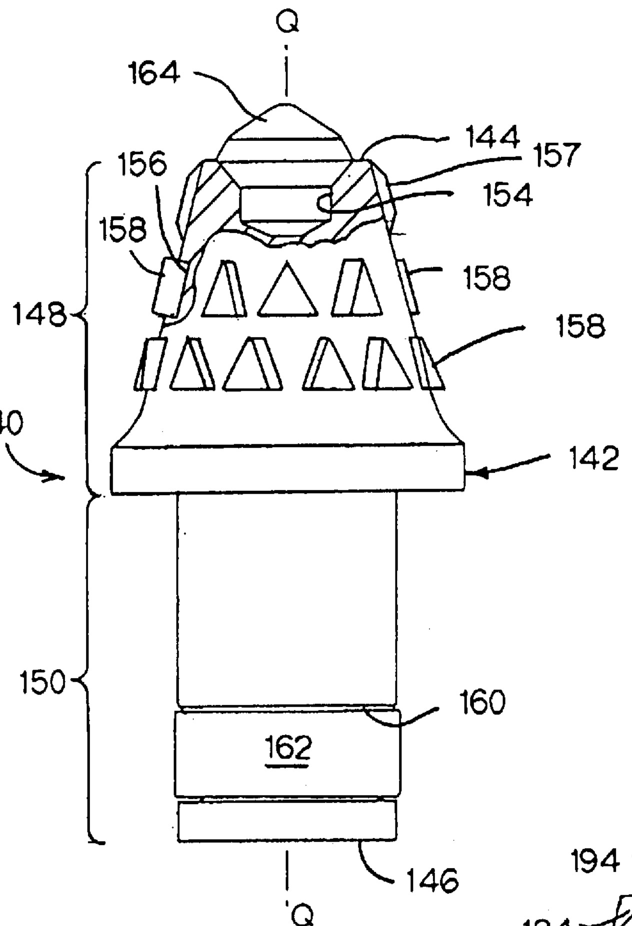
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FIG. 5

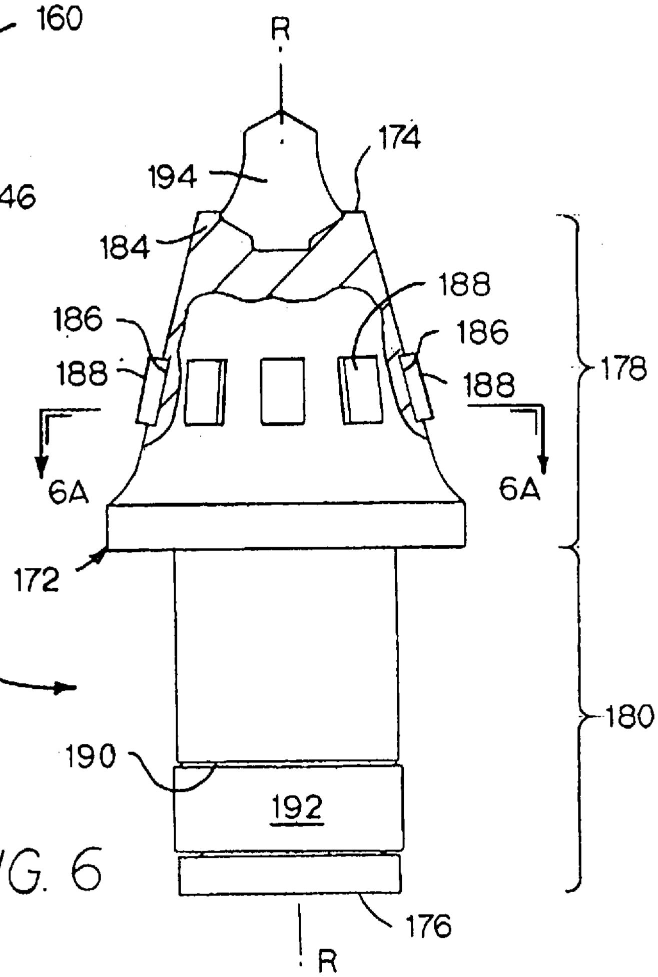
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FIG. 6

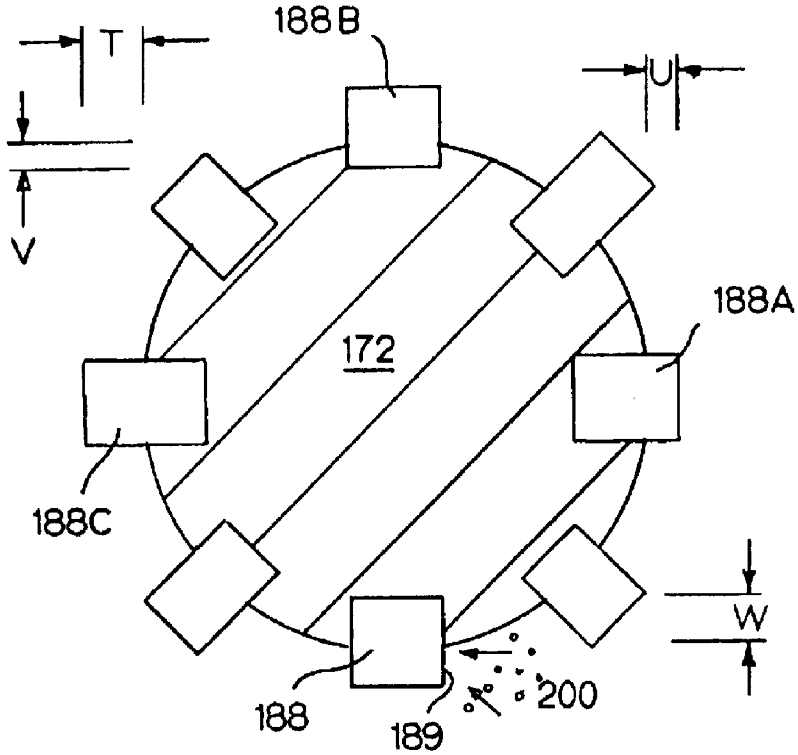

FIG. 6A

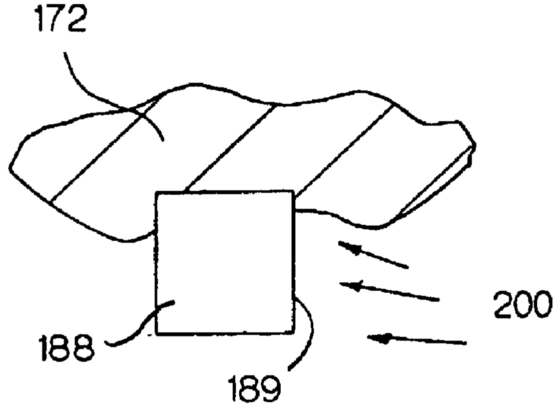

FIG. 6B

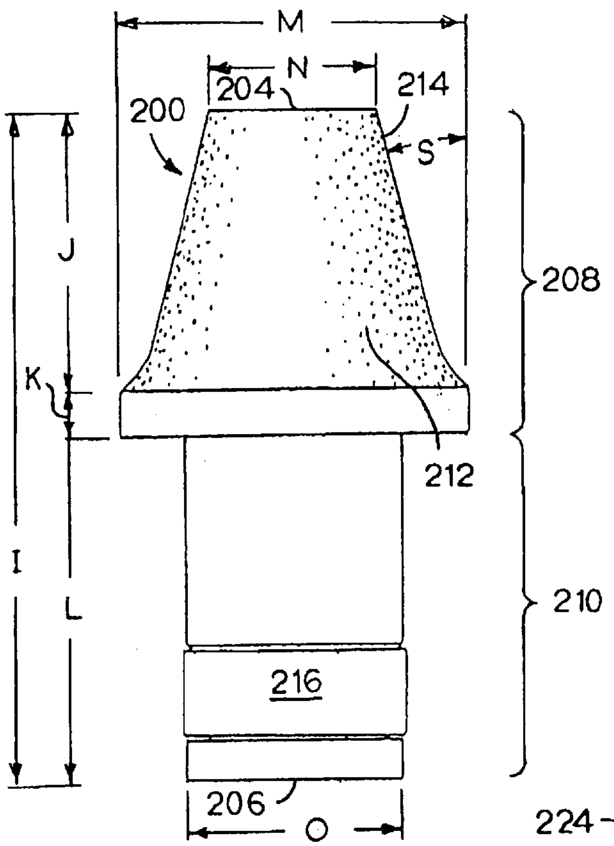
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FIG. 7

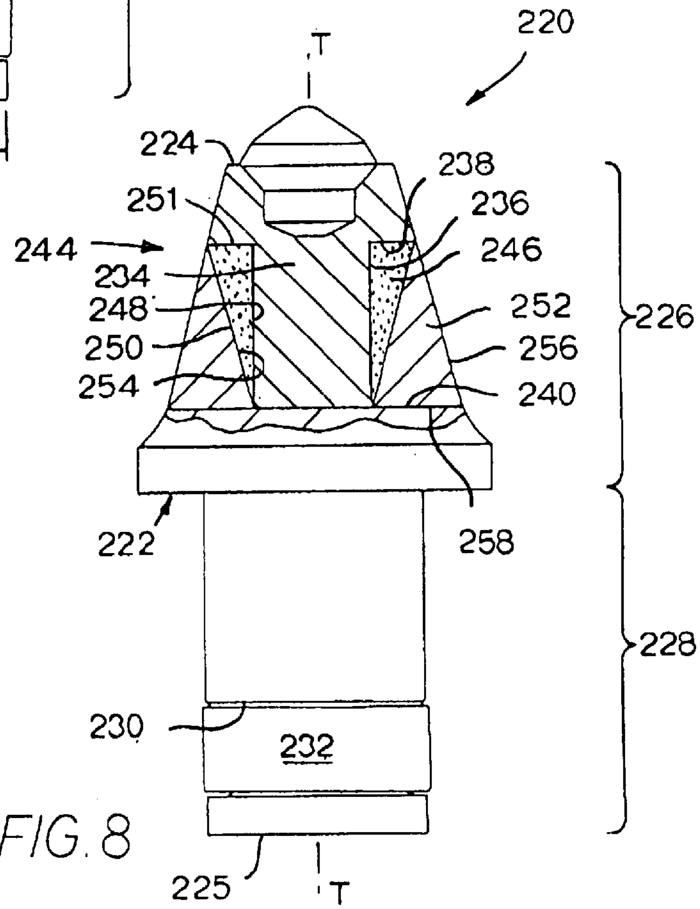
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FIG. 8

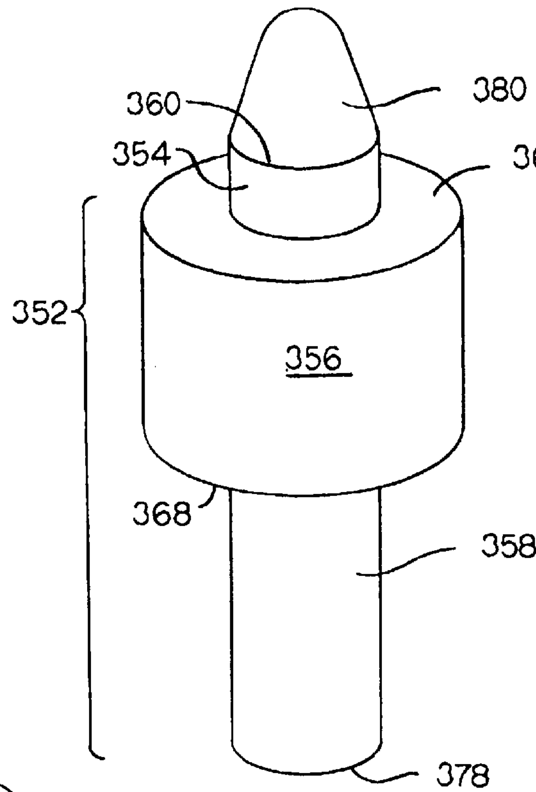

FIG. 9

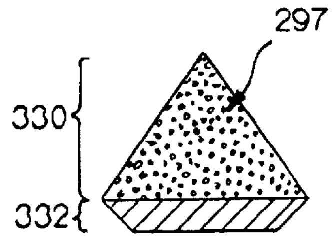

FIG. 11A

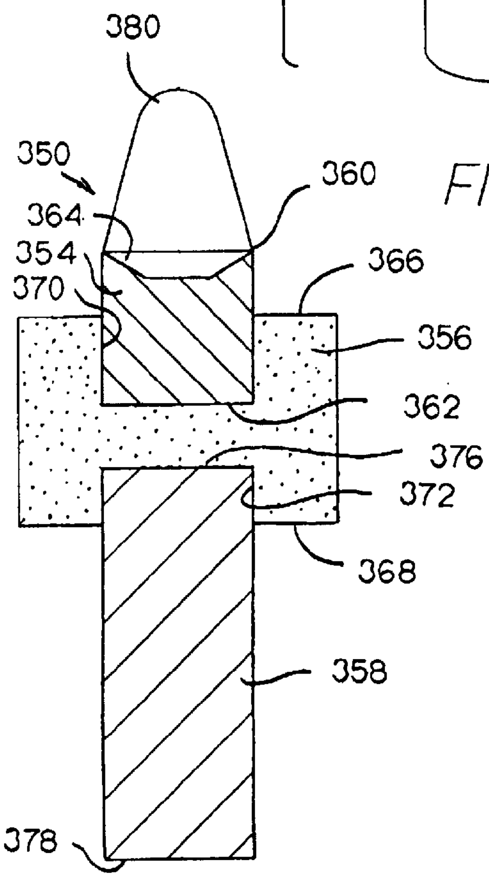

FIG. 10

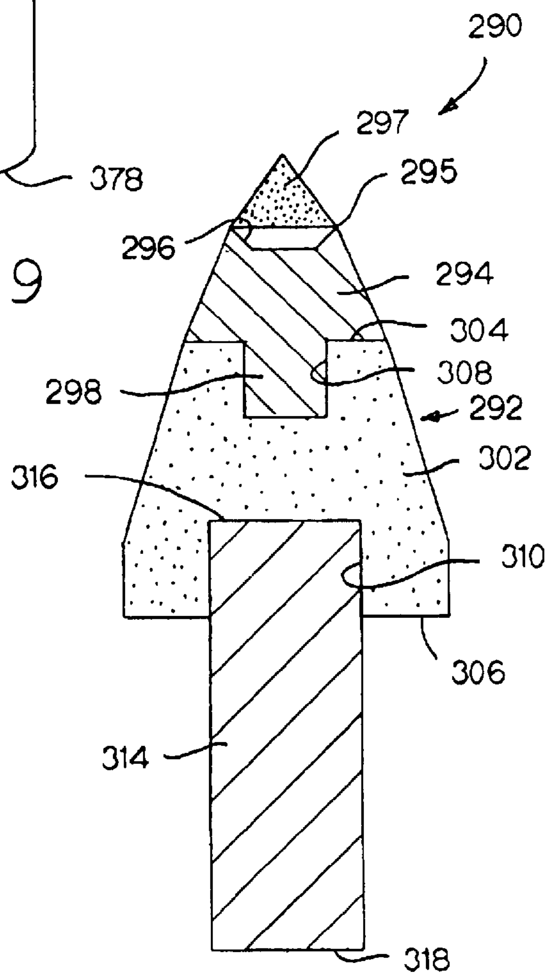

FIG. 11

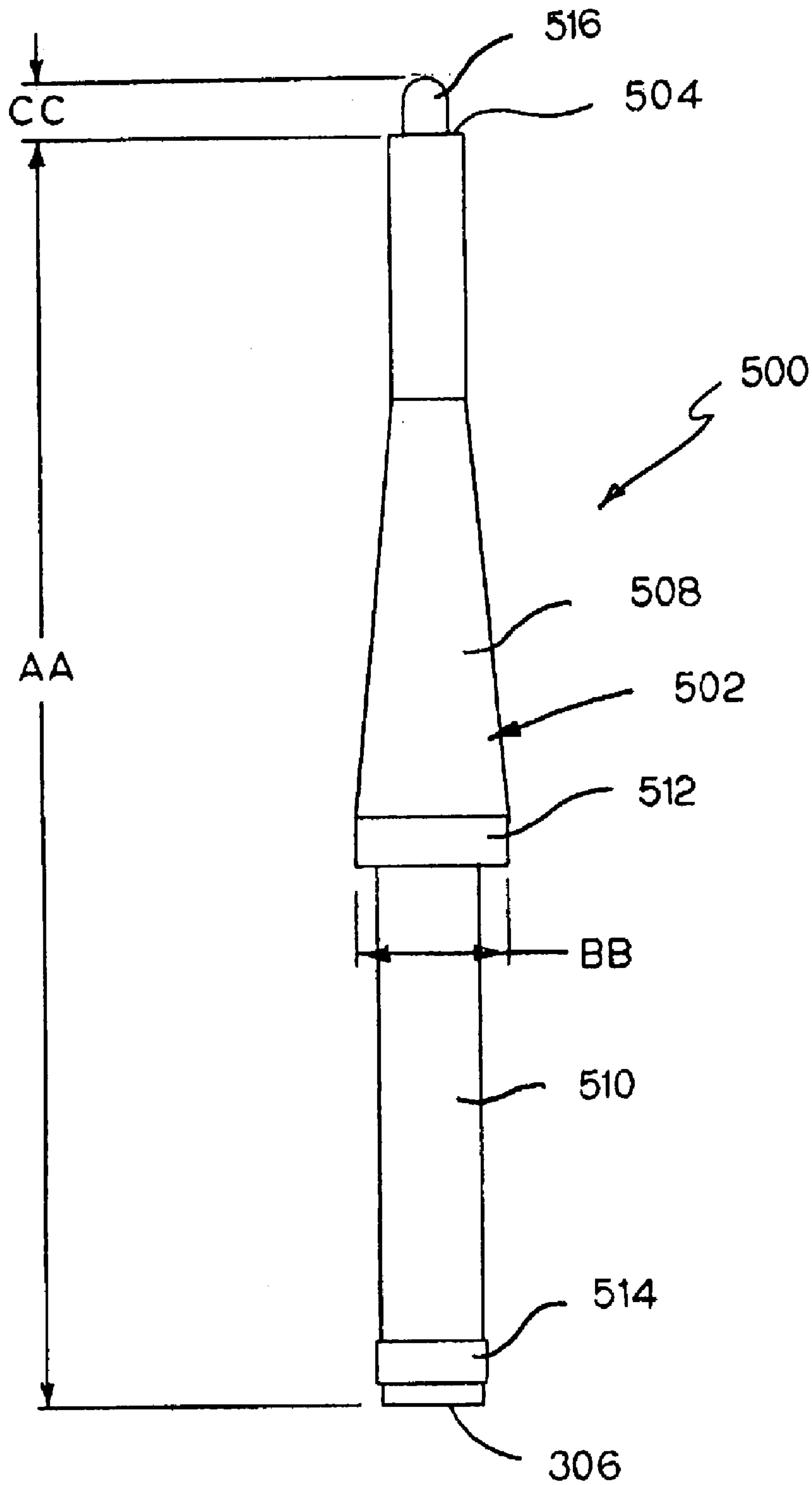

FIG. 12

CUTTING BIT USEFUL FOR IMPINGEMENT OF EARTH STRATA

BACKGROUND OF THE INVENTION

[0001] The present invention pertains to a cutting bit for impingement of earth strata. More specifically, the present invention pertains to a cutting bit for impingement of earth strata wherein the cutting bit, which exhibits excellent wear resistance and impact resistance, encounters less resistance and exhibits better rotational properties and longer useful tool life than prior cutting bits.

[0002] Heretofore, cutting bits (e.g., rotatable cutting bits) used for mining, trenching and construction applications including a road planing applications comprise an elongate steel cutting bit body. Such cutting bits also comprise a hard (e.g., cemented (cobalt) tungsten carbide) insert affixed to the axial forward end of the cutting bit body. The bore of a holder (or block) retains (in a rotatable fashion or in a non-rotatable fashion) the cutting bit at its axial rearward end. During operation such as, for example, in a road planning application, a driven drum carries a plurality of holders, each of which in turn, carries a cutting bit. The drum drives the cutting bit into impingement with the earth strata (e.g., asphaltic material of a highway) thereby breaking or disintegrating the earth strata into pieces. Since the cutting bit, and especially the cutting bit body, experience severe forces, it is very desirable that the cutting bit body possess optimum properties (e.g., wear resistance and impact resistance) suitable to withstand such a severe operating environment for an acceptable duration.

[0003] Heretofore, the typical cutting bit body used in a cutting bit for mining and construction applications has an elongate steel body that presents a relatively wide collar wherein the collar is the portion of the cutting bit body that has the greatest transverse dimension. In the case of a cutting bit with a cutting bit body of a generally cylindrical geometry, the collar is the portion that has the greatest diameter. The collar is relatively wide because the cutting bit body must have a sufficient amount of strength (or impact resistance) and wear resistance.

[0004] While the cutting bits that have the wide collar function in a satisfactory fashion, there is a drawback with these cutting bits. This drawback is that the wide collar presents a greater volume or mass of material of the cutting bit that must pass through the earth strata. This results in an increase in the resistance the cutting bit encounters upon impingement of the earth strata. Such an increase in resistance results in an increase in energy necessary to break up the earth strata, which increases fuel consumption and overall operating costs, as well as decreases or reduces overall operational efficiency for the specific application. In the case of a road planing bit, the bit impinges roadway materials such as, for example, asphaltic material. Thus, it would be highly desirable to provide an improved cutting bit that does not encounter as much resistance upon impingement of the earth strata as earlier cutting bits. By providing such a cutting bit, the fuel consumption and overall operating costs will decrease and the overall operational efficiency will increase.

[0005] As mentioned above, a cutting bit with a wider profile encounters more resistance upon impingement of the earth strata. By encountering more resistance, the cutting bit exhibits a higher rate of wear, which, in turn, causes the cutting bit to become blunter thereby reducing the overall cutting efficiency. An operator must replace more often cutting bits that experience a higher rate of wear as opposed to cutting bits that experience a lower rate of wear. In the case of a road planing application, and there can be a great amount of time spent to change out an entire set of road planing bits on a road planing drum. Thus, it would be highly desirable to provide a cutting bit that exhibits a slimmer profile thereby encountering less resistance upon impingement of the earth strata. Such a cutting bit with a slimmer profile would exhibit a lower rate of wear thereby taking a greater amount of time to become blunter, and hence, increase the overall operational efficiency of the cutting or mining or road planing operation in.

[0006] In a coal mining operation, it is most desirable if the coal is broken in to larger pieces or chunks. By doing so, fewer small particulates and fines such as, for example, coal dust, are generated during the coal mining operation. This is a desirable result since there is concern over the excessive generation of small particulates such as coal dust. In the case where the cutting bit presents a wider profile or geometry, there is the tendency for the cutting bit to pulverize the coal upon impingement, which generates small particulates. The use of a cutting bit with a wider profile results in a higher incidence of generating small particulates due to the increased resistance of the cutting bit impinging the substrate (e.g., vein of coal). Therefore, it would be highly desirable to provide an improved cutting bit that upon impingement of the earth strata (or substrate) does not result in the excessive generation of small particulates and fines such as, for example, coal dust. Further, it would be highly desirable to provide such an improved cutting bit that actually reduces the amount of small particulates and fines generated during a coal mining operation.

[0007] In the process of a cutting bit impinging the earth strata, it is desirable that the cutting bit exhibit acceptable strength or impact resistance and wear resistance. Impact resistance is desirable because the earth strata can be inconsistent in that it may contain hard anomalies. For example, in a mining operation the earth strata may contain rocks or the like in a formation of softer coal or minerals. In a road planing operation such as planing asphaltic roadway material, the cutting bits may impact a manhole cover or the life during the course of the planing operation. In a trenching operation, the cutting bits may encounter rocks or other very hard regions. Wear resistance is necessary because of the highly abrasive nature of the earth strata (e.g., asphaltic material).

[0008] During the process of a rotatable cutting bit impinging the earth strata, it is very beneficial that the rotatable cutting bit freely rotate about its central longitudinal axis. Free rotation about its central longitudinal axis maintains the geometric symmetry of the cutting bit about its central longitudinal axis, which typically results in a longer useful tool life. It would be highly desirable to provide an improved cutting bit that freely rotates about its central longitudinal axis. It would also be highly desirable to provide an improved cutting bit that possesses an inherent capability to rotate freely about its central longitudinal axis.

[0009] It is apparent that it would be very desirable to provide an improved cutting bit that encounters less resistance upon impingement of the earth strata, and yet exhibits acceptable strength or impact resistance and wear resistance. It is also apparent that it would be very desirable to provide an improved rotatable cutting bit that is freely rotatable to maintain its geometric symmetry about its central longitudinal axis. It is further apparent that it would be highly desirable to provide an improved cutting bit that exhibit an inherent capability to rotate freely about its longitudinal axis.

SUMMARY OF THE INVENTION

[0010] In one form thereof, the invention is a cutting bit for impinging earth strata. The cutting bit comprises a highly wear-resistant elongate cutting bit body that has an axial forward end and an axial rearward end, an enlarged dimension head portion at the axial forward end and a reduced dimension shank portion at the axial rearward end. The highly wear-resistant elongate cutting bit body has a maximum transverse dimension and a longitudinal axial length. The cutting bit has a superhard insert affixed to the head portion at the axial forward end of the cutting bit body. The cutting bit exhibits a slimness ratio comprising the ratio of the maximum transverse dimension to the longitudinal axial length wherein the slimness ratio ranging between about 0.15 and about 0.60.

[0011] In another form thereof, the invention is a cutting bit for impinging earth strata. The cutting bit comprises a highly wear-resistant elongate cutting bit body that has an axial forward end and an axial rearward end, an enlarged dimension head portion at the axial forward end and a reduced dimension shank portion at the axial rearward end. At least a part of the highly wear-resistant elongate cutting bit body comprises a hard component-matrix composite material to provide wear resistance. The cutting bit has a hard insert affixed to the head portion at the axial forward end of the cutting bit body.

[0012] In yet another form thereof, the invention is a cutting bit for impinging earth strata. The cutting bit comprises a highly wear-resistant elongate cutting bit body that has an axial forward end and an axial rearward end, an enlarged dimension head portion at the axial forward end and a reduced dimension shank portion at the axial rearward end. The highly wear-resistant elongate cutting bit body has a maximum transverse dimension and a longitudinal axial length. The highly wear-resistance cutting bit body comprises a substrate, and at least a part of the substrate has a hardfacing layer thereon. The cutting bit has a hard insert affixed to the head portion at the axial forward end of the cutting bit body. The cutting bit exhibits a slimness ratio that comprises the ratio of the maximum transverse dimension to the longitudinal axial length wherein the slimness ratio ranges between about 0.15 and about 0.25.

[0013] In still another form thereof, the invention is a cutting bit for impinging earth strata. The cutting bit comprises a highly wear-resistant elongate cutting bit body that has an axial forward end and an axial rearward end, an enlarged dimension head portion at the axial forward end and a reduced dimension shank portion at the axial rearward end. The highly wear-resistant elongate cutting bit body carries a wear rotator to provide wear resistance. The cutting bit has a hard insert affixed to the head portion at the axial forward end of the cutting bit body.

[0014] In another form thereof, the invention is a cutting bit for impinging earth strata. The cutting bit comprises a highly wear-resistant elongate cutting bit body that has an axial forward end and an axial rearward end, an enlarged dimension head portion at the axial forward end and a reduced dimension shank portion at the axial rearward end. The highly wear-resistant elongate cutting bit body has a maximum transverse dimension and a longitudinal axial length. The cutting bit has a hard insert affixed to the head portion at the axial forward end of the cutting bit body. The cutting bit has a slimness ratio comprising the ratio of the maximum transverse dimension to the longitudinal axial length wherein the cutting bit exhibits a slimness ratio ranging between about 0.15 and about 0.25.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The following is a brief description of the drawings that form a part of this patent application:

[0016] FIG. **1** is a side view (with a portion of the cutting bit body broken away) of a first specific embodiment of a rotatable cutting bit of the invention that comprises an elongate cutting bit body, which comprises in its entirety a hard component-matrix material, wherein a hard insert affixes to the cutting bit body and wherein there is shown the ratio of the maximum transverse dimension (E) to the longitudinal axial length (B);

[0017] FIG. **2** is a side view (with a portion of the cutting bit body broken away) of a second specific embodiment of a rotatable cutting bit of the invention wherein the cutting bit body comprises a head portion made from a hard component-matrix composite material and a shank portion made from steel and a hard insert, which is a serrated-style of cutting insert, affixes within a socket in the head portion;

[0018] FIG. **2**A is a cross-sectional view of the axial forward end of the cutting bit body of FIG. **2** showing the generally cylindrical socket that receives the hard insert;

[0019] FIG. **2**B is a cross-sectional view of the intersection between the axial rearward portion and the axial forward portion of the cutting bit of FIG. **2** showing the saw-tooth geometry of the contact area (or intersection) between these components;

[0020] FIG. **3** is a side view (with a portion of the cutting bit body broken away) of a third specific embodiment of a rotatable cutting bit of the invention wherein the cutting bit body comprises an axial forward portion made of a hard component-matrix composite material and an integral head and shank portion made of steel, which carries a long resilient retainer-washer assembly (the washer is shown in a non-operative position by solid lines and in an operative position by broken lines), and wherein a plug-style of hard insert affixes to the axial forward portion;

[0021] FIG. **3**A is a cross-sectional view of the intersection between the axial rearward portion and the axial forward portion of the cutting bit of FIG. **3** showing the sinusoidal geometry of the contact area (or intersection) between these components;

[0022] FIG. **4** is a side view (with a portion of the cutting bit body broken away) of a fourth specific embodiment of a rotatable cutting bit of the invention comprising a cutting bit body, which comprises a steel portion and a hard component-matrix composite portion, that includes an axial forward head portion that contains a plurality of generally cylindrical hard rotator wear members wherein a flat-bottom style of hard insert affixes to the cutting bit body;

[0023] FIG. **5** is a side view (with a portion of the cutting bit body broken away) of a fifth specific embodiment of a rotatable cutting bit of the invention comprising a cutting bit body, which comprises a steel body with a hardfacing deposit, that includes an axial forward head portion that contains a plurality of generally triangular hard rotator wear members wherein a hard insert affixes to the cutting bit body;

[0024] FIG. **6** is a side view (with a portion of the cutting bit body broken away) of a sixth specific embodiment of a rotatable cutting bit of the invention comprising a cutting bit body, which is made entirely of steel, that includes an axial forward head portion that contains a plurality of generally rectangular hard rotator wear members wherein a valve-seat style of hard insert affixes to the cutting bit body;

[0025] FIG. 6A is a cross-sectional view of cutting bit of FIG. **6** taken along the section line **6**A-**6**A in FIG. **6**;

[0026] FIG. **6**B is a portion of the cross-sectional view FIG. **6**A illustrated the joint between the steel bit body and one of the rotator wear members wherein the steel bit body has experienced wear during the operation;

[0027] FIG. **7** is a side view (with a portion of the coating layer broken away) of a seventh specific embodiment of a rotatable cutting bit body of the invention comprising an elongate cutting bit body made from steel with a coating layer of a hard component-matrix material on the head portion of the cutting bit body and wherein there is shown the ratio of the maximum transverse dimension (I) to the longitudinal axial length (M);

[0028] FIG. **8** is a side view (with a portion of the cutting bit body broken away) of an eighth specific embodiment of a rotatable cutting bit of the invention having an elongate cutting bit body made of steel and presenting a mediate wear region and wherein a hard insert affixes within the socket of the cutting bit body;

[0029] FIG. **9** is an isometric view of a ninth specific embodiment of a cutting bit of the invention having a cutting bit that carries a mediate wear member and wherein a hard insert affixes within the socket of the cutting bit body;

[0030] FIG. **10** is a side view of the specific embodiment of the rotatable cutting bit of FIG. **9** with the cutting bit body shown in cross-section;

[0031] FIG. **11** is a side view of a tenth specific embodiment of a cutting bit of the invention with the cutting bit body and mediate wear region shown in cross-section and wherein a polycrystalline diamond (PCD) hard insert affixes within a socket of the cutting bit body;

[0032] FIG. **11**A is a cross-sectional view of the hard insert from the tenth specific embodiment of FIG. **11** showing the polycrystalline diamond region and the cemented carbide backing region of the hard insert; and

[0033] FIG. **12** a side view of another specific embodiment of a highly wear-resistant cutting bit body wherein the slimness ratio is about 0.150.

DETAILED DESCRIPTION

[0034] Referring to the drawings, FIG. **1** illustrates a first specific embodiment of a rotatable cutting bit of the invention for impinging the earth strata, wherein the cutting bit is generally designated as **20**. Here, earth strata refers to a wide variety of substrate-type materials upon which the cutting bit impinges thereby breaking earth strata into pieces. The specific earth strata can vary depending upon the particular application. For example, in a mining application, earth strata may comprise the mined material such as coal or the like. In a trenching application, earth strata may comprise dirt and in some cases concrete. In a road planing application, earth strata may comprise the roadway materials such as, for example, asphaltic roadway material and concrete roadway material. In addition, there is the contemplation that the rotatable cutting bits of the invention are useful in foundation drilling, rock cutting, and drilling for oil and/or gas deposits. Further, although the specific embodiments illustrated herein comprise a rotatable cutting bit, there is the contemplation that the invention has application and includes non-rotatable cutting bits in that these bits do not rotate about their central longitudinal axis during operation.

[0035] The rotatable cutting bit **20**, which has an overall axial length equal to dimension A-I, and comprises an elongate cutting bit body **22**, which is a highly wear-resistant cutting bit body, that has a central longitudinal axis A-A about which the cutting bit **20** rotates during operation. The cutting bit body **22** has an axial forward end **24** and an opposite axial rearward end **26**. There is an enlarged dimension head portion (see bracket **30**) at the axial forward end **24** and a reduced dimension shank portion (see bracket **32**) at the axial rearward end **26**. In this specific embodiment, the highly wear-resistant elongate cutting bit body **22** is made of a hard component-matrix composite material. However, as an alternative, the cutting bit body maybe made of any one of a cemented carbide or a substrate with a coating layer wherein the coating layer being a material selected from the group consisting of hardfacing including hardfacing applied by a plasma transferred arc process, polycrystalline diamond, diamond (e.g., a CVD diamond film), cubic boron nitride, and polycrystalline cubic boron nitride.

[0036] One should appreciate that a highly wear-resistant elongate cutting bit body exhibits a wear resistance greater than the wear resistance of a cutting bit body made from steel compositions typically used heretofore to make cutting bit bodies.

[0037] Cutting bit body **22** further contains at its axial forward end **24** a valve seat-style socket **34** adapted to receive a hard insert **40** so that the hard insert **40** affixes to the head portion **30** at the axial forward end **24** of the cutting bit body **22**. Although the hard insert **40** will be described in more detail hereinafter, the hard insert can be made from material selected from the group including a hard component-matrix composite material, and a substrate with a coating layer wherein the coating layer being a material selected from the group consisting of hardfacing including hardfacing applied by a plasma transferred arc process, polycrystalline diamond (PCD), diamond, cubic boron nitride, and polycrystalline cubic boron nitride (PcBN). The hard insert may also be made from other hard materials known to those in the art to be suitable to function as a hard insert in a cutting bit. There should be an appreciation at the above materials are also suitable for use as the hard insert (or superhard insert) in other specific embodiments disclosed herein. There should also be an appreciation that some of the materials are what those skilled in the art consider to be superhard materials. Superhard materials include polycrystalline diamond, diamond (e.g., a CVD diamond film), cubic boron nitride, and polycrystalline cubic boron nitride. A superhard insert is an insert made from a superhard material.

[0038] Shank portion **32** contains an annular groove **36** near the axial rearward end **26** of the cutting bit body **22** wherein the groove **36** is adapted to receive a resilient retainer **38**. When the cutting bit **20** is inserted into the bore of a holder or block (not illustrated) typically used to carry a cutting bit, the resilient retainer **38** expands in a radial outward direction to frictionally engage the wall of the bore and thereby rotatably retain the cutting bit within the bore. There should be an understanding that the cutting bit **20** may use other known ways to retain the cutting bit within the bore of the holder.

[0039] As disclosed by the broken away portion of the cutting bit body **22** adjacent to the axial forward end **24** thereof, all of the elongate cutting bit body **22** is made of a hard component-matrix composite material. The hard component-matrix composite material is disclosed in U.S. Pat. No. 6,984,454 to Majagi entitled WEAR-RESISTANT MEMBER HAVING A HARD COMPOSITE COMPRISING HARD CONSTITUENTS HELD IN AN INFILTRANT MATRIX, that is assigned to Kennametal Inc., and is hereby incorporated in its entirety by reference herein. Although it will become apparent from the description hereinafter, it is contemplated that as an alternative, only a portion of the cutting bit body rather than the entire cutting bit body could be made of the hard component-matrix composite material. Further, there should be an appreciation that reference to the term hard component-matrix composite material (or a like term) refers to the material disclosed and described in U.S. Pat. No. 6,984,454 to Majagi.

[0040] Although more specific compositions are set forth below and in U.S. Pat. No. 6,984,454, the hard component-matrix composite material comprises a plurality of discrete hard constituents and matrix powder of hard particles and an infiltrant alloy bonded together to form the hard component-matrix composite. A more detailed description of the hard constituents, the matrix powder and the infiltrant alloy is set forth hereinafter.

[0041] In reference to the geometry of the cutting bit body **22** as illustrated in FIG. **1**, the axial length of the entire cutting bit body is equal to the dimension "B". The axial length of the head portion **30** is equal to dimension "C" and the axial length of the shank portion **32** is equal to dimension "D". The head portion **30** presents a generally frusto-conical shape wherein the minimum transverse dimension (or diameter) is equal to dimension "F" and the maximum transverse dimension (or diameter) is equal to dimension "E". The maximum transverse dimension of the head portion **30** exists at the collar **42** of the cutting bit body **22**. The transverse dimension of the head portion **30** gradually increases in the axial rearward direction at an angle equal to dimension "H" and a fillet transitions the frusto-conical surface into the collar **42**. The transverse dimension (or diameter) of the shank portion **32** is constant and is equal to dimension "G". Table A below sets forth selected dimensions and ranges of dimensions from the specific embodiment of the cutting bit **20** illustrated in FIG. **1**.

TABLE A

Selected Dimensions and Ranges of Dimensions for Cutting Bit 20

Dimension & Description	Preferred Dimension (millimeters unless otherwise noted)	Preferred Range for Dimension (millimeters unless otherwise noted)
A-1 - axial length of entire cutting bit 20	234	200-260
B-1 height of hard insert from axial end of the cutting bit body	15.75	10-20
B - axial length of cutting bit body	218.25	180-240
C - axial length of head portion	86.25	75-95
D - axial length of shank portion	132	120-145
E - maximum transverse dimension of head portion 30	64	50-70
F - minimum transverse dimension of head portion 30	30	20-40

TABLE A-continued

Selected Dimensions and Ranges of Dimensions for Cutting Bit 20

Dimension & Description	Preferred Dimension (millimeters unless otherwise noted)	Preferred Range for Dimension (millimeters unless otherwise noted)
G - transverse dimension of shank portion 32	35	25-45
H - angle of decrease of transverse dimension of head portion 30	5 degrees	2 degrees to 8 degrees
E/B ratio (slimness ratio)	0.29	0.26-0.32
E/A ratio	0.27	0.26-0.28

[0042] Based upon the above dimensions, there should be an appreciation that the ratio between the maximum transverse dimension of the head portion to be axial length of the cutting bit body (E/B) can vary within a specified range. More specifically, one preferred range for the ratio E/B is between about 0.26 and about 0.32. A specific value for the ratio E/B is 0.29. However, there should be an appreciation that the E/B slimness ratio could range between about 0.150 to about 0.600. There is the contemplation that the slimness ratio could be between about 0.150 and about 0.250 and between about 0.150 and about 0.200.

[0043] One can see that the specific embodiment of the cutting bit as illustrated in FIG. **1** is a cutting bit for impinging earth strata wherein the cutting bit comprises a highly wear-resistant elongate cutting bit body, which has an axial forward end and an axial rearward end. The cutting bit body has an enlarged dimension head portion at the axial forward end and a reduced dimension shank portion at the axial rearward end. Here, there should be an appreciation that essentially all of the highly wear-resistant cutting bit body is made from the hard component-matrix composite material to provide wear-resistance. When the insert is made from a superhard material, there is a superhard insert, which is affixed to the head portion at the axial forward end of the cutting bit body. The superhard insert may be made from a material different than the material of the cutting bit body. The cutting bit has a slimness ratio, which is the ratio of the maximum transverse dimension to the longitudinal axial length. The slimness ratio can range between about 0.150 to about 0.600.

[0044] Table B sets forth dimensions along the line of the dimensions in Table A, except that the cutting bits pertain to a construction tool and a trenching tool. The construction tool cutting bit body is a model RZ25 construction tool made and sold by Kennametal Inc. of Latrobe, Pa. 15650. The trenching cutting bit body is a model TS2 trenching tool made and sold by Kennametal Inc. of Latrobe, Pa. 15650.

TABLE B

Selected Dimensions and Ranges of Dimensions for a Typical Construction Tool and a Typical Trenching Tool

Dimension & Description	Construction Tool - Preferred Dimension (millimeters unless otherwise noted)	Trenching Tool - Preferred Dimension (millimeters unless otherwise noted)
A-1 - axial length of entire cutting bit	88.6	167

TABLE B-continued

Selected Dimensions and Ranges of Dimensions for a Typical Construction Tool and a Typical Trenching Tool

Dimension & Description	Construction Tool - Preferred Dimension (millimeters unless otherwise noted)	Trenching Tool - Preferred Dimension (millimeters unless otherwise noted)
B-1 height of hard insert from axial end of the cutting bit body	19	—
B - axial length of cutting bit body	69.6	159.6
C - axial length of head portion	29.9	82
D - axial length of shank portion	39.7	77.6
E - maximum transverse dimension of head portion	38.1	63.5
F - minimum transverse dimension of head portion	24	15.7
G - transverse dimension of shank portion	19.9	26.8
H - angle of decrease of transverse dimension of head portion	—	6 degrees
E/B ratio	0.55	0.40
E/A ratio	0.43	0.38

[0045] Referring to FIG. **2**, there is illustrated a second specific embodiment of a rotatable cutting bit for impinging earth strata wherein the cutting bit is generally designated as **50**. Cutting bit **50** has a cutting bit body generally designated as **52** and which has an axial rearward portion **54** and an axial forward portion **64**. In this specific embodiment, the axial rearward portion **54** is made of steel and the axial forward portion **64** is made of the hard component-matrix composite material. One should appreciate that instead of comprising the hard component-matrix composite material, the axial forward portion **64** may comprise a wear-resistant steel material. One should further appreciate that the axial rearward portion **54** and that the axial forward portion **64** may comprise steel of the same composition or of different compositions. Typically, in the case where the axial or portion **64** comprises of steel, such steel would be more wear-resistant than the steel comprising the axial rearward portion **54**.

[0046] The axial rearward portion **54** has an axial forward end **56** and an axial rearward end **58**. The axial rearward portion **54** contains an annular groove **60** adjacent to the axial rearward end **58**, as well as a conically-shaped portion **62** adjacent to the axial forward end **56**. One should appreciate that the geometry of the axial forward end **56** of the axial rearward portion **54** may be something other than of a conical geometry. For example, the geometry of the axial forward and **46** may be dendritic, planar, or non-planar wherein the objective is to increase the amount of surface area over which the axial rearward portion **54** contacts the axial forward portion **64**. Typically, in the case when an infiltration method is utilized to bonded together these two components, the bonding strength increases with an increase in the surface area over which the two components are in contact. A resilient retainer **63** is within the groove **60**. Resilient retainer **63** functions in a fashion like that of retainer **38**.

[0047] The axial forward portion **64** has an axial forward end **66** and an axial rearward end **68**. The axial forward portion **64** contains a cylindrical socket **72** at the axial forward end **66** and a conically-shaped socket **70** at the axial rearward end **68**. A hard insert **73**, which can comprise a superhard material such as, for example, polycrystalline diamond, polycrystalline cubic boron nitride, contains an axial forward conical portion **74** and an axial rearward cylindrical portion, which presents a plurality of radially projecting axial serrations **75**. The hard insert **73** affixes within the cylindrical socket by press fitting wherein the tool body surrounding the socket **72** deforms upon entry of the hard insert **73** into the socket **72** to frictionally retain the insert in the socket. However, there should be an appreciation that other methods could affix the hard insert **73** within the socket **72** wherein these other methods can include without limitation brazing, gluing and shrink fitting. Further, even though in this specific embodiment insert **73** projects past the axial forward end **66**, there should be an appreciation that the insert **73** may be flush with the surface of the axial forward end **66**. In addition, there should be an appreciation that the shape of the hard insert **73** could take on any one of a number of different geometries. For example, rather than the axial forward portion of the hard insert **73** being generally conical, it could present a geometries such as shown by hard insert **134** in FIG. **4**.

[0048] The conical socket **70** in the axial forward portion **64** receives the conical portion **62** of the axial rearward portion **54** so that the axial forward portion **64** affixes by brazing or the like to the axial rearward portion **54**. There should be an appreciation that other methods could affix the axial forward portion **64** to the axial rearward portion **54** wherein these other methods can include without limitation gluing, press fitting, shrink fitting and other mechanical means. In addition, an infiltration process such as disclosed in U.S. Pat. No. 6,984,454 to Majagi is appropriate to use to affix together the axial forward portion **64** to the axial rearward portion **54**. In such an arrangement, one could position the steel axial rearward portion **54** in a mold and position the components of the hard component-matrix composite about the conical portion **62** of the axial rearward portion **54** and then infiltrate the same so as to metallurgically join the axial forward portion **64** to the axial rearward portion **54**.

[0049] Referring to FIG. **2B**, the interface generally designated as **71** is between the axial forward portion **64** and the axial rearward portion **54**. The interface **71** presents a non-planar surface in the form of a saw-tooth configuration. Such a geometry provides a non-planar surface area at the interface.

[0050] One can appreciate that the specific embodiment of the cutting bit as illustrated in FIG. **2** is a cutting bit for impinging earth strata wherein the cutting bit comprises a highly wear-resistant elongate cutting bit body having an axial forward end and an axial rearward end. There is an enlarged dimension head portion at the axial forward end and a reduced dimension shank portion at the axial rearward end. There is a superhard insert affixed to the head portion at the axial forward end of the cutting bit body. The superhard insert being made from a material different than the material of the cutting bit body. The highly wear-resistant elongate cutting bit body includes at the axial forward end thereof an axial forward portion of the cutting bit body made of a material selected from the group consisting of a hard component-matrix composite material, a cemented carbide, and a substrate with a coating layer wherein the coating layer selected from the group consisting of hardfacing including hardfacing applied by a plasma transferred arc process, polycrystalline diamond, and cubic boron nitride.

[0051] Referring to FIG. **3**, there is illustrated a rotatable cutting bit for impinging earth strata wherein the cutting bit is generally designated as **80**. Cutting bit **80** has a cutting bit body generally designated as **82** and which comprises an axial rearward portion **84** and an axial forward portion **100**. The axial rearward portion **84** is made from steel and the axial forward portion **100** is made from the hard component-matrix composite material of U.S. Pat. No. 6,984,454 to Majagi.

[0052] The axial rearward portion **84** has an axial forward end **86** and an axial rearward end **88**. Axial rearward portion **84** has a head portion **94** with an enlarged diameter collar and a reduced diameter shank portion **87**. The axial rearward portion **84** contains an annular groove **95** in the shank **87** adjacent to the axial rearward end **88**. The axial rearward portion **84** contains a large diameter socket **90** in the axial forward end **86** thereof. A small diameter socket **92** is in the bottom surface of the large diameter socket **90**. A resilient long retainer **96** is carried within the groove **95**. Retainer **96** functions in a fashion generally like retainer **38** in that it expands in a radial outward direction to frictionally engage the wall of the bore in the holder.

[0053] The assembly further includes a washer **98** wherein FIG. **3** illustrates the washer in an inoperative position by solid lines and in an operative position by broken lines. Very briefly, prior to insertion of the shank of the cutting bit into the bore of the holder, the washer surrounds the retainer. Upon the insertion of the shank into the bore, the washer contacts the forward surface of the holder and the washer travels in an axial forward direction along the retainer. Once the shank of the cutting bit is fully within the bore, the washer is sandwiched between the rearward surface of the collar and the forward surface of the holder.

[0054] The axial forward portion **100** has an axial forward end **102** and an axial rearward end **104**. The axial forward portion **100** contains a cylindrical socket **106** at the axial forward end **102**. A generally cylindrical post **108** projects from the axial rearward end **104**. A plug-style hard insert **109**, which can comprise a superhard material such as, for example, polycrystalline diamond, polycrystalline cubic boron nitride, affixes by brazing or the like (or in the alternative can be affixed by methods that include without limitation gluing, press fitting, shrink fitting and other mechanical means) within the cylindrical socket **106**. The sockets **90** and **92** in the axial rearward portion **84** receive the axial forward portion **100** (including the post **108** being received within the socket **92**) so that the axial forward portion **100** affixes by brazing or the like (or in the alternative can be affixed by methods that include without limitation gluing, press fitting, shrink fitting and other mechanical means) to the axial rearward portion **84**. There should be an appreciation that an infiltration process such as disclosed in U.S. Pat. No. 6,984,454 to Majagi is appropriate to use to affix together these components. In such an arrangement, one can position the steel component (i.e., the axial rearward portion **84**) in a mold, and then position the components of the hard component-matrix composite that form the axial forward potion **100** about the steel component and infiltrate the same thereby metallurgically joining the components (i.e., axial rearward portion **84** and axial forward portion **100**) together.

[0055] FIG. **3**A illustrates the joinder between axial forward portion **100** and cutting bit body **82**. The area of the joinder between these components is generally designated as **111**. As can be seen, the area of joinder **111** presents a non-planar surface in the form of a sinusoidal shape. Such a geometry provides a non-planar surface area at the interface.

[0056] Referring to FIG. **7**, there is illustrated a seventh specific embodiment of the rotatable cutting bit body generally designated as **200**. The cutting bit body **200** has an axial forward end **204** and an axial rearward end **206**. Cutting bit body **200** has an axial forward portion (see bracket **208**) adjacent the axial forward end **204** and an axial rearward portion (see bracket **210**) adjacent the axial rearward end **206**. Although not illustrated, the axial forward portion contains socket adapted to receive a hard insert. The axial rearward portion **210** contains an annular groove that receives a resilient retainer **216** in a fashion like that of retainer **38** in FIG. **1**. There is a coating **212** on the generally frusto-conical surface **214** of the axial forward portion **208**. In this embodiment, the coating is made of the hard component-matrix composite material as disclosed by U.S. Pat. No. 6,984,454 to Majagi; however, it is contemplated that the coating could comprise a material selected from the group consisting of hardfacing, polycrystalline diamond, cubic boron nitride, and PTA. In the case where the exterior region is the hard component-matrix composite material, the infiltration method of U.S. Pat. No. 6,984,454 to Majagi could be used to make the cutting bit body.

[0057] In reference to the geometry of the cutting bit body **200**, the axial length of the entire cutting bit body is equal to the dimension "I". The axial length of the axial forward portion **208** is equal to the sum of the dimension "J" and "K" and the axial length of the axial rearward portion **210** is equal to dimension "L". The axial forward portion **208** presents a generally frusto-conical shape wherein the minimum transverse dimension (or diameter) is equal to dimension "N" and the maximum transverse dimension (or diameter) is equal to dimension "M". The maximum transverse dimension of the axial forward portion **208** exists at the collar of the cutting bit body. A fillet provides a transition between the frusto-conical surface and the collar. The transverse dimension of the axial forward portion gradually increases in the axial rearward direction at an angle equal to dimension "S". The transverse dimension (or diameter) of the axial rearward portion **210** is constant and is equal to dimension "O". Table B below sets forth selected dimensions and ranges of dimensions from the specific embodiment of the cutting bit body **200**.

TABLE B

Selected Dimensions and Ranges of Dimensions for Cutting Bit Body 200

Dimension & Description	Preferred Dimension (millimeters unless otherwise noted)	Preferred Range for Dimension (millimeters unless otherwise noted)
I - axial length of entire cutting bit body	218.25	210-240
J - axial length of head portion forward of the collar	73.25	60-85
K - axial length of the collar	13	5-20
L - axial length of axial rearward portion 210	132	115-145
M - maximum transverse dimension of axial forward portion 208	64	50-75
N - minimum transverse dimension of axial forward portion 208	30	20-40

TABLE B-continued

Selected Dimensions and Ranges of Dimensions for Cutting Bit Body 200

Dimension & Description	Preferred Dimension (millimeters unless otherwise noted)	Preferred Range for Dimension (millimeters unless otherwise noted)
O - transverse dimension of axial rearward portion 210	35	25-45
S - angle at which transverse dimension of axial forward portion gradually increases in the axial rearward direction	5 degrees	2 degrees to 8 degrees

[0058] Based upon the above dimensions, there should be an appreciation that the ratio between the maximum transverse dimension of the head portion to be axial length of the cutting bit body (M/I) can vary within a specified range. More specifically, the specific ratio M/I is 0.325. One preferred range of M/I is between about 0.250 and about 0.450. There is the contemplation that the M/I ratio can range between as low as about 0.150 to as high as about 0.600. There is the expectation that an especially preferred range of M/I is between about 0.150 and about 0.250 with an even more preferred range between about 0.150 and about 0.200.

[0059] In reference to the specific embodiment illustrated by FIGS. **1**, **2**, **3** and **7**, the hard component-matrix composite material exhibits impact resistance and wear resistance properties that are better than steels commonly used to make the cutting bit bodies. Thus, by using the hard component-matrix composite material (or other hard materials disclosed above), overall geometry of the cutting bit body of the cutting bit is slimmer than the geometry of earlier cutting bits. By providing a geometry or profile that is slimmer, the cutting bit encounters less resistance when impinging the earth strata. The cutting bit thus overcomes drawbacks of earlier cutting bits that have a wide collar. By decreasing the amount of resistance the cutting bit encounters upon impingement of the earth strata, there is a decrease in the energy necessary to break up the earth strata, which decreases fuel consumption and decreases overall operating costs. By providing a geometry or profile that is slimmer, there is an overall increase in operational efficiency.

[0060] Referring to FIG. **4**, there is illustrated a fourth specific embodiment of a rotatable cutting bit generally designated as **110**. Cutting bit **110** has a cutting bit body **112** with an axial forward end **114** and an axial rearward end **116**. The cutting bit body **112** has an axial rearward portion **129** made of steel joined at the intersection or interface **127** to in axial forward portion **125** made of a hard component-matrix composite material. The interface **127** presents a saw-tooth geometry. Cutting bit **110** has a central longitudinal axis P-P. Cutting bit body **112** has an enlarged dimension head portion (see bracket **118**) and a reduced dimension shank portion (see bracket **120**). The reduced to dimension shank portion **120** is integral with the axial rearward portion of the head portion **118**. The axial forward portion **125** contains a flat bottom style socket **124** at the axial forward end **114** of the cutting bit body **112**. The socket **124** is adapted to receive a hard insert wherein hard insert **134**, which can comprise a superhard material such as, for example, polycrystalline diamond, polycrystalline cubic boron nitride, affixes by brazing or the like (or in the alternative can be affixed by methods that include without limitation gluing, press fitting, shrink fitting and other mechanical means) within the socket **124**. Methods like brazing and gluing use an attachment material such as, for example, a braze alloy or glue, to attach the wear rotator to the cutting bit body. Methods like press-fitting in shrink-fitting do not use an attachment material to attach the wear rotator to the cutting bit body. The means to attach the wear rotators in the embodiment of FIG. **4** are applicable to the embodiments of FIGS. **5** and **6**. There should be an appreciation that, as an alternative, the axial rearward cylindrical portion of hard insert **134** could present serrations like such as, for example, serrations **75** in the hard insert **73** of cutting bit **50** as illustrated in FIG. **2**.

[0061] The shank portion **120** contains a groove **130** that receives a resilient retainer **132**. Retainer **132** functions like the retainer **38** of the first specific embodiment of the cutting bit **20**.

[0062] Head portion **118** contains a plurality of recesses **126** that are generally cylindrical in shape. Recesses **126** exhibit a somewhat random orientation; however, recesses **126** may exhibit a specific intentional pattern to provide specific wear properties or characteristics. A cylindrical discrete rotator wear member **128** affixes by brazing or the like (or in the alternative can be affixed by methods that include without limitation gluing, press fitting, shrink fitting and other mechanical means) into each one of the recesses **126**. In this embodiment, a portion of the surface of each one of the discrete rotator wear members **128** extends past the surface of the head portion **118** so as to present an exposed rotator (or side or lateral) surface. There should be an appreciation and that the discrete rotator wear members **128** may also be flush with the surface of the head portion **118** or, as an alternative, be recessed within the recesses **126** relative to the surface of the head portion **118**.

[0063] The discrete wear rotator members may be made of a hard material such as, for example, cemented (cobalt) tungsten carbide or the hard component-matrix composite material or cubic boron nitride, polycrystalline diamond material or polycrystalline cubic boron nitride. Further, there should be an appreciation that the discrete wear rotator members can comprise a volume or mass of hard coating (e.g., PCD) either on the surface or in the recesses or a weld bead either on the surface or in the recesses of the head portion **118**. The rotator wear members facilitate the rotation of the cutting bit about its central longitudinal axis and a description of this feature is set forth hereinafter.

[0064] Still referring to FIG. **4**, there is an appreciation that rotatable cutting bit **110** presents a cutting bit body that includes a portion of the hard component-matrix composite material and a portion of steel, a rotatable cutting bit further includes rotator wear members that are fixed to the cutting bit body.

[0065] Referring to FIG. **5**, there is illustrated a rotatable cutting bit generally designated as **140**. Cutting bit **140** has a cutting bit body **142** with an axial forward end **144** and an axial rearward end **146**, and a central longitudinal axis Q-Q. Cutting bit body **142** is made of steel. Cutting bit body **142** has an enlarged dimension head portion (see bracket **148**) and a reduced dimension shank portion (see bracket **150**). The head portion **148** contains a socket **154** at the axial forward end **144** of the cutting bit body **142**. The socket **154** is adapted to receive a hard insert wherein hard insert **164**, which can comprise a superhard material such as, for example, polycrystalline diamond, polycrystalline cubic boron nitride, affixes by brazing or the like (or in the alternative can be affixed by methods that include without limitation gluing, press fitting, shrink fitting and other mechanical means) within the socket **154**. The head portion **148** has a hardfacing deposit **157** thereon adjacent the axial forward end **144** thereof. The hardfacing can be applied by any conventional means including the plasma transferred arc method. The shank portion **150** contains a groove **160** that receives a resilient retainer **162**. Retainer **162** functions like the retainer **38** of the first specific embodiment of the cutting bit **20**.

[0066] Head portion **148** contains a plurality of recesses **156** that are generally triangular in shape. Recesses **156** exhibit an orientation comprising two rows about the circumference of the head portion **148**. However, as mentioned above, the recesses do not have to present a specific orientation in that the recesses can be randomly contained in the cutting bit or have an orientation that is asymmetric about the central longitudinal axis. There is the contemplation that the recesses may be in a helical or spiral orientation. A discrete rotator wear member **158** affixes by brazing or the like (or in the alternative can be affixed by methods that include without limitation gluing, press fitting, shrink fitting and other mechanical means) into each one of the recesses **156**. In this embodiment, a portion of the surface of the discrete rotator wear member **158** extends past the surface of the head portion **148** so as to present an exposed surface. Further, there should be an appreciation that the discrete wear rotator members can comprise a volume or mass of hard coating (e.g., PCD) either on the surface or in the recesses or a weld bead either on the surface or in the recesses of the head portion. The rotator wear members facilitate the rotation of the cutting bit about its central longitudinal axis and a description of this feature is set forth hereinafter. There is the expectation of an enhancement to the rotation of the cutting bit when the rotator wear members are in a helical or spiral arrangement.

[0067] Still referring to FIG. **5**, there is an appreciation that rotatable cutting bit **110** presents a cutting bit body that includes a portion of the hard component-matrix composite material and a portion of steel, a rotatable cutting bit further includes rotator wear members that are fixed to the cutting bit body.

[0068] Referring to FIG. **6**, there is illustrated a rotatable cutting bit generally designated as **170**. Cutting bit **170** has a cutting bit body **172** with an axial forward end **174** and an axial rearward end **176**. Cutting bit body **172** has an enlarged dimension head portion (see bracket **178**) and a reduced dimension shank portion (see bracket **180**). The head portion **178** contains a valve seat-style socket **184** at the axial forward end **174** of the cutting bit body **172**. The valve seat-style socket **184** is adapted to receive a hard insert wherein hard insert **194**, which can comprise a superhard material such as, for example, polycrystalline diamond, polycrystalline cubic boron nitride, affixes by brazing or the like (or in the alternative can be affixed by methods that include without limitation gluing, press fitting, shrink fitting and other mechanical means) within the socket **184**. The shank portion **180** contains a groove **190** that receives a resilient retainer **192**. Retainer **192** functions like the retainer **38** of the first specific embodiment of the cutting bit **20**.

[0069] Head portion **178** contains a plurality of recesses **186** that are generally rectangular in shape. Recesses **186** are oriented in a row about the circumference of the head portion **178**. A discrete rotator wear member **188** affixes by brazing or the like into each one of the recesses **186**. In this embodiment, a portion of the surface of the discrete rotator wear member **188** extends past the surface of the head portion **178** so as to present an exposed surface. Further, there should be an appreciation that the discrete wear rotator members can comprise a volume or mass of hard coating (e.g., PCD) either on the surface or in the recesses or a weld bead either on the surface or in the recesses of the head portion. The rotator wear members facilitate the rotation of the cutting bit about its central longitudinal axis and a description of this feature is set forth hereinafter.

[0070] In reference to the rotator wear members contained in the specific embodiments of FIGS. **4**, **5** and **6**, there should be an appreciation that the rotator wear members can take on most any one of a number of different geometries. The fact that the cutting bits of FIGS. **4**, **5** and **6** present wear members that exhibit specific geometries should not limit the scope of the invention to any specific geometry of rotator wear member. There should be an appreciation that the rotator wear members may be of most any size, shape, or orientation, as well as project in a radial outward direction the same or differing distances from the surface of the cutting bit or be embedded in the cutting bit body the same or differing depths. There should be an appreciation that the perimeter weighting can be symmetrical about the central longitudinal axis of the cutting bit or can be asymmetrical about the central longitudinal axis of the cutting bit.

[0071] Referring to FIG. **6**A, a left side rotator wear member **188**C (as viewed in FIG. **6**A) extends a radial distance "T" from the surface of the cutting bit body. A right side rotator wear member **188**A (as viewed in FIG. **6**A) extends a radial distance "U" from the surface of the cutting bit body. A comparison of these wear members **188**A and **188**C demonstrates that the wear members can extend or project in a radial outward direction differing distances from the surface of the cutting bit. Still referring to FIG. **6**A, the top wear member **188**B is embedded in the cutting bit body a depth "V" while the bottom wear member **188** is embedded into the cutting bit body a depth "W". A comparison of these wear members **188** and **188**B shows that the wear members can be embedded varying depths in the cutting bit body.

[0072] Referring to the specific embodiments illustrated in FIGS. **4**, **5** and **6**, the discrete rotator wear members facilitate the rotation of the cutting bit about its longitudinal axis during its operation via two fundamental ways. The first way has to do with the centrifugal force generated to the heavier perimeter weighting of the head portion of the cutting bit. The second has to do with the impingement of the debris upon the side or lateral surfaces of the discrete rotator wear members.

[0073] In reference to the centrifugal force generated to the heavier perimeter weighting of the head portion of the cutting bit, the discrete rotator wear members are at the periphery or perimeter of the head portion of the cutting bit. This is illustrated in FIG. **6**A, which is a cross-sectional view of the cutting bit of FIG. **6** taken along section line **6**A-**6**A. The orientation of the rotator wear members as shown in FIG. **6**A is representative of the other embodiments (i.e., cutting bits of FIGS. **4** and **5**) that have peripheral rotator wear members. In a typical case, the material for the rotator wear members is heavier (i.e., a greater density) than the material for the head portion. Thus, a plurality of the rotator wear members at the periphery of the head portion creates a heavier perimeter weighting of the head portion. Once the cutting bit has begun to rotate during operation, the heavier perimeter weighting of the head portion of the cutting bit create centrifugal forces and an inertia that facilitate the rotation of the cutting bit.

[0074] In reference to the impingement of the debris upon the side or lateral surfaces of the discrete rotator wear members, during operation, the cutting bit impinges the earth strata to break the earth strata into pieces. These pieces **200** impinge against the exposed surfaces (e.g., the side surfaces or lateral surfaces of the rotator wear members) **189** of the discrete rotator wear members **188** to facilitate the rotation of the cutting bit about its central longitudinal axis. FIG. **6**A shows this feature wherein debris **200** impinges against the exposed side surface **189** of the rotator wear member **188**. The force of the impinging material functions to help push or urge the cutting bit to rotate about its central longitudinal axis.

[0075] As the operation continues the head portion experiences abrasive wear to increase the amount of exposed surface of the discrete rotator wear members. This is shown in FIG. **6**B. FIG. **6**B illustrates that the joint between the bit body and the bottom rotator wear member after the bit body has experienced wear during operation. As is apparent from a comparison of FIGS. **6**A and **6**B, the amount of exposed side surface increases the effect of the debris **200** or pieces of earth strata impinging upon the exposed surface **189** increases (i.e., exerts a greater force from the impingement of debris **200** due to an increase in surface area) to better facilitate the rotation of the cutting bit.

[0076] It can thus be seen that each one of the cutting bits of FIGS. **4**, **5** and **6** provides a rotatable cutting bit with the capability to enhance the continual rotation thereof during use. The perimeter weighting (e.g., via the rotator wear members) provides an inertia that enhances the rotation of the cutting bit. The presence of the exposed surfaces of the wear members also enhances the rotation of the cutting bit during use. The discrete rotator members, which provide perimeter weighting and rotator surface area, result in beneficial features to the cutting bit. There should be an appreciation that the presence of grooves, and especially helical grooves, in the axial forward head portion of the cutting bit can enhance the continual rotation of the cutting bit during use. In this regard, the debris impinges against the surfaces that define the grooves. This impingement essentially helps drive or push the cutting bit to rotate.

[0077] Referring to FIG. **8**, there is illustrated an eighth specific embodiment of the rotatable cutting bit of the invention for impinging earth strata wherein the cutting bit is generally designated as **220**. Cutting bit **220** has a cutting bit body **222** with an axial forward end **224** and an axial rearward end **225**. Cutting bit body **222** has an axial forward portion (see bracket **226**) and an axial rearward portion (see bracket **228**). The axial forward portion **226** has a reduced diameter section **234** wherein the reduced diameter section **234** defines an interior surface **236** generally parallel to the central longitudinal axis T-T and a pair of opposite surfaces (i.e., a forward transverse surface **238** and a rearward transverse surface **240**) generally perpendicular to the central longitudinal axis T-T.

[0078] The cutting bit **220** further includes a mediate wear region generally designated as **244**. In this embodiment, the mediate wear region **244** includes an inner split ring **246** that has an interior surface **248** and an exterior surface **250**, as well as a forward surface **251**. The mediate wear region **244** further includes an outer split ring **252** that has an interior surface **254** and an exterior surface **256**, as well as a rearward surface **258**. These rings typically comprise two pieces.

[0079] When assembled to the cutting bit body, the inner ring **246** is closest to the reduced diameter section **234** so that the interior surface **248** contacts and affixes to the interior surface **236** of the reduced diameter section **234** and the forward surface **251** contacts and affixes to the forward transverse surface **238**. The interior surface **254** of the outer ring **252** contacts and affixes to the exterior surface **250** of the inner ring **246**, and the rearward surface **258** contacts and affixes to the rearward transverse surface **240**. These rings (**246**, **248**) affix to one another and the cutting bit body by brazing or the like (or in the alternative can be affixed by methods that include without limitation gluing, press fitting, shrink fitting and other mechanical means).

[0080] In this specific embodiment, the inner ring **246** is made of the hard component-matrix composite material and the outer ring **252** is made of steel. The inventors contemplate that the outer ring could be made of the hard component-matrix composite material and the inner ring could be made of steel. The inventors further contemplate that the inner and outer rings could be made of the hard component-matrix composite material of different compositions. There is the contemplation that a plasma transferred arc process can be useful to deposit hard material to form the inner ring **246**. The plasma transferred arc process is used to use a metallic coating to a substrate in order to prove its resistance against where and/or corrosion. During the process, metal powder is fed into a molten weld puddle generated by a plasma arc at a high temperature (e.g., 20,000° C.). An exemplary plasma transferred arc system is available through PLASMA Team Snc (see internet website: http://www.plasmateam.com).

[0081] There should be an appreciation that an infiltration process such as disclosed in U.S. Pat. No. 6,984,454 to Majagi is appropriate to use to affix together these rings. In such an arrangement, one can position the one of the rings in a mold, and then position the components of the hard component-matrix composite about the steel component and infiltrate the same thereby metallurgically joining the components together. Further, there should be an appreciation that the entire mediate wear region could be made of the hard component-matrix composite material using the infiltration techniques.

[0082] The axial rearward portion **228** contains a groove **230** that receives a resilient retainer **232**. Retainer **232** functions like the retainer **38** of the first specific embodiment of the cutting bit **20**.

[0083] Referring to FIGS. **9** and **10**, there is illustrated a rotatable cutting bit for impinging earth strata wherein the cutting bit is generally designated as **350**. Cutting bit **350** has a cutting bit body **352**. Cutting bit **350** has an axial forward portion **354**, a mediate wear region **356**, and axial rearward portion **358**. The axial forward portion **354** has an axial forward end **360** and an axial rearward end **362**. The axial forward portion **354** contains a socket **364** adapted to receive a hard insert wherein the hard insert **380** affixes to the axial forward portion **354** by brazing or the like (or in the alternative can be affixed by methods that include without limitation gluing, press fitting, shrink fitting and other mechanical means). The mediate wear region **356** has an axial forward end **366** and an axial rearward end **368**. The mediate wear region **356** contains a forward socket **370** at the axial forward end **366** thereof and a rear socket **372** at the axial rearward end **368** thereof. The axial rearward portion **358** has an axial forward end **376** and an axial rearward end **378**.

[0084] The socket **370** in the mediate wear region **356** receives the axial forward portion **354** and the socket **372** in the mediate wear region **356** receives the axial rearward portion **358**. The axial forward portion **354** and the axial rearward portion **358** each affix by brazing or the like (or in the alternative can be affixed by methods that include without limitation gluing, press fitting, shrink fitting and other mechanical means) to the mediate wear region **356**. Hot isostatic pressing (HIP) or rapid omnidirectional compaction (ROC) techniques can make the mediate wear region **356**. The mediate wear region **356** can comprise a hard material such as, for example, the hard component-matrix composite material and any one of the following materials: a matrix material (e.g., nickel steel) were in the hard components include cast carbides, spherical cast carbide, and macrocrystalline carbides. There is also the expectation that the hard components may comprise polycrystalline diamond.

[0085] Referring to FIG. **11**, there is illustrated a rotatable cutting bit for impinging earth strata wherein the cutting bit is generally designated as **290**. Cutting bit **290** has a cutting bit body **292**. Cutting bit **290** has an axial forward portion **294**, a mediate wear region **302**, and axial rearward portion **314**. The axial forward portion **294** has an axial forward end **295** and an axial rearward end that includes a projection **298**. The axial forward portion **294** contains a socket **296** adapted to receive a polycrystalline diamond (PCD) insert **297** wherein the hard insert **297** affixes to the axial forward portion **294** by brazing or the like (or in the alternative can be affixed by methods that include without limitation gluing, press fitting, shrink fitting and other mechanical means). There is the contemplation that the hard insert **297** may comprise cemented cobalt tungsten carbide. The mediate wear region **302** has an axial forward end **304** and a axial rearward end **306**. The mediate wear region **302** contains a forward socket **308** at the axial forward end **304** thereof and a rear socket **310** at the axial rearward end **306** thereof. The axial rearward portion **314** has an axial forward end **316** and an axial rearward end **318**.

[0086] The forward socket **308** in the mediate wear region **302** receives the axial forward portion and the rearward socket **310** in the mediate wear region receives the axial rearward portion. The axial forward portion and the axial rearward portion each affix by brazing or the like to the mediate wear region. There should be an appreciation that an infiltration process such as disclosed in U.S. Pat. No. 6,984,454 to Majagi is appropriate to use to affix together these components. In such an arrangement, one can position the steel component in a mold, and then position the components of the hard component-matrix composite about the steel component and infiltrate the same thereby metallurgically joining the components together.

[0087] In reference to the PCD insert **297**, it has an axial forward PCD region **330** of polycrystalline diamond material and a backing region **332** that provide support for the PCD region. The axial forward PCD region **330** presents a conical geometry. U.S. Pat. No. 6,344,149 to Oles, which is hereby incorporated by reference herein, discloses techniques to make the PCD insert. While most all of the axial forward PCD portion may comprise polycrystalline diamond, there should be an appreciation that the axial forward PCD region may comprise a conical backing with a layer of PCD thereon.

[0088] Referring to FIG. **12**, there is illustrated another specific embodiment of a rotatable cutting bit generally designated as **500**. Rotatable cutting bit **500** includes a highly wear-resistant cutting bit body generally designated as **502**, which has an axial forward end **504** and an axial rearward end **506**. The highly wear-resistant cutting bit body **502** has an axial length of dimension "AA". In this specific embodiment, highly wear-resistant cutting bit body **502** is made of the hard component-matrix composite material. However, there should be an appreciation that the highly wear-resistant cutting bit body **502** may comprises a hard material such as, for example, a cemented carbide. As another option, the highly wear-resistant cutting bit body **502** may comprise a substrate with a superhard coating layer, or in the alternative, the highly wear-resistant cutting bit body **502** may carry one or more wear rotators.

[0089] The highly wear-resistant cutting bit body **502** has an enlarged head portion **508** adjacent the axial forward end **504** thereof and a reduced shank portion **510** adjacent to the axial rearward end **506** thereof. A collar **512** separates the head portion **508** from the shank portion **510**. The collar **512** has a maximum transverse dimension "BB". The rotatable cutting bit **500** has a retainer **514** at the axial rearward end **506** of the highly wear-resistant cutting bit body **502**. The rotatable cutting bit **500** has a superhard insert **516** at the axial forward end **504** of the highly wear-resistant cutting bit body **502**. The superhard insert **516** extends a distance "CC" past the axial forward end **504** of the highly wear-resistant cutting bit body **502**. The slimness ratio of BB/AA, i.e., the ratio of the maximum transverse dimension to the axial length, is about 0.150.

[0090] There should be an appreciation that the cutting bit of the present invention provides an increase in useful tool life for a number of reasons. The use of a superhard material for the hard insert at the axial forward end of the cutting bit enhances the penetration of the cutting bit into the earth strata or substrate. This feature by itself increases the useful tool life of the cutting bit. The use of a cutting bit body that exhibits enhanced wear resistance lengthens the time the cutting bit body to maintain its structural integrity. Like for a hard insert comprising a superhard material, this feature by itself increases the useful tool life of the cutting bit.

[0091] The combination of the use of a superhard material for the hard insert in combination with a cutting bit body that exhibits enhanced wear resistance provides for an exceptional increase in the useful tool life of the cutting bit. More specifically, heretofore, the use of a superhard hard insert in connection with a conventional cutting bit body possesses the imitation that the useful life of the cutting bit body terminates prior to the termination of the useful life of the superhard insert. The typical consequences of the superhard insert, which still possesses useful tool life, becomes detached from the cutting bit body upon the cutting bit body wearing past its useful life. However, in the case of the combination of a superhard insert and a cutting bit body with enhanced wear resistance, the cutting bit body maintains its structural integrity thereby providing support to the superhard insert for a longer time. Thus, the termination of the useful life of the cutting bit body with enhanced wear resistance more closely matches the termination of the useful tool life of the superhard insert. The appropriation of the beneficial properties of the superhard insert and the cutting bit body with enhanced wear resistance results in a cutting bit exhibits enhanced useful tool life.

[0092] Some of the components of the cutting bits are made of steel. In reference to steel alloy compositions, the steel alloys listed in Table 1 are suitable for the manufacture of steel alloy components of cutting bits. While Table 1 lists suitable steel alloys, there should be appreciation that steel alloys other than those set forth in Table 1 below may be suitable for use in the manufacture of the cutting bit.

be crushed to obtain hard constituents wherein the hard constituents are crushed particles of a larger size wherein the particle size is measured by mesh size (e.g., −80+120 mesh).

TABLE 1

Steel Alloys (Weight Percent) Suitable for Manufacture of Components of Cutting Bits

Alloy	C %	Mn %	Ni %	Cr %	Mo %	S %	P %	Si %	Other %	Fe
15B37	0.30-0.39	1.00-1.50	—	—	—	0.03 max	0.03 max	.15-.35	B = .0005-.003	Balance
P/F 46XX	0.20-0.80	0.10-0.25	1.75-2.00	0.10 max	0.50-0.60	0.03 max	0.03 max	0.03 max	Cu = 0.15 max	Balance
4140	0.38-0.43	0.75-1.00	—	0.8-1.1	0.15-0.25	0.03 max	0.03 max	0.15-0.35	—	Balance
ASTM A231 A232	0.48-0.53	—	—	0.80-1.00	—	0.03 max	0.03 max	0.15-0.35	V = 0.15 minimum	Balance

[0093] In reference to the composition of the cemented tungsten carbide useful for the hard inserts at the axial forward end of the cutting bit, the cemented tungsten carbides may be any one of a number grades of cemented tungsten carbide that are suitable for impingement of earth strata. These cemented tungsten carbide grades may include grades that comprise between about 0.01 weight percent and about 35 weight percent cobalt with the balance tungsten carbide (the average grain size varies between about 0.01 microns and about 25 microns) and recognized impurities, as well as in the alternative various additives (e.g., the carbides, nitrides and/or carbonitrides of the elements (except for tungsten) of Group IVa, Va, and VIa of the Periodic Table). Typical grades of cemented (cobalt) tungsten carbide have a hardness of less than or equal to about 88.5 Rockwell A. An exemplary grade of cemented tungsten carbide comprises the following about 6 weight percent cobalt with the balance tungsten carbide (average grain size ranging between about 4 microns to 10 microns) and recognized impurities, and has a hardness equal to about 89.5 Rockwell A. Other grades of cobalt-bonded cemented carbides (and their properties) are disclosed in the article by Santhanam et al., entitled "Cemented Carbides" Metals Handbook Volume 2, 10th Edition Properties and Selection, wherein this article is hereby incorporated in its entirety by reference herein.

[0094] In reference to the hard component-matrix composite material, it comprises a plurality of discrete hard constituents (described hereinafter) wherein these hard constituents are held within a matrix. The matrix comprises a mass of matrix powder that comprises different kinds of hard particles and/or powders, and an infiltrant alloy that has been infiltrated into the mass of the matrix powder and the hard constituents under the influence of heat and sometimes under additional environmental influences such as, for example, in a pressure or in a vacuum. Furthermore, the infiltrant alloy may be infiltrated into the mass of hard constituents and matrix powder under various atmospheres (e.g., argon, helium, hydrogen, and nitrogen).

[0095] The hard constituents may comprise sintered cemented carbide members (which hereinafter may be called sintered cemented carbide members) that can be of various geometric shapes such as, for example, triangular. As one option, the hard constituent can present a specific pre-determined shape depending upon the specific application. As an alternative, a hard sintered cemented carbide member could

[0096] As one option, the hard constituents can be selectively positioned within the matrix of the hard composite which typically occurs in the mold prior to infiltration. It is contemplated that the hard constituents may cover between about 0.5 percent to about 90 percent of the surface area of the wear-resistant hard member. There is no intention to restrict the invention to the specific positioning of the hard constituents in the hard composite. For example, the hard constituents may be uniformly (or non-uniformly or randomly) distributed throughout the volume of the hard composite.

[0097] By mentioning the above specific hard constituent, there is no intention to limit the scope of the invention to this specific hard constituent. It is contemplated that other materials would be suitable for use as the hard constituents in the hard composite. In this regard, the following materials would appear to be suitable for use as hard constituents in the hard composite: sintered cemented tungsten carbide wherein a binder includes one or more of cobalt, nickel, iron and molybdenum; coated sintered cemented tungsten carbide wherein a binder includes one or more of cobalt, nickel, iron and molybdenum, and the coating comprises one or more of nickel, cobalt, iron and molybdenum; one or more of the carbides, nitrides, and borides of one or more of titanium, niobium, tantalum, hafnium, and zirconium; one or more of the coated carbides, coated nitrides, and coated borides of one or more of titanium, niobium, tantalum, hafnium, and zirconium wherein the coating comprises one or more of nickel, cobalt, iron and molybdenum; chromium carbides; coated chromium carbides; coated silicon carbide wherein the coating comprises one or more of nickel, cobalt, iron and molybdenum; and coated silicon nitride wherein the coating comprises one or more of nickel, cobalt, iron, copper, molybdenum or any other suitable metal; and coated boron carbide wherein the coating comprises one or more of nickel, cobalt, iron, copper, molybdenum, and any other suitable metal.

[0098] The matrix powder can comprise a crushed cemented carbide particle. The crushed cemented carbide particles may be present in a size range for these crushed cemented carbide particles equal to −325+200 mesh. Another size range for these crushed cemented carbide particles is −80+325 mesh. The standard to determine the particle size is by using sieve size analysis and the Fisher sub-sieve size analyzer for −325 mesh particles. One composition for the crushed cemented carbide particles is cobalt cemented tungsten carbide wherein the cobalt ranges between about 6 weight percent and about 30 weight percent of the cobalt cemented tungsten carbide material and tungsten carbide is the balance of the material. Another preferred composition for crushed cemented carbide particles is cobalt cemented tungsten carbide wherein the cobalt ranges between about 0.2 weight percent and about 6 weight percent of the cobalt cemented tungsten carbide material and tungsten carbide is the balance of the material.

[0099] By mentioning specific compositions, there is no intention to limit the scope of the invention to these specific cemented carbides. It is contemplated that other cemented carbides (e.g., chromium carbide) would be suitable for use as the crushed cemented tungsten carbide particles in the hard composite. In this regard, the carbides could be different from tungsten carbide (e.g., titanium carbide and chromium carbide) and the binder could be different from cobalt (e.g., nickel). It is further contemplated that the crushed cemented carbide particles may vary in composition throughout a particular hard composite depending upon the specific application. It is also contemplated that certain hard materials other than cemented carbides may be suitable to form these particles.

[0100] The matrix powder may also contain crushed cast carbide particles wherein one size range for these particles is −325 mesh. Another size range for these particles is −80 mesh. One composition for these particles is cast tungsten carbide. It is contemplated that the crushed cast carbide particles may vary in composition throughout a particular hard composite depending upon the specific application. It is further contemplated that other cast carbides or hard materials are suitable for use in place or along with the crushed cast carbide particles.

[0101] The matrix powder may further include in addition to crushed cemented carbide particles and/or crushed cast carbide particles, any one or more of the following: crushed carbide particles (e.g., crushed tungsten carbide particles that have a size of −80+325 mesh), steel particles that have an exemplary size of −325 mesh, carbonyl iron particles that have an exemplary size of −325 mesh, cemented carbide powder, and coated (e.g., nickel coating) cemented carbide particles, and nickel-coated tungsten carbide particles (−80+325 mesh).

[0102] It is desirable that the infiltrant alloy has a melting point that is low enough so as to not degrade the hard constituents upon contact therewith during the infiltration process. Along this line, the infiltrant alloy has a melting point that ranges between about 500 degrees Centigrade and about 1400 degrees Centigrade. It is contemplated that the infiltrant alloys may have a melting point that ranges between about 600 degrees Centigrade and about 800 degrees Centigrade. It is further contemplated that the infiltrant alloys may have a melting point that ranges between about 690 degrees Centigrade and about 770 degrees Centigrade. It is still further contemplated that the infiltrant alloys may have a melting point below about 700 degrees Centigrade. Exemplary general types of infiltrant alloys include copper-based alloys such as, for example, copper-silver alloys, copper-zinc alloys, copper-nickel alloys, copper-tin alloys, and nickel-based alloys including nickel-copper-manganese alloys. Exemplary infiltrant alloys are set forth in Table 2 herein below.

TABLE 2

Compositions of Infiltrant Alloys in Weight Percent

Alloy/ Composition	Cu	Ni	Zn	Mn	Ag	Sn	Nb	Solidus (Melting Point) (° C.)	Liquidus (Flow Point) ° C.
A-1	53	15	8	24	—	—	—	1150	
202	45	—	35	—	20	—	—	710	815
255	40	—	33	—	25	2	—	690	780
559	42	2	—	—	56	—	—	770	895
700	20	—	10	—	70	—	—	690	740
Cu—20Ni—10Mn	70	20	—	10	—	—	—	~1100	
Macrofil 56	56	—	43	—	—	1	—	866	888
Macrofil 65	65	15	20	—	—	—	—	1040	1075
Macrofil 49	49	10	41	—	—	—	—	921	935
C96800	81.8	10	—	—	—	8	0.2	1050	1150
Cu—20Ni—20Mn	60	20	—	20	—	—	—	1030	1050
Cu—25Ni—25Mn	50	25	—	25	—	—	—	1030	1050

By mentioning specific infiltrant alloys in Table 2, there is no intention to limit the scope of the invention to infiltrant alloys with these specific compositions and/or properties. As one alternative, the composition of the infiltrant alloy could be within the range of 5-40 weight percent nickel, 5-40 weight percent manganese and the balance copper.

[0103] Referring to an exemplary hard component-matrix composite material, the hard particles in the hard composite may comprise 100 percent crushed nickel cemented chromium carbide particles. The nickel could comprise between about 3 weight percent and about 25 weight percent of the cemented carbide with chromium carbide comprising the balance. The preferred composition of the cemented carbide is about 15 weight percent nickel and the balance chromium carbide. The particle size of the crushed cemented (nickel) chromium carbide particles can range between about −325 mesh and about +80 mesh. The infiltrant alloy can comprise between about 60 weight percent and about 80 weight percent of the hard composite and the crushed nickel cemented chromium carbides can comprise between about 20 weight percent and about 40 weight percent of the hard composite.

[0104] Referring to another exemplary hard component-matrix composite material, it can also be made from the compositions set forth in Table 3 below. The matrix powder is Mixture No. 2 taken from Table 4 hereof. The hard constituents are crushed nickel cemented chromium carbide wherein the nickel is present in an amount of 15 weight percent. The particle size of the crushed cemented (nickel) chromium carbide particles can range between about −325 mesh and about +80 mesh. The titanium diboride (TiB_2) particles have a particle size equal to −325 mesh. The infiltrant alloy was the copper-based alloy A-I set forth in Table 1. The infiltrant alloy comprised between about 60 weight percent and about 70 weight percent of the hard composite.

TABLE 3

	Compositions of the Hard Composite		
Composition	Matrix Powder Mixture No. 2 from Table 2 hereof (weight percent)	Crushed Nickel Cemented Chromium Carbide (−325 + 80 mesh) (weight percent)	Titanium Diboride Particles (−325 mesh) (weight percent)
1-A	40	40	20
2-A	80		20
3-A	66		34
4-A		66	34
5-A		50	50

[0105] In yet another example of the hard constituent-matrix composite, there are a plurality of sintered cemented carbide members that typically have a composition of 10 weight percent cobalt and the balance tungsten carbide. The matrix powder typically includes tungsten carbide, chromium carbide, as well as cobalt and nickel in the form of a binder alloy for the carbides and/or a coating on the carbides. One typical infiltrant alloy has a composition (weight percent) of copper(53%)-nickel(15%)-manganese(24%)-zinc (8%) and a melting point equal to about 1150 degrees Centigrade.

[0106] Another exemplary composition for the hard constituent-matrix composite material comprises hard constituents that comprise one or more sintered carbides wherein these carbides include tungsten, titanium, niobium, tantalum, hafnium, chromium and zirconium. The matrix powder typically comprises one or more sintered carbides, crushed sintered carbides, cast carbide, crushed carbides, tungsten carbide powders and chromium carbide powders. The infiltrant alloy has a composition (weight percent) of copper(53%)-nickel(15%)-manganese(24%)-zinc(8%) and a melting point equal to about 1150 degrees Centigrade.

[0107] In still another exemplary composition, the hard constituents that comprise crushed cemented tungsten carbide having a particle size equal to −80+120 mesh. The cemented carbide is cobalt cemented tungsten carbide where the cobalt is present in an amount of 10 weight percent. The hard composite further contains a matrix powder that could be any one of the matrix powders set forth in Table 2 through Table 6 hereof, but preferred a matrix powder may be any one of Matrix Powders Nos. 1 through 3 set forth in Table 4 hereof. The ratio by weight of the matrix powder to the infiltrant alloy is about 40:60 by weight. In some applications, the hard constituent crushed cemented tungsten carbide particles (−80+120 mesh) range between about 2.5 volume percent and about 40 volume percent of the hard composite with the balance comprising matrix powder and infiltrant alloy. However, there are some applications in which the crushed cemented tungsten carbide particles range between about 2 volume percent to about 4 volume percent of the hard composite. There are also other applications in which the crushed cemented tungsten carbide particles range between about 30 volume percent and about 40 volume percent of the hard composite.

[0108] In yet another exemplary embodiment, the hard constituents may comprise one or more sintered carbides wherein these carbides include tungsten, titanium, niobium, tantalum, hafnium, chromium and zirconium. The matrix powder typically comprises one or more sintered carbides, crushed sintered carbides, cast carbide, crushed carbides, tungsten carbide powders and chromium carbide powders. The infiltrant alloy has a composition of copper(53%)-nickel(5%)-manganese(24%)-zinc(8%) and a melting point equal to about 1150 degrees Centigrade.

[0109] The hard constituent-matrix composite material can comprise crushed cemented tungsten carbide having a particle size equal to −80+120 mesh. The cemented carbide is cobalt cemented tungsten carbide where the cobalt is present in an amount of 10 weight percent. The hard composite further contains a matrix powder that could be any one of the matrix powders set forth in Table 4 through Table 8 hereof, but preferred a matrix powder may be any one of Matrix Powders Nos. 1 through 3 set forth in Table 4 hereof. The ratio by weight of the matrix powder to the infiltrant alloy is about 40:60 by weight. In some applications, the hard constituent crushed cemented tungsten carbide particles (−80+120 mesh) range between about 2.5 volume percent and about 40 volume percent of the hard composite with the balance comprising matrix powder and infiltrant alloy. However, there are some applications in which the crushed cemented tungsten carbide particles range between about 2 volume percent to about 4 volume percent of the hard composite. There are also other applications in which the crushed cemented tungsten carbide particles range between about 30 volume percent and about 40 volume percent of the hard composite.

[0110] In some embodiments, the hard constituents can also comprise cemented carbides, silicon carbides, boron carbide, aluminum oxide, zirconia and other suitable hard materials. The matrix powder typically comprises one or more of crushed tungsten carbide, crushed cemented tungsten carbide, crushed cast tungsten carbide, iron powder, tungsten carbide powder (the tungsten carbide made by a thermit process or from co-carburized tungsten carbide), chromium carbide powder, spherical cast carbide powder and/or spherical sintered carbide powders. The infiltrant alloy has a composition of copper(53%)-nickel(15%)-manganese(24%)-zinc (8%) and a melting point equal to about 1150 degrees Centigrade.

[0111] Examples of specific matrix powders (Mixtures Nos. 1 through 20) are set forth in Tables 4 through 8 hereinafter. In reference to the composition of the matrix powders, it should be appreciated that the crushed tungsten carbide component or the crushed cast tungsten carbide component may be substituted, in whole or in part, by spherical sintered tungsten carbide and/or spherical cast tungsten carbide particles. In some cases the spherical sintered tungsten carbide and/or spherical cast carbide particles (or powders) could be used 100% in combination or alone as the hard constituents in the matrix powders.

TABLE 4

Components of the Matrix Powder Mixtures Nos. 1 through 4 (Weight Percent)

Constituent (particle size)	Mixture No. 1	Mixture No. 2	Mixture No. 3	Mixture No. 4
Crushed tungsten carbide (−80 + 325 mesh)	67 wt. %	67 wt. %	0 wt. %	0 wt. %
Crushed tungsten carbide (−325 mesh)	0 wt. %	15.5 wt. %	0 wt. %	0 wt. %
Crushed cast tungsten carbide (−325 mesh)	31 wt. %	15.5 wt. %	0 wt. %	0 wt. %
4600 steel (−325 mesh)	1 wt. %	0 wt. %	0 wt. %	0 wt. %
Carbonyl iron (−325 mesh)	1 wt. %	0 wt. %	0 wt. %	0 wt. %
Nickel (−325 mesh)	0 wt. %	2 wt. %	0 wt. %	0 wt. %
Crushed cobalt (10 wt. Percent) cemented tungsten carbide (−140 + 325 mesh)	0 wt. %	0 wt. %	100 wt. %	
Crushed nickel (10 wt. Percent) cemented tungsten carbide (−140 + 325 mesh)	0 wt. %	0 wt. %		100 wt. %

TABLE 5

Components of the Matrix Powder Mixtures Nos. 5 through 8 (Weight Percent)

Constituent (particle size)	Mixture No. 5	Mixture No. 6	Mixture No. 7	Mixture No. 8
Crushed tungsten carbide (−80 + 325 mesh)	63.65 wt. %	63.65 wt. %	0 wt. %	0 wt. %
Crushed tungsten carbide (−325 mesh)	0 wt. %	14.725 wt. %	0 wt. %	0 wt. %
Crushed cast tungsten carbide (−325 mesh)	29.45 wt. %	14.725 wt. %	0 wt. %	0 wt. %
4600 steel (−325 mesh)	.95 wt. %	0 wt. %	0 wt. %	0 wt. %
Carbonyl iron (−325 mesh)	.95 wt. %	0 wt. %	0 wt. %	0 wt. %
Nickel (−325 mesh)	0 wt. %	1.9 wt. %	0 wt. %	0 wt. %
Crushed cobalt (10 wt. Percent) cemented tungsten carbide (−140 + 325 mesh)	0 wt. %	0 wt. %	95 wt. %	
Crushed nickel (10 wt. Percent) cemented tungsten carbide (−140 + 325 mesh)	0 wt. %	0 wt. %		95 wt. %
Chromium carbide (−45 mesh)	5 wt. %	5 wt. %	5 wt. %	5 wt. %

TABLE 6

Components of the Matrix Powder Mixtures Nos. 9 through 12 (Weight Percent)				
Constituent (particle size)	Mixture No. 9	Mixture No. 10	Mixture No. 11	Mixture No. 12
Crushed tungsten carbide (−80 + 325 mesh)	53.6 wt. %	53.6 wt. %	0 wt. %	0 wt. %
Crushed tungsten carbide (−325 mesh)	0 wt. %	12.4 wt. %	0 wt. %	0 wt. %
Crushed cast tungsten carbide (−325 mesh)	24.8 wt. %	12.4 wt. %	0 wt. %	0 wt. %
4600 steel (−325 mesh)	.8 wt. %	0 wt. %	0 wt. %	0 wt. %
Carbonyl iron (−325 mesh)	.8 wt. %	0 wt. %	0 wt. %	0 wt. %
Nickel (−325 mesh)	0 wt. %	1.6 wt. %	0 wt. %	0 wt. %
Crushed cobalt (10 wt. Percent) cemented tungsten carbide (−140 + 325 mesh)	0 wt. %	0 wt. %	80 wt. %	
Crushed nickel (10 wt. Percent) cemented tungsten carbide (−140 + 325 mesh)	0 wt. %	0 wt. %	0 wt. %	80 wt. %
Nickel Coated Tungsten Carbide Powder (−325 mesh)	20 wt. %	20 wt. %	20 wt. %	20 wt. %

TABLE 7

Components of Matrix Powder Mixtures 13 through 16 (Weight Percent)				
Constituent (particle size)	Mixture No. 13	Mixture No. 14	Mixture No. 15	Mixture No. 16
Crushed tungsten carbide (−80 + 325 mesh)	60.3 wt. %	60.3 wt. %	0 wt. %	0 wt. %
Crushed tungsten carbide (−325 mesh)	0 wt. %	13.95 wt. %	0 wt. %	0 wt. %
Crushed cast tungsten carbide (−325 mesh)	27.9 wt. %	13.95 wt. %	0 wt. %	0 wt. %
4600 steel (−325 mesh)	.9 wt. %	0 wt. %	0 wt. %	0 wt. %
Carbonyl iron (−325 mesh)	.9 wt. %	0 wt. %	0 wt. %	0 wt. %
Nickel (−325 mesh)	0 wt. %	1.8 wt. %	0 wt. %	0 wt. %
Crushed cobalt (10 wt. Percent) cemented tungsten carbide (−140 + 325 mesh)	0 wt. %	0 wt. %	90 wt. %	

TABLE 7-continued

Constituent (particle size)	Components of Matrix Powder Mixtures 13 through 16 (Weight Percent)			
	Mixture No. 13	Mixture No. 14	Mixture No. 15	Mixture No. 16
Crushed nickel (10 wt. Percent) cemented tungsten carbide (−140 + 325 mesh)	0 wt. %	0 wt. %	0 wt. %	90 wt. %
Crushed nickel (15 wt %) cemented chromium carbide(Ni—Cr_3C_2) (−140 + 325 mesh)	10 wt. %	10 wt. %	10 wt. %	10 wt. %

TABLE 8

Constituent (particle size)	Components of Matrix Powder Mixtures 17 through 20 (in Weight Percent)			
	Mixture No. 17	Mixture No. 18	Mixture No. 19	Mixture No. 20
Crushed tungsten carbide (−80 + 325 mesh)	56.95 wt. %	56.95 wt. %	0 wt. %	0 wt. %
Crushed tungsten carbide (−325 mesh)	0 wt. %	13.175 wt. %	0 wt. %	0 wt. %
Crushed cast tungsten carbide (−325 mesh)	26.35 wt. %	13.175 wt. %	0 wt. %	0 wt. %
4600 steel (−325 mesh)	.85 wt. %	0 wt. %	0 wt. %	0 wt. %
Carbonyl iron (−325 mesh)	.85 wt. %	0 wt. %	0 wt. %	0 wt. %
Nickel (−325 mesh)	0 wt. %	1.7 wt. %	0 wt. %	0 wt. %
Crushed cobalt (10 wt. Percent) cemented tungsten carbide (−140 + 325 mesh)	0 wt. %	0 wt. %	85 wt. %	
Crushed nickel (10 wt. Percent) cemented tungsten carbide (−140 + 325 mesh)	0 wt. %	0 wt. %		85 wt. %
Nickel-coated tungsten carbide (−325 mesh)	15 wt. %	15 wt. %	15 wt. %	15 wt. %

[0112] Additional examples of the hard constituent-matrix composite material are set forth hereinafter. One such example of the hard constituent-matrix composite material comprises sintered cobalt (10 weight percent cobalt) cemented tungsten carbide members and the matrix powder comprised Mixture No. 1 in Table 4 and the infiltrant alloy comprised (in weight percent) a Cu(53%)-Ni(15%)-Zn(8%)-Mn(24%) alloy described above. The matrix powder comprised 40 weight percent and the infiltrant alloy comprised 60 weight percent of the combination of the matrix powder and the infiltrant alloy. Depending upon the specific application, the cemented tungsten carbide members were present in a specified amount between about 1 weight percent and about 95 weight percent with the balance of the hard composite comprising the matrix powder and the infiltrant alloy. In the alternative and depending upon the specific application, the cemented tungsten carbide members were present in a specified amount between about 1 weight percent and about 90 percent of the surface area of the hard composite.

[0113] For yet another example of the hard constituent-matrix composite material, it comprised a sintered cobalt (6 weight percent cobalt) cemented tungsten carbide member. The matrix powder comprised Mixture No. 4. The infiltrant alloy comprised in weight percent) a Cu(53%)-Ni(15%)-Zn (8%)-Mn(24%). The matrix powder comprised 45 weight percent and the infiltrant alloy comprised 55 weight percent of the combination of the matrix powder and the infiltrant alloy. Depending upon the specific application, the cemented tungsten carbide members were present in a specified amount between about 1 weight percent and about 95 weight percent with the balance of the hard composite comprising the matrix powder and the infiltrant alloy. In the alternative and depending upon the specific application, the cemented tungsten carbide members were present in a specified amount between about 1 weight percent and about 90 percent of the surface area of the hard composite.

[0114] Still another example of the hard constituent-matrix composite material is a composition that comprises sintered cobalt (6 weight percent cobalt) cemented tungsten carbide cylindrical members. The matrix powder was Mixture No. 3 as set forth in Table 1. The infiltrant alloy comprised (in weight percent) a Cu(53%)-Ni(15%)-Zn(8%)-Mn(24%). The matrix powder comprised 40 weight percent and the infiltrant alloy comprised 60 weight percent of the combination of the matrix powder and the infiltrant alloy. Depending upon the specific application the cemented tungsten carbide members were present in a specified amount between about 1 weight percent and about 95 weight percent with the balance of the hard composite comprising the matrix powder and the infiltrant alloy. In the alternative and depending upon the specific application, the cemented tungsten carbide members were present in a specified amount between about 1 weight percent and about 90 percent of the surface area of the hard composite. For some applications, the cemented tungsten carbides may be present in a range between about 1 percent to about 5 percent of the surface area. For other applications, the cemented tungsten carbide members may be present in a range between about 70 percent and about 90 percent of the surface area.

[0115] Another example of the hard constituent-matrix composite material comprises nickel-coated sintered cobalt (10 weight percent cobalt) cemented tungsten carbide members. The matrix powder comprised Mixture No. 4 from Table 1. The infiltrant alloy comprised (in weight percent) a Cu(53%)-Ni(15%)-Zn(8%)-Mn(24%). The matrix powder comprised 45 weight percent and the infiltrant alloy comprised 55 weight percent of the combination of the matrix powder and the infiltrant alloy. Depending upon the specific application, the cemented tungsten carbide members were present in a specified amount between about 1 weight percent and about 95 weight percent with the balance of the hard composite comprising the matrix powder and the infiltrant alloy. In the alternative and depending upon the specific application, the cemented tungsten carbide members were present in a specified amount between about 1 weight percent and about 90 percent of the surface area of the hard composite. For some applications, the cemented tungsten carbide members may be present in a range between about 1 percent to about 5 percent of the surface area. For other applications, the cemented tungsten carbide members may be present in a range between about 70 percent and about 90 percent of the surface area.

[0116] It is apparent from the above description that applicants have invented an improved cutting bit In the process of a cutting bit impinging the earth strata, it is desirable that the cutting bit exhibit acceptable strength or impact resistance and wear resistance. Impact resistance is desirable because the earth strata can be inconsistent in that it may contain hard anomalies. For example, in a mining operation the earth strata may contain rocks or the like in a formation of softer coal. In a trenching operation, the cutting bits may encounter rocks or other very hard regions. In a road planing operation such as planing asphaltic roadway material or concrete roadway material, the cutting bits may impact a manhole cover or the life during the course of the planing operation. Wear resistance is necessary because of the highly abrasive mature of the earth strata (e.g., asphaltic material).

[0117] It is apparent that the present invention provides an improved cutting bit that freely rotates about its central longitudinal axis. It is also apparent that the present invention provides an improved cutting bit that possesses an inherent capability to rotate freely about its central longitudinal axis.

[0118] It is further apparent that the present invention provides a cutting bit that exhibits a slimmer profile thereby encountering less resistance upon impingement of the earth strata. Such a cutting bit with a slimmer profile would exhibit a lower rate of wear thereby taking a greater amount of time to become blunter, and hence, increase the overall operational efficiency of the cutting or mining operation in. Such a cutting bit with a slimmer profile can be achieved by the use of a superhard insert in combination with a highly wear-resistant elongate cutting bit body. There should be an appreciation that the superhard insert is used in the cutting bit typically exhibits longer useful life than a conventional cemented (cobalt) tungsten carbide hard insert. This is especially the case when the superhard insert is used in conjunction with the highly where-resistant elongate cutting pick body. Such a cutting bit with a slimmer profile can also be achieved by the use of a highly wear-resistant elongate cutting bit body in conjunction with a hard insert.

[0119] It is also apparent that the present invention provides an improved cutting bit that upon impingement of the earth strata (or substrate) does not result in the excessive generation of small particulates and fines such as, for example, coal dust. There is an advantage connected a cutting bit that actually reduces the amount of small particulates and fines generated during a coal mining operation.

[0120] It is apparent that it would be very desirable to provide an improved cutting bit that encounters less resistance upon impingement of the earth strata, and yet exhibits acceptable strength or impact resistance and wear resistance. It is also apparent that it would be very desirable to provide an improved rotatable cutting bit that is freely rotatable to maintain its geometric symmetry about its central longitudinal axis.

[0121] The patents and other documents identified herein are hereby incorporated by reference herein. Other embodiments of the invention will be apparent to those skilled in the art from a consideration of the specification or a practice of the invention disclosed herein. There is the intention that the specification and examples are illustrative only and are not intended to be limiting on the scope of the invention. The following claims indicate the true scope and spirit of the invention.

What is claimed is:

1. A cutting bit for impinging earth strata, the cutting bit comprising:

a highly wear-resistant elongate cutting bit body having an axial forward end and an axial rearward end, an enlarged dimension head portion at the axial forward end and a reduced dimension shank portion at the axial rearward end, and the highly wear-resistant elongate cutting bit body having a maximum transverse dimension and a longitudinal axial length;

a superhard insert affixed to the head portion at the axial forward end of the cutting bit body; and

a slimness ratio comprising the ratio of the maximum transverse dimension to the longitudinal axial length, and the slimness ratio ranging between about 0.15 and about 0.60.

2. The cutting bit according to claim **1** wherein at least a part of the highly wear-resistant cutting bit body comprising a hard component-matrix composite material to provide wear resistance, and the hard component matrix composite material consisting of a plurality of discrete hard constituents and matrix powder of hard particles and an infiltrant alloy bonded together to form the hard component-matrix composite; and

the infiltrant alloy having a melting point between about 500 degrees Centigrade and about 1400 degrees Centigrade;

the matrix powder comprises one or more of the following: cast carbides, spherical sintered carbides, crushed cemented carbide particles, crushed cast carbide particles, crushed carbide particles, and cemented carbide powder, steel particles, carbonyl iron particles, and coated carbide particles;

the discrete hard constituents comprise one or more of cemented carbides and ceramics; sintered cemented tungsten carbide wherein a binder includes one or more of cobalt, nickel, iron and molybdenum; coated sintered cemented tungsten carbide wherein a binder includes one or more of cobalt, nickel, iron and molybdenum, and the coating comprises one or more of nickel, cobalt, iron and molybdenum; one or more of the carbides, nitrides, and borides of one or more of titanium, niobium, tantalum, hafnium, and zirconium; tungsten carbide; one or more of the coated carbides, coated nitrides, and coated borides of one or more of titanium, niobium, tantalum, hafnium, and zirconium wherein the coating comprises one or more of nickel, cobalt, iron and molybdenum; coated tungsten carbide wherein the coating comprises one or more of nickel, cobalt, iron and molybdenum; coated silicon carbide wherein the coating comprises one or more of nickel, cobalt, iron and molybdenum; coated silicon nitride wherein the coating comprises one or more of nickel, cobalt, iron and molybdenum; and coated boron carbide.

3. The cutting bit according to claim **1** wherein at least a part of the highly wear-resistant cutting bit body comprising a wear rotator to provide wear resistance and enhance rotation, and wherein the wear rotator being carried by the highly wear-resistance cutting bit body.

4. The cutting bit according to claim **3** wherein the wear rotator being attached to the cutting bit body using an attachment material.

5. The cutting bit according to claim **3** wherein the wear rotator being attached to the cutting bit body without an attachment material.

6. The cutting bit according to claim **1** wherein the highly wear-resistance cutting bit body comprising a substrate, and at least a part of the substrate having a coating layer thereon, and wherein the coating layer being a material selected from the group consisting of hardfacing including hardfacing applied by a plasma transferred arc process, polycrystalline diamond, diamond, cubic boron nitride, and polycrystalline cubic boron nitride.

7. The cutting bit according to claim **1** wherein the slimness ratio ranging between about 0.15 and about 0.25.

8. The cutting bit according to claim **1** wherein the slimness ratio ranging between about 0.15 and about 0.19.

9. The cutting bit according to claim **1** wherein the superhard insert being selected from the group consisting of a polycrystalline diamond insert, a polycrystalline cubic boron nitride insert, a cubic boron nitride insert, and a superhard coating material-coated insert.

10. The cutting bit according to claim **9** wherein the superhard coating includes hardfacing including hardfacing applied by a plasma transferred arc process.

11. A cutting bit for impinging earth strata, the cutting bit comprising:

a highly wear-resistant elongate cutting bit body having an axial forward end and an axial rearward end, an enlarged dimension head portion at the axial forward end and a reduced dimension shank portion at the axial rearward end, and at least a part of the highly wear-resistant elongate cutting bit body comprising a hard component-matrix composite material to provide wear resistance, and

a hard insert affixed to the head portion at the axial forward end of the cutting bit body.

12. The cutting bit according to claim **11** wherein the highly wear-resistant elongate cutting bit body having a maximum transverse dimension and a longitudinal axial length a slimness ratio comprising the ratio of the maximum transverse dimension to the longitudinal axial length, and the slimness ratio ranging between about 0.15 and about 0.60.

13. The cutting bit according to claim **12** wherein the slimness ratio ranging between about 0.15 and about 0.25.

14. The cutting bit according to claim **11** wherein the hard component matrix composite material consisting of a plurality of discrete hard constituents and matrix powder of hard particles and an infiltrant alloy bonded together to form the hard component-matrix composite; and

the infiltrant alloy having a melting point between about 500 degrees Centigrade and about 1400 degrees Centigrade;

the matrix powder comprises one or more of the following: cast carbides, spherical sintered carbides, crushed cemented carbide particles, crushed cast carbide particles, crushed carbide particles, and cemented carbide powder, steel particles, carbonyl iron particles, and coated carbide particles;

the discrete hard constituents comprise one or more of cemented carbides and ceramics; sintered cemented tungsten carbide wherein a binder includes one or more of cobalt, nickel, iron and molybdenum; coated sintered cemented tungsten carbide wherein a binder includes one or more of cobalt, nickel, iron and molybdenum, and the coating comprises one or more of nickel, cobalt, iron and molybdenum; one or more of the carbides, nitrides, and borides of one or more of titanium, niobium, tantalum, hafnium, and zirconium; tungsten carbide; one or more of the coated carbides, coated nitrides, and coated borides of one or more of titanium, niobium, tantalum, hafnium, and zirconium wherein the coating comprises one or more of nickel, cobalt, iron and molybdenum; coated tungsten carbide wherein the coating comprises one or more of nickel, cobalt, iron and molybdenum; coated silicon carbide wherein the coating comprises one or more of nickel, cobalt, iron and molybdenum; coated silicon nitride wherein the coating comprises one or more of nickel, cobalt, iron and molybdenum; and coated boron carbide.

15. The cutting bit according to claim **11** wherein the highly wear-resistant elongate cutting bit body having an axial forward portion adjacent the axial forward end thereof, and the highly wear-resistant elongate cutting bit body having an axial rearward portion adjacent the axial rearward end thereof, and the axial forward portion being attached to the axial rearward portion at an interface, and the interface presenting a non-planar surface area.

16. A cutting bit for impinging earth strata, the cutting bit comprising:

a highly wear-resistant elongate cutting bit body having an axial forward end and an axial rearward end, an enlarged dimension head portion at the axial forward end and a reduced dimension shank portion at the axial rearward end, and the highly wear-resistant elongate cutting bit body having a maximum transverse dimension and a longitudinal axial length;

the highly wear-resistance cutting bit body comprising a substrate, and at least a part of the substrate having a hardfacing layer thereon;

a hard insert affixed to the head portion at the axial forward end of the cutting bit body; and

a slimness ratio comprising the ratio of the maximum transverse dimension to the longitudinal axial length, and the slimness ratio ranging between about 0.15 and about 0.25.

17. A cutting bit for impinging earth strata, the cutting bit comprising:

a highly wear-resistant elongate cutting bit body having an axial forward end and an axial rearward end, an enlarged dimension head portion at the axial forward end and a reduced dimension shank portion at the axial rearward end, and the highly wear-resistant elongate cutting bit body carrying a wear rotator to enhance rotation; and

a hard insert affixed to the head portion at the axial forward end of the cutting bit body.

18. The cutting bit according to claim **17** wherein the highly wear-resistant elongate cutting bit body comprising a substrate made of steel, and the steel substrate carrying the wear rotator.

19. The cutting bit according to claim **17** wherein the wear rotator being attached to the cutting bit body using an attachment material.

20. The cutting bit according to claim **17** wherein the wear rotator being attached to the cutting bit body without an attachment material.

21. The cutting bit according to claim **17** wherein the highly wear-resistant elongate cutting bit body being perimeter-weighted, and a plurality of the discrete rotator wear members at the periphery of the head portion.

22. The cutting bit according to claim **17** wherein the discrete rotator wear members being made of a material selected from the group consisting of a hard component-matrix composite material, a cemented carbide, and a superhard material.

23. The cutting bit according to claim **17** wherein the discrete rotator wear member presenting an exposed rotator surface against which the pieces of the earth strata impinge during the engagement of the cutting bit with the earth strata, and the exposed rotator surface increases with the duration of the engagement of the cutting bit with the earth strata.

24. The cutting bit according to claim **17** wherein the head portion having an interior region with a first density and a perimeter region with a second density, and the second density being different from the first density.

25. The cutting bit according to claim **17** wherein the highly wear-resistant cutting bit body carrying a plurality of the rotator wear members, and the rotator wear members project the same distance from the head portion.

26. The cutting bit according to claim **17** wherein the highly wear-resistant cutting bit body carrying a plurality of the rotator wear members, and the rotator wear members project differing distances from the head portion.

27. A cutting bit for impinging earth strata, the cutting bit comprising:

a highly wear-resistant elongate cutting bit body having an axial forward end and an axial rearward end, an enlarged dimension head portion at the axial forward end and a reduced dimension shank portion at the axial rearward end, and the highly wear-resistant elongate cutting bit body having a maximum transverse dimension and a longitudinal axial length;

a hard insert affixed to the head portion at the axial forward end of the cutting bit body; and

a slimness ratio comprising the ratio of the maximum transverse dimension to the longitudinal axial length, and the slimness ratio ranging between about 0.15 and about 0.25.

28. The cutting bit according to claim **27** wherein the slimness ratio ranging between about 0.15 and about 0.20.

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