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(54) EARTH BORING CUTTING INSERTS AND EARTH BORING BITS INCLUDING THE SAME

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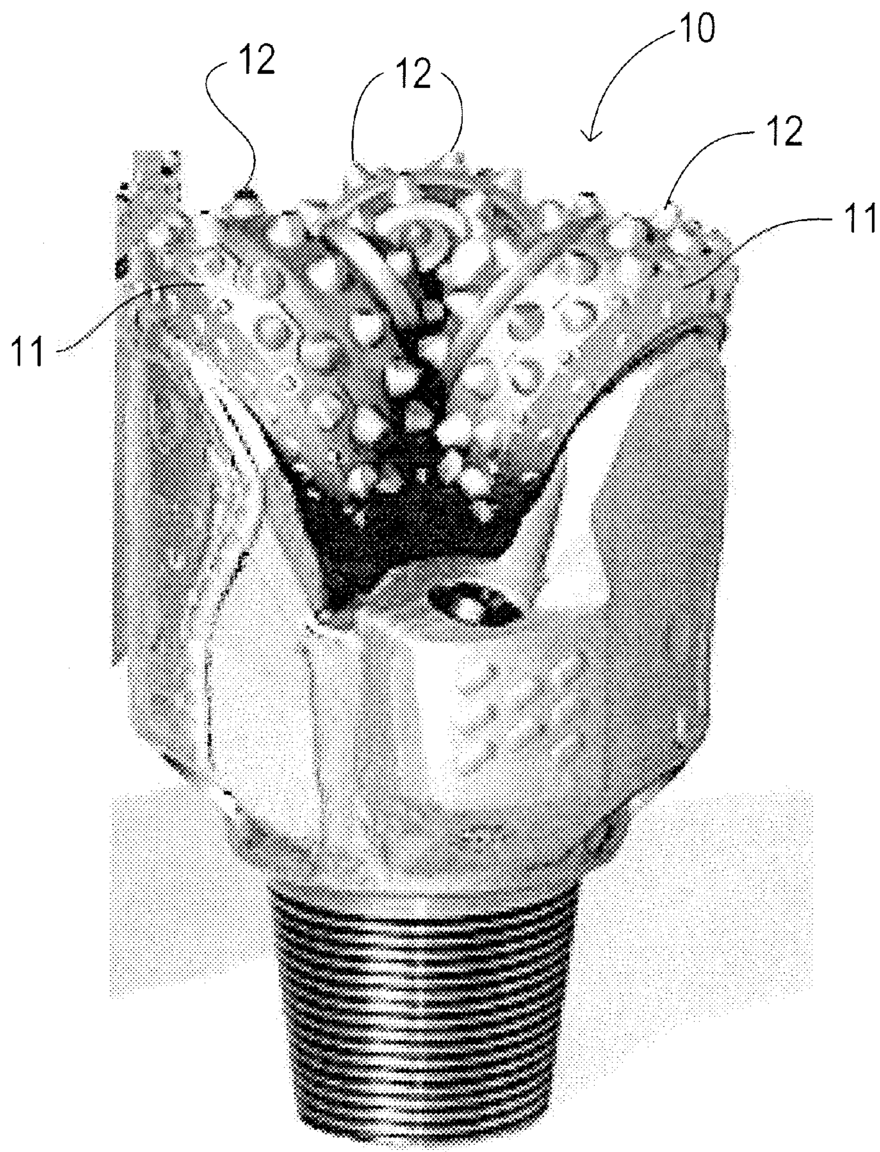
(57) **ABSTRACT**

An earth boring cutting insert including a cemented carbide comprising metal carbide grains dispersed in a metallic binder including at least one of platinum, palladium, rhenium, rhodium, and ruthenium. Also disclosed is an earth boring bit such as, for example, a rotary-cone earth boring bit or a percussion bit, including at least one earth boring cutting insert comprising a cemented carbide including a metallic binder comprising at least one of platinum, palladium, rhenium, rhodium, and ruthenium



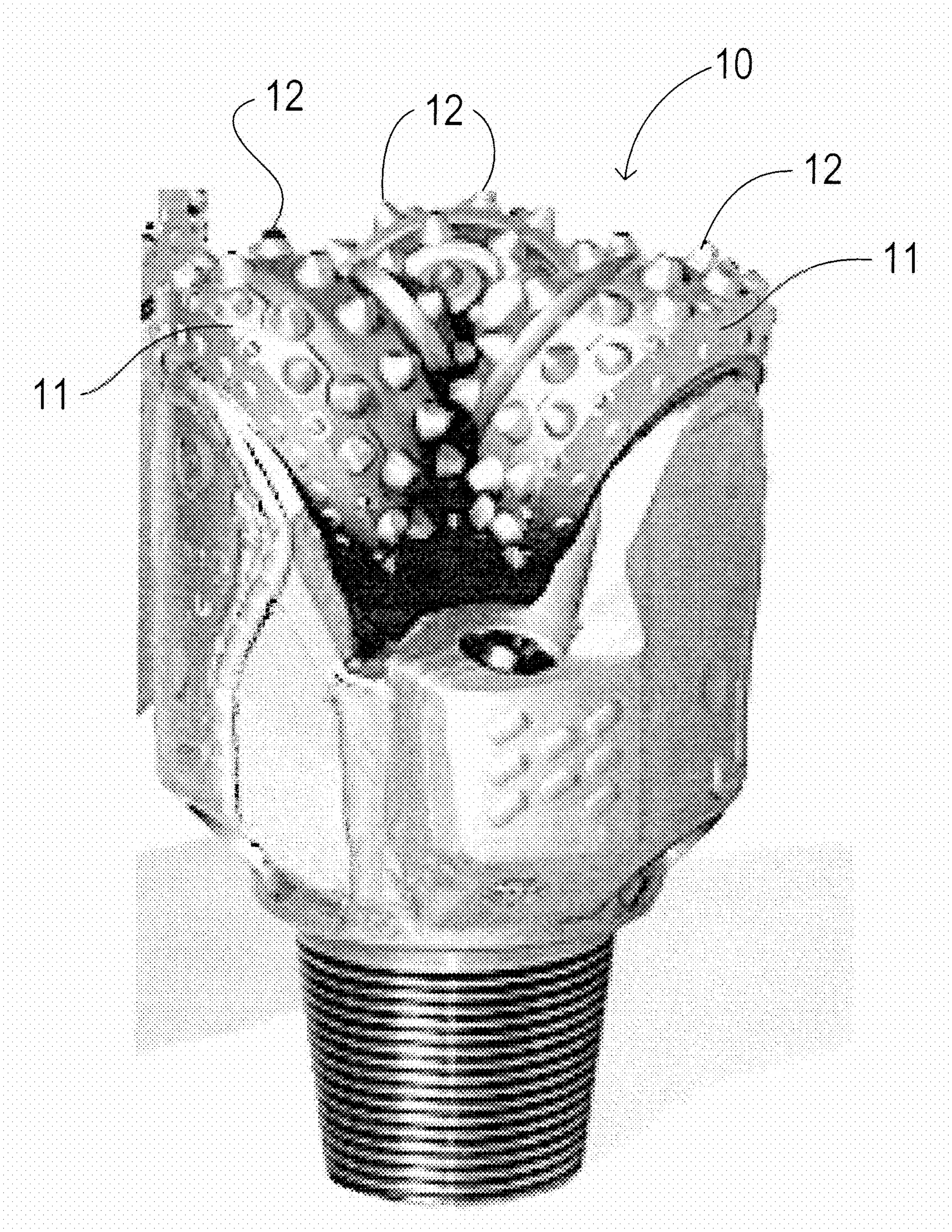


FIGURE 1

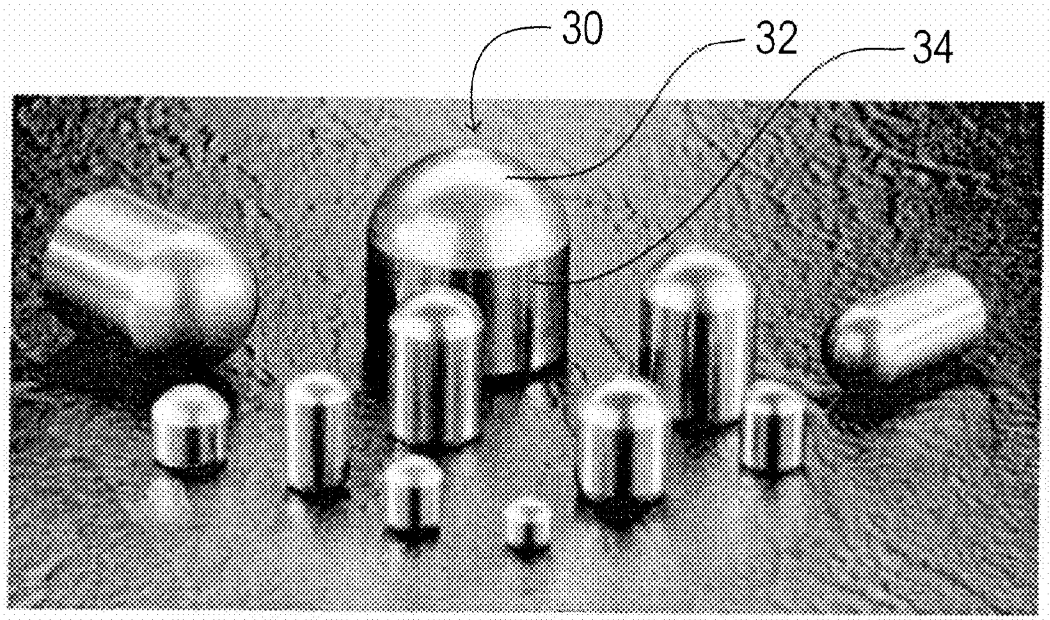


FIGURE 2A

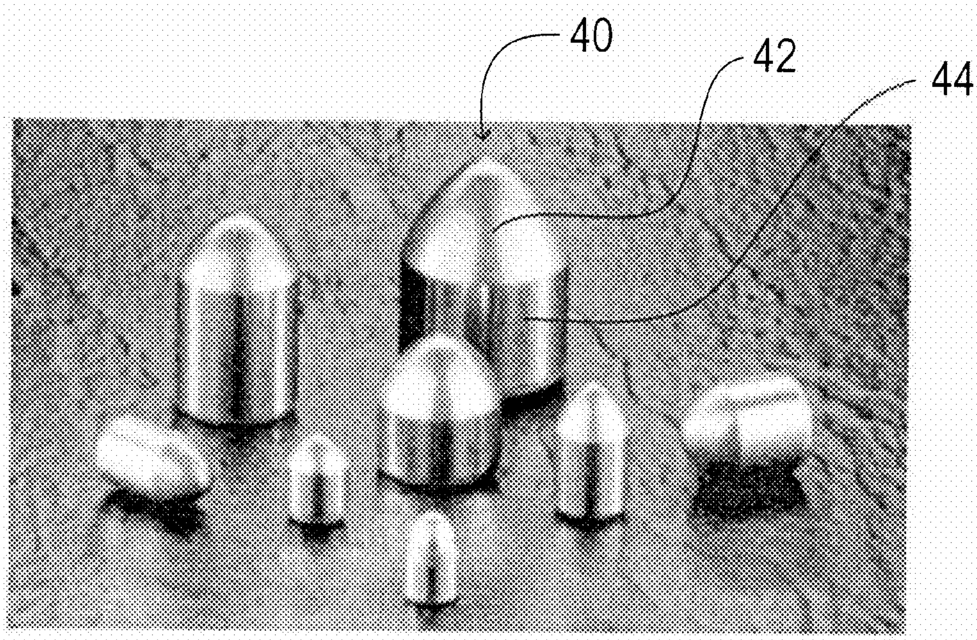


FIGURE 2B

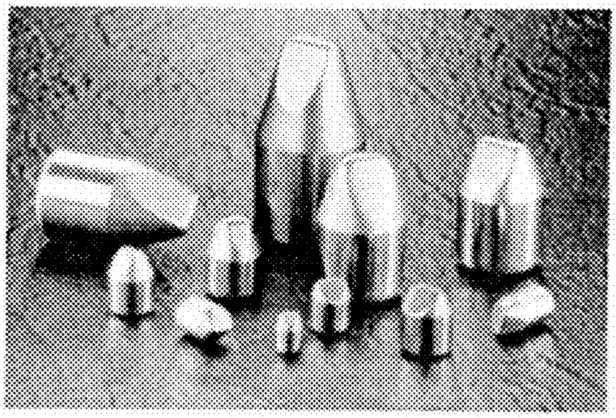


FIGURE 2C

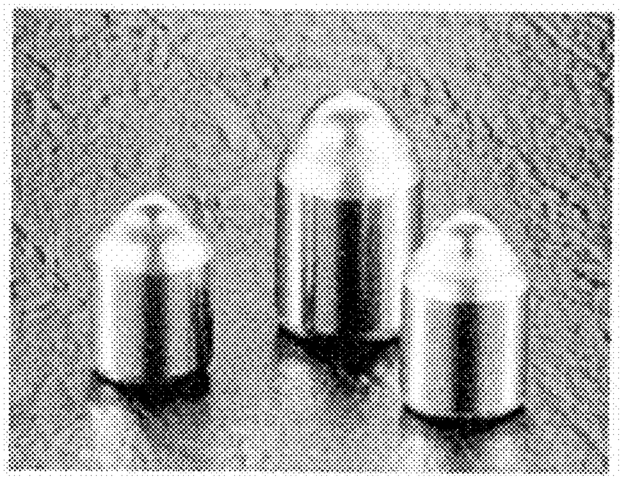


FIGURE 2D

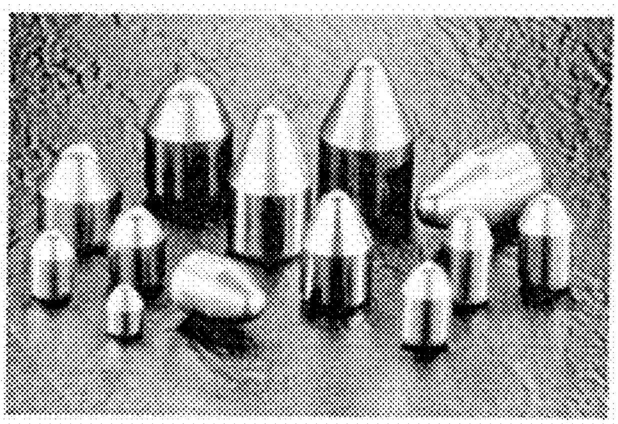


FIGURE 2E

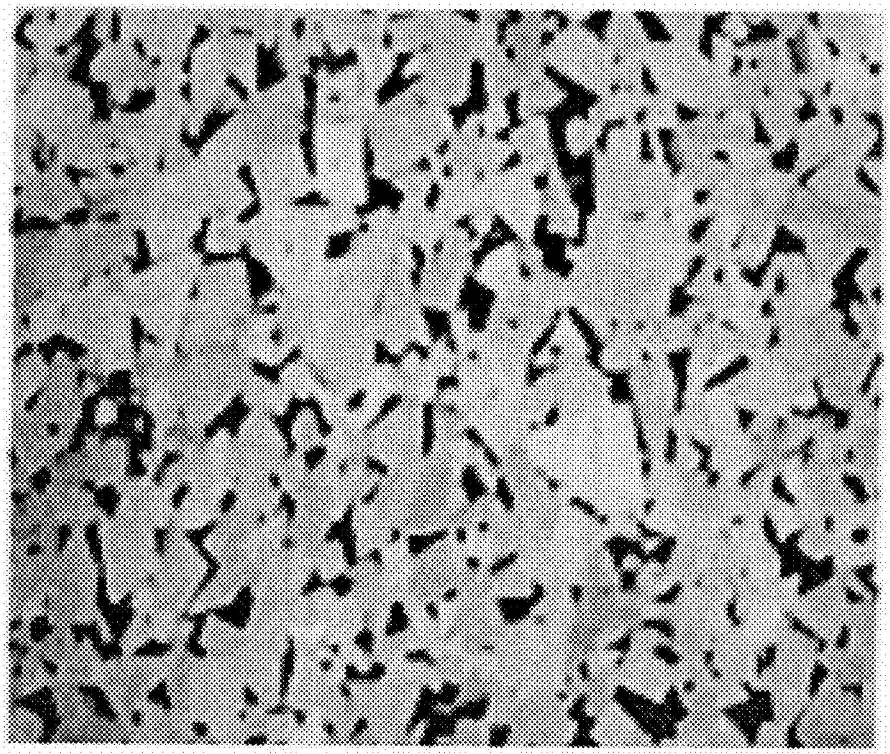
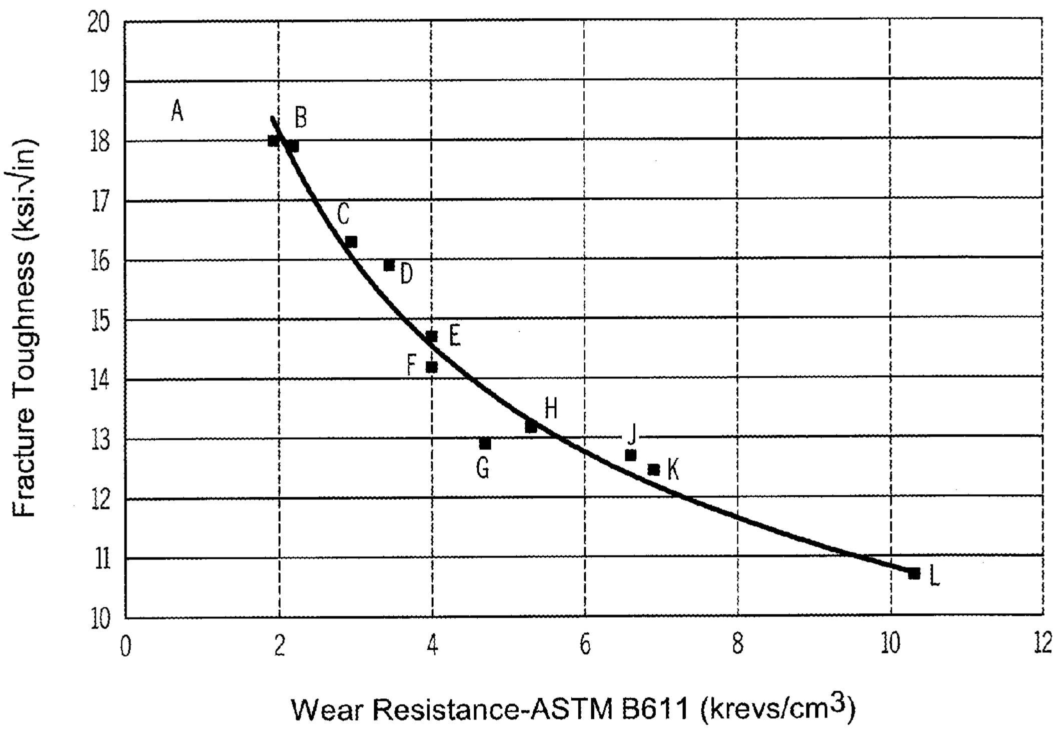


FIGURE 3


Fracture Toughness (ksi.√in)
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16
15
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C
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4
6
8
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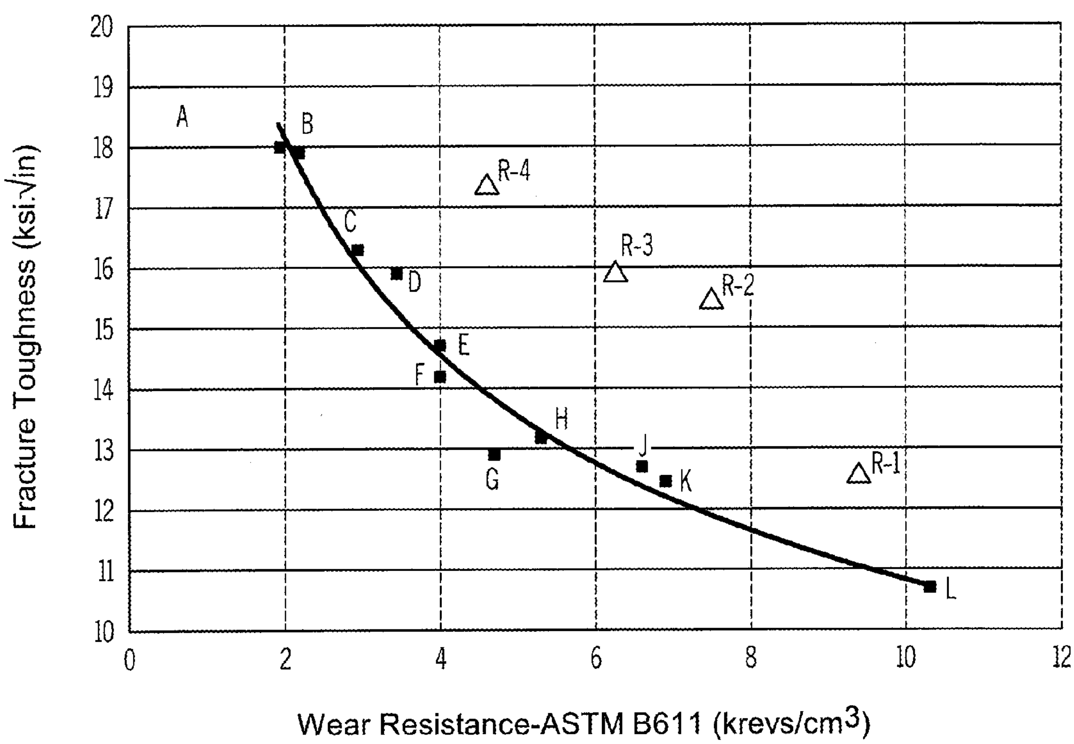
12
Wear Resistance-ASTM B611 (krevs/cm3)

FIGURE 4


Fracture Toughness (ksi.√in)
Wear Resistance-ASTM B611 (krevs/cm3)
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R-1
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R-3
R-4

FIGURE 5

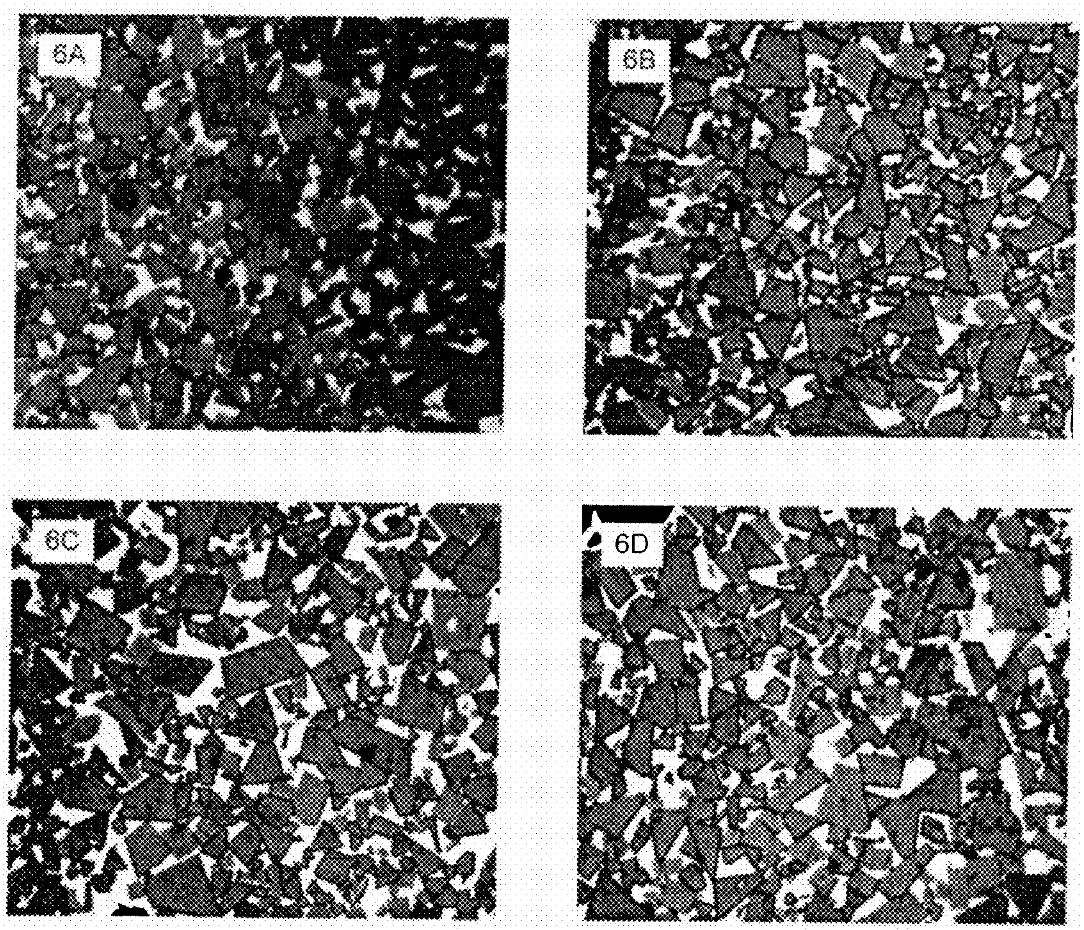


FIGURE 6

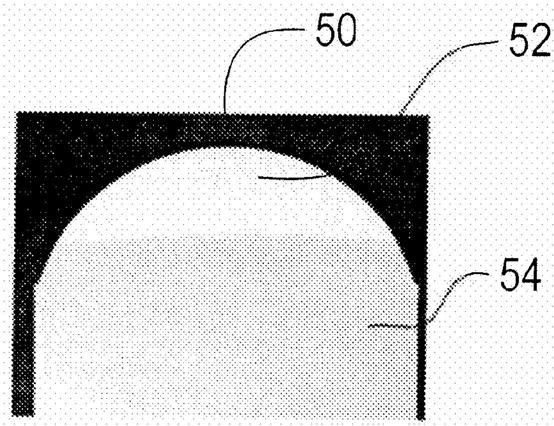
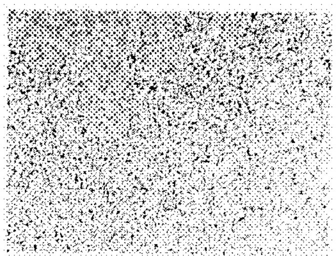
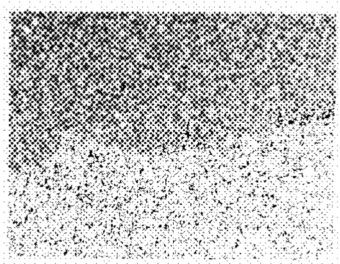


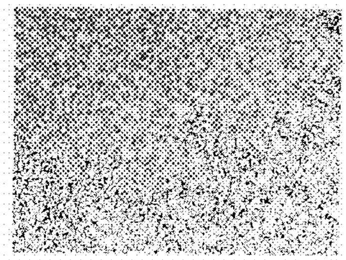
FIGURE 7(a)



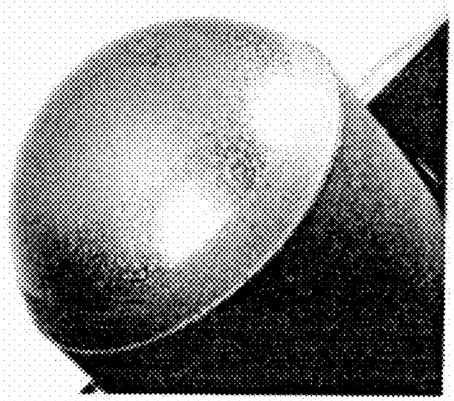
7(b)



7(c)



7(d)



7(e)

EARTH BORING CUTTING INSERTS AND EARTH BORING BITS INCLUDING THE SAME

FIELD OF TECHNOLOGY

[0001] This disclosure relates to improvements to earth boring cutting inserts including cemented carbide for use with earth boring bits such as, for example, rotary-cone earth boring bits and percussion bits (such as, for example, hammer bits). This disclosure also relates to earth boring bits including an earth boring bit body and at least one earth boring cutting insert according to the present disclosure mounted on the bit body.

BACKGROUND OF THE INVENTION

[0002] Earth boring (or drilling) bits are commonly employed for oil and natural gas exploration, mining, and excavation. Such earth boring bits may include rotatable or fixed cutting elements. For example, FIG. **1** illustrates a typical rotary-cone earth boring bit **10** including a bit body comprising rotatable cutting elements **11**, commonly referred to as "rotary cones". Cutting inserts **12**, which may be made from cemented carbide, are mounted in cutting inserts pockets located on outer surfaces of each of the rotatable cutting elements **11**. Several cutting inserts **12** may be mounted on the rotatable cutting elements **11** in various predetermined positions to optimize the cutting action of the earth boring bit **10**.

[0003] The service life of an earth boring bit is typically a function of the wear properties of the bit's cutting inserts. One technique to increase earth boring bit service life is to employ earth boring cutting inserts made of materials having improved combinations of strength, toughness, and wear resistance. Many conventional earth boring bits utilize cutting elements made from cemented carbide, which is a cemented hard particle material. The choice of cemented carbide for such applications is predicated on the fact that these materials offer very attractive combinations of strength, fracture toughness, and wear resistance, properties that are extremely important to the efficient and economical functioning of an earth boring bit. Cemented carbides are composites comprising a discontinuous dispersed phase that typically includes hard grains comprising carbides of one or more of the transition metals belonging to groups IVB, VB, and VIB of the periodic table. These transition metals include, for example, titanium (Ti), vanadium (V), chromium (Cr), zirconium (Zr), niobium, (Nb), molybdenum (Mo), hafnium (Hf), tantalum (Ta), and tungsten (W). The hard grains of the dispersed phase are bound or "cemented" together by a continuous phase of a metallic binder that typically includes on or more of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy. Among the different possible hard grain-metallic binder combinations, cemented carbides based on tungsten carbide (WC) as the dispersed phase hard grains and cobalt (Co) or nickel (Ni) as the metallic binder (i.e., WC—Co based cemented carbides and WC—Ni based cemented carbides, respectively) are commonly employed in earth boring applications.

[0004] Mechanical properties of cemented carbides important to earth boring applications largely depend on two microstructural parameters, namely, (i) the average hard grain size and (ii) the weight or volume fraction of the hard grains and/or the metallic binder in the cemented carbide. In general, the hardness and wear resistance of a cemented carbide increases as the dispersed phase hard grain size decreases and/or the metallic binder content decreases. On the other hand, fracture toughness of a cemented carbide increases as the dispersed phase hard grain size increases and/or as the metallic binder content increases. Thus, there is a trade-off between wear resistance and fracture toughness when selecting a cemented carbide grade for any application. As wear resistance increases, fracture toughness typically decreases, and vice versa.

[0005] FIGS. **2**A-**2**E illustrate a selection of different shapes and designs of conventional cemented carbide cutting inserts used with rotary-cone earth boring bits. Earth boring cutting inserts may be characterized by the shape of the insert's domed portion. Available shapes include, for example, ovoid shapes (FIG. **2**A), ballistic shapes (FIG. **2**B), chisel shapes (FIG. **2**C), multidome shapes (FIG. **2**D), and conical shapes (FIG. **2**E). The choice of the shape and cemented carbide composition (i.e., grade) employed is influenced by, for example, the type of rock to be drilled or otherwise excavated. Regardless of shape or size, earth boring cutting inserts typically include a working portion and a body portion. For example, the earth boring cutting insert **30** shown in FIG. **2**A includes dome-shaped working portion **32** and body portion **34**. Also, for example, the earth boring cutting insert **40** shown in FIG. **2**B includes ballistic-shaped cutting portion **42** and body portion **44**. The cutting action is wholly or principally performed by the working portion, while the body portion provides support for the working portion. In general, most or all of the body portion is embedded within the bit body, and the body portion is typically mounted on the bit body by press fitting or is otherwise secured in a cutting insert pocket provided on the bit body.

[0006] As previously stated, the drilling/cutting action may be at least primarily provided by a working portion of an earth boring cutting inserts. The first region of the working portion of an earth boring cutting insert that begins wearing away is the top half and, in particular, the extreme tip, of the working portion. As the top of the working portion of an earth boring cutting insert begins to flatten out, the efficiency of cutting decreases dramatically given that the rock and earth is being removed more by a rubbing action, as opposed to a more efficient cutting action. As the rubbing action continues, considerable heat may be generated by the increase in friction between the material and the cutting insert, thereby resulting in increased heating of portions of the cutting insert. If the temperature of any portion of cemented carbide earth boring cutting insert exceeds a threshold valve, thermal cracks may be initiated at the interface of the hard grains and the metallic binder. Thermal cycling of the article exacerbates propagation of thermal cracks. Crack propagation may result in fracturing of a cutting insert, which may necessitate replacement of the cutting inert or the entire bit. Retrieving a drill string from a drill hole, for example, to access and repair or place an earth boring bit including fractured cutting inserts significantly slows and adds substantial expense to the drilling process.

[0007] Accordingly, there is a need for improved cemented carbide cutting inserts useful for earth boring bits. The improved cutting inserts preferably should have an increased level of wear resistance without loss of fracture toughness. In this way, cutting efficiency may be improved and the service life of the cutting inserts, and the earth boring bit as a whole, may be extended.

SUMMARY OF THE PRESENT INVENTION

[0008] The present disclosure provides an improved earth boring cutting insert including a cemented carbide comprising greater than impurities concentrations of one or more elements selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium. The present disclosure also is directed to an earth boring bit such as, for example, a rotary-cone earth boring bit or a percussion bit, including at least one earth boring cutting insert including a cemented carbide comprising greater than impurities concentrations of one or more elements selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium.

[0009] According to one non-limiting aspect of the present disclosure, an earth boring cutting insert includes a cemented carbide comprising a metallic binder that includes at least one element selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium. In certain non-limiting embodiments, the cemented carbide includes a dispersed phase including hard grains of metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten; and a continuous phase of a metallic binder including at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and at least one element selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium, wherein the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder is 0.1 to 10 weight percent, based on the total weight of the cemented carbide.

[0010] According to another non-limiting aspect of the present disclosure, an earth boring cutting insert includes two or more regions. A first region comprises a first cemented carbide including hard grains of metal carbide dispersed in a metallic binder, wherein the metallic binder includes at least one element selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium, wherein the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder is 0.1 to 10 weight percent, based on the total weight of the cemented carbide. A second region comprises a second cemented carbide including hard grains of metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten; and a continuous phase of a metallic binder including a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is less than the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder of the first cemented carbide.

[0011] According to yet another non-limiting embodiment of the present disclosure, an earth boring cutting insert includes a working portion comprising a first cemented carbide, and a body portion including a second cemented carbide. The first cemented carbide includes a dispersed phase including hard grains of metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten. The first cemented carbide also includes a continuous phase of a metallic binder comprising at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and at least one element selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium, wherein the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder is 0.1 to 10 weight percent, based on the total weight of the cemented carbide. The second cemented carbide includes a dispersed phase of hard grains of metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten. The second cemented carbide also includes a continuous phase of a metallic binder including a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is less than the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder of the first cemented carbide.

[0012] According to a further aspect of the present disclosure, an earth boring bit includes a bit body and at least one earth boring cutting insert. The at least one earth boring cutting insert comprises a metallic binder including at least one element selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium, wherein the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder is 0.1 to 10 weight percent, based on the total weight of the cemented carbide. In certain non-limiting embodiments of the earth boring bit, the cemented carbide includes a dispersed phase including hard grains of metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten; and a continuous phase of a metallic binder comprising at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and at least one element selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium, wherein the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder is 0.1 to 10 weight percent, based on the total weight of the cemented carbide. The earth boring bit according to the present disclosure may be, for example, a rotary-cone earth boring bit or a percussion bit (such as, for example, a hammer bit).

[0013] According to yet a further non-limiting aspect of the present disclosure, an earth boring bit includes a bit body and an earth boring cutting insert comprising two or more regions. A first region of the earth boring cutting insert comprises a first cemented carbide including a metallic binder, wherein the metallic binder includes at least one element selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium, wherein the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder is 0.1 to 10 weight percent, based on the total weight of the cemented carbide. A second region of the at least one earth boring cutting insert includes a second cemented carbide including a metallic binder that includes a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is less than the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder of the first cemented carbide. The earth boring bit according to the present disclosure may be, for example, a rotary-cone earth boring bit or a percussion bit (such as, for example, a hammer bit).

[0014] According to an additional aspect of the present disclosure, an earth boring bit includes a bit body and at least one earth boring cutting insert mounted on the bit body. The at least one earth boring cutting insert includes a working portion comprising a first cemented carbide, and a body portion comprising a second cemented carbide. The first cemented carbide includes a dispersed phase of hard grains of metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten. The first cemented carbide also includes a continuous phase of a metallic binder comprising at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and at least one element selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium, wherein the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder is 0.1 to 10 weight percent, based on the total weight of the cemented carbide. The second cemented carbide includes a dispersed phase of hard grains including carbides of at least one transition metal selected from titanium, chromium, vanadium, zirconium, hafnium, tantalum, molybdenum, niobium, and tungsten. The second cemented carbide also includes a continuous phase of a metallic binder that includes a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is less than the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder of the first cemented carbide. The earth boring bit according to the present disclosure may be, for example, a rotary-cone earth boring bit or a percussion bit (such as, for example, a hammer bit).

[0015] The reader will appreciate the foregoing details and advantages of the present invention, as well as others, upon consideration of the following detailed description of certain non-limiting embodiments of the invention. The reader also may comprehend such additional details and advantages of the present invention upon making and/or using embodiments within the present invention.

BRIEF DESCRIPTION OF THE FIGURES

[0016] The features and advantages of the present invention may be better understood by reference to the accompanying figures in which:

[0017] FIG. **1** illustrates a typical rotary-cone earth boring bit comprising a bit body, roller cones, and cutting inserts;

[0018] FIGS. **2**A-**2**E illustrate different shapes and sizes of cutting inserts typically employed in earth boring bits such as ovoid (FIG. **2**A), ballistic (FIG. **2**B), chisel (FIG. **2**C), multidome (FIG. **2**D), and conical (FIG. **2**E);

[0019] FIG. **3** shows the typical microstructure of a cemented hard particle material having a continuous phase of a metallic binder, and a dispersed phase comprising hard grains;

[0020] FIG. **4** is a graph showing the relationship between wear resistance and fracture toughness for cemented carbide grades listed in Table 1;

[0021] FIG. **5** is a graph showing the relationship between wear resistance and fracture toughness for experimental cemented carbide grades listed in Table 2;

[0022] FIGS. **6**A-D are micrographs showing the microstructure of certain embodiments of cemented carbides discussed herein; and

[0023] FIGS. **7**(*a*)-(*e*) are photographs illustrating various aspects of a non-limiting embodiment of an earth boring cutting insert according to the present disclosure including first and second cemented carbides

DESCRIPTION OF NON-LIMITING EMBODIMENTS OF THE INVENTION

[0024] Various embodiments are described and illustrated in this specification to provide an overall understanding of the structure, function, properties, and use of the disclosed earth boring cutting inserts and earth boring bits. It is understood that the various embodiments described and illustrated in this specification are non-limiting and non-exhaustive. Thus, the invention is not limited by the description of the various non-limiting and non-exhaustive embodiments disclosed in this specification. The features and characteristics described in connection with various embodiments may be combined with the features and characteristics of other embodiments. Such modifications and variations are intended to be included within the scope of this specification. As such, the claims may be amended to recite any features or characteristics expressly or inherently described in, or otherwise expressly or inherently supported by, this specification. Further, Applicants reserve the right to amend the claims to affirmatively disclaim features or characteristics that are present in the prior art regardless of whether such features are explicitly described herein. Therefore, any such amendments comply with the requirements of 35 U.S.C. §112, first paragraph, and 35 U.S.C. §132(a). The various embodiments disclosed and described in this specification can comprise, consist of, or consist essentially of the features and characteristics as variously described herein.

[0025] Any patent, publication, or other disclosure material identified herein is incorporated by reference into this specification in its entirety unless otherwise indicated, but only to the extent that the incorporated material does not conflict with existing definitions, statements, or other disclosure material expressly set forth in this specification. As such, and to the extent necessary, the express disclosure as set forth in this specification supersedes any conflicting material incorporated by reference herein. Any material, or portion thereof, that is said to be incorporated by reference into this specification, but which conflicts with existing definitions, statements, or other disclosure material set forth herein, is only incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material. Applicants reserve the right to amend this specification to expressly recite any subject matter, or portion thereof, incorporated by reference herein.

[0026] The grammatical articles "one", "a", "an", and "the", as used in this specification, are intended to include "at least one" or "one or more", unless otherwise indicated. Thus, the articles are used in this specification to refer to one or more than one (i.e., to "at least one") of the grammatical objects of the article. By way of example, "a component" means one or more components, and thus, possibly, more than one component is contemplated and may be employed or used in an implementation of the described embodiments. Further, the use of a singular noun includes the plural, and the use of a plural noun includes the singular, unless the context of the usage requires otherwise.

[0027] Various embodiments disclosed and described in this specification are directed to improved cutting inserts adapted for use with earth boring bits. For example, certain embodiments of the cutting inserts according to the present disclosure may be used with percussion bits (which include, for example, hammer bits) or with rotary-cone earth boring bits for oil and natural gas exploration and extraction, mining, excavation, and related drilling and cutting operations.

According to one aspect of the present disclosure, earth boring cutting inserts described herein comprise, consist essentially of, or consist of a cemented carbide including a metallic binder comprising greater than an impurities concentration of one or more elements selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium. As discussed herein in relation to certain non-limiting embodiments, the present inventors discovered that providing a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder in the range of 0.1 to 10 weight percent, based on the total weight of the cemented carbide, significantly improves critical mechanical properties of the cutting inserts, thereby increasing the resistance of the cutting inserts to wear and prolonging the period before cutting insert failure and the need for repairing or replacing the earth boring bit. The metallic binder may include one, two, three, four, or all of platinum, palladium, rhenium, rhodium, and ruthenium, but the combined weight percentages of these elements in the metallic binder is at least 0.1 weight percent and is no greater than 10 weight percent. In other words, in certain embodiments the metallic binder may entirely lack one or more of platinum, palladium, rhenium, rhodium, and ruthenium, but the combined concentration of any such elements that are present is within the indicated concentration range.

[0028] Several terms used in the present description and in the claims have the following meanings.

[0029] As used herein, the term "cemented carbide" refers to a composite material including a discontinuous, dispersed phase including hard grains, and a continuous phase of a relatively soft metallic binder. In many conventional cemented carbides the hard grains of the dispersed phase comprise transition metal carbide, wherein the transition metal is selected from, for example, titanium, vanadium, chromium, zirconium, hafnium, molybdenum, niobium, tantalum, tungsten, solid solutions of two or more thereof, and solutions of two or more thereof. The metallic binder typically comprises at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy. The metallic binder binds or "cements" the dispersed hard grains together, and the composite exhibits an advantageous combination of the physical properties of the discontinuous and continuous phases. FIG. **3** is a micrograph of the microstructure of a representative cemented carbide. The lighter regions are dispersed hard grains of tungsten carbide, and the darker region is a continuous region of cobalt binder cementing together the hard tungsten carbide grains, thereby forming the composite. In various non-limiting embodiments, the metallic binder of the cemented carbide may also include one or more additives selected from chromium, molybdenum, boron, tungsten, tantalum, titanium, niobium, silicon, aluminum, copper, and manganese. In certain non-limiting embodiments, the metallic binder of a cemented carbide may include up to a total of 20 weight percent of the additives, based on the total weight of the binder. In other non-limiting embodiments, the metallic binder of a cemented carbide may include a total of up to 15 weight percent, up to 10 weight percent, or up to 5 weight percent of the additives, based on the total weight of the binder. As will be understood, both the dispersed phase and the metallic binder may include incidental impurities.

[0030] Numerous cemented carbide types or "grades" are produced by varying parameters that may include the composition of the materials in the dispersed and/or continuous phases, the average size of the hard grains of the dispersed phase, and/or the volume fractions of the discontinuous and continuous phases. Cemented carbides including a dispersed phase of tungsten carbide grains and a cobalt or cobalt alloy binder are the most commercially important of the commonly available cemented carbide grades. Conventional cemented carbide grades are available as powders (often referred to "cemented carbide powders"). The powders may be processed to a final monolithic form using, for example, conventional press-and-sinter techniques or other techniques known for producing cemented carbides from precursor cemented carbide powder grades.

[0031] Conventional cemented carbide grades including a discontinuous, dispersed phase of tungsten carbide grains and a continuous phase of cobalt binder exhibit advantageous combinations of ultimate tensile strength, fracture toughness, and wear resistance. As is known in the art, "fracture toughness" refers to the ability of a material to absorb energy and deform plastically before fracturing. "Toughness" is proportional to the area under the stress-strain curve from the origin to the breaking point (see McGraw-Hill Dictionary of Scientific and Technical Terms (5^{th} ed. 1994)) and may be evaluated using known mechanical test techniques. "Wear resistance" refers to the ability of a material to withstand damage to its surface. Wear generally involves progressive loss of material from an article due to relative motion between the article and a contacting surface or substance. See Metals Handbook Desk Edition (2d ed. 1998).

[0032] Certain non-limiting embodiments of earth boring cutting inserts described herein include a working portion. As used herein, a "working portion" refers to the portion of an earth boring cutting insert that principally contacts the rock, dirt, or other material to be removed or separated by the earth boring bit on which the cutting insert is mounted. In contrast to the working portion, an earth boring cutting insert also may include a "body portion" which, as used herein, refers to a portion of the earth boring cutting insert that supports the working portion. The body portion and working portion may be, but need not be, regions of a unitary earth boring cutting insert. It will be understood that in certain embodiments of an earth boring cutting insert according to the present invention, there may not exist a clear line of division between the working portion and the body portion of the cutting insert. In such embodiments, however, an ordinarily skilled person will recognize a difference between the portions in that the working portion will be adapted to principally carry out the intended function of the cutting insert, while the body portion will be adapted to principally support the working portion. Alternatively, the working portion and body portion may be formed of different materials and otherwise securely attached or bonded together so that the body portion provides the requisite support for the working portion when the cutting insert is in service.

[0033] It is generally understood that properties of cemented carbides that largely determine overall performance of earth boring cutting inserts (and hence, of the earth boring bit on which the cutting inserts are mounted) are wear resistance and fracture toughness. In order to optimize performance of earth boring cutting inserts, it is desirable to obtain the highest fracture toughness for a given level of wear resistance, and vice versa. As noted above, the wear resistance and fracture toughness properties of cemented carbides are largely influenced by two parameters of the material's microstructure, namely, the average hard grain size and the weight or volume fraction of the hard grains and/or the metallic binder. In general, the hardness and wear resistance increases as the average hard grain size decreases and/or the weight or volume fraction of the metallic binder content of the cemented carbide decreases. On the other hand, fracture toughness increases as the average hard grain size increases and/or the weight or volume fraction of the metallic binder of the cemented carbide increases. Thus, it has been believed that one invariably experiences a trade-off between wear resistance and fracture toughness when selecting a cemented carbide grade for any earth boring application.

[0034] The trade-off between wear resistance and fracture toughness in certain conventional cemented carbides is illustrated in Table 1 and in FIG. **4**. Table 1 provides a listing of conventional WC—Co based cemented carbide grades, identified as Grade A through Grade L, that are commonly used in earth boring cutting inserts and are commercially available from ATI Firth Sterling, Houston, Tex. Table 1 also lists the following for each grade: the commercial grade designation used by ATI Firth Sterling; the average WC grain size; the cobalt binder content (based on total weight of the cemented carbide); hardness; and density. The cobalt contents listed in Table 1 are weight percentages based on the total weight of the cemented carbide. The balance of each grade listed in Table 1 is tungsten carbide grains. The listed cemented carbide grades include WC grains having an average diameter (when viewed in a prepared microstructural specimen) in the range of about 4 to about 8 μm, a cobalt binder content in the range of about 8 to about 17 weight percent, with the balance constituting the WC grains. FIG. **4** is a graph plotting the relationship between wear resistance and fracture toughness for the cemented carbide grades A-L listed in Table 1. Fracture toughness was evaluated using a test method substantially equivalent to ASTM B 771-87(2006), "Standard Test Method for Short Rod Fracture Toughness of Cemented Carbides". Wear resistance was evaluated according to ASTM B 611-85(2005), "Standard Test Method for Abrasive Wear Resistance of Cemented Carbides".

TABLE 1

Grade	Commercial Grade Designation	Average WC Grain Size (μm)	Co Content (wt %)	WC Content	Hardness (HRA)	Density (g/cm^3)
A	45B	5.5	16.0	Bal.	85.5	13.90
B	147	7.0	14.0	Bal.	86.0	14.10
C	120	6.5	12.0	Bal.	86.6	14.30
D	231	5.5	10.0	Bal.	87.8	14.50
E	1865	6.5	9.0	Bal.	87.8	14.65
F	931	5.0	11.0	Bal.	87.8	14.40
G	241	4.5	10.0	Bal.	88.5	14.50
H	941	4.5	11.0	Bal.	88.5	14.40
J	91	5.0	8.5	Bal.	89.3	14.60
K	1550	5.0	7.5	Bal.	89.2	14.75
L	290	4.0	6.0	Bal.	90.3	14.90

[0035] As confirmed by the least fit curve plotted from the data points in FIG. **4** for grades A through L, fracture toughness decreases as wear resistance increases, and vice versa. Also, as is evident from FIG. **4**, all of the data points plotting the fracture toughness and wear resistance values for each of cemented carbide grades A-L lie within a relatively narrow band about the least fit curve. Given the relationship shown in FIG. **4**, metallurgists and design engineers face the dilemma of having to compromise on one or the other of wear resistance and fracture toughness when selecting a cemented carbide grade for earth boring applications.

[0036] The present inventors undertook efforts to improve the performance of cemented carbide earth boring cutting inserts by modifying the composition of the cemented carbide. With reference to the cemented carbide grades in FIG. **4**, for example, the present inventors concluded that the performance of earth boring cutting inserts including those cemented carbides could be significantly enhanced if the individual data points in FIG. **4** could be displaced in an easterly direction (i.e., increasing wear resistance without any loss in fracture toughness) and/or in a northerly direction (i.e., increasing fracture toughness without any loss in wear resistance). Thus, the arrows in FIG. **4** indicate a desired direction in which the individual data points (representing the combination of wear resistance and fracture toughness of the individual grades) might be displaced in order to enhance performance. More generally, the present inventors sought to identify modifications to composition of cemented carbide grades so as to increase wear resistance without reducing fracture toughness and/or increase fracture toughness without reducing wear resistance.

[0037] The present inventors discovered that earth boring cutting inserts including cemented carbide in which a platinum group metal such as ruthenium is added as an alloying addition to the metallic binder of the cemented carbide exhibit significantly improved properties important for earth boring applications relative to identical cemented grades lacking the addition. For example, the present inventors determined through experimentation and testing that WC—Co based cemented carbide grades based on average WC grain sizes and Co contents comparable to certain conventional cemented carbide grades listed above in Table 1, but which have been modified to include the platinum group metal ruthenium as an alloying addition to the cobalt-based metallic binder of the cemented carbides, provide substantially superior combinations of wear resistance and facture toughness compared to the corresponding conventional grades.

[0038] The experimental ruthenium-containing cemented carbides listed in Table 2 below, identified as R-1 through R-4, were prepared. The cobalt and ruthenium contents listed in Table 2 are in weight percentages based on the total weight of the cemented carbide. Each of grades R-1 through R-4 was prepared in substantially the same way, using standard press-and-sinter techniques commonly used to produce cemented carbides for earth boring cutting inserts. In preparing each of the experimental grades, WC—Co, cobalt, and ruthenium powders were blended to provide a homogenous powder blend having the desired ratio of WC particles, cobalt, and ruthenium. A portion of the powder blend was then consolidated to a green compact in rigid tooling using a compacting pressure of about 20,000 psi. The green compact was sintered in an over-pressure sintering furnace (also known as a "Sinter-Hip" furnace) at a final temperature of 1400° C., and was held at the final temperature for about 90 minutes. The sintering step resulted in inter-diffusion of the ruthenium and cobalt, producing a continuous phase of metallic binder including cobalt and ruthenium, binding together a dispersed phase of hard tungsten carbide grains. The microstructures of experimental grades R-1 through R-4 are shown in FIGS. **6**A-D, respectively. The dark regions in each micrograph are tungsten carbide grains, constituting the dispersed phase of the material, and the light regions represent the ruthenium-containing cobalt binder of the material. Table 2 provides information on the average WC grain size and the composition of experimental grades R-1 through R-4.

TABLE 2

Grade	Average WC Grain Size (μm)	Co Content (wt %)	Ru Content (wt %)	WC content
R-1	4.5	8.7	1.3	Balance
R-2	5.5	10.2	1.8	Balance
R-3	5.5	11.9	2.1	Balance
R-4	5.5	14.0	2.1	Balance

[0039] Suitable test specimens were prepared from the sintered blanks of experimental grades R-1 through R4 and tested for fracture toughness and wear resistance. Table 3 lists measured mechanical properties of the experimental grades, and FIG. **5** includes data points R-1 through R-4 plotting the relationship between wear resistance and fracture toughness for the corresponding experimental grade. Fracture toughness was evaluated using a test method substantially equivalent to ASTM B 771-87(2006). Wear resistance was evaluated according to ASTM B 611-85(2005). FIG. **5** also includes the data points and the curve presented in FIG. **4** for conventional grades A-L. The improvement in performance achieved by the ruthenium-containing experimental grades is evident from FIG. **5**. Each of the data points for the experimental grades is shifted away significantly from the least fit curve plotted from the data points for the conventional grades. It will understood that a least fit curve generated based on the four data points R-1 through R-4 in FIG. **5**, for example, would be in a position shifted in a northeasterly direction from the curve in FIG. **5** associated with the data points for the conventional cemented carbide grades. Thus, with regard to a least fit curve for data points R-1 through R-4, for any given fracture toughness, the associated wear resistance would be significantly greater than on the curve shown in FIG. **5** for the conventional grades. Also, with regard to a least fit curve for data points R-1 through R-4, for any given wear resistance, the associated fracture toughness would be significantly greater than on the curve shown in FIG. **5** for the conventional grades.

TABLE 3

Grade	Hardness (HRA)	Density (g/cm^3)	Fracture Toughness (ksi. √in)	Wear Resistance ($krevs/cm^3$)
R-1	88.9	14.5	12.6	9.3
R-2	87.7	14.4	15.5	7.5
R-3	87.1	14.2	15.9	6.3
R-4	86.4	14.0	17.3	4.6

[0040] Thus, the addition of the platinum group metal ruthenium allows for cemented carbide grades with fracture toughness at least equivalent to conventional grades, but with greater wear resistance, and vice versa. Thus, for example, greater wear resistance may be achieved without a corresponding reduction in fracture toughness, and great fracture toughness may be achieved without a reduction in wear resistance. Including embodiments of the novel cemented carbide grades in earth boring cutting inserts will increase the service life of the cutting inserts and the earth boring bit as a whole. This will reduce the frequency of cutting insert replacement, making extraction of the drill string a less frequent event, thereby lowering downtime and costs.

[0041] Accordingly, an aspect of the present disclosure is directed to an earth boring cutting insert including a cemented carbide comprising a metallic binder including ruthenium. The inventors have determined that the addition of ruthenium to the metallic binder improves the performance of the cutting inserts, as shown in the experimentation described above. Prior work indicates to the present inventors that the other platinum group metals rhodium, palladium, and platinum, as well as the element rhenium (positioned in an adjacent column of the Periodic Table) can have effects similar to those of the platinum group metal ruthenium. Accordingly, based on the results of the present inventors' testing involving additions of ruthenium, the present disclosure also contemplates the possible addition of one or more of ruthenium, platinum, palladium, rhenium, and rhodium to a metallic binder of cemented carbide comprised in an earth boring cutting insert to achieve the advantages discussed herein.

[0042] To further illustrate the scope of the present invention, various possible (prophetic) non-limiting embodiments of cemented carbides that may be included in the earth boring cutting inserts and bits according to the present invention, numbered as Examples 1-10, are provided in Table 4. All values listed in Table 4 are weight percentages based on the total weight of the cemented carbide. Grains comprising the dispersed phase of the cemented carbides include tungsten carbide (WC), titanium carbide (TiC), tantalum/niobium carbide (Ta,NbC), and/or chromium carbide (Cr_2C_3). The metallic binder of the cemented carbides includes cobalt, nickel, iron, ruthenium, rhenium, platinum, and/or palladium.

TABLE 4

Ex.	WC	TiC	Ta,NbC	Cr_2C_3	Co	Ni	Fe	Ru	Re	Pt	Pd
1	89.1	—	—	—	9.5	—	—	1.4	—	—	—
2	89.1	—	—	—	9.1	—	—	—	1.8	—	—
3	89.1	—	—	—	10.2	—	—	—	—	0.7	—
4	89.1	—	—	—	10.2	—	—	—	—	—	0.7
5	89.1	—	—	—	6.1	3.4	—	1.4	—	—	—
6	89.1	—	—	—	6.1	1.7	1.7	1.4	—	—	—
7	68.3	6.5	14.0	—	10.0	—	—	1.2	—	—	—
8	67.7	6.5	14.0		10.0	—	—	—	1.8	—	—
9	89.4	—	—	0.8	8.0	—	—	—	1.8	—	—
10	89.4	—	—	0.8	7.3	—	—	—		2.5	—

[0043] In certain non-limiting embodiments of earth boring cutting inserts according the present disclosure, the cutting inserts include a cemented carbide that comprises a dispersed phase including hard grains, and a continuous phase of a metallic binder. The earth boring cutting inserts may be, for example, adapted for use on rotary-cone earth boring bits and/or percussion bits (including, for example, hammer bits). The hard grains may include metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten. In certain non-limiting embodiments, the hard grains of the dispersed phase comprise at least one of titanium carbide, vanadium carbide, chromium carbide, zirconium carbide, niobium carbide, molybdenum carbide, hafnium carbide, tantalum carbide, and tungsten carbide. In certain non-limiting embodiments, the hard grains of the dispersed phase comprise tungsten carbide. In certain non-limiting embodiments, the metallic binder comprises at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.1 to 10 weight percent, based on the total weight of the cemented carbide. In certain non-limiting embodiments, the metallic binder of the cemented carbide comprises 0.1 to 10 weight percent ruthenium. In certain other non-limiting embodiments, the metallic binder of the cemented carbide comprises ruthenium and cobalt. In yet other non-limiting embodiments, the metallic binder of the cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is 0.3 to 7 weight percent, based on the total weight of the cemented carbide. In certain other embodiments, the metallic binder comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.5 to 5 weight percent, based on the total weight of the cemented carbide. In certain non-limiting embodiments of earth boring cutting inserts according the present disclosure, the cutting inserts include a cemented carbide comprising 2 to 40 weight percent of the metallic binder and 60 to 98 weight percent of the dispersed phase.

[0044] In certain non-limiting embodiments of earth boring cutting inserts according the present disclosure, the cutting inserts include a cemented carbide wherein the hard grains of the dispersed phase of the cemented carbide comprise, consist essentially of, or consist of tungsten carbide; and the metallic binder comprises cobalt and greater than an impurities concentration of ruthenium.

[0045] Non-limiting embodiments of earth boring bits according to the present disclosure may include a working portion and a body portion. In certain embodiments, the working portion includes a shape selected from an ovoid shape, a ballistic shape, a chisel shape, a multi-dome shape, and a conical shape.

[0046] In certain embodiments, an earth boring cutting insert according to the present disclosure includes a first region comprising a first cemented carbide, and a second region comprising a second cemented carbide. The first cemented carbide includes a metallic binder including a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.1 to 10 weight percent, based on the total weight of the cemented carbide. The second cemented carbide includes a metallic binder that includes a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is less than combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder of the first cemented carbide. In certain embodiments, the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.3 to 7 weight percent, based on the total weight of the first cemented carbide. In certain other embodiments, the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.5 to 5 weight percent, based on the total weight of the first cemented carbide. In certain non-limiting embodiments, the metallic binder of the first cemented carbide includes 0.1 to 10 weight percent ruthenium, or 0.3 to 7 weight percent ruthenium, or 0.5 to 5 weight percent ruthenium, based on the weight of the first cemented carbide. In further embodiments, the metallic binder of the second cemented carbide includes no greater than an impurities concentration of platinum, palladium, rhenium, rhodium, and ruthenium. Also, in certain embodiments, the metallic binder of the second cemented carbide does not include ruthenium.

[0047] In non-limiting embodiments directed to an earth boring cutting insert according to the present disclosure including a first region comprising a first cemented carbide, and a second region comprising a second cemented carbide, the first cemented carbide and the second cemented carbide may each individually comprise: a dispersed phase including hard grains of metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten; and a continuous phase of a metallic binder comprising at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy. According to one non-limiting embodiment of an earth boring cutting insert according to the present disclosure including a first region comprising a first cemented carbide, and a second region comprising a second cemented carbide, a dispersed phase of the first cemented carbide comprise tungsten carbide, and a metallic binder of the first cemented carbide comprises cobalt; and a dispersed phase of the second cemented carbide comprises tungsten carbide, and a metallic binder of the second cemented carbide comprises cobalt.

[0048] In non-limiting embodiments directed to an earth boring cutting insert according to the present disclosure including a first region comprising a first cemented carbide, and a second region comprising a second cemented carbide, the first region includes a working portion of the cutting insert. Possible shapes included in the working portion of the earth boring cutting insert include, for example, an ovoid shape, a ballistic shape, a chisel shape, a multi-dome shape, and a conical shape. The earth boring cutting insert may be adapted for use with at least one of a rotary-cone earth boring bit and a percussion bit (including, for example, a hammer bit).

[0049] In certain non-limiting embodiments of earth boring cutting inserts according the present disclosure, the cutting inserts include a working portion comprising a first cemented carbide, and a body portion comprising a second cemented carbide. The first cemented carbide includes a dispersed phase of hard grains including metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten. The first cemented carbide also includes a continuous phase of a metallic binder comprising at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is 0.1 to 10 weight percent, based on the total weight of the cemented carbide. In certain embodiments of the earth boring cutting insert, the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.3 to 7 weight percent, based on the total weight of the first cemented carbide. In certain embodiments of the earth boring cutting insert, the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.5 to 5 weight percent, based on the total weight of the first cemented carbide. In certain non-limiting embodiments, the metallic binder of the first cemented carbide includes 0.1 to 10 weight percent ruthenium, 0.3 to 7 weight percent ruthenium, or 0.5 to 5 weight percent ruthenium, based on the weight of the first cemented carbide. The second cemented carbide includes a dispersed phase of hard grains including metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten. The second cemented carbide also includes a continuous phase of a metallic binder comprising at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is less than the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder of the first cemented carbide.

[0050] In certain embodiments of an earth boring cutting insert according to the present disclosure including a working portion comprising a first cemented carbide, and a body portion comprising a second cemented carbide, the dispersed phase of the first cemented carbide comprises tungsten carbide, and the metallic binder of the first cemented carbide comprises cobalt and greater than an impurities concentrations of one or more elements selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium. In certain embodiments of an earth boring cutting insert including a working portion comprising a first cemented carbide, and a body portion comprising a second cemented carbide, the dispersed phase of the second cemented carbide comprises tungsten carbide, and the metallic binder of the second cemented carbide comprises cobalt.

[0051] FIGS. **7**(*a*)-(*e*) are photographs showing aspects of an embodiment of an earth boring cutting insert according to the present disclosure having a dome-shaped tip and including a first region including a first cemented carbide, and a second region including a second cemented carbide. FIG. **6**(*a*) is a cross-sectional view (taken through a longitudinal axis) and FIG. **6**(*e*) is an exterior view of earth boring cutting insert **50**. Earth boring cutting insert **50** includes a first region including a first cemented carbide **52**, and a second region including a second cemented carbide **54**. As best shown in FIG. **6**(*a*), the first cemented carbide **52** and the second cemented carbide **54** meet at a transition zone **56**. FIG. **6**(*b*) is a micrograph showing the microstructure of the dome-shaped tip region. FIG. **6**(*c*) is a micrograph showing the microstructure in the transition zone, wherein the first cemented carbide meets the second cemented carbide. FIG. **6**(*d*) is a micrograph showing the microstructure of the second cemented carbide in the second region. The first cemented carbide **52** may include a dispersed phase including hard grains of carbide of at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten; and a continuous phase of a metallic binder comprising at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is 0.1 to 10 weight percent, based on the total weight of the cemented carbide. The second cemented carbide **54** may include, for example, a dispersed phase of hard grains including metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten; and a continuous phase of a metallic binder comprising at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is less than a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder of the first cemented carbide. In a more particular embodiment, both the first cemented carbide and the second cemented carbide include a dispersed phase comprising hard grains of tungsten carbide; the first cemented carbide includes a continuous phase of a metallic binder including cobalt and a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.1 to 10 weight percent, based on the total weight of the cemented carbide; and the second cemented carbide includes 0 up to no more than an impurities concentration of each of platinum, palladium, rhenium, rhodium, and ruthenium.

[0052] An advantage of a multi-region earth boring cutting insert according to the present disclosure, such as cutting insert **50** shown in FIGS. **7**(*a*)-(*e*) is that a working portion of the cutting insert may be composed of a first cemented carbide that includes greater ruthenium than a second cemented carbide positioned in body portion of the cutting insert. Given the cost of the alloying elements, utilizing a cemented carbide including a significant level of platinum, palladium, rhenium, rhodium, and/or ruthenium only in regions of the cutting insert that will be subjected to significant wear forces may reduce the materials cost associate with producing the cutting inserts.

[0053] The present disclosure also is directed to earth boring bits, such as, for example, rotary-cone earth boring bits and percussion bits (including, for example, hammer bits), including one or more earth boring cutting inserts according to the present disclosure mounted thereon. In one non-limiting embodiment according to the present disclosure, an earth boring bit includes a bit body; and at least one earth boring cutting insert comprising a metallic binder including at least one of platinum, palladium, rhenium, rhodium, and ruthenium. In certain non-limiting embodiments, the at least one earth boring bit includes a cemented carbide comprising: a dispersed phase including hard grains including metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten; and a continuous phase of a metallic binder comprising at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.1 to 10 weight percent, based on the total weight of the cemented carbide. In certain embodiments, the metallic binder comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.3 to 7 weight percent, based on the total weight of the cemented carbide. In certain embodiments, the metallic binder comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that 0.5 to 5 weight percent, based on the total weight of the cemented carbide. In certain embodiments, the metallic binder comprises 0.1 to 10 weight percent ruthenium, 0.3 to 7 weight percent ruthenium, or 0.5 to 5 weight percent ruthenium, based on the total weight of the cemented carbide. In certain non-limiting embodiments, the cemented carbide comprises 2 to 40 weight percent of the metallic binder and 60 to 98 weight percent of the dispersed phase. In certain embodiments, the hard grains of the dispersed phase comprise at least one of titanium carbide, vanadium carbide, chromium carbide, zirconium carbide, niobium carbide, molybdenum carbide, hafnium carbide, tantalum carbide, and tungsten carbide. In certain embodiments, the hard grains of the dispersed phase comprise tungsten carbide, and the metallic binder comprises cobalt and ruthenium.

[0054] According to certain non-limiting embodiments, an earth boring bit according to the present disclosure, which may be, for example, a rotary-cone earth boring bit or a percussion bit, includes at least one earth boring cutting insert that comprises a first region including a first cemented carbide, and a second region including a second cemented carbide. The first cemented carbide includes a metallic binder comprising a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.1 to 10 weight percent, based on the total weight of the cemented carbide. The second cemented carbide includes a metallic binder that includes no more than an impurities concentration of each of platinum, palladium, rhenium, rhodium, and ruthenium, or includes a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is less than the concentration of ruthenium in the metallic binder of the first cemented carbide. In certain embodiments, the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.3 to 7 weight percent, based on the total weight of the first cemented carbide. In certain other embodiments, the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.5 to 5 weight percent, based on the total weight of the first cemented carbide. In certain embodiments, the metallic binder of the second cemented carbide includes no greater than an impurities concentration of a platinum, palladium, rhenium, rhodium, and ruthenium. In certain embodiments, the metallic binder of the second cemented carbide does not include platinum, palladium, rhenium, rhodium, and/or ruthenium in the metallic binder. In certain embodiments, the first cemented carbide and the second cemented carbide each individually comprise: a dispersed phase including hard grains including a metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten; and a continuous phase of a metallic binder comprising at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy. In certain embodiments, the dispersed phase of the first cemented carbide comprise tungsten carbide, and the metallic binder of the first cemented carbide comprises cobalt; and the dispersed phase of the second cemented carbide comprises tungsten carbide, and the metallic binder of the second cemented carbide comprises cobalt.

[0055] According to certain non-limiting embodiments, an earth boring bit according to the present disclosure includes at least one earth boring cutting insert comprising a working portion comprising a first cemented carbide, and a body portion comprising a second cemented carbide. The first cemented carbide includes a dispersed phase of hard grains including a carbide of at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten. The first cemented carbide also includes a continuous phase of a metallic binder comprising at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.1 to 10 weight percent, based on the total weight of the cemented carbide. The second cemented carbide includes a dispersed phase of hard grains including metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten. The second cemented carbide includes a continuous phase of a metallic binder comprising at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is less than a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder of the first cemented carbide. In certain embodiments, the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.3 to 7 weight percent, based on the total weight of the first cemented carbide. In certain embodiments, the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.5 to 5 weight percent, based on the total weight of the first cemented carbide. In other embodiments, the dispersed phase of the first cemented carbide comprises tungsten carbide, and the metallic binder of the first cemented carbide comprises cobalt. In certain embodiments, the dispersed phase of the second cemented carbide comprises tungsten carbide, and the metallic binder of the second cemented carbide comprises cobalt.

[0056] The various earth boring cutting inserts and earth boring bits according to the present disclosure may be made by any method of manufacturing such articles, whether known now or hereinafter developed. For example, earth boring cutting inserts according to the present disclosure may be made by first using conventional press-and-sinter manufacturing techniques to provide a billet or predetermined shape of cemented carbide. As understood by ordinarily skilled artisans, press-and-sinter techniques may include a step of producing a metallurgical powder blend having the desired composition. Here, such a powder blend may have the composition of the desired cemented carbide material, including elemental powders and/or master alloy powders providing the desired elements in the appropriate proportions. All or a portion of the powder blend is compacted under high pressure to provide a green compact. As is known in the art, the green compact may by pre-sintered to provide a "brown" compact, which may be machined to provide particular features. The compact is sintered at high temperature for a period of time sufficient to suitably consolidate and densify the compact, thereby providing a billet or pre-determined shape of sintered cemented carbide material. The sintered compact may be machined to provide a cutting insert having the desired shape and including particular features. Regarding earth boring cutting bits, the bit bodies of such bits may be made using any conventional process. For example, bit bodes formed of metallic alloy may be machined from a perform of the desired alloy material. Cemented carbide bit bodies may be produced using known manufacturing techniques. One or more earth boring cutting inserts may be mounted on a particular bit body to provide an earth boring bit.

[0057] An alternative to using elemental or master alloy powders in a powder mix as the means for including concentrations of one or more of platinum, palladium, rhenium, rhodium, and ruthenium in a metallic binder according to the present disclosure is to diffuse one or more of these elements into the metallic binder of cemented carbide earth boring inserts manufactured in a conventional press-and-sinter manner, as outlined above. Suitable techniques that may be used to diffuse elements into the metallic binder of a cemented carbide are known in the art and include, for example, techniques described in U.S. Patent Application Publication No. US 2011/0052931 A1, the entire disclosure of which is hereby incorporated herein by reference. In the event such diffusion techniques are used, a near-surface region of the cemented carbide will include a concentration gradient of the diffused element or elements in the metallic binder of the material.

[0058] Those having ordinary skill, on reading the present disclosure, may, without undue effort, identify and implement suitable methods for producing earth boring cutting inserts and earth boring bits having the characteristics described herein. Accordingly, further discussion of possible manufacturing techniques need not be provided herein.

[0059] This specification has been written with reference to various non-limiting and non-exhaustive embodiments. However, it will be recognized by persons having ordinary skill in the art that various substitutions, modifications, or combinations of any of the disclosed embodiments (or portions thereof) may be made within the scope of this specification. Thus, it is contemplated and understood that this specification supports additional embodiments not expressly set forth herein. Such embodiments may be obtained, for example, by combining, modifying, or reorganizing any of the disclosed steps, components, elements, features, aspects, characteristics, limitations, and the like, of the various non-limiting embodiments described in this specification. In this manner, Applicant reserves the right to amend the claims during prosecution to add features as variously described in this specification, and such amendments comply with the requirements of 35 U.S.C. §112, first paragraph, and 35 U.S.C. §132(a).

What is claimed is:

1. An earth boring cutting insert including:

a cemented carbide comprising a metallic binder including greater than an impurities concentration of one or more elements selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium.

2. The earth boring cutting insert of claim **1**, wherein the cemented carbide comprises:

a dispersed phase including hard grains including metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten; and

a continuous phase of a metallic binder comprising

at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and

at least one element selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium, wherein the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder is 0.1 to 10 weight percent, based on the total weight of the cemented carbide.

3. The earth boring cutting insert of claim **2**, wherein the metallic binder comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.3 to 7 weight percent, based on the total weight of the cemented carbide.

4. The earth boring cutting insert of claim **2**, wherein the metallic binder comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.5 to 5 weight percent, based on the total weight of the cemented carbide.

5. The earth boring cutting insert of claim **2**, wherein the cemented carbide comprises 2 to 40 weight percent of the metallic binder and 60 to 98 weight percent of the dispersed phase.

6. The earth boring cutting insert of claim **2**, wherein the hard grains of the dispersed phase comprise at least one of titanium carbide, vanadium carbide, chromium carbide, zirconium carbide, niobium carbide, molybdenum carbide, hafnium carbide, tantalum carbide, and tungsten carbide.

7. The earth boring cutting insert of claim **2**, wherein the hard grains of the dispersed phase comprise tungsten carbide.

8. The earth boring cutting insert of claim **2**, wherein the metallic binder comprises cobalt and ruthenium.

9. The earth boring cutting insert of claim **2**, wherein the hard grains of the dispersed phase comprise tungsten carbide, and the metallic binder comprises cobalt and ruthenium.

10. The earth boring cutting insert of claim **2**, wherein the hard grains of the dispersed phase consist essentially of tungsten carbide, and the metallic binder comprises cobalt and ruthenium.

11. The earth boring cutting insert of claim **1**, wherein the cutting insert is adapted for use with at least one of a rotary-cone earth boring bit and a percussion bit.

12. The earth boring cutting insert of claim **2**, wherein the cutting insert is adapted for use with at least one of a rotary-cone earth boring bit and a percussion bit.

13. The earth boring cutting insert of claim **1**, wherein the cutting insert comprises a working portion and a body portion.

14. The earth boring cutting insert of claim **13**, wherein the working portion includes a shape selected from an ovoid shape, a ballistic shape, a chisel shape, a multi-dome shape, and a conical shape.

15. The earth boring cutting insert of claim **2**, wherein the cutting insert comprises a working portion and a body portion.

16. The earth boring cutting insert of claim **15**, wherein the working portion comprises a shape selected from an ovoid shape, a ballistic shape, a chisel shape, a multi-dome shape, and a conical shape.

17. The earth boring cutting insert of claim **1**, wherein the cutting insert comprises:

a first region comprising a first cemented carbide including a dispersed phase including hard grains of metal carbide in a metallic binder, the metallic binder of the first cemented carbide including at least one of platinum, palladium, rhenium, rhodium, and ruthenium, wherein a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder is 0.1 to 10 weight percent, based on the weight of the first cemented carbide; and

a second region comprising a second cemented carbide including a dispersed phase including hard grains of metal carbide in a metallic binder, wherein the metallic binder of the second cemented carbide includes a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is less than the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder of the first cemented carbide.

18. The earth boring cutting insert of claim **17**, wherein the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.3 to 7 weight percent, based on the total weight of the cemented carbide.

19. The earth boring cutting insert of claim **17**, wherein the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.5 to 5 weight percent, based on the total weight of the cemented carbide.

20. The earth boring cutting insert of claim **17**, wherein the metallic binder of the first cemented carbide comprises 0.1 to 10 weight percent ruthenium, based on the total weight of the first cemented carbide.

21. The earth boring cutting insert of claim **17**, wherein the metallic binder of the second cemented carbide including no greater than an impurities concentration of ruthenium.

22. The earth boring cutting insert of claim **17**, wherein the metallic binder of the second cemented carbide does not include ruthenium.

23. The earth boring cutting insert of claim **17**, wherein the first cemented carbide and the second cemented carbide each individually comprise:

a dispersed phase including hard grains of metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten; and

a continuous phase of a metallic binder comprising at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy.

24. The earth boring cutting insert of claim **17**, wherein the first region includes a working portion of the cutting insert.

25. The earth boring cutting insert of claim **24**, wherein the working portion comprises a shape selected from an ovoid shape, a ballistic shape, a chisel shape, a multi-dome shape, and a conical shape.

26. The earth boring cutting insert of claim **17**, wherein:

the dispersed phase of the first cemented carbide comprises tungsten carbide, and the metallic binder of the first cemented carbide comprises cobalt; and

the dispersed phase of the second cemented carbide comprises tungsten carbide, and the metallic binder of the second cemented carbide comprises cobalt.

27. The earth boring cutting insert of claim **17**, wherein the cutting insert is adapted for use with at least one of a rotary-cone earth boring bit and a percussion bit.

28. An earth boring cutting insert comprising:

a working portion comprising a first cemented carbide including

a dispersed phase including hard grains of metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten, and

a continuous phase of a metallic binder comprising

at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and

at least one element selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium, wherein the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder is 0.1 to 10 weight percent, based on the total weight of the first cemented carbide; and

a body portion comprising a second cemented carbide including

a dispersed phase including hard grains of metal carbide comprising at least one transition metal selected from titanium, chromium, vanadium, zirconium, hafnium, tantalum, molybdenum, niobium, and tungsten, and

a continuous phase of a metallic binder comprising

at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and

a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is less than the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder of the first cemented carbide.

29. The earth boring cutting insert of claim **28**, wherein the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is 0.3 to 7 weight percent, based on the total weight of the first cemented carbide.

30. The earth boring cutting insert of claim **28**, wherein the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is 0.5 to 5 weight percent, based on the total weight of the first cemented carbide.

31. The earth boring cutting insert of claim **28**, wherein

the dispersed phase of the first cemented carbide comprises tungsten carbide; and

the metallic binder of the first cemented carbide comprises cobalt.

32. The earth boring cutting insert of claim **31**, wherein

the dispersed phase of the second cemented carbide comprises tungsten carbide; and

the metallic binder of the second cemented carbide comprises cobalt.

33. An earth boring bit comprising:

a bit body; and

at least one earth boring cutting insert comprising a metallic binder including at least one element selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium, wherein the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder is 0.1 to 10 weight percent, based on the total weight of the cemented carbide.

34. The earth boring bit of claim **33**, wherein the cemented carbide comprises:

a dispersed phase including hard grains of metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten; and

a continuous phase of a metallic binder comprising 0.1 to 10 weight percent ruthenium, based on the total weight of the cemented carbide, and at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy.

35. The earth boring bit of claim **34**, wherein the metallic binder comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is 0.3 to 7 weight percent, based on the total weight of the cemented carbide.

36. The earth boring bit of claim **34**, wherein the metallic binder comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is 0.5 to 5 weight percent, based on the total weight of the cemented carbide.

37. The earth boring bit of claim **34**, wherein the cemented carbide comprises 2 to 40 weight percent of the metallic binder and 60 to 98 weight percent of the dispersed phase.

38. The earth boring bit of claim **34**, wherein the hard grains of the dispersed phase comprise at least one of titanium carbide, vanadium carbide, chromium carbide, zirconium carbide, niobium carbide, molybdenum carbide, hafnium carbide, tantalum carbide, and tungsten carbide.

39. The earth boring bit of claim **34**, wherein the hard grains of the dispersed phase comprise tungsten carbide.

40. The earth boring bit of claim **34**, wherein the metallic binder comprises cobalt and ruthenium.

41. The earth boring bit of claim **33**, wherein the earth boring bit is one of a rotary-cone earth boring bit and a percussion bit.

42. The earth boring bit of claim **34**, wherein the earth boring bit is one of a rotary-cone earth boring bit and a percussion bit.

43. The earth boring bit of claim **33**, wherein the at least one earth boring cutting insert comprises:

a first region comprising a first cemented carbide including metal carbide grains dispersed in a metallic binder, the metallic binder of the first cemented carbide including at least one element selected from the group consisting of platinum, palladium, rhenium, rhodium, and ruthenium, wherein the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder is 0.1 to 10 weight percent, based on the total weight of the first cemented carbide; and

a second region comprising a second cemented carbide including metal carbide grains dispersed in a metallic binder, wherein the metallic binder of the second cemented carbide includes a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is less than the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder of the first cemented carbide.

44. The earth boring bit of claim **43**, wherein the metallic binder of the first cemented carbide comprises 0.1 to 10 weight percent ruthenium, based on the total weight of the first cemented carbide.

45. The earth boring bit of claim **43**, wherein the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.3 to 7 weight percent, based on the total weight of the first cemented carbide.

46. The earth boring bit of claim **43**, wherein the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.5 to 5 weight percent, based on the total weight of the first cemented carbide.

47. The earth boring bit of claim **43**, wherein the metallic binder of the second cemented carbide does not include ruthenium.

48. The earth boring bit of claim **43**, wherein:

the first cemented carbide comprises tungsten carbide grains, and the metallic binder of the first cemented carbide comprises cobalt; and

the second cemented carbide comprises tungsten carbide grains, and the metallic binder of the second cemented carbide comprises cobalt.

49. The earth boring bit of claim **43**, wherein the earth boring bit is one of a rotary-cone earth boring bit and a percussion bit.

50. An earth boring bit including

at least one earth boring cutting insert comprising:

a working portion comprising a first cemented carbide including

a dispersed phase including hard grains of metal carbide comprising at least one transition metal selected from titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, and tungsten, and

a continuous phase of a metallic binder comprising

at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and

at least one of platinum, palladium, rhenium, rhodium, and ruthenium, wherein the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder is 0.1 to 10 weight percent, based on the total weight of the first cemented carbide; and

a body portion comprising a second cemented carbide including

a dispersed phase including hard grains of metal carbide comprising at least one transition metal selected from titanium, chromium, vanadium, zirconium, hafnium, tantalum, molybdenum, niobium, and tungsten, and

a continuous phase of a metallic binder comprising

at least one of cobalt, a cobalt alloy, nickel, a nickel alloy, iron, and an iron alloy, and

a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium that is less than the combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder of the first cemented carbide.

51. The earth boring bit of claim **50**, wherein the metallic binder of the first cemented carbide comprises 0.1 to 10 weight percent ruthenium, based on the total weight of the first cemented carbide.

52. The earth boring bit of claim **50**, wherein the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.3 to 7 weight percent, based on the total weight of the first cemented carbide.

53. The earth boring bit of claim **50**, wherein the metallic binder of the first cemented carbide comprises a combined concentration of platinum, palladium, rhenium, rhodium, and ruthenium in the metallic binder that is 0.5 to 5 weight percent, based on the total weight of the first cemented carbide

54. The earth boring bit of claim **50**, wherein

the dispersed phase of the first cemented carbide comprises tungsten carbide; and

the metallic binder of the first cemented carbide comprises cobalt.

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