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(54) HARD FORMATION INSERT AND PROCESS FOR MAKING THE SAME

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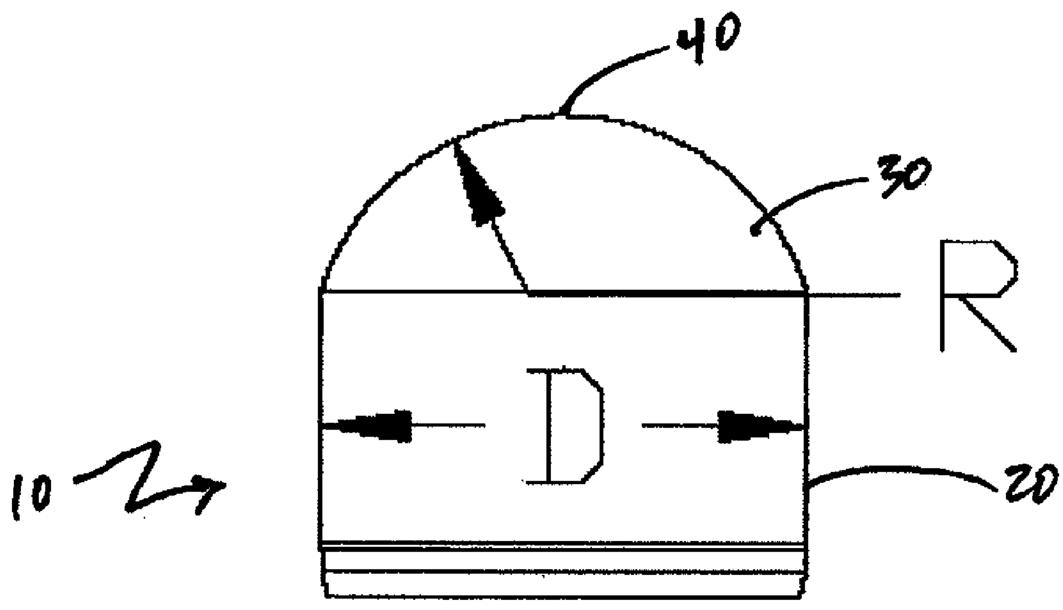
(57) ABSTRACT

A drilling insert includes a cylindrical body and a top portion of the drilling insert. The top portion is on top of the cylindrical body providing a contact area, wherein the contact area provides a flat area for distributing contact stress when the drilling insert impacts the formation.



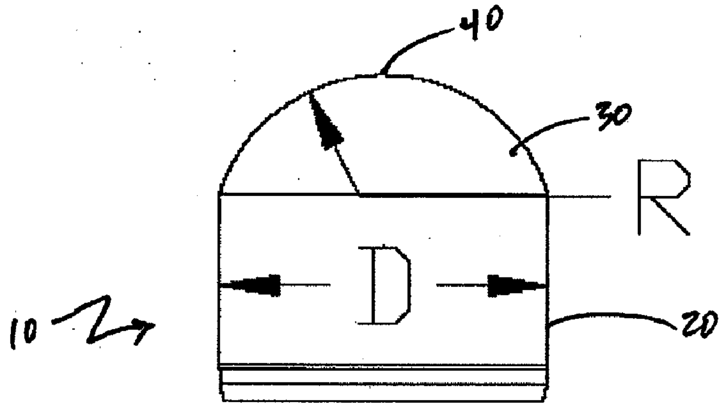


Fig. 1

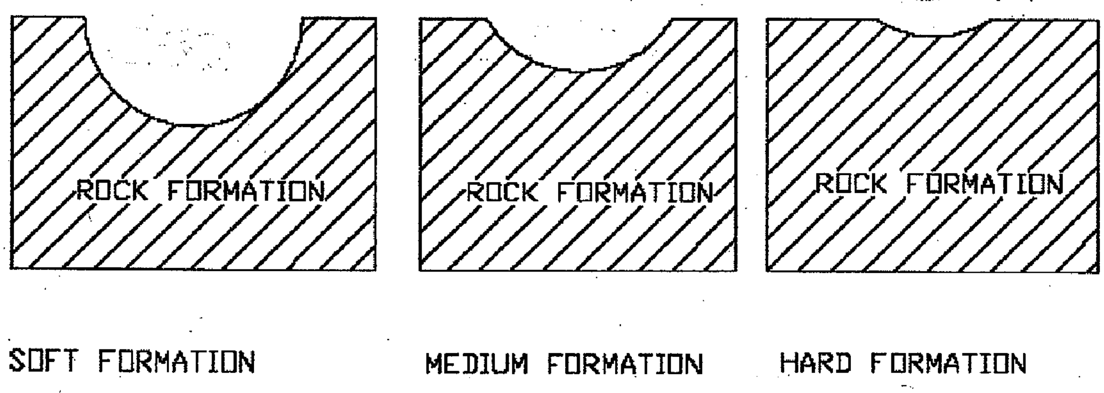


Fig. 2A Fig. 2B Fig. 2C

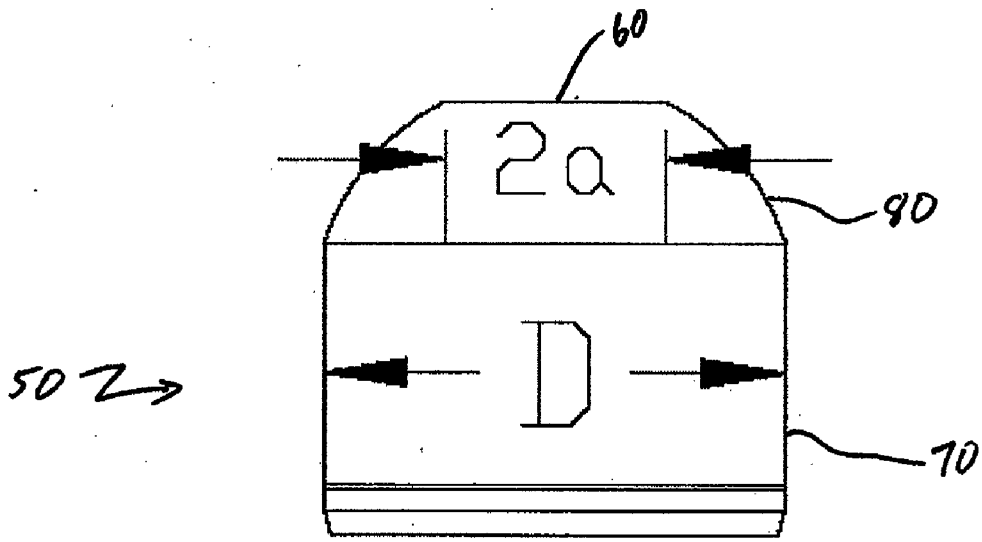


Fig. 3

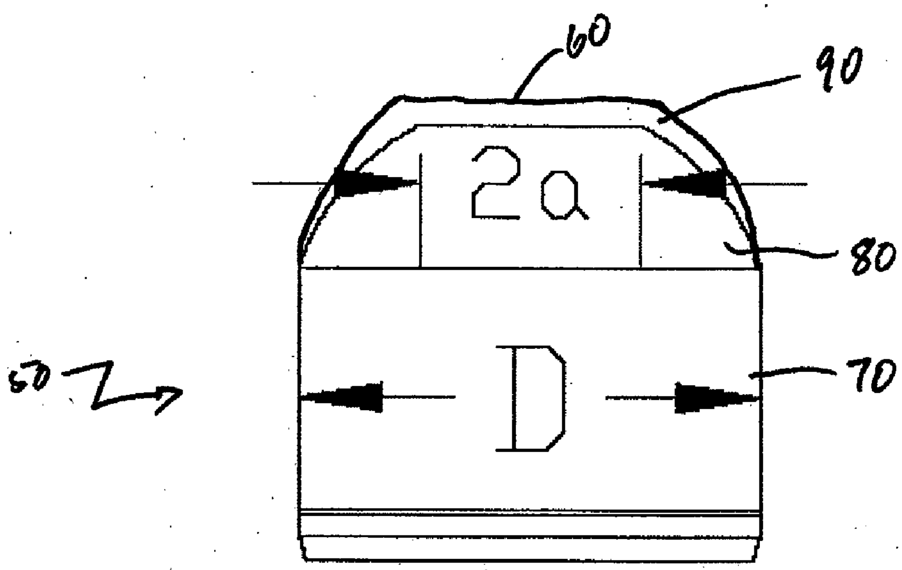


Fig. 4

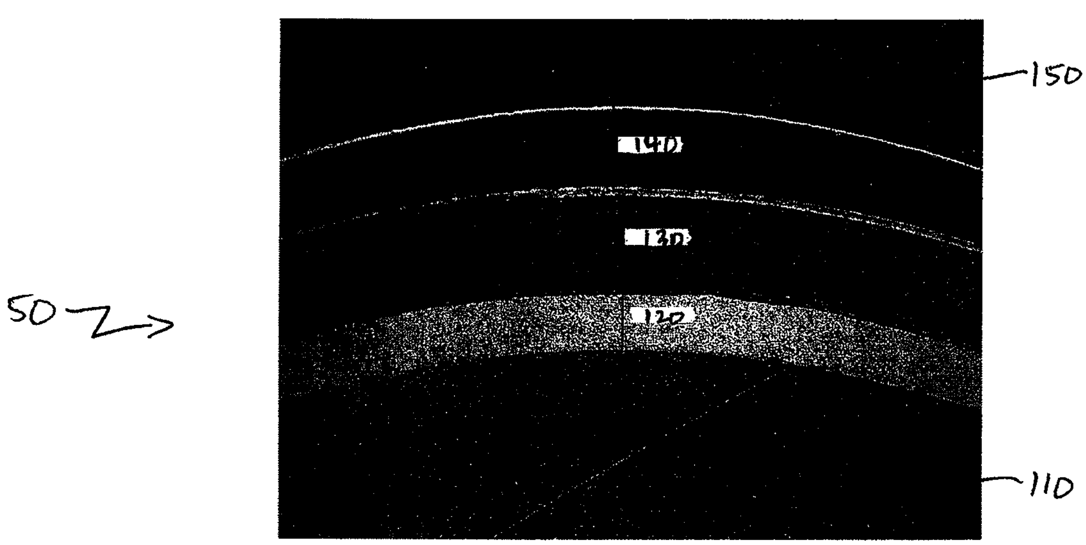


Fig. 5

HARD FORMATION INSERT AND PROCESS FOR MAKING THE SAME

RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 60/023,713 filed Jan. 25, 2008.

BACKGROUND

[0002] In drilling operations, semi-round top drilling structures (inserts) can be used for oil, gas, and mining applications and exploration. These inserts are made of hard materials to withstand the abrasive nature of formations. For example, the inserts may formed using hard materials, including cemented carbide, a polycrystalline diamond compact (PDC), or any other suitable material, or may utilize a hard base material coated with one or more layers of another hard materials. PDC inserts can be used to successfully drill medium to hard formations. In some embodiments, inserts utilized for percussive or hammer drilling have a round top dome radius (R) of which is related to the diameter (D) of the insert.

[0003] In medium to hard formations with compressive strengths of 15,000 to 25,000 psi, inserts wear with little or no chipping. A percussive bit can drill over 5,000 feet with rate of penetration (ROP) ranging from 90 ft/hr to 130 ft/hr. However, in harder formations with compressive strengths of 25,000 psi and higher, inserts can fail prematurely at relatively less total footage drilled when compared to medium hard formations. Failure of the inserts can occur when the insert structure chips extensively or the insert breaks entirely. In the case of PDC inserts, a diamond layer can chip and sometimes delaminate completely. Additionally, cracks originating in the diamond layer can propagate deep into the body of the insert. This behavior is sometimes described as impact fatigue of the inserts. Impact fatigue of inserts can lead to catastrophic failure when inserts break in half along a vertical axis and/or inserts are sheared at the body of the bit resulting in early pull out of the bit from the hole at great cost and time.

SUMMARY

[0004] One embodiment provides a drilling insert including a cylindrical body and a top portion of the drilling insert. The top portion is on top of the cylindrical body providing a contact area, wherein the contact area provides a flat area for distributing contact stress when the drilling insert impacts the formation.

[0005] Another embodiment provides A drilling insert includes a cylindrical body and a top portion of the drilling insert. The top portion of the drilling insert on the cylindrical body provides a contact area for impacting a formation, wherein the top portion is dome shaped with a truncated tip.

[0006] The foregoing has outlined some of the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The foregoing and other features and aspects of the present invention will be best understood with reference to the following detailed description of a specific embodiment of the invention, when read in conjunction with the accompanying drawings, wherein:

[0008] FIG. **1** is an illustrative embodiment of a geometry of a cutting structure (i.e. insert) used in percussive drill bits;

[0009] FIG. **2**A illustrates an insert penetrating into a soft rock formation;

[0010] FIG. **2**B illustrates an insert penetrating into a medium rock formation;

[0011] FIG. **2**C illustrates an insert penetrating into a hard rock formation;

[0012] FIG. **3** illustrates an embodiment of an insert providing an increased contact area;

[0013] FIG. **4** is an embodiment of an insert providing an increased contact area and a surface layer; and

[0014] FIG. **5** is an embodiment of an insert providing multiple layers of materials.

DETAILED DESCRIPTION

[0015] Refer now to the drawings wherein depicted elements are not necessarily shown to scale and wherein like or similar elements are designated by the same reference numeral through the several views.

[0016] FIG. **1**. is an illustrative embodiment of a geometry of a cutting structure (i.e. insert) **10** used in percussive drill bits. A percussive bit includes several rows of inserts **10** of different sizes.

[0017] Insert **10** may provide a generally cylindrical portion **20** and a dome shaped top portion **30**. Cylindrical portions **20** of inserts **10** with a diameter (D) are housed by a drill bit, while top portions **30** of inserts **10** protrude from the drill bit. Top portion **30** of insert **10** is dome shaped with a curvature defined by a radius (R). The diameter of insert **10** is in the range of ⅝ to 1 inch and the ratio of R/D is in the range of 0.4 to 0.55.

[0018] The drill bit is impacted by an air driven piston or the like when it is in contact with a formation causing top portions **30** of inserts **10** to penetrate into a formation thereby fracturing the rock. The extent of penetration of inserts **10** into a formation is dependent on the radius (R) and impact energy of the hammer. In addition, a fluid may be injected to remove broken chips or particles of rock. The rate of drilling as defined by the footage drilled per hour (i.e. rate of penetration ROP) is determined by among other factors, the impact energy of the hammer, bit design, hardness of the rock formation, and speed of removal of the chips from the hole.

[0019] The phenomenon of contact stresses, also referred to as Hertzian contact stress, between two hard materials that deform elastically under load illustrates that the Hertzian stresses between surfaces varies inversely as square of indentation (penetration) size. Consequently, with decreasing penetration of inserts in harder formation, stresses felt at the tip of inserts will increase exponentially. At some point stress felt by the insert will exceed the strength of the polycrystalline diamond compact (PDC) layer and the PDC layer can develop cracks causing delamination and/or propagation into the body of the insert.

[0020] During initial impact, tip **40** of insert **10** is subjected to very high stress as it makes contact with the formation. Top portion **30** of insert **10** penetrates in to the formation causing the rock to fracture. During the initial period of contact between insert **10** and the formation, the stress felt by tip **40** of insert **10** is focused in a very small area of contact. As a result, the initial stress on tip **40** is extremely high. As insert **10**

penetrates further into the formation, the area of contact continues to increase spreading the stress felt by insert **10** over a larger area, which decreases the stress felt by top portion **30** of insert **10**.

[0021] FIG. **2**A-C illustrates the extent of insert penetration into soft to hard rock formations. FIG. **2**A illustrates that inserts can penetrate to the full dome height in a soft rock formation. FIG. **2**B illustrates that the dome of an insert partially penetrates into a medium rock formation. FIG. **2**C illustrates that the indent size on harder formations is significantly less than both the soft and medium formations. As shown, penetration of inserts in harder formations can be significantly less than the softer rock formations spreading forces over a smaller contact area. This causes higher stress on inserts that can rise above their fracture strength. Providing a flat tip on inserts (i.e. increasing the contact area) will in effect lower the stress below the fracture strength of inserts. Lowering the stress on the inserts could eliminate failure of inserts and may also increase the endurance (i.e. fatigue life) of inserts.

[0022] FIG. **3** illustrates an embodiment of an insert **50** providing an increased contact area **60**. By changing the shape of insert **50** to increase contact area **60**, the contact stresses can be lowered significantly. Insert **50** provides a cylindrical portion **70** and a top portion **80**. In one embodiment, cylindrical portion **70** is a circular cylinder with a diameter (D) and is housed in a drill bit. However, in other embodiments any suitable cylinder may be utilized, such as an elliptic cylinder and the like. Top portion **80** protrudes from the drill bit and penetrates into a formation during drilling.

[0023] In one embodiment, top portion **80** begins as a dome shaped member that protrudes from cylindrical portion **70**. The dome has a radius (R) defining the curvature of the dome, and the ratio of R/D is in the range of 0.4 to 0.55 in a preferred embodiment. In other embodiments, top portion **80** may be oval shaped dome, ellipse shaped dome, or any other suitable dome-like shape. Contact area **60** of insert **50** is increased by truncating top portion **80**. In one embodiment, contact area **60** is substantially flat to provide a plane on which contact is intended to occur. By truncating the dome shaped top portion **80** to increase contact area **60**, the region of contact between insert **10** and the rock formation is changed from a point **40** (FIG. **1**) to a contact area **60** (FIG. **2**), thereby spreading initial impact stress over a larger area. In a preferred embodiment, the width of contact area **60** is a function of the penetration depth (a) of insert **50**. For example, as shown in FIG. **2**, contact area **60** has a width equal to two times the penetration depth. While preferred ratios for R/D and a/D are provided, any suitable ratios may be utilized in other embodiments.

[0024] Inserts **50** can be manufactured from a cemented carbide, polycrystalline diamond compact (PDC), and/or other hard materials by the conventional method of manufacturing. In some cases, hard surface materials may be bonded to a base, such as a strong metallic base. If insert **50** is made of PDC materials, it can be modified by electro discharge machining (EDM) of top portion **80** of insert **50** to a predetermined height of the dome. Another method of creating a larger contact area **60** for insert **50** is to provide a very large radius (R) well above current values. However, the disadvantage of a large radius is that it significantly reduces dome height of inserts and consequently the extent of penetration into the rock formation.

[0025] In another embodiment, insert **50** can be manufactured by providing a pre shaped configuration prior to high pressure high temperature pressing of insert **50** and then finishing insert **50** to size. This method of manufacturing provides an economical process for manufacturing inserts **50**. By providing a larger surface area on insert **50**, contact stresses on the diamond surface will be decreased. Contact stresses will vary as a function of a/D ratio, where 'a' is determined by the depth of penetration of the insert into the rock.

[0026] FIG. **4** is an embodiment of an insert **50** providing an increased contact area **60** and a contact adjustment layer **90**. Insert **50** provides cylindrical portion **70** and a truncated top portion **80**. A surface layer **90**, which is preferably made of material(s) that are not prone to chipping, is placed on top portion **80**. In one embodiment, contact adjustment layer **90** utilizes material(s) that are capable of wearing away to provided a flat surface aligned with the surface of the rock formation during drilling. In another embodiment, contact adjustment layer **90** utilizes material(s) that are capable of deforming under compressive stress to provide a flat surface aligned with the surface of the rock formation during drilling. In other embodiments, contact adjustment layer **90** may utilize material(s) that are capable of wearing away and/or deforming to provide a flat surface aligned with the surface of the rock formation during drilling. For example, contact adjustment layer **90** may utilize materials such as cemented carbide with high concentrations of metals, cermets or a composite material including ceramic and metallic materials, a mixture of cemented carbide and diamond, and any other suitable material. In some embodiments, insert **50** may include several contact adjustment layers **90** utilizing a variety of materials. By allowing contact adjustment layer **90** to wear away and/or deform into a flat surface, contact area **60** of insert **50** can adjust to substantially align contact area **60** in parallel with the surface of the rock formations. In other embodiments, the flat contact area is pre-formed during the manufacturing of the drilling insert and the flat contact area is not modified during drilling. However, in embodiments providing a contact adjustment layer, drilling inserts can modify the alignment of the flat contact area during drilling operations. The one or more contact adjustment layers of the drilling inserts wear away and/or deform to maximize the contact area between an insert and the formation.

[0027] FIG. **5** is an embodiment of an insert **50** providing multiple layers of materials. A substrate **110** of insert **50** serves as a base on which additional layers of insert **50** are assembled on. Substrate **110** can be made from materials such as carbide and the like. First transition layer **120** and second transition layer **130** provide hard layers of material that are capable of standing up to the high compressive stress exerted on insert **50** during drilling. Transition layers **120** and **130** may utilize materials such as diamond, a mixture of diamond and carbide, or the like. Contact adjustment layer **140** provides a layer that may wear and/or deform to adjust the contact area of insert **50**. Specimen mounting layer **150** may provide and outer layer for insert **150** made of plastic, bakelite, or the like. In other embodiments, any suitable substitute may be utilized for the materials discussed herein.

[0028] Inserts with increased contact areas will make it possible to drill harder formations more economically. Conventional drilling inserts are prone to cracking, chipping, and/or delamination at high stress levels. By increasing the contact area between inserts and a rock formation, forces are spread over a larger area of the inserts, thereby decreasing the stresses exerted on the inserts. By increasing the contact area, the rate of penetration (ROP) and the life of inserts can be increased. Preliminary testing has shown that shaped inserts utilized with a 9¾ inch bit allowed drilling of 1500 ft at a rate of 139 ft/hr compared to 1100 ft with round tipped inserts.

[0029] From the foregoing detailed description of specific embodiments of the invention, it should be apparent that a system for increasing the contact area of a drilling insert that is novel has been disclosed. Although specific embodiments of the invention have been disclosed herein in some detail, this has been done solely for the purposes of describing various features and aspects of the invention, and is not intended to be limiting with respect to the scope of the invention. It is contemplated that various substitutions, alterations, and/or modifications, including but not limited to those implementation variations which may have been suggested herein, may be made to the disclosed embodiments without departing from the spirit and scope of the invention as defined by the appended claims which follow.

What is claimed is:

1. A drilling insert comprising:

a cylindrical body; and

a top portion of the drilling insert on top of the cylindrical body providing a contact area, wherein the contact area provides a flat area for distributing contact stress when the drilling insert impacts the formation.

2. The drilling insert of claim **1**, wherein the top portion is a dome shaped member with a truncated tip, and the flat area provided by the truncated tip is pre-formed.

3. The drilling insert of claim **2**, wherein the truncated tip is created by electro discharge machining (EDM).

4. The drilling insert of claim **2**, wherein the truncated tip is created by pre-shaping the drilling insert before performing a high pressure high temperature manufacturing process.

5. The drilling insert of claim **1**, wherein a width of the flat area is a function of a penetration depth of the drilling insert.

6. The drilling insert of claim **1**, wherein a width of the flat area is two times a penetration depth of the drilling insert.

7. The drilling insert of claim **1**, wherein the drilling insert is utilized in a percussive drill bit.

8. The drilling insert of claim **1**, wherein the top portion includes a surface layer, and the surface layer is modified to form the flat area during use of the drilling insert.

9. The drilling insert of claim **8**, wherein the surface layer comprises a material that deform to form the flat area under contact stresses during drilling.

10. The drilling insert of claim **8**, wherein the surface layer comprises a material that wears away to form the flat area during drilling.

11. A drilling insert comprising:

a cylindrical body; and

a top portion of the drilling insert on the cylindrical body providing a contact area for impacting a formation, wherein the top portion is dome shaped with a truncated tip.

12. The drilling insert of claim **11**, wherein the truncated tip provides a flat area of contact for distributing contact stress, and the flat area is preformed.

13. The drilling insert of claim **12**, wherein a width of the flat area of contact is two times a penetration depth of the drilling insert.

14. The drilling insert of claim **12**, wherein a width of the flat area of contact is a function of a penetration depth of the drilling insert.

15. The drilling insert of claim **11**, wherein the truncated tip is created by electro discharge machining (EDM).

16. The drilling insert of claim **13**, wherein the truncated tip is created by pre-shaping the drilling insert before performing a high pressure high temperature manufacturing process.

17. The drilling insert of claim **11**, wherein the drilling insert is utilized in a percussive drill bit.

18. The drilling insert of claim **11**, wherein the top portion includes a surface layer, and the surface layer is modified to form the flat area during use of the drilling insert.

19. The drilling insert of claim **8**, wherein the surface layer comprises a material that deform to form the flat area under contact stresses during drilling.

20. The drilling insert of claim **8**, wherein the surface layer comprises a material that wears away to form the flat area during drilling.

* * * * *