

[54] COMBINATION ROTARY AND
PERCUSSION DRILL BIT

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175/402, 406, 409, 407, 374

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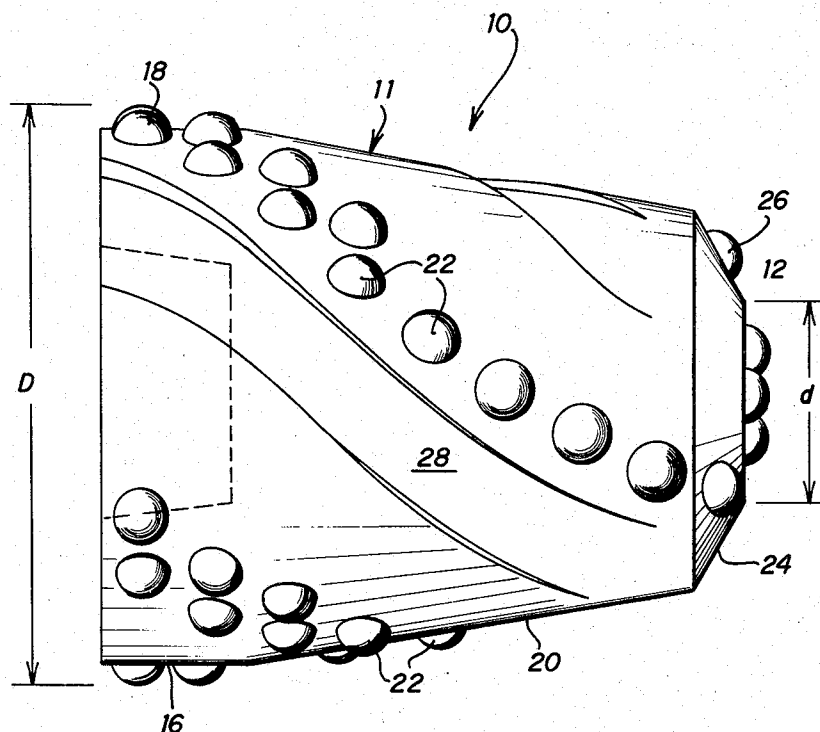
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[57] ABSTRACT

A substantially solid drill bit having a generally frusto-conical shape, with a cylindrical base and a relatively narrow tip; the ratio of base diameter to tip diameter optimally falls within the range of 2 to 7; the included angle of the conical section is preferably about 34°, but it may be as small as 20° and as large as 90°. Means are provided on the base so that the bit may be turned in the hole in the manner of an auger, and means are also provided so that the bit may receive impact loads from a hammer or the like, and transmit the same to such hard matter as may be encountered. Hardened inserts or buttons are arranged in helical rows to facilitate removal of cuttings from the hole.

10 Claims, 2 Drawing Figures



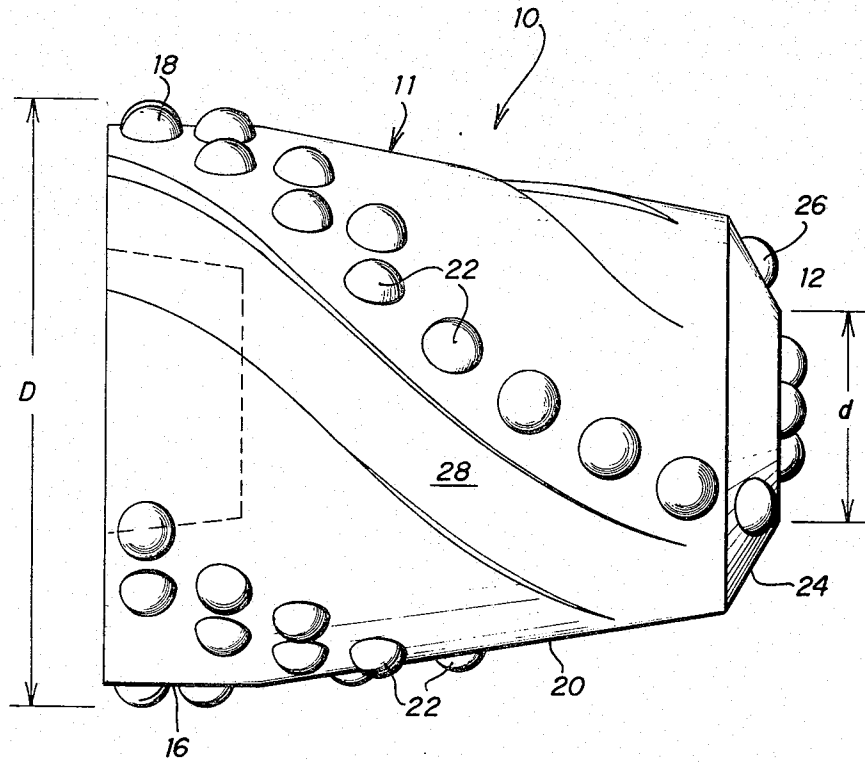


FIG. 1

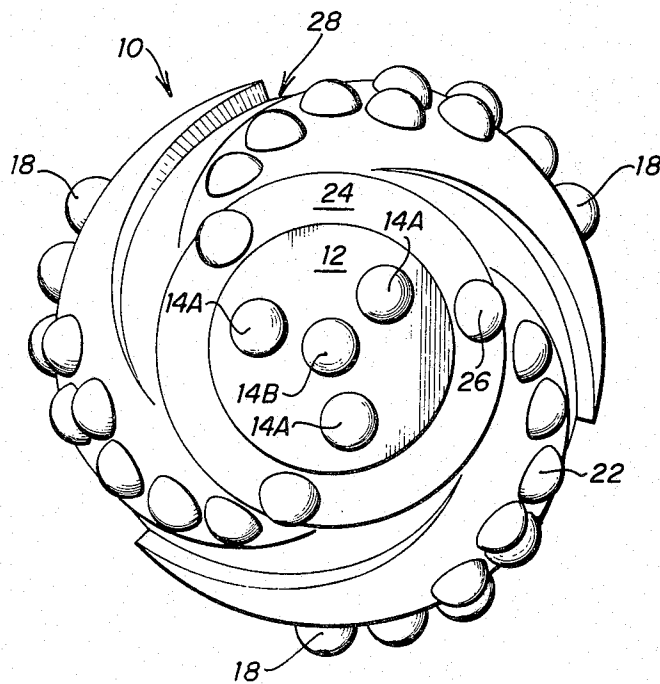


FIG. 2

COMBINATION ROTARY AND PERCUSSION DRILL BIT

This invention relates generally to drill bits, and more particularly to a bit which is capable of rotary action (in the manner of an auger) as well as percussion action (in the manner of a chisel).

During the course of drilling a hole through many structures and soils, it is common to encounter matter of different densities and hardnesses. When the hole is to be drilled in the earth's surface, it is common to initially encounter relatively soft earth or overburden, followed by different levels of soft shales, clays, sandstones, limestones, quartzites, and granites. Each of these different materials has its own unique properties, and it has been common in the art to design a tool bit which is optimized so as to cut very efficiently through each of the particular materials. Regrettably, however, the sequential encountering of different materials as a hole is drilled has usually necessitated the removal of the bit (and the attached drill stem) in order to permit a change from a first bit to another bit which is more nearly appropriate for the newly encountered material. During the change-over from one type of bit to another, obviously no progress is being made in furthering the hole depth, and most of the investment in equipment and labor is essentially being wasted. Accordingly, it is an object of this invention to provide a drill bit which is capable of going through a variety of materials characterized by different hardnesses and resistances, such that a single tool bit may be started at the top of the ground and maintained in the hole until the hole is completed.

Another typical situation in which material of different physical characteristics is encountered is that involving the remodeling of certain buildings. That is, when plumbers and electricians have to replumb or rewire a building, it is common for them to have to drill holes completely through a finished wall (or floor), both of which frequently include a hard outer material, a soft insulation-type material interiorly of the wall, and a similar hard material on the other side of the wall. In the past, a tool bit which was optimally designed for drilling through a hard material (such as masonry or concrete) would tend to "choke" on relatively soft woods and fiber insulation. Accordingly, it is an object of this invention to provide a drill bit which can be started at one surface of a composite wall and drilled continuously therethrough, even while encountering materials of different physical characteristics.

It is a further object of the invention to provide a tool which is capable of rotary action, which is most effective when the matter being drilled is relatively soft; and also to provide a tool which is capable of percussion action, which is the action that is characteristic of chisels and similar tools for working on hard matter.

These and other objects and advantages will be apparent from the specification and the drawings provided herewith.

In the drawing:

FIG. 1 is a elevation, side view on a typical embodiment of the drill bit.

FIG. 2 is a front end view of a drill bit, showing how four inserts or buttons are preferably located to form effective extensions of three helical rows of inserts along the sides of the frustoconical body.

Referring initially to FIG. 1, a drill bit 10 in accordance with the invention is shown in elevation. The bit

10 has a generally solid body 11 with a substantially cylindrical base 16 and one or more hardened inserts 18 which protrude radially therefrom, i.e., they are oriented perpendicular to the longitudinal axis of the bit. The base 16 and its inserts 18 are adapted to serve as a gauging member to define the size of the finished hole. In order to more nearly insure that the hole size will not significantly vary from top to bottom, it is preferable that there be a plurality of radial gauging inserts 18, so that any wear occasioned by the gauging action will be distributed over more than one insert. The base 16 also has a conventional square recess or splines or the like which are adapted to mate with a driving member such that torque forces may be applied to the bit 10. As is customary with other percussion tools, means are also provided in the base to receive axial loads from a ram or hammer or the like. External splines may also be provided in the manner of popular "downhole" tools. Hence, in a suitable manner, the bit is provided with means whereby it may be both rotated and driven axially forward.

The body 11 has a relatively narrow tip 12 which is adapted to make initial contact with the matter to be penetrated. In the preferred embodiment, the tip or point 12 is relatively flat-tipped. By use of this expression, it is intended to suggest that the tip is generally flat, but a slight deviation from a plane would not render the bit inoperative. One reason for preferring the relatively flat surface is to provide a small area at the point of the bit which can repeatedly take direct axial loads as close as practicable along a line which coincides with the geometric axis of the bit. Such axial loads are typically placed on the bit 10 through use of a conventional percussion-type drilling rig, and the axial thrust of the bit is preferably imparted to the underneath rock through hardened means such as a plurality of symmetrically arranged hardened inserts 14 A, B on the point 12. For economy reasons, among others, a plurality of small inserts are preferable to one large insert. (The preferred arrangement for a plurality of hardened inserts or buttons 14 A, B will be discussed subsequently.) The inserts on the tip preferably are pressed into holes that are drilled along lines which are parallel to the longitudinal axis of the bit 10.

The point 12 is rather small in comparison with the base 16 in order to promote good penetration in relatively soft materials; but it cannot be too small or there will be no space for downwardly facing buttons 14 A, B. Whether the tip 12 is flat or convex, it still will have a measurable diameter, which is shown in FIG. 1 by the dimension d . The cylindrical base 16 also has a diameter, which is indicated in FIG. 1 by the dimension D . In order to foster rapid penetration by the drill bit 10, it has been found that the ratio of base diameter to tip diameter (i.e., D to d) should be at least 2 and preferably no greater than about 7. The preferred ratio is about 4.

It has been found that an optimum ratio provides at least two favorable results. First, the sides of the drilled hole tend to be somewhat compressed by the downwardly moving "pointed" bit, so that there is less tendency for the sides of the drilled hole to collapse and fall to the bottom of the hole. This naturally means that there can be less particulate matter to be removed from the hole. (The result of drilling a hole in soil with a pointed bit also may be considered to be analogous to shaping wet concrete with a trowel.)

Because the tip is always much smaller than the base, the drill bit of this invention is, of course, aptly described as "pointed." (The difference between this bit and others will be even more apparent when this bit is compared with those disclosed, for example, in U.S. Pat. No. 3,581,835 to Stebley or U.S. Pat. No. 3,485,301 to Stewart.)

The second favorable result of the pointed shape is that the initial contact of a hardened insert against a rock or the like occurs near the axis of rotation of the bit. Since any given insert mounted in a bit will usually take axial loads (i.e., loads applied along the longitudinal axis of the insert) better than transverse (or torque) loads, those inserts at the very tip of the bit will last longer in the bit if they strike a rock while rotating at a relatively low linear speed. To perhaps better appreciate this point, it should be remembered that a bit designed to function with hardened inserts can be rendered ineffective by either of two events: 1) the inserts themselves can wear down to the extent that they no longer protrude above the base metal where they are most effective; or, 2) the inserts can remain relatively unscathed but their supporting metal can be worn away such that a relatively good insert can be simply knocked loose from the bit. (In this regard, it is believed that there are more premature bit failures due to lost inserts than due to worn inserts.) Keeping in mind that the tangential velocity of any point on a rotating body—such as a drill bit—is given by the product of the angular velocity of the body (ω) and the distance of the point from the axis of rotation (R), then establishing a low distance R for those inserts on the tip means they will tend to remain in the bit longer, and the bit can be kept in the hole where it is productive.

Between the point 12 and the cylindrical base 16 is a generally conical section 20, such that the bit in external appearance has the shape of a frustoconical body. It has been found that an optimum included angle for the conical section is about 34°, although the angle may be as little as 20° and as large as 80°. If the included angle is too small, the bit will tend to be rather long, thereby requiring more hardened inserts (which are expensive) along the side than would otherwise be required—without any concomitant increase in performance. A relatively narrow bit would also tend to be too weak to endure the bit abuse that characterizes percussion drilling. If the included angle is too large, the bit 10 will tend to have a shape that is too blunt to foster rapid penetration into the ground. A blunt bit would also tend to be less efficient in removing cuttings from the hole, thereby placing more demand on any fluid that is being used to remove cuttings.

A table showing representative values for typical bits is provided below.

Nominal Hole Size	Bit Included Angle		Tip Diameter		D/d (approx.)	
	Large	Small	Large	Small	High	Low
2"	50°	20°	1"	3/8"	5.3	2
4"	70°	20°	2"	1"	4.0	2
8"	80°	20°	3"	1 1/4"	6.6	2.7
12"	80°	20°	3 3/4"	2"	6.0	3.2
18"	90°	30°	4 1/2"	2 1/2"	7.2	4

It will be observed that low values for the included angle of a pointed bit are more commonly preferred when the bit diameter is small, e.g., 2 inches; large di-

ameter bits are characterized by their ability to perform satisfactorily with larger included angles. Somewhat larger tip diameters are also preferable with larger bits because of the severe dynamic loads to which large bits are subjected.

Provided on the conical section 20 are hardened inserts or buttons 22 of, for example, a metallic carbide, arranged in helical rows which preferably are of a substantially constant pitch, said rows extending from the tip 12 to the base 16. Each row of inserts 22 winds at least 120° around the bit as it traverses the distance from the tip to the base. "Downhole" bits are designed to be turned clockwise, and so the row of helical inserts on such a bit would naturally have a right hand turn, whereby rotary movement of the bit will tend to force the cuttings upward and around the bit. Straight percussion drills are designed to turn counter-clockwise, so the twist for a row of inserts on a percussion-type tool would be left-handed; again, the result will be an upward thrust on the cuttings as the bit is rotated in the hole. The preferred arrangement of the inserts in all the rows 22 is substantially the same, so that the hole will be "cleared" of cuttings in less than a full revolution of the bit.

Also, it is preferred that the distribution of inserts in a given row 22 be more dense in the area where the peripheral speed of the bit is greater. That is, where the diameter of the bit is large (near the cylindrical base), it is preferable that there be more inserts than where the diameter is small (near the tip). As shown in the drawing, the inserts 22 are arranged linearly near the point 12; but, it is not feasible to keep the inserts strictly linear as the diameter of the conical section becomes larger and there is the desire to increase the quantity of inserts. The solution is to create a double row of inserts near the base.

Besides the obvious purpose of having hardened inserts on the bit 10 in order to cut into hard material, the grouped inserts for this bit are effective to produce a "pumping" action in removing cuttings. Thus, the protruding row of inserts establish an elevated ridge which is adapted to "pump" cuttings past the bit during rotary movement. To this end, the inserts are obviously placed very close together. In fact, near the point of the bit they are generally separated by little more than one sixteenth of an inch. Near the base 16 where the inserts are more numerous, they may be separated by a greater distance; but the inserts in a given row near the base are preferably staggered so that they still cooperate to form an effective "vane" to remove cuttings from the hole. The maximum separation of adjacent inserts should be no more than the diameter of the inserts.

Referring next to FIG. 2, the hardened inserts 14 A, B are shown on a bit which has three helical rows of inserts 22. The three inserts 14 A are symmetrically ar-

ranged at the corners of an imaginary isosceles triangle, with a single insert 14 B at the center of the imaginary triangle. The inserts are preferably arranged on the tip

12 so that they form effective extensions of the helical rows of inserts 22. Thus, a chip of rock or the like which is knocked loose in the bottom of the hole will be steadily pushed upward along a path which goes around and past the bit 10 without any dramatic reversal in its direction of movement.

Since it is desirable to have the inserts 14 A, B on the point cooperate with the inserts 22 on the side, it is appropriate that there be a transition surface between the relatively flat point 12 and the conical section 20. Referring again to FIG. 1, a transition surface 24 is provided in the form of a generally frustoconical surface having an included angle of about 120°. Inserts 26 are mounted so that their axes are perpendicular to this surface 24, such that they form an effective link between inserts 14 A, B and inserts 22—as far as pushing cuttings past the bit is concerned.

In cooperation with the helical rows of protruding inserts 22, it is frequently desirable to provide helical surface grooves 28 in the body between the rows of inserts. In particular, the grooves 28 are useful near the top of the bit where a large quantity of cuttings may have to be pushed past the bit. As shown in FIG. 1, the groove 28 extends from (or begins) on the cylindrical base 16 and continues on to near the point 12. The grooves 28 need not extend all the way to the tip 12, but they should go at least half way.

Apertures 30 for the discharge of a drilling fluid are typically located near the forward end of a groove 28.

To further increase the longevity of the bit 10, it is preferred that the entire bit be coated to a thickness of at least 0.005 inch with a hard metallic coating after the various inserts have been placed on the body. By "hard coating," it is intended to refer to a chromebased material having a hardness of, say, 500 on the Brinell scale. For convenience, the "hard coating" will hereinafter be referred to as the chrome plate. That portion of the chrome plate which lies over the hardened inserts will likely be knocked off the raised parts of the inserts, but that portion of the coating which covers the juncture of the inserts and the body will tend to last much longer. The longer the coating lasts, the longer a protected insert will remain in the bit where it was placed, and the longer a bit can be left in a hole which is being drilled.

While only the preferred embodiments of the invention have been disclosed in great detail herein, it will be apparent to those skilled in the art that modifications thereof can be made without departing from the spirit of the invention. Thus, the specific structure shown herein is intended to be exemplary and is not meant to be limiting, except as described in the claims appended hereto.

What is claimed is:

1. A combination rotary and percussion drill bit, comprising:
 - a. a substantially solid body having a relatively narrow and flat point which is adapted to make initial contact with the matter to be penetrated;
 - b. a substantially cylindrical base having one or more hardened inserts protruding radially therefrom, said base and its inserts being adapted to serve as a gauging member, and said base having both means against which torque forces may be applied and means against which axial forces may be applied, whereby the bit may be both rotated and driven axially forward;

- c. a generally frustoconical sidewall section extending between the narrow point of the body and the larger cylindrical base thereof;
 - d. a plurality of hardened inserts mounted on the bit and protruding outwardly from the frustoconical surface thereof, said inserts being arranged substantially symmetrically in helical rows extending from the point to the base, and each row winding at least 120° around the bit as it traverses the distance from the point to the cylindrical base, and the protruding inserts in a given row being closely spaced to effectively establish an elevated ridge which is adapted to urge cuttings around and past the bit during rotary movement thereof, and the spacing between adjacent inserts being less than the width of said inserts; and
 - e. hardened means on the point for fracturing such brittle material as may be encountered during drilling.
2. The drill bit as claimed in claim 1 wherein the hardened means on the point comprises a plurality of hardened inserts which are mounted so as to form effective extensions of the helical rows of hardened inserts on the frustoconical section.
 3. The drill bit as claimed in claim 1 wherein the ratio of base diameter to point diameter lies within a range of about 2 to about 7, and wherein the included angle of the generally frustoconical section is within the range of about 20° to 80°.
 4. The drill bit as claimed in claim 1 wherein the included angle of the generally conical section is approximately 34°.
 5. The drill bit as claimed in claim 1 wherein each of the hardened inserts comprise metallic carbide inserts having a generally cylindrical body which is pressed into respective apertures in the bit body, and the distance between adjacent hardened inserts is at least one sixteenth inch but less than the diameter of the inserts.
 6. The drill bit as claimed in claim 1 wherein a helical groove is provided in the surface between each two adjacent rows of hardened inserts, with the groove beginning at a point along the cylindrical base and terminating at a point at least half way from the base toward the point, with said grooves being adapted to cooperate with the hardened inserts to force cuttings around and past the bit during rotary movement thereof.
 7. A combination rotary and percussion drill bit, comprising:
 - a. a substantially solid body having a relatively narrow and flat point which is adapted to make initial contact with the matter to be penetrated;
 - b. a substantially cylindrical base having one or more hardened inserts protruding radially therefrom, said base and its inserts being adapted to serve as a gauging member, and said base having both means against which torque forces may be applied and means against which axial forces may be applied, whereby the bit may be both rotated and driven axially forward;
 - c. a generally conical section extending between the point of the body and the cylindrical base thereof;
 - d. a plurality of hardened inserts mounted on the bit and protruding outwardly from the conical surface thereof, said inserts being arranged in helical rows extending from the point to the base, and each row winding at least 120° around the bit as it traverses the distance from the point to the cylindrical base,

and the protruding inserts in a given row being closely spaced to effectively establish an elevated ridge which is adapted to urge cuttings around and past the bit during rotary movement thereof;

- e. hardened means on the point for fracturing such brittle material as may be encountered during drilling; and
- f. a transition surface extending between the relatively flat point and the generally conical section, said transition surface comprising a generally frustoconical surface with an included angle of about 120°.

8. A combination rotary and percussion drill bit, comprising:

- a. a substantially solid body having a relatively narrow and flat point which is adapted to make initial contact with the matter to be penetrated;
- b. a substantially cylindrical base having one or more hardened inserts protruding radially therefrom, said base and its inserts being adapted to serve as a gauging member, and said base having both means against which torque forces may be applied and means against which axial forces may be applied, whereby the bit may be both rotated and driven axially forward;
- c. a generally conical section extending between the point of the body and the cylindrical base thereof;
- d. a plurality of hardened inserts mounted on the bit and protruding outwardly from the conical surface thereof, said inserts being arranged in helical rows extending from the point to the base, and each row winding at least 120° around the bit as it traverses the distance from the point to the cylindrical base, and the protruding inserts in a given row being closely spaced to effectively establish an elevated ridge which is adapted to urge cuttings around and past the bit during rotary movement thereof;
- e. hardened means on the point for fracturing such brittle material as may be encountered during drilling; and
- f. there being three surface grooves winding around the bit between three helical rows of hardened inserts mounted on the bit, and the plurality of hardened inserts on the point comprise four inserts which are arranged with three at the corners of an isosceles triangle and the fourth is at the center of the triangle.

9. A combination rotary and percussion drill bit, comprising:

- a. a substantially solid body having a relatively narrow and flat point which is adapted to make initial contact with the matter to be penetrated;
- b. a substantially cylindrical base having one or more hardened inserts protruding radially therefrom, said base and its inserts being adapted to serve as a gauging member, and said base having both means against which torque forces may be applied and means against which axial forces may be applied, whereby the bit may be both rotated and driven axially forward;

c. a generally conical section extending between the point of the body and the cylindrical base thereof;

- d. a plurality of hardened inserts mounted on the bit and protruding outwardly from the conical surface thereof, said inserts being arranged in helical rows extending from the point to the base, and each row winding at least 120° around the bit as it traverses the distance from the point to the cylindrical base, and the protruding inserts in a given row being closely spaced to effectively establish an elevated ridge which is adapted to urge cuttings around and past the bit during rotary movement thereof, and wherein the hardened inserts are spaced on the conical section in such a way that the quantity of inserts is greater as the diameter of the conical section increases, as measured from the point to the base; and

e. hardened means on the point for fracturing such brittle material as may be encountered during drilling.

10. A drill bit adapted for use in percussion drilling apparatus, comprising:

- a. a substantially solid body having a relatively narrow and flat point which is adapted to make initial contact with the matter to be penetrated, and a substantially cylindrical base having means against which torque forces may be applied and means against which axial forces may be applied, whereby the bit may be both rotated and driven axially forward, and a relatively narrow and generally frustoconical sidewall section extending between the point and the cylindrical base, with the ratio of the base diameter to the point diameter being within the range of about 7 to 2, and further including a frustoconical transition surface lying between the relatively flat point and the frustoconical sidewall section, and the included angle of said frustoconical transition surface being about 120°;
- b. a plurality of hardened inserts mounted on the bit and protruding outwardly from the frustoconical sidewall section, said inserts being arranged in helical rows of a substantially uniform pitch extending from the point to the base, and each row winding partially around the bit as it traverses the distance from the point to the cylindrical base, with the arrangement of inserts in the rows being substantially the same, and the protruding inserts in a given row being closely spaced to effectively establish an elevated ridge which is adapted to guide cuttings around and past the bit during rotary movement thereof;
- c. hardened means on the point for fracturing such brittle material as may be encountered during drilling; and
- d. a hard metallic coating on the body which at least covers the juncture of the hardened inserts and the body, whereby the body is protected from excessive wear at the sensitive locations where the hardened inserts are mounted.

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