April 5, 1966 E. R. PETERS 3,243,924

DIAMOND DRILL BIT

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FIG. 1

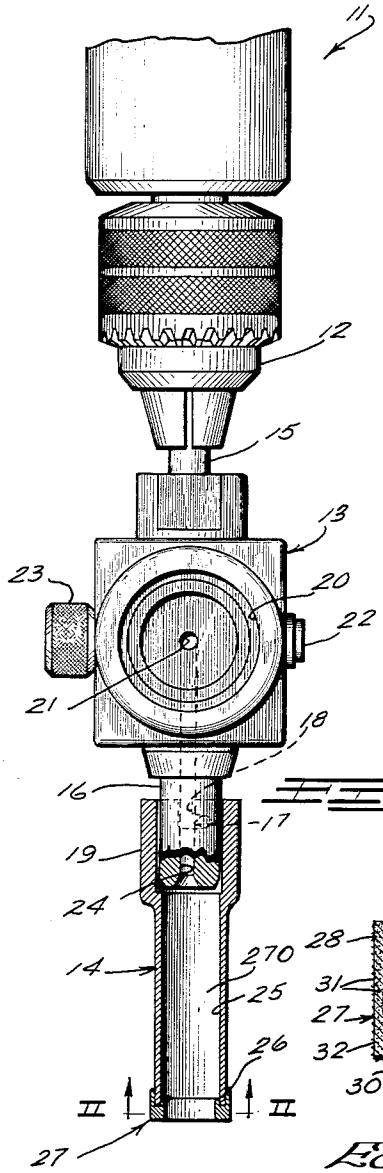


FIG. 1A

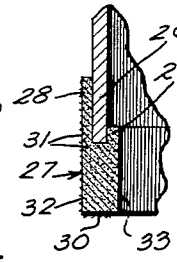


FIG. 2

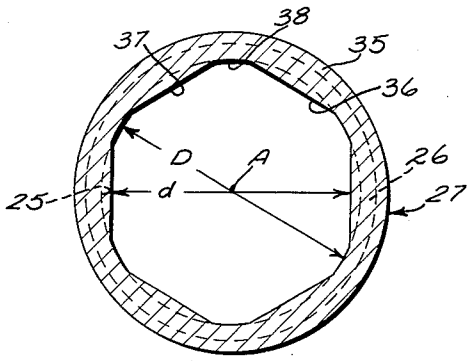


FIG. 3

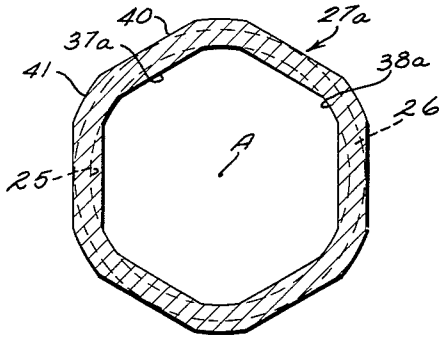
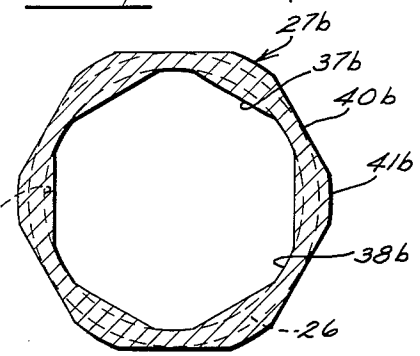


FIG. 4



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FIG. 7

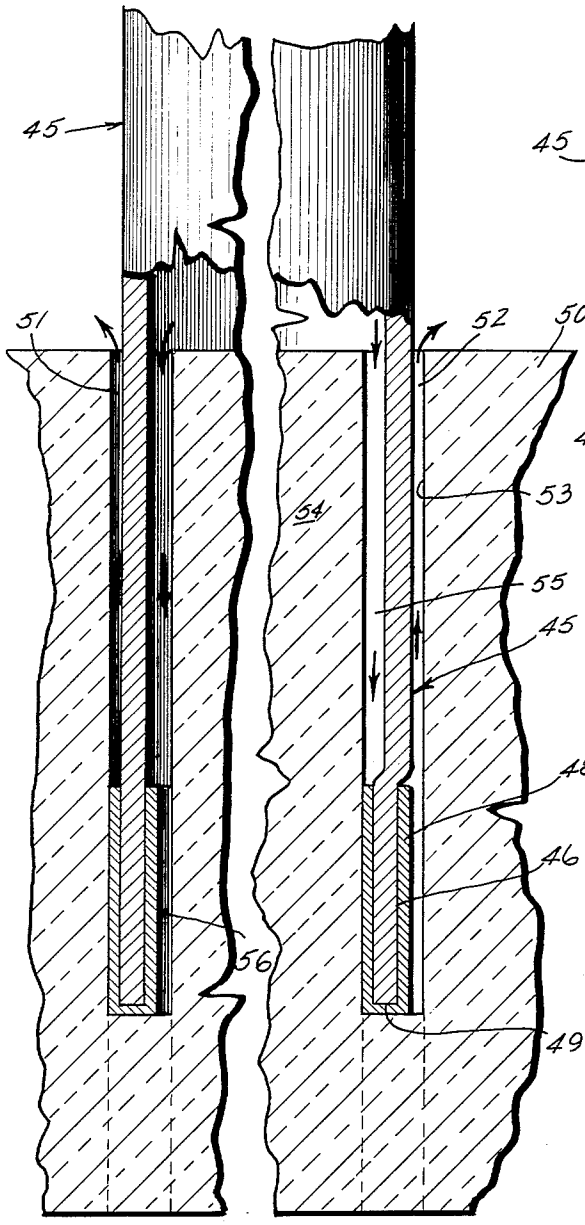


FIG. 5

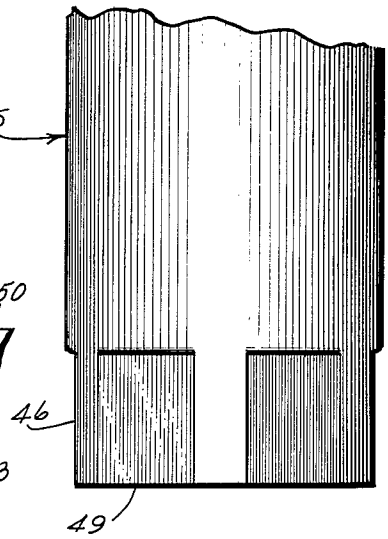
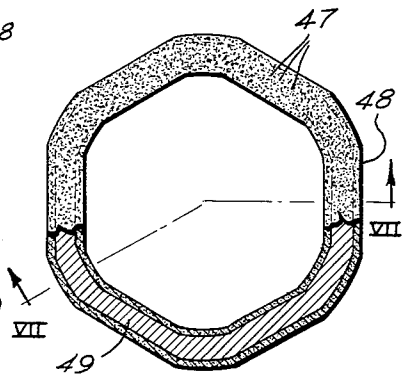


FIG. 6



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3,243,924

DIAMOND DRILL BIT

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Filed Jan. 6, 1964, Ser. No. 335,949
8 Claims. (Cl. 51—356)

This invention relates to a composite rotary tubular abrasive drill bit of the type that is adapted to be connected to a source of power and to a source of liquid coolant under pressure for portable use in the drilling of holes in vitreous or ceramic material, such as glass, tile, porcelain, cement, stone and the like.

Prior drill bits of this general type have been made by relatively expensive operations that include the milling or otherwise forming of axially extending inner and/or outer grooves in the tubular metal drill shank toward the working end thereof to provide clearances for the passage of the liquid coolant between the bit end and the material being drilled. In accordance with my present invention, such relatively expensive operations are eliminated. Instead of forming grooves in the shank of the bit, a hollow, thin-walled cylindrical metal tube of uniform wall thickness throughout is used and there is secured to the free or working end thereof, as an axial extension thereof, an abrasive annulus of such inner and outer geometrical form in cross-section as to provide clearance spaces during drilling for the passage of the cooling fluid into the hole being drilled to effect cooling of the annulus and removal of the detritus from the hole. Such an annulus of the selected geometrical form, selected from circles and polygons, is suitably formed by molding about the shank end of the tubular blank, a matrix composed of powdered metal and diamond particles, and bonding such diamond-impregnated annulus to the end of the shank. Alternatively, the metal of the shank end can itself be formed, as by an upsetting, die-forming or swaging operation, into the desired inner and outer regular geometrical shapes in cross-section and such end can then be electroplated or otherwise coated with a layer of diamond particles.

In its preferred form, the inside of the annulus of the drill bit of my invention has a regular, polygonal shape in cross-section while the outside of the annulus has either a circular or a regular polygonal shape in cross-section. In general, polygons having between 4 and 10 sides are suitable for my purposes. Where both the inner and outer surfaces are polygonal in cross-section, the respective polygons can be either "in-phase," that is, the polygons are coaxial with inner and outer parallel planar surfaces, or can be "off-phase," that is, while coaxial, the inner and outer faces are offset and non-parallel. The expression "interrupted," as used herein to refer to some of the regular polygonal shapes, means that in some instances, the planar surfaces forming the polygonal shape in cross-section, instead of being joined by single lines forming apices of the polygon, are joined by arcuate surfaces substantially coincident with portions of the cylindrical surfaces of the shank or coaxial with such cylindrical surfaces. In the case of the interrupted polygonal shapes, it is these arcuate surfaces on the inside of the annulus that provide clearances for the flow of liquid coolant into the hole being drilled; and it is the planar

surfaces on the outside of the annulus that provide clearances for the flow of coolant out of the hole being drilled. All inner and outer surfaces extend rectilinearly the full height of the annulus. The end face of the annulus is generally flat or planar for its transverse extent. All such surfaces of the annulus, constituting the abrasive surfaces, are diamond-impregnated or diamond-layered, if plated, to impart the abrasive properties to the annulus that are required for rapid, effective drilling of holes in the materials to be drilled and for longevity of the useful life of the bit.

It is therefore an important object of this invention to provide a relatively inexpensive, yet efficient, composite rotary tubular abrasive drill bit of novel and improved construction.

It is a further important object of this invention to provide, as the working end for a tubular drill shank, an abrasive annulus that has an inner regular polygonal shape and either an outer circular or an outer regular polygonal shape in cross-section, whereby the flow of coolant liquid past said annulus into and out of the hole being drilled is facilitated, wear of the bit is retarded and its useful life prolonged.

Other and further objects of this invention will be apparent to those skilled in this art from the following detailed description, when considered in conjunction with the accompanying drawings, which, by way of preferred example, illustrate several embodiments of the invention.

On the drawings:

FIGURE 1 is an elevational view of portable drill, partly broken away and partly in section, illustrating a composite rotary tubular abrasive drill bit of my invention in assembled relationship;

FIGURE 1A is an enlarged fragmentary sectional view of the abrasive annulus of FIG. 1;

FIGURE 2 is an enlarged sectional view taken substantially along the line II—II of FIGURE 1, illustrating one embodiment of my invention;

FIGURE 3 is a similar enlarged sectional view of an "in-phase" polygonal annulus constituting a second embodiment of my invention;

FIGURE 4 is a similar enlarged sectional view of an "off-phase" polygonal annulus constituting a third embodiment of my invention;

FIGURE 5 is a fragmentary, enlarged, elevational view of the free end of a tubular bit blank having an "in-phase" polygonal annulus similar to that illustrated in FIGURE 3, but especially adapted for forming a diamond-metal annulus by electroplating;

FIGURE 6 is a bottom plan view of the bit shown in FIGURE 5 after the electroplating operation; and

FIGURE 7 is an enlarged, broken, longitudinal sectional view, taken substantially along the broken line VII—VII of FIGURE 6, illustrating the operation of the bit in the drilling of a hole in material to be drilled.

As shown in the drawings:

In FIGURE 1 the reference numeral **11** indicates generally a portable type of drill, including a chuck portion **12** forming a part of a motor-driven drive mechanism, and a casing **13** for operative attachment to such drive mechanism (not shown) through said chuck **12**, and, in turn, for attachment at its lower end to a hollow, tubular bit **14**. Said casing **13** houses a drive shaft **15**, the upper end of which is engaged by said chuck **12** and the lower

extended end **16** of which is provided with a pin **17** for engagement within a bayonet slot **18** formed in the upper, thickened, tubular end **19** of said bit **14**. Said casing **13** is further provided with a laterally opening boss **20** for connection to a source of liquid coolant under pressure and for introduction of such coolant through a transverse bore **21** into the interior of the casing. Flow through the bore **21** is controlled by means of a manually operated rotary-type plug-valve **22**, having a knurled end **23** for manipulation thereof. Said transverse passage **21** communicates with a through-passage extending longitudinally of the driven shaft **16**, the lower end of which through passage is indicated at **24**. Accordingly, coolant under pressure from a source (not shown) is admitted into the passage **21** by control of the valve **22** and thence through the passage **24** into the upper end of the hollow tubular drill bit **14**.

For a further description of the drill bit assembly, reference is made to the copending application of Herbert C. Ovshinsky Ser. No. 301,542, filed Aug. 12, 1963, owned by the same assignee as the instant application. Other arrangements for the introduction of the coolant under pressure into the hollow drill bit **14**, such as that shown in the Miller Patent No. 2,996,061, may, however, be used. The details of construction of the drill assembly and coolant system constitute merely the environment for the use of the hollow tubular drill bit of my invention.

The drill bit **14** comprises a shank portion **25** of substantially cylindrical form with a uniformly thin, seamless wall extending between the thickened upper portion **19** and the lower free end **26**. The shank of the bit thus provides a passage **270** throughout its length forming a continuation of the through-passage **24** for the coolant. Said bit **14** is preferably formed of steel or other ferrous metal or alloy, and may be formed by molding or casting to the desired shape, or can be made from a blank of seamless steel tubing by an upsetting or forging operation to provide the thickened upper end **19**. In general, bits for the purposes of my present invention are of relatively small diameter, usually between about a quarter inch and one inch inside diameter, but larger bit diameters can be used.

In FIGS. 1 and 1A, there is shown an abrasive annulus **27** secured to the free end **26** of the shank **25** as an axial extension of said shank to form the working end thereof. Said annulus **27**, in general, is formed of a matrix of powdered metal and diamond particles molded about and bonded to the free end **26** of the shank by any usual powdered metallurgy method. As is customary, a bonding metal or alloy, sometimes termed an infiltrant, is admixed with the powdered metal matrix and diamond particles to effect a bonding of the matrix to the shank end and a cementing of the particles of the matrix to one another to form a rigid annulus **27**. Said annulus, as illustrated in FIG. 1A, has an upwardly extending outer portion **28** that is bonded to the outer surface of the shank end **26**, and a shorter, upwardly extending inner portion **29** bonded to the inner surface of said shank end **26**. The lower extremity of said annulus **27** is generally flat or planar, as at **30**. Where the annulus **27** is formed by molding, as just described, diamond particles **31** are well distributed not only through the mass of the annulus, but on or in the exposed surfaces thereof, including the outer surface **32**, the end surface **30** and the inner surface **33**.

As illustrated in FIGURES 2–4, inclusive, the shape of the annulus **27** in cross-section may be either circular or polygonal on the outside, but is always polygonal on the inside when made in accordance with my present invention. In FIGURE 2, the annulus **27** in cross-section has a circular outer surface **35** and an interrupted, regular hexagonal surface **36** on the inside. Thus, the outer surface **35** is truly cylindrical for the height of the annulus **27** and has an outside diameter slightly greater than the outside diameter of the shank end **26**, shown in dotted lines in FIG. 2. The inner surface **36**, which has been referred to as an interrupted hexagon, has six planar surfaces **37** of equal width and equi-spaced about the interior of the annulus, and these planar surfaces are joined by narrower, arcuate surfaces **38**, which are coincident with the inner surface of the shank **25**. In view of the relatively narrower width of the arcuate surfaces **38**, the inner surface **36** of the annulus **27** shown in FIG. 2 is referred to as a polygon, and specifically, a hexagon, but it is actually an interrupted polygon since the vertices are not true single line vertices, but are arcuate surface vertices, as indicated at **38**.

As will later be explained, this provision of polygonal, or interrupted polygonal inner surfaces provides a clearance between the material surrounding the hole that is drilled and the annulus **27** for the passage of the liquid coolant into the hole. This follows from the fact that the effective inner diameter *d* between opposed planar surfaces **36** is less than the effectived diameter D between the opposed arcuate surfaces **38**. Since the planar surfaces **36** effect a cutting action due to the presence of diamond particles in such surfaces, the annular hole being cut will have an inside diameter equal to the diameter *d*, thereby leaving the clearances referred to between the arcuate surfaces and the core of the material that is cut by the abrasive annulus.

In the form of annulus shown in FIG. 3, the annulus **27*a*** in cross-section has an interrupted polygonal shape on the inside, provided by the planar surfaces **37*a*** and the arcuate surfaces **38*a***, exactly similar to that described in connection with the structure of FIG. 2, but the outside, instead of being circular as in FIG. 2, is also interrupted polygonal shape, being formed with outer planar surfaces **40** and intermediate arcuate surfaces **41**. The form in cross-section of the annulus illustrated in FIG. 3 is that previously referred to as "in-phase" polygonal, since the inner and outer planar surfaces **37*a*** and **40** are parallel and the inner and outer arcuate surfaces **38*a*** and **41** are symmetrical about the axis A of the bit. Thus, the wall of the annulus **27*a*** is substantially of uniform thickness throughout, the inner and outer surface being, in effect, those generated by lonigtudinally extending straight lines intersecting the interrupted inner and outer polygons of the cross-section and normal to its plane. As before, clearance sapces are formed during drilling between the arcuate inner surfaces **38*a*** and the core of the material being drilled, but in addition, outside clearances are formed during drilling between the flat surfaces **40** on the outside of the annulus and the outer wall of the hole being drilled. This will be more fully explained in conjunction with the description of FIGS. 5, 6 and 7.

FIGURE 4 illustrates a further embodiment of the invention in which the interrupted inner and outer polygonal surfaces are "off-phase." Similar elements of the annulus illustrated in cross-section in FIG. 4 are indicated by similar reference numerals to those of FIG. 3 but with the subscript *b*. As before, due to the interrupted polygonal form of the annulus in cross-section on the inside and outside, clearances will be formed during drilling for the flow of the liquid coolant down into the hole on the inside and upwardly out of the hole on the outside.

In the embodiment of the invention illustrated in FIG. 5, the lower end of a cylindrical, thin-walled blank **45**, similar to the shank **25**, is formed with a lower working end **46** that in cross-section is of interrupted polygonal shape both on the inside and outside, with the polygons "in-phase," as in FIG. 3. In this case, however, the working end **46** of the blank **45** is itself formed to the "in-phase" shape illustrated in FIGS. 5 and 6, and the inner, outer and end surfaces of said working end **46** are then coated with diamond particles, indicated as at **47**, by a plating process in accordance with the known art of plating diamonds on metallic surfaces. Simultaneously with the plating of the diamond particles **47** onto the surfaces of the shank working end **46**, a layer of metal is co-

deposited with the diamonds and forms the bond between the diamonds and the shank end **46**. Preferably, the plating is so carried out as to provide a layer of single-particle diamond thickness, but heavier layers of diamonds may be employed. The coating of the diamond-metal layer, indicated by the reference numeral **48**, is continuous for the full height of the working end **46**, both on the inside and outside, and also across the lower flat end **49** of the working end of the bit.

FIGURE 7 illustrates the operation of a rotary tubular abrasive drill bit having a working end such as the working end **46** of the bit shown in FIGS. 5 and 6. As shown in FIG. 7, the reference numeral **50** represents the material to be drilled, which may, for instance, be a sheet of heavy plate glass. Due to the "in-phase" polygonal shape in cross-section, the working end **46** of the bit shank **45** cuts a hole **51** that is annular in shape but that is of smaller inside diameter and larger outside diameter than the cylindrical portion of the shank **45**. There is thus an annular clearance space, indicated by the reference numeral **52**, between the outer surface of the cylindrical portion of the shank **45** and the outer wall **53** of the annular hole being drilled. On the inside, between the core **54** that is left unstanding as the hole is being drilled, and the inner surface of the shank **45**, there is formed a passage **55** for the flow of the liquid coolant downwardly into the hole. Despite the flat nature of the end face **49** of the working end of the bit, there will be a flow of the liquid coolant across the end face from the inside to the outside and upwardly through the annular passage **52** and out of the hole. The presence of the diamonds **47** in the end face **49** ensures some slight clearance for this lateral flow of the coolant around the end of the bit. As will be understood, there are as many clearance spaces **51** and **53** about the periphery of the working end of the drill bit as there are planar faces in the polygonal surfaces of the working end, namely, six such passages on the inside and six such passages on the outside where the annulus is hexagonal, or interrupted hexagonal, in shape. Also, while FIGURE 7 illustrates a bit having a working end formed by the plating of metal and diamond particles thereon, the same general result is obtained where the annulus is a matrix of metal and diamond particles molded to the same interrupted hexagonal shape in cross-section, as in the case of the bit of FIGURE 3.

While the invention has been illustrated as embodying interrupted polygonal shapes, other embodiments in which the shapes are truly regular polygons, are within the concept of my invention. In such embodiments, instead of narrow arcuate surfaces joining the planar surfaces of the polygonal shapes, the planar surfaces intersect along truly rectilinear lines that form true apices, or vertices. It is these vertices, then, that provide the clearances, or passages, for the liquid coolant along the inside of the annulus at the working end of the bit, as illustrated in FIG. 7.

Where the interrupted polygonal shapes are used, the following will serve to give an example of the dimensions that have been found suitable in the case of a drill bit having an annulus with an O.D. of 1" and an I.D. of 0.875" (nominal dimension). In producing a regular polygonally shaped annulus, such as that of FIG. 3 or 6, whether of six sides, as there shown, or of a larger number of sides, such as eight, the desired depth of water passage, as for instance the clearance space indicated by the reference numeral **56** in FIG. 7, is 0.017 to 0.020". This is accomplished by providing a maximum I.D. dimension, viz. that of D (FIG. 2), equal to 0.910", instead of the nominal I.D. dimension of 0.875 referred to above. This would mean the removal of sufficient metal on the inner arcuate surfaces **38**, **38***a*, or **38***b* or an outward displacement of these arcuate surfaces during the forming of the shank end, as, for instance, the end **46** (FIG. 5), to give this maximum I.D. dimension of 0.910". The result would be the provision of six water passages, or clearances **56** (FIG. 7), of 0.017" depth, where the polygonal shape is that of a hexagon. Where the shape is that of an octagon, there would be eight such water passages or clearances, each approximately 0.017" in depth.

In those embodiments where true rectilinear apices are provided, similar water passages are provided by such apices. This is the case where smaller bit shanks, such as those with a ⅝" O.D. dimension are used.

Since the size of diamond particles is generally on the order of 50 particles to a carat, or even finer, such particles have been indicated in the drawings merely by dots, both in elevation and plan view and also in section. In place of diamonds, other abrasive particles of a hardness of at least 9 in the Moh's scale of hardness can be used.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. A composite rotary tubular abrasive drill bit having one end adapted for connection to a source of power and having a free working end, said bit comprising

a hollow cylindrical shank of substantially uniform wall thickness throughout its length, said shank affording a through passage for a liquid coolant during drilling, and

an abrasive annulus secured to the free end of said shank, said annulus in cross-section having an inner polygonal shape of a minimum transverse dimension less than the inner diameter of said shank and of a maximum transverse dimension equal to said shank inner diameter,

thereby providing axially extending coolant flow passages between said annulus inner surface and the material being drilled,

said annulus in cross-section having an outer regular geometrical shape selected from the groups consisting of polygons and circles each having a maximum outer transverse dimension greater than the outside diameter of said shank.

2. A composite rotary tubular abrasive drill bit as defined by claim **1**, wherein both the outer and inner surfaces of the annulus are polygonal in cross-section.

3. A composite rotary tubular abrasive drill bit as defined by claim **1**, wherein both the outer and inner surfaces of the annulus are hexagonal in cross-section.

4. A composite rotary tubular abrasive drill bit as defined by claim **1**, wherein both the outer and inner surfaces of the annulus are hexagonal in cross-section with the hexagons in phase.

5. A composite rotary tubular abrasive drill bit as defined by claim **1**, wherein both the outer and inner surfaces of the annulus are hexagonal in cross-section with the hexagons out of phase.

6. A composite rotary tubular abrasive drill bit as defined by claim **4**, wherein the inner and outer surfaces and the end surfaces of said annulus are provided with a layer of diamond particles of substantially one-diamond particle thickness.

7. A composite rotary tubular abrasive drill bit having one end adapted for connection to a source of power and to a source of liquid coolant under pressure, said bit comprising

a hollow cylindrical shank of substantially uniform wall thickness throughout its length,

said shank affording a through-passage for said liquid coolant during the drilling of an annular hole in material to be drilled,

an abrasive annulus secured to said free end of said shank,

said annulus having inner and outer parallel planar surfaces extending axially the full height of said annulus and forming polygonal shapes in cross-section with arcuate surfaces joining successive planar surfaces around the inner and outer periphery of said annulus,

the inner arcuate surfaces being substantially coincident with portions of the inner surface of said shank,

the free end surface of said annulus being generally planar, and

diamond particles secured in all of the inner and outer surfaces and in the end surface of said annulus to impart to said surfaces an abrasive cutting action.

8. A composite rotary tubular abrasive drill bit as defined by claim 7, wherein

said polygonal shapes are hexagonal, and

said diamond particles are in surface layers substantially one particle in thickness.

References Cited by the Examiner

UNITED STATES PATENTS

1,600,054	9/1926	MacLaughlin et al.	51—267
3,153,885	10/1964	Keller et al.	51—267

ROBERT C. RIORDON, *Primary Examiner.*