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DIAMOND BITS HAVING DIAMONDS POSITIONED IN CONCENTRIC CIRCLES ON THE DRILLING FACE

Original Filed March 6, 1967

2 Sheets-Sheet 1

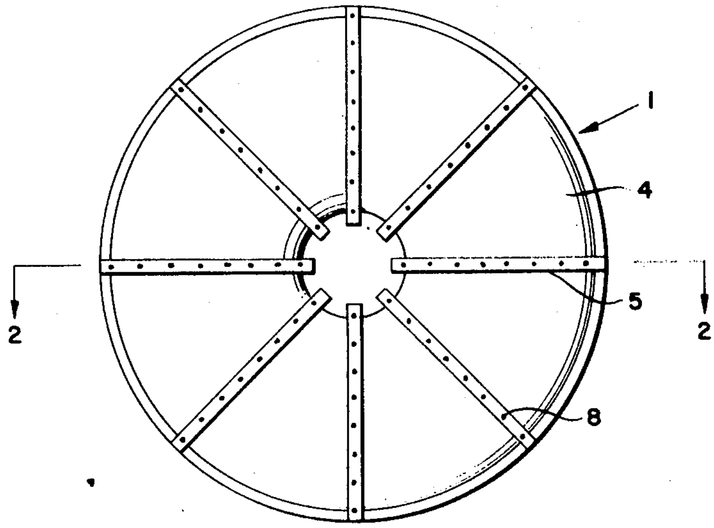

FIG. 1

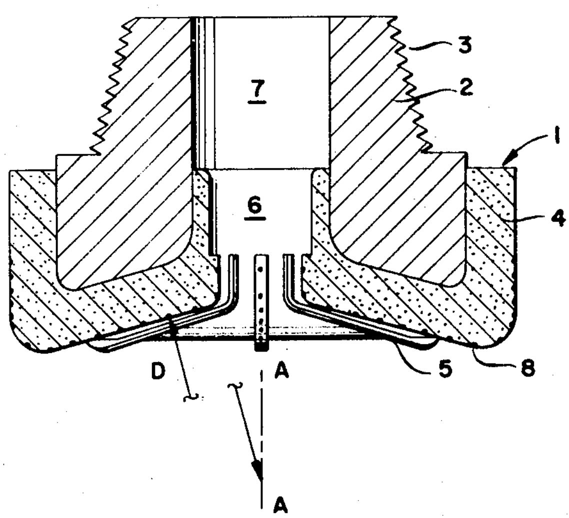

FIG. 2

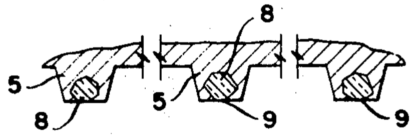

FIG. 3

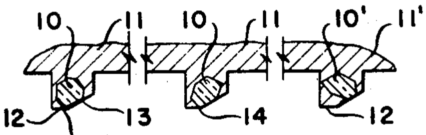

FIG. 4

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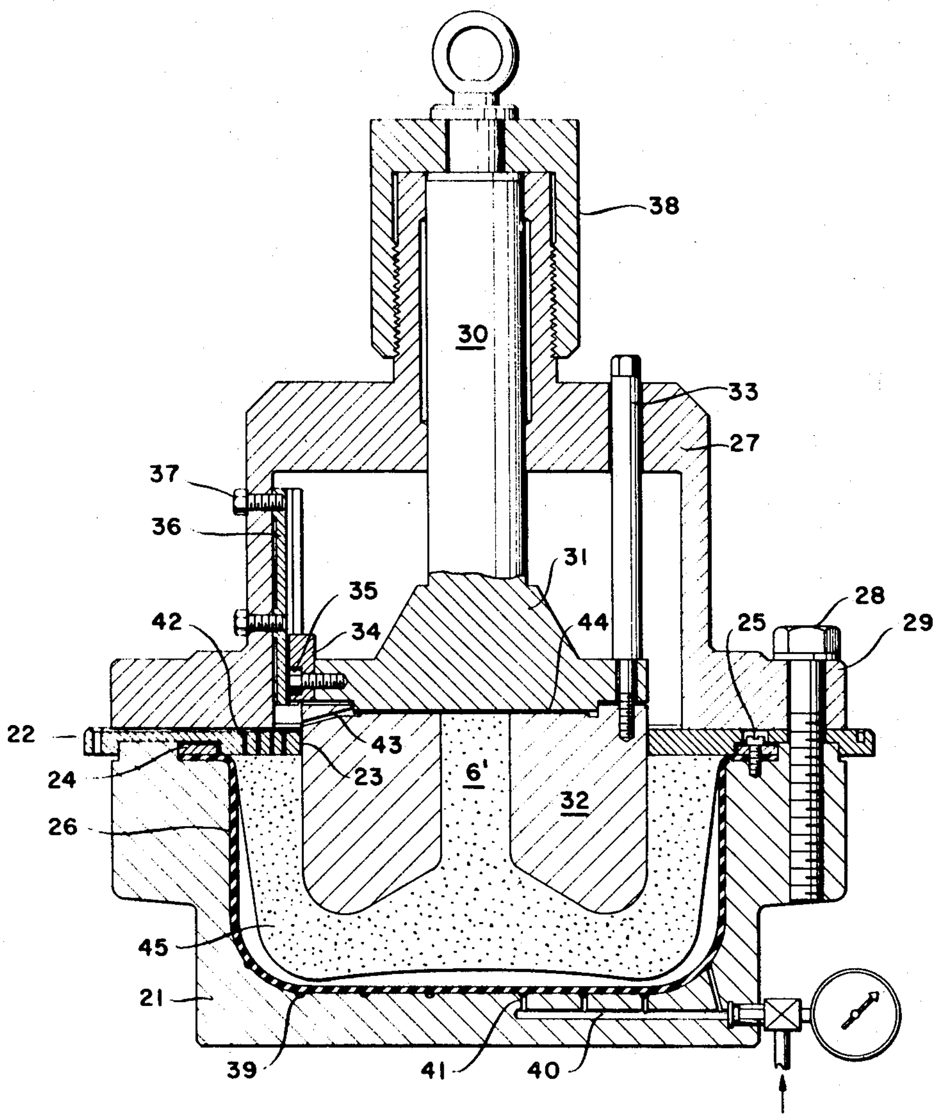

FIG. 5

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DIAMOND BITS HAVING DIAMONDS POSITIONED IN CONCENTRIC CIRCLES ON THE DRILLING FACE

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Int. Cl. E21b 9/36

U.S. Cl. 175—329 7 Claims

ABSTRACT OF THE DISCLOSURE

A drilling bit having diamonds embedded in the drilling face, with the diamonds arranged in a pattern of concentric circles having axes coinciding with the axis of the bit. All of the diamonds in a given circle will subscribe a common path in the face of the material being drilled. A method of manufacture of such a bit is disclosed, along with a special mold for practicing the method.

This application is a divisional application of my copending application Ser. No. 620,839, filed Mar. 6, 1967.

Diamond bits are in particular applied when drilling holes through rock material of poor drillability, which is often required when drilling in subsurface formations for searching and/or recovering oil or other valuable products.

These bits are of the rotary type and the diamonds thereof exert a scraping action on the rock through which a hole is being drilled, while the bit is loaded in an axial direction and rotated around its central axis.

Bits of this type are especially useful for drilling through deep, abrasive, hard formations, since their lifetime when drilling through such formations is greater than with any other type of rotary rock bit such as a roller bit. Consequently, a diamond bit has to be replaced less frequently than a bit of another type. The higher material and manufacturing costs of a diamond bit with respect to other types of bits are easily compensated by the advantages obtained as a result of the reduction in time required to replace the worn bits during drilling operations.

The invention is concerned with the provision of a sintered diamond drilling bit which will be less liable to damage of the diamonds due to overload than known bits.

The invention of said copending application is also concerned with a method of manufacturing a sintered diamond drilling bit, in which several steps are taken to insure that the arrangement of the diamonds in the sintered bit body is as accurate as possible, in order to divide the load on the bit as evenly as possible over all the diamonds.

A further object of the invention is the provision of a sintered diamond drilling bit, in which an extremely small number of diamonds is required for carrying out the required cutting action.

The method of manufacturing a sintered diamond bit according to the invention of said copending application comprises the following steps;

(a) Forming a graphite mold by placing a mixture of graphite particles and liquid into a cup-shaped flexible membrane, introducing a pattern of the bit in an opening provided in a plate arrangement at the open side of the cup-shaped membrane, such that the rim of the opening fits closely around the circumference of the pattern, densifying the mixture by pressing part of the liquid out of the mixture by providing a fluid pressure on the outer side of the membrane, reducing the fluid pressure to atmospheric pressure, retracting the pattern out of the opening, and removing the graphite mold out of the membrane;

(b) Vaporizing the remaining part of the liquid from the graphite mold;

(c) Placing diamonds in the mold along circles which have their centers on the central bit axis, filling the mold with a mass of powder material to be sintered, and placing a quantity of binder material on top of the mass;

(d) Subjecting the mold with the contents thereof to sintering temperature, and

(e) Removing the sintered diamond bit from the mold after the sintering process is over.

With this process it is possible to insure that the distances between the central bit axis of the diamond bit and the cutting tops of those diamonds located on a common circle vary at most 0.1 millimeter, when measured in directions rectangular to the bottom profile to be cut by the bit.

A means for carrying out part of the method according to the invention of said copending application, comprises a housing open to one side, a plate member provided with an opening therein arranged on the open side of the housing, a flexible membrane sealingly connected at the rim thereof to the open end of the housing, and means for connecting the space between the housing and the membrane to a pressure source.

The invention may be carried into practice in various ways but two specific embodiments will not be described by way of example with reference to the accompanying drawings in which:

FIG. 1 shows a view of the cutting end of a sintered diamond bit according to the invention taken in the direction of the axis in FIG. 2;

FIG. 2 shows a cross-section of this bit on the line **2—2** of FIG. 1;

FIG. 3 shows cross-sections of ridges of the bit on a larger scale;

FIG. 4 shows cross-sections similar to those shown in FIG. 3, but with ridges of different form, and

FIG. 5 shows a molding apparatus for forming a graphite mold of the drilling bit, which mold is to be used in the sintering process.

As shown in FIG. 2 the drilling bit **1** comprises a shank **2** provided with coupling means, such as screwthread **3**, for coupling the bit via a sub (not shown), to a drill string. The shank **2** is connected to a sintered mass **4**, which is provided with ridges **5**, arranged as shown in FIG. 1, radially with respect to the central axis of the bit. A conduit **6** is arranged in the sintered body **4**, which conduit communicates with the cavity **7** of the shank **2** for passing drilling fluid out of the drill string to the lower side of the bit **1** during drilling operations carried out thereby.

Diamonds **8** are placed in the ridges **5** in such a way that the diamonds are located on circles which have their centers on the central bit axis. Preferably each diamond **8** forms together with diamonds **8** arranged in other ridges **5**, a set of diamonds which is arranged on a common circle. By way of example, FIG. 3 shows cross-sections of three ridges **5** at the locations of diamonds belonging to a common circle.

As will be seen from the following description of the method of manufacturing the present drill bit, the diamonds are arranged during the manufacturing of the bit on the bottom of channels provided in a graphite mold, which mold is subsequently filled with a mass of powder material suitable to be sintered at a suitable temperature to a single body by the addition of a binder material. Thus, the diamonds **8** will, as shown in FIG. 3, contact the lower boundaries of the ridges **5**.

During the drilling operation of a bit having diamonds **8** arranged in ridges **5** as shown in FIGS. 1–3, each set of diamonds located on a common circle will cut the formation along a common track. An equal distribution of the load over the diamonds equally spaced along a common circle is only possible if the distances D between the central bit axis A—A and the cutting tops of the diamonds belonging to a common circle are, when measured in directions perpendicular to the bottom profile to be cut by the bit, are equal to each other. It will be clear that this is impossible due to the nature of the processes, which have to be followed in manufacturing the bit. By applying the method according to the invention, however, these distances D will vary within extremely small tolerances. In fact the maximum variation in these distances will be at most 0.1 millimeter. Thus, in the bits according to the invention the diamonds equally spaced along a common circle and cutting in a single track will be substantially equally loaded. Consequently, no overload of diamonds will occur, which overload would normally result in a consecutive breaking of the diamonds, unless the total load on the bit was reduced, which would, however, cause a reduction in penetration rate of the bit.

In using the bit according to the present invention, however, the load is evenly distributed over all the diamonds arranged in the bit, which allows the maximum load to be applied to each diamond. Thus, a considerable penetration rate can be obtained with a minimum number of diamonds.

The number of diamonds belonging to a common circle need not be equal to the number of ridges. In a bit having nine ridges, the diamonds may e.g. be placed on common circles containing 1, 3 or 9 diamonds, which are evenly distributed with respect to the bit axis.

In the bit manufactured according to the present method, the distances between corresponding points of the ridges of the bit axis A—A vary at most 0.05 millimeter when measured in directions perpendicular to the bottom profile cut by the bit.

The penetration rate can even further be improved by arranging the diamonds **10** in the manner indicated in FIG. 4. Ridges **11** are used, which instead of having flat bottoms have bottoms consisting of a portion **12**, and a portion **13** arranged at an angle to the portion **12**. It will be clear, that if the channels applied in the graphite mold in which the bit is to be sintered, have bottom portions **12** and **13** identical to those shown in FIG. 4, the diamonds **10** which are placed in these channels will contact, provided that they are neither too great nor to small, both portions **12** and **13** in each ridge **11**. Consequently, the contact points **14** lying on bottom portions **12**, will be less blunt than the contact points **9** in the construction shown in FIG. 3. The width of the portions **12** has to be chosen in relation to the dimensions of the diamonds **8** which are to be used. To this end, all the diamonds have to be within a certain size range if they are to be applied to a bit having bottom portions **12** of a certain width. If the dimensions of a diamond are too great, there will be no contact point with the bottom portion **12** as indicated by diamond **10′** in ridge **11′**. If desired, the side walls of the ridges **5** may be sloped in the way as indicated in FIG. 3 to give the ridge a wider base and more strength.

It will be clear that the invention is not limited to the bit as shown in FIGS. 1–4 of the drawing and that several modifications may be made. Thus, the ridges **5** (or **11**) need not be arranged radially with respect to the central bit axis as shown in FIG. 1, but they may also be arranged such that in the view taken along the axis toward the bottom, they touch a common circle which has its center on the central bit axis. Further these radially arranged ridges may be curved. In another embodiment the ridges may be arranged more or less concentrically with respect to the bit axis.

Although the flushing conduit **6** has been shown in FIG. 1 to be arranged concentrically with respect to the central axis of the bit **1**, this conduit may as well be placed eccentrically, which may be desirable for example when no core should be left in the rock which is being drilled.

The shape of the bit body parts lying between the ridges **5**, may be in any convenient way provided that it is suitable for guiding the flow of flushing liquid out of the opening **6** towards the sides of the bit body and along the diamonds **8**, as well as for enabling an easy removal of the chips cut by the action of the diamonds **8**. Further, the invention is not limited to the shape of the shank **2**, which shank is used for connecting the bit to a drill string via a sub. If desired, the shank **2** may have a cylindrical form. In another manner, several small cylinders are arranged in the body **4**, which cylinders are provided with screw threaded openings for connecting a flange thereto by means of bolts. The flange may be provided with means for coupling the same to a drill string, drill collar or sub, or may form part of these latter means. A very suitable manner of mounting the shank **2** in the body **1** has been shown in copending U.S. application 594,839, filed Nov. 16, 1966.

The method of manufacturing a sintered diamond bit will now be described. To obtain the required accuracy in the setting of the diamonds, a special molding technique has been developed to form the graphite mold in which the bit is to be sintered. An apparatus in which such a technique may be carried out is shown in FIG. 5 of the drawing. The molding apparatus comprises a housing **21** having a cup-shaped interior which is open at its upper side. A plate **22** provided with an opening **23** is arranged on the upper side of the housing and centered and supported by the housing **21**. A ring member **24** is connected to the housing **21** by suitable means, such as bolts **25** for clamping a flexible membrane **26** (e.g. manufactured of rubber or other similar material) to the housing **21**.

On the housing **21** and the plate **22** there is mounted a bridge member **27** by means of bolts **28** (of which only one is shown) which bolts are arranged in a flange **29** of the bridge member **27** and the vertical wall of the housing **21**.

A rod **30** is provided with a flange **31** on which a pattern **32** of the bit to be manufactured is connected by bolts **33**. The rod **30** is slidably arranged in the bridge member **27**, and rotation thereof is prevented by a slide wedge **34** connected to the flange **31** by a bolt **35** and cooperating with a guide member **36** connected to the bridge member **27** by bolts **37**.

The rod **30** can be moved vertically with respect to the bridge member **27** as well as to the housing **21** on which the bridge member **27** has been mounted, by rotation of a nut member **38** cooperating by screw threads with the bridge member **27**. The nut member **38** is locked in an axial sense with respect to the rod **30** and can be freely rotated therearound.

On the inner wall of the housing **21** a network of shallow channels **39** is arranged with at least one point thereof communicates via a bore **40** with a pressure source (not shown). Bore **40** passes through the wall of the housing **21**, and suitable conduits **41** communicate with the channels **39**, and with the bore **40** leading the pressure source.

If desired, the membrane **26** may be flat in the non-stressed condition. By lowering the pressure in the bore **40** to below atmospheric pressure, the membrane will be pressed against the inner wall of the housing **21** in the position as shown in FIG. 5. The pressure source (not shown) communicating with the conduit **40** is then of a type which can produce pressures higher as well as lower than atmospheric pressure.

To obtain in the graphite mold an exact negative form of the bit to be manufactured, a pattern of the bit is made, which pattern has exactly the same exterior shape (ridges **5**, channel **6**) as the bit shown in FIG. 1. For sake of simplicity, however, only the channel **6′** has been shown in the pattern **32** in FIG. 5. The pattern **32** is preferably made of metal, and has been machined very carefully. The variation in the distances between the central axes of the pattern and the places on the ridges where (in the bit) the diamonds which are to cut a common track, are to be located is maximum 0.02 millimeter when measured in a direction perpendicular to the bottom profile of the pattern.

In the position as indicated in FIG. 5, the pattern **32** fits accurately with its upper end in the opening **23** in the plate **22** without, however, sealing this opening. Suitable channels and conduits (such as **42**, **43**, and **44**) are provided in the plate **22**, pattern **32** and beteewn pattern **32** and flange **31** respectively for draining the liquid which is pressed out of the liquid/graphite mixture which will finally form the graphite mold **45**.

In the particular pattern **32** indicated in the drawing, the lower inner part has been conically shaped. It will, however, be clear that the method according to the invention is not limited to the use of a type of pattern as shown in the drawing, but may be applied for any other pattern as well. If desired, other channels than channel **6'** may be provided in the pattern **32**. These channels will, in the sintered bit body, act as flushing channels for guiding the flow of drilling fluid to the required parts of the bit and/or the hole. Since the shape and arrangement of such flow channels is known per se and do not form part of the invention, these channels are not described in detail. It is noted, however, that the channels arranged in the pattern **32** have to be shaped such that the pattern can be easily removed out of the graphite mold after the molding operation is over, which removal should not damage the channels formed in the mold by the ridges on the pattern **32**.

The method of forming a graphite mold by means of the apparatus as shown in the drawing, will now be described in detail.

With the bridge member **27** and the pattern **32** removed from the housing **21**, the space inside the cup-shaped flexible membrane **26** is partially filled with a mixture substantially consisting of graphite particles and liquid, such as water. Thereafter the bridge member **27** having the pattern **32** either in the extended position, or in some other position, is placed on the housing **21** and connected thereto by the bolts **28**. If the pattern **32** is in the non-extended position with respect to the bridge member **27** when the latter is mounted on the housing **21**, the pattern is moved into the position as indicated by FIG. 5 by rotation of the nut **38**.

Subsequently, a fluid, preferably oil, is supplied under pressure from a suitable (not shown) pressure source via the conduits **40** and **41** to the channels **39** arranged in the inner wall of the housing **21**. By the network of channels **39**, the fluid is initially distributed over the surface of the membrane **26**, thereby exerting compression forces on the graphite/liquid mixture arranged within the membrane **26**. By this action, part of the liquid is displaced from the mixture and drained via conduits **42**, **43**, **44** and the narrow gap present between the wall of the opening **23** and the pattern **32**, which gap allows the passage of water and air, but prevents the passage of graphite particles. The mixture is thereby densified.

The pressure exerted on the outer side of the membrane **26** should be as constant as possible. If a pump is used for raising the pressure of the fluid, care has to be taken that the variations in pressure are relatively small, say only 5% of the average pressure. It is preferred, however, to use a pressurized gas stored in a gas bottle, as a pressure source. If desired, this gas may be supplied directly to the space between the membrane **26** and the housing **21**, or it may be applied to a vessel containing a liquid, which vessel communicates at its lower end via a conduit to the said space.

If the variations in pressure are too great, the graphite particles will not be evenly compressed, which results in deviations in the mold with respect to the pattern **32**, which deviations unfavorably affect the life time of the bit sintered in said mold.

It has been found that the most homogeneous structure of the graphite mold will be obtained, if the pressure rise preceding the pressurizing period of the operation takes place very quickly, preferably within a few seconds.

The length of the period over which the mold is subjected to compressive forces is determined experimentally for each mixture. The compression period is over after maximum densification of the mixture has been reached, and no more liquid escapes from the above-mentioned conduits **42**, **43**, **44** and the narrow gap between the opening **23** and the pattern **32**.

Thereafter the pressure is removed from the outside of the cup-shaped membrane **26**, and the pattern **32** is carefully lifted and retracted from the opening **23** by rotating the nut **38**. This will only be possible if the parts of the pattern **32** have been designed such that they are slightly conical in downward direction, and will, during upward movement of the pattern easily free themselves from their corresponding parts of the mold without damaging them.

After the pattern **32** has been lifted through the opening **23**, the bridge member **27** and the plate **22** are removed and the graphite mold **45** is removed from the housing **21**, such as for example, by loosening the ring member **24** and lifting the membrane **26** together with the mold **45** from the housing **21**, or by inverting the housing **21** together with the mold or by injecting fluid via the conduit **40**. If the membrane **26** is of the type which is flat in the non-stressed condition, the mold will be lifted from the housing **21** by the elasticity of the membrane **26**.

The remaining part of the water, which has not been removed by the pressurizing operation of the mold is now removed therefrom, for example by drying the mold at ambient temperature or by exposing the mold to a moderate heating.

Thereafter the mold is ready for the sintering process. To this end, diamonds are carefully placed along circles in the channels which have been produced in the mold by ridges of the pattern **32**. Due to the molding process according to the invention, the mold is a very accurate negative of the pattern **32**.

By the application of small quantities of adhesive material, the diamonds are kept in place with the powder material suitable to be sintered is introduced into the mold. If desired, a shank suitable for connecting the sintered bit to a drill string, etc., is placed in the mold (compare for example FIG. 2, which shows the position of the shank **2** with respect to the bit body **4**, consisting of the sintered mass).

The shank **2** may be made of a material which has the same or about the same expansion coefficient as the powder to be sintered. Hereby, undesirable stresses within the mass to be sintered, as well as within the mold, which would occur as a result of the temperature changes during the sintering process, are prevented. Such stresses would distort the bit contour, thus displacing the diamonds in such a way that the load exerted on the bit during drilling will be unevenly distributed over the diamonds.

The powder mass to be sintered may consist of tungsten and tungsten carbide, and the shank **2** may be formed by tungsten, either in solid form or in powder form. The shank **2** may be sintered to the tungsten. The screw thread **3** is to be cut after the sintering process.

If the shank **2** is formed by a powder mass, a graphite mold (not shown) may be used for forming the outer surface of the shank. The screw thread **3** may be formed on this latter graphite mold or may be cut on the shank later on.

The shank **2** is preferably mounted in an annular groove which is formed in the sintered body **4**, whereafter the shank **2** is brazed to the body **4**, preferably by the process described in co-pending U.S. patent application 594,839, filed Nov. 16, 1966.

Before placing the mold together with the diamonds and the powder to be sintered into a sintering oven, an amount of binder material (such as German silver when sintering tungsten and/or tungsten carbide powder) is placed in the powder material. To prevent distortion during the cooling process following the sintering process, it has been found that the amount of binder material must not be greater than the volume of the pore space of the powder mass. If greater amounts of binder material are applied, the binder material remains in liquid form on top of the powder material and solidifies in situ thereby causing distortion of the bit body, which results in an uneven load distribution over the diamonds when the bit is rotated under load when drilling a hole through rock material.

If desired, the graphite mold may be strengthened by supporting it at the outer side thereof, e.g. by placing it in a cup-shaped supporting member, which member may be made of graphite. Preferably there is used a graphite cup, which is made of a solid block of graphite, for example by turning it on a lathe. If required, the outer side of the graphite mold is brought into a form to match the interior wall of the cup-shaped supporting member by scraping any undesired graphite therefrom.

Strengthening of the mold by inserting reinforcements in the graphite/liquid mixture before pressurizing it, is considered unattractive since this may give rise to distortions of the mold during the manufacturing process and/or during the sintering process.

The invention is not limited to a particular shape of the interior of the housing **21**, and/or of the member **26**. This latter need not be flat in the non-stressed condition. The housing, or the membrane is pre-formed, is preferably symmetrical with respect to the central axis thereof and has a cross-section as indicated in FIG. 5 of the drawing. Preferably, the central axes of the pattern **32** and the housing **21** coincide.

The graphite mold, optionally supported by a cup-shaped member, and containing diamonds, powder material, binder material, and optionally a shank for coupling purposes, after being placed in the sintering oven is heated to a temperature suitable to sinter the powder material to a common unit, without burning the diamonds. As such processes are known per se, no details need to be given here, regarding the sintering temperatures and sintering periods required for the various types of sinter material and binder material, which may be applied.

By way of example, some details will be given of a molding and sintering operation of a 6" diamond bit. The bit had a shape corresponding to the shape of the pattern **32** as shown in FIG. 5. The membrane **26** had a diameter of about 210 millimeters, was about 1 millimeter thick and was made of rubber. The deviations of the tops of the ridges **5** (FIG. 1) on concentric circles (along which the diamonds are to be placed) were measured, and the greatest variation occurring in the distances between these tops and the centrol axis of the pattern **32** (FIG. 5), measured in a direction perpendicular to the bottom profile to be cut by a bit according to pattern **32**, was 0.02 millimeter.

A mixture consisting of 60% graphite particles and 40% water was manually introduced in the membrane **26**. Thereafter, the pattern **32** was clamped in the position as indicated in the drawing, and oil under pressure was supplied to the channel **40**. Within 5 seconds the pressure within the space bounded by the membrane **26** and the inner wall of the housing **21** was raised from 1 to 30 kilograms per square centimeter, which latter pressure was applied over a period of 120 minutes during period water was pressed out of the mixture and the mixture was densified. Thereafter, the pressure was brought down to 1 kilogram per square centimeter. Subsequently, the pattern **32** was retracted from the graphite mold and the plate **22** and the ring member **24** were removed so as to enable the lifting of the mold **45** from the apparatus.

After removal of the graphite mold the remaining part of the water contained within the pores of the graphite mold was removed by heating the mold gradually over a period of 40 hours from ambient temperature to 120° C. The mold was thereafter cooled down slowly. Eventually this drying may take place in the sintering oven by slowly heating up the mold containing the diamonds, sintering mass and binder.

The diamonds used in this particular bit were between 1/7 and 1/6 carat and applied in channels of the mold which had the shape of the ridges **11** shown in FIG. 4. The width of the portions **12** was 0.8 millimeter.

After the diamonds had been glued in place by a suitable adhesive, a mass of tungsten carbide powder was poured into the mold. Subsequently an amount of 3 kilograms German silver was added on top of the mass and the mass was heated in an inert atmosphere up to a temperature of 1120° C. over a period of 2.5 hours. Subsequent cooling down of the sintered mass to room temperature took 12 hours.

Thereafter, the sintered bit was placed on a measuring stand, for measuring the greatest variation in the distances between the cutting tops of diamonds belonging to a common circle and the central axis, when measured in a direction perpendicular to the bottom profile to be cut by the bit. The greatest variation was 0.1 millimeter. The variation was 0.05 millimeter or less for about 75% of the diamonds.

The method according to the invention of said copending application allows the manufacture of graphite molds suitable for sintering purposes, which molds have dimensions which are so close to the design dimensions, that the diamonds which are applied in the various channels formed by the ridges of the pattern **32** before the sintering material is applied to the mold, have in the sintered bit such a mutual position that the load is evenly distributed over all the diamonds which are arranged over the ridges **5** and equally spaced along the circles which have their centers on the central bit axis. The drawback of an uneven load distribution over the diamonds which results in a breaking out of the diamonds one after the other is thereby prevented.

It will be clear that the present invention is not limited to the example given but that various alternatives may be applied in the molding and sintering process, as well as in the constructive details of the bit.

I claim as my invention:

1. A sintered diamond drilling bit comprising:

a sintered, hard, wear-resistant body member having an upper portion and lower portion;

a shank member extending from the upper portion of said body member;

axially extending conduit means through said body member and said shank member;

cutting means extending from the lower portion of said body member;

said cutting means comprising a plurality of ridges formed on the lower portion of said body member; and

a plurality of diamonds at least partially embedded in each of said ridges and having at least a portion thereof exposed, said diamonds being positioned in a plurality of concentric common circles of differing diameters whose centers coincide with the axis of said body member, the lower parts of each of the diamonds in any given circle lying in a common plane or conical surface, whereby all of the diamonds in any given circle subscribe a common path as the bit rotates in the face of the material being drilled.

2. A diamond drilling bit according to claim 1 wherein the ridges extend along straight lines passing through the central axis of the bit.

3. A diamond drilling bit according to claim 1 wherein the conduit means is centered about the central axis of the bit.

4. A diamond drilling bit according to claim 1 wherein the shank member is of a different material than that of said body member and includes means for securing the bit to the lower end of drill string means.

5. In a diamond drilling bit of the type having a body with an upper shank for connection to the lower end of a rotary drill string and a lower face for engaging the material at the bottom of a borehole, and a conduit extending in an axial direction through the body for passage of drilling fluid: a substantial portion of the material of the body adjacent said lower face being a sintered, hard, wear-resistant material; a plurality of ridges formed in said lower face and extending downwardly from said lower face, the ridges forming a pattern on the lower face radiating generally outwardly from a central part thereof and providing cutting means for engagement with the bottom of the borehole; a plurality of diamonds at least partially embedded in each of said ridges and each diamond having at least a portion thereof exposed at the lower-most part of the ridge, the diamonds being positioned in a plurality of concentric circles of differing diameters with the centers of the circles coinciding with the central axis of the body, whereby all of the diamonds in a given circle will subscribe a common path in the material drilled at the bottom of the borehole, the diamonds being positioned such that the lowermost part of each of the diamonds in a given circle will be in a common plane or conical surface with that of all of the other diamonds in each circle so that none of the diamonds will receive preferential wear or stress while engaging the bottom of the borehole.

6. In a diamond drilling bit according to claim 5, the ridges being arranged along straight radial lines converging at the central axis of the body.

7. In a diamond drilling bit according to claim 5, the lower face of the body being composed of sintered tungsten or mixture of tungsten and tungsten carbide, along with a binder material.

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JAMES A. LEPPINK, Primary Examiner