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METHOD OF CONNECTING A STEEL BLANK TO A TUNGSTEN BIT BODY

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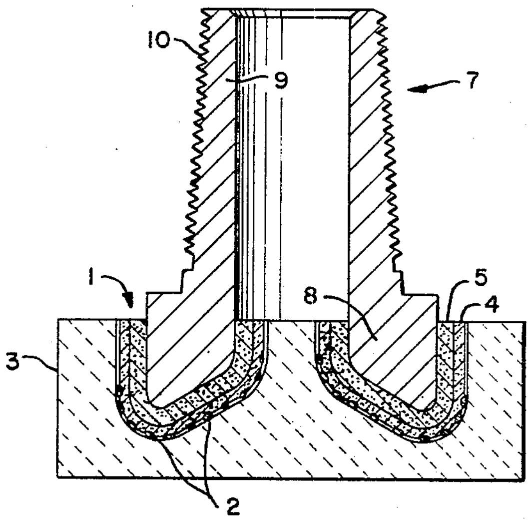

FIG. 1

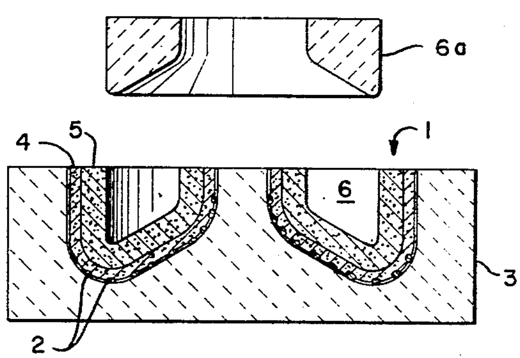

FIG. 2

INVENTOR:
ROBIJN FEENSTRA
BY: J. H. McCarthy
HIS AGENT

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METHOD OF CONNECTING A STEEL BLANK TO A TUNGSTEN BIT BODY

Robijn Feenstra, Rijswijk, Netherlands, assignor to Shell Oil Company, New York, N.Y., a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

A steel blank is connected to a tungsten bit body by bonding the contact planes of the body and the blank together at a temperature that is less than the critical temperature of the steel blank so as to avoid the tremendous volume changes that occur in steel at this temperature.

The present invention relates to drill bits employed in drilling oil and gas wells and pertains more particularly to a method of connecting a steel blank to a bit body consisting of a mass of sintered tungsten (e.g., tungsten powder and/or tungsten carbide powder). In particular, the present invention relates to a manner of providing the sintered body of a diamond bit for use in deep well drilling, with a steel tool joint, sub or shank which is suitable for connecting the sintered bit body to a drill string.

Diamond bits are manufactured by filling a graphite mold of the bit body, with tungsten powder and/or the desired places within the mold. To connect the mass to the drill string, a steel blank, which is later provided with a screw thread so as to act as a sub or shank, is placed in the mass of powder filling the mold, after which the mold with the powder and the blank is placed in a suitable furnace. A binder material, such as german silver, is placed on the top of the powder, and the furnace is heated to sintering temperature which is about 1130° C., and, of course, well below the temperature at which the diamonds would be adversely affected.

At sintering temperature, the binder material liquefies and flows into the pore space of the powder material, as well as between the powder material and the wall of the steel blank. Cooling down of the mold with its contents causes solidification of the binder material, thereby forming an integral mass of the powder material containing the diamonds, to which mass the steel blank is attached. A screw thread is thereafter cut on the blank, thereby converting it into a sub or tool joint pin which is suitable to be connected to the lower end of a drill collar.

It has been found, however, that due to the difference in the expansion coefficients of the sintered mass and the steel blank the sintered mass will be liable to crack during the cooling period. In addition, this weakens the bond between the blank and the sintered mass, and it also distorts the sintered mass which will adversely affect the cutting properties of the diamonds carried by the sintered mass.

A possible solution for the above problem is the use of a number of small metal plugs, provided with internal screw threads, which plugs are sintered together with the powder, and allow the application of a flange connected to a sub, which flange is provided with openings carrying bolts for connecting this flange to the sintered bit body. Since the dimensions of these plugs are small compared to the dimensions of the sintered mass, cracking of the sintered mass does not occur during cooling. Although this construction is very useful for testing diamond bits in the laboratory, it is unsuitable for field use on account of the use of the bolt connections.

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It has also been proposed to sinter the powder in the mold together with the diamonds, but without the steel blank. After the sintering process is over and the sintered mass has cooled down, the steel blank is brazed with copper to the sintered mass by heating the whole assembly to a temperature which is lower than the sintering temperature. This will result, depending on the construction of the blank and the sintered mass, in cracking of the sintered mass or breaking of the bond between the blank and the sintered mass. If the blank is placed in a groove arranged in the sintered mass, even both phenomena may occur.

Accordingly, the invention is concerned with connecting a steel blank member to a tungsten bit body member consisting of a mass of sintered tungsten powder and/or tungsten carbide powder, by such a method as to obtain a strong bond between the steel blank and the sintered mass, without distortion or cracking of the sintered mass or breaking of the bond between the steel blank and the sintered mass.

According to the invention, the method of connecting a steel blank to a tungsten bit body consists in bonding the contact planes of the mass and the blank together at a temperature which is less than 723° C., the lower critical temperature of the steel blank. Critical temperatures, also called critical points, of steel are those temperatures at which structural changes take place in the steel while it is in the solid condition. These critical temperatures vary with the rate of heating or cooling of the steel and with different alloys. The lower critical temperature for a steel is that point at which pearlite begins to change into austenite. This lower critical temperature occurs about 723° C. for some pure iron-carbon alloys. The structural change of the steel from pearlite to austenite and vice-versa is accompanied by a volume change of very specific nature. This volume change may be as much as 1.6% over certain temperature ranges.

The bond may be obtained by the application of a bonding composition such as a resin composition which cures at a temperature below 723° C., or by a brazing composition, which has a melting range below 723° C. In other words, the body may be obtained by the application of a bonding composition or agent having an effective bonding temperature that is less than the lower critical temperature of the steel member. Effective bonding temperature as used herein is that temperature to which the bonding composition must be raised during the course of establishing an effective bond. The bonding composition may be either a resin composition that cures at a temperature below the lower critical temperature of the steel member or a brazing or soldering composition having a melting point below said critical temperature.

The invention may be carried into practice in various ways, but one specific embodiment will now be described by way of example with reference to the accompanying drawing which shows a longitudinal section of a diamond drill bit which is suitable to drill deep wells through hard rocks.

FIGURE 1 is a section through the assembled tool bit; and

FIGURE 2 is a section through the bit body as molded.

The bit body includes a sintered mass **1** carrying the diamonds **2** and has been formed by means of a mold **3**. The mold consists of graphite, and may be formed by turning a solid block of graphite on a lathe and cutting a negative form of the desired bit design in the block.

The required number of diamonds **2** are then distributed according to a desired pattern in the mold, whereafter the mold is filled with powder material, such as tungsten powder or tungsten carbide, suitable to be bonded together by a binder material. If desired, the outer wall **4** of the mass **1** may be formed by tungsten carbide powder, whereas the interior layer **5** is constituted by tungsten powder. An annular channel **6** may be formed in the tungsten powder mass **5** by placing a graphite ring *6a* of the dimensions corresponding to the channel **6** in the mass of tungsten powder **5**.

After the mold **3** has been filled with the required amounts of tungsten **5** and tungsten carbide **4**, an amount of suitable binder material, such as german silver consisting of 65 vol. percent copper, 18 vol. percent nickel and 17 vol. percent zinc, is placed on top of the tungsten carbide powder **4** and/or tungsten powder **5**. Thereafter the mold **3** with its contents is placed in a suitable sintering furnace in which the mold is heated in a neutral atmosphere to a temperature higher than the melting temperature of the binder material. When applying german silver as a binder, the sintering temperature of 1130° C. will be sufficient since the melting range of this binder is 1120° C.

On melting, the binder material sweeps through the pore space of the powdered masses **4** and **5** and is evenly distributed thereover. During the cooling period following the heating period in the furnace, the binder solidifies, thereby strongly bonding the powder particles of the mass **1** to an integral unit. Since the diamonds **2** are for the greater part enclosed by the sintered particles, these diamonds are firmly retained in the sintered mass **1**.

After the sintered mass **1** has cooled down to ambient temperature, the graphite mold **3**, as well as the ring in the channel **6**, if present, is removed from the body **1** (e.g., by destroying). Thereafter the body **1** is placed on a lathe and the form and dimensions of the channel **6** are brought into accordance with the lower end of the metal blank **7** by means of a cutting tool.

The metal blank **7** comprises a lower part **8** which is preferably of a cross-section which is substantially of the same shape as the cross-section of the body **1**. The clearance between the blank **7** and the body **1** has been calculated such that at brazing temperature, it has a clearance suitable for brazing (e.g., about 0.1 millimeter).

The upper part **9** of the blank **7** has an external screw thread **10**, which enables the body **1** to be connected by screwing action to a drill collar or drill string suitable so that it can be lowered into a borehole and be rotated therein under a load sufficiently high to have the diamonds **2** exert a scraping action on the bottom of this hole for increasing the depth thereof. The screw thread **10** is not cut into the blank **7** until after the latter has been connected to the body **1**.

After the blank **7** has been placed in the channel **6**, and the body **1** and the blank **7** have been put into a heating furnace and have been heated to a temperature lower than 723° C., the critical temperature of the steel blank, a very small clearance will remain between the outer wall of the blank **7** and the inner wall of the channel **6**. An amount of low temperature brazing composition is placed at one side of the blank **7** just above the clearance between the blank **7** and the channel **6**. The brazing composition, on melting, flows into the clearance and fills it completely.

A suitable brazing composition is formed by a silver solder comprising 50 vol. percent silver, 18 vol. percent cadmium, 16.5 vol. percent zinc and 15.5 vol. percent copper. Since the flow point of this solder is about 635° C., a furnace temperature between 635° C. and 723° C. is sufficient to heat the solder to a temperature above its melting range. The space around the contact planes which are to be bonded by the solder is filled with nitrogen gas to decrease the danger of carbonisation of the steel.

By gradually cooling down the furnace to ambient temperature, a strong bond will be formed between the contact planes of the blank **7** and the body **1** by the solder solidifying therebetween. No cracks will be formed in the parts of the body **1** in the neighborhood of the steel blank **7**. This is due to the fact that during the soldering process, the temperature of the steel blank is not raised above 723° C., its lower critical temperature, this temperature being the bottom temperature of a temperature range over which pearlite is converted into austenite when the temperature of the steel is raised, and over which austenite is converted into pearlite when the temperature of the steel is lowered.

These conversions from pearlite to austenite and vice-versa are accompanied by volume changes of a very specific nature. Thus, on cooling down steel over the temperature range of maximum 910° C. to 723° C., an increase of volume of 1.6% will occur. Since the shrinking action of the sintered mass, however, is quite normal when cooling it down from a high temperature, it will become apparent that in a construction such as the present diamond bit, in which the steel blank and the sintered body have a very close fit, undesired stresses will occur when cooling this construction over the above-mentioned temperature range of 910° C. to 723° C., in particular when a bond has already been formed between the steel blank and the sintered body.

It will be clear that, by applying methods in which the bond between the contact planes of the steel blank and the sintered body is formed at a temperature lower than 723° C., the lower critical temperature of the steel member, no problems regarding overstressing of the construction will occur. One of the methods which makes use of a low-temperature brazing solder has already been described above. It will be appreciated that the invention is not restricted to the particular type of solder or bonding composition used in the above explanation of the invention, but that any other type of brazing solder or bonding composition may be used which has a flow point or melting range which is lower than 723° C., the lower critical temperature of the steel member, and is capable of forming a sufficiently strong bond between the available areas of the contact planes of the blank and the body.

Another way of obtaining a bond between the blank and the body without creating undesired stresses within these components of the bit in the use of a bonding composition such as a resin which will cure at a temperature lower than 723° C., the lower critical temperature of the steel member, and sufficiently adhere to the blank as well as to the body to withstand the forces which are exerted in the bond between the contact planes of the bit components when the bit is in operation in drilling a hole in an underground formation. One example of such resins is a glycidyl polyether of 2,2-bis(4-hydroxyphenyl)propane, known under the tradename of Epon® resins, which can be cured, depending on the curing agent and the curing period, at any temperature between room temperature and 200° C.

It will be obvious that various modifications may be made in the method and apparatus according to the invention and that the specific details of the method and apparatus as described herein are merely illustrative.

I claim as my invention:

1. Method of minimizing differential expansion and contraction between a steel blank member and a sintered tungsten earth drill bit member while permanently bonding said members together, comprising the steps of:

forming one of said members with a recessed portion;

forming the other of said members with a portion dimensioned to mate with said recessed portion in spaced relationship at maximum bonding temperature;

placing said portion of said other member within said recessed portion;

maintaining said portions in spaced relation at said maximum bonding temperature;

providing a bonding composition having an effective bonding temperature that is less than the minimum critical temperature of said steel member;

placing said bonding composition in the space formed upon the mating of said members;

applying heat to said bonding composition at a temperature sufficient to bring said bonding composition substantially to its effective bonding temperature; and

cooling said members to ambient temperature to effect a permanent bond between said members, thereby minimizing the stressing of said members, and eliminating the cracking and distortion of said bit member and the weakening of said bond.

2. The method of claim 1 including the step of:

adding diamonds to the surface of said sintered tungsten bit, said diamond inclusions having at least a portion thereof exposed.

3. The method of claim 1 including the further step of:

exposing at least the mating portions of said members with an inert gas during at least said heating step.

4. The method of claim 1 wherein the step of providing said bonding composition comprises employing a resin which will cure at a temperature of less than the critical temperature of said steel member.

5. The method of claim 3 wherein the step of providing said bonding composition comprises employing a brazing solder having a melting point which is lower than the critical temperature of said steel member.

6. The method of claim 1 wherein the step of applying heat to said bonding composition comprises applying heat to at least one of said members.

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JOHN F. CAMPBELL, Primary Examiner

J. L. CLINE, Assistant Examiner

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