

PATENT SPECIFICATION

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(54) EARTH BORING BIT HAVING CARBURISED BEARING SURFACE

(71) We, HUGHES TOOL COMPANY, a Company organised and existing under the laws of the State of Delaware, United States of America, of 5425 Polk Avenue, Houston, Texas 77023, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates in general to the treatment of steel bearing surfaces, and in particular to steel friction or plain bearings especially adapted for earth boring drill bits in which special treatments are utilized to achieve a carburized case with a high carbon content surface to improve resistance to galling.

In the earth boring industry the original rolling cutter type drill bit had steel friction type bearings with carburized cases having a relatively low surface carbon content. The carburizing technique in those days utilized what is commonly known as "pack" carburizing. Such procedures did not produce carburized cases with high surface carbon content because the bearing members were hardened from a non-carburizing atmosphere in order to prevent unwanted carburization of the surfaces to be subsequently machined or welded.

More recently, anti-friction bearings having balls and rollers were utilized in rolling cutter type drill bits. These bearings had case hardened surfaces produced by using either pack carburizing or gas carburizing. In those bits utilizing pack carburizing, carburized cases with high carbon surface contents were not obtained for the reason explained above. Although possible, it is advisable to avoid high surface carbon contents in anti-friction bearing bits when carburizing in a gas atmosphere because fatigue spalling more frequently occurs in parts subjected to multiple stress reversals when the carburized surface carbon content is high. Since anti-friction drill bit bearings are sub-

jected to excessively high stresses and many stress reversals, the high surface carbon contents are avoided.

The invention may be summarized as an earth boring drill bit and method of production having at least one steel plain or friction type bearing surface carburized and hardened in such a manner producing extremely high surface carbon. The surface carbon is sufficiently high that free carbides are produced at the surface. Depending upon the type of steel and heat treatment following carburization, the free carbides may be visible during microscopic examination as distinctive microconstituents, or may be so finely dispersed that they cannot be resolved in normal microscopic examination. In either situation there is a substantial quantity of free carbides. To obtain free carbides at the surface of the bearing the carbon content at the surface should exceed 0.9% (by weight). Free carbides means more specifically a surface having an average carbon content higher than about 0.9% to give a combination of a solid solution of gamma iron (carbon dissolved in iron) and free carbides that do not go into solution when the steel is heated slightly above the eutectoid temperature of about 1350°F, depending upon alloy content. Ideally, the surface carbon content is as high as practicable, for example, 1.20% for AISI 8720 steel and SAE EX30 or 1.00% for AISI 4815 steel. In steel friction bearings intended for earth rock bit usage, the high surface carbon content produces an exceptionally gall resistant surface. Ideally, the high carbon surface and/or sometimes the opposing surface, which may not have high surface carbon, are provided with a sacrificial, solid lubricant such as a soft metal or a metallic compound. The above as well as other objects, features and advantages of the invention will become more fully apparent in the following detailed description, reference being made to the accompanying drawings in which:

Figure 1 is a fragmentary side elevation view in longitudinal section illustrating a

typical earth boring drill bit having plain or friction bearing surfaces to support a cutter that rotates against a bore hole bottom, and

5 Figure 2 is a fragmentary side elevation view in longitudinal section that illustrates the lower one half of another of the many alternate forms of bearings to which the invention may be applied.

10 With reference to Figure 1 the numeral 11 designates the body or head section of an earth boring drill bit which includes a cantilevered pin or journal 13 that supports a rotatable, generally cone-shaped cutter 15 having teeth 17.

15 The bearing configuration illustrated in Figure 1 is completely of the plain or friction type, utilizing a plug retainer 18 extending through a drill hole 19 formed obliquely relative to the axis 21 of the bearing and into a mating groove 23 formed concentrically with the rotational axis 21.

20 A lubrication passageway 25 extends from a lubrication reservoir (not shown) in an upper portion of the bit body, the passageway extending partially through the retainer pin 18 and into a space 26 between the cantilevered journal 13 and cutter 15.

25 An O-ring 27, or other suitable form of seal means, is confined between a portion 29 of the cantilevered journal 13 and the walls of a groove 31 formed preferably in the cutter 15. The retainer pin 18 is secured in position by weldment 35 in a receiving depression 37 formed in the bit body 11 and in one end of plug retainer 18.

30 The invention may be applied to bearings having a combination of friction and anti-friction bearings means, such as shown in Figure 2. This bearing has friction surfaces that engage at 39, an anti-friction ball bearing 41, and additional friction bearing surfaces defined by a bushing 43 and a thrust button 45 secured in the rotatable cutter 15 to engage a pilot pin portion 47 of the journal 13. The rotatable cutter 15 has in this instance teeth 17 of sintered tungsten carbide that protrude from confining apertures in the cutter to illustrate that the invention is not limited in its broadest aspects to any particular type of cutter.

35 An earth boring drill bit had its plain or friction bearing surfaces such as those 39 shown in Figures 1 and 2 carburized and heat treated to produce high surface carbon in accordance with the principles of the invention as follows:

40 A drill bit head section having a bearing pin form of AISI 8720 steel was first heated after copper plating all except the selected friction bearing surface to a temperature of 1700 to 1710°F. in a gas carburizing furnace containing an atmosphere with a carbon potential of 1.35%. The head section was maintained in the furnace at these conditions for approximately nine hours.

Next, the head section was cooled in the same carburizing atmosphere for a period of approximately twenty minutes to below about 800°F. and then cooled to room temperature in air. This prevents loss of the surface carbon.

For hardening purposes, the head section was then reheated to 1500 to 1510°F. in a furnace having a carburizing atmosphere with a carbon potential of 1.00% to prevent substantial loss of surface carbon. The head section was held at this temperature under these conditions for a period of from 30 to 45 minutes.

Next the head section was quenched in agitated oil directly from the carburizing atmosphere for a period of approximately 30 minutes. The oil temperature during this procedure was maintained at a temperature in a range from 70 to 140°F.

After quenching, the head section was then washed in water containing detergent for a period of approximately ten minutes at a temperature of approximately 150°, although temperature is not particularly critical.

Then, the head section was tempered in an air atmosphere for approximately one hour at a temperature of 325 to 340°F.

The carburized case of the bearing of the head section treated above was analysed and found to have a surface carbon content of 1.21%. The bearing pin of another head section so treated was found to have a surface carbon content of 1.27%.

As is commonly known in the drill bit industry, selected areas of the head sections are protected from carburization with copper plating about .002 inches thick. This is important also where some of the bearing means are of the anti-friction type, as shown in Figure 2 which are detrimentally affected by high surface carbons in the range herein disclosed. Also sharp corners should not have high surface carbon to minimize the generation of fatigue cracks. Other methods to prevent carburization of selected surfaces such as the use of stop-off paint are well known in the art.

The carbon potential of the carburizing atmosphere may be less than the 1.35% specified above but should not be below about 1.10% to satisfactorily obtain 0.9% surface carbon on the bearing surface. The 0.9% value represents an average value since there is generally some variation of carbon content across the surface. When hardening from a carburizing atmosphere, which may be the original or an additional such atmosphere, the carbon potential should not fall below 0.9% to prevent substantial loss of free carbides at the surface.

It is advantageous when friction bearings have high surface carbon produced according to the invention, to treat at least one of the bearing surfaces with a sacrificial, solid

lubricant that ideally is a soft metal or a metallic compound. This treatment, which may wear rapidly during initial use of the bearing, enables the breaking-in of the hard, high carbon surface in a manner that substantially lengthens the life of the bearing. For the AISI 8720 steel that is carburized as explained above, the best sacrificial, solid lubricant tested thus far is iron sulphide. Iron sulphide treatment is sometimes known as the "Caubet" treatment and is explained in detail in U.S. Patent No. 3,467,585. The cutter 15 was formed of AISI 4815 steel, was carburized and hardened as explained above, and had its bearing surfaces ground to ensure concentricity within permissible tolerance. This grinding results generally in a surface carbon of about 0.8% or below. This combination with the "Caubet" treated 8720 steel journal, carburized as explained above yielded best results when utilized in earth boring drill bits.

A second example of a satisfactory sacrificial, solid lubricant for a carburized journal surface involves treatment of the high surface carbon bearing surface with a manganese phosphate. The carburized bearing was immersed for a period of 20 to 25 minutes in an essentially saturated solution of manganese phosphate in the presence of a slight excess of phosphoric acid, the solution being heated and maintained at a temperature of 200 to 210°F.

Other sacrificial solid lubricant treatments include coating of copper, silver, cadmium, alloys thereof, or other of the soft anti-galling metals in the manners commonly known in the art. However, metallic compounds such as manganese iron phosphate or iron sulphide are the most advantageous since they diffuse into the steel of the bearing and in effect become an integral part thereof.

The iron sulphide surface treatment is especially advantageous for another reason; namely that it may be used in those areas of the journal and cutter engaged by the seal means 27. The iron sulphide in the alloy steel surface has a smooth low friction surface condition that is not detrimental to seal life, and may even prolong it. When treated with manganese phosphate the surface tends to be detrimental to seal means such as O-rings. There the seal areas should be protected from the treatment by suitable means such as a lacquer coating for example.

It is possible in the carburizing step explained above that the time of carburization may be greater or less than nine hours. The length of time for carburization affects primarily the depth of carburization, although to obtain high surface carbon it is necessary to carburize for a certain minimum period of time, as for example six hours. A bearing surface treated in accordance with the foregoing method produced free carbides at the surface. Head sections with these bearing surfaces were

assembled into a sealed and lubricated drill bit having a rotatable cone also having carburized steel bearing surfaces and showed improved bearing life when compared with known prior art drill bits.

It should be understood that the surface carbon content explained above occurs in an extremely shallow depth from the surface. The surface carbon content is measured from a cut that is .005 inch deep and represents an average depth of .0025 inch. The carbon gradient falls rapidly from this shallow depth, but it has been found that this is the important depth in which galling resistance must be improved. Any additional bearing life after the bearing wears .005 inch is extremely short. Therefore, even though the carbon gradient falls rapidly from the surface, treatment of bearing surfaces in accordance with the foregoing method improves galling resistance significantly. A secondary advantage of the invention is that the free carbides improves the wear resistance of seal surfaces, such as the O-ring surface shown in the drawing.

By way of a second example an AISI 4815 type steel head section was treated in accordance with the foregoing method and was found to have a bearing surface carbon content of 1.00%. Testing of this bit under actual drilling conditions showed that its bearing life was improved.

Treatment of an additional steel such as an SAE EX30 in accordance with the foregoing method yielded a surface carbon content similar to the example given above in connection with the AISI 8720 steel.

While the invention has been disclosed in but a few of its forms, it should be apparent to those skilled in the art that it is not so limited but is susceptible to various changes and modifications without departing from the spirit thereof. For example earth boring drill bits having friction bearing surfaces that are pack carburized to obtain free carbides at the surface fall within the broad scope of the invention. When using pack carburization, it is not feasible to quench directly from the carburizing atmosphere. Thus, the quenching should be done after the bearing surface has been coated with copper or given other treatment to prevent the loss of free carbides at the surface when heating the surface in a low carbon atmosphere to pre-quench temperatures.

WHAT WE CLAIM IS:—

1. A method of producing earth boring drill bits of the kind comprising at least one cutter rotatable on a journal, the cutter and journal having mating friction type bearing surfaces, at least one of said surfaces being of steel having high surface carbon, said method comprising the steps of carburising at least one of the journal and the cutter in a gaseous atmo-



lubricant that ideally is a soft metal or a metallic compound. This treatment, which may wear rapidly during initial use of the bearing, enables the breaking-in of the hard, high carbon surface in a manner that substantially lengthens the life of the bearing. For the AISI 8720 steel that is carburized as explained above, the best sacrificial, solid lubricant tested thus far is iron sulphide. Iron sulphide treatment is sometimes known as the "Caubet" treatment and is explained in detail in U.S. Patent No. 3,467,585. The cutter 15 was formed of AISI 4815 steel, was carburized and hardened as explained above, and had its bearing surfaces ground to ensure concentricity within permissible tolerance. This grinding results generally in a surface carbon of about 0.8% or below. This combination with the "Caubet" treated 8720 steel journal, carburized as explained above yielded best results when utilized in earth boring drill bits.

A second example of a satisfactory sacrificial, solid lubricant for a carburized journal surface involves treatment of the high surface carbon bearing surface with a manganese phosphate. The carburized bearing was immersed for a period of 20 to 25 minutes in an essentially saturated solution of manganese phosphate in the presence of a slight excess of phosphoric acid, the solution being heated and maintained at a temperature of 200 to 210°F.

Other sacrificial solid lubricant treatments include coating of copper, silver, cadmium, alloys thereof, or other of the soft anti-galling metals in the manners commonly known in the art. However, metallic compounds such as manganese iron phosphate or iron sulphide are the most advantageous since they diffuse into the steel of the bearing and in effect become an integral part thereof.

The iron sulphide surface treatment is especially advantageous for another reason; namely that it may be used in those areas of the journal and cutter engaged by the seal means 27. The iron sulphide in the alloy steel surface has a smooth low friction surface condition that is not detrimental to seal life, and may even prolong it. When treated with manganese phosphate the surface tends to be detrimental to seal means such as O-rings. There the seal areas should be protected from the treatment by suitable means such as a lacquer coating for example.

It is possible in the carburizing step explained above that the time of carburization may be greater or less than nine hours. The length of time for carburization affects primarily the depth of carburization, although to obtain high surface carbon it is necessary to carburize for a certain minimum period of time, as for example six hours. A bearing surface treated in accordance with the foregoing method produced free carbides at the surface. Head sections with these bearing surfaces were

assembled into a sealed and lubricated drill bit having a rotatable cone also having carburized steel bearing surfaces and showed improved bearing life when compared with known prior art drill bits.

It should be understood that the surface carbon content explained above occurs in an extremely shallow depth from the surface. The surface carbon content is measured from a cut that is .005 inch deep and represents an average depth of .0025 inch. The carbon gradient falls rapidly from this shallow depth, but it has been found that this is the important depth in which galling resistance must be improved. Any additional bearing life after the bearing wears .005 inch is extremely short. Therefore, even though the carbon gradient falls rapidly from the surface, treatment of bearing surfaces in accordance with the foregoing method improves galling resistance significantly. A secondary advantage of the invention is that the free carbides improves the wear resistance of seal surfaces, such as the O-ring surface shown in the drawing.

By way of a second example an AISI 4815 type steel head section was treated in accordance with the foregoing method and was found to have a bearing surface carbon content of 1.00%. Testing of this bit under actual drilling conditions showed that its bearing life was improved.

Treatment of an additional steel such as an SAE EX30 in accordance with the foregoing method yielded a surface carbon content similar to the example given above in connection with the AISI 8720 steel.

While the invention has been disclosed in but a few of its forms, it should be apparent to those skilled in the art that it is not so limited but is susceptible to various changes and modifications without departing from the spirit thereof. For example earth boring drill bits having friction bearing surfaces that are pack carburized to obtain free carbides at the surface fall within the broad scope of the invention. When using pack carburization, it is not feasible to quench directly from the carburizing atmosphere. Thus, the quenching should be done after the bearing surface has been coated with copper or given other treatment to prevent the loss of free carbides at the surface when heating the surface in a low carbon atmosphere to pre-quench temperatures.

WHAT WE CLAIM IS:—

1. A method of producing earth boring drill bits of the kind comprising at least one cutter rotatable on a journal, the cutter and journal having mating friction type bearing surfaces, at least one of said surfaces being of steel having high surface carbon, said method comprising the steps of carburizing at least one of the journal and the cutter in a gaseous atmo-

- sphere having a carbon potential sufficient to achieve free carbides at the bearing surface of the journal or cutter, and quenching the journal or cutter directly from a carburising atmosphere to harden the bearing surface without substantially loss of free carbides at said surface.
- 5 2. A method according to claim 1 including the further step of tempering the journal or cutter after it has been carburised and quenched.
- 10 3. A method according to claim 1 or claim 2 wherein the carburisation is carried out in an atmosphere having a carbon potential of at least 1.10% to produce free carbides at the bearing surface, and wherein the carburising atmosphere from which the journal or cutter is quenched has a carbon potential of at least 0.90%.
- 15 4. The method defined by any of claims 1 to 3 which comprises the further step of providing at least one of said bearing surfaces with at least one antigalling solid lubricant.
- 20 5. The method defined by claim 4 in which said antigalling solid lubricant comprises a soft antigalling metal.
- 25 6. The method defined by claim 4 in which said antigalling solid lubricant comprises a metallic compound.
- 30 7. The method defined by claim 6 in which said antigalling solid lubricant comprises iron sulphide.
- 35 8. The method defined by claim 6 in which said antigalling solid lubricant comprises manganese iron phosphate.
9. An earth boring drill bit comprising at least one cutter rotatable on a journal, the cutter and journal having mating friction type bearing surfaces, at least one of said journal and cutter being of carburised and hardened steel having free carbides at the bearing surface thereof.
- 40 10. The drill bit defined by claim 9 in which at least one of said bearing surfaces is provided with at least one antigalling solid lubricant.
- 45 11. The drill bit defined by claim 10 in which the antigalling solid lubricant comprises a soft metal.
- 50 12. The drill bit defined by claim 10 in which the antigalling solid lubricant comprises a metallic compound.
- 55 13. The drill bit defined by claim 10 in which the antigalling solid lubricant comprises iron sulphide.
- 60 14. The drill bit defined by claim 10 in which the antigalling solid lubricant comprises manganese iron phosphate.
- 65 15. The method of producing earth boring drill bits according to claim 1 and substantially as hereinbefore described.
16. An earth boring drill bit according to claim 9 and substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.
17. An earth boring drill bit according to claim 9 and substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.

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