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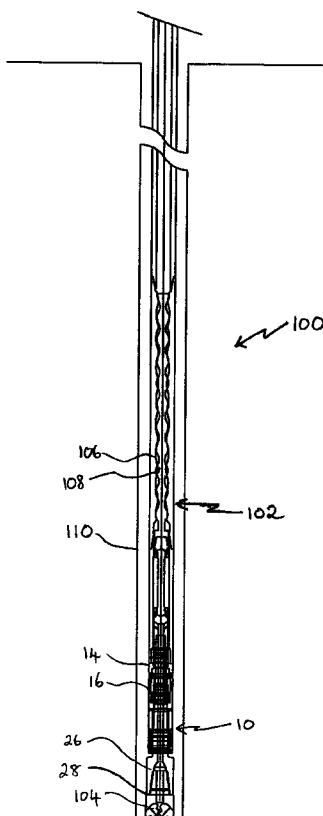
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(54) Titre : METHODE DE FORAGE DE TERRAIN QUI UTILISE UN ROULEMENT ETANCHE DE FOND DE TROU,
METHODE DE SCELLEMENT DE ROULEMENT DE FOND DE TROU ET ROULEMENT DE FOND DE TROU
(54) Title: METHOD OF EARTH DRILLING USING A SEALED DOWNHOLE BEARING ASSEMBLY, METHOD OF
SEALING A DOWNHOLE BEARING ASSEMBLY AND A DOWNHOLE BEARING ASSEMBLY



(57) Abrégé/Abstract:

A method of earth drilling with a sealed bearing assembly and a sealed bearing assembly. A first step involves providing a bearing assembly that has a bearing chamber sealed with fixed sealing assemblies of axially aligned seals, including a primary seal and

(57) **Abrégé(suite)/Abstract(continued):**

back up seals. The sealing assemblies are capable of withstanding an intended pressure differential. A second step involves drilling with the earth drilling assembly in a downhole environment in which pressure within the bearing chamber is at hydrostatic pressure with the relative pressure differential caused by pumping activity being borne by the fixed sealing assemblies. The bearings and back up seals positioned within the sealed bearing chamber operate under relatively low pressure thereby prolonging bearing and seal life.

ABSTRACT OF THE DISCLOSURE

A method of earth drilling with a sealed bearing assembly and a sealed bearing assembly. A first step involves providing a bearing assembly that has a bearing chamber sealed with fixed sealing assemblies of axially aligned seals, including a primary seal and
5 back up seals. The sealing assemblies are capable of withstanding an intended pressure differential. A second step involves drilling with the earth drilling assembly in a downhole environment in which pressure within the bearing chamber is at hydrostatic pressure with the relative pressure differential caused by pumping activity being borne by the fixed sealing assemblies. The bearings and back up seals positioned within the sealed bearing chamber
10 operate under relatively low pressure thereby prolonging bearing and seal life.

TITLE OF THE INVENTION:

Method of earth drilling using a sealed Downhole Bearing Assembly, Method of Sealing a Downhole Bearing Assembly and a Downhole Bearing Assembly

5 FIELD OF THE INVENTION

The present invention relates to a method of sealing a downhole bearing assembly and a downhole bearing assembly constructed in accordance with the method.

BACKGROUND OF THE INVENTION

10 Downhole bearing assemblies typically include a tubular housing and an inner mandrel which is telescopically received in the tubular housing. A plurality of bearings are positioned between an exterior surface of the mandrel and an interior surface of the housing; radial bearings to withstand radial loading and thrust bearings to withstand axial loading.

15 Early attempts to seal downhole bearing assemblies to prevent the incursion of corrosive drilling fluids with fixed seals resulted in seal failure. For this reason, a category of downhole bearing assembly developed in which provision is made to deliberately flow drilling fluids through the tool. In theory, this flow through has the beneficial effect of lubricating and cooling the bearings; however, the harmful effects of the drilling fluid
20 unavoidably have an adverse effect upon bearing life.

Some success was later achieved having a sealed bearing chamber within the tool that was pressure balanced. This resulted in the development of a second category of tools, in which pressure in a sealed lubricant filled bearing chamber is always equal to the pressure
25 outside of the bearing chamber. This pressure balancing is, typically, achieved with at least one pressure balancing piston. As hydrostatic pressure increases, the balancing piston shifts to exert a like pressure upon lubricant in the bearing chamber. When surface pumps are activated, the balancing piston shifts to exert a like pressure upon lubricant in the bearing chamber. In theory, seal life is prolonged due to the fact there is equal pressure on either side
30 of the seal, however, experience has shown that eventually seal failure occurs and drilling fluids leak into the bearing chamber.

In order to improve the operation of the downhole bearing assembly with a pressure

balancing piston, efforts were made to develop better seals. One form of seal developed that was particularly durable was a carbide seal. The carbide seal, however, only operated properly when a thin film of lubricant was present between the carbide sealing surfaces. To meet this requirement a third category of downhole bearing assembly was developed. This form of downhole bearing assembly has a reservoir of lubricant and utilizes a piston that has unequal surface areas at opposed ends. The unequal surface areas results in the bearing chamber being placed under greater pressure than the pressure outside of the bearing chamber. This causes lubricant to slowly leak out through the carbide seals, and ensures they are always lubricated. The need of a reservoir, however, requires that the length of the tool be increased at a time when the trend is for shorter tools to facilitate horizontal and directional drilling.

SUMMARY OF THE INVENTION

The present invention relates to an alternative method of sealing a downhole bearing assembly that is based upon an alternative theory as to the cause of seal failure.

According to one aspect of the present invention there is provided a method of earth drilling, comprising the following steps. A first step involves forming an earth drilling assembly which includes a downhole drive mechanism, a drill bit, and a bearing assembly disposed between the downhole drive mechanism and the drill bit. The bearing assembly has a bearing chamber with opposed ends. Bearings are disposed within the bearing chamber. Each of the opposed ends of the bearing chamber are sealed with fixed sealing assemblies of axially aligned seals, including a primary seal and back up seals. The sealing assemblies are capable of withstanding a pressure differential. A second step involves drilling with the earth drilling assembly in a downhole environment in which pressure within the bearing chamber is at hydrostatic pressure with the pressure differential caused by pumping activity being borne by the primary seal of the fixed sealing assemblies. The bearings and back up seals positioned within the sealed bearing chamber operate under relatively low pressure thereby prolonging bearing and seal life.

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The various aspects of the present invention, as will hereinafter be further described, were developed upon the premise that pressure balancing of the bearing chamber was actually

reducing, as opposed to prolonging both bearing life and seal life. Existing sealing methods include a plurality of redundant back up seals. In theory, there is not stress upon those seals until a failure occurred in an adjacent seal, thereby bringing the redundant back up seal into fluid communication with drilling fluid. It was believed, however, that as the pressure in the bearing chamber was increased to match hydrostatic pressure in combination with a pump operating pressure, the redundant sequential back up seals were pressed into sealing engagement with such force, that by the time they were required they were already substantially worn. Similarly, it was believed that operating the bearings under pressure served to accelerate bearing wear. When a downhole bearing assembly was constructed to test this theory, it was discovered that friction was reduced substantially and drilling operations were much more efficient. In fact, friction was reduced to such a great extent that the required pump operating pressure during drilling operations was also reduced. Operating at lower pressures also enabled less expensive seals and bearings to be used without sacrificing performance. Superior operating performance was achieved in a tool that has a much lower cost to build.

According to another aspect of the invention there is provided an earth drilling assembly which includes, in combination, a downhole drive mechanism, a drill bit, and a bearing assembly disposed between the downhole drive mechanism and the drill bit. The bearing assembly has a bearing chamber with opposed ends. Bearings are disposed within the bearing chamber. Each of the opposed ends of the bearing chamber are sealed with fixed sealing assemblies having a sequential array of axially aligned seals. The sealing assemblies are capable of withstanding a pressure differential. Pressure within the bearing chamber during drilling operations is at hydrostatic pressure with the pressure differential caused by pumping activity being borne by the primary seal of the fixed sealing assemblies. The bearings and back up seals positioned within the sealed bearing chamber operate under relatively low pressure thereby prolonging bearing and seal life.

According to another aspect of the present invention there is provided a method of sealing a downhole bearing assembly which includes the following steps. A first step involves providing a tubular outer housing having a first end, a second end, and an interior surface defining a central bore that extends between the first end and the second end. A

second step involves providing an inner mandrel having a first end, a second end and an exterior surface, the second end of the mandrel being telescopically received in the central bore of the outer housing to form a bearing chamber between the interior surface of the housing and the exterior surface of the mandrel. A third step involves providing bearings
5 disposed within the bearing chamber between the exterior surface of the mandrel and the inner surface of the housing to withstand radial and axial loads. A fourth step involves positioning fixed seal assemblies of axially aligned seals positioned around the exterior surface of the mandrel at each of the first end and the second end of the housing. The sealing assemblies are capable of withstanding a pressure differential. Pressure within the bearing
10 chamber during drilling operations is at hydrostatic pressure with the pressure differential caused by pumping activities being borne by the primary seal of the fixed sealing assemblies. The bearings and the back up seals positioned within the sealed bearing chamber operate under relatively low pressure thereby prolonging both bearing and seal life.

15 According to another aspect of the present invention there is provided a Downhole Bearing Assembly which includes a tubular outer housing having a first end, a second end, and an interior surface defining a central bore that extends between the first end and the second end. An inner mandrel is provided having a first end, a second end and an exterior surface. The second end of the mandrel is telescopically received in the central bore of the
20 outer housing to form a bearing chamber between the interior surface of the housing and the exterior surface of the mandrel. Bearings are disposed within the bearing chamber between the exterior surface of the mandrel and the inner surface of the housing to withstand radial and axial loads. Fixed seal assemblies of axially aligned seals are positioned around the exterior surface of the mandrel at each of the first end and the second end of the housing. The sealing
25 assemblies are capable of withstanding a pressure differential. Pressure within the bearing chamber during drilling operations is at hydrostatic pressure with the pressure differential caused by pumping activities being borne by the primary seal of the fixed sealing assemblies. The bearings and the back up seals positioned within the sealed bearing chamber operate under relatively low pressure thereby prolonging both bearing and seal life.

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BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the invention will become more apparent from the following description in which reference is made to the appended drawings, the drawings are for the purpose of illustration only and are not intended to in any way limit the scope of the invention to the particular embodiment or embodiments shown, wherein:

5 **FIGURE 1** is a side elevation view, in section, of an earth drilling assembly constructed in accordance with the teachings of the present invention positioned in a downhole environment.

FIGURE 2 is a side elevation view, in section, of a downhole bearing assembly portion of the earth drilling assembly illustrated in **FIGURE 1**.

10 **FIGURE 3** is an exploded side elevation view, in section, of the downhole bearing assembly illustrated in **FIGURE 2**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

 The preferred embodiment, a downhole bearing assembly generally identified by
15 reference numeral 10, will now be described with reference to **FIGURES 1** through 3.

 Referring to **FIGURE 2**, downhole bearing assembly 10 includes a tubular outer housing 16. Referring to **FIGURES 2** and 3, for ease of assembly housing 16 is comprised of two parts, a bearing housing 12 and a top sub 14. Referring to **FIGURE 2**, bearing housing
20 12 and top sub 14 are matingly connected together by a threaded female connector 13 and a threaded male connector 15. Housing 16 has a first end 18, a second end 20, and an interior surface 22 defining a central bore 24 that extends between first end 18 and second end 20. An inner mandrel 26, drawn out of proportion to all other components in **FIGURE 3**, has a first end 28, a second end 30 and an exterior surface 32. Referring to **FIGURE 2**, second end 30
25 of mandrel 26 is telescopically received in central bore 24 of outer housing 16 to form a bearing chamber 34 between interior surface 22 of housing 16 and exterior surface 32 of mandrel 26. Referring to **FIGURE 2**, bearings 36 are disposed within bearing chamber 34 between exterior surface 32 of mandrel 26 and interior surface 22 of housing 16 to withstand radial and axial loads. Referring to **FIGURE 3**, bearings include bushing sleeves 40 that
30 bear radial loads and thrust bearings 42 that bear axial loads.

 Referring to **FIGURE 2**, fixed sealing assemblies 44 are provided at first end 18 and

second end 20 of housing 16. Sealing assemblies 44 have sequential arrays of axially aligned seals positioned circumferentially around exterior surface 32 of mandrel 26 in sealing contact interior surface 22 of housing 16. Sealing assemblies 44 are capable of withstanding an intended pressure differential of at least 750 pounds per square inch.

5 Referring to **FIGURE 3**, each of sealing assemblies 44 includes a first seal carrier sleeve 46 and a second carrier sleeve 48. Each of first carrier sleeve 46 and second carrier sleeve 48 has circumferential grooves 50 with "O" ring seals 52 positioned in each circumferential groove 50. A first snap ring 54 maintains first seal carrier sleeve 46 and a first polymer sealing ring 56 in a fixed position against a shoulder 58. A second snap ring 60 maintains a second

10 polymer seal ring 62, second seal carrier sleeve 48, and a wiper seal 64 in a fixed position relative to first snap ring 54.

Referring to **FIGURE 1**, downhole bearing assembly 10 forms part of an earth drilling assembly, generally indicated by reference numeral 100. Earth drilling assembly 100

15 includes a downhole drive mechanism 102 and a drill bit 104. Drive mechanism 102 includes a stator 106 and a rotor 108. Downhole bearing assembly 10 is disposed between downhole drive mechanism 102 and drill bit 104. Drill bit 104 detachably coaxially attaches firmly at first end 28 of mandrel 26 of downhole bearing assembly 10. The unique aspect of downhole bearing assembly 10 is the manner in which it is sealed and the advantages that provides

20 when earth drilling as part of earth drilling assembly 100, as will hereinafter be further explained as part of a description of the use and operation of downhole bearing assembly 10.

The use of downhole bearing assembly 10 will now be described with reference to **FIGURES 1 through 3**. Referring to **FIGURE 1**, earth drilling assembly 100 is

25 provided as described above. Earth drilling assembly 100 includes downhole drive mechanism 102, drill bit 104, and downhole bearing assembly 10 disposed between downhole drive mechanism 102 and drill bit 104. When drilling with earth drilling assembly 100 in a downhole environment 110, the pressure within bearing chamber 34 of downhole bearing assembly 10, illustrated in **FIGURE 2**, is at hydrostatic pressure. The relative pressure

30 differential caused by pumping activity is borne by fixed sealing assemblies 44, illustrated in **FIGURE 3**. Bearings 36 and "O" ring seals 52 positioned within sealed bearing chamber 34 as illustrated in **FIGURE 2** operate under relatively low pressure thereby prolonging bearing

and seal life.

When downhole bearing assembly 10 was constructed and used as part of earth drilling assembly 100 to test this theory, it was discovered that friction was reduced substantially and drilling operations were much more efficient. In fact, friction was reduced to such a great extent, the required pump operating pressure during drilling operations was also substantially reduced. Operating at lower pressures also enabled less expensive seals and bearings to be used without sacrificing performance. Superior operating performance was achieved in a tool that had a much lower cost to build.

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It will be apparent to one skilled in the art that modifications may be made to the illustrated embodiment without departing from the spirit and scope of the invention as hereinafter defined in the Claims.

15

**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

- 5 1. A method of earth drilling, comprising the steps of:
forming an earth drilling assembly which includes a
downhole drive mechanism, a drill bit, and a bearing assembly
disposed between the downhole drive mechanism and the drill
bit, the bearing assembly having a bearing chamber with
10 opposed ends, bearings being disposed within the bearing
chamber, each of the opposed ends of the bearing chamber being
sealed with fixed sealing assemblies having a sequential array
of axially aligned seals, the sealing assemblies being capable
of withstanding an intended pressure differential between
15 pressure within the bearing chamber that is lower than
hydrostatic pressure outside the bearing chamber; and
drilling with the earth drilling assembly in a downhole
environment in which the pressure within the bearing chamber
is less than hydrostatic pressure outside the bearing chamber
20 with the intended pressure differential being borne by the
fixed sealing assemblies, such that the bearings and seals
positioned within the sealed bearing chamber operate under the
pressure within the bearing chamber that is lower than the
hydrostatic pressure, thereby prolonging bearing and seal
25 life.

2. An earth drilling assembly, comprising:

a downhole drive mechanism;

a drill bit;

a bearing assembly disposed between the downhole drive
5 mechanism and the drill bit, the bearing assembly having a
bearing chamber with opposed ends, bearings being disposed
within the bearing chamber, each of the opposed ends of the
bearing chamber being sealed with fixed sealing assemblies
having a sequential array of axially aligned seals, the
10 sealing assemblies being capable of withstanding an intended
pressure differential, such that pressure within the bearing
chamber during drilling operations is less than hydrostatic
pressure outside the bearing chamber with the relative
pressure differential being borne by the fixed sealing
15 assemblies, the bearings and seals positioned within the
sealed bearing chamber operating under pressure within the
bearing chamber that is lower than hydrostatic pressure
thereby prolonging bearing and seal life.

3. A method of sealing a downhole bearing assembly, comprising the steps of:

5 providing a tubular outer housing having a first end, a second end, and an interior surface defining a central bore that extends between the first end and the second end;

10 providing an inner mandrel having a first end, a second end and an exterior surface, the second end of the mandrel being telescopically received in the central bore of the outer housing to form a bearing chamber between the interior surface of the housing and the exterior surface of the mandrel;

providing bearings disposed within the bearing chamber between the exterior surface of the mandrel and the inner surface of the housing to withstand radial and axial loads;

15 positioning fixed seal assemblies having a sequential array of axially aligned seals positioned circumferentially around the exterior surface of the mandrel at each of the first end and the second end of the housing, the sealing assemblies being capable of withstanding an intended pressure differential, such that pressure within the bearing chamber during drilling operations is less than hydrostatic pressure outside the bearing chamber with the relative pressure differential being borne by the fixed sealing assemblies, the bearings and the seals positioned within the sealed bearing chamber operating under pressure within the bearing chamber
20 that is less than hydrostatic pressure thereby prolonging both bearing and seal life.

4. A Downhole Bearing Assembly, comprising:

a tubular outer housing having a first end, a second end, and an interior surface defining a central bore that extends between the first end and the second end;

5 an inner mandrel having a first end, a second end and an exterior surface, the second end of the mandrel being telescopically received in the central bore of the outer housing to form a bearing chamber between the interior surface of the housing and the exterior surface of the mandrel;

10 bearings disposed within the bearing chamber between the exterior surface of the mandrel and the inner surface of the housing to withstand radial and axial loads;

fixed seal assemblies having sequential arrays of axially aligned seals positioned circumferentially around the exterior surface of the mandrel at each of the first end and the second end of the housing, the sealing assemblies being capable of withstanding an intended pressure differential, such that pressure within the bearing chamber during drilling operations is less than hydrostatic pressure outside the bearing chamber with the relative pressure differential being borne by the fixed sealing assemblies, the bearings and the seals positioned within the sealed bearing chamber operating under pressure within the bearing chamber that is less than hydrostatic pressure outside the bearing chamber thereby
25 prolonging both bearing and seal life.

5. The downhole bearing assembly as defined in Claim 4, wherein the sealing assemblies are capable of withstanding an intended pressure differential of at least 750 pounds per square inch.
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6. The downhole bearing assembly as defined in Claim 4, wherein at least one bushing sleeve disposed between the exterior surface of the mandrel and the interior surface of the housing to bear radial loads.
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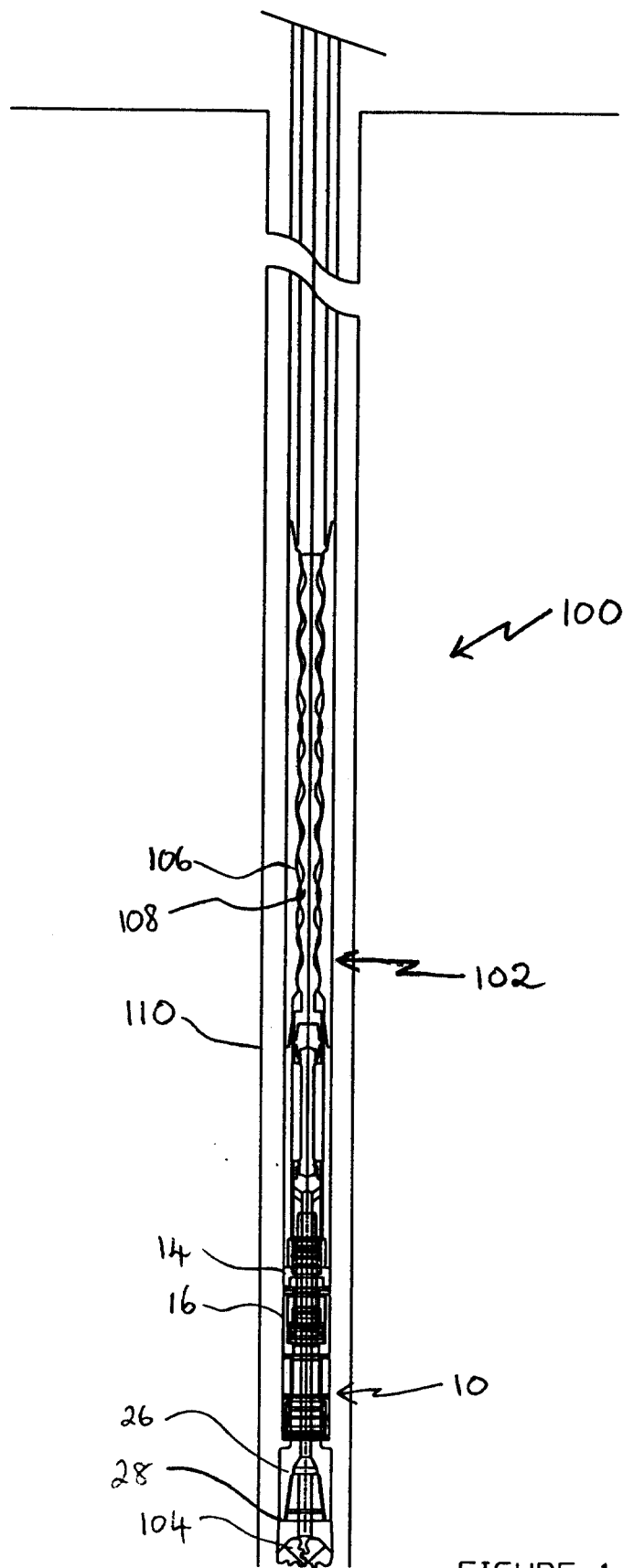


FIGURE 1

