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(54) **TWO-CENTRE ROTARY BORING BIT AND METHOD FOR DEEPENING AN EXISTING WELL**

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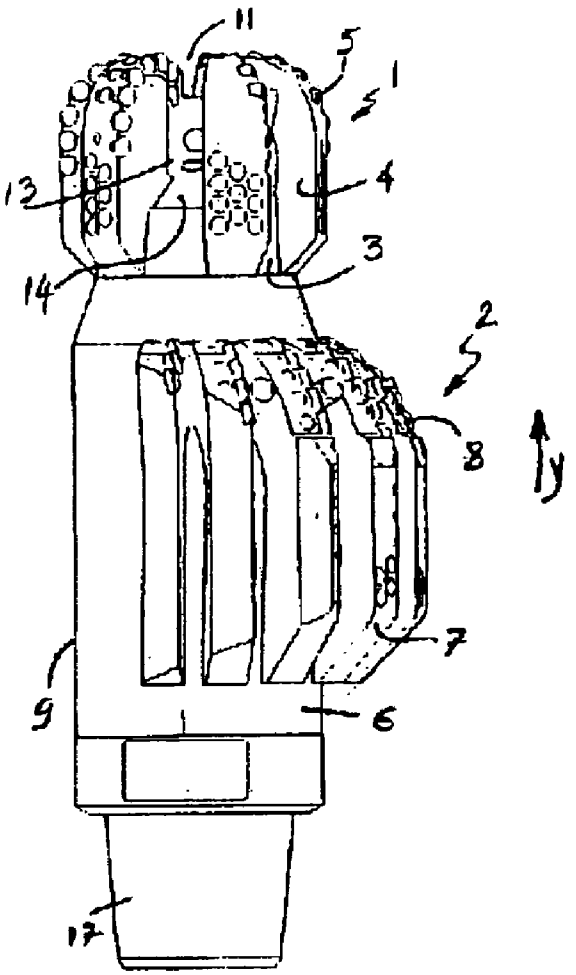
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(57) **ABSTRACT**

Two-centre rotary boring bit for boring wells, comprising, on the one hand, a pilot tool (**1**) comprising a body of revolution with an axial core (**3**) and radial blades (**4**) bearing cutting elements (**5**) and, on the other hand, an enlarging tool (**2**) fitted behind the pilot tool and laterally offset therefrom, the pilot tool having, on its front face, a central region (**11**) that has no cutting elements in order to allow the creation of a core sample (**12**), said central region being in communication with a cavity (**13**) situated between two blades (**4**) of the pilot tool (**1**) and serving to remove the core sample toward the periphery of the boring bit.



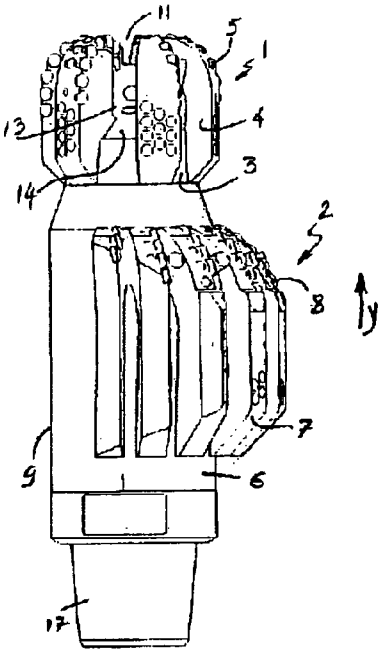


Fig. 1

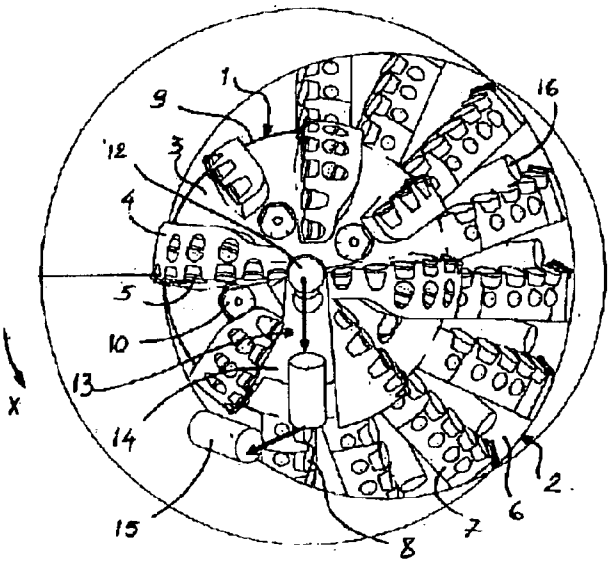


Fig. 2

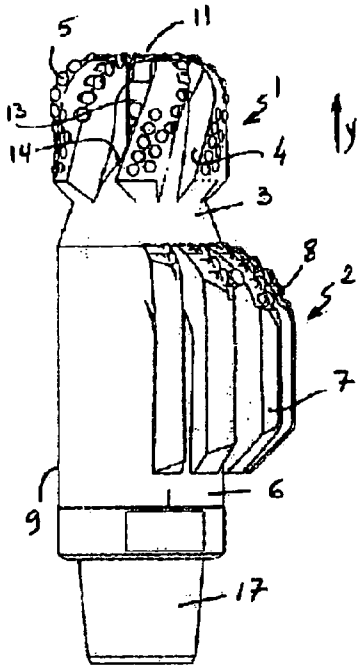


Fig. 3

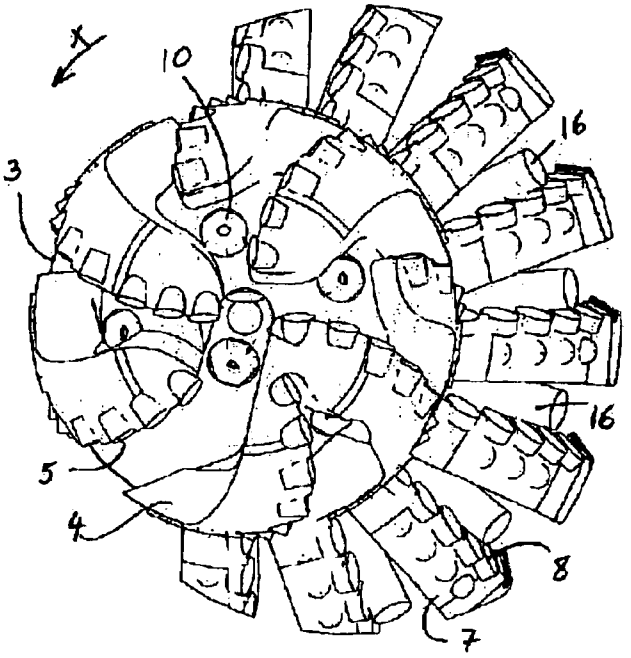


Fig. 4

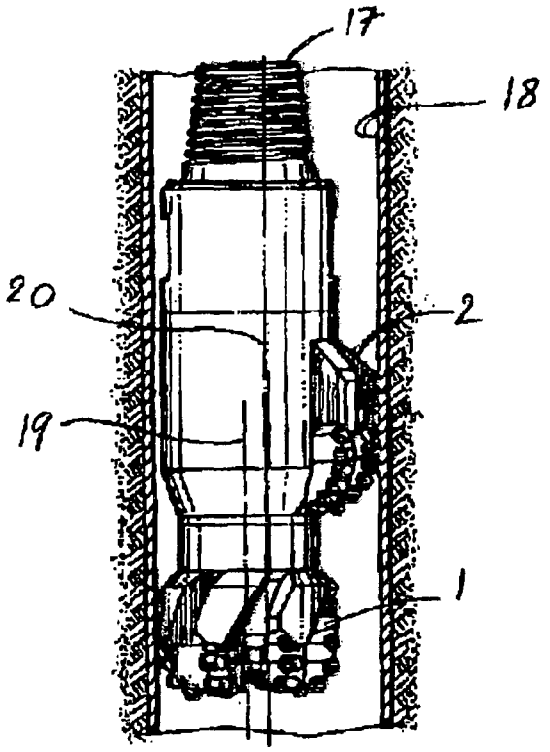


Fig. 5

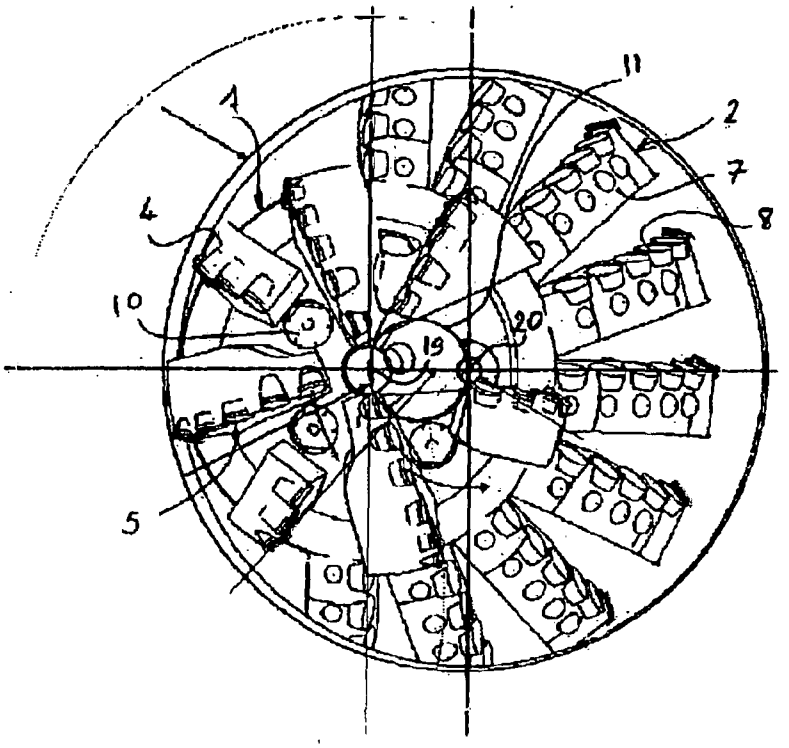


Fig. 6

TWO-CENTRE ROTARY BORING BIT AND METHOD FOR DEEPENING AN EXISTING WELL

FIELD OF THE INVENTION

[0001] The invention relates to rotary boring bits, especially to boring bits intended for the boring of wells in deposits of fluids such as oilfield or gas field.

[0002] The invention relates more particularly to a rotary boring bit of the two-centre type comprising a pilot tool followed by an enlarging tool.

PRIOR ART

[0003] Boring bits are boring tools intended to be fixed to the end of a drill string in order to bore a well to a useful underground deposit, such as an oilfield, a gas field, water reservoir, ore or coal deposit. The drill string is supported by a tower located at the surface. A drilling mud is generally injected inside the drill string in order to exit via the boring bit and rise back up to the surface, through the annular space formed between the drill string and the well in the process of boring. The function of the drilling mud is to cool the boring bit and to remove the debris from boring up to the surface.

[0004] Rotary boring bits of the two-centre type are well known in boring techniques, where they are used for boring wells of large diameter or for deepening while widening existing wells. These known boring bits, disclosed in particular in U.S. Pat. No. 5,678,644 and US 2002/0 104 688 comprise a pilot tool, followed by an enlarging tool, these two tools forming a rigid unitary set. The pilot tool comprises a body of revolution with an axial core, carrying at one end, radial and frontal blades provided with cutting elements and, at the other end, a threaded endfitting for attaching it to the drill string. The enlarging tool is inserted between the pilot tool and the threaded endfitting. It comprises a body provided with cutting elements on only one portion of its periphery, in such a way that it is asymmetrical, its cutting elements acting like a milling cutter in order to widen the well in the process of boring, behind the pilot tool.

[0005] In known two-centre boring bits, described hereinabove, the effect of the asymmetric profile of the enlarging tool is to unbalance the boring bits during the boring. This particularity constitutes a disadvantage of the known two-centre boring bits, by decreasing the quality and precision. It furthermore subjects the boring bit to interfering forces, able to damage it prematurely.

[0006] When these known two-centre boring bits are used to deepen exiting wells, they are usually therein subjected to an epicycloidal movement until they exit the tubing. As soon as the pilot tool of the boring bit exits the tubing, the boring bit resumes the normal boring of the well, with widening. Under the effect of the epicycloidal movement, the cutting elements located in the central portion of the pilot tool are subjected to a movement of precession and rotate in the opposite direction, which is detrimental for these cutting elements when they come into contact with the bottom of the well.

SUMMARY OF THE INVENTION

[0007] The invention aims to overcome the aforementioned disadvantages of the known boring bits described hereinabove.

[0008] The invention aims more particularly to provide a rotary boring bit of the two-centre type, of a new design, able to prevent an unbalancing of the boring bit.

[0009] Another object of the invention consists in providing a boring bit of the two-centre type having an improved effectiveness and which allows a higher boring precision.

[0010] An additional object of the invention is to improve the productivity of the rotary boring bits of the two-centre type, by making higher boring speeds possible.

[0011] The invention also has for object to increase the precision of the geological analysis of the rock formation in the process of boring.

[0012] An additional object of the invention is to provide a two-centre boring bit which is especially adapted for use in an existing well for deepening it, especially for use in a well having a diameter substantially equal to the largest cross-sectional dimension of the enlarging tool of the boring bit.

[0013] Consequently, the invention relates to a two-centre rotary boring bit for boring wells, comprising, on the one hand, a pilot tool comprising a body of revolution with an axial core and radial blades carrying cutting elements and, on the other hand, an enlarging tool located behind the pilot tool and laterally offset relative to the latter; according to the invention, the boring bit is characterised in that the front face of the pilot tool has an axial central region which is devoid of cutting elements for allowing the creation of an axial core sample, said central region being in communication with a cavity located between two blades of the pilot tool and allowing evacuation of the core sample toward the periphery of the boring bit.

DETAILED DESCRIPTION OF THE INVENTION

[0014] In this specification, the terms 'front', 'rear', 'in front of', 'behind', 'anterior' and 'posterior' are defined in relation to the direction of the progression of the boring bit in a well in the process of boring. Due to this definition, the pilot tool is located in front of the enlarging tool and the front face of the pilot tool is the face of the one that is facing the working face.

[0015] In its general design, the boring bit according to the invention is of the type of the one described in U.S. Pat. No. 5,678,644.

[0016] The pilot tool comprises a body of revolution provided with cutting elements. The body of revolution comprises an axial core the rear portion is arranged in order to be attached to a drill string coupled to a motor. The attaching of the core to the drill string is usually carried out by a threaded endfitting arranged on the rear face of the core.

[0017] A plurality of radial blades are approximately uniformly distributed along the periphery of the core and they carry the cutting elements. The material that constitutes the core and blades is not critical for the definition of the invention. It can be steel, tungsten carbide or an abrasive material made of impregnated diamond.

[0018] The cutting elements are not critical for the definition of the invention and can be all cutting elements commonly used in rotary boring bits. They can in particular be PDC cutting elements or infiltrated abrasive elements. PDC (Polycrystalline Diamond Compact) cutting elements are well known in the mine drilling sector. They comprise a polycrystalline diamond pellet on a cemented tungsten carbide substrate and they are usually obtained by compressing a mixed powder of diamond and cobalt on the tungsten carbide substrate. Infiltrated abrasive elements are also well

known in mine drilling techniques and are usually obtained by mixing a powder of diamond (possibly with a powder of metal carbide added, for example tungsten carbide) with a powder of a meltable binder (for example a Cu—Mn solder) and by submitting the mixture created as such to a compacting followed by sintering. Information on this technique is available in US 2002/0125048A1.

[0019] The enlarging tool is laterally offset relative to the pilot tool (transversally to the axis of the pilot tool), such that a portion of its lateral peripheral surface is protruding relative to the peripheral surface of the pilot tool. The peripheral surface of the pilot tool is, by definition, the surface of the latter which is facing the wall of the well in the process of boring. Similarly, the peripheral surface of the enlarging tool is the surface of the latter which is facing the wall of the well in the process of boring. In the boring bit according to the invention, the aforementioned portion protruding from the peripheral surface of the enlarging tool is separated from the axis of rotation of the boring bit by a distance greater than the maximum radius of the pilot tool (the axis of rotation of the boring bit coinciding with the axis of symmetry of the pilot tool). Subsequently, the aforementioned portion of the peripheral surface of the enlarging tool shall be designated as 'widened portion'.

[0020] The enlarging tool is located behind the pilot tool. It carries, on its aforementioned widened portion, cutting elements. The material of the enlarging tool, the profile of the enlarging tool and the cutting elements that are provided on it are not critical for the definition of the invention. It is generally preferred that the enlarging tool comprises a core and radial blades in its widened portion, said blades carrying the cutting elements. In this particular embodiment of the invention, the core and the blades can be made of steel, the cutting elements being PDC cutting elements.

[0021] The enlarging tool and the pilot tool form a stiff composite assembly, substantially undeformable. These two tools can include a single tool body, carrying the cutting elements. Alternatively, they can be formed of the undeformable assembly of two separate tool bodies (one body for the pilot tool and one body for the enlarging tool).

[0022] It is preferred, according to the invention, that the core and the blades of the pilot tool and of the enlarging tool be made of steel and that their respective cutting elements be PDC cutting elements. Alternatively, a portion of the PDC cutting elements can be replaced with abrasive elements made of infiltrated diamonds. In a modified embodiment, the pilot tool and at least the widened portion of the enlarging tool can be made of metal-infiltrated carbide, as it is well known in the technique of oil boring tools.

[0023] In the boring bit according to the invention, the blades of the pilot tool extend on the lateral face of the tool body.

[0024] According to a first characteristic of the invention, the blades of the pilot tool are extended on the front face of the latter, while still leaving therein an axial central region, devoid of blades and of cutting elements. This allows the creation of an axial core sample during the boring.

[0025] According to a second characteristic of the invention, said axial central region of the pilot tool is in communication with a cavity located between two blades of the pilot tool. The function of the cavity is to ensure the evacuation of the core sample toward the periphery of the boring bit, then in the annular region delimited behind the boring bit, between the drill string and the wall of the well in the process of boring. For this purpose, said cavity is delimited by two lateral surfaces and a clearance surface located in the back relative to the front face of the tool. These two lateral surfaces can, advantageously, be two successive blades of the pilot tool.

[0026] Additional information relating to the two characteristics of the invention defined hereinabove is available in WO 2008/149240 (TOTAL S.A.).

[0027] It is desirable, according to a particular embodiment of the invention, that the pilot tool comprise a device for breaking the core sample. The function of this device for breaking is to break the core sample at regular intervals in such a way as to obtain fragments as regular as possible. In this embodiment of the invention, the device for breaking can for example include an abrasion-resistant pellet, fitted in the aforementioned cavity of the pilot tool. This pellet can for example be a PDC cutting element or a pellet made of an infiltrated abrasive element.

[0028] In the boring bit according to the invention, the core sample stabilises the boring bit, by exerting a counter reaction to the lateral forces resulting from the dissymmetry of the enlarging tool. The core sample as such opposes a lateral deviation of the pilot tool. The diameter of the aforementioned central region of the pilot tool conditions the diameter of the core sample. It is to be calculated for the base of the core sample resists to the lateral forces generated by the enlarging tool during normal use of the boring bit and prevents a lateral displacement of the pilot tool. Selecting this diameter will depend on diverse parameters, among which are in particular the dimensions of the boring bit, the type of cutting elements that it is provided with and the geological nature of the rock in which the well is bored (non-exhaustive list of examples). It must be determined in each particular case by those skilled in the art.

[0029] In an advantageous embodiment of the boring bit according to the invention, a portion of the peripheral surface of the enlarging tool is radially set back relative to the peripheral surface of the pilot tool; in this embodiment, the cavity of the pilot tool for evacuating the core sample ends up at this set back portion of the enlarging tool. This embodiment facilitates the evacuation of the debris of the core sample and their transfer behind the boring bit.

[0030] In another advantageous embodiment of the invention, the blades of the pilot tool are spiralled. This embodiment of the invention facilitates the evacuation of debris from the core sample. In a preferred alternative to this embodiment of the invention, the enlarging tool comprises blades, which are spiralled and located in the prolongation of the blades of the pilot tool. This alternative of the invention improves the evacuation of debris from the core sample behind the boring bit.

[0031] In an additional embodiment of the invention, the boring bit further comprises, in a well-known manner in known boring bits, channels for supplying drilling mud. These channels ends up through the front face of the pilot tool, between its blades and they communicate with an axial channel exiting into an internal duct of the drill string.

[0032] Compared with known two-centre boring bits, the two-centre boring bit according to the invention has better stability, greater effectiveness and productivity and greater precision in a boring operation. The evacuation of debris from the core sample moreover allows a more precise a mineralogical analysis of the geological layers that the well passes through.

[0033] The boring bit according to the invention draws a substantial advantage from the fact that it combines an enlarging tool and a region for creating a core sample. By allowing the boring of wells with large diameters, the enlarging tool makes possible at the same time to create core samples of large diameter, which has the advantageous consequence of allowing higher boring speeds and a better geological analysis of the rock.

[0034] The boring bit according to the invention has applications for the boring of all types of wells for diverse applications. It is especially suited for boring artesian wells or deep wells in deposits of coal, ore, oilfield or gas field.

[0035] The boring bit according to the invention has an especially advantageous application for deepening existing wells and in particular for boring in plugs of mortar at the bottom of the latter. In this application of the invention, a boring bit is selected and is introduced substantially exactly in the existing well (usually tubed). The overall diameter of the enlarging tool of the boring bit is substantially equal to the diameter of the well. In an advantageous embodiment of the invention, especially suited to this application, the diameter of the aforementioned central region of the pilot tool is at least equal to the difference between the overall diameter of the enlarging tool and the diameter of the pilot tool. The overall diameter of the enlarging tool is, by definition, its largest cross-section dimension at the axis of rotation of the pilot tool. When a boring bit according to this embodiment of the invention is used to deepen an existing well, none of its cutting elements is submitted to a movement of precession. In this embodiment of the invention, around said central region, a sufficient crown of cutting elements needs to be left for allowing to bore through the bottom of the well.

[0036] The invention then also relates to a method for deepening existing wells implementing a two-centre boring bit in accordance with the invention. The invention especially relates to such a method wherein the radius of the central region of the pilot tool of the boring bit is at least equal to the difference between the radius of the well and the radius of the pilot tool.

BRIEF DESCRIPTION OF THE FIGURES

[0037] Particularities and details of the invention shall appear in the following description of the annexed figures, which show a few particular embodiments of the invention.

[0038] FIG. **1** is an elevational view of an embodiment of the boring bit according to the invention;

[0039] FIG. **2** is a front view of the boring bit of FIG. **1**;

[0040] FIG. **3** is an elevational view of another embodiment of the boring bit according to the invention;

[0041] FIG. **4** is a front view of the boring bit of FIG. **3**;

[0042] FIG. **5** shows a two-centre boring bit in a well that is being deepened; and

[0043] FIG. **6** is a front view of a particular embodiment of the boring bit according to the invention.

[0044] In these figures, the same reference notations designate identical elements.

DETAILED DESCRIPTION OF PARTICULAR EMBODIMENTS

[0045] The boring bit, shown in FIGS. **1** and **2**, associates over a unitary body, a pilot tool **1** and a finishing tool **2**.

[0046] The pilot tool **1** is of revolution. It comprises an axial core **3** made of steel and radial blades **4** made of steel. The radial blades **4** carry cutting elements **5** at their periphery. The cutting elements **5** are advantageously PDC cutting elements.

[0047] The enlarging tool **2** comprises a core **6** made of steel, extending the core **3** of the pilot tool **1**. The core **6** carries radial blades **7** made of steel on a portion of its periphery, with the remaining portion **9** of its periphery being in the extension of the core **3** of the pilot tool **1**. The radial blades **7** bear cutting elements **8** made of PDC.

[0048] The blades **7** of the enlarging tool are laterally offset relative to the pilot tool **1**, in such a way that their cutting elements **8** are protruding in relation to the peripheral surface of the pilot tool **1**. The portion **9** of the enlarging tool **2** is set back relative to the periphery of the pilot tool **1**.

[0049] The core **6** is extended by a threaded endfitting **17** in order to attach it to the drill string, not shown.

[0050] Channels **10**, serving for the supply of drilling mud, exit through the front face of the pilot tool **1**. Similarly, channels **16** for supplying drilling mud exit between the blades (**7**) of the enlarging tool **2**.

[0051] In accordance with the invention, the blades **4** of the pilot tool are interrupted in the anterior central region **11** of this tool. This central region **11** is centred on the axis of the boring bit (coinciding with the axis of the pilot tool), in such a way that, during the boring of the well, a cylindrical rock core sample **12** is formed.

[0052] The pilot tool **1** further comprises a cavity **13** for the evacuation of the core sample **12**. This cavity **13** is delimited between two blades **4** and an inclined clearance surface **14**, that ends up in front of the portion **9** of the core **6** of the enlarging tool **2**.

[0053] In order to dig a well by means of the boring bit of FIGS. **1** and **2**, the boring bit is set into rotation in the direction of the arrow X (FIG. **2**) and it is displaced axially in the direction of the arrow Y (FIG. **1**) through a rock formation. As it goes deeper into the rock, the pilot tool **1** digs the well that the enlarging tool then widens. The core sample **12** which is formed in the anterior central region **11** of the pilot tool **1** maintains the boring bit unit in the axis of the well being dug, despite the lateral forces generated by the enlarging tool **2**. As the boring bit progresses in the rock formation, the core sample **12** is deviated laterally over the clearance surface **14** of the cavity **13** wherein it the core sample gets broken and its debris **15** are evacuated toward the mouth of the well by the drilling fluid. In an alternative of the invention, an abrasion-resistant pellet (not shown) is placed in the cavity **13**, for breaking the core sample **12** as it is created. This pellet can for example be a PDC pellet.

[0054] In the boring bit of FIGS. **3** and **4**, the blades **4** of the pilot tool **1** are spiralled. The radial blades **7** of the enlarging tool **2** are straight. Alternatively, they could be spiralled in the same direction as the blades **4** of the pilot tool **1**.

[0055] In FIG. **5**, an existing well is diagrammatically shown, wherein a two-centre boring bit has been introduced, for the purpose of extending said well. The well, shown as an axial cross-section, is tubed with a metal tube **18**. The boring bit is sized and positioned in such a way that the overall diameter of its enlarging tool **2** is substantially equal to the diameter of the well. The boring bit being positioned as such in the well, its axis **19** (axis of symmetry of the pilot tool and of the threaded endfitting **17**) is offset relative to the axis **20** of the well. During the deepening of the well, the boring bit is submitted to an epicycloidal movement. According to the invention, the central region **11** of the pilot tool is delimited by a circle which is centred on the axis **19** and of which the radius

is equal to the distance separating the two axes **19** and **20**. Its radius is substantially equal to the difference between the radius of the well **18** and the radius of the pilot tool **1**.

[0056] FIG. **6** shows the circular central region **11** of the boring bit of FIG. **5**. This central region **11** is delimited between the axis **19** of the boring bit and the axis **20** of the well **18**.

1. Two-centre rotary boring bit for boring wells, comprising, a pilot tool comprising a body of revolution with an axial core and radial blades carrying cutting elements and, an enlarging tool located behind the pilot tool and laterally offset relative to the pilot tool, wherein the front face of the pilot tool (**1**) has an axial central region (**11**) which is devoid of cutting elements (**5**) for allowing the creation of an axial core sample (**12**), said central region being in communication with a cavity (**13**) located between two blades (**4**) of the pilot tool and serving to evacuate the core sample toward the periphery of the boring bit.

2. Boring bit according to claim **1**, wherein the cavity (**13**) is delimited by two blades (**4**) of the pilot tool (**1**) and a clearance surface (**14**) set back relative to the front face of said pilot tool.

3. Boring bit according to claim **1**, wherein the enlarging tool (**2**) is offset relative to the pilot tool (**1**), in such a way that a portion (**9**) of its peripheral surface is radially set back relative to the peripheral surface of the pilot tool and in that the cavity (**13**) of the pilot tool (**1**) ends up in said portion (**9**) of the peripheral surface of the enlarging tool.

4. Boring bit according to claim **1** wherein the enlarging tool (**2**) comprises a core (**6**) with radial blades (**7**) carrying cutting elements (**8**) and in that the cavity (**13**) exits between two blades (**7**) of the enlarging tool.

5. Boring bit according to claim **1** wherein the blades (**4**) of the pilot tool (**1**) are spiralled.

6. Boring bit according to claim **5**, wherein the blades (**7**) of the enlarging tools (**1**) are spiralled and located in the prolongation of the blades of the pilot tool.

7. Boring bit according to claim **1** wherein the pilot tool (**1**) further comprises a device for breaking the core sample (**12**).

8. Boring bit according to claim **7**, wherein the device for breaking comprises an abrasion-resistant pellet, located in the central region (**11**) of the pilot tool (**1**).

9. Boring bit according to claim **1** wherein the diameter of the central region (**11**) of the pilot tool (**1**) is adjusted so that the core sample (**12**) resists the lateral forces generated by the enlarging tool (**2**) during use of the boring bit.

10. Boring bit according to claim **1** wherein the diameter of the central region (**11**) of the pilot tool (**1**) is at least equal to the difference between the overall diameter of the enlarging tool (**2**) and the diameter of the pilot tool (**1**).

11. Boring bit according to claim **1** further comprising channels (**10**) for supplying drilling mud, which ends up through the front face of the pilot tool (**1**).

12. Boring bit according to claim **11**, wherein channels (**16**) for supplying drilling mud exit between the blades (**7**) of the enlarging tool **2**.

13. Boring bit according to claim **1** wherein the cores (**3**, **6**) and the blades (**4**, **7**) are made of steel and the cutting elements (**5**, **8**) comprise elements made of PDC.

14. (canceled)

15. Method for deepening existing wells, comprising the step of implementing a two-centre boring bit in accordance with claim **1**.

16. Method according to claim **15**, wherein the radius of the central region (**11**) of the pilot tool (**1**) of the boring bit is at least equal to the difference between the radius of the well (**18**) and the radius of the pilot tool (**1**).

* * * * *