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(54) **DRILL PIPE**

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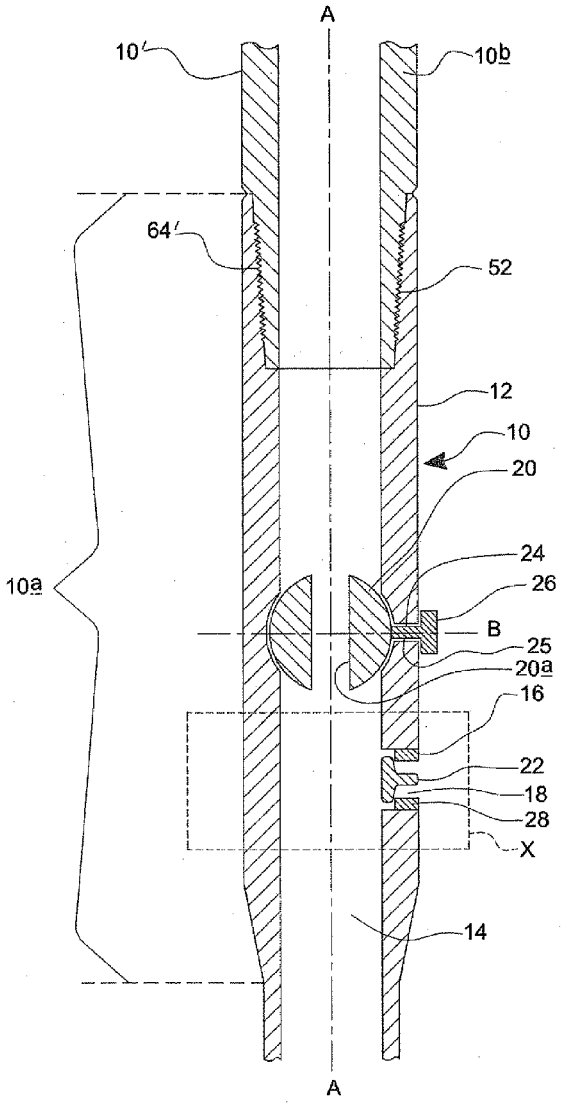
(57) **ABSTRACT**

A drill pipe (**10**) having an elongate tubular body (**12**) with an interior surface enclosing a main bore (**14**) which extends generally parallel to a longitudinal axis (A) of the tubular body (**12**) from a first end to a second end of the tubular body (**12**), a side port (**16**) provided in an exterior surface of the tubular body (**12**), a side bore (**18**) extending through the body (**12**) from the main bore (**14**) to the side port (**16**), and a valve assembly (**20**, **22**) which is operable to substantially prevent flow of fluid along the main bore (**14**) and to substantially prevent flow of fluid along the side bore (**18**), wherein the valve assembly (**20**, **22**), side port (**16**) and side bore (**18**) are provided in a first connection portion (**10***a*) of the drill pipe (**10**) at the first end thereof, the first connection portion (**10***a*) comprising a thickened portion of the tubular body (**12**) in which the separation of the interior surface and the exterior surface is substantially greater than the adjacent portion of the tubular body (**12**), the length of the connection portion (**10***a*) parallel to the longitudinal axis (A) of the tubular body (**12**) being less than 64 cm.



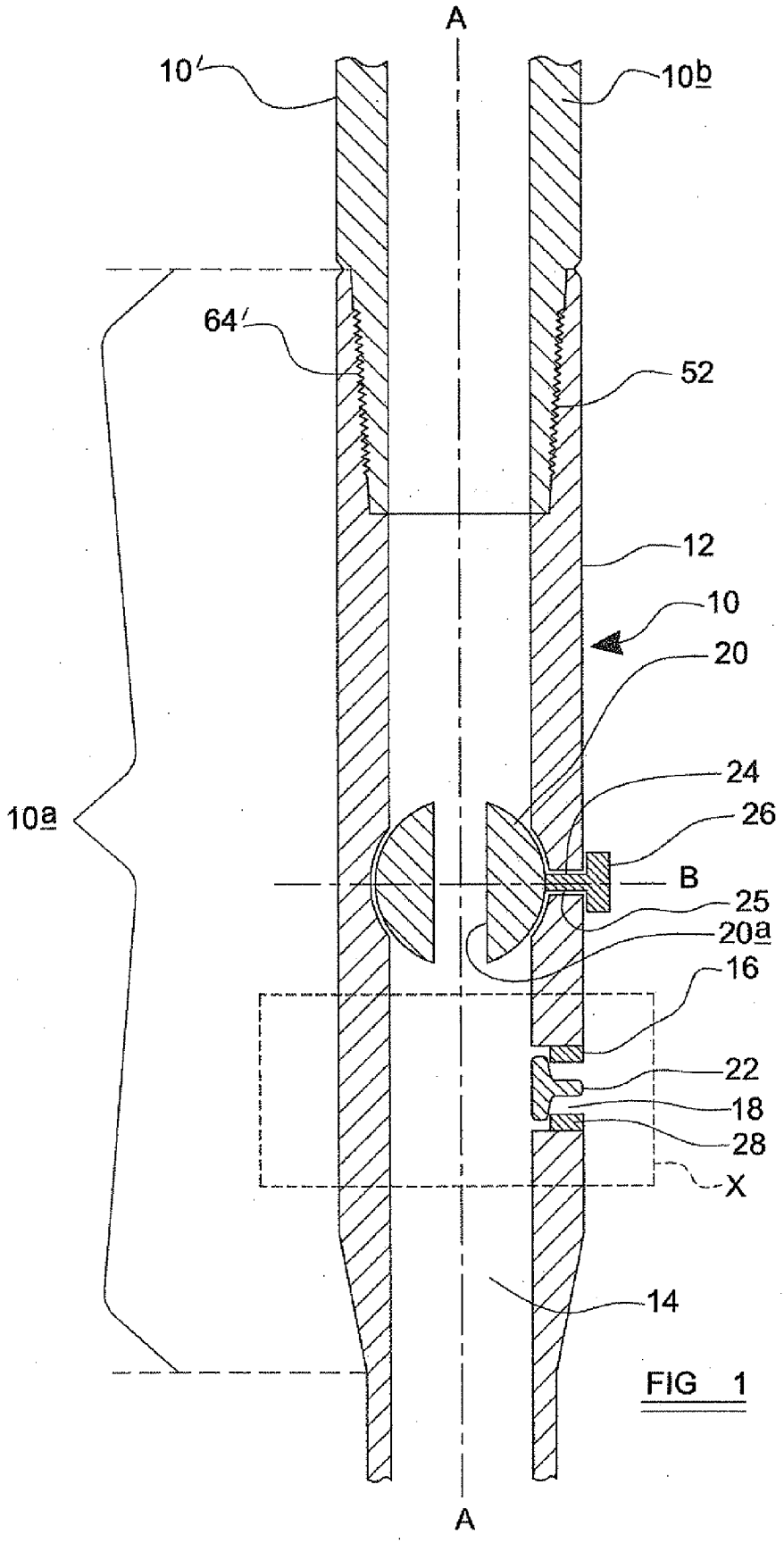


FIG 1

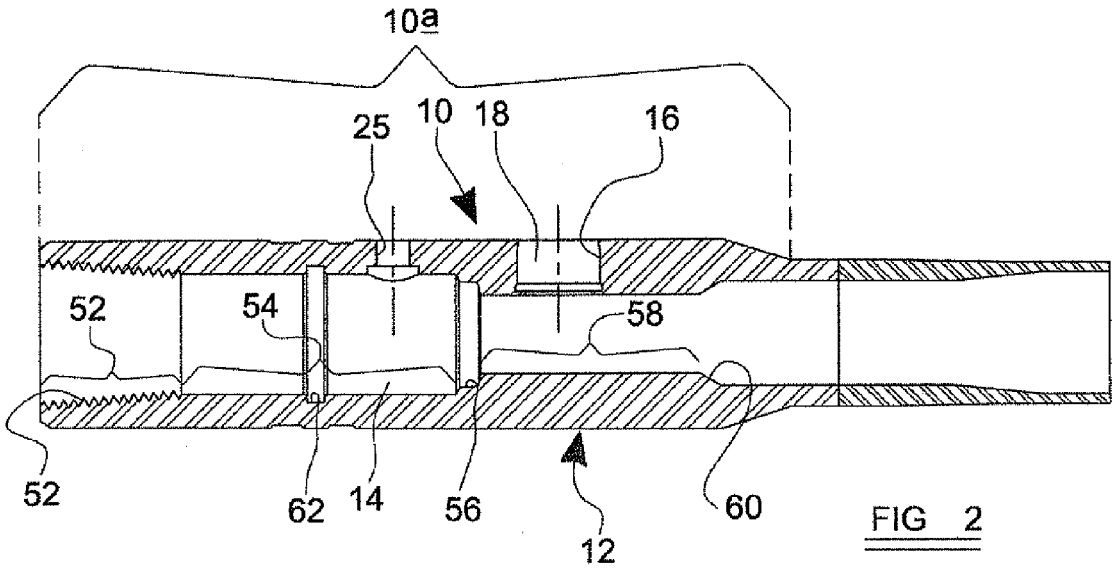


FIG 2

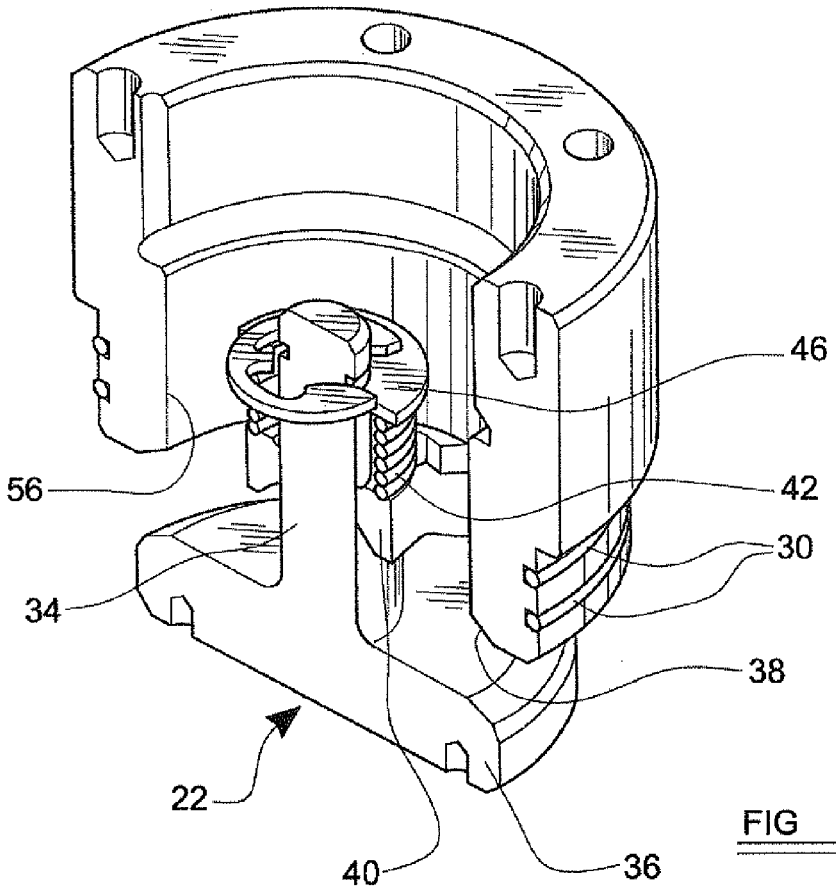


FIG 3

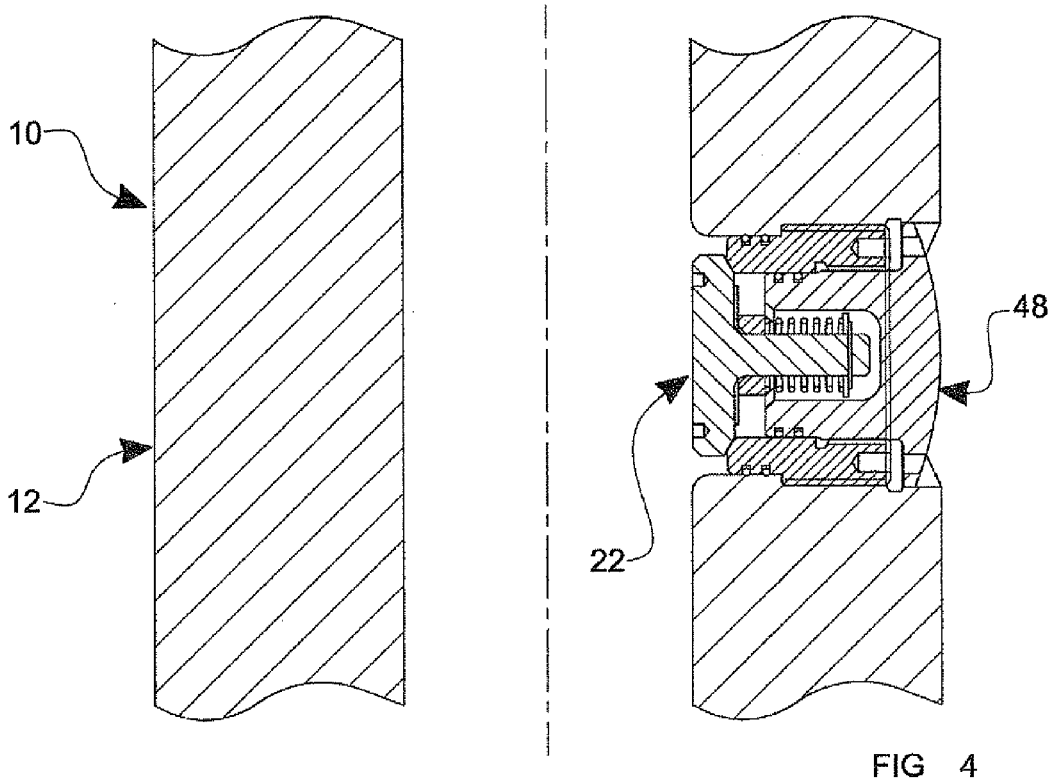
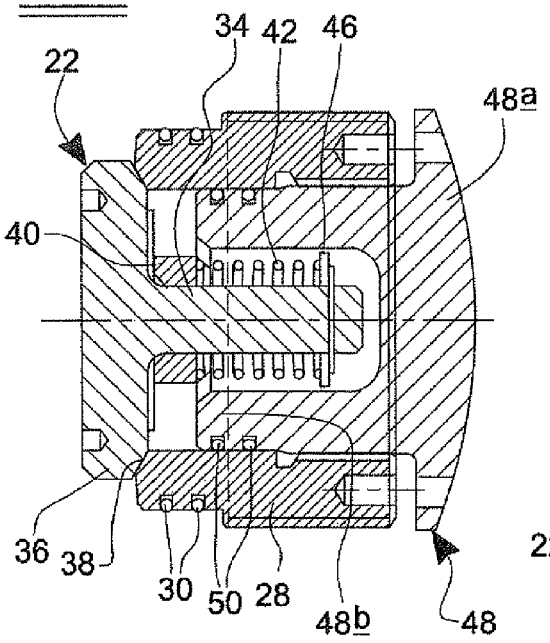


FIG 4

FIG 5



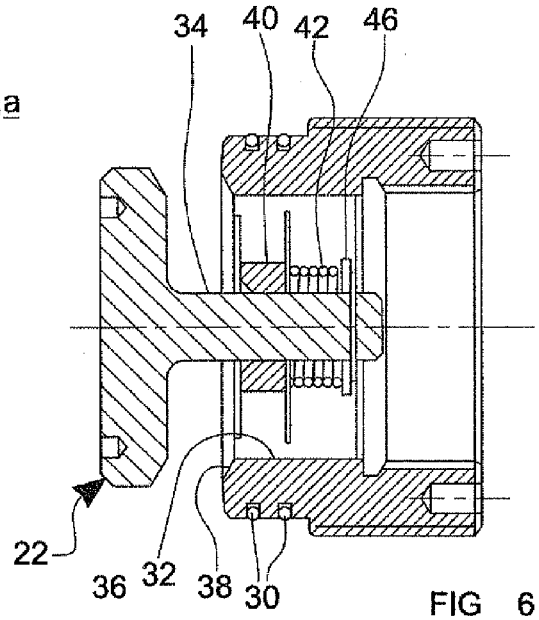


FIG 6

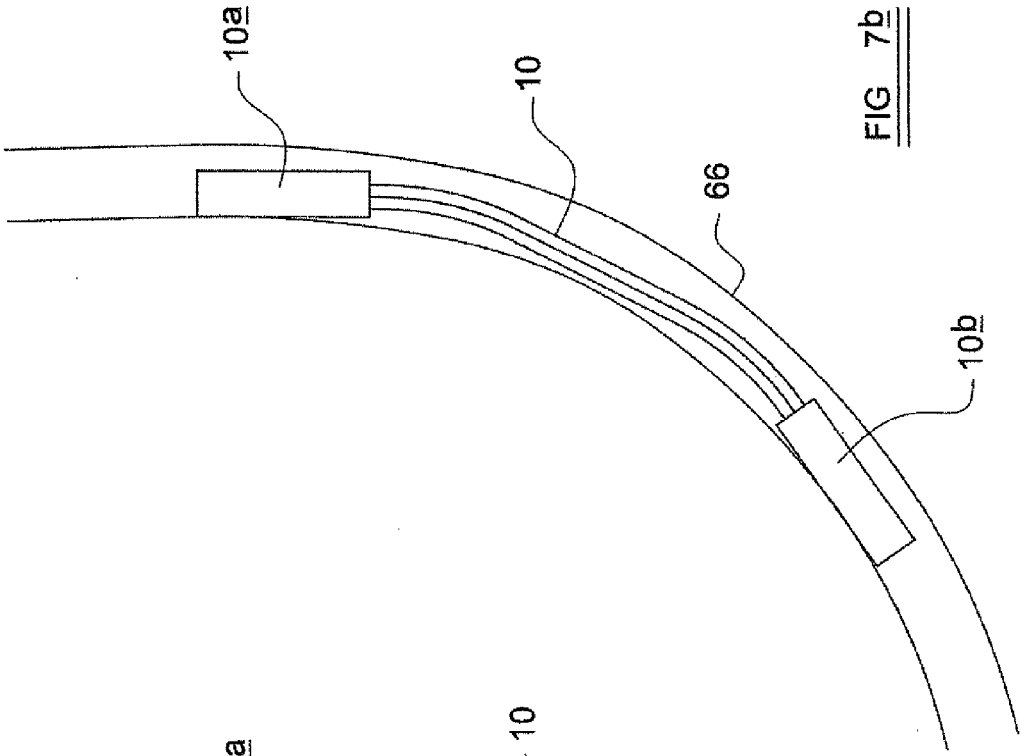


FIG 7b

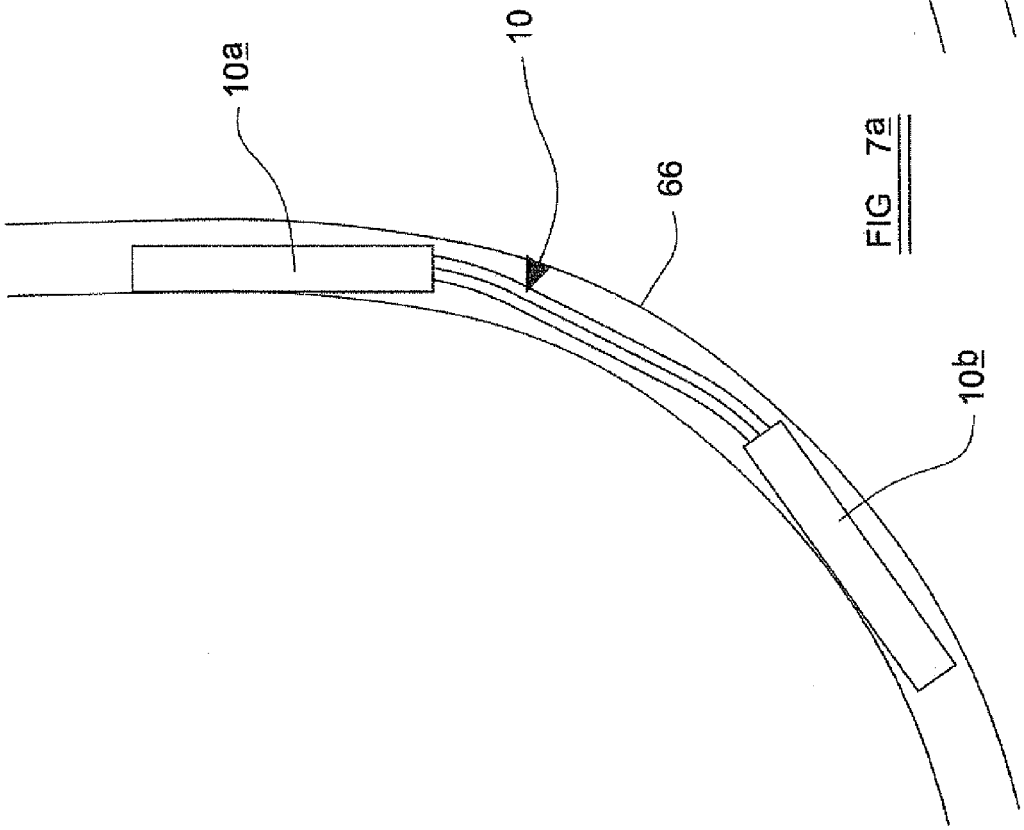


FIG 7a

DRILL PIPE

FIELD OF THE INVENTION

[0001] The present invention relates to a drill pipe, particularly, but not exclusively to a drill pipe for use in drilling an oil or gas well.

DESCRIPTION OF RELATED ART

[0002] The drilling of a borehole or well is typically carried out using a steel pipe known as a drill pipe or drill string with a drill bit on the lowermost end. The drill string comprises a series of tubular sections, which are connected end to end.

[0003] The entire drill pipe may be rotated using a rotary table, or using an over-ground drilling motor mounted on top of the drill pipe, typically known as a 'top-drive', or the drill bit may be rotated independently of the drill pipe using a fluid powered motor or motors mounted in the drill string just above the drill bit. As drilling progresses, a flow of mud is used to carry the debris created by the drilling process out of the borehole. Mud is pumped down the drill pipe to pass through the drill bit, and returns to the surface via the annular space between the outer diameter of the drill pipe and the borehole (generally referred to as the annulus). The mud flow also serves to cool the drill bit, and to pressurise the borehole, thus substantially preventing inflow of fluids from formations penetrated by the drill pipe from entering into the borehole. Mud is a very broad drilling term and in this context it is used to describe any fluid or fluid mixture used during drilling and covers a broad spectrum from air, nitrogen, misted fluids in air or nitrogen, foamed fluids with air or nitrogen, aerated or nitrified fluids to heavily weighted mixtures of oil and or water with solid particles.

[0004] Significant pressure is required to drive the mud along this flow path, and to achieve this, the mud is typically pumped into the drill pipe using one or more positive displacement pumps which are connected to the top of the drill pipe via a pipe and manifold.

[0005] Whilst the main mud flow into the well bore is achieved by pumping mud into the main bore at the very top end of the drill pipe, it is also known to provide the drill pipe with a side bore which extends into the main bore from a port provided in the side of the drill pipe, so that mud can be pumped into the main bore at an alternative location to the top of the drill pipe.

[0006] For example, as drilling progresses, and the bore hole becomes deeper and deeper, it is necessary to increase the length of the drill pipe, and this is typically achieved by disengaging the top drive from the top of the drill pipe, adding a new section of tubing to the drill pipe, engaging the top drive with the free end of the new tubing section, and then recommencing drilling.

[0007] To facilitate the connection of the new length of tubing to the top of the drill pipe, each end of each section of drill pipe is provided with what is known as a "tool joint" which comprises a portion of the drill pipe with a greater wall thickness than the central portion of the drill pipe. The increased wall thickness is achieved by providing a taper which increases the outer diameter of the drill pipe, whilst the internal diameter of the drill pipe is substantially constant along the entire length of the drill pipe including the tool joint. The tool joint at one end of each length of drill pipe is typically provided with a male threaded connector portion, whilst the tool joint at the other end is provided with a female threaded connector portion. Two adjacent sections of drill pipe may therefore be joined by screwing the male connector portion of one into the female connector portion of the other. Such a tool joint is illustrated in U.S. Pat. No. 6,244,631, for example.

[0008] It will, therefore, be appreciated that pumping of mud down the drill pipe ceases during this process. Stopping mud flow in the middle of the drilling process is problematic for a number of reasons, and it has been proposed to facilitate continuous pumping of mud through the drill string by the provision of a side bore in each section of drill string. This means that mud can be pumped into the drill string via the side bore whilst the top of the drill string is closed, the top drive disconnected and the new section of drill string being connected.

[0009] In one such system, disclosed in U.S. Pat. No. 3,298,385, at the top of each section of drill string, there is provided a side bore which is closed using a plug, and a valve member which is pivotable between a first position in which the side bore is closed whilst the main bore of the drill string is open, and a second position in which the side bore is open whilst the main bore is closed. During drilling, the valve is retained in the first position, but when it is time to increase the length of the drill string, the plug is removed from the side bore, and a hose, which extends from the pump, connected to the side bore, and a valve in the hose opened so that pumping of mud into the drill string via the side bore commences. A valve in the main hose from the pump to the top of the drill string is then closed, and the pressure of the mud at the side bore causes the valve member to move from the first position to the second position, and hence to close the main bore of the drill string.

[0010] The main hose is then disconnected, the new section of tubing mounted on the drill string, and the main hose connected to the top of the new section. The valve in the main hose is opened so that pumping of mud into the top of the drill string is recommenced, and the valve in the hose to the side bore closed. The resulting pressure of mud entering the top of the drill string causes the valve member to return to its first position, which allows the hose to be removed from the side bore, without substantial leakage of mud from the drill string. The side bore may then be sealed permanently, for example by welding a plug onto the side bore, before this section of drill string is lowered into the well.

SUMMARY OF THE INVENTION

[0011] According to a first aspect of the invention we provide a drill pipe having an elongate tubular body with an interior surface enclosing a main bore which extends generally parallel to a longitudinal axis of the tubular body from a first end to a second end of the tubular body, a side port provided in an exterior surface of the tubular body, a side bore extending through the body from the main bore to the side port, and a valve assembly which is operable to substantially prevent flow of fluid along the main bore and to substantially prevent flow of fluid along the side bore, wherein the valve assembly, side port and side bore are provided in a first connection portion of the drill pipe at the first end thereof, the first connection portion comprising a thickened portion of the tubular body in which the separation of the interior surface and the exterior surface is substantially greater than the adjacent portion of the tubular body, the length of the connection portion parallel to the longitudinal axis of the tubular body being less than 64 cm.

[0012] Well bore are not always completely straight, and in directional drilling it is common to drill curved sections of well bore. To achieve this, it is necessary for the drill pipe to be sufficiently flexible to allow it to bend around the curved sections of well bore as drilling progresses. By incorporating the valve assembly required for continuous mud circulation into the tool joint, and by minimising the length of the tool joint, the stresses experienced by the drill pipe when it is bent around a curved section of well bore can be more evenly distributed along the length of the drill pipe, and the maximum stress experienced can be reduced. This may assist in improving the fatigue resistance of the drill pipe.

[0013] Preferably the valve assembly includes a first valve member which is movable between an open position, in which flow of fluid along the main bore is permitted, and a closed position, in which flow of fluid along the main bore is substantially prevented, and a second, separate, valve member which is movable between an open position, in which flow of fluid along the side bore is permitted, and a closed position, in which flow of fluid along the side bore is substantially prevented.

[0014] The first valve member may comprise a ball which is rotatable between the open position and the closed position.

[0015] The second valve member may be mounted at least predominantly within the side bore, and may be slidable in the side bore between the open position and the closed position.

[0016] Preferably the first connection portion is provided with a first threaded portion.

[0017] Preferably there is a second connection portion at the second end of the tubular body, the second connection portion also comprising a thickened portion of the tubular body in which the separation of the interior surface and the exterior surface is substantially greater than the adjacent portion of the tubular body. In this case, preferably the second connection portion is provided with a second threaded portion which is a mate for the first threaded portion. This means that the drill pipe can be connected to another identical drill pipe by mating of the first threaded portion of one drill pipe with the second threaded portion of the other drill pipe. The first threaded portion may be provided in the interior surface of the drill pipe, i.e. the first connection portion may be the female connector, and the second threaded portion may be provided in the exterior surface of the drill pipe, i.e. the second connection portion is the male connector.

[0018] An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, of which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. **1** shows a schematic illustration of a cross-section through end portions of two interconnected drill pipes according to the invention,

[0020] FIG. **2** shows a cross-section through an end portion of a drill pipe according to the invention, the valve assembly having been omitted from the drawing for clarity,

[0021] FIG. **3** shows a perspective view of a section through part of the valve assembly of the drill pipe illustrated in FIG. **1**,

[0022] FIG. **4** shows a cross-section through the portion of the drill pipe labelled X in FIG. **1**,

[0023] FIG. **5** is a detailed cross-section through the part of the valve assembly illustrated in FIG. **4**,

[0024] FIG. **6** is a detailed cross-section through the part of the valve assembly shown in FIG. **5** without the cap, and

[0025] FIGS. **7***a* and **7***b* are schematic illustrations of two different configurations of drill pipe in a curved section of well bore.

DETAILED DESCRIPTION OF THE INVENTION

[0026] Referring now to FIG. **1**, there is shown a section of drill pipe **10**, having a tubular body **12** through which is provided a main bore **14** which extends generally parallel to a longitudinal axis A of the tubular body from a first end to a second end of the tubular body **12**. As is typical for drill pipes, in this example, the exterior surface of the tubular body **12** is generally circular in transverse cross-section, and the main bore **14** is cylindrical and extends axially through the tubular body **14** from a first end **12***a* to a second end of the tubular body **12**. A side port **16** is provided in the exterior surface of the tubular body **12**, and a side bore **18** extends through the tubular body **12** from the main bore **14** to the side port **16**, in this example, generally perpendicular to the main bore **14**.

[0027] The drill pipe **10** is provided with a valve assembly which is operable to substantially prevent flow of fluid along the main bore **14** and to substantially prevent flow of fluid along the side bore **18**. In this example, the valve assembly comprises two separate valve members—a first valve member **20** which is movable between an open position, in which flow of fluid along the main bore **14** is permitted, and a closed position, in which flow of fluid along the main bore **14** is substantially prevented, and a second valve member **22** which is movable between an open position, in which flow of fluid along the side bore **18** is permitted, and a closed position, in which flow of fluid along the side bore **18** is substantially prevented.

[0028] In this example, the first valve member **20** is a conventional Kelly valve which comprises a ball which is rotatable about an axis B generally perpendicular to the longitudinal axis A by means of a pin **24** which extends from the main bore **14** through a further bore **25** to the exterior surface of the tubular body **12**. The pin **24** has a head **26** which is shaped to be engagable with a tool such as a spanner or Allan key, and the tool used to rotate the ball between the open position and the closed position. The ball is provided with a central bore **20***a* which lies parallel to the longitudinal axis A of the tubular body **12** when the valve member **20** is in the open position, and which lies generally perpendicular to the longitudinal axis A when the valve member **20** is in the closed position. It will be appreciated that the valve member **20** is shown in the open position in FIG. **1**, and that flow of fluid along the main bore **14** of the drill pipe **10** can occur via the central bore in the ball **20** when in this position. In contrast, as the ball is rotated about axis B, the ball blocks flow of fluid along the main bore **14**.

[0029] In this example, the second valve member **22** is mounted at least predominantly within the side bore, and is slidable in the side bore **18** between the open position and the closed position. In this example, the second valve member **22** comprises a poppet check valve which is mounted in a generally cylindrical valve housing **28** which is retained in a corresponding recess at the side port **16** in the exterior surface of the drill pipe **10**. In this example, one side bore **18** is provided in the drill pipe **10**, although it should be appreciated that more than one may be included to increase the cross-section available for flow of mud of the drill pipe **10** via the side bore **18**. The valve housing **28** is retained by means of a screw thread (not shown) which engages with a corresponding screw thread in the side bore **18**, but it will be appreciated

that bolts, or any other appropriate fastening means could be used. Alternatively the valve housing **28** could be integral with the tubular body **12** of the drill pipe **10**.

[0030] Two O-rings **30** are mounted each in a circumferential groove provided in the exterior surface of the valve housing **28** and provide a fluid tight seal between the valve housing **28** and the tubular body **12** of the drill pipe **10**. The valve housing **28** is also provided with a central bore **32** which is generally parallel to the side bore **18** in the drill pipe **10** and in which is located the valve member **22**. The valve member **22** includes a stem **34** one end of which is mounted centrally on a disc **36** so that the stem **34** extends generally normal to the disc **36** to a free end of the stem. A circular valve seat **38** is provided at the interior end of the valve housing **28** which is adjacent the main bore **14** of the drill pipe **10**. The valve member **22** is located such that the stem **34** extends into the central bore **32** of the valve housing **28** from the interior end thereof, whilst the disc **36** lies in the side bore **18** without protruding into the main bore **14** of the drill pipe **10**, outside the valve housing **28** and adjacent the interior end thereof. The diameter of the disc **36** is greater than the diameter of the central bore **32** and of the valve seat diameter of the valve seat **38**, so when the valve member **22** is in the closed position, the disc **36** engages with the valve seat **38**, providing a generally fluid tight seal which substantially prevents fluid flow along the side bore **18** in the drill pipe **10**.

[0031] In order to locate the valve member **22** radially within the central bore **32** of the valve housing **28**, an annular flange **40** is provided which extends from the valve housing **28** into the central bore **32**. The flange **40** includes a central aperture which is just slightly larger in diameter than the stem **34** of the valve member **22**, and the stem **34** of the valve member **22** extends through this aperture. The valve member **22** is biased into the closed position by means of a helical spring **42** which extends between a generally circular groove provided in the flange **42** and a collar **46** fixed to the free end of the stem **34**. It is therefore necessary to move the valve member **22** against the biasing force of the spring **42** in order to move it out of the closed position to the open position, in which fluid can flow through the central bore **32** via the space between the valve seat **38** and disc **36**. The valve member **22** is configured such that this may be achieved by the supply of pressurised fluid to a hose connected to the side bore **18** of the drill pipe **10**.

[0032] The central bore **32** of the valve housing **28** is threaded so that a cap **48** can be provided as illustrated in FIGS. **4**, and **5**. The cap **48** is provided with a generally circular top part **48***a* from which extends a generally cylindrical wall **48***b* of smaller diameter than the top part **48***a*. The wall **48***b* extends into the central bore **32** of the valve housing **28**, and is provided with two O-rings **50** each of which is located in a circumferential groove around the exterior surface of the wall **48***b*. The screw thread by means of which the cap **48** is retained in the valve housing **28** is provided on the exterior surface of the wall **48***a* between the top part **48***a* and the O-rings **50**.

[0033] The O-rings **50** engage with the central bore **32** of the valve housing **28** to provide a substantially fluid tight seal. This ensures that the cap **48** provides a secondary seal preventing fluid flow through the side bore **18** in the drill pipe **10** in case the seal provided by the valve member **22** fails.

[0034] Other fastening means may be used to retain the cap **48** in the valve housing **28**. For example, a bayonet lock or similar type of quick connection methods may be used instead of the thread.

[0035] During the usual operational mode of the drill pipe there exists a pressure inside the main bore **14** that forces the valve member **22** against the seat **38**. To use the second valve, during the connection of a new length of drill pipe, the cap **48** is removed. The cap **48** may also be provided with a relief slot (not shown) to allow safe venting of any pressure trapped in the central bore **32**. Once the cap **48** is removed an adapter (not shown) can be threaded into the thread, with similar O-rings to the O-rings **50** on the cap **48** being provided to ensure a substantially fluid tight seal between the valve housing **28** and the adapter. Fluid pressure can then be supplied through this adapter which will start lifting the disc **36** from the seat **38** once the applied pressure is sufficient to overcome the biasing force of the spring **42** and exceeds the internal pressure in the bore **14** of the drill pipe **10**. At this point the second valve **22** is opened and flow will pass through the circumferential clearance into the main bore **14** of the drill pipe **10**.

[0036] Once the flow is stopped, and the pressure in the adapter is reduced below the pressure in the drill pipe **10**, the second valve **22** will close. The spring **42** will always ensure that the valve **22** is held in a closed position at all times when there is no pressure applied from the internal bore of the drill pipe **10** and there is no pressure applied externally.

[0037] It should be appreciated that the invention is not restricted to this configuration of valve assembly, and the second valve **22** may, advantageously, be as described in our co-pending patent application WO 2010/046653.

[0038] The first and second valves **20**, **22**, side port **16** and side bore **18** are all provided in a first connection portion **10***a* of the drill pipe **10** at the first end thereof, the first connection portion **10***a* comprising a thickened portion of the tubular body **12** in which the separation of the interior surface and the exterior surface is substantially greater than the adjacent portion of the tubular body **12**.

[0039] The thickening may be achieved by maintaining the internal diameter of the drill pipe **10** constant along its entire length, the outer diameter increasing at the first end **10***a*, as illustrated in FIG. **1**. Alternatively, in addition to the increase in the outer diameter, further thickening may be provided by decreasing the internal diameter over at least a portion of the connection portion **10***a*, as illustrated in FIG. **2**. In the embodiment of the invention shown in FIG. **2**, the internal diameter of the drill pipe **10** decreases in stages from the very end of the drill pipe **10**. First, there is provided a first tapered portion **52** in which the internal diameter decreases linearly and which, in this example is threaded, then there is a portion of constant internal diameter **54** through which the pin receiving bore **25** extends, followed by a step **56** in which the internal diameter is reduced further in two stages to a second portion of constant internal diameter **58**, through which the side bore **18** extends. Finally, there is a second tapered portion **60** in which the internal diameter increases slightly. The first constant internal diameter portion **54** is provided with a circumferential internal groove **62** which in use, receives a retainer ring that holds the ball valve **20** in place.

[0040] There is a second connection portion at the second end of the tubular body **12**, the second connection portion **10***b* also comprising a thickened portion of the tubular body **12** in which the separation of the interior surface and the exterior

surface is substantially greater than the adjacent portion of the tubular body **12**. In this example, the second connection portion **10***b* is provided with a second threaded portion **64** which is a mate for the first threaded portion **52**. The first threaded portion **52** is provided in the interior surface of the drill pipe **10**, i.e. the first connection portion is the female connector, and the second threaded portion **64** is provided in the exterior surface of the drill pipe **10**, i.e. the second connection portion **10***b* is the male connector. This means that the drill pipe **10** can be connected to another identical drill pipe **10'** by mating of the first threaded portion **52** of one drill pipe **10** with the second threaded portion **64'** of the other drill pipe **10'**, as illustrated in FIG. **1**.

[0041] The length of the first connection portion **10***a* parallel to the longitudinal axis of the tubular body is between 19 inches (48 cm) and 25 inches (64 cm). Ideally it is less than 24 inches long, and in this example is 23.85 inches long.

[0042] By incorporating the valve assembly required for continuous mud circulation into the tool joint, and by minimising the length of the tool joint, the stresses experienced by the drill pipe when it is bent around a curved section of well bore can be more evenly distributed along the length of the drill pipe **10**. This is illustrated in FIGS. **7***a* and **7***b*, which show a curved portion of well bore **66** containing two different configurations of drill pipe **10**. In FIG. **7***a*, the first and second connection portions **10***a*, **10***b* are relatively long, whilst in FIG. **7***b*, the first and second connection portions **10***a*, **10***b* are relatively short. It can be seen that in FIG. **7***a* there is a sharper bend at the transition between the thicker, and therefore stiffer, connection portions and the thinner, and therefore more flexible, central portion of the drill pipe, than there is in FIG. **7***b*. In this way, the maximum stress experienced by the drill pipe can be reduced, and this may assist in improving the fatigue resistance of the drill pipe **10**.

[0043] When used in this specification and claims, the terms "comprises" and "comprising" and variations thereof mean that the specified features, steps or integers are included. The terms are not to be interpreted to exclude the presence of other features, steps or components.

[0044] The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

What is claimed is:

1. A drill pipe having an elongate tubular body with an interior surface enclosing a main bore which extends generally parallel to a longitudinal axis of the tubular body from a first end to a second end of the tubular body, a side port provided in an exterior surface of the tubular body, a side bore extending through the body from the main bore to the side port, and a valve assembly which is operable to substantially prevent flow of fluid along the main bore and to substantially prevent flow of fluid along the side bore, wherein the valve assembly, side port and side bore are provided in a first connection portion of the drill pipe at the first end thereof, the first connection portion comprising a thickened portion of the tubular body in which the separation of the interior surface and the exterior surface is substantially greater than the adjacent portion of the tubular body, the length of the connection portion parallel to the longitudinal axis of the tubular body being less than 64 cm.

2. A drill pipe according to claim **1** wherein the valve assembly includes a first valve member which is movable between an open position, in which flow of fluid along the main bore is permitted, and a closed position, in which flow of fluid along the main bore is substantially prevented, and a second, separate, valve member which is movable between an open position, in which flow of fluid along the side bore is permitted, and a closed position, in which flow of fluid along the side bore is substantially prevented.

3. A drill pipe according to claim **2** wherein the first valve member comprises a ball which is rotatable between the open position and the closed position.

4. A drill pipe according to claim **2** wherein the second valve member is mounted at least predominantly within the side bore, and is slidable in the side bore between the open position and the closed position.

5. A drill pipe according to claim **1** wherein the first connection portion is provided with a first threaded portion.

6. A drill pipe according to claim **5** wherein the first threaded portion is provided in the interior surface of the drill pipe, and the second threaded portion is provided in the exterior surface of the drill pipe.

7. A drill pipe according to claim **1** wherein there is a second connection portion at the second end of the tubular body, the second connection portion also comprising a thickened portion of the tubular body in which the separation of the interior surface and the exterior surface is substantially greater than the adjacent portion of the tubular body.

8. A drill pipe according to claim **7** wherein the second connection portion is provided with a second threaded portion which is a mate for the first threaded portion.

* * * * *