SEALING DEVICE FOR SEALING OF HOLES IN THE WALL OF A PIPE IN A CURVED OIL WELL, AN ANCHORING DEVICE FOR THE SEALING DEVICE AND A TOOL FOR MOUNTING OF THE SEALING DEVICE AND THE ANCHORING DEVICE

A sealing device (6) for sealing holes in a casing (1) of a curved oil well, comprising a pipe device (52, 53) together with a packing (60, 62) and an engagement section (50, 51) at each end of the pipe device (52, 53). The packings (60, 62) are radially expandable when mutually opposing axial forces are exerted against the ends of the pipe device (52, 53). The pipe device comprises at least two pipes (52, 53) whose opposite end sections (70, 71) are sealingly connected to each other via a universal coupling. The invention also comprises a tool (5) for mounting the sealing device (6), comprising a connecting pipe (12), at each end of which is a head (10, 11), which can be connected to the end sections of the pipe device (52, 53). The heads are arranged to be pressed against each other, e.g. by means of a hydraulic device (14) for expansion of the packings (60, 62). The invention further comprises an anchoring device (81, 84, 85) to hold the sealing device (6) securely in the casing (1).
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Sealing device for sealing of holes in the wall of a pipe in a curved oil well, an anchoring device for the sealing device and a tool for mounting of the sealing device and the anchoring device

The invention relates to a sealing device for sealing of holes in the wall of a pipe, such as a casing, in a curved oil well, an anchoring device for the sealing device and a tool for mounting of the sealing device and the anchoring device, as specified in the introduction to claims 1, 12 and 8, respectively.

In US 3 443 638 it is disclosed that for sealing a hole in a first pipe string for the transport of fluid in an oil well, a sealing device can be mounted comprising a second pipe string, at each end of which there is a packing device, which provides a seal between the pipe strings. The sealing device is thereby provided in the first pipe string in such a manner that the hole is located between the packing devices. This device enables the transport of fluid to continue in the second pipe string after the device has been installed.

The packing devices comprise muff-like packings which are placed around the second pipe string, and one end of which is permanently connected with it, the other, free end being able to be distended in an umbrella-like manner to abut against the inner wall of the first pipe string by means of respective coaxial, conical pipe muffs or slips, the narrow end of which are inserted between the free end of the packing and the pipe section which contains the packing.

In order to instal the inner packing, i.e. the packing which has to be placed innermost, i.e. at the bottom of the well, it is first necessary to mount a stop in the hole. This stop comprises a ring which by means of a conical piece of pipe is firmly wedged against the pipe wall in the first pipe string.

Since the introduction of the second, straight pipe string, which is manufactured in one piece and is relatively rigid, presents difficulties, particularly if the first pipe string is curved, the second pipe string comprises a number of short individual pipe pieces, which are inter-connected by means of a mounting tool. In order to mount the device the tool is taken out of the well, connected to a first pipe piece which carries the packing which has to be installed innermost in the well, and transported down in this, as it is brought to abutment against the stop. Thereupon the tool is repeatedly run out of and into the well for the connection of new pipe pieces to those which are already mounted in the well.
After the last pipe piece which contains the outer, i.e. the upper packing, has been connected, the pipe pieces are pressed together so that both packings are distended. This installation is very time-consuming and therefore expensive.

It is not advantageous to remove other equipment which may be located in the well in order to perform normal well work, i.e. not extraordinary work as a consequence of failure, etc., for the introduction of the sealing device by means of this equipment, since replacement of equipment is time-consuming.

Further, there are known sealing devices which permit subsequent use of a drill string in order, e.g., to make the well deeper. During the introduction of the drill string the sealing device is cut into small pieces by means of the drill, the sealing device being made of relatively weak materials. However, it is evident that this will cause the sealing effect to be reduced or at worst lost, and milling of this kind can thus entail a safety hazard and an economic risk.

The known devices are further intended for production pipes with a relatively small diameter, e.g. 0.2042 m. They are not suitable for sealing cracks with a length of several metres in pipes of large diameter, e.g. casings with a diameter of up to 0.762 m, and which are located in a well whose longitudinal axis extends in a number of successive curves with a radius which varies between, e.g., approximately 190 m and 570 m, the well finally extending horizontally.

In US 4 773 478 there is disclosed a hydraulic tool in which a press head with a piston device, and a head cup are connected via a rod and a cutting device, and where the heads exert a force couple for mounting a packing with two related slips. After the packing and the slips have been mounted, the heads are separated from each other by breaking the cutting device. The head cup thus remains in the well, partially blocking it.

In US 4 852 654 it is disclosed that wedge pieces with a cross section in the form of a sector of a circle can be held together when they are placed around a cylindrical object, thus forming an assembly corresponding to a slips, a breakable ring or a circlip being placed in the outer groove of the wedge pieces. This slips assembly comprises a large number of components and is relatively difficult to instal.
The object of the device according to the invention is to provide a sealing device, an anchoring device and a tool of the type mentioned in the introduction, which are not encumbered by the above-mentioned disadvantages.

The characteristics of the sealing device, the anchoring device and the tool according to the invention will be presented in the characteristic features specified in the respective claims.

The invention will now be described in more detail with reference to the drawing which schematically illustrates embodiments of the device according to the invention.

Fig. 1 is a longitudinal section through a section of a bore hole with a sealing device and a tool according to the invention, only that part of the longitudinal section which is located on the left side of the hole's longitudinal axis being shown, and it should be understood that the sealing device and the tool are substantially symmetrical about the longitudinal axis, apart from some indicated channels and certain related hydraulic components.

Figs. 2 and 3 are a section of two sealing sections which are indicated by II and III respectively in fig. 1, on an enlarged scale.

Fig. 4 is a longitudinal section through an anchoring device.

Fig. 5 is that section which is indicated by V in fig. 4, on an enlarged scale.

Fig. 6 is a view of that section of the anchoring device which is illustrated in fig. 5, viewed in the direction of the arrow VI.

As shown in fig. 1 a casing 1 extends downwards into a well in the bedrock 2. The casing 1 is damaged, e.g. there are two holes 3, 4 which require to be repaired. In order to repair the damage, i.e. sealing the holes in order to prevent leakage from the bedrock to the inside of the casing 1, a tool 5 which contains a sealing device 6 has been inserted into the casing and lowered to the damage location via a pipe string 7, e.g. a drill string.
In the following description it should be understood that the well's opening is located on that side of the tool which faces the upper edge of the figure, and that the expression "up" refers to the direction towards the opening of the well.

The casing, the drill string, the tool and the sealing device are substantially symmetrical about a longitudinal axis 8 of the well. However, it will be understood that for the sake of simplicity there are included in the left half of the illustrated figure some channels, valves and a hydraulic cylinder for the operation of a lock pin of the tool, it being understood that no corresponding components or sections need to be shown on the right half of the figure.

The tool 5 comprises an upper head 10 and a lower head 11 which are connected to each other by means of a connecting pipe 12, and whose cross section has a circular outer contour. The upper head comprises a supporting part 13 the upper part of which is sealingly connected with a lower section of the drill string 7, and the lower part of which is sealingly connected with the upper end section of the connecting pipe 12, e.g. by means of screw threads.

The supporting part 13 of the upper head contains a piston part 14 which is slidable upwardly and downwardly in relation to the supporting part 13. For this purpose the supporting part 13 has two outer cylinder sections which are provided consecutively in the axial direction, where the upper cylinder section has a larger diameter than the lower cylinder section, a downwardly projecting shoulder 17 thus being formed between them. The surfaces of the upper and lower cylinder sections are indicated by reference numbers 15 and 16 respectively.

In the same way the piston part 14 has two borings which extend consecutively in the axial direction, the diameters of the borings being adapted to the diameters of the respective cylinder sections of the supporting part, and the upper and lower boring surfaces are indicated by 18 and 19 respectively. The borings define an upwardly facing shoulder 20. The upper and lower surfaces 15,18 and 16,19 respectively of the cylinder sections and the borings constitute coacting pairs of sliding surfaces. At the borings the piston part contains packing rings 21 and 22 respectively which seal the space between the piston part and the supporting part.

From a central, axially extending boring 23 which is provided in the supporting part 13, and which communicates with a central boring in the drill string 7, there
extends in the supporting part 13 a radially extending boring 24 which communicates with the space 25 which is defined by the shoulders 17, 20 and the surfaces 16 and 18. In the boring 24 there is provided a first adjustable pressure relief valve 94 which opens and permits the flow of fluid from the boring 23 to the space 25 only when the degree of the pressure in the fluid in the boring 23 has exceeded by a precisely defined value the degree of the well pressure at the location of the leakage in the well.

A stop 27 of the supporting part 13 is arranged to abut against the lower end of the piston part and to restrict the movement of the piston part downwards in relation to the supporting part 13.

At the lower, radially outer section of the piston part 14 there is provided a circumferential, downwardly facing shoulder 28.

The lower head 11 comprises a housing 30 which has a central boring 31, which communicates via the connecting pipe 12 with the central boring of the drill string.

In the housing 30 there is provided a radially extending, cylindrical chamber or cylinder 33 which is restricted radially inwards by a bottom 36. In the cylinder 33 there is provided a piston 37 which can slide in the cylinder, and contains a packing 39 which creates a seal between the chamber's cylindrical wall and the piston. The piston 37 divides the cylinder 33 into a radially outer cylinder section 102 and a radially inner cylinder section 103.

From the boring 31 there extends in the housing a channel 32 to the outer cylinder section 102, and in the channel 32 there is provided a second adjustable pressure relief valve 96, which opens and permits the flow of fluid from the boring 31 to this cylinder section 102 only when the degree of pressure in the fluid in the boring 31 has exceeded the degree of pressure in the space 25 by a precisely defined value.

At the opening of the channel 32 which faces the boring 31, there is provided a nipple 95, to which can be connected a pressure fluid pipe, e.g. a pipe of a hand pump (not shown).
From the inner cylinder section 103 of the cylinder 33 there extends in the housing 30 a channel 97 to the space in the well which is located under the housing 30. The channel 97 ventilates the radially inner section 103 of the chamber 33, thus preventing a hydraulic lock from being formed when the piston 37 is moved.

There further extends from the boring 31 a channel 100 which similarly communicates with the well space which is located under the housing 30. In this channel there is provided a one-way valve which permits fluid to flow only in the direction from this well space to the boring 31.

The piston has a cylindrical extension or pin 38 which projects radially outwardly through a boring 34 which leads into a cylindrical, outer surface 35 of the head 11. The pin 38 contains a packing 41 which creates a seal between the boring 34 and the pin 38. A spring 40, which is provided between the piston 37 and the bottom 36, attempts to move the piston 37 radially outwards to a position in which the pin projects out of the boring 34.

The sealing device 6 is provided as a flexible muff, which by means of the tool and the drill string is located radially inside the damaged sections of the casing.

The sealing device 6 comprises an upper slips 50 which is provided concentrically in relation to and around the upper head, and the upper end section of which is arranged to rest on its shoulder 28.

Furthermore the sealing device comprises a lower slips 51 with a cylindrical, inner surface whose diameter is adapted to the diameter of the outer, cylindrical surface of the lower head 11, thus enabling the lower slips 51 to slide axially on the outside of the lower head.

The radially outer surface and the lower end section of the upper slips 50 are in the form of a conical surface and extend taperingly downwards, and the radially outer surface of the upper end section of the lower slips 51 is in the form of a conical surface and extends taperingly upwards.

The lower slips 51 has a radial boring whose diameter corresponds to the diameter of the pin 38, thus enabling the pin to be inserted into this boring when the piston 37 is pressed radially outwards by the spring 40. The axial movement
of the slips 51 in relation to the lower head can thereby be prevented. By connecting the above-mentioned hand pump to the nipple 95 and pumping fluid into the outer cylinder section 102 of the chamber 33, the piston 37 and thereby the pin 38 can be moved radially inwards against the force exerted by the spring 40, thus permitting axial movement of the slips 51 in relation to the lower head.

Between the slips 50, 51 there extends an upper pipe 52 and a lower pipe 53. As is also illustrated in fig. 2, the upper end section 55 of the upper pipe 52 is inserted with little clearance into the lower end section of the upper slips 50, thus enabling these sections to slide axially relative to each other. In the same manner the lower end section 57 of the lower pipe 53 is inserted with little clearance into the upper end section of the lower slips 51, thus enabling these sections to slide relative to each other.

At the radially outer surface 54 of the upper pipe 52 there is provided a sleeve-shaped upper packing 60, whose upper end section 61 rests radially on the outside of the conical, lower end section of the upper slips 50.

The lower section 69 of the packing is permanently connected to the upper end section 55 of the upper pipe by means of gluing, vulcanizing or in some other manner. The upper section of the packing is lightly glued or in some other easily releasable manner attached at 68 to the upper slips 50, this section of the packing 60 thus being kept close to the upper slips 50 until it is moved in relation to the packing 60 as will be explained in more detail below. Thus it is ensured that the packing will not inadvertently come into contact with and be pulled out by components of the well when the sealing device is positioned in the well.

Similarly the upper end section of a lower packing 62 is tightly connected with the radially outer surface of the lower end section 57 of the lower pipe 53, the lower end section 63 of this packing resting on and attached in an easily releasable manner to the lower end section of the lower slips 51.

The upper end section 55 of the upper pipe 52 is inserted in and abuts against the upper slips 50. In order to secure the upper pipe 52 to the upper slips 50 there extends through at least a pair of aligned holes which are provided in these parts, a shear pin 67 (see fig. 2). In a similar manner a shear pin extends through the lower pipe 53 and the lower slips 51.
Moreover in the upper slips 50 there is provided at least one radially inwardly open recess 64, the lower end wall of which extends downwardly and radially inwardly. In the recess there is provided a wedge body 65, the lower end section of which extends in a similar manner. A spring body 66 attempts to press the wedge body 65 downwards. In a similar manner there is provided in the lower slips 51 at least one similar recess which, however, is facing in the opposite direction. Its upper wall and the upper end section of a wedge body which is provided in the recess extend radially inwards and upwards. This wedge body is influenced by a spring body which attempts to press it upwards.

The surface of the wedge body which faces the upper and the lower pipes 52,53 respectively is provided with sawtooth shaped teeth which are arranged for engagement with the adjacent surface of the facing pipe.

As is better illustrated in fig. 3, the lower end section of the upper pipe 52 has a larger internal diameter than the rest of this pipe, and the section with a larger diameter is terminated at the top by a downwardly facing shoulder 76. This end section thus forms a sleeve section 70 with a radially inner, cylindrical surface 72.

The upper end section of the lower pipe 53 has a smaller external diameter than the rest of this pipe, this end section thus forming a pin section 73 and this pin section has a barrel-shaped surface 74, whose maximum diameter is slightly smaller than the diameter of the cylindrical surface 72 of the sleeve section 70. The pin section 73 is terminated at the top by an upwardly facing end surface 71.

For sealing the opening between the pin section 73 and the sleeve section 70 there are provided packings 75 in circumferential grooves in the sleeve.

The shoulder 76 of the upper pipe 52 and the end surface 71 of the lower pipe 53 are arranged to abut against each other and are complementary, being in the shape of a surface section of a sphere with the centre located on the longitudinal axis 8 of the sealing device.

On the outside of the connection point for the upper and lower pipes 52,53, to these is attached a sleeve 78 made of an elastic material such as rubber. In order to secure the connection between the sleeve 78 and the pipes the sleeve can have
radial projections 79 which engage with circumferential grooves of the pipes, and the sleeve 78 can be attached to the pipes 52,53 by means of vulcanization.

An interconnection of this type for the pipes 52,53 of the sealing device creates a tight universal coupling between these pipes and can, for example, withstand a fluid pressure of approximately 100 bar which is exerted against the outside and 180 bar against the inside in connection with casings with a diameter of approximately 0.508 m, with the possibility of higher pressures for pipes of smaller diameter.

The function of the tool and the sealing device will now be explained.

First of all the sealing device is mounted on the tool in the position which is shown in fig. 1. For this purpose, e.g., the connection between the upper head 10 and the connecting pipe 12 is first loosened. The lower slips 51 of the sealing device 6 is then fed over the lower head 11, the pin 38 having been brought to the position, in which it is radially drawn into the boring 34, by means of a fluid pump to which the nipple 95 has been connected, whereupon the pin is permitted to be inserted into the radial boring in the lower slips 51, this slips 51 thus being secured on the lower head. The piston part 14 of the upper head 10 is then inserted into the upper slips 50 until it abuts against the shoulder 28, whereupon the supporting part 13 is connected with the connecting pipe 12 and the tool with the mounted sealing device is connected with the drill string 7.

The tool and the sealing device are then together lowered down the well by means of the drill string until the packings 60,62 of the sealing device are located above and below the damaged area in the casing respectively. If during this lowering operation the sealing device passes through well sections which are curved in the longitudinal direction, the barrel and spherical surface connection between the upper and lower pipes 52,53 of the device will permit an angular displacement between the longitudinal axes of these pipes, thus enabling the sealing device to be brought unimpeded to the damage location.

The pressure of the fluid in the drill string is then increased until the first pressure relief valve 94 opens. The fluid pressure is then so great that the vertical force which is exerted on the shoulder 20 of the upper head's piston part 14 causes the shear pins 67 to be sheared and the slips 50,51 are pushed against each other and axially in between the adjacent packings 60,62 and the
respective, adjacent pipe end sections 55, 57 after first having broken the relatively weak adhesive connection at 68 between the packings and the slips. During this relative movement of the slips and the pipes, the wedge bodies 65 will be conveyed along the upper and the lower pipes 52, 53 respectively and prevent the return movement of these parts.

Moreover the end sections 61, 63 of the packings 60, 62 will be pressed outwards like an umbrella by means of the slips 50, 51 until they abut tightly against the inside of the casing and the piston part 14 possibly abuts against the stop 27.

The pressure of the fluid in the drill string 7 is then further increased, until the second pressure relief valve 96 opens and the force which is exerted by the fluid in the outer cylinder section 102 of the chamber 33 radially inwards against the piston 37 is greater than the radially outwardly directed force which is exerted by the spring 40 against the piston 37 and the frictional force between the pin 38 and the lower slips 51. The piston 37 and the pin 38 will then be moved radially inwardly until the pin has been brought all the way out of the boring in the lower slips 51.

The tool can now be pulled up, the sealing device remaining sealingly pressed against the casing.

In order to obtain better axial retention of the sealing device in the casing 1, e.g. in order to prevent it from following the drill string when it is conveyed past the sealing device, anchoring devices 80 similar to the one which is illustrated in fig. 4 can be provided above and below it. These can be mounted by means of the same tool 5 which has been described above.

The anchoring device 80 comprises a tubular distance or central piece 81 in which the outer surface of the central piece's upper and lower end section 82, 83 is substantially in the form of the surface of a truncated cone, the end sections being tapered towards their respective ends. The end section of the cone which has the largest diameter can extend in a curve away from the narrow end of the cone, so that it makes an even transition into the cylindrical section of the piece of pipe. This curved section is indicated by the reference number 92 in fig. 5.

The end sections of the central piece are fed into upper and lower wedge sleeves 84, 85 respectively, whose inter-facing end sections 86, 87 are provided
complementarily conical in relation to the end sections of the central piece, as is
good illustrated in fig. 5 which shows the section V in fig. 4 on an enlarged
scale. The radially outer surface of the central piece's conical end sections 82,83
and possibly also its central section have sawtooth shaped projections which are
arranged to penetrate the facing surface of the wedge sleeves or the casing 1.
Similarly the outer wall of the conical end sections of the wedge sleeves 84,85
have sawtooth shaped projections which are arranged to penetrate the inner wall
of the casing 1. Shear pins 88 extend through pairs of borings which to begin
with are mutually aligned and which are provided in the central piece 81 and
wedge sleeves 84,85 respectively.

As is illustrated in fig. 6 the conical end sections 86,87 of the wedge sleeves
84,85 have axial slots 89, thereby forming fingers 90 which are defined by these
slots 89, and which extend from a section near the boring for the shear pin to
near the thin end of the respective wedge sleeves. Thus between the finger tips
bridge sections 91 are formed which can break when the wedge sleeves are
moved towards the central section of the central piece.

The anchoring device is provided on the tool in the manner which is described
above in connection with the sealing device, the tool then having a connecting
pipe 12 with a length which is adapted to the length of the anchoring device.

After an increase in the pressure of the fluid in the drill string and cutting off
the shear pins 88 and breaking the bridge sections 91 between the fingers 90, the
wedge sleeves 84,85 are moved towards each other and thereby slide on the
central piece 81, while at the same time being pressed radially outwards. When
they abut against the casing 1, continued increase in pressure will cause the teeth
of the central piece 81 to penetrate the wedge sleeves 84,85, while at the same
time the teeth of the wedge sleeves penetrate the casing 1. Due to the curved
section 92 the tips of the fingers will be very tightly wedged here between the
casing and the central piece 81. The anchoring device has thereby become
securely anchored to the casing.

As has been described above in connection with the sealing device, a final
further increase in the pressure of the fluid occurs, whereby the pin 38 is pulled
radially into the lower head 11, thus releasing it, after which the tool can be
pulled up.
During the lowering of the sealing device the anchoring device can act as a support for the lower head during the installation of the sealing device. After the installation of the sealing device, an additional anchoring device can be mounted above it, thus safeguarding the sealing device against axial displacement in both directions away from the location of damage to the casing 1.

The distance between the end packings 61,62 of the sealing device can be adapted to different lengths of the damaged sections of the casing by means of upper and lower pipes 52,53 with adapted lengths or by means of additional pipes which are provided between these pipes. In the same way a tool can then be used with a connecting pipe 12 with adapted length or additional pipes which are connected to the connecting pipe 12.

It will be understood that the sealing device and the tool according to the invention can easily be adapted to suit different lengths of casing damage and that the same heads of the tool can be used in connection with sealing devices with the same slips and end packings.

The same tool can also be used for mounting anchoring devices in the casing.

Furthermore the barrel and spherical surface connection between the upper and lower pipes 52,53 of the sealing device also enable the sealing device as a mechanically connected unit to be conveyed to the damage location even through a well which is curved in the longitudinal direction. The tool's heads can thereby be supported by a supporting tube which is sufficiently flexible to allow it to easily conform to the curvature of the well.

The fact that the sealing device can be lowered as a unit avoids the necessity of having to raise and lower the drill string several times, which is very time-consuming and thus very expensive, and the ability to use the drill string as a hoisting device avoids the necessity of acquiring and installing a separate hoisting device.

If required, the upper head can also have a cylindrical outer surface and include a withdrawable pin similar to the pin 38 of the lower head. Moreover the lower head can be in the form of a cutter tool, thus enabling the drill string to be lowered directly after the sealing device has been mounted in order to continue a drilling operation. Alternatively, after the tool has been pulled up, a casing with
a slightly smaller diameter than the repaired casing can be lowered through the sealing device.

It will be understood that if an anchoring device is first provided below the location of damage to the casing, the sealing device can be mounted by means of the tool without the use of pressure fluid, since it is sufficient that a sufficiently great downward-acting force is exerted against the supporting part 13 for the piston part 14 to be moved downwards in relation to the connecting pipe 12. Thereby, for example, the pressure release valve 94 as a non-return valve can create a hydraulic lock in the space 25, and the necessary power can be provided by the weight of the drill string.
PATENT CLAIMS

1. A sealing device (6) for sealing a leakage point (3,4) in the wall of a pipe in an oil well, especially a casing (1), and which comprises a pipe device (52,53), each end of which carries a radially expandable packing (60,62), which is arranged to be expanded in order to provide a seal between the pipe device (52,53) and the casing (1) by exerting an axial force against an engagement section (50,51) of each of the end sections of the pipe device, where the engagement sections (50,51) are arranged to be brought into engagement with respective engagement bodies (10,11) of a mounting tool (5), via which the force can be exerted, the sealing device (6) being arranged to be inserted into the casing (1) while the packings (60,62) are in an unexpanded condition, characterized in that the pipe device comprises at least two pipes (52,53) which extend substantially coaxially after each other in the longitudinal direction, where end sections (70,73) of the pipes (52,53) located opposite each other are arranged to abut against each other when the axial force is exerted, and are connected to each other via a universal connection device (70,71,72,73,74,75,76,77,78) which permits relative mutual angular movement of the pipes while maintaining a fluid-tight mutual connection of the pipes (52,53).

2. A sealing device according to claim 1, characterized in that the connection device comprises a muff (78) of an elastic material which overlaps the mutually opposite end sections of the adjoining pipes (52,53) and is permanently connected to them.

3. A sealing device according to claim 1 or 2, characterized in that mutually opposite end sections of adjoining pipes (52,53) comprise a pin section (73) and a sleeve section (70) formed complementarily thereto, respectively, where the pin section is inserted into the sleeve section (70) in order to secure the concentricity of the cross section of adjoining pipes located at the same axial position in the pipe device (52,53).

4. A sealing device according to claim 3, characterized in that the inside surface of the sleeve section (70) is cylindrical and the outer surface of the pin section (73) is barrel-shaped.

5. A sealing device according to claim 3 or 4.
characterized in that the universal connection device comprises at least one annular packing (75) which is located around the pin section (73) and seals the opening between the pin section (73) and the sleeve section (70).

6. A sealing device according to one of the above-mentioned claims, characterized in that the engagement sections (50,51) are arranged for releasable connection with the engagement bodies (10,11), and that the pipe device (52,53) has a central, through-going axial boring, through which the engagement body (11) which is arranged for connection with the lower engagement section (51), i.e. the engagement section which is located innermost in the oil well, can be passed after the expansion of the lower packing (62).

7. A sealing device according to one of the preceding claims, where the packings (62,63) are lip packings, whose lip (61) by means of the engagement bodies which are provided as slips (50,51), whose radial outer surface is in the form of a conical surface, and the narrow end of which faces the lip (61), can be expanded by means of axial displacement of the slips (50,51) towards the respective lips, characterized in that the lip (61) is glued to the slip (50,51) when it is not expanded, the adhesive connection being broken when the slip (50,51) is moved towards the packing (60,62), and that the large end of the packing is permanently connected to the end section (52,53) of the pipe device, e.g. by vulcanization.

8. A tool for mounting a sealing device (6) as specified in one of the preceding claims, which tool (5) comprises a press head (10) and a holding-on head (11) which are connected to respective end sections of a connecting pipe (12), the press head (10) comprises a supporting part (13) and a piston part (14) which are sealingly axially movable on the supporting part (13), and between opposite, substantially radially extending surface sections of the supporting part (13) and the piston part (14) there is provided a space (25), into which a pressure fluid can be introduced in order to create the axial force and a movement of the press head (10) against the holding-on head (11) in the longitudinal direction of the connecting pipe (12), characterized in that the outer diameter of the connecting pipe (12) and at least the head (11) which is arranged to be lowered first into the casing (1), is smaller than the inner diameter of the pipe device (52,53) of the sealing device when this head's engagement body (38) is located in the position in which it is not engaged with the associated engagement section (51) of the sealing device (6),
that the distance between the heads (10,11) substantially corresponds to the
distance between the end sections (50,51) of the sealing device, that the heads' (10,11) engagement bodies (28,38) are arranged to be brought into engagement
with the respective engagement sections (50,51) of the sealing device when the
tool's heads (10,11) are located at the end sections of the sealing device, and that
the supporting part (13) is arranged for releasable connection with an end section of a pipe string (7), which can be inserted into the well, such as a drill pipe string.

9. A tool according to claim 8,
characterized in that the engagement body of the head (10) which is arranged to be inserted last into the casing (1), is composed of a radially extending shoulder (28) which is arranged to abut against a shoulder of the sealing device.

10. A tool according to one of the claims 8 or 9,
characterized in that the engagement body of at least the head (11) which is arranged to be inserted first into the casing (1), is composed of a radially movable body (38) which is arranged to engage with an end section of the sealing device when it is moved radially outwards, and that the head (11) is arranged to be moved through the pipe device (52,53) when the body (38) is pulled radially inwards.

11. A tool according to one of the claims 8 - 10,
characterized in that the connecting pipe (12) is composed of at least one piece of pipe (52,53) which is releasably connected with the heads (10,11), and which is arranged for connection with additional pipe pieces, the end sections of which are formed with a pin and a sleeve respectively for extension of the tool.

12. An anchoring device for a sealing device (6) as specified in one of the claims 1 - 7 and to be mounted in the axial direction beside the sealing device by means of a tool (5) as specified in one of the claims 8 - 11, characterized in that it comprises two slips (84,85) and a distance piece (81) located between these, where each of the end sections (82,83) of the distance piece (81) has an outer conical surface, whose narrow end faces away from the central section of the distance piece, calculated in the axial direction, the slips (84,85) are complementarily conical in shape in relation to the end sections of the distance piece (81) and comprise known per se longitudinal slots (89) which extend at regular intervals in the slip's circumferential direction and from near
the wide end of the slips, the slots (89) being terminated near the narrow end of the slips (84,85), whereby the remaining sections (91) near the narrow end and in the axial extension of the slots (89) can be broken during axial displacement of the slips (84,85) towards the central section of the distance piece (81).
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: E21B 33/12
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: E21B
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

ORBIT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Relevant to claim No.</th>
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<td>US, A, 4852654 (R.K. BUCKNER ET AL), 1 August 1989 (01.08.89), the whole document</td>
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<td>US, A, 4901794 (J.L. BAUGH ET AL), 20 February 1990 (20.02.90), the whole document</td>
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Date of the actual completion of the international search: 2 May 1994
Date of mailing of the international search report: 08-05-1994

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