



(11) **EP 3 204 591 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
23.01.2019 Bulletin 2019/04

(51) Int Cl.:
E21B 17/10^(2006.01) E21B 47/18^(2012.01)

(21) Application number: **15775225.4**

(86) International application number:
PCT/EP2015/073167

(22) Date of filing: **07.10.2015**

(87) International publication number:
WO 2016/055530 (14.04.2016 Gazette 2016/15)

(54) **A METHOD AND A CENTRALIZER SYSTEM FOR CENTRALIZING A CASING IN A WELL BORE**
VERFAHREN UND ZENTRIERSYSTEM ZUR ZENTRALISIERUNG EINES BOHRROHRES IN EINEM BOHRLOCH
PROCÉDÉ ET SYSTÈME CENTREUR POUR LE CENTRAGE D'UN TUBAGE DANS UN Puits DE FORAGE

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

(30) Priority: **08.10.2014 NO 20141201**

(43) Date of publication of application:
16.08.2017 Bulletin 2017/33

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(56) References cited:
WO-A1-95/09968 GB-A- 2 402 954
GB-A- 2 447 545 US-A1- 2006 124 310
US-B1- 8 851 193

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Description

[0001] The present invention relates to a method and a system for centralizing of a casing in a well bore before the casing is cemented in the well bore.

During drilling of a hydrocarbon well, the bore hole is at least in part provided with a casing which is cemented to the surrounding formations of the well bore. When a casing is cemented, cement is flowed through the casing and up through the annulus which is formed between the casing and the surrounding formations. Before cementing of a casing starts, the casing is preferably centralized, i.e. the casing is positioned centrally in the well bore. The centralizing of the casing improves the cementing of the casing and prevents that the cement does not stick properly to the outside of the casing or the surrounding formations and that canals with polluted liquid is formed within the cement.

To centralize the casing before it is cemented to the formations, a centralizer is used. There are a number of centralizers available on the market. They do, however, have the problem that the centralizers which provide a good centralizing of the casing also hinders the cement in its flow past the centralizer which may cause problems with the cementing job due to too high hydraulic pressure loss.

In the British patent publication GB 2402954 A, considered as the closest prior art, there is disclosed a system for centralizing a casing in a well bore before cementing of the casing where a centralizer is mounted on the casing and the centralizer comprises a receiving unit that is capable of receiving a wireless signal in form of a pressure wave. The casing is positioned in the well bore and a signal generator that is located at the surface sends a pressure wave down the well bore. The pressure wave is received by the receiving unit which activates the centralizer that will centralize the casing in the well bore.

The objective of the present invention is therefore to provide a method and a system for centralizing of the casing before the cementing takes place which does not have the above mentioned problems.

These objectives are achieved with a method for centralizing a casing in a well bore as defined in independent claim 1; a centralizer system for centralizing a casing in a well bore as defined in independent claim 12 and the use of a wireless signal to initiate the centralizing of a casing in a well bore before cementing of the casing as defined in independent claim 20. Further embodiments of the invention are defined in the dependent claims.

A method for centralizing a casing in a well bore before cementing of the casing in the well bore is therefore provided, where the method comprises the steps of:

- mounting at least one centralizer on the casing, where the at least one centralizer comprises a receiving unit capable of receiving a wireless signal in form of a pressure wave,
- positioning the casing in the well bore at a desired

position,

- providing a wireless signal generator for generation and transmission of a wireless signal in form of a pressure wave which the receiving unit of the at least one centralizer is capable of receiving, and
- transporting the signal generator down the well bore towards the casing and activating the signal generator such that the signal generator transmits the wireless signal, whereafter the receiving unit, on reception of the wireless signal, activates the at least one centralizer and the at least one centralizer centralizes the casing in the well bore.

[0002] The signal generator is transported down the well bore towards the casing. For the purpose of transporting the signal generator down the well bore, a transport element may be transported down the well bore where the transport element comprises the signal generator.

[0003] The signal generator may be triggered to start transmitting the wireless signal as the signal generator is approaching the casing or upon arrival at the casing. For example, the signal generator may be triggered to start transmitting the wireless signal when the pressure in the well fluids surrounding the at least one transport element exceeds a predetermined value. What the predetermined value will be, will obviously vary from well to well and the depth of the position of the casing centralizer and how far from the casing centralizer it is desired that the signal generator starts transmitting the wireless signal, but a skilled person, knowing the pressure profile of the well, can obviously arrange the signal generator such that the signal generator is triggered to start transmitting the wireless signal as the pressure in the well fluid surrounding the signal generator reaches a desired value.

[0004] Alternatively the signal generator may be triggered to start transmitting said wireless signal when the temperature in the well fluids surrounding the at least one transport element exceeds a predetermined value. As above, what the predetermined value will be, will obviously vary from well to well and the depth of the position of the casing centralizer and how far from the casing centralizer it is desired that the signal generator starts transmitting the wireless signal. But a skilled person, knowing the pressure profile of the well, can obviously arrange the signal generator such that the signal generator is triggered to start transmitting the wireless signal as the temperature of the well fluid surrounding the signal generator reaches a desired value.

[0005] To reduce the probability that the signal generator is not triggered to start generating and transmitting the wireless signal, the signal generator may be triggered to start generating and transmitting the wireless signal when the surrounding temperature or pressure reaches their respective predetermined values. Whichever predetermined value is reached first will then trigger the signal generator to start generating and transmitting the wireless signal.

[0006] Alternatively, the signal generator may be mechanically triggered to start transmitting said wireless signal when the signal generator arrives at the casing. There are many possible ways that a mechanical trigger could be configured. One possibility is to include a mechanical trigger in a stop element in the casing, for example the casing shoe. When the transport element, in which the signal generator is arranged, hits the casing shoe, a mechanical trigger, such as a spring-loaded, pivotable lever or similar element which is arranged to trigger the signal generator, triggers the signal generator which will start to generate and transmit the wireless signal. The mechanical triggering of the signal generator may obviously be used in combination with the triggering of the signal generator by the surrounding pressure and/or temperature reaching the predetermined value.

[0007] Instead of being configured to be triggered to start generating and transmitting the wireless signal as the signal generator approaches or arrives at the casing, the signal generator in the transport element may be configured to continuously or intermittently transmit the wireless signal while being transported through the well bore. The receiving unit and transmitting unit in the at least one transport element may be configured such that the receiving unit is capable of receiving the wireless signal when the at least one transport element with the signal generator generating and transmitting the wireless signal is within a predetermined distance from the receiving unit. Such a predetermined distance can be selected by taking into account the type of wireless signal that the signal generator transmits and the medium through which the wireless signal will be travelling, and regulating the strength of the transmitted wireless signal accordingly.

[0008] The well bore may be provided with a plurality of centralizers where the centralizers are signally connected, either through one or more signal cables or through wireless communication, such that when the receiving unit of a first centralizer receives the wireless signal, the signal is forwarded to at least one, but preferably all the remaining centralizers which will initiate centralizing of the respective casings on which they are mounted.

[0009] The wireless signal is preferably a non-electromagnetic signal and can be in the form of a pressure wave which preferably is a sound wave or a sound signal.

[0010] The transport element is preferably pumped down the well bore by using a fluid, for example the cement slurry which will be used to cement the casing in the well bore, but other fluids may also be used. If the transport element is pumped by using cement slurry, the transport element may be the viper plug which is commonly used to separate the cement slurry from other well fluids since the signal generator can easily be incorporated in a viper plug.

[0011] There is further provided a centralizer system for centralizing a casing in a well bore before cementing of the casing in the well bore, where the centralizer system comprises:

- at least one centralizer which is adapted for mounting on the casing, the at least one centralizer comprising a receiving unit capable of receiving a wireless signal in form of a pressure wave,
- a wireless signal generator which is adapted for transport down the well bore and for generation and transmission of a wireless signal in form of a pressure wave which the receiving unit of the at least one centralizer is capable of receiving,

wherein the at least one centralizer is configured such that the at least one centralizer is activated for centralizing of the casing when the receiving unit receives a wireless signal transmitted by the signal generator.

[0012] The signal generator is transported down the well bore and the signal generator is in that case adapted for transport down the well bore. Alternatively, to protect the signal generator, the centralizer system may further comprise a transport element, where the transport element comprises the signal generator.

[0013] The signal generator may be configured to start generating and transmitting the wireless signal when a certain criteria is met. For example, the centralizer system may be provided with a pressure sensor which can be comprised in the signal generator or in the transport element if the signal generator is provided in a transport element, where the signal generator is configured to be activated when the pressure in the fluid in well bore exceeds a predetermined value. The pressure sensor is configured and positioned such that it is capable of measuring the pressure in the well fluid surrounding the signal generator or the transport element when the signal generator is provided in a transport element. Alternatively, the centralizer system may comprise a temperature sensor which can be comprised in the signal generator or the transport element if the signal generator is provided in a transport element, where the signal generator is configured to be activated when the temperature in the well bore exceeds a predetermined value. The temperature sensor is configured and positioned such that it is capable of measuring the temperature in the well fluid surrounding the signal generator or the transport element when the signal generator is provided in a transport element.

[0014] The centralizer system may also comprise both a temperature sensor and a pressure sensor which are preferably comprised in the signal generator or the transport element if the signal generator is provided in a transport element, where the signal generator is configured to be activated when the temperature or the pressure in the fluid in the well bore surrounding the signal generator or the transport element exceeds a predetermined value, whichever of the two (i.e. the pressure or the temperature) reaches its predetermined value first. By using both a pressure sensor and a temperature sensor, the probability that the signal generator is not activated is considerably reduced.

[0015] Alternatively, the at least one centralizer and/or the casing and/or the signal generator or the transport

element if the signal generator is provided in a transport element, may be provided with a mechanical device which activates the signal generator when the signal generator arrives at the casing. As mentioned above, one option would be to include a spring-loaded mechanical trigger in a stop element in the casing, for example the casing shoe. The mechanical trigger may be a spring-loaded, pivotable lever, a switch or a similar element which is arranged to trigger the signal generator. When the signal generator or the transport element in which the signal generator is arranged, hits the casing shoe, a mechanical trigger such as a spring-loaded, pivotable lever, triggers the signal generator which will start to generate and transmit the wireless signal. The mechanical trigger may be arranged in the signal generator or the transport element and be configured such that the signal generator is triggered to start generating the wireless signal when the casing shoe is hit.

[0016] The mechanical triggering of the signal generator may obviously be used in combination with a pressure sensor and/or a temperature sensor as described above such that the triggering of the signal generator is done by the surrounding pressure and/or temperature reaching the predetermined value. If the pressure and/or the temperature in the fluid surrounding the signal generator or the transport element if the signal generator is provided in a transport element, fail to reach their predetermined value or values, the mechanical device for triggering of the signal generator can serve as a fail safe device to make sure that the signal generator is triggered to start generating and transmitting the wireless signal such that the centralizer centralizes the casing before the casing is cemented.

[0017] The centralizer system may comprise a plurality of centralizers where the centralizers are signally connected such that when the receiving unit of a first centralizer receives the wireless signal, the signal is forwarded to at least one of the remaining centralizers which will initiate centralizing of the casing on which it is mounted.

[0018] The wireless signal is preferably a pressure wave in form of a sound signal, i.e. the signal generator generates a sound signal which is received by the receiving unit whereby the centralizer will be activated for centralizing of the casing.

[0019] The signal generator may be provided in a transport element for safe transport through the well. When the cement slurry is pumped down the well, viper plugs are usually provided to separate the cement slurry from the other fluids in the well. The transport element may therefore be a viper plug, i.e. the signal generator may be embedded in a viper plug, preferably a viper plug which precedes the cement slurry through the well.

[0020] There is further provided for the use of a wireless signal to initiate the centralizing of a casing in a well bore before cementing of the casing, wherein the wireless signal is in the form of a pressure wave. The pressure wave is generated by a signal generator and received by a receiving unit which is capable of detecting the pressure

wave and upon detecting the wireless signal, i.e. the pressure wave, a centralizer, which is mounted on the casing, is activated for centralizing of the casing. The pressure wave is preferably a sound wave.

[0021] The centralizer may comprise a centralizer body which is mountable on a casing, for example by bolts, by welding or by any other suitable fastening methods. The centralizer further comprises at least one, but preferably three or more centralizing elements which are attached to the centralizer body and which are movable in radial or partially radial direction such that the centralizing elements engage with the formations in the well bore and thereby centralizes the casing before the casing is cemented in the bore hole.

[0022] The receiving unit may be mounted to or be an integral part of the centralizer body. The receiving unit is signally connected to the actuator, either with signal cables or by means of wireless communication such as blue tooth. The receiving unit is configured to be capable of receiving the wireless signals transmitted by the signal generator. When the signal generator transmits the wireless signal as the signal generator is moving down through the well or as it arrives at the casing, the receiving unit receives the wireless signal transmitted by the signal generator and then sends a signal to the actuator which will actuate the centralizing elements which will be moved in a radial or partially radial direction relative to the casing and engage with the formations of the well bore such that the casing is centralized in the well bore. Thereafter, cement is flowed through the casing and into the annulus for cementing of the casing to the surrounding formations of the well bore.

[0023] If desired the receiving unit or the actuator may also be configured to send a signal, either through a communication cable or wirelessly, to a control central when the centralizing elements have been actuated, whereby an operator is informed that the casing has been centralized and the casing may be cemented in the well bore.

[0024] In an embodiment the at least one centralizing element may be rigid and movable in a radial or partially radial direction for engagement with the formations in the well bore. The centralizer system may further comprise a first link element and a second link element which are rotatably connected to the at least one centralizer element. One or both of the first link element and the second link element should be rotatably connected to the actuator device of the at least one actuator.

[0025] Alternatively, the at least one centralizing element may be radially flexible for engagement with the formations in the well bore. Preferably the at least one centralizing element comprises a first end and a second end where one or both of the first end and the second end is/are connected to the actuator device of the at least one actuator.

[0026] The actuator device of the at least one actuator may comprise a piston/cylinder arrangement. Alternatively the actuator device of the at least one actuator may comprise a rotatable shaft with left and right hand screw

threads which are in engagement with respectively the first link element and the second link element.

[0027] Preferably the centralizer comprises three or more centralizing elements. These centralizing elements are preferably equally spaced around the circumference of the centralizer body.

[0028] The centralizer system may comprise a control unit which is signally connected, either through signal cables or through wireless communication, to the receiving unit and to the actuator. When the receiving unit detects the wireless signal transmitted by the signal generator, a signal is sent to the control unit which in turn sends a signal to the actuator for actuation of the centralizing elements. The control unit may be a separate entity or may be integrated with the receiving unit.

[0029] In the following different embodiments of the present invention will be described with reference to the drawings where

Figure 1 schematically illustrates a first embodiment of a centralizer mounted on a casing and in an active position.

Figure 2 schematically illustrates the first embodiment of the centralizer in an inactive position and mounted on a casing which is positioned in a well bore.

Figure 3 schematically illustrates the first embodiment of the centralizer shown in figure 2 in an active position.

Figure 4 schematically illustrates a second embodiment of the centralizer in an inactive position and mounted on a casing.

Figure 5 schematically illustrates the second embodiment of the centralizer shown in figure 4 in an active position.

Figure 6 schematically illustrates the centralizer system with the signal generator arranged in a transport element.

Figure 7 schematically illustrates a variant of the centralizer system where the transport element is provided with a pressure sensor and a temperature sensor.

Figure 8 schematically illustrates a variant of the centralizer system which is a combination of the variants shown in figures 6 and 7.

[0030] The embodiments of the present invention described in detail below are similar and the same reference numbers are used on the drawings for the same features of the two embodiments. It should be understood that the embodiments shown in the figures are schematically

drawn and only the features necessary for the understanding of the invention are included in the figures. The first five figures show two possible embodiments of the centralizer, while the last two figures relates to the centralizer system.

[0031] Referring to figures 1-3 there is shown a first embodiment of a centralizer 12 which comprises a centralizer body 18 which is mounted on a casing 14. The centralizer 12 is mounted on the casing before the casing is lowered into the well bore 15, for example by clamping, bolting, welding or any other suitable ways of attaching the centralizer body 18, and thereby the centralizer 12, to the casing 14. When the casing with the centralizer 12 is lowered into the well bore 15, the centralizer is in an inactive position as shown in Figure 2. When the casing is in the desired position in the well bore, the centralizer can be actuated and then assumes an active position as shown in Figure 3 where the centralizer 12 has centralized the casing 14 in the well bore 15.

[0032] The centralizer 12 comprises at least one, but preferably three or more centralizing elements 20 with a first end portion 21 and a second end portion 22, and an actuator 36 comprising an actuator device 37. The centralizing elements 20 are preferably spaced equally around the centralizer body 18 in a circumferential direction. The actuator actuates a radial or partially radial movement of the centralizing elements 20 as will be explained below. A movement of the centralizing elements 20 in a partially radial direction means that the movement of the centralizing element 20 has a radial component as well as an axial component relative to the longitudinal axis A of the casing 14.

[0033] The centralizer further comprises a first link element 24 with a first end portion 25 and a second end portion 26 and a second link element 28 with a first end portion 29 and a second end portion 30. The first end portions 21 of the centralizing elements 20 are rotatably connected to respective first end portions 25 of the first link elements 24, and the second end portions 22 of the centralizing elements 20 are rotatably connected to respective second end portions 29 of the second link elements 28.

[0034] The second end portion 25 of the first link element 24 is rotatably connected to the centralizer body 18 or to the actuator device 37. The second end portion 30 of the second link element 28 is rotatably connected to the centralizer body 18 or to the actuator device 37. Either one or both of the second end portion 25 of the first link element 24 and the second end portion 30 of the second link element 28 is/are connected to the actuator device 37.

[0035] For centralizing of the casing the actuator 36 actuates the actuator device 37 which causes the axial distance between the second end portion 25 of the first link element 24 and the second end portion 30 of the second link element 28 to be reduced.

[0036] The actuating device 37 may for example be formed as a piston/cylinder arrangement where the sec-

ond end portions 25, 30 of the first link element 24 and the second link element 28 are connected respectively to the piston and the cylinder. When the length of the piston/cylinder arrangement is reduced, the centralizing element 20 will be forced out and will engage with the wall 16 of the well bore.

[0037] The actuating device 37 may also be in the form of a rotatable shaft with left and right hand screw threads which are in engagement with the second end portions 25, 30 of the first link element 24 and the second link element 28 respectively in a similar way to a rack and pinion gear. When the shaft is rotated such that the second end portions 25, 30 of the first link element 24 and the second link element 28 are moved towards each other, the centralizing element 20 is moved in a radial direction relative to the axis A and engages with the wall 16 of the well bore 15, whereby the casing is centralized.

[0038] Another option to effect a radial or a partially radial movement of the centralizing elements 20 shown in Figures 1-3 would be to use a pair of wedge shaped surfaces which are adapted for axial movement which will simultaneously cause a radial movement. Each centralizing element 20 may be formed with a first wedge surface which is arranged with an acute angle relative to the longitudinal axis A, and the centralizer body 18 may be formed with a corresponding second wedge surface. When the centralizing elements 20 are moved in the axial direction by the actuator device 17, the centralizing elements will simultaneously be moved in a radial direction due to the wedging effect until they engage with the wall 16 of the well bore 15. In order to provide only radial movement of the centralizing element 20, a separate wedge element could be arranged between the centralizing element 20 and the surface of the centralizer body which is inclined relative to the longitudinal axis A.

[0039] The centralizer system 10 further comprises a receiving unit 40. The receiving unit 40 is signally connected to the actuator 36 such that the receiving unit is capable of sending a signal to the actuator 36 which will cause the actuator device 37 to actuate the centralizing elements 20 so that the casing 14 is centralized in the well bore 15. The actuator device 40 may be connected to actuator 36 by means of a signal cable or by wireless communication such as blue tooth.

[0040] In Figures 4-5 a second embodiment of the centralizer is shown wherein the centralizing element 20 is made of a flexible material such as spring steel. In this embodiment the first end portion 21 and the second end portion 22 of the centralizing element 20 are preferably rotatably connected to the actuator device 37. The actuator device 37 may be a piston/cylinder arrangement or a rotatable shaft working in a similar way to a rack and pinion gear as explained above. The length of the actuator device 37 can thereby be reduced which forces the flexible centralizing element 20 to bend outwards and engage with the wall 16 of the well bore 15. As with the first embodiment of the present invention, there is provided at least one such flexible centralizing element, but

preferably three or more flexible centralizing elements 20 are provided equally spaced around the circumference of the centralizer body 18. As the flexible centralizing elements 20 engage with the wall of the well bore 15, the casing 14 on which the centralizer 12 is attached, is centralized in the well bore 15. The rest of the second embodiment of the invention, such as the receiving unit 40, is the same as the first embodiment of the invention shown in Figures 1-3 and the description of the common features are not repeated here.

[0041] The centralizer system shown in figures 6-8 illustrates the centralizer system 10 where a centralizer 12 of the same type as the centralizers described above, is mounted on the casing 14. As shown in figure 6, a transport element 43 is provided with a signal generator 42 which is capable of generating and transmitting a wireless signal in the form of a pressure wave, preferably a sound wave. The signal generator 42 may be turned on before the signal generator is moved down the well such that the wireless signal is transmitted constantly or intermittently as the transport element 43 moves down the well towards the casing 14. In figure 6, the casing is provided with one or more stop elements 13, for example one or more casing shoes, which a transport element 43 hits when the transport element arrives at the casing.

[0042] The signal generator may be turned on by a partly or completely mechanical device (not shown in the figures). One or more of the stop elements 13 or, more preferably, the transport element 43 may be provided with a mechanical element such as a spring-loaded lever, a button-like element, a switch or another type of mechanical device that is suitable for turning on the signal generator. As the lever is pivoted or the button-like element is pressed in when the transport element 43 hits the stop elements 13, the signal generator 42 may be turned on directly or the movement of the lever, the button-like element or the switch may generate a signal that in turn activates the signal generator. When the receiving unit 40 subsequently detects the wireless signal transmitted by the signal generator 42, the actuator 36 is activated and the centralizing of the casing 14 is performed.

[0043] The receiving unit 40 further comprises a control unit (not shown on the figures) which transmits a signal to the actuator 36 for actuation of the actuator device 37 as soon as the antenna or vibration/sound sensor 41 detects the wireless signal transmitted by the signal generator 42.

[0044] In figure 7 a variant of the centralizer system 10 is shown. The casing 14 is in this embodiment not provided with stop elements 13. Instead the transport element is provided with one or more sensors which are capable of measuring one or more physical parameters of the transport element's surrounding environment as the transport element is moved down the well. Typically such physical parameters could be the pressure and the temperature in the fluid surrounding the transport element. The temperature and the pressure of the well fluids in a well typically increases with the depth of the well,

and for any given well, the signal generator may be set to start operating when the temperature and/or the pressure in the fluid surrounding the transport element reach a predetermined value. To monitor the temperature and/or the pressure the transport element 43 may therefore be provided with a temperature sensor 44 and/or a pressure sensor 45 which is capable of measuring the temperature and pressure of the fluid surrounding the transport element 43 respectively. The embodiment of the transport element 43 shown in figure 7 is provided with both a temperature sensor 44 and a pressure sensor 45, but could have been provided with only a temperature sensor 44 or only a pressure sensor 45 depending on the situation. However, providing the transport element with both a temperature sensor and a pressure sensor will provide a considerably reduced risk that the signal generator 43 is not activated.

[0045] In figure 8 a variant of the centralizer system 10 is shown where the casing 14 is provided with stop elements 13, typically a casing shoe. The centralizer system may therefore be provided with a mechanical device which starts the signal generator 42 when the transport element 43 hits the stop elements in the same way as explained in detail above. The transport element 43 is also provided with sensors 44, 45 which are capable of measuring physical parameters of the fluid surrounding the transport element, for example temperature and/or pressure, as explained above. The signal generator 42 of the centralizing system 10 shown in figure 8 can therefore be activated by the temperature in the fluid surrounding the transport element 43 reaching a predetermined value or the pressure in the fluid surrounding the transport element 43 reaching a predetermined value or mechanically when the transport element 43 hits the stop elements 13 in the casing 14.

[0046] When the casing is cemented, the cement slurry is usually preceded by a viper plug which separates the cement slurry 51 from the well fluids 50 in front of the cement slurry. A viper plug may therefore conveniently be used as a transport element for the signal generator. The signal generator 42 is integrated in the viper plug which will protect the signal generator from environmental hazards and prevent the signal generator from getting damaged as it is transported or pushed down the well by the cement slurry towards the casing 14 with the casing centralizer 12.

[0047] The receiving unit 40 further comprises a control unit (not shown in the figures) which transmits a signal to the actuator 36 for actuation of the actuator device 37 as soon as the antenna 44 detects and reads (identifies).

[0048] In use, the centralizer system 10 works as follows. A centralizer 12 as shown in figures 1-3 or figures 4-5 is attached to the casing 14 which is to be centralized in the well bore 15. The casing 14, together with the attached centralizer 12 in an inactive position is lowered to the desired position in the well bore 15. This is shown in Figure 2 where the casing 14 with the centralizer 12 in the inactive position is not centralized in the well bore

15. A signal generator 42, which is moved down the well in a direction 48, preferably by the cement slurry which is later used to cement the casing to the formations in the well bore, generates and transmits a wireless signal in the form of a pressure wave, such as a sound wave. The pressure waves are detected by the receiving unit 40 which then sends a signal to the actuator 36 whereby the centralizing elements 20 are moved radially until they are in engagement with the wall 16 of the well bore 15. This is shown in Figure 3 where the centralizer 12 is in an active position and the casing 14 is positioned centrally in the well bore 15. When the casing 14 has been centralized by the centralizer 12, cement 51 may be flowed through the casing 14 and up the annulus between the casing and the formations for cementing of the casing as indicated in Figure 3.

[0049] For all embodiments of the invention, the centralizer system is based on the fact that the receiving unit 40 and the signal generator 42 are cooperatively configured, i.e. the signal generator generates and transmits a wireless signal, in the form of a pressure wave such as a sound wave, which the receiving unit is capable of receiving. The receiving unit 40 may be provided with an antenna 41 or another device or sensor capable of detecting the wireless signal transmitted by the signal generator 42. When the signal generator 42 is within a distance of the receiving unit 40 where the receiving unit 40 is capable of detecting the wireless signal that is transmitted by the signal generator, the receiving unit will transmit a signal to the actuator 36 so that centralizing of the casing 14 is carried out.

[0050] The present centralizer system 10 is described above with various ways of ensuring that the signal generator 12 is activated such that the casing centralizer is activated and the casing 14 is centralized before the casing 14 is cemented in its position in the well bore. It should be understood that the signal generator 42 may be transported down the well, either integrated in a transport element 42, such as a viper plug, or as a separate entity, such that the wireless signal, for example in the form of pressure waves produced by the signal generator 42 are transmitted down the well. When the signal generator 42 is transported down the well, it may be operating and transmitting pressure waves from the moment it is entered the well at the top of the well, or the signal generator 42 may be activated in different ways as the signal generator approaches the casing 14, not only by using temperature sensors, pressure sensors or mechanical devices as explained above, but also other feasible devices such as an inductive coil.

[0051] It should be understood that the claimed invention is not limited to the embodiments described above, since many modifications may be carried out within the range of the claims. The scope of the claimed invention is thus limited only by the claims.

Claims

1. Method for centralizing a casing (14) in a well bore (15) before cementing of the casing in the well bore, the method comprising the steps of:

mounting at least one centralizer (12) on the casing (14), the at least one centralizer (12) comprising a receiving unit (40) capable of receiving a wireless signal in form of a pressure wave, positioning the casing (14) in the well bore (15) at a desired position, providing a wireless signal generator (42) for generation and transmission of a wireless signal in form of a pressure wave which the receiving unit (40) of the at least one centralizer (12) is capable of receiving,

characterized in that the signal generator (42) is transported down the well bore (15) towards the casing and the signal generator (42) is activated such that the signal generator transmits the wireless signal and whereafter the receiving unit (40), on reception of the wireless signal, activates the at least one centralizer (12) and the at least one centralizer (12) centralizes the casing (14) in the well bore (15).
 2. Method according to claim 1, wherein a transport element (43) is transported down the well bore, the transport element (43) comprising the signal generator (12).
 3. Method according to one of the claims 1-2, wherein the signal generator (42) is triggered to start transmitting the wireless signal as the signal generator (42) is approaching the casing (14) or upon arrival at the casing (14).
 4. Method according to one of the claims 1-3, wherein the signal generator (42) is triggered to start transmitting said wireless signal when the pressure in the well fluids surrounding the at least one transport element (43) exceeds a predetermined value.
 5. Method according to one of the claims 1-3, wherein the signal generator (42) is triggered to start transmitting said wireless signal when the temperature in the well fluids surrounding the at least one transport element (43) exceeds a predetermined value.
 6. Method according to one of the claims 1-3, wherein the signal generator (42) is mechanically triggered to start transmitting said wireless signal when the signal generator (43) arrives at the casing (14).
 7. Method according one of the claims 1-2,
- wherein the signal generator (42) in the transport element (43) continuously or intermittently transmits the wireless signal while being transported through the well bore (15).
8. Method according to one of the claims 1-7, wherein a plurality of centralizers (12) are provided in the well bore (15) and that the centralizers (12) are signally connected such that when the receiving unit (40) of a first centralizer (12) receives said wireless signal, the signal is forwarded to at least one of the remaining centralizers (12) which will initiate centralizing of the casing (14) on which it is mounted.
 9. Method according to one of the claims 1-8, wherein the pressure wave is a sound signal.
 10. Method according to one of the claims 1-9, wherein the transport element (43) is pumped down the well bore by cement slurry.
 11. Method according to one of the claims 1-10, wherein transport element (43) is a viper plug.
 12. A centralizer system (10) for centralizing a casing (14) in a well bore (15) before cementing of the casing (14) in the well bore (15), the centralizer system (10) comprising:

at least one centralizer (12) which is adapted for mounting on the casing (14), the at least one centralizer (12) comprising a receiving unit (40) capable of receiving a wireless signal in form of pressure waves, wherein the at least one centralizer (12) is configured such that the centralizer (12) is activated for centralizing of the casing (14) when the receiving unit (40) receives the wireless signal transmitted by a signal generator (42)

characterized in that the centralizer system (10) comprises a wireless signal generator (42) which is adapted for transport down the well bore (15) and for generation and transmission of the wireless signal in form of a pressure wave which the receiving unit (40) of the at least one centralizer (12) is capable of receiving.
 13. Centralizer system according to claim 12, **characterized in that** centralizer system (10) comprises a transport element (43), the transport element (43) comprising the signal generator (42).
 14. Centralizer system according to one of the claims 12-13, **characterized in that** the centralizer system (10) comprises a pressure sensor (45) comprised in the signal generator (42) or the transport element (43), the signal generator (42) being adapted to be acti-

vated when the pressure in the well bore (15) exceeds a predetermined value.

15. Centralizer system according to one of the claims 12-14,
5
characterized in that the centralizer system (10) comprises a temperature sensor (44) comprised in the signal generator (42) or the transport element (43), the signal generator (42) being adapted to be activated when the temperature in the well bore (15) exceeds a predetermined value.
10
16. Centralizer system according to one of the claims 12-14,
15
characterized in that the at least one centralizer (12) and/or the signal generator (42) and/or the transport element (43) is provided with a mechanical device which activates the signal generator (42) when the signal generator arrives at the casing (14).
20
17. Centralizer system according to one of the claims 12-15,
25
characterized in that the centralizer system (10) comprises a plurality of centralizers (12) and that the centralizers (12) are signally connected such that when the receiving unit (40) of a first centralizer (12) receives said wireless signal, the signal is forwarded to at least one of the remaining centralizers (12) which will initiate centralizing of the casing (14) on which it is mounted.
30
18. Centralizer system according to one of the claims 12-17,
35
characterized in that the pressure wave is a sound signal.
19. Centralizer system according to one of the claims 12-18,
40
characterized in that the transport element (43) is a viper plug.
20. Use of a method according to any one of claims 1-11 to initiate the centralizing of a casing (14) in a well bore (15) before cementing of the casing (14), wherein the wireless signal is in the form of a pressure wave and the wireless signal is transmitted by the signal generator (42) that is transported down the well bore (15).
45
21. Use of a system according to any one of claims 12-19 to initiate the centralizing of a casing (14) in a well bore (15) before cementing of the casing (14), wherein the wireless signal is in the form of a pressure wave and the wireless signal is transmitted by the signal generator (42) that is transported down the well bore (15).
50
22. Use of a wireless signal according to claim 20 or 21,

wherein the pressure wave is a sound wave.

Patentansprüche

1. Verfahren zum Zentrieren eines Futterrohrs (14) in einem Bohrloch (15) vor dem Einzementieren des Futterrohrs im Bohrloch, wobei das Verfahren die folgenden Schritte umfasst:
10
 Montieren von wenigstens einer Zentriereinrichtung (12) am Futterrohr (14), wobei die wenigstens eine Zentriereinrichtung (12) eine Empfangseinheit (40) umfasst, die imstande ist, ein Drahtlossignal in Form einer Druckwelle zu empfangen,
 Positionieren des Futterrohrs (14) in dem Bohrloch (15) an einer gewünschten Position,
 Bereitstellen eines Drahtlossignalgenerators (42) zum Generieren und Übertragen eines Drahtlossignals in Form einer Druckwelle, welche die Empfangseinheit (40) der wenigstens einen Zentriereinrichtung (12) zu empfangen imstande ist, **dadurch gekennzeichnet, dass** der Signalgenerator (42) in dem Bohrloch (15) zum Futterrohr hinunterbefördert wird und der Signalgenerator (42) aktiviert wird, sodass der Signalgenerator das Drahtlossignal überträgt, wonach die Empfangseinheit (40) beim Empfang des Drahtlossignals die wenigstens eine Zentriereinrichtung (12) aktiviert und die wenigstens eine Zentriereinrichtung (12) das Futterrohr (14) in dem Bohrloch (15) zentriert.
30
2. Verfahren nach Anspruch 1, wobei ein Beförderungselement (43) in dem Bohrloch hinunterbefördert wird, wobei das Beförderungselement (43) den Signalgenerator (12) umfasst.
35
3. Verfahren nach einem der Ansprüche 1 bis 2, wobei der Signalgenerator (42) ausgelöst wird, um die Übertragung des Drahtlossignals zu starten, wenn sich der Signalgenerator (42) dem Futterrohr (14) nähert oder beim Futterrohr (14) eintrifft.
45
4. Verfahren nach einem der Ansprüche 1 bis 3, wobei der Signalgenerator (42) ausgelöst wird, um die Übertragung des Drahtlossignals zu starten, wenn der Druck in den Bohrlochflüssigkeiten, die das wenigstens eine Beförderungselement (43) umgeben, einen vorbestimmten Wert übersteigt.
50
5. Verfahren nach einem der Ansprüche 1 bis 3, wobei der Signalgenerator (42) ausgelöst wird, um die Übertragung des Drahtlossignals zu starten, wenn die Temperatur der Bohrlochflüssigkeiten, die das wenigstens eine Beförderungselement (43) um-

geben, einen vorbestimmten Wert übersteigt.

6. Verfahren nach einem der Ansprüche 1 bis 3,
wobei der Signalgenerator (42) mechanisch ausge-
löst wird, um die Übertragung des Drahtlossignals
zu starten, wenn der Signalgenerator (43) beim Fut-
terrohr (14) eintrifft. 5
7. Verfahren nach einem der Ansprüche 1 bis 2,
wobei der Signalgenerator (42) in dem Beförde-
rungselement (43) das Drahtlossignal kontinuierlich
oder intermittierend überträgt, während er durch das
Bohrloch (15) befördert wird. 10
8. Verfahren nach einem der Ansprüche 1 bis 7,
wobei eine Vielzahl von Zentriereinrichtungen (12)
in dem Bohrloch (15) vorgesehen ist und die Zen-
triereinrichtungen (12) signalmäßig derart verbun-
den sind, dass, wenn die Empfangseinheit (40) einer
ersten Zentriereinrichtung (12) das Drahtlossignal
empfängt, das Signal zu wenigstens einer der übrigen
Zentriereinrichtungen (12) weitergeleitet wird,
welche die Zentrierung des Futterrohrs (14) initiiert,
an dem sie montiert ist. 15 20
9. Verfahren nach einem der Ansprüche 1 bis 8,
wobei die Druckwelle ein Schallsignal ist. 25
10. Verfahren nach einem der Ansprüche 1 bis 9,
wobei das Beförderungselement (43) mittels Ze-
mentschlamm in dem Bohrloch hinuntergepumpt
wird. 30
11. Verfahren nach einem der Ansprüche 1 bis 10,
wobei das Beförderungselement (43) ein Viper Plug
ist. 35
12. Zentriersystem (10) zum Zentrieren eines Futter-
rohrs (14) in einem Bohrloch (15) vor dem Einze-
mentieren des Futterrohrs (14) in dem Bohrloch (15),
wobei das Zentriersystem (10) Folgendes umfasst: 40

wenigstens eine Zentriereinrichtung (12), die
dafür eingerichtet ist, an dem Futterrohr (14)
montiert zu werden, wobei die wenigstens eine
Zentriereinrichtung (12) eine Empfangseinheit
(40) umfasst, die imstande ist, ein Drahtlossig-
nal in Form von Druckwellen zu empfangen,
wobei die wenigstens eine Zentriereinrichtung
(12) derart ausgebildet ist, dass die Zentrierein-
richtung (12) aktiviert wird, um das Futterrohr
(14) zu zentrieren, wenn die Empfangseinheit
(40) das Drahtlossignal empfängt, das durch ei-
nen Signalgenerator (42) übertragen wird,
dadurch gekennzeichnet, dass das Zentrier-
system (10) einen Drahtlossignalgenerator (42)
umfasst, der dafür eingerichtet ist, in dem Bohr-
loch (15) hinunterbefördert zu werden und das 45 50 55

Drahtlossignal in Form einer Druckwelle, das die
Empfangseinheit (40) der wenigstens einen
Zentriereinrichtung (12) zu empfangen imstan-
de ist, zu generieren und zu übertragen.

13. Zentriersystem nach Anspruch 12,
dadurch gekennzeichnet, dass das Zentriersys-
tem (10) ein Beförderungselement (43) umfasst, wo-
bei das Beförderungselement (43) den Signalgene-
rator (42) umfasst.
14. Zentriersystem nach einem der Ansprüche 12 bis 13,
dadurch gekennzeichnet, dass das Zentriersys-
tem (10) einen Drucksensor (45) umfasst, der in dem
Signalgenerator (42) oder dem Beförderungsele-
ment (43) enthalten ist, wobei der Signalgenerator
(42) dafür eingerichtet ist, aktiviert zu werden, wenn
der Druck in dem Bohrloch (15) einen vorbestimmten
Wert übersteigt.
15. Zentriersystem nach einem der Ansprüche 12 bis 14,
dadurch gekennzeichnet, dass das Zentriersys-
tem (10) einen Temperatursensor (44) umfasst, der
in dem Signalgenerator (42) oder dem Beförde-
rungselement (43) enthalten ist, wobei der Signal-
generator (42) dafür eingerichtet ist, aktiviert zu wer-
den, wenn die Temperatur in dem Bohrloch (15) ei-
nen vorbestimmten Wert übersteigt.
16. Zentriersystem nach einem der Ansprüche 12 bis 14,
dadurch gekennzeichnet, dass die wenigstens ei-
ne Zentriereinrichtung (12) und/oder der Signalge-
nerator (42) und/oder das Beförderungselement (43)
mit einer mechanischen Vorrichtung versehen ist,
die den Signalgenerator (42) aktiviert, wenn der Si-
gnalgenerator beim Futterrohr (14) eintrifft.
17. Zentriersystem nach einem der Ansprüche 12 bis 15,
dadurch gekennzeichnet, dass das Zentriersys-
tem (10) eine Vielzahl von Zentriereinrichtungen (12)
umfasst und dass die Zentriereinrichtungen (12) si-
gnalmäßig derart verbunden sind, dass, wenn die
Empfangseinheit (40) einer ersten Zentriereinrich-
tung (12) das Drahtlossignal empfängt, das Signal
zu wenigstens einer der übrigen Zentriereinrich-
tungen (12) weitergeleitet wird, welche die Zentrierung
des Futterrohrs (14) initiiert, an dem sie montiert ist.
18. Zentriersystem nach einem der Ansprüche 12 bis 17,
dadurch gekennzeichnet, dass die Druckwelle ein
Schallsignal ist.
19. Zentriersystem nach einem der Ansprüche 12 bis 18,
dadurch gekennzeichnet, dass das Beförderungs-
element (43) ein Viper Plug ist.
20. Verwendung eines Verfahrens nach einem der An-
sprüche 1 bis 11 zum Initiieren des Zentrierens eines

Futterrohrs (14) in einem Bohrloch (15) vor dem Einzementieren des Futterrohrs (14), wobei das Drahtlossignal in Form einer Druckwelle vorliegt und das Drahtlossignal durch den Signalgenerator (42) übertragen wird, der das Bohrloch (15) hinunterbefördert wird.

21. Verwendung eines Systems nach einem der Ansprüche 12 bis 19 zum Initiieren des Zentrierens eines Futterrohrs (14) in einem Bohrloch (15) vor dem Einzementieren des Futterrohrs (14), wobei das Drahtlossignal in Form einer Druckwelle vorliegt und das Drahtlossignal durch den Signalgenerator (42) übertragen wird, der das Bohrloch (15) hinunterbefördert wird.

22. Verwendung eines Drahtlossignals nach Anspruch 20 oder 21, wobei die Druckwelle eine Schallwelle ist.

Revendications

1. Procédé pour centrer un tubage (14) dans un trou de forage (15) avant la cimentation du tubage dans le trou de forage, le procédé comprenant les étapes :

de montage d'au moins un centreur (12) sur le tubage (14), ledit au moins un centreur (12) comprenant une unité de réception (40) capable de recevoir un signal de liaison sans fil sous la forme d'une onde de pression, de positionnement du tubage (14) dans le trou de forage (15) à une position souhaitée, de fourniture d'un générateur de signal de liaison sans fil (42) pour la génération et la transmission d'un signal de liaison sans fil sous la forme d'une onde de pression que l'unité de réception (40) dudit au moins un centreur (12) est capable de recevoir,

caractérisé en ce que le générateur de signal (42) est transporté le long du trou de forage (15) vers le tubage et le générateur de signal (42) est activé de sorte que le générateur de signal transmette le signal de liaison sans fil et après cela l'unité de réception (40), lors de la réception du signal de liaison sans fil, active ledit au moins un centreur (12) et ledit au moins un centreur (12) centre le tubage (14) dans le trou de forage (15).

2. Procédé selon la revendication 1, dans lequel un élément de transport (43) est transporté le long du trou de forage, l'élément de transport (43) comprenant le générateur de signal (12).

3. Procédé selon l'une des revendications 1 et 2, dans lequel le générateur de signal (42) est déclen-

ché pour débiter la transmission du signal de liaison sans fil alors que le générateur de signal (42) s'approche du tubage (14) ou lorsqu'il arrive au niveau du tubage (14).

4. Procédé selon l'une des revendications 1 à 3, dans lequel le générateur de signal (42) est déclenché pour débiter la transmission dudit signal de liaison sans fil lorsque la pression dans les fluides de puits entourant ledit au moins un élément de transport (43) dépasse une valeur prédéterminée.

5. Procédé selon l'une des revendications 1 à 3, dans lequel le générateur de signal (42) est déclenché pour débiter la transmission dudit signal de liaison sans fil lorsque la température des fluides de puits entourant ledit au moins un élément de transport (43) dépasse une valeur prédéterminée.

6. Procédé selon l'une des revendications 1 à 3, dans lequel le générateur de signal (42) est déclenché mécaniquement pour débiter la transmission dudit signal de liaison sans fil lorsque le générateur de signal (43) arrive au niveau du tubage (14).

7. Procédé selon l'une des revendications 1 et 2, dans lequel le générateur de signal (42) dans l'élément de transport (43) transmet continûment ou par intermittence le signal de liaison sans fil tandis qu'il est transporté à travers le trou de forage (15).

8. Procédé selon l'une des revendications 1 à 7, dans lequel une pluralité de centreurs (12) sont prévus dans le trou de forage (15) et les centreurs (12) sont connectés par signal de sorte que, lorsque l'unité de réception (40) d'un premier centreur (12) reçoit ledit signal de liaison sans fil, le signal est envoyé à au moins l'un des centreurs (12) restants qui lancera le centrage du tubage (14) sur lequel il est monté.

9. Procédé selon l'une des revendications 1 à 8, dans lequel l'onde de pression est un signal sonore.

10. Procédé selon l'une des revendications 1 à 9, dans lequel l'élément de transport (43) est descendu dans le trou de forage par le coulis de ciment.

11. Procédé selon l'une des revendications 1 à 10, dans lequel l'élément de transport (43) est un bouchon tête de vipère.

12. Système de centreur (10) pour centrer un tubage (14) dans un trou de forage (15) avant la cimentation du tubage (14) dans le trou de forage (15), le système de centreur (10) comprenant :

au moins un centreur (12) qui est conçu pour être monté sur le tubage (14), ledit au moins un

- centreur (12) comprenant une unité de réception (40) capable de recevoir un signal de liaison sans fil sous la forme d'ondes de pression, dans lequel ledit au moins un centreur (12) est configuré de sorte que le centreur (12) soit activé pour centrer le tubage (14) lorsque l'unité de réception (40) reçoit le signal de liaison sans fil transmis par un générateur de signal (42),
caractérisé en ce que le système de centreur (10) comprend un générateur de signal de liaison sans fil (42) qui est conçu pour être transporté le long du trou de forage (15) et pour la génération et la transmission du signal de liaison sans fil sous la forme d'une onde de pression que l'unité de réception (40) dudit au moins un centreur (12) est capable de recevoir.
13. Système de centreur selon la revendication 12, **caractérisé en ce que** le système de centreur (10) comprend un élément de transport (43), l'élément de transport (43) comprenant le générateur de signal (42).
14. Système de centreur selon l'une des revendications 12 et 13, **caractérisé en ce que** le système de centreur (10) comprend un capteur de pression (45) compris dans le générateur de signal (42) ou l'élément de transport (43), le générateur de signal (42) étant conçu pour être activé lorsque la pression dans le trou de forage (15) dépasse une valeur prédéterminée.
15. Système de centreur selon l'une des revendications 12 à 14, **caractérisé en ce que** le système de centreur (10) comprend un capteur de température (44) compris dans le générateur de signal (42) ou l'élément de transport (43), le générateur de signal (42) étant conçu pour être activé lorsque la température dans le trou de forage (15) dépasse une valeur prédéterminée.
16. Système de centreur selon l'une des revendications 12 à 14, **caractérisé en ce que** ledit au moins un centreur (12) et/ou le générateur de signal (42) et/ou l'élément de transport (43) est pourvu d'un dispositif mécanique qui active le générateur de signal (42) lorsque le générateur de signal arrive au niveau du tubage (14).
17. Système de centreur selon l'une des revendications 12 à 15, **caractérisé en ce que** le système de centreur (10) comprend une pluralité de centreurs (12) et **en ce que** les centreurs (12) sont connectés par signal de sorte que, lorsque l'unité de réception (40) d'un premier centreur (12) reçoit ledit signal de liaison sans
- fil, le signal est envoyé à au moins l'un des centreurs (12) restants qui lancera le centrage du tubage (14) sur lequel il est monté.
18. Système de centreur selon l'une des revendications 12 à 17, **caractérisé en ce que** l'onde de pression est un signal sonore.
19. Système de centreur selon l'une des revendications 12 à 18, **caractérisé en ce que** l'élément de transport (43) est un bouchon tête de vipère.
20. Utilisation d'un procédé selon l'une quelconque des revendications 1 à 11 pour lancer le centrage d'un tubage (14) dans un trou de forage (15) avant la cimentation du tubage (14), dans laquelle le signal de liaison sans fil est sous la forme d'une onde de pression et le signal de liaison sans fil est transmis par le générateur de signal (42) qui est transporté le long du trou de forage (15).
21. Utilisation d'un système selon l'une quelconque des revendications 12 à 19 pour lancer le centrage d'un tubage (14) dans un trou de forage (15) avant la cimentation du tubage (14), dans laquelle le signal de liaison sans fil est sous la forme d'une onde de pression et le signal de liaison sans fil est transmis par le générateur de signal (42) qui est transporté le long du trou de forage (15).
22. Utilisation d'un signal de liaison sans fil selon la revendication 20 ou 21, dans laquelle l'onde de pression est une onde sonore.

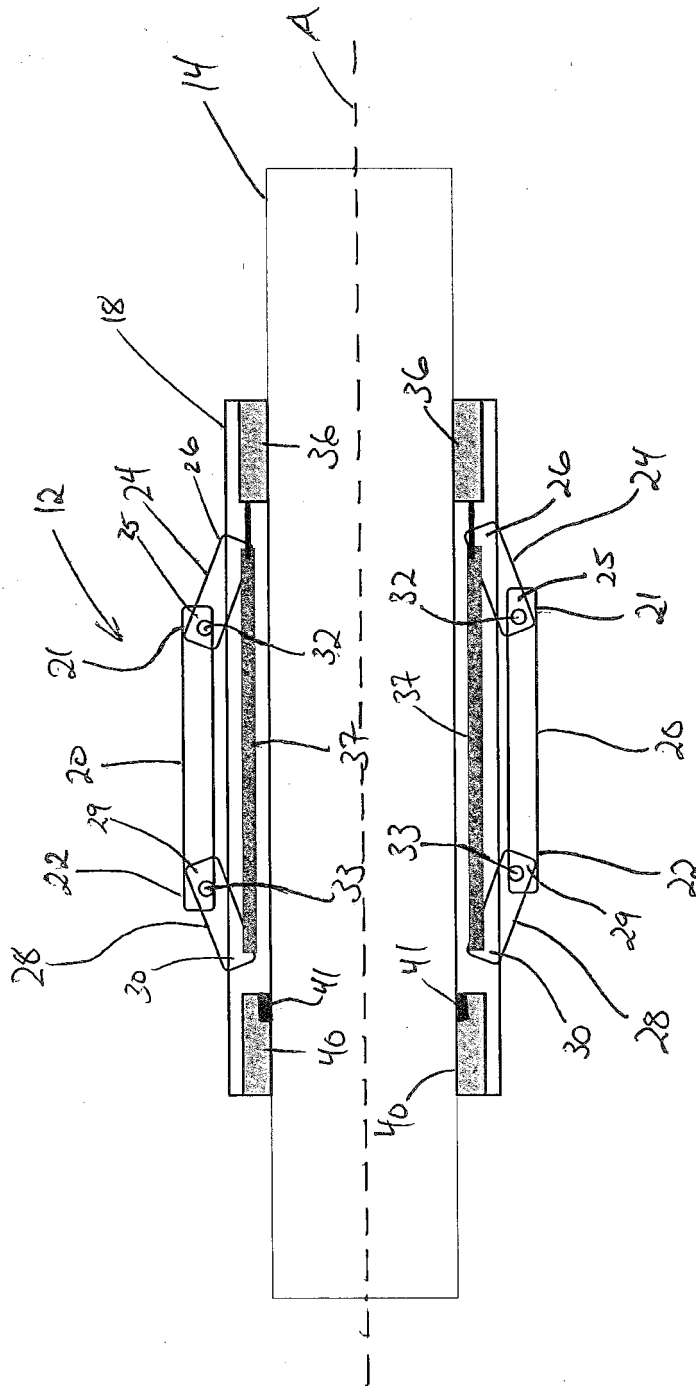


Fig. 1

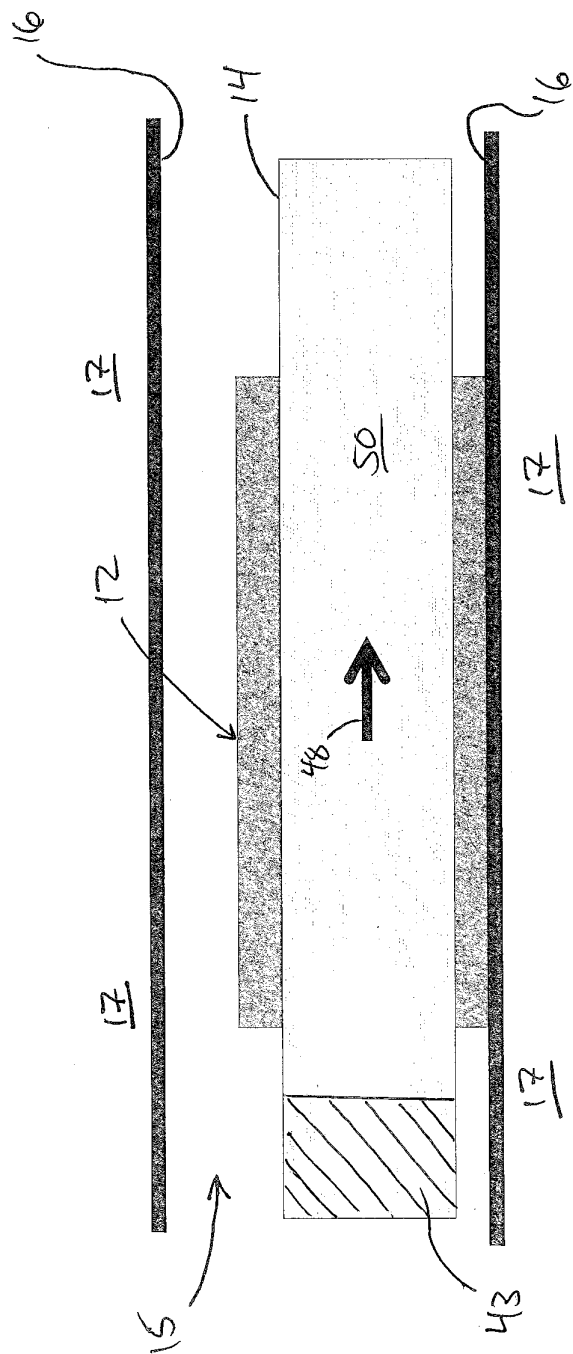


Fig. 2

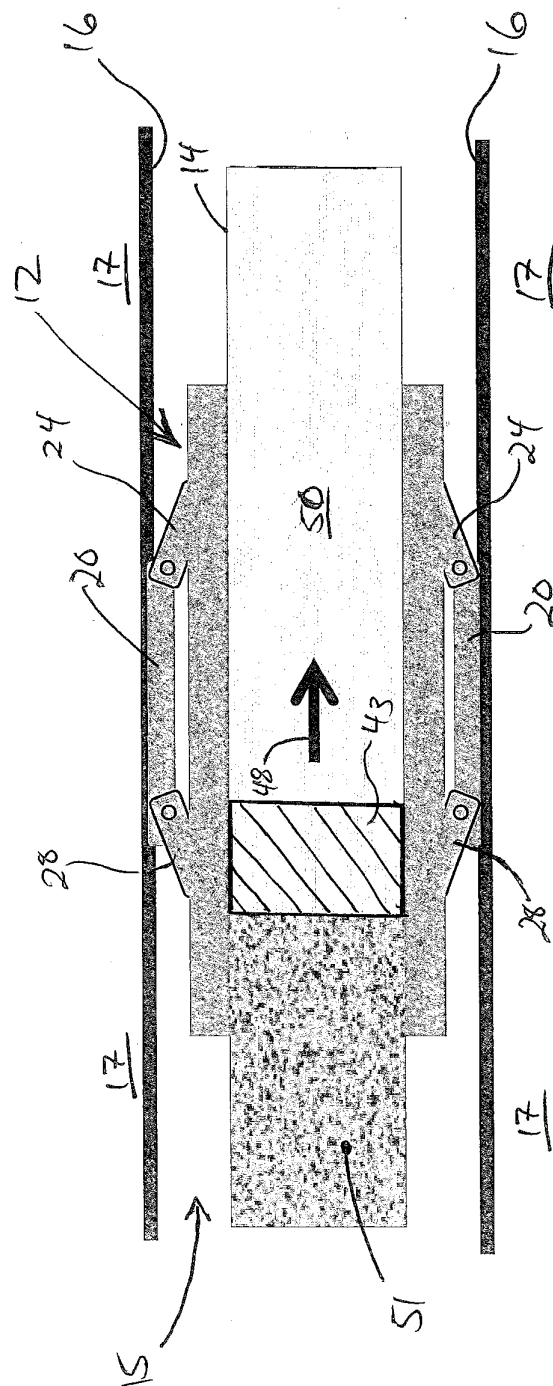
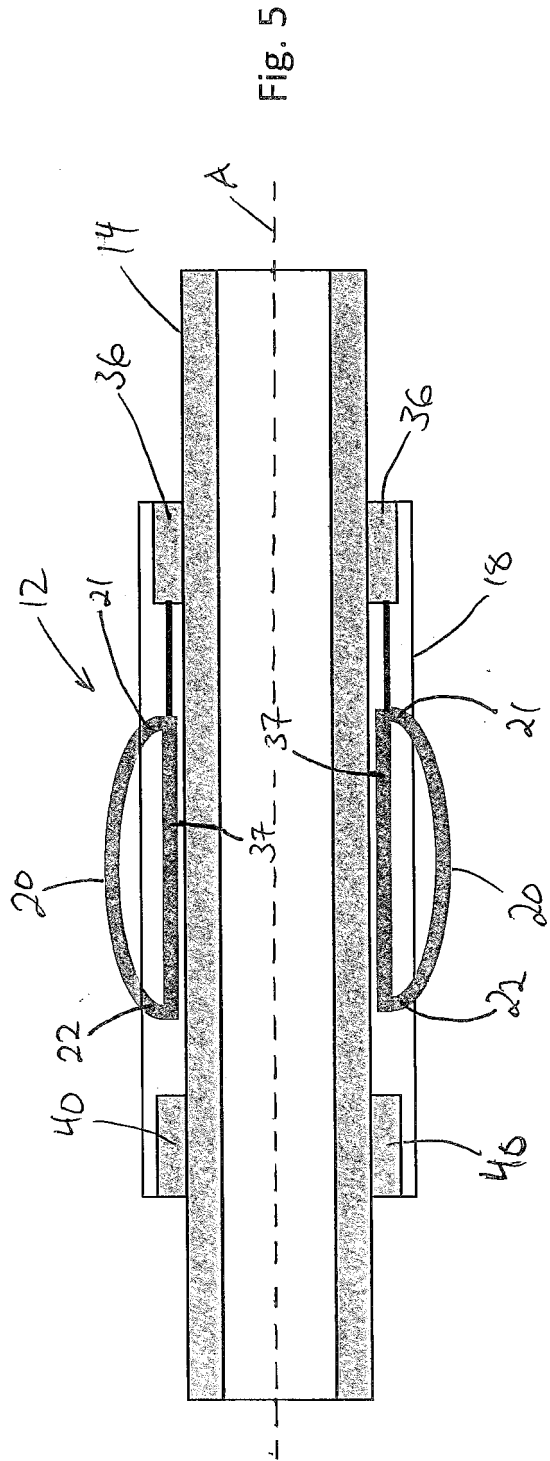
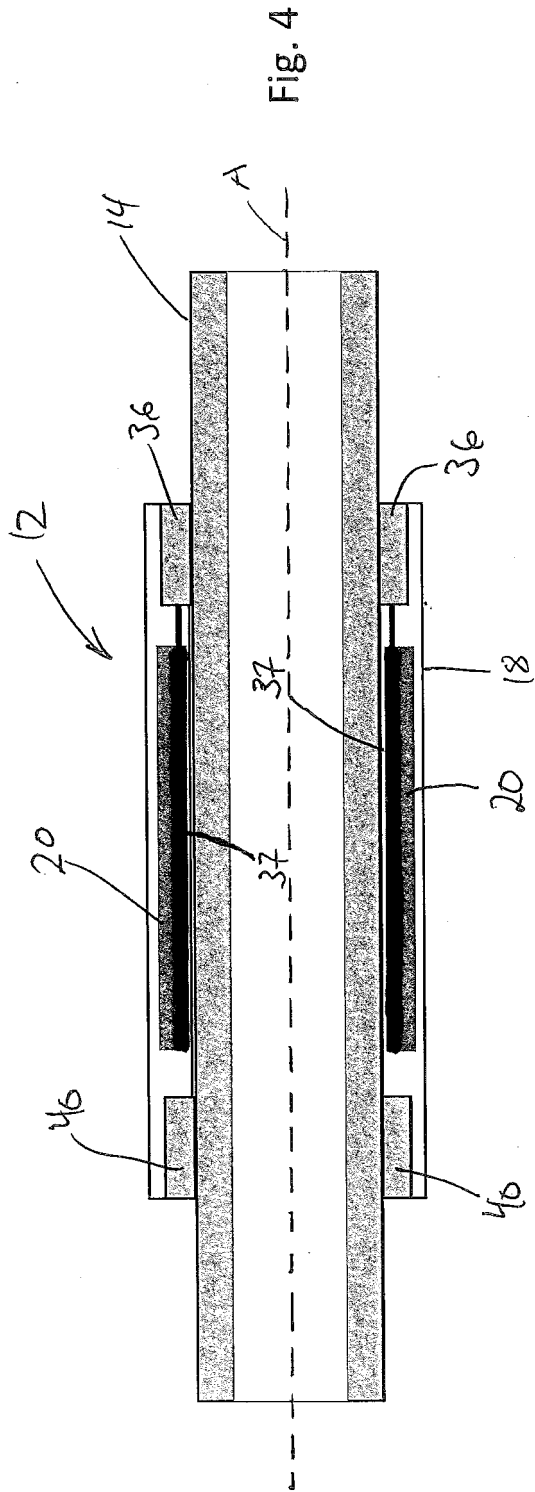


Fig. 3



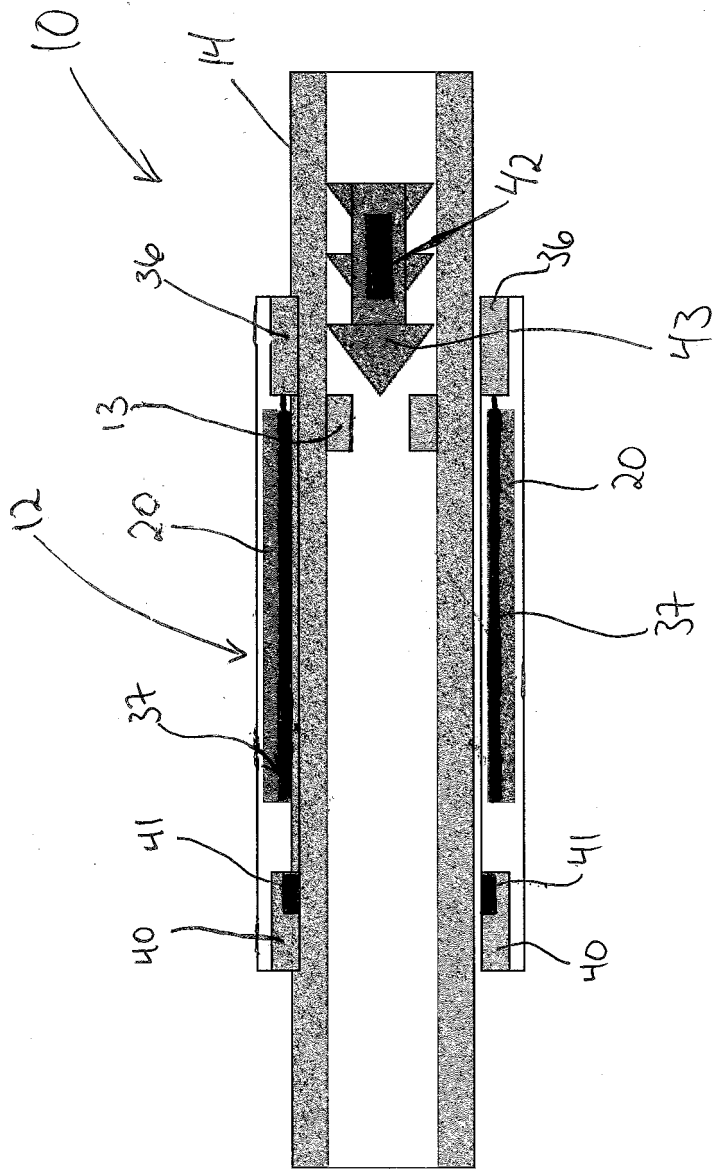


Fig. 6

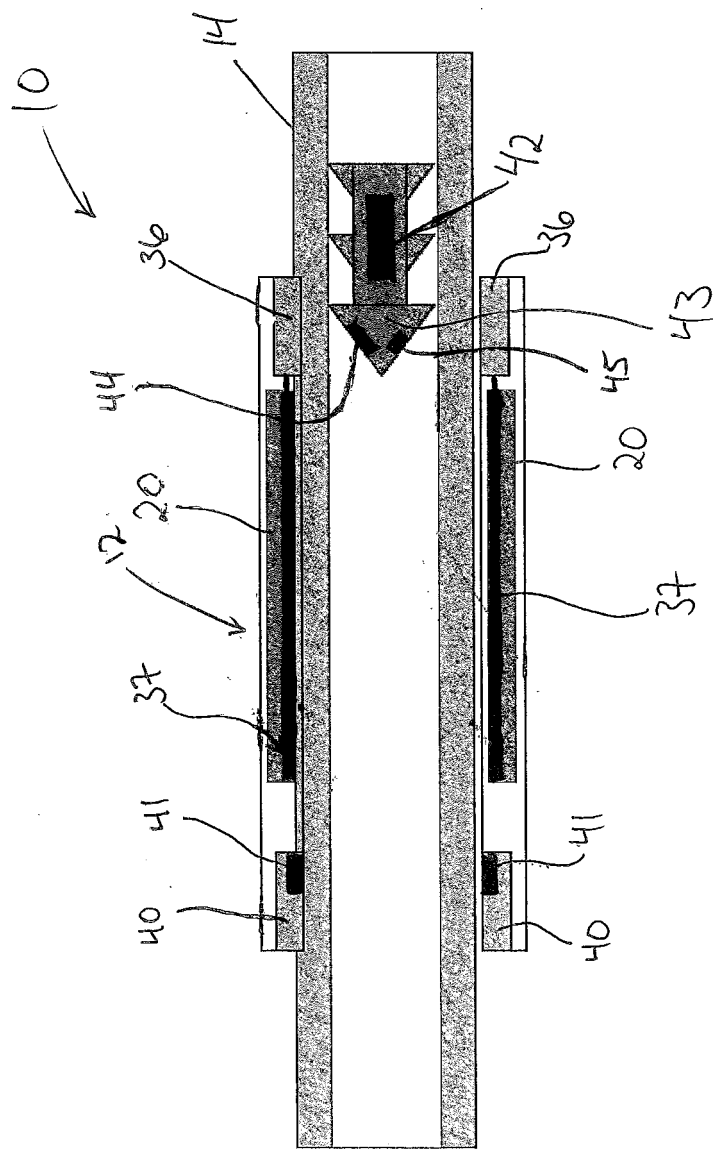


Fig. 7

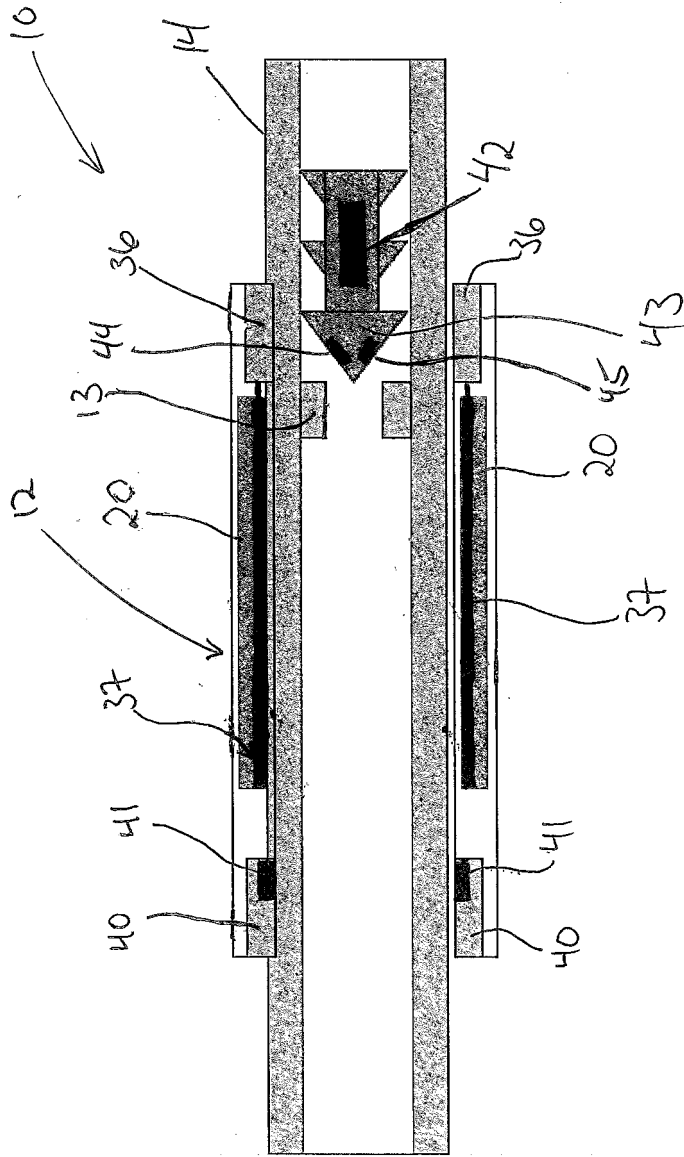


Fig. 8

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- GB 2402954 A [0001]