Title: A METHOD AND AN APPARATUS FOR CONTROLLING A WELL BARRIER

Abstract: The invention regards a method for controlling a well barrier (401, 1002) arranged so as to be able to be inserted into a well for allowing a first well zone to be separated from a second well zone by means of a sealing element (409, 903, 1006), wherein the method comprises setting a pressurized fluid in communication with an activating element (905, 906, 1004, 1005) by selectively controlling an opening device (913, 914, 915), and wherein the activating element (905, 906, 1004, 1005) influences opening of the sealing element (409, 903, 1006) to provide communication between said first and second well zones, wherein the method further comprises the step of influencing the pressurized fluid supplied to the activating element (905, 906, 1004, 1005) by the well pres-ure upstream or downstream of the sealing element (409, 903, 1006). The invention also regards a well barrier (401, 1002) for execution of the method.
before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

with international search report
A METHOD AND AN APPARATUS FOR CONTROLLING A WELL BARRIER

This invention regards a system and a method related to Remote Activated Downhole Tools and Devices used in association with wells for the production of hydrocarbons. More specific, the invention regards a method and an apparatus for controlling a well barrier arranged for being run into a well to separate a first well zone from a second well zone by a sealing element.

Background

Wells for the production of hydrocarbons are designed in a range of different ways, depending on a number of influencing factors. Such factors include production characteristics, safety, well servicing, installation- and re-completion issues, downhole monitoring and control requirements and compartmentalisation of producing zones.

This patent application regards downhole devices, in particular, barrier elements such as plugs, packers and valves that are applied for varying tasks during the construction and servicing of wells.

Downhole devices, common well components, design features and servicing techniques are described in the following sections (UPPERCASE LETTERS are used as sub-headings to facilitate the reading):
The terminology "plugs and packers" refer to a range of zonal isolation devices. When referring to a "plug" and a "packer", respectively, there is room for confusion, as the terms tend to be mixed. However, in general, a plug is normally referred to as an isolation device that seals both in the annular space between the plug and the wellbore as well in the centre of the plug itself. A packer is normally referred to as an isolation device that seals in the annular space between the packer and the wellbore, but not in the centre of the packer itself. Also, the term "packer" is often used in conjunction with inflatable packers, where a liquid is pumped into the sealing element in order to inflate this and create a seal between the inflatable packer body and the inner bore of the production tubular. Inflatable packers are not as frequently applied as the more standard plugs and packers applying compression set elastomer elements, and in some more exotic versions, expandable metal-to-metal seals.

Many wells, in particular offshore wells, include a production packer in the lower section of the production tubular. The production packer is mainly for safety issues, in order to provide a barrier against the highly pressurised fluids in a hydrocarbon reservoir.

Plugs and packers are commonly used in connection with compartmentalisation of reservoir zones, in order to enable a future zone isolation of certain producing intervals.

Plugs and packers are also used in connection with intervention operations, to isolate sections of the well,
to hang off other devices and similar purposes. Plugs and packers used to isolate sections of the well are often referred to simply as "plugs". A certain type of specialised packers, referred to as "straddle packers", comprising two isolation elements, are used for isolation of upper and/or intermediate production zones, while still allowing for production from lower lying zones through a centre bore in said straddle packer.

- Plugs and packers can have useful applications throughout a well's life cycle, and can be installed (and removed) on drill pipe, on the completion string itself or using well servicing techniques such as wireline, coiled tubing or snubbing.

**VALVES**

- Many wells, in particular offshore wells, include a downhole safety valve installed in the production tubular. The downhole safety valve is mainly for safety issues to provide a barrier element between the high-pressurised reservoir and the atmospheric surroundings.

- Circulation valves are used to provide such as flow access between the production tubular and the annular conduit between the production tubing and the surrounding casing, to displace from one fluid type to another fluid type, often in connection with the completion and eventual recompletion of the well. Similar valves are also utilised in connection with the injection of fluids such as scale inhibitors to prevent salt deposits in the production tubular.

- Zone control valves. Many wells penetrate multiple reservoir sections. The production profile of differ-
ent reservoir sections might deviate significantly with respect to pressure, flow rate, fluid type and similar. Zone control valves are used to open/close access to zones and, in some instances, to regulate flow by means of a variable flow access through the valve body.

In addition to packers and valves, well design can comprise a range of components, such as permanently installed monitoring devices and artificial lift systems.

WELL DESIGN AND WELL COMPLETION

The installation of the production tubular, including a selection of the above described components, and the wellhead is referred to as completing the well.

During completion, one normally utilises temporary barriers in the well. Such barriers could be intervention plugs and/or disappearing plugs mounted in the lower end of the production tubing or the higher end of the well's liner. The reason for using temporary barriers is that the barriers of the producing well, such as the downhole safety valve, the packer and/or the wellhead, are not operational yet in the completion stage. Hence, a heavy fluid combined with said temporary barrier systems provides for the required barrier functions during the completion stage.

WELL SERVICING

In general, during the life of a well for the production of hydrocarbons several methods for servicing are applied to enhance the producing capability of the said well. During such servicing operations one might use barriers such as temporary barriers in the said well. Such barriers could be intervention plugs and/or disappearing plugs and/or valves. Temporary
barriers can be used to isolate existing producing intervals, to enable investigation and service and/or opening of other producing zones in the said well. At later stages such barriers might be removed to regain communication with the original producing zone, to regain production from the said zone or to open the said zone to enable injection of fluids and chemicals to enhance the producing capabilities of the said well or other wells producing from the same reservoir zone.

NOVEL WELL DESIGNS

Evolution of oil wells has entailed methods and well designs such as multi lateral wells and side-tracks and smart well completions.

A multilateral well is a well with several "branches" in the form of drilled bores that origin from a main bore. The method enables a large reservoir area to be drained by means of one well.

A side track well is typically an older production well that is used as the basis for drilling one/multiple new bores. Hence, only the bottom section of the new producing interval needs to be drilled, hence time and costs are saved.

Smart well completions are typically applied in wells with several producing and/or injecting zones and/or wells with several bores (i.e. multilateral wells). Such smart well completion components consist of a series of monitoring systems and/or flow control valves which can be used to monitor and control production from each producing interval in the well or injection into each interval in the well. Such smart well monitoring systems and valves are normally operated remotely through hydraulic and/or electric communication (and in some cases partly fibre optic) lines that run all the way from the lower (reservoir) section of a well to the surface. Often, as
a backup solution, smart well valves can also be manipulated by an intervention operation (such as coiled tubing, wireline, or slickline), should the control line based activation systems for some reason fail to operate.

Smart well valves may comprise on/off valves (i.e. either fully open or fully shut) as well as variable opening chokes/flow control valves.

New well designs such as the ones described above have in a number of cases entailed a new challenge in the form of inaccessible areas of the well. In particular, this may apply for multilateral wells and sidetrack wells. Here, it is normally deemed as non-desireable to perform interventions in the side branches of the well as the risk of getting stuck in the junction between branches and/or causing other types of damage to the well are perceived to be of too high a risk, or the branches simply being physically impossible to enter (in any acceptable, controllable manner). Neither is it in most cases possible to bring control lines (hydraulic, electric, fibre optic) into branches of a well as per today.

Hence, the operation of the above described well components as well as the completion of the well itself will in some cases require new systems and methods for the remote operation of plugs, packers, valves and monitoring systems, as traditional ways of conduct no longer are possible.

PROBLEMS ASSOCIATED WITH WELL COMPLETION AND SERVICING

In addition to the problem with non-accessible areas in wells, several other factors may inflict challenges to the operation of well equipment. Such factors include fill material, corrosion, scaling (salt deposits inside the well tubular as well as on locations such as the surfaces of related tooling), and damage to control lines during completion of
the well.

The following examples are given to illuminate such possible problem scenarios:

1. Packers and/or plugs - Fill related challenges:
Common well operations involve the use of a packer or plug to isolate a zone or to hang off equipment such as data acquisition devices or flow control devices. Fill material resulting from the production of other (higher located) producing zones or from the drilling of a sidetrack or from a cleanout of the well may precipitate onto the packer or plug, such that mechanical profiles for the equalising and/or retrieval of the packer or plug become inaccessible. As a result retrieving tools cannot be engaged properly with the packer or plug, as required to equalise and/or retrieve the packer or plug.

2. Packers and/or plugs - corrosion related challenges: Corrosion of materials in a packer or plug may result in damage to mechanical design features and cause similar problems as described above.

3. Packers and/or plugs - scale related challenges:
Scaling (i.e. salt deposits in the wellbore) may occur in the packer or plug and cause similar problems as described above. Scale might also entail fill problems as described in point 1 above, as scale might loosen from parts of the wellbore and fall down onto the plug/packer in question. Finally, scale may also form restrictions in the wellbore, narrowing down the inner diameter of the tubular, and preventing well servicing operations due to servicing tool not being able to get through the scale caused restriction.

4. Valves - damage to hydraulic and electric control lines:
A valve or set of valves intended for flow control and/or
circulation purposes may installed in a well. If the well
is a smart well, the valve or set of valves are linked to
surface via a hydraulic and/or electric (or fibre optic)
control line required to operate the said valve or set of
valves. During installation and/or during the life of the
well such control lines may become damaged and as a result
the valve or set of valves cannot be operated in normal
manner or not at all. As a result important operational
requirements cannot be performed in the said well.

As described in the examples above, there is a range of pos-
sible scenarios that could lead to one or multiple downhole
tools, such as plugs, packers and valves, becoming non-
accessible/non functional for direct mechanical operation in
a well.

Further, the provision of communication and/or powering means
to do operations in branches of wells represents a great
challenge. Bringing a control line into a branch is not possi-
able as per se, and well servicing operations in branches
are associated with either significant risk or cost or both.
As a consequence, measurement and control tasks in branch
wells are normally limited to areas where the branch enters
the main bore of the well, and can normally not be executed
within the branch (es) itself.

EXISTING METHODS TO SOLVE DESCRIBED PROBLEMS

In order to monitor and control single branches of a multi-
lateral or a sidetrack well, the possibilities are limited.
Normally, such monitoring and control has to be performed by-
means of smart well components located in the main bore of
the well as discussed above. In cases with a larger number of
branches, such method for monitoring and control of each sin-
gle branch becomes impracticable and may also become very expensive. Further, local monitoring and control within the various branches is not possible applying such methods.

In cases where mechanical design features, required to operate and/or retrieve a packer or plug, have become inaccessible or faulty due to challenges related to fill material and/or scaling and/or corrosion, several methods exist to attempt to rectify the situation. Such methods include cleanout by means of jetting nozzles, drill bits referred to as mills and/or underreamers, wireline bailing operations, or pure circulation of liquids. Jetting nozzles may be applied in attempt to pressure wash critical areas to make the mechanical profiles required for retrieval accessible. Mills and/or underreamers are special designed drill bits used to grind fill materials and/or scale off the mechanical design features required for retrieval of the packer or plug. Wireline bailing implies the running of small suction pump devices on wire, an operation that normally entails a large number of trips in the hole and consequently a long operational time. Circulation of liquids are used to attempt washing out fill materials obstructing the mechanical design features required to retrieve the packer or plug. All the known methods as described above may be of high cost.

In many cases such intervention methods are not successful, and as a result the packer or plug may have to be destroyed by means of a drilling operation. In such an operation a purpose designed drill bit is used to destroy the packer or plug. In many cases such demolition is not successful and as a result the well may be sidetracked and/or plugged and abandoned.

In cases where hydraulic and/or electric control lines required for the operation of a valve or set of valves are dam-
aged, the following alternatives are available to remedy the situation.

- In cases where a valve or set of valves cannot be operated due to damaged control lines, the valve or set of valves can be operated by means of an intervention operation such as coiled tubing or wireline. This is high cost operations for such operation of valves, and the operational flexibility becomes very limited as a result.

- Another method to remedy such a situation is to recomplete the well. However, this is a very costly operation, and the risk of damaging the new control lines is equal to the original completion operation of the well. As a result such operations are seldom performed.

The objective of the invention

The objective of the invention is to provide a novel and alternative system to add functionality and redundancy to the operation of downhole mechanical devices such as packers, plugs and valves. An entailing objective of the invention is to provide alternative, preferably stand-alone solutions to the operations of plugs, packers and valves associated with wells- for the production of hydrocarbons.

THE INVENTION

In a first aspect of the invention there is provided a method for controlling a well barrier arranged so as to be able to be inserted into a well for allowing a first well zone to be separated from a second well zone by means of a sealing element, wherein the method comprises setting a pressurized fluid in communication with an activating element by selectively controlling an opening device, and wherein the acti-
vating element influences opening of the sealing element to provide communication between said first and second well zones, wherein the method further comprises the step of influencing the pressurized fluid supplied to the activating element by the well pressure upstream or downstream of the sealing element.

In a preferred embodiment the opening device is controlled by wireless signals. In one embodiment the wireless signals are transmitted from a transmitter located at a surface of the well. In another embodiment the wireless signals are transmitted from a tool being inserted into the well. The tool is normally run into the well after installation of the well barrier. However, the tool may alternatively be run into the well prior to installation of the well barrier.

In one embodiment of the invention, the receiver system has transceiver capabilities, and so has the said transmitter system.

A person skilled in the art will appreciate that the wireless signals could be wireless signals by means of pressure or alternative variations in the wellbore fluids, as acoustic signals in fluid or conduit pipe, as electromagnetic signals or other wireless signals. Upon receipt of said activation signal, a set of operations, such as the operation of one or a series of system components is initiated, for example the operation of a downhole motor which again operates a piston opening a channel in the packer or plug, which will equalize pressure over the packer or plug and/or open channels in the packer/plug in order to allow any fill material to fall down through the packer or plug.

Patent application NO 20061275, owned by the applicant for this patent, describes a signal transmission system and
method for applying such wireless signals to a downhole device and is incorporated herein by reference.

In alternative embodiments, the activation signal is not wireless, but a direct connection of nature. The signal transmission link could be a fibre optic line. In other embodiments, the signal transmission link could be electric or hydraulic lines. Typically, the latter cases would include situations where downhole components are installed so deep that an electric or hydraulic line cannot transfer the required energy to operate downhole components, but that communication signals still can be transmitted.

In one embodiment said pressurized fluid is the well fluid located upstream or downstream of the sealing element. Alternatively, said pressurized fluid is a fluid located within an accumulator chamber influenced by the well fluid, but wherein the fluid within the accumulator chamber is separate from the well fluid. In one embodiment the fluid within the accumulator chamber is pre-compressed to a pressure lower than the well pressure at a working depth, and prior to inserting the well barrier into the well.

In a second aspect of the present invention there is provided a well barrier for use in a well for production of hydrocarbons, the well barrier being arranged for installation in the well for allowing a first well zone to be separated from a second well zone by means of a sealing element, wherein an activating element is arranged for influencing the sealing element to provide communication between said first and second well zone, wherein the activating element is arranged to be initiated by the pressure in an activating fluid that is supplied to the activating element by a controlled opening device, the pressure in the activating fluid being influenced by the well pressure upstream or downstream of the sealing
In one embodiment the activating fluid is well fluid that is communicated via a channel from the well upstream or downstream of the sealing element to the activating element.

In one embodiment the activating fluid is a fluid located in an accumulator chamber separate from the well fluid, the volume of the accumulator chamber being influenced by the well pressure upstream or downstream of the sealing element.

In one embodiment said opening device includes a receiving means, at least one energy source and a driving means. In one embodiment each of the receiving means and the driving means is powered by an energy source of their own. In a preferred embodiment the energy sources have different characteristics.

In one embodiment of the invention, a downhole packer and/or plug is equipped with various components required to receive an activation signal followed by operation of one or a series of components, as for example operation of a downhole motor which again operates a screw attached to a piston, which will equalize pressure over the packer or plug, open the plug so that fill can be transported through it and actively loosen any packed fill material allowing it to fall down through the packer or plug. The active loosening of packed fill material might be achieved by means of mechanical components such as transport screws, or alternative components such as vibrating components.

In another embodiment of the invention, a downhole packer and/or plug is equipped with various components required to receive an activation signal followed by operation of one or a series of components, as for example operation of a downhole motor which again operates a piston covering a communication channel between the upper and lower sides of the element.
packer or plug, which will equalize pressure over the packer or plug.

In another embodiment of the invention, a downhole vale or set of valves is equipped with various components required to receive an activation signal followed by operation of one or a series of components, as for example operation of a downhole motor which again operates a valve to a desired position.

Typical application and operation

Common applications are the operation of packers, plugs, valves and monitoring systems. In general, all downhole components requiring mechanical operation and/or communication, in particular downhole components that for some reason suffer from mechanically malfunctioning or has become non-accessible for intervention tool strings or permanent communication/power lines, could be subject of the invention.

Hereinafter, a norrimTtffing-examplenof-preferred embodiments are described and visualized in the accompanying drawings, in which:

Figure 1 shows a simplified example of one embodiment of the invention;

Figure 2 shows examples of preferred general system features for a generalised embodiment of the invention;

Figure 3 shows one specific example of setting a packer element by means of a communication, activation and powering system built into the wall of an annular shaped well tool;
Figure 4 shows an example of operating (equalising and/or opening) a well servicing packer that is covered by well debris;

Figure 5 shows an alternative example of operating (equalising and/or opening) a well servicing packer that is covered by well debris;

Figure 6a shows even another alternative example of operating (equalising and/or opening) a well servicing packer that may be exposed to well debris (not shown);

Figure 6b shows a section taken through line A-A in fig. 6a;

Figure 7 illustrates one major problem related to well servicing packers being covered by well debris,

Figure 8 shows the first step of an example of operating (equalising and/or opening) a well servicing packer that is covered by well debris for a preferred embodiment of the invention;

Figure 9 shows the second step of an example of operating (equalising and/or opening) a well servicing packer that is covered by well debris for a preferred embodiment of the invention;

Figure 10 shows how one preferred modular embodiment of the invention, comprising a communication and activation system, is interfaced towards a well servicing packer in one end, and a disintegrating plug in the other end, and how such embodiment of the invention is interfaced and utilised to remove said disintegration plug,

Figure 11a shows one example of mechanical design features for a system intended for operating (equalising
and/or opening) a well tooling device according to one embodiment of the invention;

Figure 11b shows a section taken through line B-B in fig. 11a;

Figure 12a shows another example of mechanical design features for a system intended for operating (equalising and/or opening) a well tooling device according to one embodiment of the invention;

Figure 12b shows a section taken through line C-C in fig. 12a;

Figure 13 shows another example of mechanical design features for a system intended for operating (equalising and/or opening) a well tooling device according to one embodiment of the invention; and

Figure 14 shows a plug pulling tool that also comprises a wireless transmitter and/or receiver.

Figure 1 illustrates an example of operating according to the invention. Here, one sees a wellbore 101 where a downhole device 102 is installed. Such device could be a plug, a valve or other types of downhole device. The downhole device is associated with a signal receiver 103 and an activation system 104. A wireline 105 and associated toolstring 106 is used to deploy a signal transmitter 107 into the well 101. Also, it is illustrated by means of a set of dotted lines that the well comprises a well section that is available for intervention 108 and a well section that is non-available for intervention 109. The toolstring 106 may be equipped with a wellbore anchor 110. This said anchor 110 may be necessary to assure stability of the transmitter 107 during operation in order to impose an optimum signal into the primary signalling
medium (the well fluid) and/or a secondary/complementary signalling medium (the steel tubing of the well 101). Typically, the transmitter 107 is designed for producing a signal with sufficient strength to overcome obstacles related to solids and/or liquids as well as well geometries with poor signal carrying (for instance acoustic signal carrying) properties.

Figure 2 illustrates a generic design of the downhole device 102. The tubular of the well is not shown. The signal receiver 103 and activation system 104 are illustrated as modular, somewhat external components, but could in other embodiments be fully incorporated in the main body of downhole device 102. The opposite applies for all components illustrated to be within the body of downhole device 102. In alternative embodiments, one or more of such components could be modular and/or external modules if such are required to facilitate such as easy production, assembly, operation and maintenance of the overall system.

Further, according to figure 2, for embodiments where the signal receiver 103 is set up to receive a wireless transmitted signal; for such an embodiment this implies that the downhole device 102 has to be fully autonomous, hence contain both power and communication means within its given framework. For downhole, autonomous devices to be practical to use, they might have to be able to last for very prolonged periods of time. This again represents a significant challenge:

- Conventional, non-rechargeable batteries are by far the dominating energy source for relevant stand-alone downhole devices as per today.
- For most known applications, the lifetime of such battery operated systems is limited upwards to approxi-
mately one year.

• In high temperature wells, batteries will suffer more significantly from the phenomenon of self-discharge than in lower temperature wells (typically below 100 degrees C). In high temperature cases, the lifetime of battery operated systems might be seriously affected, and perhaps reduced by 50-75% compared to more normal (lower temperature) well regimes. It is known, as a rule of thumb, that the self discharge rate of a conventional battery may double per 10 degree C temperature increase in temperature ranges exceeding 100 degrees C.

In order to overcome such powering requirements, for embodiments of the invention that need to be installed in a well for prolonged periods of time, the signal receiver 103 of the downhole device 102 and other relevant systems are proposed powered by an energy generator 201 that, for most perceivable situations is combined with an energy storage and distribution unit 202 such as a re-chargeable battery with associated steering electronics. In embodiments requiring shorter lifetime, the energy generator 201 and energy storage and distribution unit 202 can be replaced by conventional non-rechargeable batteries. This is expected to become a commonly applied embodiment of the invention.

Upon receiving an activation signal at signal receiver 103, the activation system 104 is initiated. In one embodiment of the invention, the activation system 104 initiates a desired operation directly. In other embodiments of the invention, the activation system initiates desired operations through an electronic logic 203. This could for example be the case if one or more internal components of downhole device 102 that are meant to be either addressed and/or activated in certain desired sequences, or if several autonomous devices 102 with
different signal addresses are located at various locations in the well. Further to figure 2, the following system 102 modules and functions are within the scope of the invention:

- Activating elements 204. In one embodiment of the invention, this is a motor driven actuator system that is used to operate/activate a mechanical device, for example a pressure equalising device associated with a plug. In other embodiments of the invention, such activation element(s) 204 could be explosive detonators, charged gas chambers, pilot valves and/or other sub-systems (pistons, screws, gears, pressure boosting chambers, any-cascading electrical/mechanical system) applied to initiate/activate/execute the operation of devices/elements (such as a sealing element) of downhole device 102.

- Device/element to be operated 206. In one embodiment of the invention, this could be a mechanical equalising device for a plug. In other embodiments, this could be a valve-er-a-disintegrating-element-within a plug/packer body, in order to open the plug/packer centre or other areas of the plug for fluid communication and/or transport of fill, mechanical fill transportation systems and similar. In one embodiment of the invention, this could be a mechanical system for opening, closing or adjusting a downhole choke or similar flow-control valve or other valve.

- (Secondary) power source(s) 205. This is a power source(s) with the capacity to provide significant amounts of energy in order to do a power consuming operation such as the operation of the device to be operated 206 as described above. The need for a secondary power source is believed to be detrimental for system functionality, as neither power generators and re-
chargeable batteries nor conventional non-rechargeable batteries are perceived to be able to provide sufficient energy to operate the device 206 and other relevant high-energy system components in all relevant cases. In a preferred embodiment of the invention, the (secondary) power source 205 is a thermal battery. Thermal batteries are "dormant" high-power batteries that are activated by means of operating a small detonator (explosive cap). When activated, thermal batteries normally have a lifetime less than 24 hours, but with the capacity of massive energy supply during that limited lifetime. Hence one or multiple thermal batteries will form a good secondary power source 205 in order to design a downhole device 102 with the capacity of performing a number of subsequent operations, especially if there is a time lag exceeding 24 hours between respective operations. In other embodiments of the invention, the secondary power source 205 comprises pyrotechnical materials or high pressure gases or atmospheric chambers, radioactive sources or other power sources. In one embodiment of the invention, the secondary power source 205 comprises a combination of two or more types and/or amounts of said power sources.

- Confirmation transmitter 207. In a preferred embodiment of the invention, the downhole device 102 comprises a confirmation transmitter 207 that emits a signal as a confirmation that a desired operation is effectuated. This signal can then be read by receiving systems incorporated in related well tooling (106, 107) or located on the surface. Such signal could be a wireless signal by means of pressure or alternative variations in the wellbore fluids, as acoustic signals in fluid or conduit pipe, as electromagnetic signals or other wireless sig-
nals transmitted to a receiver node located at surface or another location in the wellbore. In another embodiment, such signal could be a signal transmitted in a fibre optic, electric, hydraulic or other line connection to a receiver node located at surface or another location in the wellbore. In other embodiments of the invention, confirmation of executed operation could also be verified by monitoring parameter changes that are related to the activation process, such as pressure changes, noise, and other physical changes. In one embodiment of the invention, confirmation is confirmed by the release of a physical object from the downhole device 102.

- Data acquisition module 208. In one embodiment of the invention, the downhole device 102 comprises a data acquisition system 208. Such data could comprise downhole pressure, temperature, flow rate, fluid properties as well as other relevant downhole measurements known to those skilled in the art. In one embodiment, upon receiving an activation command, the downhole device 102, uploads acquired data by means of the transmitter 207. In this embodiment, the downhole device 102 could represent an autonomous data acquisition device located in a non-accessible area of a well, for example in a branch of a multilateral well, that at regular and/or commando-determined intervals uploads data. For a branch installed downhole device 102, such data would typically be uploaded by means of a wireless signal to a receiver node located at surface or another location in the wellbore, or related well tooling (106,107).

By means of the components outlined in figure 2, the downhole device 102 and accessories represents the following important
characteristics:

• Long-life monitoring 103 and activation 104 capability with respect to registering an activation signal and executing an activation operation. In a preferred embodiment of the invention, this is ensured by system functionality and modules that represent low energy consumption and associated energy generation requirements. Hence, for a preferred embodiment of the invention, the downhole device 102 can lay "dormant" in the well, awaiting an activation command whilst spending an absolute minimum of energy, preferably below a level where an energy generator 201 can provide equal to or larger amounts of energy than what the monitoring 103 and activation 104 components consume.

• In a preferred embodiment of the invention, significant powering capabilities in order to perform high-power consuming operations, such as mechanical operation of components are provided. Such capacities are provided by means of the (secondary) power source(s) 205.

• In a preferred embodiment of the invention, by means of such primary (low energy) and secondary (high energy) system power modules, the downhole device 102 is capable of meeting requirements to long system life combined with high power consuming operation capabilities.

Further to figure 2, for a system according to the invention, one or multiple of outlined system components could be omitted, depending of the scope of work that the system is intended for. Also, the location and order of operation of system components could deviate from what is outlined in figure 2.

Figure 3 illustrates one specific way and a preferred embodi-
ment for designing a downhole device 102 in order to energize and operate a device/element 206 (the given example yields a packer element 310 to be set). This example applies in the case where all system components associated with downhole device 102 has to be mounted inside the wall section 306 of a tubular (or other shaped) element. This could be the case if there is a strict need to provide an open centred area of the downhole device 206, which could be the case for devices such as (straddle) packers, smart-well valves etc. In this case, the receiver sensor 302 reads a received wireless setting command 301. The receiver sensor 302 is interrogated by a receiver electronics module 303 in order to interpret registrations from the sensor/receiver 302. When there is a positive detection of an activation signal, i.e. an initiating command, the electronics 303 emit a signal/impulse to fire a detonator 304 that again ignites a pyrotechnic charge 305 that is moulded to fit inside a slot in the wall 306 of the downhole device 102. As the pyrotechnic charge 305 burns, it generates pressurised gas that imposes a large pressure on the piston 307. The piston 307 is forced downwards, and pushes hydraulic oil 308 which again forces a wedge-shaped element 309 downwards and forces this to compression-expand a packer element 310 and forces this to set against the tubing wall 311. Alternatively, the wedge shaped element 309 is replaced by means of an alternative element (s) with similar function - i.e. to compress the bottom packer element 310. The receiver sensor 302 and associated electronics module 303 is powered by means of a power module 312 such as a battery. The dotted line 313 illustrates the centre of the downhole device 102, indicating that the described system components are located inside the wall 306 of the downhole device 102 housing.

Further to figure 3; this only illustrates one of a variety
of ways of designing a system that sets in this case a packer element 310 or operates any general device/element 206 of a downhole device 102 further to the general methods described herein. Also, those skilled in the art will appreciate that figure 3 merely serves as a principle sketch and that exact system and method details may vary.

In figure 3, the choice of a detonator 304 for initiation of the operation and a pyrotechnic power charge 305 as a secondary power source 205 is based on a perception that such a design could be optimal for in-wall mounted systems, where space restraints would limit such as the size (hence power) of motors. However, other possible methods could be applied. Such methods involve:

- Motors operating on battery power. For instance, a secondary thermal battery that operates a motor which again applies force on the mechanic components that force the (packer) element 3 to set.

- Release of highly pressurised gas into a piston chamber. A pilot valve, pyrotechnic detonator or similar, exposing a "power chamber" to a compressed gas reservoir (high pressure gas chamber that forms part of the system design), or the wellbore pressure which again works against an atmospheric chamber to create the necessary forces to operate mechanic components that force the lower packer element 3 to set.

- Routing of highly pressurised well fluids into a piston chamber. A pilot valve or similar, exposing a "power chamber" to pressurised well fluid which again works against an atmospheric chamber to create the necessary forces to operate mechanic components that force the lower packer element 3 to set.
• Release of a pre-compressed mechanical spring assembly

• Any relevant method for directly and/or indirectly generating a force on a packer element in an autonomous manner.

• Any combination of the above methods, combined with a valve or another type of barrier located in the bottom section of the straddle packer, said valve/barrier opens or "disappears" in other manners upon a finalised setting of the bottom packer element.

• A pump that inflates the lower packer element by use of an in-built reservoir or by means of pumping well fluids into the lower packer element 3.

• Any method for setting a packer element in general.

• Releasing relevant swelling fluid to self-swelling packers.

Figure 4 illustrates the system for another embodiment of the invention. The tubular of the well is not shown. Here, one sees a plug or packer assembly 400 comprising a plug or packer 401 attached to an actuator sub 402. In this example, the actuator sub 402 is made modular, to be attached to the plug or packer 401. The internal of the plug or packer 401 is filled with some type fill material 403, being any fill material expected in a well related to the production of hydrocarbons. The actuator sub 402 comprises a ("listening") sensor 404, a power device 405 such as a battery, an electronic section 406, an electrical motor 407, a gearbox 408, a sealing cone 409, and a nipple profile 410. Typically, the ("listening") sensor 404 is a piezoelectric disc, an accelerometer, a radio antenna or a magnetostrictive material.
Prior to installation the actuator sub 402 is attached to the plug or packer 401, and the sealing cone 409 provides a pressure seal against the nipple profile 410. The assembly 400 is installed in a well. Before the assembly 400 is to be retrieved the actuator 402 is operated. This is achieved as follows: An activation signal, such as a wireless signal, is transferred from a distant transmitter through a media such as the wellbore and/or the wellbore fluids, and picked up by the listening sensor 404. The electronic section 406 interprets all signals picked up by the sensor 404. Upon receipt of the correct activation signal the electronic section 406 will activate the electrical motor 407 to move the sealing cone 409 downwards. This operation will result in that pressure is equalized across the assembly 400, and allow the fill material 403 to fall down through the assembly 400. The gearbox 408 may be required to generate sufficient force to move the sealing cone 409 downwards. The complete system is powered by the power device 405. When this operation is completed the internal section of the plug assembly will be clean and ready to be retrieved by standard practises.

It will be recognised by those skilled in the art that figure 4 merely serves for the purpose of illustrating the idea behind the invention. Alternative design variations may apply. In particular, the following items and functions may vary:

• A sealing cone 409 as described might not be sufficient to provide a reliable stand-alone pressure seal both ways. In alternative embodiments of the invention, such sealing cone or similar system feature might be replaced or supplemented by alternative valve systems as known per se. In one embodiment, one part of such valve systems could have the purpose of holding the required pressure whereas another part of such valve system could
have the purpose of preventing fill from entering the pressure containing part of the valve system, hence add risk to the operation of such valve system. In this embodiment, it becomes natural to define the actuator sub 402 by means of "clean" and "unclean" system modules.

- In other embodiments of the invention, the operation of the actuator sub 102 may comprise numerous sequential steps, and the actuator sub 102 may comprise numerous subs system components (by means of power sources, activating elements and other components) in series and/or parallel in order to achieve a successful operation. For instance, one system module could operate a valve system to equalise pressure. In a preferred embodiment, such valve system is located in a "clean" area of the plug. Further, a secondary system module could be operated to open the flow-by area of the plug or packer in such a manner that fill could fall down and through said plug or packer (i.e. all sensitive "clean area" modules are operated successfully prior to exposing these to fill or other pollutants from the "unclean" area).

Also, it will be recognised for a person skilled in the art, that a plug/packer concept as shown in figure 4 may be designed to fit for operations with new, specialised pulling tools. I.e. such pulling tools could be equipped with signal transmitting capabilities in addition to general features required for the pulling of a plug/packer. In that way, one would not need two separate runs to pull the plug/packer as could be the case further to today's methods and philosophies (i.e. one run on electric wireline to remotely equalise/open the plug and one run on mechanic wireline to pull the plug). The same philosophy will apply for alterative embodiments and applications such as but not limited to shifting tools for
valves.

Figure 5 illustrates an overall system for another embodiment of the invention. The tubular of the well is not shown. The main difference from figure 4 is the inclusion of a transport screw 501. Again, before the assembly 400 is to be retrieved the actuator 402 is operated by means of an activation signal from a remote transmitter. The signal is picked up by the listening sensor 404. The electronic section 406 interprets all signals picked up by the listening sensor 404. Upon receipt of the correct signal the electronic section 406 will activate the electrical motor 407 to rotate the transport screw 501 and move the sealing cone 409 (upwards for this embodiment). This operation will result in that pressure is equalized across the assembly 400, and loosen any packed fill material 403, allowing it to fall down through the assembly 400. A gearbox 408 may be required to generate sufficient force to move the sealing cone. Further, independent and/or multiple motor/gear systems might be applied to operate the cone 409 and transport screw 501, respectively. The complete system is powered by the power device 405. When this operation is completed the internal section of the plug assembly will be clean and ready to be retrieved by standard practices.

Again, as described for figure 4, figure 5 is merely given to describe an idea, and does only describe one of a number of possible embodiments. Alternative design variations may apply, and the additional comments given in the explanation to figure 4 also applies here.

Figure 6a illustrates an overall system for yet another embodiment of the invention. The tubular of the well is not shown. Here, one sees a plug or packer assembly 400 comprising a plug or packer 401 attached to an actuator sub 402.
The actuator sub 402 comprises a listening sensor 404, a power device 405 such as a battery, an electronic section 406, an electrical motor 407, a gearbox 408, a perforated section 601, and a piston 602. The perforated section 601 may be only a channel from the inside (centre) of the actuator sub 402 to the outside (annulus towards production tubing).

Prior to installation the actuator sub 402 is attached to the plug or packer 401, and the piston 602 provides a pressure seal against the perforated section 601. The assembly 400 is installed in a well. Before the assembly 400 is to be retrieved the actuator 402 is operated. A remote signal is transferred through the wellbore and picked up by the sensor 404. The electronic section 406 interprets all signals picked up by the listening sensor 404. Upon receipt of the correct signal the electronic section 406 will activate the electrical motor 407 to move piston 602 upwards or downwards. This operation will result in that pressure is equalized across the assembly 400. The gearbox 408 may be required to generate sufficient force to move the sealing cone downwards. The complete system is powered by the power device 405. When this operation is completed the pressure is equalized and the plug assembly 400 can be retrieved by standard practises.

Fig. 6b shows a section of the actuator sub 402 taken through line A-A in fig. 6a.

Figure 7 illustrates one general problem related to well servicing packers being covered by well debris. Here, a plug pulling tool 701 is attempted attached to a plug 401 that has been installed in the well at an earlier instance. The reason for installing plug 401 might as an example have been related to the isolation of producing zone 702 while servicing zone 703. During such servicing, debris 704 has been released and fallen on top of plug 401. As a result, the plug pulling tool
701 can not be engaged to the plug, and this might entail significant consequences with respect to subsequent costs and operational complexity to remedy the situation. A person skilled in the art would appreciate that figure 7 only illustrates one of numerous scenarios where a plug 401 or any other relevant tooling can not be operated as desired due to debris 704 or other well related problematic (corrosion, scale and other related problems).

Figure 8 shows the first step of an example of operating (equalising and/or opening) a well servicing packer that is covered by well debris for a preferred embodiment of the invention. Here a packer 401 is installed in a well by attaching it to the production tubular by means of methods as known per se. In a given scenario, the risk of debris or related problems has been perceived to be significant, hence a system according to a preferred embodiment of the invention has been attached to the bottom end of the plug - to overcome such problems. The attached tooling comprises an outer housing 901 that contain flow channels 902. During installation in the well, where the attached tooling forms part of the plug/barrier system, the flow channels 902 are closed by means of a closure member 903 that is held in a preferred position by means of shear bolts 904. Further, the closure member 903 is attached to a shaft 905 that is connected to a piston 906 that is mounted inside a cylinder chamber 907. Seals 908 ensure that the inside of the cylinder chamber 907 is kept at atmospheric pressure prior to the activation process to come. A male ratch module 909 mounted on the shaft 905 corresponds with a female ratch module 910 mounted inside the cylinder 907. A ("listening") sensor 911 is mounted at a convenient location of the tooling, in order to ensure as good signal re-
ceiving capabilities as possible. The sensor 911 is inter-
rogated by electronics module 913 through a communication
line 912. The entire system is powered by battery 914. Upon
receiving an activation command by sensor 911, the activation
process is started. Motor 915 is operated to retract motor
shaft 916 from fluid channel 917. Well fluid will then be
able to flow into the tool via fluid channel 917. Debris fil-
ter 918 is included to prevent particles and similar from
plugging fluid channel 917 during operation. Flow reducer 919
is included to prevent the system from being "shocked" to a
state of damage due to the tremendous power released when
opening an atmospheric chamber to the well pressure. The well
fluid will enter the cylinder chamber 907 to the left (upper
side) of piston 906. As a result, piston 906 will be driven
to the right (downwards). One-way valve 920 will release
overpressurised gas/air when the time comes to retrieve the
plug assembly, as this could create a hazardous situation to
personnel and equipment when in free air. Finally, process
bellows 921 ensures that the inside of the motor chamber 922
contains the same pressure as the well pressure. This entails
that there is no thrust force acting on motor shaft 916 dur-
ing operation, and that motor 915 can be operated on rela-
tively low power. In another embodiment of the invention, the
process bellows 921 is replaced by a piston, membrane or al-
ternative pressure equalisation system.

Figure 9 shows the second step of an example of operating
(equalising and/or opening) a well servicing packer that is
covered by well debris for a preferred embodiment of the in-
vention. Here, the closure member 903 has been pulled to the
right (downwards) so that the channels 902 are opened. Hence
debris can be removed either by falling down through channels
902, alternatively by producing the well through channels 902
in order to remove the debris. In a preferred embodiment of
the invention, closure member 903 has a conic shape and the channels 902 are made in a similar, tilted angle in order to facilitate particles falling down through the channels 902 (like as for an hour-glass). The male ratch module 909 mounted on the shaft 905 has during activation been stung into female ratch module 910 and hereby locked closure member 903 into this new position. In other embodiments of the invention, the operation of closure member 903 is reversible and in even other embodiments of the invention, the operation of opening and closing by means of closure member 903 is repeatable.

Figure 10 shows how one preferred modular embodiment of the invention, comprising a communication and activation system, is interfaced towards a well servicing packer in one end, and a disintegrating plug in the other end, and how such embodiment of the invention is interfaced and utilised to remove said disintegration plug. As for figures 8 and 9, a sensor 911 is interrogated by an electronics module 913 powered by a battery module 914, and activation takes place by means of operating a member such as a motor 915 to open a fluid channel 917. However, for this embodiment all modules are built into the wall of the tooling itself, in order to provide for a centre bore, which may be required to maximise the production of the well, or to facilitate the subsequent intervention of well service tooling through the shown system. In this embodiment of the invention, the operation of motor 915 causes wellbore pressure or alternative high pressure contained in a tool reservoir to access a removal mechanism 1003 of a disintegrating plug 1002. As an example, such removal mechanism 1003 may comprise a pressure activated detonation cap (ignitor) 1004 that set off a more powerful explosive charge 1005 in order to fulfil the plug element 1006 disintegration operation. The tubular of the well is not shown.
A very distinctive feature shown in figure 10, and that forms part of a preferred embodiment of the system, is an accumulator, here in the form of a ring-shaped piston 1007 mounted inside an annular shaped piston chamber 1008. In alternative embodiments, the piston 1007 and piston chamber 1008 could have other forms and shapes than shown in figure 10, or be replaced by alternative design such as a membrane design. Further, the accumulator may comprise pressure-boosting features, such as differential areas on each side of the piston 1007. In the case where debris falls on top of the plug assembly, this entails the possibility of plugging of port 1009 which provides the access point for well fluids in order to undertake the removal of disintegration plug 1002. This could cause malfunction in the subsequent plug disintegration process. To avoid such plugging problems, the piston chamber 1008 is primed with fluid, e.g. a compressible gas, or air, prior to installation in the well. During installation in the well, the piston 1007 will be displaced to the right (downwards) hence compressing the fluid. Normally, during installation process, the overall system will not be exposed to debris (this will take place during subsequent well operations), hence the gas inside the piston chamber will be pre-compressed prior to the debris being present, and plugging of port 1009 will not represent a functionality risk anymore.

Further, by means of the invention of such accumulator comprising piston 1007 and chamber 1008, there will not be a need to prime the tooling with compressed gas on surface (which could be an alternative if debris problems were expected), which would add safety to the operation. However, in one preferred embodiment the fluid within the accumulator chamber 1008 is pre-compressed to a pressure lower than the well pressure at a working depth, and prior to inserting the well barrier into the well. By means, this will reduce the
requirements to volume of the accumulator space. For example, by pre-compressing the gas in the accumulator chamber to a pressure equal to common work air pressure, circa 6 bar, the accumulator chamber can be made significantly smaller than for the example using of a at atmospheric pressure. However, by keeping the pre-compression pressure relatively low, the invention entail a far smaller safety risk than a system containing a gas chamber pre-compressed to pressures above the well pressure at working depth.

Figure 11 shows one example of mechanical design features for a system intended for operating (equalising and/or opening) a well tooling device according to one embodiment of the invention. The tubular of the well is not shown. Here fluid channels 601, intended to equalise and/or open a downhole tooling system are initially covered by a mandrel that forms part of a piston 602. The piston 602 is held in place by an anchor 1101. The anchor 1101 is fixed to the outer tool mandrel 1102 by methods known as per se such as welds 1103. Long oval slots, illustrated by means of dotted lines 1104 and 1104' are made into mandrel 1102 in order for piston 602 to move longitudinally in a downward direction upon activation. An anchor flange 1105 is used to hold the piston 602 in place, connected to the anchor 1101. Cascade rings 1106 as known from parachuting and space shuttle applications are used to connect the anchor 1101 and anchor flange 1105, and tensioning bolts 1107 are used to make the connection firm at a desired tension. Activation takes place by communication techniques as described herein. During the activation process, a motor 1108 is used to release the cascade ring system 1106 whereupon the connection between the anchor 1101 and anchor flange 1105 is broken. Subsequently, the spring 1109 will extend and shift the piston 602 downwards so that fluid channels 601 are opened.
Figure 12 shows another example of mechanical design features for a system intended for operating (equalising and/or opening) a well tooling device according to one embodiment of the invention. The tubular of the well is not shown. Here, the piston 602 is shifted downwards by means of operating pump 1201 so that fluid with a higher relative pressure than the surroundings is pumped into the closed chamber 1202. The pump chamber 1203 is pre-filled with a fluid that the pump 1201 can handle in order to avoid pumping of well fluid, however in alternative embodiments of the invention, the pump 1201 could pump well fluids directly. Piston 1204 is included to separate the clean fluid inside the pump chamber 1203 from the well fluids that are entering the system via channel 1205.

Figure 13 shows another example of mechanical design features for a system intended for operating (equalising and/or opening) a well tooling device according to one embodiment of the invention. The tubular of the well is not shown. Here, a flapper valve 1301 is held in a fixed position by means of a lock ring 1302 on the lower side and a lock shoulder 1303 on the upper side. The lock shoulder 1303 is attached to a lock cylinder 1304 that is attached to the outer housing 1305 by methods as known per se. The lock ring 1302 is attached to a lock mandrel 1306. The lock mandrel 1306 is attached to the outer housing 1305 by means of a cascade ring system 1106 as illustrated in figure 11. By operating motor 1108 or similar device to disengage a release wire 1307, the cascade ring system 1106 is released and collapses. This causes lock mandrel 1306 and lock ring 1302 to shift downwards whereupon flapper valve 1301 opens. Lock mandrel 1306 contains one or more longitudinal slots, illustrated by lines 1109 and 1110, in order for cascade rings 1106 to operate freely during the collapsing process.
Figure 14 shows a plug pulling tool 701 that also features a wireless transmitter and/or receiver 1401. Further, figure 14 shows a plug 401 that has been installed in the well at an earlier instance, the plug being associated with a wireless activable bottom sub 1402, with functionality such as to open channels between the well section above the plug and the well section below the plug upon receiving a wireless activation command. The combination of a traditional pulling tool with a wireless transmitter/transceiver is of novel art and not known in the industry. The intention with this novel art pulling tool is to enable the opening and retrieval of the plug 401 during one intervention in the hole, rather than using one run in the hole for the wireless activation signal transmission and a second run in the hole for the physical attaching to the plug.

Do note that for figures 11-14, only key system components are shown. It has not been a scope for these figures to show all required accessories nor the exact location and assembly of components.

Finally, the descriptions and drawings presented herein only represent examples of embodiments related to the invention. Further, any concept, system and method as well as combination of concept(s), system(s) and method(s) described in any text or figure herein could be extended to apply in conjunction or combination with other concepts, systems and methods described. All combinations of concepts, systems and/or methods also comprise part of the objective of the invention. All interfacing, combination and utilisation with existing equipment, techniques and methods also comprise part of the invention.

The invention both comprises modular design that interfaces towards 3rd party tooling (such as plugs and/or packers) as
well as total design where the parts encompassed by the invention are built into such tooling as a stand-alone product.
Patent claims

1. A method for controlling a well barrier (401, 1002) arranged so as to be able to be inserted into a well for allowing a first well zone to be separated from a second well zone by means of a sealing element (409, 903, 1006), wherein the method comprises setting a pressurized fluid in communication with an activating element (905, 906; 1004, 1005) by selectively controlling an opening device (913, 914, 915), and wherein the activating element (905, 906; 1004, 1005) influences opening of the sealing element (409, 903, 1006) to provide communication between said first and second well zones, characterized in that the method further comprises the step of influencing the pressurized fluid supplied to the activating element (905, 906; 1004, 1005) by the well pressure upstream or downstream of the sealing element (409, 903, 1006).

2. The method of claim 1, wherein the method further comprising controlling the opening device (913, 914, 915) by means of wireless signals.

3. The method of claim 2, wherein the method includes transmitting the signals from surface of the well.

4. The method of claim 2, wherein the method includes transmitting the signals from a tool (701) being inserted into the well.

5. The method of claim 1, wherein the pressurized fluid is the well fluid located upstream or downstream of the sealing element (409, 903, 1006).
6. The method of claim 1, wherein the pressurized fluid is a fluid located within an accumulator chamber (1008) influenced by the well fluid, but wherein the fluid within the accumulator chamber (1008) is separate from the well fluid.

7. The method of claim 6, wherein the fluid within the accumulator chamber is pre-compressed to a pressure lower than the well pressure at a working depth, and prior to inserting the well barrier (401, 1002) into the well.

8. A well barrier (401) for use in a well for production of hydrocarbons, the well barrier (401) being arranged for installation in the well for allowing a first well zone to be separated from a second well zone by means of a sealing element (409, 903, 1006), wherein an activating element (905, 906; 1004, 1005) is arranged for influencing the sealing element (409, 903, 1006) to provide communication between said first and second well zone, characterized in that the activating element (905, 906; 1004, 1005) is arranged to be initiated by the pressure in an activating fluid that is supplied to the activating element by a controlled opening device (913, 914, 915), the pressure in the activating fluid being influenced by the well pressure upstream or downstream of the sealing element (409, 903, 1006).

9. The well barrier (401) according to claim 8, wherein the activating fluid is well fluid that is communicated via a channel (917) from the well upstream or downstream of the sealing element (409, 903, 1006) to the activating element (905, 906; 1004, 1005).
10. The well barrier (401) according to claim 8, wherein the activating fluid is a fluid located in an accumulator chamber (1008), the activating fluid being separate from the well fluid, and wherein the volume of the accumulator chamber (1008) is influenced by the well pressure upstream or downstream of the sealing element (409, 903, 1006).

11. The well barrier (401) according to claim 8, wherein the opening device (913, 914, 915) is controlled by wireless signals.

12. The well barrier (401) according to claim 11, wherein the wireless signals are transmitted from a transmitter located outside the well.

13. The well barrier (401) according to claim 11, wherein the wireless signals are transmitted from a tool (701) inserted into the well.

14. The well barrier (401) according to claim 13, wherein the tool (701) is a pulling tool.

15. The well barrier (401) according to claim 11, wherein the opening device (913, 914, 915) includes a receiving means (913), at least one energy source (914) and a driving means (915).

16. The well barrier (401) according to claim 15, wherein each of the receiving means (913) and the driving means (915) are powered by an energy source (914) of their own.

17. The well barrier (401) according to claim 16, wherein the energy sources (914) have different characteristics.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

| Classification (IPC) | E21B23/06 | E21B33/12 | E21B33/1295 |

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)

E21B

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

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

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>WO 2004/061265 A (BAKER HUGHES INC [US]) 22 July 2004 (2004-07-22) page 7 - page 8 the whole document</td>
<td>1-5, 8-17</td>
</tr>
<tr>
<td>A</td>
<td>WO 2007/108700 A (WELL TECHNOLOGY AS [NO]; TINNEN BAARD MARTIN [NO]; GODAGER OEIVIND [NO]) 27 September 2007 (2007-09-27) cited in the application the whole document</td>
<td>6, 7, 10</td>
</tr>
<tr>
<td>A</td>
<td>WO 98/55731 A (CAMCO INT [US]) 10 December 1998 (1998-12-10) the whole document</td>
<td>1-17</td>
</tr>
</tbody>
</table>

**X** Further documents are listed in the continuation of Box C. **X** See patent family annex.

Special categories of cited documents:

- **Y** document defining the general state of the art which is not considered to be of particular relevance
- **E** earlier document but published on or after the international filing date
- **L** document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- **O** document referring to an oral disclosure, use, exhibition or other means
- **P** document published prior to the international filing date but later than the priority date claimed

- **T** later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- **X** document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- **Y** document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- **S** document member of the same patent family

Date of the actual completion of the international search: 26 May 2009

Date of mailing of the international search report: 04/06/2009

Name and mailing address of the ISA/
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016

Authorized officer: Morri sh, Susan

[Form PCT/ISA/21 0 (second sheet) (April 2005)]
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>EP 1 138 872 A (HALLIBURTON ENERGY SERV INC [US]) 4 October 2001 (2001-10-04) the whole document</td>
<td>1-17</td>
</tr>
<tr>
<td>Patent document cited in search report</td>
<td>Publication date</td>
<td>Patent family member(s)</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA 2511826 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB 2413139 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 1996793 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NO 325821 B1</td>
</tr>
<tr>
<td>US 2001013415 A1</td>
<td>16-08-2001</td>
<td>AU 756064 B2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AU 5602399 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69916397 D1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69916397 T2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA 2292541 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NO 995941 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 6012518 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2004020776 A2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 6651749 B1</td>
</tr>
</tbody>
</table>

Form PCT/ISA/21 0 (patent family annex) (April 2005)