**Title:** METHOD FOR FORMING A CASING WINDOW

**Abstract**

The method and apparatus of the present invention allow the creation of a window in casing downhole using explosive techniques. Locating stakes (10) are initially placed and subsequently surveyed for their depth and orientation. The window-cutting tool locates itself on one of the stakes, and the explosive charges are oriented with respect to the lug downhole so that when the tool is fired, the cuts are made with the appropriate orientation at the proper depth. In the preferred embodiment, horizontal cuts are made, followed by vertical cuts. The tool has the capability of positioning itself adjacent the casing which is to be explosively cut. The strips that are created after the horizontal and vertical cuts are concluded are fished out using a variety of alternative techniques. Another locating or orienting lug, which has been initially installed, can subsequently be used to locate and orient an anchoring device for a whipstock so that the sloping face of the whipstock is pointed directly at the window that has just been explosively cut.
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METHOD FOR FORMING A CASING WINDOW

FIELD OF THE INVENTION

The field of this invention relates to the making of openings in downhole tubulars, particularly casing.

BACKGROUND OF THE INVENTION

Frequently, in existing wells, windows or openings need to be cut in the casing to allow kicking off a deviation from the existing wellbore for further exploitation of hydrocarbons in a formation. The traditional techniques for producing windows has been to secure a whipstock in the proper orientation and to use one or more mills to literally drill through the casing wall. Various types of mills and whipstocks have been employed for such procedures. A typical one-trip window-milling system is the Jurgen's U.S. Patent No. 5,109,924.

However, using one or more mills in combination with a whipstock is a procedure that has its uncertainties. Some applications involve chrome casing, which is particularly hard to penetrate, thus increasing the time required to mill a window.

Using a rotary mill in combination with a whipstock requires that fluid be circulated to remove the cuttings. Having fluid circulation puts pressure on the formation which can adversely affect the performance of the well later when it is put into production. Additionally, using traditional milling techniques involves having a rig available that can handle the rotational requirements for the mill, as well as the pumping and screening requirements for the circulating fluid which removes the cuttings. Use of the traditional milling techniques also has limitations on the whipstock angles that may be used. Additionally, creating a large amount of small cuttings also creates potential problems if they are not effectively removed from the wellbore with the circulating fluid. Prior techniques which have involved milling in combination with circulation have created the need to squeeze uphole intervals.

Accordingly, there exists a need for an improved technique for creating windows in casings. The objects of the invention include the accomplishment of the
creation of a window without drilling or circulation. A simple wireline or electric line
rig is all that is necessary for surface equipment to create the window. Another
objective of the invention is the placement of depth and orientation markers which can
be used in conjunction with the equipment for proper orientation and location thereof.
Such lugs or slots also fulfill the objective of providing location and orientation for a
subsequent anchoring mechanism for a whipstock which is used to kick off the lateral
through the window that has just been prepared. The strips created when the window
is made are removed using a variety of fishing techniques. Thus, another objective of
the invention is to greatly speed up the time required to produce a complete window
and remove the strips from the wellbore in fairly large pieces, as compared to prior
techniques involving milling the portion of the casing, which will become the window,
into very small pieces. The locating lugs or slots also accomplish an objective of the
invention for provision of orientation and depth markers in an existing well to support
a variety of future uses, among which are the kicking off of additional lateral bores
from the main bore.

**SUMMARY OF THE INVENTION**

The method and apparatus of the present invention allow the creation of a
window in casing downhole using explosive techniques. Locating stakes or slots are
initially placed and subsequently surveyed for their depth and orientation. The
window-cutting tool locates itself on one of the stakes or slots, and the explosive
charges are oriented with respect to the lug downhole so that when the tool is fired,
the cuts are made with the appropriate orientation at the proper depth. In the
preferred embodiment, horizontal cuts are made, followed by vertical cuts. The tool
has the capability of positioning itself adjacent the casing which is to be explosively
cut. The strips that are created after the horizontal and vertical cuts are concluded are
fished out using a variety of alternative techniques. Another locating or orienting lug,
which has been initially installed, can subsequently be used to locate and orient an an-
choring device for a whipstock so that the sloping face of the whipstock is pointed
directly at the window that has just been explosively cut.
DETAILED DESCRIPTION OF THE DRAWINGS

Figures 1a-1d are a sectional elevational view of the tool shown in the run-in position.

Figures 2a-2d are the tool shown in Figures 1a-1d in the ready-to-fire position to make a vertical cut.

Figures 3a-3c show the tool of the present invention during the insertion of the locating studs.

Figures 4a-4c show the tool in combination with guns to make horizontal cuts.

Figures 5a-5c are the tool of the present invention with the attachment for making a vertical cut.

Figures 6a-6c are the tool of the present invention shown with a magnetic retrieving tool for removing the cut strip.

Figure 7 is an elevational view of the strips in the casing after the cuts are made.

Figure 8 shows one way to retrieve the strips using a tool which launches a stake into the strip which is tethered to the tool.

Figure 9 is an elevational view of the strips cut in the casing, showing elongated slots cut therein.

Figure 10 shows the technique of retrieving the strips shown in Figure 9 with a retrieving tool which has a member which extends into the slots in the strips.

Figure 11 is a plan view of the device for launching stakes through the casing in the run-in position.

Figure 12 is the stake launching device of Figure 11 shown in the fired position with the stake extending through the casing.

Figure 13 is an elevational view showing a casing patch with a groove installed in the casing.

Figure 14 is a side view of Figure 13, showing a downhole tool with a stud engaging the groove in the casing patch.
DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The apparatus and method can best be understood by referring to Figures 1a-1b. As shown in Figure 1b, a locator stud 10 is fired into the wall of the casing 12. Figure 3c illustrates the firing tools for firing stud 10, as well as a second and lower stud 14 into the casing 12. Stud 10 is fired from gun 16, while stud 14 is fired from gun 18. The guns 16 and 18 are placed in the off-center position shown in Figure 3 by virtue of a pivoting link 20 actuated by rod 22. The precise operation of this linkage will be described below with regard to other details on the invention. It should be noted that in a preferred embodiment, the lugs or studs 10 and 14 are installed in the same plane so that subsequent use of an orientation tool to determine the orientation of stud 10 also determines the depth and orientation of stud 14. A known casing collar locator or logging tools 24 can be run as part of the bottomhole assembly to facilitate the determination of a precise depth at which the studs 10 and 14 are to be inserted. While the insertion of singular studs at two discrete elevations oriented in a common plane is illustrated, those skilled in the art will appreciate that other patterns and numbers of studs can be inserted with stud guns, such as 16 and 18, without departing from the spirit of the invention. As illustrated in Figure 1b, the stud 10 literally penetrates through the casing 12 and leaves a head 26 extending into the casing 12. Other stud shapes are within the scope of the invention.

Figures 11 and 12 illustrate the tool that is used to insert the locator stud 10 shown in Figure 1b, as well as any other locator studs which may be used. The tool has a body 112 which is generally rounded. Within the tool is a shear bolt 114, which is engaged temporarily to a piston 116. An explosive charge 118 of a type well known in the art is disposed around the periphery of shear bolt 114. The charge 118 is inserted in lateral hole 119, which is only visible in Figure 12 after the piston 116 has shifted. The explosive is actuated from the surface via a control system of a type well known in the art. When the explosive 118 is set off, pressure develops which is channeled toward the piston 116. Pressure develops in cavity 120, which results in shearing the piston bolt 114, and because of seals 122 and 124, the pressure built up in cavity 120 launches the piston 116, which is mounted directly behind the stake or stud.
10. The stud 10 has a seal 126 which prevents wellbore fluid from filling cavity 127. Annular cavity 127 decreases in volume as piston 116 is propelled by the explosive charge 118. The body 112 is sized such that when the piston 116 finishes its stroke in a given piece of casing 12, the stud 10 is launched through the casing 12. The stud 10 is equipped with a shoulder 128 which catches the inside wall 130 of the casing 12. Assembly is facilitated using nut 132, which forms part of chamber 127. Nut 132 also has a passage 134 through which the stake 10 is inserted for launching into the casing 12. The threaded connection 136 for nut 132 is sealed by seal 138. Accordingly, the body 112 can be disposed in such a manner as it comes to rest against the inner casing wall 130, as shown in Figure 11. Appropriate controls are actuated from the surface to set off the explosive 118. The pressure built up as a result of setting off the explosive 118 occurs in chamber 120, where the shear bolt 114 fails from excess pressure and the developed pressure is retained from blowing back by seal 140 around the shear bolt 114. As shown in Figure 12, a portion of the shear bolt 114 remains intact after the stud 10 is launched. The cavity 120 is enlarged due to the setting off of the explosive 118. The remainder of the shear bolt 114 rides with piston 116 as piston 116 propels the stud 10 into the casing 12. When launching stud 10 in casing 12 of known inside diameter, the body 112 and piston 116 are configured such that on full extension of piston 116 as it comes in contact with nut 132, the stud 10 has progressed sufficiently through the casing 12 to have its shoulder 128 against the inside surface 130 of the casing 12 with the piston 116 directly behind it. This technique is preferred to avoid an insufficient force on the stake 10, which may cause it to drop to the bottom of the wellbore, or an overly aggressive force on stake 10, which may force it completely through the casing 12. As an alternate to installing studs such as 10, as described above, a casing patch 150 shown in Figure 13 can be installed in the casing 152. Known techniques, such as radial expansion, are used to install the casing patch 150. A groove 154 is placed in the casing patch 150 for ultimate engagement by a stud 156, which extends from a downhole tool 158 such that the stud 156 orients the downhole tool 158 when it is properly located in the groove 154. The top of the patch 150 is tapered toward groove 154 to rotate tool 158 until the stud 156 and
confirmation pin 160 find their way into the groove 154. A signaling technique to the surface can also be employed to alert the surface personnel that the stud 156 has entered the groove 154. A breakable confirmation pin 160 is installed in alignment with the stud 156. The pin 160 can support the weight of the tool 158 such that surface personnel will known that it has managed to orient itself in the groove 154. Once that is determined, the tool 158 can be picked up from the surface and abruptly brought down to break off the pin 160. Since when pin 160 is properly in the slot 154 the stud 156 is also in the slot 154 above it, the breaking of the pin 160 will allow the downhole tool 158 to move further downwardly until the stud 156 engages the bottom 162 of the groove 154, thus ensuring its proper depth and angular orientation in the wellbore. As will be described below, a variety of different tools can be located and supported in the wellbore in this manner. The use of a casing patch with a groove is an alternative to the explosive insertion of locating studs through the wall of the casing, as described above. In the alternative, the casing patch 150 itself can have a stud mounted to it in lieu of a stud which penetrates the wall of the casing. However, in the preferred embodiment using a casing patch, the groove 154 is preferred to a stud in the casing patch to avoid unnecessary reduction of clear area within the wellbore for other operations. In all other respects, the procedures outlined below are applicable to the casing patch technique shown in Figures 13 and 14, as well as to the embedded stud technique described above.

Referring now to Figure 1b, it can be seen that the tool of the present invention has a body 28 which has a taper 30 which extends from a lower end 32 to an elongated longitudinal slot 34. The slot 34 extends down to taper 30 and ends at upper end 36. Ultimately, as the body 28 is lowered from the surface, the taper 30 engages the head 26 of stud 10, and the body 28 is thus oriented to ultimately present the slot 34 in alignment with head 26 so that the body 28 moves downwardly until, as shown in Figure 1b, the head 26 of stud 10 encounters a confirmation pin 38. The confirmation pin 38 is screwed into a boss 40 which extends from a mandrel 50. Actuating rod 42 is connected to orienting collar 44. Orienting collar 44 is also connected to rod 22. Rod 22 is connected to decentralizer bar or link 20, as best shown in Figure 2c.
At the surface the body 28 is lowered, and when the confirmation pin 38 rests on the head 26 of stud 10, a signal that the string is being supported in the wellbore is indicated on the operator's console (not shown). To confirm that the slot 34 has in fact aligned with stud 10, the operator lifts the body 28 (and with it mandrel 50) a few feet and lets them drop. As a result, the confirmation pin 38 is sheared off, as seen by comparing Figure 1b to Figure 2b. The body 28 continues to travel downwardly with head 26 engaged by slot 34. Ultimately, head 26 encounters a tang 46 connected to sleeve 48 which is, in turn, mounted over mandrel 50. Spring 52 biases sleeve 48 toward the position illustrated in Figure 1b. As the body 28 is lowered and head 26 of stud 10 pushes tang 46 up, compressing spring 52, rod 42 moves up with respect to mandrel 50. Eventually, as shown in Figure 2a, tang 46 contacts the upper end 36 of slot 34. As a result, rod 42 pulls up collar 44 which, in turn, pulls up rod 22 which, in turn, extends link 20 outwardly. What is pictured in Figures 1d and 2d is the vertical casing cutter apparatus 54. Cutter 54 has a body 56 with an opening 58 which is parallel to the longitudinal axis of the body 28.

Mandrel 50 has a link 60 fixed at its lower end at thread 62. Link 60 has a pivot pin 64 which connects link 66 to link 60. Finally, link 66 has a pivot pin 68 which connects link 66 to link 70. A shock tube 72 connects link 70 to body 56. The shock tube 72 has an opening 74 through which the detonator assembly 76 is connected. The body 56 has a weight 78 located at its lower end. In the preferred embodiment, the vertical casing cutter 54, which is of a known design, makes a single cut of a predetermined length. Additional trips can be made into the well with the same tool having the body 56 at a different orientation with respect to body 28 so as to facilitate making a vertical cut away from the initial cut. In the preferred embodiment, the window which is being cut is preferably no more than 180° circumferentially around the casing 12. Typically for a window of that magnitude, three cuts are made so that the strips, which are cut away from the casing 12, themselves, have a width no greater than the inside diameter of the casing 12. The body 56 has a series of linear-shaped charges which are aligned with the slot 58 which fire when detonated with the detonator 76 in a known manner. Those skilled in the art can see that prior to firing,
the explosive charges 80 shown for the vertical cutter 54 are brought closer to the
casing 12, as link 20 is rotated about pivot 82 which puts the body 56 in the offset
position, shown in Figure 2d, with slot 58 pressed up against the inside surface of the
casing 12.

Those skilled in the art can appreciate that the proper positioning of the body
56 improves the ultimate vertical cut which is made with the tool 54. It is the presence
of the linkage of links 60, 66, and 70, which allows the offset movement seen by
comparing Figures 1d and 2d upon actuation of rod 22 and link 20. In view of the
small distances involved, the elevation of pivot 68 is essentially unchanged throughout
the range of motion illustrated between the run-in position of Figure 1b and the ready-
to-fire position of Figure 2b. It should be noted that links 66 and 70 are constrained to
pivot in a single plane to avoid changing the orientation of slot 58 as a result of
actuation of rod 22.

Those skilled in the art will appreciate that initially the studs 10 and 14 are
properly located for depth using known devices such as a casing collar locator 24.
Upon setting the studs, such as 10 and 14, through the casing 12, the assembly shown
in Figures 3a-3c is removed and other known orientation tools are run-in the well to
determine precise angular orientation of studs 10 and 14. At this time, the depth of
studs 10 and 14 is known from the previous operation but can also be confirmed on a
subsequent run. Once the precise angular orientation of the studs 10 and 14 is known,
cutting the window can commence. Figure 4 illustrates the horizontal cutting tool 84.
The horizontal cutting tool 84 has linear charges at three elevations 86, 88, and 90.
The linear charges extend for the desired width of the window, typically approximately
180° of the casing or less. The reason a second cut is made at elevation 88 is to
facilitate the removal of the strip, which is cut from the casing 12. This is preferably
done within one foot of the cut at elevation 86. The cut at elevation 90 defines the
bottom of the window, while the cut at elevation 86 defines the top of the window.
The spacing of the three elevations 86, 88, and 90 is a matter of tailoring the tool for
the specific application. The cut at elevation 88 is optional and other techniques, as
will be described below, are available for removal of the strip from the casing 12.
In each case, the same upper tool assembly is used, except at the bottom the horizontal cutting tool 84 is replaced by the vertical cutting tool 54, as shown in Figure 5c. Since the vertical cuts are close to each other, it is preferred that one vertical cut be made at a time. Thus, for a window of approximately a width of 180 degrees around the casing 12, it will take three cuts to cut the window and produce two strips, each of which has a width that is smaller than the inside diameter of the casing. The strip 92 is illustrated in section in Figure 6c. In the preferred embodiment, all of the horizontal cuts illustrated in Figure 4c can be made simultaneously. Once the three horizontal cuts at elevations 86, 88, and 90 have been made and the three vertical cuts using vertical cutter 54 have been made, the strips 92 may need to be removed. In some applications, it will be acceptable to allow the strips 92 to drop down the wellbore 94. As shown in Figure 6c, the apparatus of the present invention can also be used with a magnetic retrieving tool 96. This tool houses a plurality of magnets 98 which can be initially shielded for the trip down the wellbore 94. When the tool is actuated by virtue of the operation of link 20, as previously described, the magnets 98 become unshielded from their nonmagnetic cover (not shown). An alternative is to pivotally mount the magnets 98 and steer them toward the strips 92 when in position, such as shown in Figure 6c.

Another technique for fishing out the strips 92 can be seen by examining Figures 7 and 8. Figure 7 illustrates the shapes of the strips after three horizontal cuts and three vertical cuts are made. A tool similar to guns 16 and 18, as shown in Figure 3c, can be employed to shoot a stud 100 into the large strips. This time the stud 100 is tethered to a line 102 which connects it to the retrieving tool, shown schematically as 104. Thus, the retrieving tool 104 launches the stud 100 through the strip 92, whereupon the strip 92 can be removed to the surface.

It should be noted that the horizontal cut at elevation 88 simplifies handling of the segments of strip 92, particularly if the strip 92 falls outwardly outside the casing, such as illustrated in Figure 6c. Additionally, after the vertical and horizontal cuts are made, a TV camera with a light source can be lowered into the well to visually observe the position of the strip segments 92. The tool 96 can also have a pushaway
mechanism schematically illustrated as 105 in Figure 6c. The pushaway mechanism 105 contacts the uncut portion of the casing 12 to urge the magnetic retrieving tool 96 back into casing 12 so that if the strip segment 92 engaged to the magnets 98, the strip can be pulled back inside the casing if it has in fact fallen outside the casing, as illustrated in Figure 6c.

Alternatively, the technique in Figures 7 and 8 can be used to retrieve the larger pieces of the strip 92 by shooting studs into them and retaining contact via a connecting line 102.

Another technique illustrated in Figures 9 and 10 involves cutting a slot 106 in the strip segment 92. The retrieving tool 108, shown schematically in Figure 10, has a tang 110 which can go into the slot 106 for retrieval of the strip 92. Yet, other fishing techniques can be employed to remove the strips 92 if, indeed, they must be removed for the particular application. If the above-described techniques do not result in retrieval of the strips 92, a video camera can be run down the well with a light source to determine the precise position of the strips 92 to assist in further fishing efforts.

After the fishing operation is concluded, the lower stud 14 can be used in conjunction with an anchor device or a whipstock so that the whipstock, itself, is at the proper elevation and orientation at the newly cut window after the removal of the strips 92. Such anchors can be packers or other devices. The whipstock can even be cemented in place while temporarily supported on the stud 14. A plurality of studs such as 14 can be placed at nearby elevations so that if a new lateral into the same zone is desired the orientation and depth of a new window will be known without additional survey work in the wellbore.

The studs 10 and 14 can be coated with a mildly radioactive material to aid in locating them at a future time. Numerous studs, such as 10 and 14, can be run in the wellbore, especially where the wellbore 94 extends through a variety of pay zones. At some time in the future, such other studs can be located and used to create windows using the technique that is described above without additional survey work.

The locator studs 10 and 14 can be made of a magnetic material to facilitate locating them at a later time. In that sense, additional studs, such as 10 and 14 which
are included in the wellbore into the casing 12, act akin to survey markers used on the surface to alert the surface personnel as to when a particular point in the wellbore has been reached. With these depth markers' known orientations, there is no need for future depth measurements with casing collar locators or other tools that measure depth. The studs, such as 10 and 14, can have different amounts of extension or different shapes, and for a given application, one or more studs, such as 10, can be placed at the same elevation, but rotated away from each other. By placing the studs 10 and 14 after the casing has been set and cemented, their location is known definitely, as opposed to locating such studs as 10 and 14 into the casing when originally run-in. Such studs can support downhole tools such as perforating guns, whipstocks, and also serve as depth markers to alert surface personnel that a particular tool has reached a particular depth. Even if tubing is subsequently run into the casing 12 to a certain depth, the studs, such as 10 and 14, can still be located below the end of the tubing.

While certain discrete tasks have been described that can be accomplished on individual trips into the wellbore 94, those skilled in the art will appreciate that such tasks can be combined into a single trip as opposed to multiple trips. Additionally, the cutting tools can be used in conjunction with surveying tools, such as casing collar locators 24. Additionally, the installation of the studs 10 and 14 can also be combined with use of one or more cutting tools, such as 54 and 84.

The advantages of the system are that it cuts a window in a casing 12 with greater speed. No circulation is required, as is needed when milling tools and a whipstock are used for making a window. Only a wireline rig is necessary to accomplish the operation, as opposed to a more expensive rotary rig with capabilities of pumping and rotating a string to operate the mills. Higher whipstock angles in the order of greater than 5° and up to over 35° are possible when the technique is used, as opposed to prior whipstock angle designs which have ranged in the order of 1-3°. The planting of various orientation lugs in the wellbore, of the type shown as 10 or 14, makes future operation simple because depth and orientation have already been determined when such studs were initially installed. The technique involving cutting
large rectangular strips makes the strips 92 easier to remove and does away with the need to deal with small metal cuttings which are created using a milling technique.

The apparatus and method disclosed above has many applications apart from the application described in detail as the preferred embodiment. The apparatus and method facilitates orienting strings in a multi-string well one time in relation to a stake. Additional runs to perforate or perform other well operations would not require further orientation. In cutting operations for very large casings or pipe, it is significant to keep the total explosives set off at any one time to a level of between 5 and 10 pounds of total high-explosive load. This is generally required to minimize the blast.

By using the stake 10, multiple runs can be made to cut a section one at a time. The stake 10 would allow exact orientation from run to run. In many cases, it is desirable to orient perforating or liner slotting devices for hydraulic fracturing. By using the stake 10, well operation can be simplified for both single and multiple runs and still orient to a desired direction. The stake 10 is desirable to speed well operations in the area of depth control, particularly in hostile environment wells. In blowout wells, a relief well is drilled next to the blowout well. A stake can be placed in the relief well in a certain orientation to the well blowing out. A perforating gun could then be run in the relief well to shoot the well that is blowing out to allow kill weight fluid to control the blowout. For tubing-conveyed perforating or wireline gun hanger applications, the stake can be placed to allow a perforating system to be deployed in a well and released using the stake. A stake can be placed on the low side of a deviated well to allow tubing-conveyed perforating guns with a guide shoe to be swiveled using a swivel sub into the proper direction before firing. This is a more exact method as in orienting tubing-conveyed perforating guns as compared to fins being placed in the tandems together with a swivel sub. A stake can be placed in a well using electric line for exact depth control. Slickline, perforating or other operations could be conducted with improved differential depth control from the stake. The depth control could also be of aid with internally flush pipe depth control and other pipes where casing collar locators do not work well. In slickline applications, a stake could be located on a confirming bolt. The bolt can then be sheared and the locating tool, with a slot completely
through it, could be lowered to any depth desired to allow for positive depth location.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made without departing from the spirit of the invention.
CLAIMS

1. A method for facilitating downhole operation at a predetermined depth in a wellbore, comprising:
   installing a locator member in the wellbore;
   measuring the location of the locator member in the wellbore; and
   running in a downhole tool until it interacts with the locator member so that its location is known.

2. The method of claim 1, further comprising:
   using a stud as the locator member.

3. The method of claim 2, further comprising:
   using a gun to fire the stud into the casing downhole.

4. The method of claim 1, further comprising:
   mounting a stud to the downhole tool;
   securing a casing patch having a slot, which functions as the locator member, to be engaged by the stud; and
   locating the tool by interaction of the stud with the slot.

5. The method of claim 3, further comprising:
   measuring the depth and orientation of the stud.

6. The method of claim 4, further comprising:
   measuring the depth and orientation of the slot.

7. The method of claim 5, further comprising:
   providing an orientation groove for engagement with the stud on an explosive cutter which serves as the downhole tool; and
   providing a surface signal that the groove on the cutter has engaged the
8. The method of claim 7, further comprising:
   making a plurality of strips of casing with the explosive cutter; and
   moving away the strips to create a window in the casing.

9. The method of claim 8, further comprising:
   running in a whipstock and securing it to the stud;
   using the known depth and orientation of the stud to preconfigure the
   whipstock so that its sloping face is properly oriented into the window when it engages
   the stud; and
   drilling a lateral bore through the window.

10. The method of claim 8, further comprising:
    cutting vertically and horizontally to create a plurality of strips, each of
    whose width is less than the inside diameter of the casing.

11. The method of claim 10, further comprising:
    fishing at least one of the strips using magnetic forces.

12. The method of claim 10, further comprising:
    fishing at least one of the strips by embedding a tether into it from a
    retrieving tool.

13. The method of claim 10, further comprising:
    fishing at least one of the strips by cutting an opening in it and inserting
    a retrieving tool into the opening to remove it.

14. The method of claim 11, further comprising:
    using a lateral displacement device on a magnetic retrieving tool so as
to pull strips into the casing when engaged by magnetic force to facilitate their removal.

15. The method of claim 3, further comprising:

pushing the gun against the casing wall; and

driving the stud with a piston having a predetermined stroke such that when the piston stroke is concluded, the stud has penetrated the casing wall.

16. The method of claim 15, further comprising:

providing a head on the stud; and

configuring the piston stroke on the gun, when abutting the casing, to drive the stud into the casing so that the head comes in close proximity with the casing inside diameter at the conclusion of the stroke of the piston.

17. The method of claim 9, further comprising:

using a whipstock having a face angle greater than 5°.

18. The method of claim 6, further comprising:

providing an explosive cutter as the downhole tool with the stud;

orienting the explosive cutter by engaging the groove on the casing patch with the stud; and

providing a surface signal of the engagement of the stud and groove.

19. The method of claim 18, further comprising:

making a plurality of strips of casing with the explosive cutter; and

moving away the strips to create a window in the casing.

20. The method of claim 19, further comprising:

running in a whipstock having a stud mounted to it and securing the stud to the slot;
using the known depth and orientation of the slot to preconfigure the
whipstock so that when the stud engages the slot, the sloping face of the whipstock is
properly oriented into the window; and
drilling a lateral bore through the window.

21. The method of claim 20, further comprising:
cutting vertically and horizontally to create a plurality of strips, each of
whose width is less than the inside diameter of the casing.

22. The method of claim 21, further comprising:
fishing at least one of the strips using magnetic forces.

23. The method of claim 21, further comprising:
fishing at least one of the strips by embedding a tether into it from a
retrieving tool.

24. The method of claim 21, further comprising:
fishing at least one of the strips by cutting an opening in it and inserting
a retrieving tool into the opening to remove it.

25. The method of claim 22, further comprising:
using a lateral displacement device on a magnetic retrieving tool so as
to pull strips into the casing when engaged by magnetic force to facilitate their
removal.

26. The method of claim 20, further comprising:
using a whipstock having a face angle greater than 5°.
FIG. 1d

FIG. 2d

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### INTERNATIONAL SEARCH REPORT

#### A. CLASSIFICATION OF SUBJECT MATTER
- IPC 6 E21B23/00
- IPC 6 E21B29/02
- IPC 6 E21B29/06
- IPC 6 E21B47/024
- IPC 6 E21B43/119

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)
- IPC 6 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)

#### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>1,2,4,6</td>
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<tr>
<td>X</td>
<td>US 4 646 831 A (MARSH JOHN L ET AL) 3 March 1987 see column 1, line 16-44 see column 7, line 37-40 see figure 1</td>
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Further documents are listed in the continuation of box C.

- **X** Patent family members are listed in annex.

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### Date of the actual completion of the international search
13 November 1997

### Date of mailing of the international search report
26/11/1997

### Authorised officer
Schouten, A

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<th>Relevant to claim No.</th>
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<tr>
<td>X</td>
<td>US 5 458 209 A (HAYES LEW ET AL) 17 October 1995 see column 11, line 44 – column 12, line 23 see figures 7A, 7B</td>
<td>1, 2</td>
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<tr>
<td>X</td>
<td>US 4 807 704 A (HSU FRANK H ET AL) 28 February 1989 see column 3, line 23-40 see figure 2</td>
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</tr>
<tr>
<td>X, P</td>
<td>GB 2 304 760 A (Tiw Corp) 26 March 1997 see page 14, line 11 – page 15, line 27 see page 20, line 5-17 see figures 7-10</td>
<td>1, 4, 6</td>
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<tr>
<td>A</td>
<td>US 3 791 043 A (RUSSELL M) 12 February 1974 see column 6, line 8-41 see figure 6</td>
<td>1</td>
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<tr>
<td>A</td>
<td>US 2 679 898 A (V.L. FORSYTH ET AL) 1 June 1954 see the whole document</td>
<td>1</td>
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<tr>
<td>US 4304299 A</td>
<td>08-12-81</td>
<td>CA 1182442 A</td>
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<td>GB 2080371 A,B</td>
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<tr>
<td>US 4646831 A</td>
<td>03-03-87</td>
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<tr>
<td>US 5458209 A</td>
<td>17-10-95</td>
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<td>US 4807704 A</td>
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<td>EP 0310215 A</td>
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<tr>
<td>GB 2304760 A</td>
<td>26-03-97</td>
<td>CA 2184322 A</td>
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<tr>
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<td>12-02-74</td>
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<td>01-06-54</td>
<td>NONE</td>
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