APPARATUS FOR FORMING A SECTION OF CASING BELOW CASING ALREADY IN POSITION IN A WELL HOLE

Inventors
Victor J. Beissinger
Glenn D. Johnson
By

Attorneys
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Victor J. Beissinger
Glenn L. Johnson

By

Attorney

Fig. 15

Fig. 16

Fig. 17

Inventors
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Victor J. Beissinger, Los Angeles, and Glenn D. Johnson, Compton, Calif.; said Beissinger assignor to Richfield Oil Corporation, Los Angeles, Calif., a corporation of Delaware, and said Johnson assignor to Bash-Ross Tool Company, Los Angeles, Calif., a corporation of California

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This invention relates to the art of lining wells, such as oil wells, with casings and is particularly directed to an apparatus by means of which a section of well casing may be formed at the end of a casing which has already been positioned in a well hole.

It is a customary procedure on completing an oil well to install in the well a string of casing known as a well casing in order to maintain the well bore and to prevent fluid from some of the formations from entering the well. This well casing is usually cemented in position at its lower end at least. After the well casing has been set in the well hole it may become desirable to extend the length of the casing below the bottom of the well casing as already set. Furthermore, it may become desirable to replace a section of the well casing already set. Thus, for example, where a section of the well casing is found to be defective or leaking, it may be desirable to remove this section of the casing. Also, it may be desirable to remove a portion of the well casing to perform additional operations back of the well casing, such as additional cementing operations. After the removal of the section of the casing, it may become necessary to install a new section of casing.

Previous to the present invention, whenever it has been found desirable to install another section of casing in a well hole after a well casing has been set in position, it has been necessary to install sections of casing of smaller exterior diameter than the interior diameter of the well casing already set in position, and this necessarily reduces the size of the well bore.

It is the general object of the present invention to provide an apparatus by which a new section of well casing of the same size as the casing previously set in the well may be formed at any desired position in the well hole.

Another object of the present invention is to provide an apparatus by which a new section of well casing formed in the well may be aligned with the previously set well casing.

Another object of the present invention is to provide an apparatus by which a section of the well casing already set in a well hole may be removed and a new section of well casing of substantially the same size formed in the place thereof.

We have found that a new section of well casing of substantially the same size as the well casing already set in the well, may be formed in the well hole and aligned with previously formed sections by the process and apparatus hereinafter described. In the process of the present invention the elements of a section of well casing are established in retracted position on a setting string. In this retracted position they may be lowered through the previously set well casing, although they are adapted to be expanded into a position to form a section of well casing of the full diameter of the previously set well casing. On lowering to the desired position, connection is made between these elements to the previous well casing in order to align the elements therewith. The setting string is then manipulated to move the elements from their retracted position into the position formed in the new casing, the setting string disconnected from the elements and withdrawn from the well hole. Finally the elements are cemented to the well hole. The new section of casing thus formed is anchored in place aligned with the old casing, and its formation does not reduce the size of the well hole.

The apparatus of the present invention includes the casing elements of the new section of casing to be installed, the setting string, and means for releasably connecting the elements to the setting string, which means allow for the positioning or assembling of the elements in a retracted position. This means also includes means by which on relative longitudinal movement between the elements and the setting string the elements may be moved from the retracted to a casing-forming position. The elements are provided with spring arms or other suitable interconnecting means by which connection may be established between the elements and the previously formed well casing, both in the retracted and expanded positions of the elements, whereby the new casing section so formed is automatically aligned with the previously set well casing.

The apparatus of the present invention, together with many further advantages of the invention, will be fully understood from a description of a preferred example of the invention, and for that purpose we have elected to illustrate an example of the invention as applied to the task of forming a new section of casing in place of a defective section of the well casing previously set in the well. The apparatus by which new sections of a well casing can be formed at their position in the well hole will be apparent from the following description.

In the drawings:
Figure 1 is a diagrammatic, vertical section through a well showing a well casing cemented...
in position and having a defective or leaky section which is to be removed.

Figure 2 is a view of the same well after the defective casing has been removed and the bore milled out preliminary to the forming of the new well casing.

Figure 3 is a view of the same well showing the apparatus of the present invention in position adjacent the opening in the old well casing thus produced, and preliminary to the formation of the new casing section.

Figure 4 is a view of the same well after the step of moving the staves to form the new casing section.

Figure 5 is a view of the same well after the cementing step.

Figure 6 is an enlarged elevation, mainly in vertical section, of the apparatus positioned in the well bore and before the expanding operation.

Figure 7 is a fragmentary perspective view of one of the bottom centering members.

Figure 8 is a view of the apparatus in over-expanded position, as taken on the line 8—8 of Fig. 10.

Figure 9 is a section through the apparatus, taken on the line 9—9 of Fig. 6.

Figure 10 is a fragmentary elevation of the staves assembled in position to form the new casing section.

Figure 11 is a section on the line 11—11 of Fig. 10.

Figure 12 is a fragmentary elevation of one of the inner staves.

Figure 13 is a fragmentary elevation of one of the outer staves before the addition of the guard members.

Figure 14 is a fragmentary elevation of one of the inner-stave members showing the openings for the installation of the cam boxes.

Figure 15 is an enlarged fragmentary vertical quarter section of the apparatus in the well hole before the expanding operation.

Figure 16 is a similar view after the over-expanding operation.

Figure 17 is a similar view after the release of the mandrel from the formed casing section.

Figure 18 shows a modified form of the upper dog to be used where the new casing is to be formed below the well casing.

Referring to the drawings, the casing section to be produced is formed from a plurality of casing elements. As illustrated, these casing elements are shown in the form of staves. The staves are divided into two units, a set of inner staves 2 and a set of outer staves 3. There are equal numbers of inner and outer staves. In the preferred form of the invention, four outer staves are employed. These staves might be produced through slitting a section of well casing longitudinally. The staves are of the usual thickness of well casing ordinarily employed in oil wells, or may be of heavier material, and therefore have inherent rigidity. The staves are assembled as indicated in Figure 9 with the inner staves 2 in one concentric series on the mandrel 4. The outer staves are arranged in a second concentric series and staggered relative to the inner staves 2.

In this position the staves are sufficiently compacted so that they may be lowered through the previously set well casing in the well. To form the well casing both the inner staves 2 and the outer staves 3 are moved radially from the position illustrated in Figure 9, the inner staves 2 being interposed between the outer staves so that they become finally arranged in a circumferential series.

To guide the stave members in these operations, the stave members 2 and 3 are provided with cooperating guide means. For this purpose the inner staves are provided with a plurality of pins 5 adjacent their edges. The pins 5 extend radially from the staves. The outer staves are provided with slots 6 extending inwardly in a circumferential direction from their edges, and in position for receiving the pins 5. The interfitting engagement between the pins 5 and the slots 6 lock the staves 2 and 3 from relative longitudinal movement while permitting both circumferential and radial movement of the staves. They also permit a relative radial movement between the staves so that the inner staves may be positioned as described, back of the outer staves. Preferably at each of the slots 6 the outer staves are provided with guards 7 which are indicated as preferably welded to the staves. The guards 7 extend beyond the edges of the staves and are provided with elongated apertures 8 which through a portion of their length align with the slots 6 but which extend beyond the edges of the outer staves 3. These apertures receive the ends of the pins 5; the ends of the apertures limiting the circumferential separation of the staves.

Tension means are provided for yieldingly urging the stave members toward the axis of the apparatus. For this purpose we preferably employ a number of elastic bands 9 which are indicated.

Figure 9, 10, and 17, are of eccentric type and are intended to cooperate with cam surfaces 12 on cam boxes 13. Each of the inner staves 2 is originally provided with at least two longitudinally spaced apertures 14, as illustrated in Figure 14, and the cam boxes 13 are welded in position in said apertures 14. Counterclockwise rotation of the cams 11 from the position indicated in Figure 15 by longitudinal movement of the mandrel 4 relative to the stave members will expand or move the inner stave members 2 radially outward. This positions the inner staves 2 and also the cam boxes 13, as illustrated in position illustrated in Figures 8 and 16. We refer to this position as the over-expanded position since the staves have now been advanced radially to slightly beyond the position in which they are finally to rest. In this expansion of the stave members the apertures 8 in the guards 7 control the relative circumferential movement of the staves 2 and 3 and limit the separation of the staves.

As the cam 11 passes the center position shown in Figure 16, it disengages from the cam box 13 and drops into the position shown in Figure 17, wherein the staves are released from the mandrel.
until their edges contact under the influence of the tension bands 9 and assume their final position.

Each of the inner stave members 2 is provided at its upper end with a spring arm 15 having dogs 16 at their other ends, the dogs providing fingers 17 and shoulders 18. The spring arms 15 are compressed inwardly when the apparatus is passing through the well casing, but when the apparatus is positioned below the well casing, the arms expand and the fingers 17 contact the inner surface of the casing and come to center the apparatus with reference to the well casing. In the expanded position the shoulders 18 are adapted to ensure the bottom of the well casing and stop the upward movement of the device when the mandrel is elevated. This provides a point of mechanical support for the device so that the upward movement of the mandrel may be translated into a force for pivoting the casing 11. Preferably there are also provided spring arms 19 at the lower ends of the outer stave members 2. These spring arms are provided with dogs 20 having fingers 21 for centering the apparatus with reference to the lower section of well casing, and have enlarged portions provided shoulders 22 for limiting the descent of the apparatus.

At the lower ends of the dogs 20 have flanges 35 and the lower ends of the staves 3 overlap the flanges 35. Preferably there is installed in the apparatus a bearing surface between the mandrel and staves 2 and 3; and while various bearing surfaces might be provided we have indicated the mandrel 4 as provided with a collar 34 adapted to contact the upper ends of the flanges 35 to serve as this bearing surface. The staves 2 are indicated as of shorter length at their lower ends than the staves 3. In order to provide clearance for the movement of the dogs 20 on the spring arms 19.

For certain purposes, particularly where the apparatus is to be used in a process of forming a section of casing in the open hole below the well casing, additional centering devices may be employed, for which purpose the mandrel 4 is indicated as attached to a spring formed centering device 23.

With the apparatus described, the method of the present invention is as follows: Referring to Figure 1 of the drawings, we have indicated diagrammatically a typical well hole 24. Such a well hole is indicated as having the well-known water string 25 with a shoe 26 at its lower end. This water string is cemented in place, as indicated at 27. A well casing 28 is indicated as suspended at its upper end in the well hole by slips 29 mounted in a landing head 30. The well casing 28 extends to the bottom of the well and is there cemented into position, as indicated at 31. In the drawings the section marked X of the well casing 28 is indicated as of leaking and defective construction.

In the process of the present invention, this defective section is first milled or cut away. For this purpose there may be employed any usual milling or cutting equipment, not shown. Following the removal of the defective portion of the well casing, the formation back of the well casing is enlarged, as indicated at 32, by means of any suitable expandable cutter or reaming tool. The enlargement of the bore removes the mud cake or other foreign impermeable material from the well bore and not only provides adequate space for the subsequent formation of a new casing section but also provides unrestricted access to the permeable formation back of the well casing and facilitates securing a good bond between the formation and the cement to be introduced as hereinafter described.

The staves 2 and 3 are then assembled in the position indicated in Figures 6 and 9 on the mandrel; that is the inner staves form one circle and the outer staves form a second circle, concentric therewith, with the outer staves staggered relative to the inner staves. In this assembling operation the pins of the inner staves are fitted into the slots for the outer staves, and the pins for the mandrel are properly engaged with their cam surfaces. The tension bands are positioned as indicated, and the mandrel carrying these staves is attached to the end of a drill pipe 33. The apparatus is then lowered into the well hole.

When the arms 19 pass below the ends of the casing 28 above the enlargement 32 of the well hole, the arms expand until the flanges 35 on the dogs 20 contact the lower end of the outer staves 2. In this position further lowering of the apparatus allows the fingers 21 to pass into the well casing 28 below the enlargement 32 where they are in position to center the device as hereinafter pointed out. When the shoulder 22 of the dogs 20 strike the upper end of the casing 28 below the enlargement 32 they arrest the further descent of the apparatus and signal the operator that the apparatus is at the proper depth in the well hole. When the spring arms 19 are attached to the staves 2 pass below the casing 28 they expand immediately and cause their fingers 17 to contact the inner surface of the casing 28 and center the device with reference to the upper portion of the well casing 28.

The operator now elevates the drill pipe 33 and on contact between the shoulder 18 and the well casing 28 the upward movement of the staves is arrested and further upward movement of the drill pipe 33 causes the counter-clockwise rotation of the pins 14, expanding the staves as heretofore described and interposes the inner staves 2 between the alternate outer staves 3, forming the same into a circumferential series to conform to a well casing section. Further movement of the drill pipe 33 releases completely the mandrel from the thus-formed well casing section and the drill pipe above mandrel are then withdrawn from the well hole. As the outer staves 3 expand, the fingers 21 on the dogs 20 move outwardly into position to contact the well casing 28 below the enlargement 32 of the well hole and these fingers then center and align the formed well casing section with the lower portion of the well casing 28.

The produced casing section is then cemented in position in any ordinary or desired manner. For example, a packer may be lowered down and positioned at a medial point along the newly formed well casing section. Cement is then pumped down the well casing and caused to flow under the bottom of the staves into the enlargement 22 of the well hole and up around the two ends of the casing 28 and back of the newly formed casing, locking the old casing 28 with the new casing section. Subsequently the packer is removed and at the setting of the cement the bore of the new pipe section is drilled out to conform with the bore of the portions of the casing 28 above and below the new section.

In drilling out the bore of the newly formed casing, the dogs 16 and 20 are drilled out. To facilitate the drilling out of these dogs they are
preferably formed of a friable or readily drillable material, such as cast iron. The pins 5, guards 7, elastic bands 9 and spring arms 15 and 19 remain imbedded in the cement back-of-the newly formed casing section and anchor and reinforce the section.

Now referring to Figure 18 of the drawings, we have shown a modification of the apparatus which may be used where the new well casing is to be formed below the already set well casing. In Figure 18 the well casing 13 is indicated as terminating as usually in a float-shoe 35. The dose 18 attached to the spring arm 15 in this modification have fingers 17 which are provided with heads or hooks 37 which are adapted to catch on the float-shoe 35 and suspend the newly formed section from said float-shoe until the newly formed section has been cemented in place.

With the apparatus of the present invention it is therefore possible to install a section of well casing of full size in a well hole after the well casing has been set in position in the well hole. By means of the present invention it is therefore possible to preserve the diameter of the well, the diameter of which has previously been always reduced by these operations.

While the specific examples of the apparatus herein described are well adapted to carry out the objects of the invention, it will be obvious that various modifications may be made in the details of the apparatus employed, without departing from the principles of the invention, and this invention includes such modifications and advantages as come within the scope of the appended claims.

We claim:

1. An apparatus for forming sections of casing in a well hole, comprising a mandrel, a set of inner staves and a set of outer staves supported by said mandrel, expanding means interconnected said mandrel and staves for moving the staves radially upon relative axial movement between said mandrel and staves, and guiding members interconnected said staves operative for guiding the staves into circumferential alignment on radial expansion of the staves.

2. An apparatus for forming well casing sections in a well hole having an inner set and a concentric outer set of casing staves, a mandrel supporting said staves, interconnected expanding members between the mandrel and staves for radial advancement of the staves on relative axial movement between the staves and mandrel, and tension means for yieldingly urging the staves radially.

3. An apparatus for forming a casing section in a well hole below a previously set casing, comprising a mandrel, a plurality of casing staves mounted on the mandrel, radially advancing members between said staves and mandrel for radially advancing the staves on relative axial movement between the mandrel and staves, said staves having interconnected guide members for circumferentially aligning the staves when radially advanced, and centering arms connected to the staves adapted for making centering contact with the casing set below which the casing section is to be formed.

4. In an apparatus for forming a section of casing, a plurality of inner casing staves and a complementary number of outer casing staves, a pin and slot guiding connection between the inner and outer staves, and spring arms connected to the staves having centering fingers.
Previously set well casing on lowering of the elements and setting string adjacent thereto, said means being adapted for establishing connection between said elements and said previously set well casing while said elements are connected to said setting string.

VICTOR J. BEISSINGER,
GLENN D. JOHNSON.