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METHOD AND APPARATUS FOR USE IN GRAVEL PACKING WELLS

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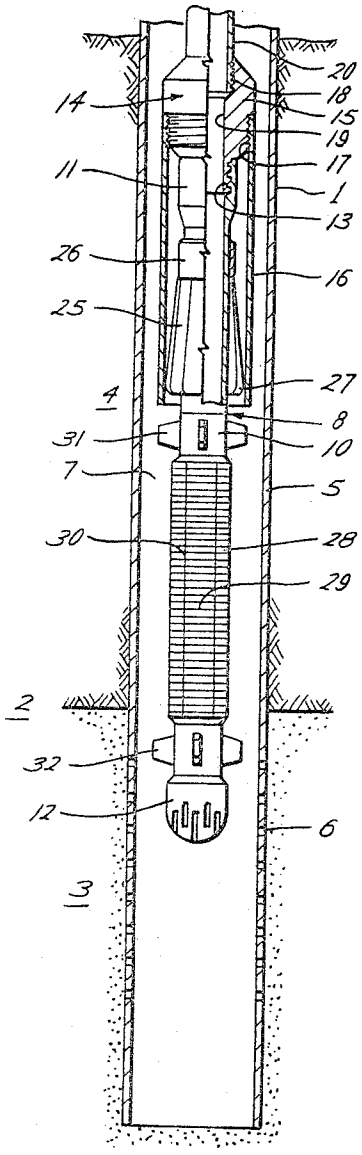



Fig. 1

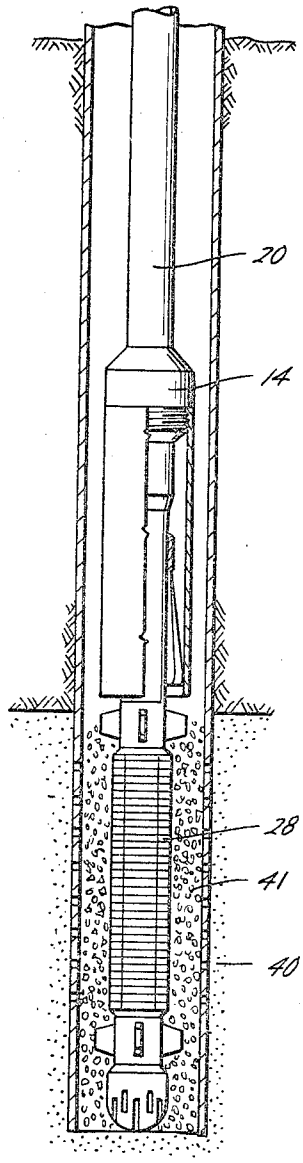



Fig. 2

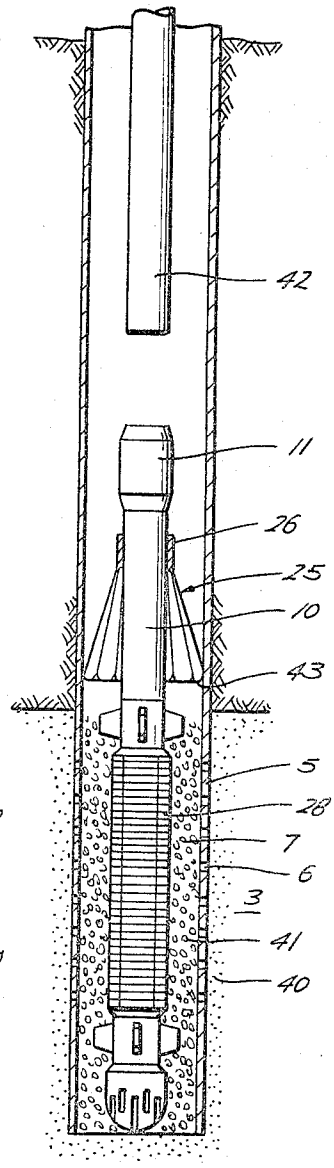



Fig. 3

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# METHOD AND APPARATUS FOR USE IN GRAVEL PACKING WELLS

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Int. Cl. E21b *43/04, 33/12, 23/06*

## ABSTRACT OF THE DISCLOSURE

For use in gravel packing a well, a gas pervious basket is provided which is placed in inverted position above the producing formation. The basket is expansible so that the lower portion thereof will contact the borehole or casing adjacent the producing formation. Gravel is thus retained beneath the basket, while formation gases are free to pass through the basket.

In the drilling and producing of wells, such as oil, gas and water wells, various problems are encountered with the formation in which the well is drilled. For example, such formations generally contain large amounts of sand. After production of the well has ensued, sand from the formation is drawn into the well along with the well fluids and is produced along with the oil, water or gas. Not only does this contaminate the fluid being produced often to the point of rendering the whole well-producing process uneconomical, but it also causes erosion of the formation immediately surrounding the well bore. This disruption of the surrounding formation can eventually cause the formation to cave-in on the well bore, terminating the useful life of the well.

Various means have been employed to prevent sand from moving into the producing conduit of the well. One such method is called "gravel-packing," and this involves hydraulically packing a multitude of minute gravel particles around the producing conduit. The gravel, which is carefully chosen according to size based on grain size of the sand, well pressure, and other factors, is placed in the formation outside a perforated casing which is set in the borehole, and sometimes within the casing in the annulus between casing and production conduit. Gravel may be similarly placed in an open hole beneath the casing. The placement of gravel in this manner is done according to methods some of which are well known in the art, for example as disclosed in L. A. Layne, U.S. Patent No. 1,975,162.

When gravel is distributed in the producing formation in this manner, the formation is supported and the velocity of flow of well fluids through countless channels is controlled. Since the gravel used has a higher permeability than the formation sand, the fluids move at a lower velocity through the gravel at the sand-gravel interface. The sand thus does not have a tendency to enter the well fluid and contaminate it, and the formation is not seriously eroded.

Gravel packing methods have become extremely beneficial to the well driling art, and the use of such methods is now quite widespread. When gravel is placed in the annulus between casing and producing conduit adjacent the producing zone of a producing formation, means must be employed in the annulus above the gravel for retaining the gravel in place adjacent the producing zone. Such means have in the past customarily comprised a packer.

The use of packers in such context is disadvantageous for several reasons. First of all, such packers must occupy substantially all the annular space, and therefore gases entrapped in the formation may not escape upwardly, but instead build up below the packer. This causes the



packer to act as a piston, and the gas pressure below the packer may build up to such an extent that the packer or casing is ruptured, seriously damaging the well. Further, in some wells especially where thermal recovery operations are employed, the temperatures are so great that conventional heat-sensitive packers cannot be used. And perhaps the greatest problem with the use of packers is that, after the packer has been in position for a while, it is often extremely difficult to pull without damaging the borehole and associated apparatus.

These and other problems inherent in prior art gravel packing methods are alleviated by use of the present invention, which employs an inverted basket member to retain the gravel adjacent the producing zone, in the annulus between casing and production conduit, and which provides a method which can be readily performed at the surface of the well.

In summary, the invention comprises a basket which is connected in an inverted position to a lower portion of the production conduit of a well. The basket is adapted to be compressed for passing it downhole without contact with the borehole, and means are provided for opening the basket once it is placed in position just above a gravel-packed producing formation. The means for opening the basket are desirably attached to an upper portion of the production conduit—in this manner, the basket may be readily opened upon separation of the upper and lower portions of producing conduit. Once the basket is opened, production of the well may proceed with the gravel being held in place adjacent the producing formation while formation gases are allowed to pass through the gas-pervious basket. Production of well fluids, meanwhile, proceeds through the production conduit which is appropriately perforated beneath the upper portion of the basket.

In order that the invention may be more clearly understood, it will be explained in terms of one specific embodiment which is illustrative only and not limiting of the scope of the invention. This embodiment is illustrated in the accompanying drawings which form a part of this specification and wherein:

FIGURE 1 is an elevational view, partially in section, showing an initial step in accordance with this invention and further illustrating one embodiment of the apparatus employed.

FIGURE 2 is also an elevational view, illustrating a second step in the method of the invention.

FIGURE 3 is an elevational view illustrating a later step in the method of this invention, wherein the well is adapted for production of well fluid.

Referring now in greater detail to the drawings, wherein like reference numerals represent like parts, a borehole **1** has been drilled into a producing formation **2**. The producing formation comprises generally a producing zone **3** and a nonproducing zone **4**. Into the borehole **1** is placed a tubular casing **5**. The casing **5** is perforated at a plurality of points **6** adjacent the producing zone **3**, so that well fluids from the producing zone **3** may flow through the casing walls into the interior of the casing **5**.

Being run into the well in FIGURE 1 are gravel retaining means, means for releasing the gravel retaining means, and sections of the production conduit.

The production conduit **8** shown in FIGURE 1 comprises a length of tubing **10** which is flared into a section of enlarged diameter, or internally threaded box **11**, at its uppermost (in the orientation shown in FIGURE 1) extremity, and terminates at its lowermost (again with respect to the FIGURE 1 orientation) extremity in a rounded end portion **12**. An annulus **7** is defined between casing **5** and tubing **10**.

Gravel retaining means are carried by the tubing **10**. Means for releasing the gravel retaining means—such as

the releasing tool **14** is threadedly engaged with the tubing **10** by the internal threads **13** of the box **11**.

Releasing tool **14** comprises generally a cylindrical mandrel **15** which has an elongate tubular sleeve **16** extending axially therefrom. The sleeve may be integral with the mandrel **15**, or as in the illustrated embodiment may be threadedly connected as at **17** adjacent the outer periphery of the mandrel. The releasing tool contains means for connecting it to a letting-in tool, such means desirably comprising the threads **18** on an inner bore **19** of the mandrel. A pipe **20**, extending to the surface of the well bore, is threadedly connected to the mandrel **15** at the threads **18**, and this pipe is used to lower the FIGURE 1 apparatus into the well bore.

Located on the tubing **10** beneath releasing tool **14** is a gravel retaining means, which in this embodiment comprises generally an inverted gas-pervious basket **25**. By "inverted" is meant that in its usual orientation of use in this invention, as illustrated in FIGURES 1–3, the basket is upside-down with respect to its customary use in other operations. Though any convenient basket means might be employed, it has been found desirable to use baskets which have been heretofore employed in well cementing operations by such as Halliburton Company of Duncan, Okla., and, under the mark "Metal Petal" basket, Baker Oil Tools, Inc. of Los Angeles, Calif. Such a basket comprises generally a tubular base portion **26** which fits around the tubing, and a plurality of staves **27** extending axially from said base portion. The staves **27** are adapted to be compressed so that the overall shape of the basket is generally cylindrical, but when released the end of the staves opposite the base **26** will project radially outwardly to assume their natural position and give a more or less upside-down V-shape appearance to the basket.

The tubing **10** beneath the basket means is adapted to receive the well fluid from the producing zone **3**. For facility in admitting well fluid to the tubing, the tubing contains openings (not shown) through which the fluid may flow from the annulus **7** into the production conduit **8**. Surrounding these openings is means for preventing flow of gravel into the openings along with the well fluid. Such means may conveniently comprise a tubular well screen **28** which contains a multitude of minute slots **29** too small for gravel to enter. The screen may include a number of longitudinal welds **30**, although it is noted that any suitable means for admitting well fluids while restricting entry of gravel would be satisfactory, and the particular well screen illustrated in this embodiment need not necessarily be employed.

Above and beneath the tubing section **10** which is to receive the well fluid into the production conduit **8**, may desirably be located centering guide lugs **31** and **32** for facility in positioning the basket means and lower tubing section in the borehole.

The method of gravel packing and retaining gravel according to this invention may be readily understood by reference to FIGURES 1–3 in sequence.

FIGURE 1 illustrates the lower section of tubing with the associated basket means being run into the hole, the staves of the basket means being compressed by the sleeve of releasing tool **14** in order to allow free passage of the apparatus down hole.

The perforated tubing which is to receive the well fluids into the production conduit is then positioned in the well adjacent the producing formation **3**, such as illustrated in FIGURE 2. Gravel **41** is then packed into the annulus **7** between casing and tubing in any suitable manner well known in the art. It will be understood that gravel may also be packed into the area around said casing on the exterior of said borehole, if desired.

The releasing tool and associated apparatus are then turned, from the surface, to threadedly disconnect this apparatus from the gravel retaining means. In this respect, the threads **13** on the interior of box **11** are conveniently left-hand threads, while the threads **17** and **18** are conveniently right-hand threads, so that the releasing tool assembly may be readily disconnected from the rest of the apparatus shown in FIGURE 1 without affecting the various threadedly connected parts of that apparatus.

When the releasing tool is disconnected from the basket means and the sleeve **16** is withdrawn from contact with the staves **27** of the basket, as by pulling upwardly on the pipe **20**, the staves **27** assume their natural position and the ends of the staves opposite base **26** engage the inside wall of the casing around the entire periphery thereof, as seen at **43** in FIGURE 3. The releasing tool **14** and pipe **20** are then withdrawn from the well. This complete operation is readily handled from the surface. As seen in FIGURE 3, the basket **25** is thus effective for retaining therebelow, adjacent the producing zone, the gravel **41**.

Sections of tubing **42** of sufficient overall length to reach from the box **11** to the well surface for example, are then lowered into the hole. The lowermost such section may have at the bottom thereof threads convenient for mating with the threads **13** of box **11**. Such tubing may then be made-up with the box **11**, and an overall production conduit is defined by the lower tubing sections **10** and upper sections **42**. Alternately, the tubing section **42** may terminate some distance above the box **11**, as in FIGURE 3.

The producing well is illustrated in FIGURE 3, with the well fluids flowing from the producing zone **3** of the producing formation **1**, through the sand **40** and into the gravel packed annulus **7** by way of the perforations **6** in casing **5**. The well fluid then flows into the perforated tubing **10** through the screen **28**, and enters the production conduit **8**, from whence it is brought to the surface and transported to storage tanks or to a pipeline, etc.

It is noted in the FIGURE 3 embodiment that the lowermost end of the tubing section **42** does not engage the box **11**, but terminates instead some distance above the box. When this embodiment is used the casing **5** in the area around box **11** functions as the production conduit connecting lower tubing section **10** and upper tubing **42**. The reason for use of this particular embodiment is to allow the gases passing up the annulus between casing and tubing to be passed out the top of the well not through the annulus but through the tubing string **42**. A production packer may be placed around the string **42** if desired.

Entrapped gas or other fluids in the production zone **3** which migrate into the annulus **7** under pressure, may pass through the gas-pervious basket **25** and exit through the annulus around box **11** and thence through the tubing **42**. But the gravel **41**, which is prevented from entering the production conduit by the well screen **28** or other suitable means, cannot pass into the tubing **42** because it is retained adjacent the producing zone **3** by the expanded basket **25**.

The well screen **28** may become clogged during production of the well, or for various other reasons such as work-over of the well, it may be desirable to withdraw the basket means from the well. When and if this is desired, it is easily accomplished since the basket will readily slide along the inside wall of the casing in contact therewith. For this reason, it is seen that the utility of this invention is most significant in those wells which are not operating at extremely high pressures in the production zone. Also, the releasing tool may be passed back down-hole to again compress the staves **27** and remove the basket to the surface.

It is readily seen that the invention has provided method and apparatus for gravel packing a well, and for operation of a producing well having gravel packed in the annulus thereof, which prevents the gravel from flowing away from the producing zone while at the same time allowing entrapped gases from the producing zone to escape.

Further, it is seen that method and apparatus is pro-

vided which allow for convenient retention of gravel in almost any well situation with the possible exception of extremely high pressure wells, even those in which thermal recovery operations are employed.

Still further, it is seen that the invention provides a gravel retaining means which can be readily pulled from the well if desired, without damaging the borehole or the various apparatus in the well.

It is also seen that method and apparatus are provided wherein the gravel retaining means may be lowered into the hole and released from the surface.

Although the invention has been described in terms of a specific embodiment, it will be understood by those skilled in the art that various changes may be made in the structures herein shown without departing from the scope of the invention, which is defined by the following claims.

I claim:

1. In a well comprising a borehole drilled into a producing formation, a perforated casing in said borehole adjacent a producing zone, and a production conduit extending to said producing zone, a method of gravel packing the well and retaining the gravel therein comprising:

lowering into said well to a point adjacent said producing zone inverted gas-pervious basket means having a plurality of compressed staves;

placing gravel in the area beneath said basket means adjacent said producing zone;

releasing said staves of said basket means whereby said staves assume a position in contact with said casing at points substantially around the entire periphery of said casing, the base of said basket being located above said points; and,

producing said well, whereby well fluids flow from said producing zone through said gravel into said production conduit, said gravel being retained in position adjacent said producing zone by said basket means while entrapped gases in said formation may be passed upwardly through said basket.

2. In a well comprising a borehole drilled into a producing formation to a producing zone, apparatus for retaining gravel in said borehole adjacent said producing zone comprising:

a production conduit in said borehole extending to said producing zone;

basket means having its upper end around and attached to a lower portion of said production conduit, the lower end of said means being compressable into a first position whereby said basket can be passed through said borehole without contacting said borehole, and being expandable into a second position whereby at least a part of said basket is in contact with said borehole around the entire periphery thereof; and,

a sleeve surrounding said basket and connected to an upper portion of said conduit for compressing said basket, and means permitting disconnection in the well bore of said upper portion of said conduit from said lower portion, whereby said upper portion and sleeve may be moved upwardly so that said basket may expand into contact with said borehole.

3. Apparatus in accordance with claim 2, wherein said production conduit comprises a tubing, perforations in said tubing, and a well screen around said perforations for keeping said gravel out of said tubing while allowing well fluids to flow into the interior thereof.

4. Apparatus in accordance with claim 2, wherein said basket means is pervious to gas, whereby gas under pressure from said producing zone may pass upwardly through said borehole.

5. Apparatus in accordance with claim 2, wherein gravel is also packed on the exterior of said borehole.

6. Apparatus in accordance with claim 2, wherein said borehole has therein a tubular casing, said casing being perforated in an area adjacent said producing zone.

7. In a well comprising a borehole drilled into a producing formation and a production conduit extending to a producing zone, a method of gravel packing the well and retaining the gravel therein comprising:

lowering into said well to a point adjacent said producing zone inverted gas-pervious basket means having a plurality of compressed staves;

placing gravel in the area beneath said basket means adjacent said producing zone;

releasing said staves of said basket means whereby said staves assume a position in contact with said borehole at points substantially around the entire periphery of said borehole, the base of said basket being located above said points; and,

producing said well, whereby well fluids flow from said producing zone through said gravel into said production conduit, said gravel being retained in position adjacent said producing zone by said basket means while entrapped gases in said formation may be passed upwardly through said basket.

8. In a well comprising a borehole drilled into a producing formation to a producing zone, apparatus for retaining gravel in said borehole adjacent said producing zone comprising:

a production conduit in said borehole extending to said producing zone;

a perforated casing in said borehole adjacent said producing zone;

basket means having its upper end around and attached to a lower portion of said production conduit, the lower end of said means being compressable into a first position whereby said basket can be passed through said borehole without contacting said borehole or said casing, and being expandable into a second position whereby at least a part of said basket is in contact with said casing around the entire periphery thereof; and,

a sleeve surrounding said basket and connected to an upper portion of said conduit for compressing said basket, and means permitting disconnection in the well bore of said upper portion of said conduit from said lower portion, whereby said upper portion and sleeve may be moved upwardly so that said basket may expand into contact with said casing.

9. Apparatus in accordance with claim 8, wherein said basket means comprises a generally tubular base which fits around said production conduit, and a plurality of staves extending axially therefrom, said staves being capable of being compressed into a first position not in contact with said borehole or casing, and of being expanded into a second position whereby the ends of said staves opposite said base are in contact with said borehole or casing.

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U.S. Cl. X.R.

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