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[54] **WELL COMPLETION IN FRIABLE SANDS**

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[52] **U.S. Cl.** **166/278**

[51] **Int. Cl.** **E21b 43/04**

[58] **Field of Search** 166/278, 314, 276

[56] **References Cited**

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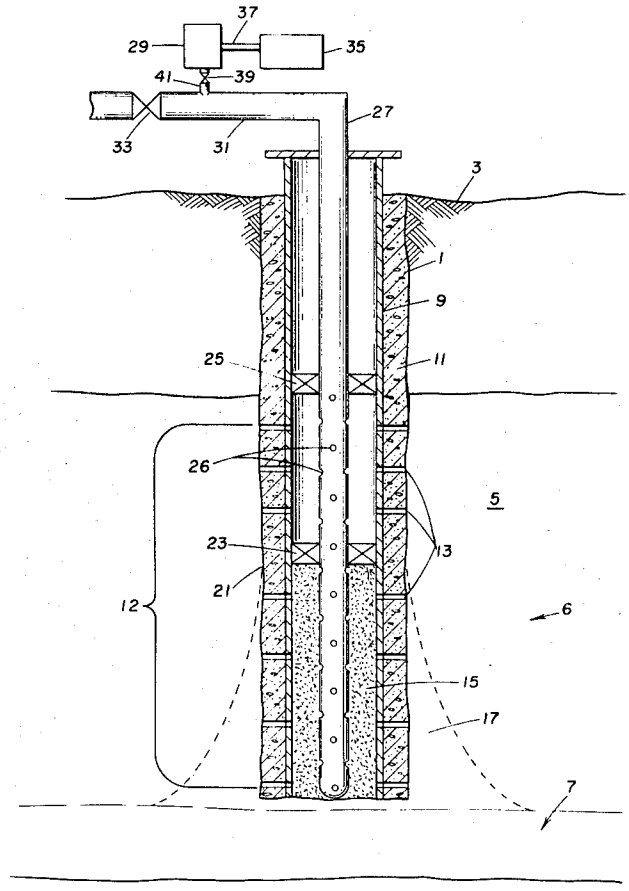
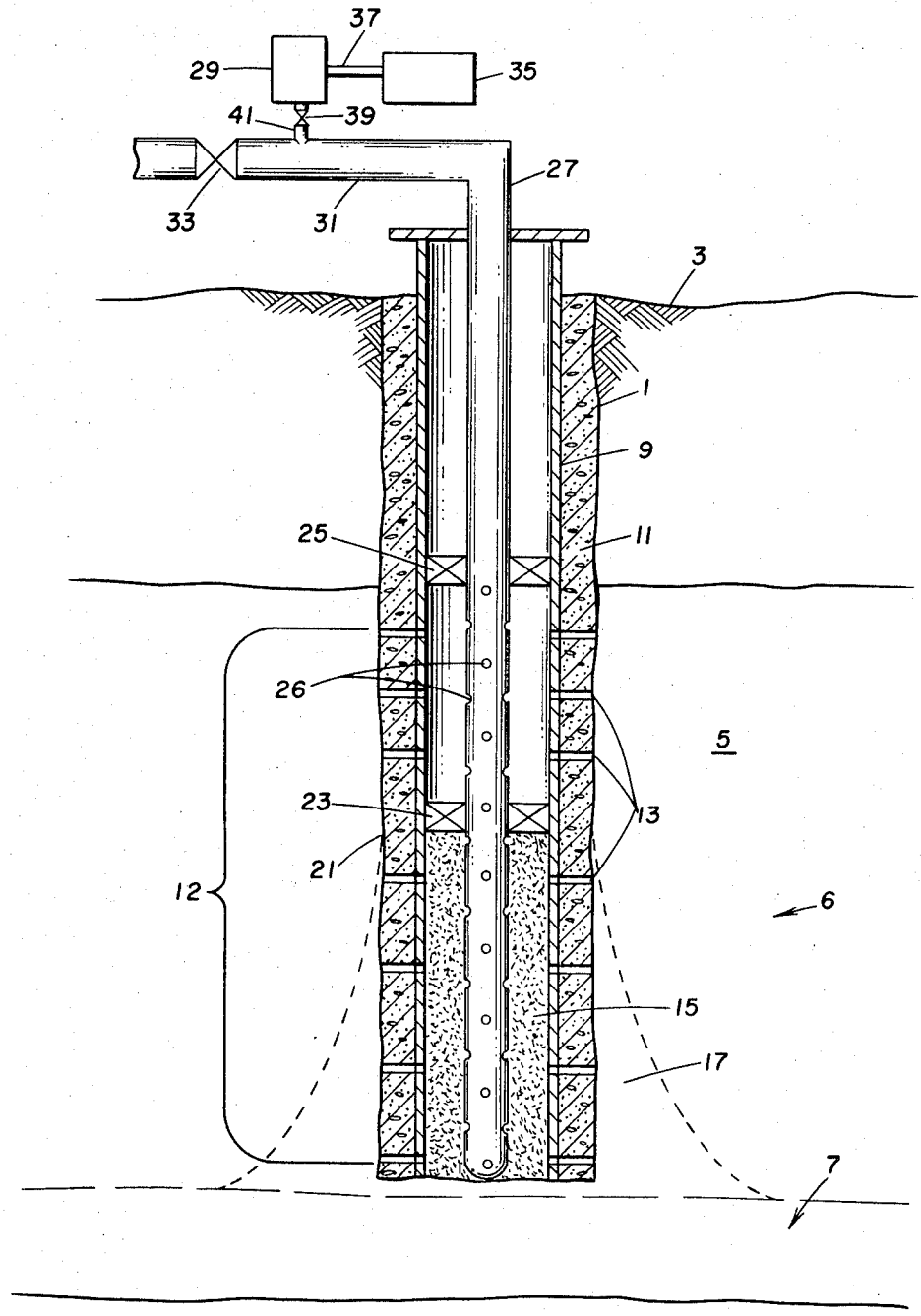
[57] **ABSTRACT**

This specification discloses a well completion system for use in unconsolidated formations and a process for producing fluids from wells penetrating such formations. A well is provided that extends into the unconsolidated formation and has an open production interval that communicates with the formation. A sand retainer is installed adjacent a lower portion of the open production interval. The sand retainer extends from the lower extremity of the open production interval upward to an intermediate location of the open production interval. Fluids are produced from the well at a rate such that sand arches are formed and the formation is stabilized, thus permitting a high rate of production of hydrocarbons with a minimum production of sand from that portion of the unconsolidated formation above the sand retainer. Concomitantly therewith fluids are produced from the formation through the sand retainer, which sand retainer controls the flow of sand from the portion of the formation adjacent the sand retainer.

12 Claims, 1 Drawing Figure





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WELL COMPLETION IN FRIABLE SANDS

BACKGROUND OF THE INVENTION

This invention relates to the production of fluids from subterranean formations and more particularly to well completion systems for use in unconsolidated formations and to processes for producing fluids from wells penetrating such formations.

In the production of hydrocarbons from hydrocarbon-bearing unconsolidated formations, a well is provided which extends from the surface of the earth into the unconsolidated formation. The well normally terminates within the formation above the location of any bottom water which may underlie the hydrocarbons in the formation. The well may be completed by employing conventional completion practices, such as running and cementing casing in the well and forming perforations through the casing and cement sheath surrounding the casing, thereby forming an open production interval which communicates with the formation.

The production of hydrocarbons from unconsolidated formations may result in the production of sand along with the hydrocarbons. Produced said is undesirable for many reasons. It is abrasive to components within the well, such as tubing, pumps and valves, and must be removed from the produced fluids at the surface. Further, it may partially or completely clog the well, thereby making necessary an expensive workover. In addition, the sand flowing from the formation may leave therein a cavity which may result in caving the formation and collapse of the casing.

A technique commonly employed for controlling the flow of sand from an unconsolidated formation into a well involves the forming of a gravel pack in the well adjacent the entire portion of the unconsolidated formation exposed to the well. Thereafter, hydrocarbons are produced from the formation through the gravel pack and into the well. Gravel packs have generally been successful in mitigating the flow of sand from the formation into the well. However, the flowing of fluids through the gravel pack results in a pressure drop across the gravel pack. This pressure drop results in loss of energy from the formation, thereby reducing the total amount of and rate at which the hydrocarbons may be produced from the formation into the well.

SUMMARY OF THE INVENTION

In accordance with this invention there is provided a well completion system for use in a well penetrating an unconsolidated formation of the earth. In a well having an open production interval in an unconsolidated formation there is provided a sand retainer that is located adjacent a lower portion of the open production interval which said retainer terminates at its upper extremity at an intermediate location of the open production interval.

In a further aspect of this invention there is provided a method of producing a well which utilizes the above-described system. In carrying out this method, fluids are produced through the sand retainer. Concomitantly therewith fluids are produced from the formation into the well through an upper portion of the open production interval above the sand retainer.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is a schematic view, partially in cross section, of a well completed in an unconsolidated subsurface formation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

This invention is directed to well completion systems for use in unconsolidated formations and to process for producing fluids from wells penetrating such formations. This invention enables the mitigation of two of the major problems which occur in the production of hydrocarbons from unconsolidated formations. One of these problems concerns the reduced production rate from the formation which results from the use of a gravel pack to control the flow of sand from the formation. The other problem concerns the damage to the formation which results from water-coning.

With reference to the drawing, there is illustrated a well 1 which extends from the surface of the earth 3 into an unconsolidated formation 5 having a hydrocarbon-bearing portion 6 and a bottom water portion 7. The well 1 normally terminates above the upper level of botom water 7. Well 1 is equipped with casing 9 that is bonded to the walls of the well by cement sheath 11. Perforations 13 extend through casing 9 and cement sheath 11, thereby forming an open production interval 12 that provides for fluid communication between the interior of well 1 and unconsolidated formation 5. Production tubing 27, extending from the surface of the earth to the wellbore bottom, and communicating through openings 26 with the interior of well 1, may be provided for transporting fluids from well 1 upward to the surface of the earth. The equipment thus described for completing well 1 is conventional and other suitable completion systems may be employed.

In accordance with the present invention there is provided a well completion system for use in a well penetrating an unconsolidated formation of the earth. The well 1 penetrates the unconsolidated formation 5 and normally terminates above bottom water 7. There are provided perforations 13 through the casing 9 and cement sheath 11, thereby forming an open production interval 12 which communicates with the unconsolidated formation 5. A sand retainer 15 is provided in a well 1 adjacent a lower portion of the open production interval 12. The sand retainer 15 extends upward from the lower extremtiy of open production interval 12 to an intermediate location thereof.

Preferably, the sand retainer 15 is a gravel pack. Gravel packs and techniques of placing them in wells are readily available at economic cost in the oil industry. The gravel pack may take the form illustrated in the drawing wherein it is formed intermediate production tubing 27 and casing 9 and held in place by hold-down packer 23. In such completion, a packer 25 is normally set intermediate production tubing 27 and casing 9 at about the upper location of unconsolidated formation 5 to ensure that fluids produced from unconsolidated formation 5 flow into the open portion of production tubing 27. Other types of gravel packs may be employed. For example, a gravel pack may be placed outside of casing 9 immediately adjacent unconsolidated formation 5. Also, consolidated gravel packs may be employed. A service for forming a consolidated gravel pack is available under the trade name of Con-

pac. Other means than gravel packs may be employed as sand retainer **15.** For example, an epoxy resin may be injected into the formation to consolidate the formation and thereby control the sand production therefrom. A service whereby a resin is employed for controlling unconsolidated formation sands is available under the trade name of Eposand. Both Conpac and Eposand are offered by Halliburton Services, Inc., and are described on page 2422, Vol. 2, 29th Revision of the COMPOSITE CATALOG OF OIL FIELD AND SERVICES, WORLD OIL, 1970–1971. Also, mechanical said retainer means, such as screens and slotted pipes, may be employed.

In accordance with a preferred embodiment of this invention, the sand retainer **15** terminates at approximately the uppermost location **21** to which a water cone **17** will rise from bottom water **7** when the well **1** is produced at a predetermined production rate for a specified time. Thus, the production of sand from the zone of the unconsolidated formation **5** that is invaded by water cone **17** is controlled by sand retainer **15.** Preferably, the sand retainer **15** is located adjacent no more than the lower 75 percent of the open production interval **12.** This allows the maximum production rate of fluids to be realized from at least the uppermost 25 percent of the open production interval **12** while controlling the production of sand from the zone of the unconsolidated formation **5** invaded by water cone **17.** This also allows water to be produced from the water cone **17** through the sand retainer **15** and thereby to limit the upward extension of water cone **17.**

In accordance with another aspect of this invention, fluids are produced from the unconsolidated formation **5** through the sand retainer **15** and into well **1.** Concomitantly therewith fluids are produced from the unconsolidated formation **5** into well **1** through an upper portion of the open production interval **12** above the sand retainer **15.** The fluids are produced from the unconsolidated formation **5** at a rate such that sand arches are formed and the formation is stabilized adjacent the open production interval **12** of well **1.** The sand arches are formed as a result of cohesion or capillary forces between the sand grains. The formation is stabilized as a result of the overburden stress acting on the sand grains in the arch. The sand arches can be considered to be the mechanism by which the unconsolidated formation **5** is consolidated, thus allowing fluids to be produced at a high rate therefrom without producing any substantial amount of solid materials, referred to as sand, from the formation. The production of fluids at a high rate from the unconsolidated formation **5** results in the formation of a water cone **17** which cones upward from the bottom water **7** into well **1.** This water cone **17** and the resulting high concentration of water associated therewith reduces the capillary pressures existing in the zone of the unconsolidated formation invaded by the water cone, thereby causing the failure of the sand arches in the affected zone. The sand retainer **15** controls the production of sand from the affected zone of the unconsolidated formation **5** while allowing hydrocarbons and water to be produced from this portion of the formation into well **1.** The production of water from the water cone **17** through the sand retainer **15** tends to limit the upward extension of water cone **17.** Thus, in accordance with this invention, said production is controlled by the sand retainer **15** from that zone of the formation damaged by the water cone **17,** and sand production is controlled by the sand arches in that portion of the formation adjacent the open production interval **12** and above the water cone **17.**

In accordance with still another aspect of this invention, the sand retainer **15** is positioned in well **1** prior to any substantial disturbance of unconsolidated formation **5** by production of fluids therefrom. Subsequently, fluids are produced from the formation at a sufficiently high rate to form sand arches in the formation. Preferably, the sand arches are formed slowly around each perforation to stabilize the formation. This is done by incrementally increasing the production rate and producing at each rate until sand-free production is obtained. This incremental increase in the production rate is continually increased above the rate at which sand-free production is obtained until either the flow capacity of the production tubing is reached or until formation stability is no longer attained. By forming the sand arches in accordance with the above procedure, sudden shifts within the formation are avoided, thereby lessening the chance of the occurrence of formation failures. In addition, the chance is lessened for a large volume of sand to be produced when the well is first put on production.

Once the well is placed on the production it is preferred that it not be shut in, in order to avoid any alterations in the stress distribution in the formation which would subject the formation to shock and possibly cause some sand production from the hydrocarbon-producing interval before equilibrium is again attained. Should it become necessary to close in the well this may be done by closing valve **33.** Prior to opening valve **33** it is preferred that a gas-filled surge vessel **29** be connected into the production line **31** to minimize shock to the formation when the formation is again put on production. The surge vessel **29** is charged with high pressure gas from a gas source **35** through pipe **37** and is connected into the production line **31** by opening valve **39** in line **41.** The high pressure gas in surge vessel **29** should be at a pressure no higher than the pressure existing in formation **5.**

What is claimed is:

1. A method of producing fluids from an unconsolidated formation, said formation being penetrated by a substantially vertical well having an open production interval communicating with said unconsolidated formation, comprising:

a. producing fluids from said formation into said substantially vertical well through a sand retainer located adjacent a lower portion of said open production interval, said sand retainer terminating at its upper extremity at an intermediate location of said open production interval; and

b. concomitantly with step (a) producing fluids from said formation into said substantially vertical well through an upper portion of said open production interval above said sand retainer.

2. The method of claim **1** wherein said sand retainer is located adjacent no more than the lower 75 percent of said open production interval.

3. The method of claim **1** wherein said sand retainer comprises a gravel pack.

4. A method of producing hydrocarbons and water contained in an unconsolidated formation, said hydrocarbons being underlain by bottom water, said formation being penetrated by a well having an open produc-

tion interval communicating with said unconsolidated formation, the steps comprising:

producing hydrocarbons and water from said formation into said well through a sand retainer located adjacent a lower portion of said open production interval, said sand retainer extending from the lower extremity of said open production interval upward to approximately the uppermost level to which a water cone will rise from said bottom water; and

producing hydrocarbons from said formation into said well through an upper portion of said open production interval above said sand retainer.

5. The method of claim **4** wherein said sand retainer comprises a gravel pack.

6. The method of claim **5** wherein said gravel pack extends from the lower extremity of said open production interval upward for no more than 75 percent of said open production interval.

7. A method of producing fluids from an unconsolidated formation, said formation being penetrated by a well having an open production interval communicating with said unconsolidated formation, comprising:

a. forming a sand retainer in said well adjacent a lower portion of said open production interval, said sand retainer extending from the lower extremity of said open production interval and terminating at its upper extremity at an intermediate location of said open production interval;

b. producing fluids at a first rate from said well until sand-free production is attained;

c. repeating step (b) at incremental higher production rates until a production rate is attained at which sand-free production is no longer attained; and

d. producing fluids from said well at a production rate slightly less than said rate at which sand-free production is no longer attained.

8. The method of claim **7** wherein said sand retainer comprises a gravel pack.

9. The method of claim **8** wherein said gravel pack is adjacent no more than the lower 75 percent of said open production interval.

10. A substantially vertical well extending from the surface of the earth and penetrating an unconsolidated formation, said substantially vertical well having an open production interval communicating with said unconsolidated formation and having a sand retainer located adjacent a lower portion of said open production interval and terminating at its upper extremity at an intermediate location of said open production interval.

11. The well of claim **10** wherein said sand retainer comprises a gravel pack.

12. The well of claim **11** wherein said gravel pack is located adjacent no more than the lower 75 percent of said open production interval.

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