United States Patent

[11] **3,556,222**

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[21] Appl. No. **785,959**
[22] Filed **Dec. 23, 1968**
[45] Patented **Jan. 19, 1971**

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[54] **METHOD AND APPARATUS FOR IMPEDING GAS FLOW INTO PRODUCTION WELLS**
8 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **166/314,** 166/106, 166/236
[51] **Int. Cl.** **E21b 43/08**
[50] **Field of Search** ..... 166/278, 314, 51, 68, 105, 106, 114—116, 227, 236; 103/220

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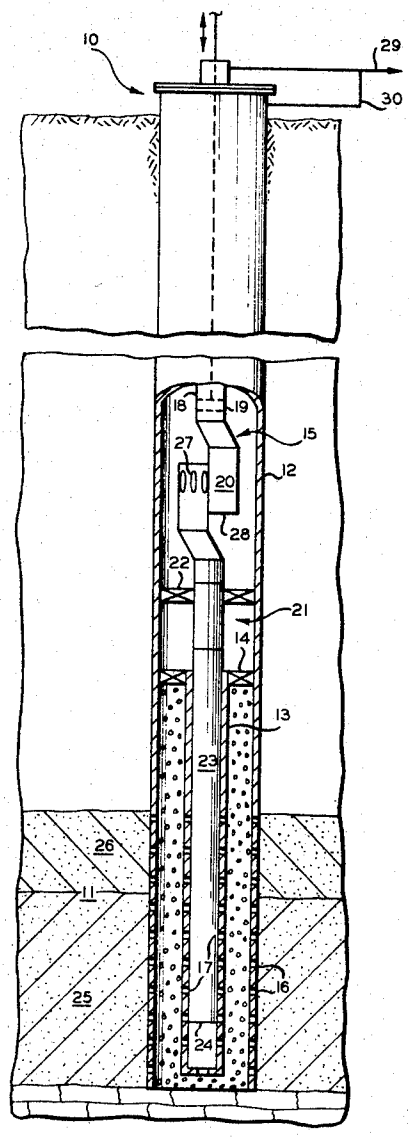
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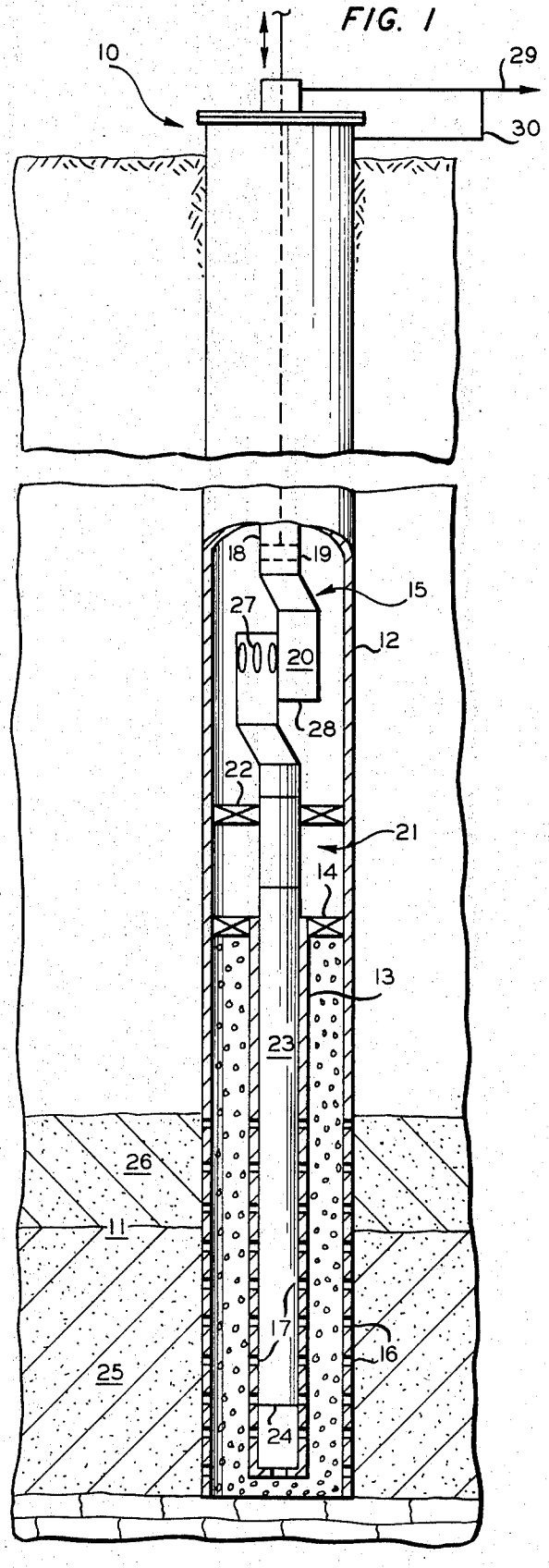
ABSTRACT: An apparatus for reducing gas production of an oil well having a slotted liner gravel-packed opposite the producing formation. The apparatus includes a tailpipe disposed concentrically in the liner, and a packer for sealing the upper end of the tail pipe. The lower, open end of the tailpipe is located near the bottom of the formation so that an upper gas zone in the formation is sealed off from the tailpipe inlet by oil in the wellbore.



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FIG. 1



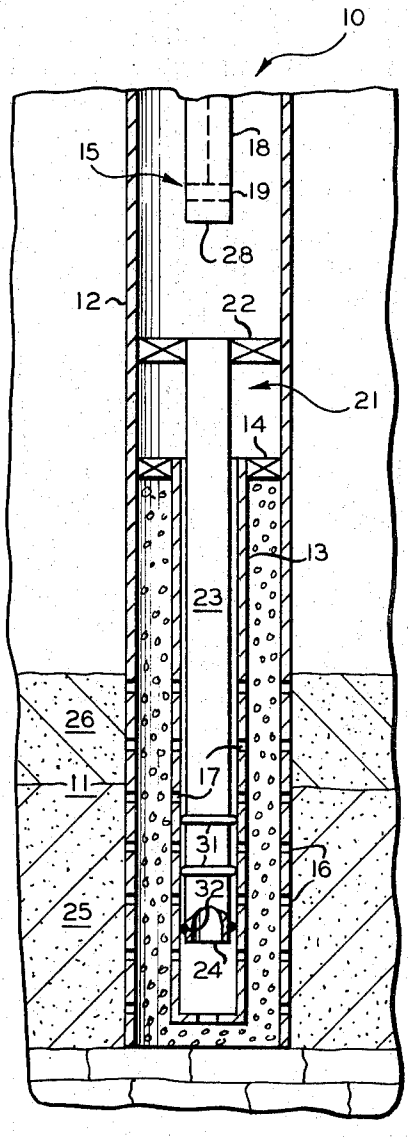


FIG. 2

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METHOD AND APPARATUS FOR IMPEDING GAS FLOW INTO PRODUCTION WELLS

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to a method and apparatus for producing oil wells. In one aspect the invention relates to a method and apparatus for reducing the gas-oil ratio of high gas producing wells.

A common technique for completing oil wells, particularly wells producing from unconsolidated sand formations, involves setting the casing through the producing sand, perforating the casing, and gravel packing the perforated interval. Typical gravel-packing apparatus includes a slotted, or perforated, liner and a sealing member or packer. The liner is generally set opposite the perforated interval of the casing with gravel occupying the annular space between the liner and the casing. The size of the gravel is selected so that formation sands are filtered out of the fluids entering the wellbore. The gravel-packing technique of the general type described has been particularly successful when used in formation characterized as unconsolidated sands. The filtering out of the sand prevents "sanding up" and/or pump damage.

While effective for its intended purpose, the downhole equipment required to gravel pack a well presents well-servicing problems. For example, if a well begins producing at an excessively high gas-oil ratio, which is evidence that free gas is entering the wellbore, the well must be serviced or worked over to shut off the gas production. High gas production may be due to a variety of downhole equipment and reservoir conditions. The cement surrounding the casing may have failed, establishing communication between an upper, cased-off sand and the lower producing interval; or the gas may be coming from an upper gas cap; or the gas may be due to a secondary gas packet created by the release of dissolved gas in the formation. Excessive gas production from the reservoir reduces the oil production and dissipates reservoir energy. Good production practice requires that the producing gas-oil ratio (GOR) be maintained below a predetermined limit, the limit depending on the producing characteristics of the formation. The conventional technique for combating gas production is to pull the gravel-packed liner and cement squeeze the zones contributing free gas. This operation, of course, is quite expensive, making it economically prohibitive for marginal wells.

The purpose of the present invention is to provide a well-completion method and apparatus which effectively reduces the GOR in high gas producing wells. Briefly, the invention contemplates the use of a production string cooperatively arranged with the gravel packed liner so that the oil enters the production string at an elevation substantially below the gas zone. The lower end of the production string is provided with a tailpipe, which snugly fits into the gravel-packed liner. The lower open end of the tailpipe, which constitutes the inlet for the production string, is located near the bottom of the formation contributing the free gas production. it has been found that by locating the inlet of the production string at an elevation opposite the oil zone of a formation having a gas zone, the free gas production is substantially reduced and, in some cases, completely eliminated. The outside diameter of the tailpipe must be sized in relation to the inside diameter of the liner to present a close conformity when the former is inserted in the latter. A close conformity is required to prevent the flow of free gas in the annular space separating the tailpipe and the liner.

DRAWINGS

FIG. 1 is a schematic, sectional view of a producing oil well illustrating the downhole equipment installed according to this invention; and

FIG. 2 is a view similar to FIG. 1 illustrating another arrangement of the downhole equipment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to FIG. 1, the equipment in a well 10 producing from a formation 11 is seen to include a casing 12 extending through the formation 11, a gravel-packed liner 13 hung from a casing packer 14, and a production string shown generally as 15. An interval of the casing 12 opposite the producing formation 11 is provided with perforations 16 which permit the entry of formation fluids into the wellbore. The liner 13 hung from the packer 14 extends concentrically through the casing 12 and has formed therein a plurality of slots or perforations 17. A packing medium such as gravel occupies the annular space separating the casing 12 and the slotted liner 13. Methods for locating the downhole equipment to provide the illustrated arrangement described thus far is conventional and well within the skill of the art.

The producing string 15 includes conventional tubing 18 hung from the wellhead and terminating with a bottom hole tubing pump 19, a bottom hole gas separator 20 disposed below the tubing pump 19, and a tailpipe assembly 21 disposed below the separator 20. The tailpipe assembly 21 has a sealing member or packer 22 from which depends a tailpipe 23. The tailpipe 23 extends downwardly through the upper, open end of the slotted liner 13 and concentrically through a portion of the liner 13, terminating at a lower open end 24. The packer 22 is set in the casing 12 at an elevation above the liner packer 14 to locate the open end 24 near the bottom of the producing formation 11. Thus it will be appreciated that formation fluids must enter the production string 15 through inlet 24 located near the bottom of the formation 11. The sealing of the upper end of the tailpipe 23 to prevent the flow of fluids up the annulus separating the liner 13 and tailpipe 23 can also be effected by screw fitting the upper end of the tailpipe 23 into the liner packer 14. It should be pointed out that the annulus between the liner 13 and tailpipe 23 does not appear in FIG. 1 because of the close tolerance required.

The producing formation 11 is illustrated as having a lower oil producing zone 25 and an upper gas producing zone 26. In this embodiment, only one producing formation is shown but in actual practice the well may be completed in many vertically spaced formations or sands.

In accordance with the principles of this invention, the lower, open end 24 of the tailpipe 23 is located near the bottom of the oil zone 25. With the equipment so positioned, it has been found that the oil zone 25 contributes the major portion of formation fluids with the gas zone 26 contributing minor amounts. The annular space separating the tailpipe 23 and the liner 13 must be sufficiently small so that oil in that space provides a fluid seal between the tailpipe inlet 24 and the gas zone 26. The permissible tolerance between the outside diameter of the tailpipe 23 and the inside diameter of the liner 13 will depend, to a great extent, on the viscosity of the crude which acts as a sealing agent in the annular space. Experience has shown that with heavy viscous crude a tolerance up to 0.5 inch is permissible. However, tolerances preferred are in the range from about 0.1 inch to about 0.3 inch. In practice, the oil contributed by the oil zone 25 provides a seal between the annular spaces separating the liner 13 and the casing 12, and the tailpipe 23 and the liner 13. This oil seal in annular portions of the annular spaced formed by the liner 13 and the casing 12 and the tailpipe 23 and the liner 13 effectively blocks the downward flow of gas in the wellbore. In order for the gas to enter the inlet 24 it must cone or channel through the oil seal.

The second embodiment of the invention is illustrated in FIG. 2. The equipment is generally the same as that shown in FIG. 1 with the exception that the production string 15 is discontinuous and that the tailpipe 23 is provided with sealing members. In locating the tailpipe 23 in this embodiment, the tail pipe 23 is lowered to the desired location and the packer 22 set. The tubing 18 is then backed off to the producing elevation of the pump 19.

In this embodiment of the invention, the tailpipe **23** is provided with neoprene O-rings **31** to insure the seal in the annulus between the liner **13** and tailpipe **23**. This, of course, permits a greater tolerance between the liner **13** and tailpipe **23** since the sealing is due to the O-rings and not the tight fit described above. Annular circumferential grooves **32** are milled in the tailpipe **23** at longitudinally spaced intervals for receiving the O-rings **31**. The internal annular surface of each O-ring **31** engages the outer periphery of the tailpipe **23** while the outer annular surface of the O-ring **31** engages the internal surface of the liner **13**. The tailpipe **23** is located in the liner **13** so that the O-rings **31** engage a nonslotted or blank section.

When the well **10** is placed on production with the downhole equipment arrangement as illustrated in FIG. **1**, formation fluids enter the wellbore passing through the casing perforations. **16**. Now, because of the resistance to flow in the tight annulus between the liner **13** and the tailpipe **23**, the oil flows through the gravel-packed zone, entering the liner **23** through the perforations **17** below the lower end **24** of the tailpipe **23**. The oil in the gravel-packed zone and the annulus between the liner **13** and the tailpipe **23** seals the lower inlet end **24** of tailpipe **23** from the upper gas zone **26** of formation **11**. The fluids flow through the tailpipe **23** and are discharged through slots **27** in the gas separator **20**. The gas rises in the casing annulus while the oil enters inlet **28** of pump **19**. The oil is pumped to the surface through tubing **18** by a conventional sucker rod pump and discharged into flow line, schematically illustrated as **29**. The gas may be commingled with the oil in the flow line **29** by wellhead connection **30**.

In the well of FIG. **2**, the formation fluids enter the liner **13** through the slots **17** disposed below the O-rings **31**. The fluids entering the tailpipe inlet **24** flow upwardly into the casing **12**. The gas rises in the casing annulus while the oil enters pump inlet **28**.

The following is an example of an actual field installation.

EXAMPLE

The well in which the apparatus and method of this invention was tested was originally completed with 7-inch O.D. casing and a 3½-inch O.D. slotted liner gravel-packed through a 50 foot producing interval with 12—16-mesh gravel. Initially the well produced at an acceptable GOR. However, after prolonged production, the GOR gradually increased, reaching a maximum of 2,500 when the well was shut-in. Production characteristics at the time of shut-in were 340 b.p.d. at a GOR of 2,500.

It was believed that the gas was entering through a top portion of the producing interval. In an effort to combat the gas production, a production string similar to that illustrated in FIG. **1** was installed. Several joints of 2.785-inch flush joint tubing, which constituted the tailpipe in this example, suspended below the gas separator was inserted in the liner having an inside diameter of 2.99 inches. The tailpipe packer was set about 30 feet above the top of the liner packer locating the lower open end of the tailpipe opposite the bottom of the producing interval. This arrangement provided a clearance of 0.102-inch in the annulus between the liner and the tailpipe. The well was returned to production and after 30 days, the following test was recorded: 280 b.p.d. and 1,780 GOR.

Since the producing conditions were generally the same for both before and after the well service, it may be concluded that the reduction of GOR was due to the novel arrangement of the downhole equipment.

Based on the favorable results obtained in the above described example, similar equipment was installed in other problem wells, the results being tabulated along with the results of the example.

As reflected by the table, the equipment arranged according to this invention does, in fact, reduce the producing GOR to acceptable levels. It should be pointed out that the data were obtained by conventional testing methods and at near stable producing conditions.

	Stabilized production without tail pipe		Stabilized production with tail pipe	
	B.p.d.	GOR	B.p.d.	Gor
Test well:				
Example	340	2,500	280	1,780
A	280	1,670	230	1,030
B	140	2,900	120	1,500
C	230	2,500	410	295

While the results in some of the test wells do not appear spectacular, it should be pointed out that conservation laws in some areas require that the GOR be maintained below certain limits, and that without the equipment of this invention the wells would be shut-in. For example, if the GOR limit were 2,500, three of the wells listed above would be shut-in. However, the use of the tailpipe according to this invention enables continued production. Thus the economic benefits attributable to this invention in the above examples are quite obvious.

While the preferred embodiments of this invention have been described in particular detail, it should be emphasized that variations and modifications may be made therein without departing from the scope and spirit of this invention as set forth in the appended claims.

I claim:

1. In an oil well having a casing and a slotted liner gravel-packed within the casing and opposite a producing formation, an apparatus for reducing the production of free gas from an upper portion of the formation, said apparatus comprising: a casing packer set at a point above said liner, and a tailpipe depending from said packer and extending through a portion of said liner, said tailpipe having a lower end located near the bottom of said formation, said lower end providing an inlet for the production of formation fluids and said tailpipe and said packer being provided with passages for conducting formation fluids therethrough, the outside diameter and the inside diameter of said tailpipe and said liner, respectively, being particularly sized so that the annulus formed by said tailpipe and liner has a clearance not greater than 0.5 inches.

2. The invention as recited in claim **1** wherein said tailpipe and said liner are particularly sized to provide a clearance in said annulus in the range from about 0.1 inch to about 0.3 inch.

3. The invention as recited in claim **1** wherein the apparatus further comprises means located above said packer for artificially lifting formation fluids to the surface.

4. The invention as recited in claim **3** wherein said artificial means includes a sucker rod pump.

5. In an oil well producing from a formation having an upper portion which contributes free gas, and having a slotted liner gravel-packed through said formation, a production string comprising:

tubing extending from the surface to an elevation above said formation, said tubing being provided with a bottom hole pump having an inlet;

a bottom hole gas separator disposed below said pump inlet; and

a tailpipe assembly including a packer disposed below said separator, and a section of flush joint pipe depending from said packer, said packer being set in said well at an elevation above said gravel-packed liner, said flush joint pipe extending into said liner and terminating at an elevation near the bottom of said formation, the diameters of said flush joint pipe and said liner being such to provide a fluid seal in the annulus separating the two.

6. The invention as recited in claim **5** wherein the flush joint pipe and the liner are particularly sized to provide a clearance in said annulus of not greater than 0.5 inch.

7. The invention as recited in claim **6** wherein the diameter of said pipe and said liner are particularly sized to provide a clearance in said annulus in the range from about 0.1 inch to about 0.3 inch.

8. A method for reducing the gas-oil ratio of an oil well producing free gas from a subterranean formation, said well having a casing extending from the surface to at least the top of said formation, and a slotted liner gravel-packed opposite said formation, said method comprising the steps of:

inserting a section of tailpipe of predetermined length in said liner for forming an annulus between the tailpipe and liner having a clearance less than about 0.5 inches;

locating the upper end of said tailpipe at an elevation above said liner so that the lower end of said tailpipe is disposed opposite the lower portion of said formation;

sealing the annulus between the upper end of the tailpipe and the casing; and

producing the well.