United States Patent

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[54] **METHODS AND APPARATUS FOR INHIBITING THE ENTRANCE OF LOOSE FORMATION MATERIALS INTO A WELL BORE**
10 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **166/315,** 166/231
[51] **Int. Cl.** **E03b 3/18**
[50] **Field of Search** 166/227, 230, 231, 315

[56] **References Cited**

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ABSTRACT: As a representative embodiment of the invention disclosed herein, an elongated flexible tubular screen is dependently coupled to a ported tubular mandrel having one or more collapsible centralizers mounted thereon and a fishing neck on its closed upper end. The tool is lowered through a production string and into a previously perforated interval of the well bore below the packer and the lower end of the tubular screen is rested on the bottom of the well bore or a plug previously set below the perforated interval. The tool is then lowered further so that the weight of the mandrel will collapse the tubular screen into a coil around the internal wall of the casing but still leave the ports in the tubular mandrel extending well above the uppermost perforations of the perforated interval. Thus, should the well subsequently produce sand or other unconsolidated formation materials, the coiled screen will be covered with such loose materials to provide a filter bed around the screen. In this manner, the connate fluids which are subsequently produced will be strained through the filtering media and pass on through the tubular screen and the perforated mandrel thereabove.

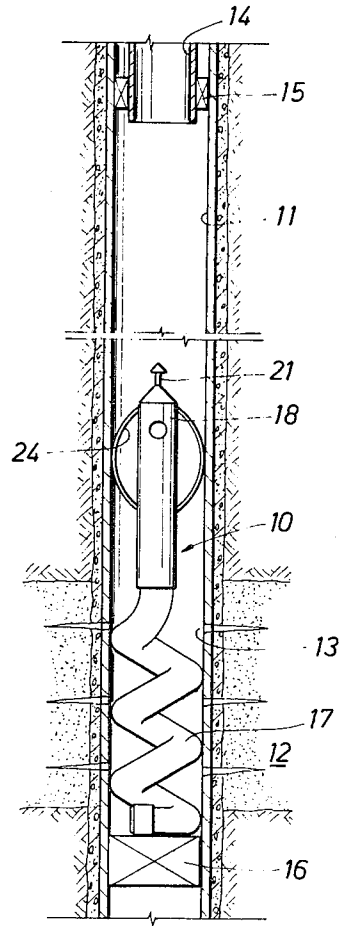


FIG. 1

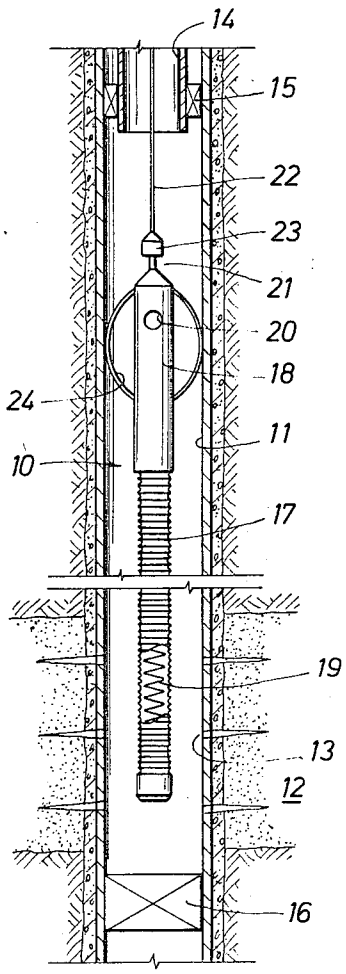


FIG. 2

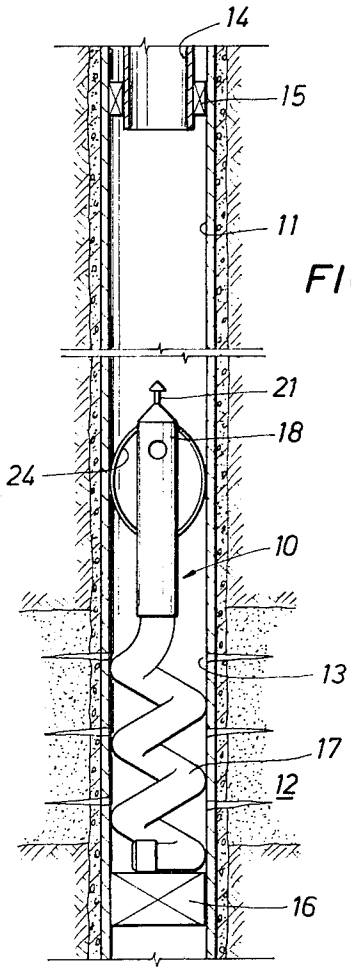
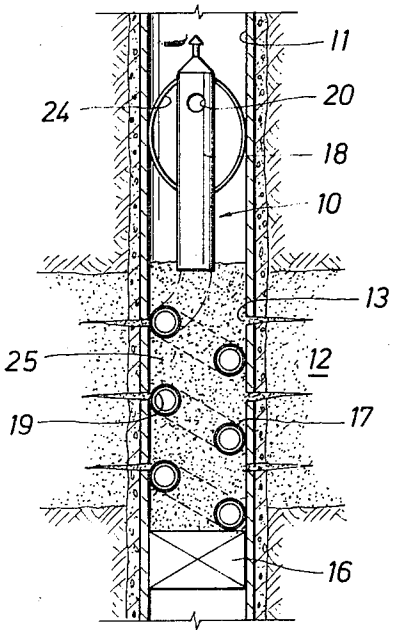


FIG. 3



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METHODS AND APPARATUS FOR INHIBITING THE ENTRANCE OF LOOSE FORMATION MATERIALS INTO A WELL BORE

It is, of course, widely recognized that unconsolidated earth formations present serious problems during the useful production life of many oil wells. For example, unless appropriate unless appropriate preventative measures are taken, loose or unconsolidated formation materials such as sand and the like will flow into the well bore and eventually fill the well bore or else be carried to the surface by the produced fluids and damage production equipment. Thus, when a well of this nature is being completed, it is customary either to inject suitable chemical consolidating agents into such loose formations or else to place a screened liner in the well bore over the perforated interval. Once this is done, the production tubing and packer is installed and the well is placed on production.

Regardless of the particular completion techniques initially employed, it is not at all uncommon for such wells to sooner or later begin producing sand and the like. When this happens, the usual practices employed heretofore require that the production string be pulled from the well to permit one or more of the typical recompletion procedures to be conducted for inhibiting further production of sand. It will be appreciated, therefore, that the removal of the production string and subsequent recompletion operations as well as the attendant loss of production will represent a significant expense.

Accordingly, it is an object of the present invention to provide new and improved methods and apparatus for completing a production well to preclude the subsequent entrance of loose formation materials into the well bore as connate fluids are being produced.

This and other objects of the present invention are attained by coupling a longitudinally flexible tubular screen member to the lower end of an elongated rigid tubular body having one or more fluid ports near its upper end and one or more centralizing devices arranged thereon. This tool is lowered through a well production string and into a perforated well bore interval below the production packer to rest the lower end of the screen on either the bottom of the well bore or a previously positioned plug set below the perforated interval. Thereafter, by continuing to lower the assembly, the weight of the rigid tubular body will collapse the longitudinally flexible tubular screen into a generally helical configuration extending upwardly along the casing wall traversing the perforated interval. The length of the elongated tubular body is selected to position its fluid ports well above the uppermost perforations of the perforated interval once the filtering tool has come to rest in the well bore. As a result, once production is again commenced, unconsolidated formation materials entering the well bore will progressively cover the coiled screen member. Thereafter, connate fluids subsequently entering the well bore will be strained through the permeable body of loose formation materials surrounding the coiled screen as the fluids enter the screen and flow into the rigid tubular body thereabove where they will be exhausted through the fluid ports into the well bore above the upper surface of the formation materials covering the screen.

The novel features of the present invention are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may be best understood by way of the following description of exemplary methods and apparatus employing the principles of the invention as illustrated in the accompanying drawings, in which:

FIGS. 1–3 illustrate a preferred embodiment of new and improved apparatus as it may be employed while practicing the methods of the present invention.

Turning now to FIG. 1, a new and improved well tool 10 arranged in accordance with the present invention is shown in a typical cased well bore 11 which, as illustrated, penetrates a producible earth formation 12 comprised of loose formation materials. To gain access to the unconsolidated formation 12, one or more perforations, as at 13, have been previously

produced with a typical perforating gun (not shown) for providing fluid communication between the cased well bore 11 and the earth formation 12. As is customary, a production string including a string of small-diameter production tubing 14 is suspended in the well bore 11 and its lower end extended through the typical production packer 15 which is set therein above the perforations 13 for isolating the formation 12 from the well bore above the packer.

If, perchance, the well bore 11 extends a significant distance below the formation 12, the lower portion of the well bore will have been previously blocked, as at 16, by setting either a typical bridge plug (such as that shown in U.S. Pat. No. 3,298,440) or a through-tubing bridge plug (such as those shown in U.S. Pat. No. 3,460,618, U.S. Pat. No. 3,460,624 or U.S. Pat. No. 3,460,625) a short distance below the lower limits of the earth formation to provide a convenient support or base. Alternatively, if the bottom (not shown) of the well bore 11 is only a short distance below the lower limits of the formation 12, it will, of course, be appreciated that the plug 16 might not be necessary.

As shown in FIG. 1, in the preferred manner of arranging the apparatus 10 of the present invention, a greatly elongated flexible tubular screen 17 having its lower end closed is dependently coupled from the lower end of an elongated rigid tubular body 18 of substantial weight. As will subsequently be explained, the tubular screen 17 is cooperatively arranged to bend easily in relation to its longitudinal axis so as to readily assume a generally helical configuration whenever opposed axial forces are applied thereto. The flexible tubular screen 17 should, however, be of sufficient strength to not be easily crushed or flattened by moderate inwardly directed radial forces.

It will be appreciated that various types of pervious materials can be used to form the tubular screen 17. As pointed out above, it is necessary only that the screened member 17 be readily collapsed longitudinally into a helix by the weight of the mandrel without being radially crushed (i.e., flattened). As a preferred manner of forming the screen 17, a tube of a noncorrosive wire mesh or wire cloth is formed around a lightweight coil spring, as at 19, which will prevent inward crushing of the finely meshed tube without unduly limiting its collapse into a helical coil.

As illustrated in FIG. 1, one or more fluid ports, as at 20, are provided adjacent to the upper end of the rigid tubular member 18. A typical fishing neck 21 closing the upper end of the tubular member 18 is mounted thereon so that the tool 10 can be conveniently lowered into the well bore 11 as by a typical cable 22 having an overshot 23 releasably connected to the fishing neck. In the preferred embodiment of the tool 10, a plurality of typical centralizing springs, as at 24, are cooperatively mounted around an intermediate portion of the tubular body 18 for retaining the heavy body in a generally concentric relationship within the well bore 11. It will, of course, be appreciated that the centralizing springs 24 are appropriately arranged to collapse inwardly as the tool 10 is lowered through the tubing string 14 and then expand outwardly once the tool emerges into the well bore 11 below the packer 15.

Accordingly, as illustrated in FIG. 2, once the filtering tool 10 has been lowered into the well bore 11, the lower end of the depending screen 17 will come to rest on the plug 16. Thus, by virtue of the minimum resistance of the tubular screen 17 to bending about its longitudinal axis, as the heavy tubular body 18 continues to move downwardly the tubular screen will be successively collapsed into a generally helical configuration or a convenient stack of successively nested coils. It should be noted that the overall length of the tubular screen 17 is selected so that, when collapsed, it will be coiled upwardly around the wall of the cased well bore 11 to at least a position in the vicinity of the uppermost perforation 13 in the perforated interval.

Thus, as depicted, once the new and improved filtering tool 10 has come to rest on top of the plug 16, the entire perforated interval of the well bore 10 will be lined with the helically con-

figured screen member 17. It will, of course, be recognized that by virtue of the considerable length of the screen 17, the meshed material forming the screen will present a substantial flow area through which connate fluids will readily flow into the interior of the screen. Particular note should also be made that the length of the tubular body 18 is selected so that once the screen 17 has come to rest on top of the plug 16 (or the bottom of the well bore 11) and the screen is coiled upwardly along the casing wall, the flow ports 20 in the body will be positioned well above the uppermost perforation 13 of the perforated interval.

Accordingly, as illustrated in FIG. 3, once the filtering assembly 10 is in position, production of connate fluids from the formation 12 is commenced. It is perhaps best that the initial production of these connate fluids be at low regulated rate which is calculated to be sufficient to only slowly draw sand and other unconsolidated formation materials into the perforated interval of the well bore 11 without risking damage to the tubular screen 17. If this is the case, careful regulation of the initial production rate from the formation 12 will result in a quantity of sand and the like, as at 25, being admitted into the perforated interval of the well bore for filling the spaces around the tubular screen 17 as schematically illustrated in FIG. 3. Then, once it is believed that the spaces around the tubular screen 17 have been at least partially filled with the sand 25, production of the well may be commenced in the usual manner with assurance that no further quantity of sand will be produced since the sand that has been packed around the tubular screen will now serve as a porous filter media.

On the other hand, it will be appreciated that even if connate fluids are initially produced from the earth formation 12 at normal rates of production, the coiled configuration of the longitudinally collapsed tubular screen 17 will present a substantial number of flow baffles tending to direct the fluids in irregular paths as they proceed upwardly in the perforated interval of the well bore 11. Thus, by directing the produced connate fluids in such back-and-forth flow patterns, loose formation materials and the like will tend to settle out of the flowing fluids so as to progressively fill the spaces around the coiled screen 17.

In either case, as the perforated interval of the well bore 11 is progressively filled with the loose formation materials 25, it will be appreciated that the least path of resistance for the flow of the connate fluids will ultimately be directly between the perforations 13 and the interior bore of the screen 17 rather than upwardly through the packed body of sand 25 around the exterior of the screen. In this manner, regardless of the initial rate of production, once the perforated interval has been filled to a sufficient depth with unconsolidated formation materials, as at 25, any subsequently produced connate fluids will flow directly through the filtering media into the screen 17.

It will be appreciated that once the screen 17 is coiled upwardly along the perforated interval and the loose formation materials 25 are packed around the screen, the substantial length of the screen will assure that there is a substantial flow area through which connate fluids can enter the interior of the screen. This will, of course, minimize the pressure drop of the fluids entering the tool 10. It should also be noted that by virtue of the coiled configuration of the screen 17, a substantial portion of the screen will lie immediately adjacent to the several perforations 13. Thus, a significant portion of the fluids entering the well bore 11 can enter the walls of the screen 17 without having to pass very far through the packed formation materials 25. This, too, will contribute greatly in reducing the overall pressure drop of the connate fluids flowing from the formation 12 and the interior of the tool 10.

The tool 10 can, of course, be easily retrieved without removing the production tubing 14 and the packer 15 from the well bore 11. Thus, should extra-fine sand particles or scale plug the formation 12, the permeable barrier 25, or the screen 17, a suspension cable, as at 22, and an overshot, as at 23, can easily be dropped through the tubing 14 and coupled to the fishing neck 21 once the sand plug 25 is washed out such as with a conventional concentric tubing rig (not shown). A new tool 10 could be easily reinstalled in the well bore 11 as previously described.

Accordingly, it will be appreciated that the present invention has provided new and improved methods and apparatus for preventing the entrance of unwanted formation materials into a production well penetrating an unconsolidated formation without having to remove the production string to perform routine workover operations. By suspending a greatly elongated flexible tubular screen from the lower end of a rigid tubular member having sufficient weight to readily collapse the screen, the screen will be formed into a helix as the tool is set in a well bore. Once it is set, this new and improved tool will provide a filter which will prevent the continued entrance of loose formation materials into the well bore.

While only a particular embodiment of the present invention and one mode of practicing the invention have been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects; and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. A method for inhibiting the production of loose formation materials from a well bore having a production string disposed therein and terminating above a perforated interval of the well bore traversing an earth formation containing such loose formation materials and comprising the steps of: lowering a tubular body having an elongated flexible tubular screen dependently coupled thereto and a flow passage in said body through said production string and into said perforated interval for resting the lower end of said tubular screen on a surface defining the lower limit of said perforated interval and positioning said flow passage above the upper limit of said perforated interval; lowering said body still further into said well bore for imposing the weight of said body onto the upper end of said tubular screen to collapse said tubular screen into a helix around the walls of said perforated interval; producing an initial quantity of connate fluids from said earth formation for drawing loose formation materials into said perforated interval until said tubular screen is believed to be covered with said loose materials to provide a filtering media of said loose materials around said tubular screen; and, thereafter, producing additional connate fluids from said earth formation through said filtering media and into said tubular screen for straining subsequently entering loose formation materials from said additional connate fluids.

2. The method of claim 1 wherein said initial quantity of connate fluids is produced at a lower rate than the production rate of said additional connate fluids.

3. The method of claim 1 wherein the combined lengths of said tubular screen and said body are sufficient to leave at least said flow passage above said upper limit of said perforated interval after said tubular screen is collapsed.

4. The method of claim 3 wherein said initial quantity of connate fluids is produced at a lower rate than the production rate of said additional connate fluids.

5. A method for installing a screen in a well bore having a production string disposed therein and terminating above a perforated interval of the well bore traversing an earth formation containing loose formation materials and comprising the steps of: coupling a suspension cable to a tubular body having a lateral flow passage therein and an elongated flexible tubular screen dependently coupled thereto and in fluid communication with said flow passage, said tubular screen having an overall length greater than the height of said perforated interval above a surface defining its lower limit; lowering said tubular body and screen on said cable through said production string and into said perforated interval for positioning said flow passage above the upper limit of said perforated interval; and releasing said cable from said tubular body for dropping said tubular body onto said tubular screen to collapse said tu-

bular screen into a helical configuration coiled upwardly around the walls of said perforated interval and support said tubular body with its said flow passage above said upper limit of said perforated interval.

6. Well-completion apparatus adapted for installation in a perforated interval of a well bore traversing an earth formation containing loose formation materials and having a production string terminating thereabove for providing communication to the surface, and comprising: an elongated rigid tubular body having a flow passage therein between the lower end of said body and an upper portion thereof; an elongated tubular screen formed of a flexible, finely meshed, fluid-pervious material having its upper end dependently coupled to said lower end of said body and its lower end blocked so that the sole fluid communication into said tubular screen is by way of said fluid-pervious material defining the wall surfaces of said tubular screen, said length and material of said tubular screen being cooperatively selected to enable said tubular screen to collapse into a helical configuration whenever the weight of said body is imposed on said upper end of said tubular screen; and means on the upper end of said body adapted for releasable connection to a suspension cable for lowering said body and tubular screen through a production string and into a perforated interval therebelow.

7. The well-completion apparatus of claim 6 further including centralizing means cooperatively arranged on said body for maintaining said body coaxially disposed in a well bore.

8. The well-completion apparatus of claim 6 wherein the length of said tubular screen is selected to be greater than the overall length of a perforated interval of a well bore in which said apparatus is to be installed.

9. The well-completion apparatus of claim 8 wherein the length of said body is selected to position said upper portion thereof above the upper limit of a perforated interval into which said tubular screen has been collapsed.

10. The well-completion apparatus of claim 6 further including a coil spring coaxially fitted within said tubular screen and operatively arranged for preventing the flattening of said tubular screen once it has been collapsed into said helical configuration.

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