

[54] THERMAL INSULATION OF WELLS

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[58] Field of Search.....166/285, 291, 292, 302, 303,
166/57, 242, DIG. 1; 252/62

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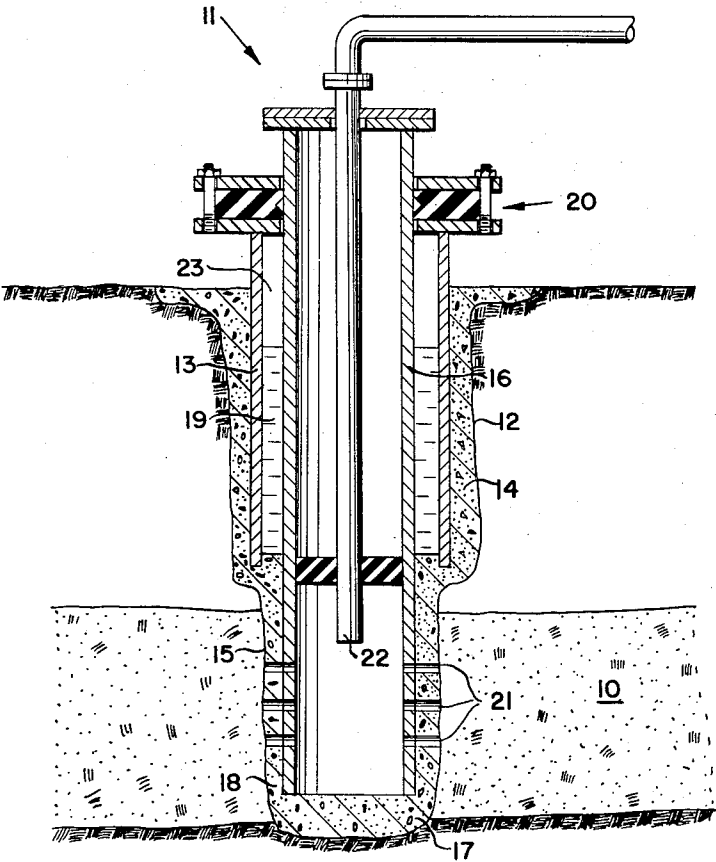
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[57] ABSTRACT

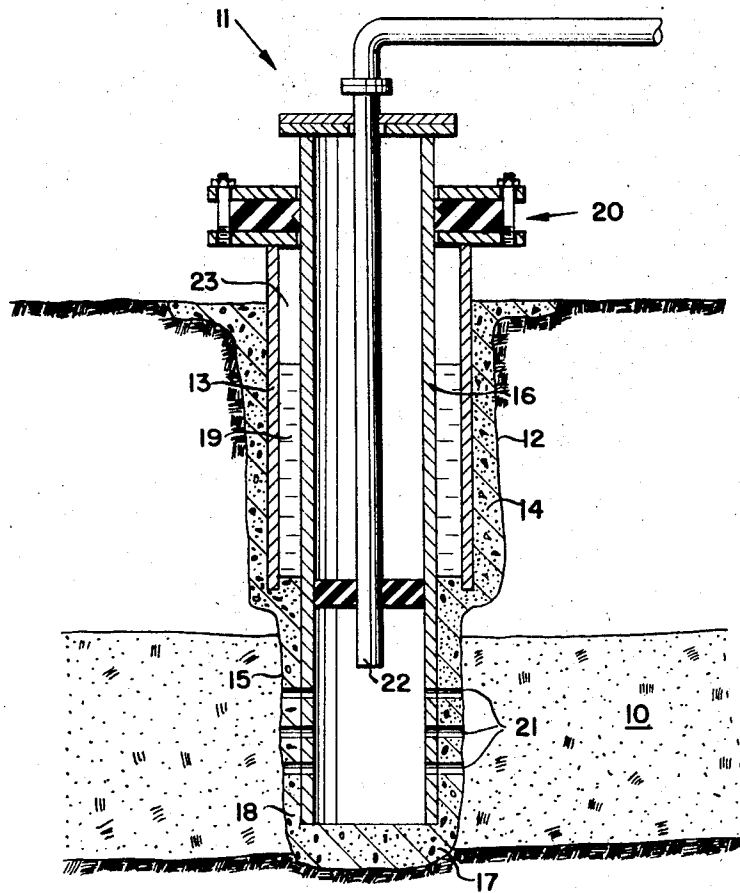
A method for thermally insulating a well, such as a steam injection well or a well which produces oil through perma-frost formations, by filling an annular space between two strings of casing in the wells with heat insulating vermiculite slurry.

5 Claims, 1 Drawing Figure



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THERMAL INSULATION OF WELLS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of completing wells. More particularly, this invention relates to a method for thermally insulating a well.

2. Description of the Prior Art

A number of processes for the recovery of minerals from sub-surface deposits through wells involve the injection of a heated fluid into the deposit. For example, an often used technique for stimulating the production of a viscous crude oil from a sub-surface oil reservoir is to inject steam into that reservoir through a steam-injection well to heat the oil and reduce its viscosity.

As the heated fluid moves down an injection well it tends to lose heat to the surrounding earth formation and to the pipe which is usually present in such wells. This heat loss reduces the efficiency of the mineral recovery process. In addition, as the pipe is heated it tends to expand. If the linear expansion of the pipe is restricted, stresses are generated in the heated pipe which may cause the pipe to fail structurally. For example, pipe of the type commonly used in steam injection wells when free to expand grows longer by about 1 inch per hundred feet of length for every 100° Fahrenheit increase in temperature. If the heated pipe is bound to the earth formations through which it passes with a material, such as cement, which prevents the pipe from growing in length, stresses will develop which may lead to the failure of the pipe.

A number of techniques have been suggested for reducing the loss of heat in the wellbore from injected hot fluid. Among these is the use of heat insulating injection tubing string within a borehole cased with a larger diameter string of pipe which is cemented in place. It has been found that effective insulation may be obtained with an injection tubing string comprising a number of joints of double walled pipe having an insulating material disposed in the annular space between the double walls of the pipe. However, such double walled pipe is expensive to manufacture.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a method for completing a thermal injection well with conventional single walled tubular pipe in a manner which will reduce heat loss from injected hot fluid as it passes down the well and which will reduce casing failures due to stresses induced by the thermal expansion of well casings.

According to an embodiment of the invention a thermal injection well is drilled to near the top of a zone of interest and a relatively large diameter casing is set in the wellbore in a conventional manner. The wellbore is then extended through the zone, and a smaller diameter casing is run from the surface to bottom of the well. This smaller diameter casing is cemented across the zone of interest and the annular space between the casings is filled with a slurry of vermiculite. Hot fluid injection may then be commenced; however, controlled application of heat may be necessary initially to dry the vermiculite without causing excessive steam pressure in the slurry as it is dehydrated.

BRIEF DESCRIPTION OF THE DRAWING

The FIGURE shows a cross-sectional view of a sub-surface earth formation traversed by a well completed in accordance with the method of this invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to the FIGURE, we see a sub-surface earth formation 10 into which it is desired to inject a heated fluid. To provide an insulated injection well 11 according to the method of this invention, one may extend a borehole 12 from the surface to a point adjacent the formation 10 into which hot fluid is to be injected. This borehole 12 may then be cased with a first

casing 13 of relatively large diameter. This first casing 13 may be run into the hole and set in a conventional manner as by fixing the casing 13 in place with a cement 14.

The well 11 is then extended into the formation 10 by drilling a borehole 15 with equipment capable of passing through the casing 13. A second casing 16 of smaller diameter than the first casing 13 is then extended into the well 11 from the surface to a point adjacent the bottom 17 of the extended borehole 15. The smaller casing 16 may then be cemented adjacent the formation of interest 10 with a cement 18, and a slurry 19 of expanded vermiculite may be placed in the annular space 23 between the larger casing 13 and the smaller casing 16.

The vermiculite slurry 19 may comprise a mixture of vermiculite and any liquid capable of forming a suspension therewith. A preferred liquid is water. The slurry is preferably mixed to have the maximum vermiculite to liquid ratio consistent with the requirement that the slurry be capable of being pumped into place as hereinafter described.

The vermiculite slurry may be installed in any suitable manner. For example, the smaller diameter casing 16 may be provided with a means (not shown), such as a stage cementing collar, adjacent the lowermost portion of the annular space 23 in which it is desired to install the vermiculite which means will allow the annular space to be opened into fluid communication with the interior of this smaller casing 16. In such a case the smaller casing 16 may be cemented across the formation 10 and vermiculite slurry 19 may then be circulated down the smaller casing 16 and up the annular space 23 displacing any fluid in the annular space 23 through this means.

A preferred method for placing the vermiculite slurry 19 in the annular space 23 is to pump the vermiculite slurry down the smaller casing 16 before the cement 18 is in place. Thus an amount of slurry sufficient to fill the annular space 23 may be pumped down the casing 16 and then displaced into the annular space 23 by cement 18. The cement 18 is preferably positioned around the casing 16 in an amount substantially equivalent to the minimum amount required to assure the creation of a fluidtight seal around the smaller casing 16 sufficient to prevent the flow of steam into the annular space 23 between the larger casing 13 and the smaller casing 16 above the formation 10.

At the surface, the annular space 23 may be sealed off with a slip type packoff means 20 of a conventional type which is capable of maintaining a fluidtight seal while allowing the smaller casing 16 to move upwardly or downwardly relative to the larger casing 13. Thus the well 11 is provided with a substantially free standing casing 16 which may thermally expand without incurring any substantial additional axial stresses. The well is also provided with a conventional cemented casing 13 which protects zones above the formation 10 to be treated from invasion by a foreign fluid. In addition, the casing 16 is insulated by the vermiculite slurry from the surrounding formations thus reducing heat losses to these formations as heated fluids pass through the casing 16, or tubing 22.

After placement of the cement 18 and the vermiculite slurry 19 the well 11 is preferably opened into fluid communication with the formation 10 as by perforating the smaller casing 16 and the cement 18 with a number of perforations 21 in a conventional manner. Steam or other heated fluid may then be injected into the formation 10 through the well 11. This steam injection may be carried out directly through the casing 16 or the well may be provided with an injection tubing string 22. The heated fluid is preferably initially injected into the formation 10 at a controlled rate to gradually dehydrate the vermiculite slurry without causing excessive steam pressure in the slurry. That is, the temperature and quantity of heated fluid injected are regulated so that the vermiculite slurry 19 is maintained at a predetermined temperature near the boiling point of water to effectually dehydrate the vermiculite at a rate low enough to avoid the formation of pockets of steam or gas within the annular space 23 between the casings 13 and 16.

While this invention has primarily been discussed as it applies to the insulation of hot fluid injection wells, it should be understood that the vermiculite insulating technique disclosed herein is equally applicable to the insulation of hot fluid production wells. For example, a vermiculite filled annular space formed according to the above teachings may be used to reduce the rate of heat transfer from produced fluids to surrounding earth formations in situations where such heat loss is undesirable such as where the surrounding earth formation comprises a perma-frost zone which will melt if heated by such produced fluids. Of course, in such an application if the temperature of the produced fluids is less than the boiling temperature of water or other slurry forming liquid used, there is no danger that steam pockets may form as the vermiculite is dehydrated.

In summary, this invention provides a method for insulating a well wherein an annular space between two strings of tubular pipe is filled with a vermiculite slurry after the pipe is positioned within the well. More particularly the invention comprises the steps of drilling a borehole from the surface at least to a point adjacent the bottom of a zone in which heat loss is desired to be minimized, extending into the borehole and substantially through the zone a first tubular casing of relatively large diameter, extending into the borehole and substantially through the zone a second tubular casing of smaller diameter, pumping a slurry comprising vermiculite suspended in a carrier liquid into the annular space between the first and second tubular casings, and closing the annular space adjacent the bottom of the zone with a seal off means such as cement or a packer.

I claim as my invention:

1. A method for insulating a well through which a fluid passes between a sub-surface earth formation and the surface of the earth comprising the steps of:

- drilling a borehole from the surface at least to a point adjacent the bottom of a zone in which heat loss is desired to be minimized;
- extending into the borehole and substantially through said zone a first tubular casing of relatively large diameter;
- extending into the borehole and substantially through said zone a second concentric tubular casing of smaller diame-

ter;

pumping a nonsetting slurry comprising vermiculite suspended in a carrier liquid into the annular space between said first and second tubular casings;

closing the annular space adjacent the bottom of said zone with a seal-off means; and

drying the vermiculite by controlled application of heat to vaporize the carrier liquid.

2. The method of claim 1 wherein said carrier liquid is water.

3. A method for insulating a well through which hot fluid is injected into a sub-surface formation of interest comprising the steps of:

extending a borehole to a point adjacent the top of said formation of interest;

running a string of relatively large diameter casing into the borehole;

extending the borehole into the formation of interest;

running a second string of smaller diameter casing from the surface to a point adjacent the bottom of the borehole;

mixing a nonsetting slurry comprising vermiculite and carrier liquid;

placing said slurry in the annular space between the larger and smaller diameter casings; and

cementing the smaller casing adjacent the formation of interest.

4. The method of claim 3 wherein the carrier liquid is water and wherein the method comprises the additional steps of:

opening the borehole into fluid communication with the formation of interest; and

injecting a hot fluid into the zone of interest at a controlled rate to dehydrate the vermiculite slurry without causing excessive steam pressure in the slurry.

5. The method of claim 3 including the step of fixing the top of said smaller diameter casing with a slip type packoff means capable of providing a substantially fluidtight seal off of the annular space between said larger and smaller diameter casing strings while simultaneously allowing said smaller diameter casing to move upwardly or downwardly relative to said larger diameter casing.

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