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Perkins

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[54] **METHOD OF WELL PRODUCTION IN PERMAFROST**

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Related U.S. Application Data

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[52] **U.S. Cl.** **166/314,** 166/306

[51] **Int. Cl.** **E21b 43/00**

[58] **Field of Search** ..... 166/DIG. 1, 305 R, 305 D, 166/314, 306

[56] **References Cited**

UNITED STATES PATENTS

3,363,692	1/1968	Bishop	166/306
3,563,311	2/1971	Stein	166/314 X
3,677,340	7/1972	Blount et al.	166/DIG. 1 X
3,679,264	7/1972	Van Huisen	166/52 X
3,720,267	3/1973	Allen et al.	166/314
3,721,298	3/1973	Corbett et al.	166/DIG. 1 X
3,766,985	10/1973	Willhite	166/DIG. 1 X

OTHER PUBLICATIONS

"Permafrost or Permanently Frozen Ground and Related Engr. Problem," by Siemon W. Muller, J. W. Edwards, Inc., Ann Arbor, Michigan (1947), TA 710.m8 pp. 70–74 & 140–143.

"Investigation of Permafrost," The Oil & Gas Journal, June 2, 1971, pp. 115–119.

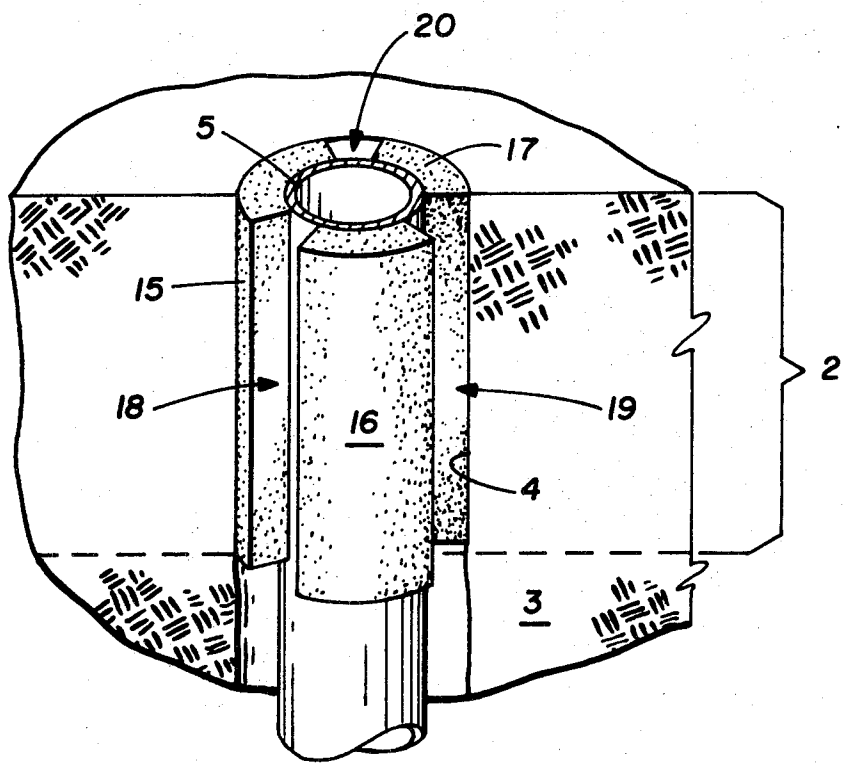
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[57] **ABSTRACT**

A method and apparatus for drilling, completing, and-/or producing a well through a permafrost zone wherein a liquid such as water is either introduced into a thawed region of the permafrost to prevent compaction of the permafrost or liquid is removed from a thawed region in the permafrost zone to prevent the generation of abnormal pressure on a wellbore and/or apparatus therein should the liquid freeze. A method for completing a well in a permafrost zone wherein a pipe is run into the wellbore adjacent to the casing and the pipe is perforated after placement in the wellbore to provide means for introducing liquid into and removing liquid from the permafrost zone.

7 Claims, 3 Drawing Figures



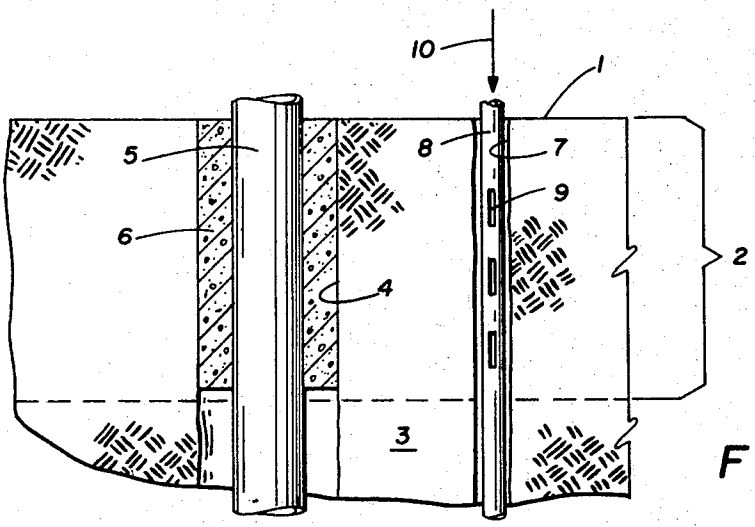


FIG. 1

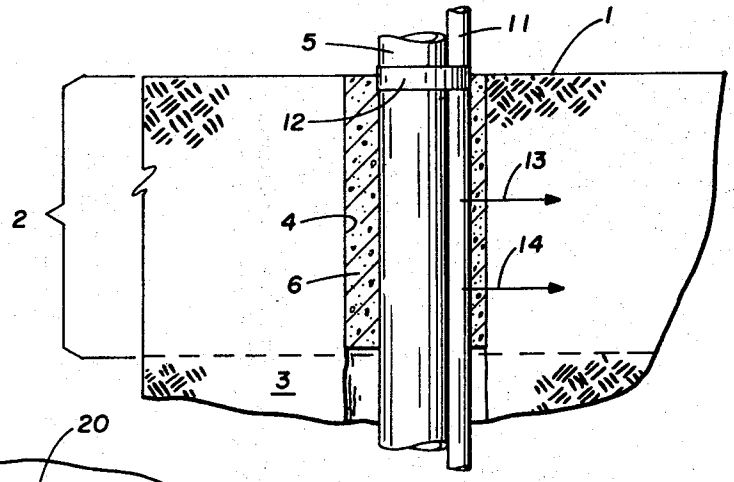


FIG. 2

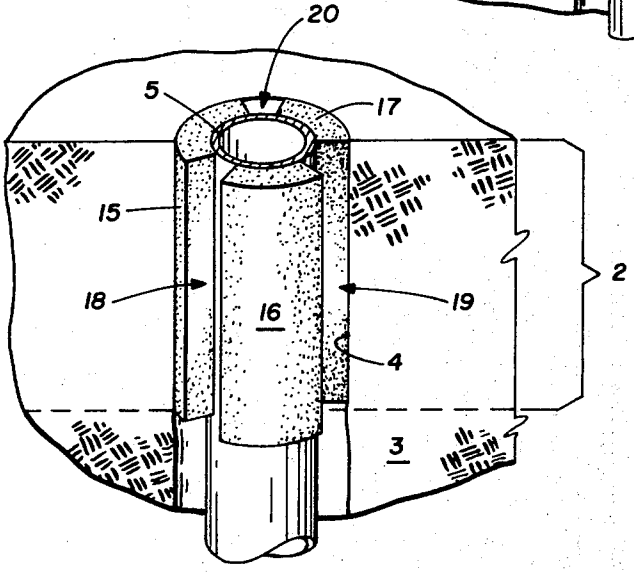


FIG. 3

METHOD OF WELL PRODUCTION IN PERMAFROST

CROSS REFERENCES TO RELATED APPLICATION

This application is a division of application Ser. No. 339,513, filed Mar. 9, 1973.

BACKGROUND OF THE INVENTION

Heretofore in the drilling, completion, and production of wells through a permafrost zone, strenuous efforts have been made to prevent any thawing of the permafrost whatsoever. This avoids, among other things, compaction of the permafrost, e.g., subsidence of the thawed permafrost and, possibly, the ground level. However, in certain instances, it is virtually impossible to avoid thawing a limited region of permafrost no matter how great the effort.

Once there is a thawed region in the permafrost near the wellbore, the thawed region can have a freezable liquid therein, e.g., water. It is desirable, should the thawed region refreeze again, to remove sufficient of the freezable liquid so that upon refreezing of the thawed region and conversion of any liquid water present into ice, abnormal pressures not be built up on the wellbore and/or any apparatus therein by the refreezing process.

SUMMARY OF THE INVENTION

According to this invention there is provided a metod for drilling, completing, and/or producing a well through a permafrost zone wherein a liquid is injected into one or more thawed regions in an amount and under a pressure sufficient to prevent substantial compaction of the permafrost materials in the thus treated thawed region or regions.

This invention also includes removing liquid from a thawed region in an amount sufficient to prevent the buildup of absornal pressures on the wellbore and/or any apparatus therein due to refreezing of the thawed region.

There is also provided well apparatus in a wellbore in a permafrost zone wherein there is a pipe means, e.g., casing, in the wellbore and means for at least one of introducing liquid into and/or removing liquid from the permafrost zone, particularly in the vicinity of the wellbore.

There is also provided a method for completing a well in a permafrost zone wherein besides running casing into the wellbore, a pipe is run into the wellbore adjacent the casing. After the running of the pipe, it is perforated toward the permafrost at a plurality of points to provide a pipe means adjacent the casing which can be used for the introduction of liquid into the permafrost or the removal of liquid from the permafrost.

Accordingly, it is an object of this invention to provide a new and improved method and apparatus for drilling, completing, and/or producing a well through a permafrost zone. It is another object to provide a new and improved method and apparatus for drilling, completing and/or producing a well through permafrost and in the vicinity of one or more thawed regions of permafrost. It is object to provide a new and improved method and apparatus for relieving stress on a wellbore in permafrost and/or any apparatus therein when one or more thawed regions in the permafrost at least partially refreeze. It is another object to provide a new and

improved method and apparatus for drilling, completing, and/or producing a well in permafrost wherein compaction of any thawed regions of permafrost is prevented or minimized. It is another object to provide a new and improved method and apparatus for drilling, completing and/or producing a well in permafrost wherein subsidence of the earth's surface due to thawing of one or more regions in the permafrost is prevented.

Other aspects, objects and advantages of this invention will be apparent to those skilled in the art from this disclosure and the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a cross section of apparatus according to one embodiment of this invention and for carrying out the method of this invention.

FIG. 2 shows apparatus according to another embodiment within this invention and for carrying out the method of this invention.

FIG. 3 shows yet another embodiment of apparatus within this invention and capable of carrying out the method of this invention.

More specifically, FIG. 1 shows the earth's surface 1 below which is a permafrost zone 2. Below permafrost zone 2 is unfrozen earth 3. A first wellbore 4 is drilled through the permafrost zone 2 and into unfrozen ground 3 an indefinite distance. Pipe means such as conventional casing 5 is set in wellbore 4 by way of cement 6. Spaced from wellbore 4 but in the vicinity of that wellbore is a second wellbore 7 which also is drilled through permafrost 2 and into unfrozen ground 3. Wellbore 7 can extend partly into permafrost zone 2 or all the way to the bottom of zone 2, or all the way through zone 2 and into unfrozen ground 3 as shown in FIG. 1, as desird. A perforate pipe means 8 is placed in wellbore 7, pipe means 8 being perforate in that it has a plurality of slots 9 through the wall thereof and along the length of pipe 8 in permafrost zone 2. Slots 9 give open communication between permafrost zone 2 and the interior of pipe 8 so that a liquid can be passed downwardly through pipe 8 as shown by arrow 10 and outwardly through slots 9 into thawed regions of permafrost zone 2. Pipe 8 can be capped or otherwise plugged at its lower end (not shown) or can be open at its lower end to allow liquid to enter and/or leave a thawed region by way of said lower end and, if desired, to be connected below the permafrost. Conversely, liquid in permafrost zone 2 can pass through slots 9 into the interior of pipe 8 and be pumped in a conventional manner by surface or downhole pumps upwardly to the earth's surface to remove freezable liquid from the permafrost before it refreezes. Slots 9 can be any sort of aperture(s) in pipe 8, e.g., round holes, pores, and the like, or even conventional perforation holes caused by lowering a perforation gun into the interior of pipe 8 and perforating same in a conventional manner well-known in the petroleum industry. A primary goal of pipe 8 is to provide a vertical passageway with a plurality of access openings along the length thereof in the permafrost zone for the introduction and/or removal of liquid relative to the permafrost zone.

FIG. 2 shows wellbore 4 with casing 5 cemented therein by cement 6 except that casing 5 has a pipe means 11 strapped thereto by strap means 12 so that when casing 5 was run into the wellbore, pipe 11 was run with the casing. Pipe 11 can be run with the casing,

or before or after the casing is run as desired, it not being necessary that pipe **11** be strapped to casing **5.** The point in this embodiment is that pipe **11** is in the same wellbore with the casing and can even be cemented in place with the casing. Pipe **11** can be perforate as run or can be imperforate as run. If pipe **11** is imperforate, after it is in place and cemented, if cementing is to be carried out, a conventional perforating gun is lowered through pipe **11,** oriented toward the sides of the wellbore, i.e., toward the permafrost and not toward casing **5,** and then perforated in one or more places as shown by arrows **13** and **14.** In this way pipe **11,** any cement therearound, and even permafrost zone **2** can be perforated to provide the desired liquid access port(s) along the length of pipe **11** which is in permafrost zone **2.**

FIG. **3** shows casing **5** in wellbore **4** in permafrost zone **2** wherein the cement surrounding casing **5** is divided into segments **15** through **17,** inclusive. Adjacent segments are spaced apart from one another to form a plurality of upstanding passageways **18** through **20,** inclusive. Passageways **18** through **20** provide vertical access in the same manner as pipes **8** and **11** of FIGS. **1** and **2,** respectively. These passageways, being open adjacent the walls of wellbore **4,** also provide access to permafrost zone **2** for the introduction of liquid thereinto upon the withdrawal of liquid therefrom.

The liquid introduced into the permafrost to prevent compaction of materials therein due to thawing can be any liquid which is substantially nondeleterious to the permafrost. Obviously, fresh water, salt water, and the like, can be employed. Similarly, aqueous materials such as water having one or more freezing point depressants mixed therewith, and the like, can be employed as well. Nonaqueous liquids can also be employed if desired and suitable for the specific purpose to be accomplished.

The amount of liquid employed will vary widely depending upon the particular situation and the liquid used. Generally, liquid will be used in an amount and under a pressure sufficient to prevent substantial compaction of permafrost materials in the thawed region or regions to be treated. The liquid can be injected at any desirable temperature, preferably at a temperature which will prevent substantial additional thawing of the permafrost. As regards water or aqueous liquids, these can be injected at a temperature near the freezing point of the water or liquid injected under the conditions then prevailing in the treated thawed region. The pressure of injection for the liquid can vary widely, again depending upon the particular sitatuion of the treated material and need not be a substantial pressure. Generally, the injection pressure will be at least about one psig, preferably at least about 25 psig.

When freezable liquid such as water is removed from a thawed region prior to refreezing of that region, the liquid should not be removed in an amount sufficient to allow substantial compaction of the permafrost but should be removed in an amount sufficient to prevent buildup of abnormal pressures which could adversely affect the wellbore and/or any apparatus therein, e.g., due to expansion of the water or other liquid during freezing. The liquid will generally flow out of the refreezing region and up through pipes **8, 11,** etc., to the earth's surface. However, if desired, pumps (surface or downhole) can be used to assist in removing this liquid. If, for example, pipe **8** is in communication with another permeable region such as a porous region elsewhere in the permafrost or even below the permafrost the liquid could flow to these other regions. For example, the liquid could flow downwardly to the bottom of pipe **8** and into a permeable region below the permafrost instead of flowing upwardly to the earth's surface.

Liquid handling means other than pipes **8** and **11** of FIGS. **1** and **2,** respectively, and open channels **18** through **20** of FIG. **3,** can be employed to accomplish the purposes of this invention. For example, liquid permeable cement could be employed in lieu of cement **6** in FIG. **1,** the permeable cement being deliberately porous so as to admit the percolation of substantial amounts of liquid vertically therethrough. other types of liquid permeable packing beside permeable cement can be employed around casing **5.** For example, the annulus between the exterior of casing **5** and the interior of wellbore **4** of FIG. **1** can contain, instead of cement **6,** a bed of solid particles such as gravel. The interstices between the solid particles provides passageways for vertical flow of liquid into or out of permafrost zone **2** and along the annulus containing the bed of solid particles. The longitudinally channelized cement of FIG. **3** can also be considered as a liquid permeable packing and can be produced in a number of ways, not the least of which is the deliberate performance of a poor cementing job wherein the cement channelizes around a foreign liquid such as drilling mud and the like which is left in the annulus. Also, the cement can deliberately be mixed with oil or an oil base material or drilling mud so that when laminar flow is set up in the annulus between casing **5** and wellbore **4** the foreign liquid channelizes through the cement. After the cement is hardened and the foreign liquid removed, open passageways such as passageways **18** through **20** of FIG. **3** will then be left.

EXAMPLE

Apparatus substantially the same as that shown in FIG. **1** is set up in a permafrost zone approximately 2,000 feet in depth. Pipe **8** extends down to the bottom of permafrost zone **2** and is capped at its lower end. Salt water at a temperature of 50°F. and pressure of 25 psig is forced downwardly in pipe **8** and outwardly through slots **9** and into thawed regions of permafrost zone **2** caused by the production of hot oil through casing **5.** The water is injected in an amount sufficient to prevent subsidence of earth surface **1** in the vicinity of wellbores **4** and **7.**

When production of hot oil through casing **5** is ceased for any substantial period of time, liquid water flows from the permafrost through slots **9,** into the interior of pipe **8,** and back to the earth's surface thereby removing liquid water from the thawed zones as the thawed zones refreeze due to being surrounded by still frozen permafrost. The liquid water is removed from zone **2** by way of pipe **8** in an amount sufficient to prevent substantial pressure buildup on wellbore **4,** cement **6,** and casing **5** contained therein but not in an amount sufficient to allow subsidence of earth surface **1** prior to refreezing of the thawed regions of permafrost.

Reasonable variations and modifications are possible within the scope of this disclosure without departing from the spirit and scope of this invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method for producing a well through a permafrost zone wherein at least one thawed region in said permafrost zone occurs and the liquid in said at least one thawed region is subject to refreezing, the improvement comprising removing freezable liquid from at least one of said thawed regions, said liquid being removed in an amount sufficient to prevent the buildup of abnormal pressures on said wellbore and any apparatus therein due to the refreezing of said liquid.

2. A method according to claim 1 wherein said liquid is essentially water.

3. A method according to claim 2 wherein casing is present in said wellbore in said permafrost zone and sufficient liquid water is removed to prevent physical damage to said casing when the remaining liquid water refreezes into ice.

4. A method according to claim 1 wherein said liquid is not removed in an amount sufficient to cause substantial compaction of said permafrost.

5. A method according to claim 1 wherein said liquid is aqueous.

6. A method according to claim 1 wherein said liquid is disposed of at the earth's surface.

7. A method according to claim 1 wherein said liquid is disposed of elsewhere under the earth's surface.

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