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Perkins

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[54] **METHOD FOR NORMALIZING STRESSES AND STRAINS IN A WELL CASING IN A PERMAFROST ZONE**

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[52] **U.S. Cl.** ..... **166/302;** 166/DIG. 1; 61/36 A; 175/17

[51] **Int. Cl.**[2] ... **E21B 43/00;** E02B 3/00; E21B 7/00

[58] **Field of Search** ..... 166/DIG. 1, 302; 175/57, 175/17, 65; 61/36 A, 50

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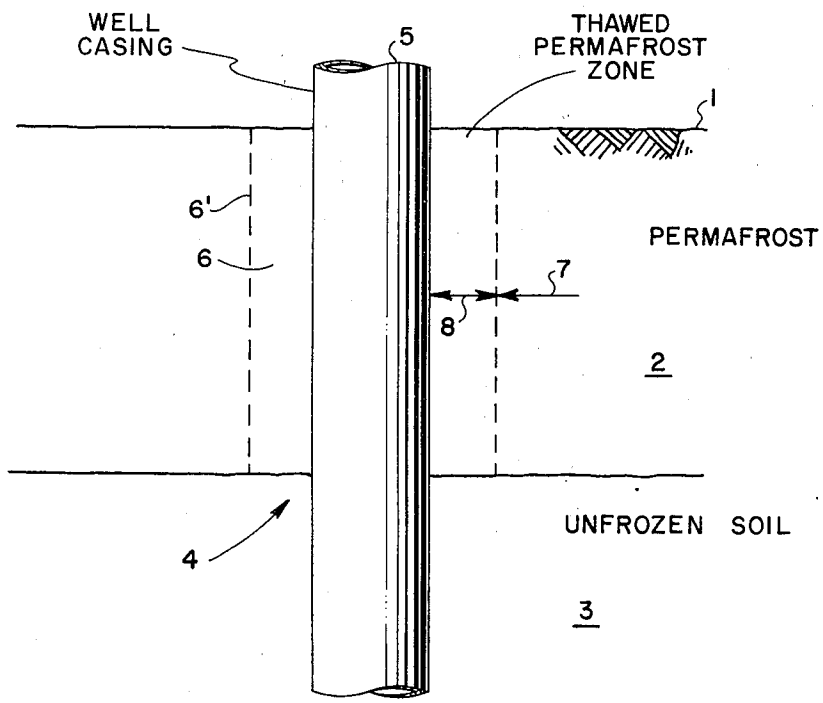
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[57] **ABSTRACT**

A method for rendering stresses and strains in a well casing more uniform throughout the length of the casing in a permafrost zone, the permafrost adjacent the casing being at least partially thawed, wherein the permafrost is allowed to refreeze at least in part until the well casing can physically move relative to the thawed soil thereby rendering such stresses and strains more uniform throughout the casing length.

7 Claims, 2 Drawing Figures



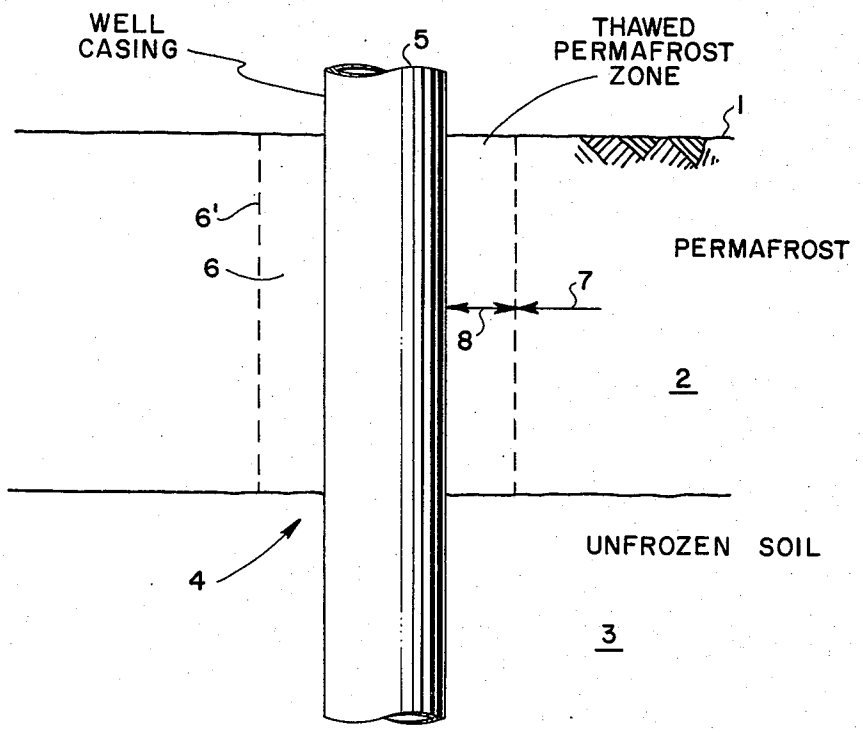

WELL CASING
5
THAWED PERMAFROST ZONE
1
6'
6
PERMAFROST
7
8
2
4
UNFROZEN SOIL
3

FIG. 1

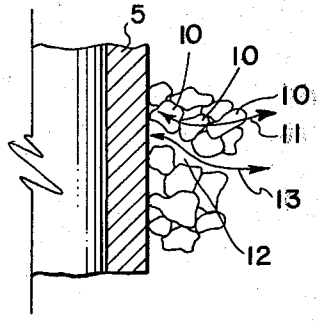

5
10
10
10
11
13
12

FIG. 2

METHOD FOR NORMALIZING STRESSES AND STRAINS IN A WELL CASING IN A PERMAFROST ZONE

BACKGROUND OF THE INVENTION

Permafrost is permanently frozen soil and most often contains mixtures of compactible soil constituents such as clay and silt (e.g., clay and quartz fines), less compactible soil constituents such as sand and gravel, and frozen water. In a number of locations in the world, oil reservoirs have been discovered which lie below permafrost zones thereby requiring that any wells that are drilled into and produced from such reservoirs pass through a permafrost zone. In such situations the normal operations of drilling and completing the well and thereafter producing fluids from the reservoir through the well can sometimes generate sufficient heat to cause a portion of the permafrost zone that is adjacent the wellbore to thaw at least in part thereby converting the permafrost from a uniformly frozen solid to a mixture of soil particles as set forth hereinabove and possibly other particles (all of which are collectively referred to hereinafter simply as "soil") and liquid water in the pores of the soil.

The thawed soil contains various mixtures of compactible and relatively uncompactible constituents. Due to this varying lithology in the permafrost there can be an uneven generally downward (there may be localized areas where there is some upward deflection) movement of the thawed permafrost. The uneven movement of the thawed permafrost generally causes the well casing to undergo uneven stresses and, therefore, be strained in a similarly uneven manner.

The net result then is a single string of well casing passing through the permafrost zone which at various points along its length can have substantially differing strains induced therein. This is undesirable because it is conceivable that localized strains could reach such proportions that sufficient localized damage could be done to the casing to interfere with the drilling and/or production of the well.

SUMMARY OF THE INVENTION

It has been found that the thawed permafrost applies force to the well casing through the soil particles and through the liquid-full pores that thread their ways through the thawed soil and that in a normal situation of thawed permafrost pressing against the well casing most of the stress applied to the well casing is transmitted through the soil particles and not through the liquid-full soil pores. The soil particles bearing on the well casing have a relatively high shear strength and therefore drag (upwardly or downwardly depending on the location along the casing) against the casing and induce stresses in the casing itself. These stresses, as explained hereinabove, can be significantly uneven over the length of the casing in the permafrost zone and thereby cause significantly uneven strain in the casing itself.

In accordance with this invention, the thawing of the permafrost zone adjacent the wellbore is terminated or at least reduced to a point where refreezing of the thawed permafrost can occur since the outer edge of the thawed permafrost zone is adjacent to a relatively infinite source of frozen permafrost. The frozen permafrost will refreeze the thawed permafrost if given an opportunity so to do.

The refreezing of the thawed permafrost is allowed to proceed until the casing can physically move relative to the thawed soil. This can occur when the pore pressure in the coil increases due to the expansion of refreezing water until it approaches the force transmitted through the soil particles themselves. Since water does not have a substantial shear strength, the casing can readily physically move relative to the thawed soil when the liquid pore pressure in the thawed permafrost soil approaches the pressure transmitted by the soil particles themselves. The uneven stresses and strains along the length of the casing will then be automatically essentially equalized or at least rendered more uniform throughout the length of the casing in the permafrost zone.

Accordingly, it is an object of this invention to provide a new and improved method for rendering more uniform the stresses and strains in a wellbore casing in a permafrost zone wherein at least part of the permafrost is at least partially thawed.

It is another object to provide a new and improved method for carrying out drilling and/or producing operations through permafrost.

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 a well through a permafrost zone.

FIG. 2 shows an enlarged view of a section of well casing with thawed permafrost adjacent thereto.

More specifically, FIG. 1 shows the surface of the earth 1 under which is a permafrost zone 2. Beneath permafrost zone 2 is unfrozen soil 3. A wellbore 4 extends from the earth's surface through zone 2 and through as much of zone 3 as is necessary to reach an oil and/or gas reservoir (not shown).

Wellbore casing 5 extends the length of the wellbore 4 from the earth's surface to the reservoir. Although this invention is described relative to the use of well casing, it should be understood that the term "casing" is used generically to cover any type of pipe or other conducting means which may be deployed adjacent the permafrost. Normally, the casing will be an assembly of single diameter pipes throughout the length of the permafrost zone, but may also include two or more pipes of decreasing diameter as one progresses down through permafrost zone 2 toward unfrozen zone 3. The casing can have cement deployed between it and the permafrost or some other material disposed in the same relative position so long as the thawed permafrost soil particles and liquid contact that intermediate material, because the same effect of uneven stressing can be imposed on the casing even when, for example, cement is disposed in the conventional manner between the casing and the permafrost itself.

FIG. 1 shows an annular thawed permafrost zone 6 of uniform diameter from top to bottom. The showing of a uniform annular thawed permafrost zone is for simplicity's sake only, and under actual conditions can vary radically from such an idealized configuration. Variations in the thawing configuration can cause even greater localized stressing and, therefore, strains in casing 5 than when uniform thawing is encountered as shown for zone 6.

The still frozen permafrost in zone **2** presses against the thawed permafrost zone **6** with a force in the direction of arrow **7.** Force **7** is transmitted by way of solid soil particles and liquid pore pressure through zone **6** to casing **5,** casing **5** pressing back against the frozen permafrost as shown by double arrow **8.**

As can be seen more clearly in FIG. **2,** part of the force **7** is transmitted to casing **5** through thawed soil particles **10** as shown by arrow **11** while the remainder of force **7** is transmitted to casing **5** through pore **12** as shown by arrow **13.**

The force transmitted by arrow **11** is substantially greater than the force transmitted by arrow **13** so that the solid thawed permafrost soil particles **10** are firmly pressed against casing **5** while the thawed particles **10** tend to subside due to the relatively greater compactibility of some of the particles, but that when a source of heat within casing **5** (e.g., the passing of drilling fluid through the inside of the pipe during drilling or the production of relatively warm oil and/or gas from the reservoir to the earth's surface during production) is terminated or reduced significantly, zone **6** will start to refreeze at its outer edge or interface **6'**.

According to this invention the refreezing of liquid water in the pores in the thawed permafrost zone **6,** due to the expansion of the liquid water upon refreezing, causes substantial increases in the pore pressure, e.g., the pressure in pore **12.** The pore pressure increases upon continued refreezing until the pore pressure represented by arrow **13** approaches, or even equals or exceeds, the pressure transmitted through the soil itself as represented by arrow **11.** When this point is reached, all of the liquid water in the pores has not refrozen so that liquid water is still in physical contact with the outer wall of casing **5.** Since liquid water is adjacent the outer wall of casing **5,** since that liquid water is transmitting forces approaching the forces transmitted through the soil particles themselves, and since the liquid water has essentially no shear strength, casing **5** can easily physically move relative to soil particles **10** thereby substantially equalizing throughout the length of casing **5** in zone **2** the unequal stresses and strains previously caused by thawing zone **6** and uneven compaction of the thawed permafrost along the length of casing **5** in zone **6.** The pore pressure, in all situations, need not even equal much less exceed the force transmitted through the said particles themselves in order to achieve the advantages of this invention. It is sufficient in a significant number of situations if the pore pressure is merely raised a significant amount toward the magnitude of the soil particle transmitted force but yet still be substantially below the actual magnitude of such force. Because the lithology, temperature, pressure and many other parameters can vary substantially from situation to situation in a wellbore, it is impossible to quantify the minimum amount of bore pressure increase required for all situations, but it is clear that the pore pressure must be increased toward the magnitude of the soil particle transmitted force, i.e., approach such force, and that at some time during such approach (increase in pore pressure) the casing will be rendered sufficiently more movable relative to the soil particles to realize the advantages of this invention.

Thus, refreezing of zone **6** in its entirety is not normally necessary to achieve the advantages of this invention, the amount of refreezing allowed to occur being only that necessary to allow the casing to physically move relative to the thawed soil. When this stage is reached, the stresses and strains in casing **5** will automatically be rendered more uniform and thereafter the previously curtailed or reduced well operations such as drilling or production can be brought back to their normal operating levels. Thereafter the stresses and strains in the casing in the permafrost zone will remain relatively uniform throughout notwithstanding the return to such normal operating levels.

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 rendering stresses and strains more uniform throughout a length of well casing that is adjacent an at least partially thawed permafrost zone, said thawed zone containing thawed soil and liquid in the pores thereof, said thawing having been caused by one or more well operations, said method comprising at least limiting said well operations so that refreezing can occur in at least part of said thawed zone, allowing said refreezing to occur in said thawed zone until said casing can physically move relative to said thawed soil, and thereafter continuing said well operations.

2. A method according to claim **1** wherein said well operations are the drilling of said well.

3. A method according to claim **1** wherein said well operations are the production of fluids from said well.

4. A method according to claim **1** wherein said well operations are a combination of drilling said well and producing fluids therefrom.

5. A method according to claim **1** wherein said refreezing is allowed to occur until the liquid pore pressure in said thawed zone approaches the pressure transmitted by the thawed soil itself.

6. A method according to claim **1** wherein said refreezing is allowed to occur until the liquid pore pressure in said thawed zone is at least equal to the pressure transmitted by the thawed soil itself.

7. A method according to claim **1** wherein said casing has cement disposed between it and said thawed zone.

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