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Perkins

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[54] **WELL INSULATION METHOD**

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Related U.S. Application Data

[63] Continuation of Ser. No. 84,656, Oct. 28, 1970, abandoned.

[52] **U.S. Cl.**..... **166/315,** 166/DIG. 1, 166/57

[51] **Int. Cl.**..... **E21b 23/00**

[58] **Field of Search**..... 166/DIG. 1, 57, 302, 166/303

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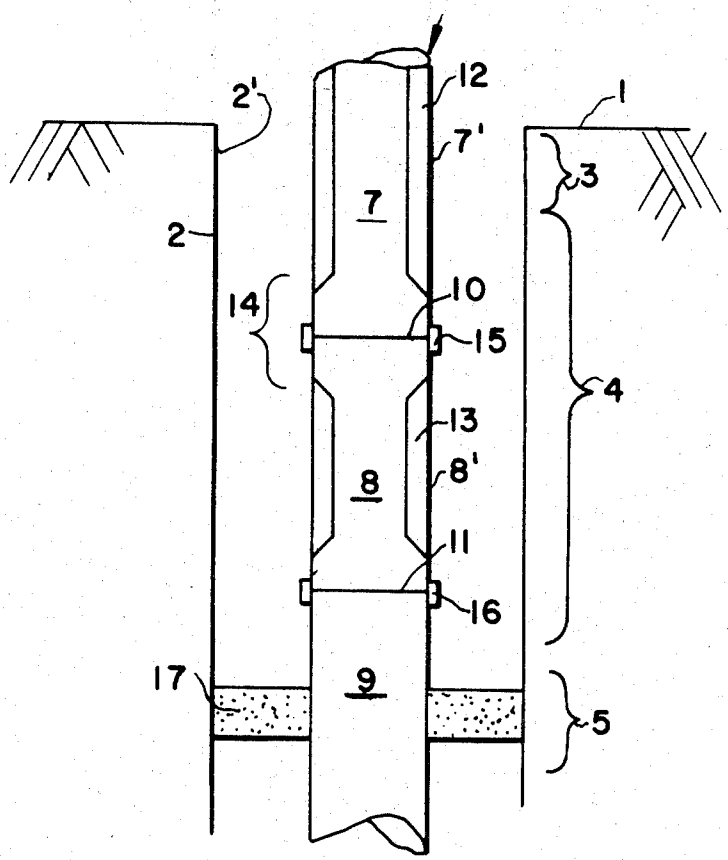
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[57] **ABSTRACT**

A method for terminally insulating one or more casing strings from the walls of a wellbore which includes employing annular zones in which at least part of the air has been displaced and replaced by a gas which remains gaseous under the temperature and pressure conditions obtaining in the annular zone when placed in the wellbore and which has a thermal conductivity substantially less than that of air.

10 Claims, 2 Drawing Figures



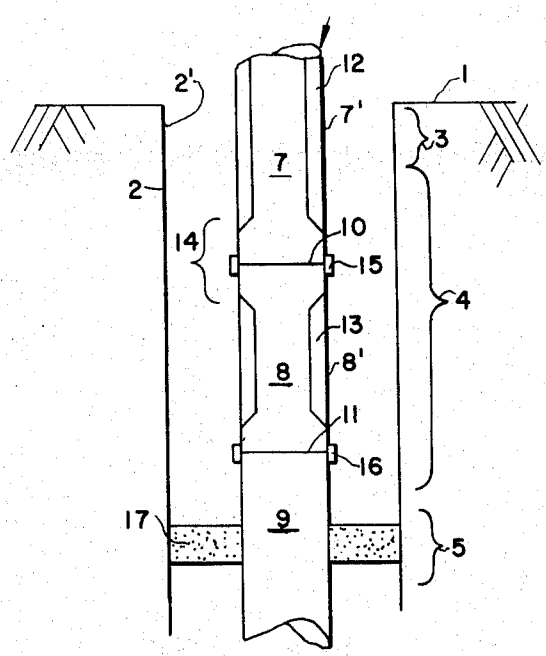

12
1
2'
7'
3
7
2
14
10
15
4
13
8
8'
11
16
17
9
5

FIG. 1

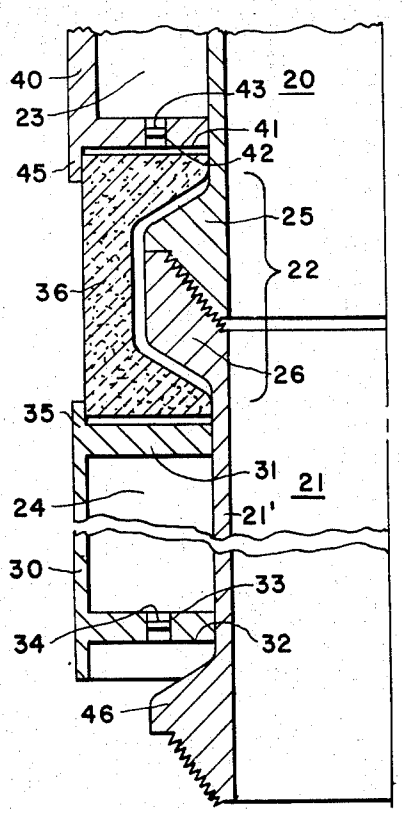

40
43
20
23
41
42
45
25
22
36
26
35
31
21
24
21'
30
33
34
32
46

FIG. 2

WELL INSULATION METHOD

CROSS REFERENCES TO RELATED APPLICATIONS

This is a continuation of U. S. Pat. application Ser. No. 84,656, filed Oct. 28, 1970, now abandoned.

BACKGROUND OF THE INVENTION

Heretofore in the production of warm fluids such as petroleum gas and/or petroleum liquid from a wellbore in the earth through a permafrost zone whereby part of the permafrost could be melted upon continued exposure to the warm fluid, it has been proposed to surround the pipe (casing or tubing) in the wellbore with solid thermal insulation such as polyerethane foam. The insulation normally extends from the earth's surface down to the bottom of the permafrost zone in a continuous cylindrical form.

Thermal insulation applied in this manner to the outside of pipe is expensive to apply to each joint of the pipe as it passes into the wellbore because this takes up the time of the rig and the workmen to apply the insulation. The insulation is also quite fragile under the normal conditions by which pipe of any type is inserted into a wellbore and, therefore, is likely to be at least partially scraping or otherwise broken off from the pipe before the pipe is set into its final position in the wellbore. Further, some porous insulation does not act as efficiently in a wellbore if the liquid, which is almost always present in a wellbore, penetrates the pores of the insulation and/or if the pressures present in the wellbore, particularly near the lower end thereof, are sufficient to collapse at least part of the pores in the insulation.

Thus, it is highly desirable to have an efficient type of insulation which is quite durable under normal operating and pipe emplacement conditions on a well so that one can be certain that the insulation is intact when the pipe is emplaced in its final position in the wellbore and which does not take up an undue amount of time of the rig and personnel when running the pipe into the wellbore.

SUMMARY OF THE INVENTION

According to this invention all of the above requirements are met by minimizing the amount of solid insulation used and in physically protecting the minor amount of solid insulation that is used.

According to this invention there is provided a method for thermally insulating the interior of one or more sections of casing, tubing, or other pipe, hereinafter referred to collectively as casing or casing string, in the permafrost zone of a wellbore. There is provided a closed, air containing, annular zone around and along at least part of the interior or interiors to be insulated, displacing a substantial portion of air from the annular zone and replacing at least part of the displaced air with a gas (vapor) which will remain a gas after the casing is emplaced in the wellbore and which has a thermal conductivity at 32°F. of substantially less than 5.572×10^{-5} gram-calories/(second) (square centimeter) (degrees centigrade/centimeter).

Hereinafter all reference to thermal conductivity values are based upon the given units unless otherwise specified. The above thermal conductivity units represent the quantity of heat in gram-calories which is transmitted per second through a section of material 1 centimeter thick and 1 square centimeter in area when the temperature difference between the two sides of the section is 1°C. These thermal conductivity values can be transformed into English units, i.e., Btu/(second)(square inch)(degree F./inch) by multiplying the value given by 0.00560.

This invention therefore provides a method whereby fluids hot enough to melt permafrost can be continuously produced through a permafrost zone for a long period of time such as 20 years without substantially melting the permafrost itself.

Accordingly, it is an object of this invention to provide a new and improved method for producing wells through a permafrost zone. It is another object to provide a new and improved method for thermally insulating casing in a wellbore. It is another object to provide a new and improved method for producing hot fluid through permafrost without substantially melting the permafrost. It is another object to provide a new and improved method for thermally insulating at least one part of a wellbore in a manner wherein the insulation will stand up under normal handling and emplacement of casing in the wellbore.

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 wellbore containing a permafrost zone and with casing emplaced therein in accordance with this invention.

FIG. **2** shows a cross-section of a casing embodiment within this invention.

More specifically, FIG. **1** shows the earth's surface **1** with wellbore **2** drilled therein, the bottom of the wellbore not being shown for sake of brevity. Wellbore **2** passes through a tundra zone **3** at the earth's surface which extends downwardly a short distance of, for example, 2 feet to a permafrost zone **4.** Below zone **4** is unfrozen earth zone **5.**

A casing string **6,** which can be one or more strings of concentric casing including tubing or similar pipe, is shown to be composed of a plurality of individual sections of casing denoted by reference numerals **7, 8,** and **9.** Casing section **7** is fixed to a conventional wellhead (not shown) which is well known in the art. Section **7** extends downwardly into the permafrost zone and terminates at joint line **10.** The casing string shown is a primary or outer casing which is spaced from and directly exposed to face **2'** of the wellbore.

Casing section **8** starts at line **10** and extends downwardly to joint line **11.** Casing sections **7** and **8** contain inwardly extending, closed annular chambers **12** and **13,** respectively. These chambers terminate a finite distance from the ends of each section of casing so that, for example, when sections **7** and **8** are joined at line **10** there is a finite distance **14** of substantially uninsulated casing space. Uninsulated space **14** contains solid insulation, not shown, as will be discussed hereinafter in detail in FIG. **2.**

Casing sections **7** and **8** are joined to one another by each threading into a separate conventional sleeve type coupling **15** which is well known in the art. Casing sections **8** and **9** are also joined at line **11** by a separate sleeve coupling **16.**

Casing section **9** starts at joint line **11** and extends downwardly out of the permafrost zone **4** into unfrozen

zone 5 and is cemented in by way of cement 17 so that it supports casing sections 7 and 8 and the wellhead.

FIG. 2 shows an enlarged cross-section of the bottom portion of a casing section such as section 7 of FIG. 1 and an upper portion of a casing section such as section 8 of FIG. 1, except that the upper section in FIG. 2 is section 20 and the lower section is section 21, respectively. The uninsulated space 22 between outwardly extending, closed annular chamber 23 of section 20 and outwardly extending, closed annular chamber 24 of section 21 is shown to have a different type of coupling means which is also within the scope of this invention.

The coupling means employed in FIG. 2 is a conventional pin and box type connection wherein pin 25 of section 20 threads into box 26 of section 21.

The right cylindrical closed annular chamber 24 is composed of an outer sleeve 30 which is spaced from the outer wall 21' of section 21 by way of annular rings 31 and 32. Annular ring 32 has a port 33 therein and a removable plug 34 by which gases can be passed into and/or removed from the closed interior of chamber 24.

Chamber 24 has holding members 35 extending outwardly from either end thereof and extending over a portion of solid insulation member 36 to help hold insulation 36 in place and also to protect insulation 36 from scraping or impact by an outside force which would damage the insulation itself. Insulation 36 is provided to cover the uninsulated part 22 between adjacent chambers 23 and 24. Similar insulation is provided in FIG. 1 on the interior of sections 7, 8, and 9 in the uninsulated spaces such as space 14.

Chamber 23 has an outer sleeve 40 joined at the bottom by annular ring 41. Annular ring 41 also has a port 42 and plug 43 for the same purposes as port 33 and plug 34 of ring 32. The upper end of chamber 23 (not shown) is similar in configuration to that of chamber 24 with its upper annular ring 31 and protection member 35, just as the lower end of section 20 is similar to the lower end of section 21, i.e., annular rings 32 and 41 with their ports, extension members 45 and 35, and pin members 25 and 46.

It can be seen from the drawings that the closed annulus zones 12 and 13 of FIG. 1 and 23 and 24 of FIG. 2 can extend inwardly or outwardly from the casing section whose interior is to be insulated from the wellbore wall 2' and that gaps between adjacent annulus ends of adjacent casing sections are filled with insulation material.

The insulation is protected by the annulus zones themselves and/or by extension members if, as shown in FIG. 2, the annulus zones are on the outside of the casing. The insulation is protected by the outer walls 7' and 8' of the casing sections themselves if the annulus zones extend inwardly as shown in FIG. 1 because the insulation is placed on the interior of the casing sections in space 14 between the ends of adjacent inwardly extending annulus zones.

By the method of this invention the annular zones or chambers described in FIGS. 1 and 2 initially contain air and are provided around and along the length of at least part of the interior of the casing or casing sections to be insulated. For example, zone 12 extends around the periphery of section 7 and also extends substantially the entire length of section 7. This is also true as shown for section 8 with its surrounding zone 13. A substantial portion, at least about 5 volume percent, of the air present is displaced from the annular zone and is replaced at least in part with a gas which is substantially inert to the materials forming the annular zone, e.g., the materials forming section 21, sleeve 30, and rings 31 and 32.

The gas can be employed to replace all or part of the air displaced from the annular zone. If only a part of the air is replaced with the gas of this invention a subambient pressure (vacuum) can be formed in the interior of the annular zone which will enhance its insulating characteristics. The pressure in the annular zone need not be of a vacuum nature and can just as well be an ambient or super-ambient pressure as desired. The pressure in the annular zone will, however, be below the vapor pressure of the gas or gases, i.e., gas components, present in that zone and can generally range from about 10^{-5} to about 1,500, preferably from about 10^{-5} to about 760, millimeters of mercury. The gas will normally be at a temperature below about 32°F. after emplacement of the casing section in the wellbore and will generally be at a temperature in the range of from about 14 to about 32°F. and should remain substantially in the gaseous state at these temperatures and pressures.

Generally, some condensation of the gas in the annulus after emplacement of the casing can be tolerated and therefore the presence of some liquefied gas or other liquid in the annulus is within the scope of this invention. It is preferable that no more than about 5 volume percent liquid, based on the total volume of the particular annular chamber, be present in any annulus.

The gas or gases employed must also have a thermal conductivity at 32°F. of substantially less than 5.572×10^{-5} and preferably less than 5.300×10^{-5}.

By employing the above method, the wellbore wall can be very efficiently thermally insulated from the interior of one or more sections of casing while minimizing the use of solid insulating material and additionally by rendering unnecessary extremely high vacuums. Instead of employing an extremely high vacuum in annular zones 24 and 25 for its thermal insulating effect, a lower grade vacuum can be employed and if the air remaining with this lower grade vacuum is replaced by one or more gases as defined for this invention, similar thermal insulating efficiency obtained as with the higher grade vacuum. This is advantageous in that it can be easier to maintain a lower grade vacuum in an annular zone for a period of 20 years or more than to maintain a higher grade vacuum. Thus, with the use of a lower grade vacuum and the air remaining displaced by the gas employed in this invention, the chances of maintaining the vacuum in the wellbore for a number of years is increased without sacrifice in thermal insulating efficiency.

If desired, the annular zones of this invention can have other insulating material employed therein, such as radiant insulating material, as desired. Hydrogen or other gaseous diffusion barriers can be employed on the interior and/or exterior of these zones to prevent the migration of gases such as hydrogen to the interior of the zone. Corrosion resistant materials can be placed on the exteriors of the zones so that the formation of gases such as hydrogen due to corrosion is minimized. Conventional getter materials (gas absorbing materials) can be employed in the interior of the annular zones to absorb any gas that may leak or diffuse into the zone if a vacuum is imposed therein so that the

magnitude of the vacuum initially imposed in that zone can be substantially maintained.

Solid insulation used in the uninsulated area between adjacent annular zones of adjacent casing sections can be any material which is substantially non-porous, or contains pores, bubbles, voids, and the like, or is composed of two or more separate layers of materials, etc. By "solid" what is meant therefore is any thermal insulating material which will maintain its shape although not confined on all sides. Suitable insulation includes polymers such as polyvinylchloride, polyehtylene, polypropylene, foamed polyethylene, foamed polypropylene, nylon, polytetrafluorethylene, polyurethane, asbestos, and the like.

Suitable gases useful in this invention include, but are not limited to, acetone, ammonia, argon, benzene, carbon dioxide, carbon disulfide, chlorine, chloroform, methane, ethane, propane, ethyl alcohol, ethyl ether, methyl alcohol, methyl ether, methylethylether, ethylene, hydrogen sulfide, methyl chloride, methyl bromide, methyl iodide, ethyl chloride, ethyl bromide, ethyl iodide, ethyl fluoride, ethylene chloride, ethylene bromide, ethylene iodide, ethylene fluoride, nitrous oxide, n-butane, isobutane, n-pentane, isopentane, sulfur dioxide and the like. The methyl ethyl, and ethylene halides can contain 1 to 6 halogen atoms and when containing 2 or more halogen atoms, the atoms can be the same or different types of halogens.

When the annular zones are employed on the ouside of the casing sections as shown in FIG. 2 the zones should be ended a finite distance from the end of each section, the finite distance being sufficient to allow the emplacement of various tools such as, slips, tongs, and the like on the ends of the casing section (such as box **26**) without touching in a damaging way any part of zone **24** including protection member **35.** When the zones extend on the interior of the section such as shown in FIG. 1 the sections can be run closer to the end of the section than in the embodiment of FIG. 2 because the outer surface of the section can be grasped at any point with a rig working tool without fear of damaging the interiorally extending annular zone.

Although FIG. 1 shows a single string of casing passing through the wellbore, a plurality of concentric strings of casing, tubing, and the like can be employed with one or more of the strings having a plurality of annular zones extending along at least part of the length of each string, e.g., extending along the depth of the permafrost zone **4.** A plurality of concentric casing strings can be employed and one or more of these casing strings can have the annular zones of this invention, each casing string which does have annular zones having an annular zone for a plurality of sections in the string, the zones of each string collectively extending along at least a part of the length of each string.

EXAMPLE

Steel casing for an oil well having pin and box type connections with exteriorally extending annular zones substantially shown in FIG. 2 is employed. In the casing 9⅝ inch outside diameter C–75 API casing in 40 foot lengths is used as the inside walls while the outer sleeves **30** and **40** of FIG. 2 are 13⅜ inch outside diameter C–75 API casing steel thereby providing an annular spacing for the annular zones of about 4 inches.

Substantially all of the air in each of the annular zones is removed and replaced with methyl iodide which has a thermal conductivity at 32°F. of 1.098×10^{-5}.

The solid insulation **36** is a right cylindrical block of solid polyvinyl chloride having a wall thickness of about 1 inch and a height of about 4¾ inches.

This casing string is employed in a wellbore passing through a permafrost zone wherein the permafrost at the wellbore face is at a temperature in the range of from about 14° to about 32°F. Liquid petroleum oil at a temperature of about 160°F. is pumped through the interior of the casing for at least one year without substantial melting of the permafrost face which is approximately 5 inches from the outer surface of the casing string.

The above example is repeated except that the annular zones are evacuated to a vacuum of about 10 millimeters of mercury and the air remaining in the vacuum zone removed and replaced with carbon disulfide which has a thermal conductivity at 32°F. of 1.615×10^{-5}. The casing sections, when joined into a string and emplaced in the wellbore as described above, with liquid petroleum oil at a temperature of about 160°F. pumped therethrough for at least 1 year similarly thermally insulates the permafrost face of the wellbore from melting for at least 1 year.

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. In a method for thermally insulating from the permafrost walls of a wellbore the interior of a casing string formed from a plurality of casing sections, the improvement comprising providing at least one closed air containing annular zone around and along at least part of the interior to be insulated, displacing a substantial portion of said air from said annular zone, replacing at least part of said displaced air with a gas which is substantially inert to the materials forming said annular zone, said gas in said annular zone being at a temperature no greater than about 32°F., said gas having a thermal conductivity at 32°F. of substantially less than 5.572×10^{-5} gram-calories/(second)(square centimeter)(°C./centimeter), the pressure in said annular zone being below the vapor pressure of the gas components present in said annular zone, said pressure being from about 10^{-5} to about 1,500 millimeters of mercury, and disposing said annular zone in said wellbore between the interior portion of said casing to be insulated and the walls of said wellbore.

2. A method according to claim **1** wherein said thermal conductivity of said gas is less than 5.300×10^{-5} gram-calories/(second)(square centimeter)(°C./centimeter).

3. A method according to claim **1** wherein a plurality of concentric casing strings are placed in said wellbore and at least one of said casing strings is provided with at least one of said annular zones.

4. A method according to claim **3** wherein a plurality of said casing strings is provided with a plurality of said annular zones along at least part of the length of at least one of said plurality of casing strings.

5. A method according to claim **1** wherein said gas is at least one of acetone, ammonia, argon, benzene, carbon dioxide, carbon disulfide, chlorine, chloroform, methane, ethane, propane, ethyl alcohol, ethyl ether,

methyl alcohol, methyl ether, methylethylether, ethylene, hydrogen sulfide, methyl halide, ethyl halide, ethylene halide, nitrous oxide, n-butane, isobutane, n-pentane, isopentane, and sulfur dioxide.

6. A method according to claim **5** wherein said gas is at a temperature of from about 14° to about 32°F. and a pressure of from about 10^{-5} to about 760 millimeters of mercury.

7. A method according to claim **4** wherein solid thermal insulation is provided between adjacent zones of adjacent casing sections in a casing string.

8. A method according to claim **1** wherein said at least one annular zone contains insulation.

9. A method according to claim **5** wherein said methyl halide, ethyl halide, and ethylene halide contain from one to six halogen atoms.

10. A method according to claim **9** wherein when at least two halogen atoms are present in the halide, the atoms are different types of halogens.

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