United States Patent

Blount et al.

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[54] PERMAFROST COMPLETION

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

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

[58] **Field of Search**.....166/DIG. 1, 315, 272, 302, 166/303, 57; 138/113, DIG. 9

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[57] **ABSTRACT**

This specification discloses completion methods for wells drilled through permafrost zones of the earth. Two concentric strings of casing are set in a well and liquid is withdrawn from the annulus intermediate these casing strings adjacent the permafrost zones, leaving the annulus dry. Thereafter, insulation is installed in the dry annulus adjacent the permafrost zones.

8 Claims, 2 Drawing Figures

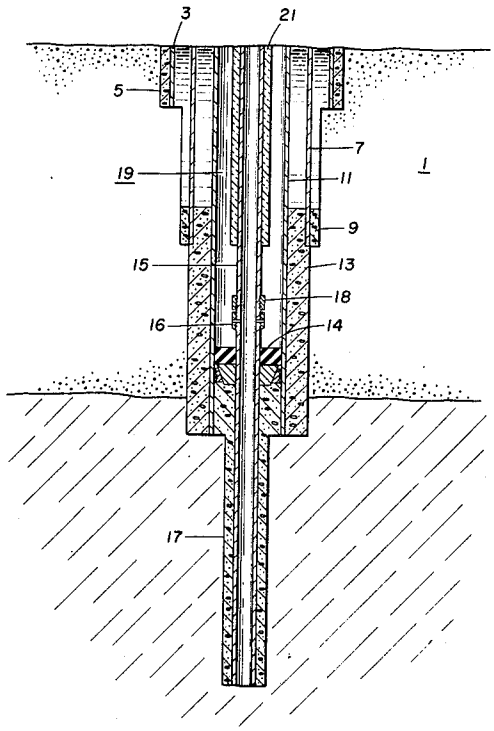


FIG. 1

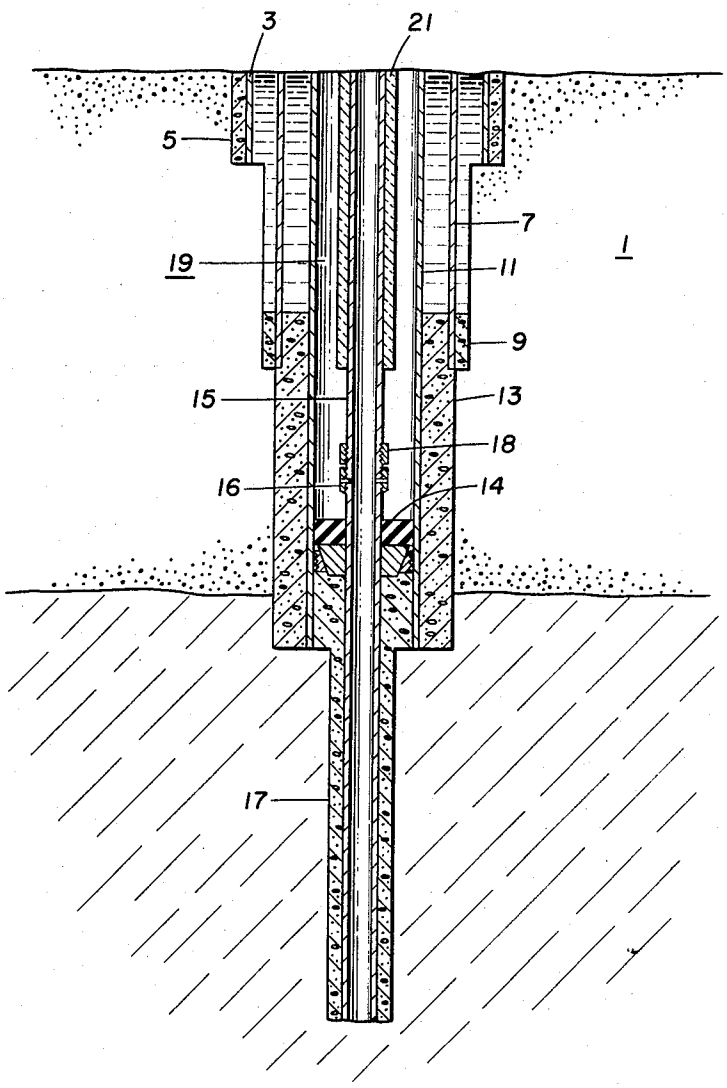
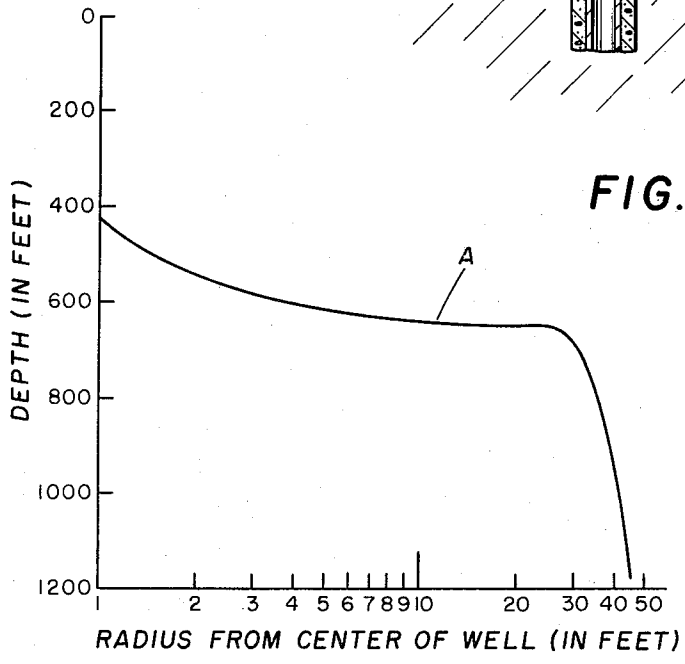


FIG. 2



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PERMAFROST COMPLETION

BACKGROUND OF THE INVENTION

This invention relates to methods and apparatus for completing wells drilled through permafrost zones of the earth. More particularly, this invention relates to methods and apparatus for completing wells whereby the permafrost is not thawed by the heat of produced fluids.

Problems have been encountered in completing wells drilled in areas where permafrost exists, namely, on the North Slope of Alaska and Northern Canada. One such problem is the tendency of the permafrost around the producing wells to melt. Melting of the permafrost would leave unsupported long strings of casing. Such melting would also cause subsidence of the permafrost zone in the vicinity of the well and subsidence of the surface, thereby damaging surface installations.

Various techniques may be used in completing wells drilled through permafrost zones. One such technique involves the use of one or more shear-pin slip joints in the upper part of the permafrost casing string. This completion technique does not avoid melting the permafrost but rather permits the slip joint in the permafrost string to telescope upon melting of the permafrost and concurring ground subsidence, thereby avoiding stresses in the permafrost string.

Another technique involves the use of a vacuum-bottle arrangement. Two short lengths of concentric pipe sections are sealed to form a closed annulus and refrigeration coils are welded to the outside of the larger pipe. A vacuum is pulled on the annulus and the apparatus lowered in the well. Refrigeration is used as needed to keep the permafrost from thawing.

Another possible technique involves the use of insulated tubing. For example, the outside of the production tubing string may be wrapped with insulation before it is run into the well.

SUMMARY OF THE INVENTION

In accordance with the present invention there are provided new and improved techniques for completing wells penetrating a permafrost zone of the earth. A surface string of casing is lowered into the well to extend from the earth's surface and penetrate the permafrost zone. A production string of casing is then lowered through the surface string into the well to extend from the earth's surface through the permafrost and to terminate below the surface string. Accumulated liquid is withdrawn from the annulus formed intermediate the surface string and production string and insulation is installed in the annulus adjacent the permafrost.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a vertical section of a well penetrating the earth and illustrating an embodiment of this invention.

FIG. 2 is a graph illustrating the location of a 32° F. isotherm after 20 years.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

This invention relates to a method of completing a well drilled through the permafrost zone of the earth. In carrying out this invention a well is drilled and cased to provide an annulus intermediate two concentric casing strings adjacent the permafrost zone. Accumulated liquids are then withdrawn from the annulus to provide a dry section of the annulus adjacent the permafrost zone and insulation then is installed in this section. By installing this insulation in the dry section of the annulus intermediate the casing strings adjacent the permafrost zone, the inner strings of the well are isolated thermally from the permafrost. Reservoir fluids can then be produced through the well without melting the permafrost.

Referring to FIG. 1, there is illustrated a particular well in which the invention may be carried out. A large diameter hole is drilled about 40 feet into the permafrost zone 1 and 30-inch conductor pipe 3 is lowered into the hole and cemented thereto by cement 5. A 24-inch hole is then drilled to about

700 feet and a 20-inch permafrost string 7 is lowered into the hole. The lower 200 feet of permafrost string 7 is cemented by cement 9. A 20½-inch underreamed hole is then drilled to about 3,000 feet and a 16-inch surface string 11 is lowered into the hole and cemented by cement 13. Thereafter, a hole is drilled to total depth and a 7-inch production string 15 is lowered thereinto and cemented by cement 17. Production string 15 is hung in surface string 11 by casing hanger 14 at about 1,500 feet. A circulating valve 16 is installed in production string 15 above hanger 14, and a backoff joint 18 is installed above circulating valve 16. After placing cement 17 intermediate production string 15 and surface string 11, circulating valve 16 is opened to provide a passage between the interior of production string 11 and annulus 19 and liquid is used to circulate out the excess cement from annulus 19 above hanger 14 leaving annulus 19 and production string 15 liquid-filled. This leaves annulus 19 and backoff joint 18 above circulating valve 16 free of cement.

In accordance with the present invention, accumulated liquid is withdrawn from annulus 19 adjacent the permafrost and intermediate production string 15 and surface string 11, leaving annulus 19 dry. This accumulated liquid may be withdrawn by swabbing the interior of production string 15 while circulating valve 16 is open, thereby removing the accumulated liquid from both the interior of production string 15 and annulus 19 adjacent permafrost zone 1. Circulating valve 16 is then closed.

In accordance with a particular embodiment of the invention, production string 15 is backed off at backoff joint 18 and removed from the well. Insulation 21 is then installed at the surface about this portion of the production string and thereafter the insulated string is lowered into the well and reconnected to the lower portion of production string 15. The insulation 21 is thereby installed in the dry annulus. It is very important that the insulation be installed in a dry annulus and that the insulation be kept dry. Liquid causes distortion of the insulation and greatly reduces its insulation value. Should the insulation ever become wet it should be removed, the liquid removed from the annulus, and new insulation reinstalled in the dry annulus. Circulation valve 16 and backoff joint 18 facilitates the replacement of the insulation. Circulation valve 16 may be opened and production string 15 swabbed as previously described. Thereafter production string 15 is backed off at backoff joint 18 and removed from the well. The wet insulation is replaced with dry insulation and the insulated production string is run back into the well and reconnected into backoff joint 18. The circulation valve 16 is then closed.

Polyurethane foam, either molded or extruded, has been found to be very satisfactory in completing wells in accordance with this invention. Molded polyurethane foam is preferred, however, for several reasons. It is more convenient to install in the wells and any optimum shape and length can be obtained. Also a high-density, relatively impermeable skin can be obtained on the molded section and the individual pieces are less subject to damage while handling and running into the hole.

In accordance with a specific embodiment of this invention, a well is drilled into the earth and through a permafrost zone of a thickness of at least 800 feet. In completing the well a 7-inch production string is run within a 16-inch surface string and a circulating valve is positioned within the production string at a location of at least 750 feet below the surface and a backoff joint is positioned within the production string at a location of at least 700 feet below the surface. Accumulated water is then removed from the production string and annulus intermediate the production string and surface string, leaving at least the upper 750 feet of each free of water. The production string is then backed off and removed from the well. Polyurethane insulation that is 2.9 inches thick and has a density of at least 2 pounds per cubic foot and preferably 3 to 4 pounds per cubic foot is installed on at least 700 feet of the production string and the production string is then run into the dry annulus and connected with the backoff joint.

It has been determined that a well completed in accordance with the above technique will keep the upper portion of the permafrost frozen for 20 years at a production rate of 25,000 barrels per day. This is illustrated graphically by FIG. 2. Curve A is a plot of a 32° F. isotherm after 20 years. The abscissa is radius from center of well (in feet) and the ordinate is depth in feet. This plot is based on a production rate of 25,000 barrels per day. Material located above curve A is frozen and material below it is thawed. From this it is seen that at least the upper 450 feet of the permafrost will remain frozen for 20 years. Thus, surface subsidence and associated problems are alleviated by this completion technique.

What is claimed is:

1. In a process of completing a well penetrating a permafrost zone of the earth, the steps comprising:

a. lowering a surface string of casing into said well, said surface string extending from the earth's surface and penetrating said permafrost zone;

b. lowering a production string of casing through said surface string into said well, said production string extending from said earth surface through said permafrost and terminating below said surface string and forming an annulus intermediate said surface string and said production string;

c. opening a passage located in said production string thereby providing fluid communication between said production string and said annulus and swabbing said production string and lowering the liquid level in said production string and said annulus thereby withdrawing accumulative liquid from said annulus; and

d. installing insulation in said annulus adjacent said permafrost.

2. The process of claim 1 wherein said insulation is polyurethane foam.

3. The process of claim 2 wherein said insulation is molded polyurethane foam.

4. The method of claim 1 wherein said insulation is installed by removing a portion of said production string from said well and installing an insulated production string in said well.

5. A well penetrating a permafrost zone of the earth comprising:

a first string of casing extending at least 750 feet from the earth's surface;

a second concentric string of casing within said first string and extending below the bottom of said permafrost zone;

a circulating valve in said second concentric string of casing located at least 750 feet below said earth's surface;

means sealing said annulus to provide at least 750 feet of dry annulus below said earth's surface; and

insulation located in said dry annulus adjacent said permafrost zone.

6. The apparatus of claim 5 wherein said insulation is polyurethane.

7. The apparatus of claim 6 wherein said insulation is molded polyurethane foam.

8. The apparatus of claim 5 further comprising a backoff joint in said second concentric string of casing located above said circulating valve and at least 700 feet below said earth's surface.

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