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[54] **WELL COMPLETION SYSTEMS**

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Related U.S. Application Data

[62] Division of Ser. No. 57,636, July 23, 1970.

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

[51] **Int. Cl.** **E21b 43/24,** E21b 43/10

[58] **Field of Search** 166/.5, 57, 67, 84–89, 166/208, 302, 315

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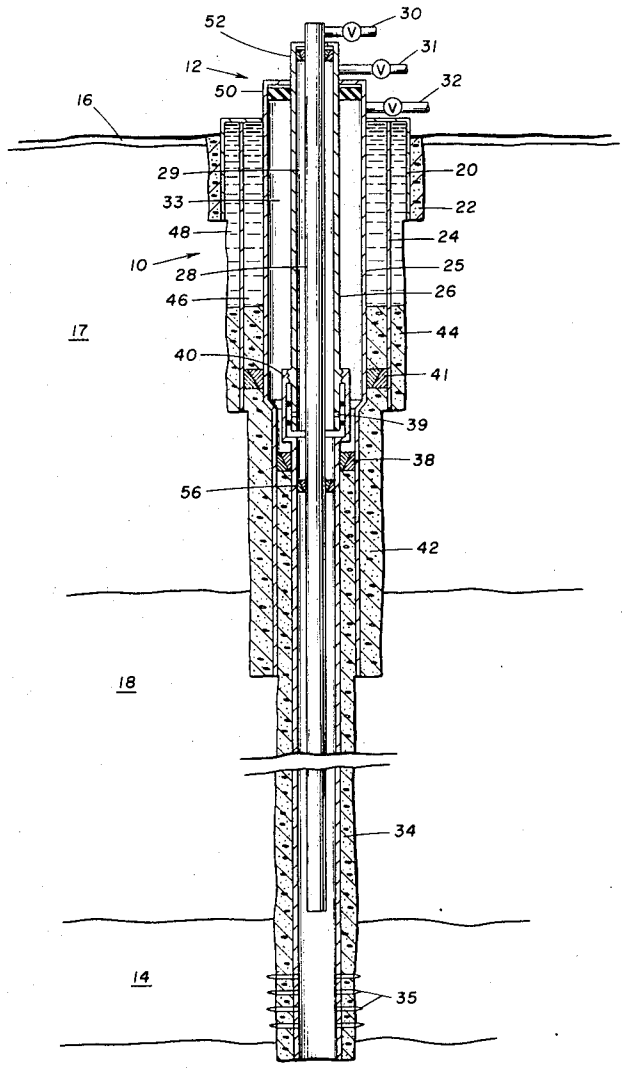
Primary Examiner—James A. Leppink

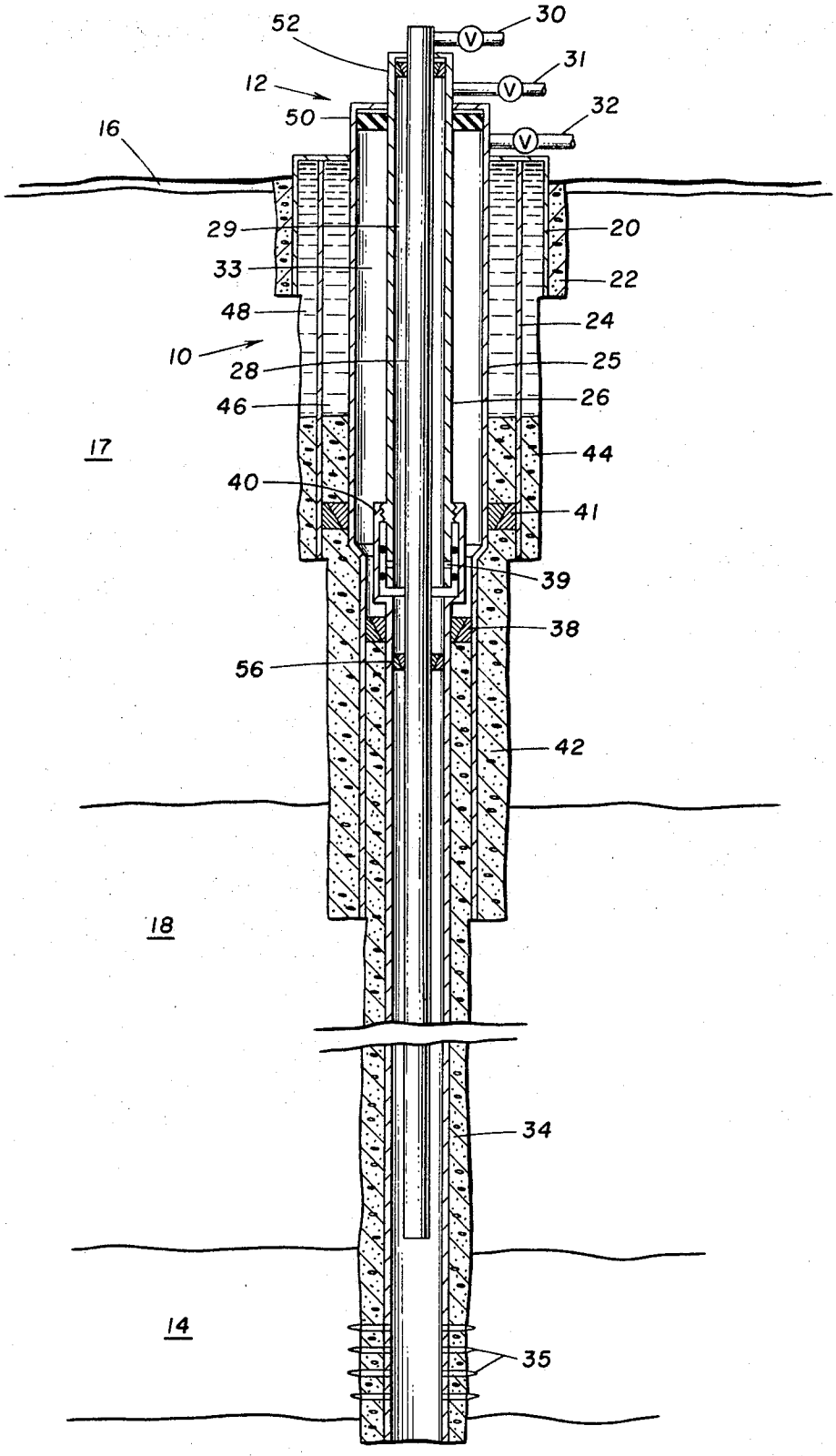
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[57] **ABSTRACT**

Well completion system for wells penetrating a permafrost zone in the earth. The system comprises a protective casing and a production casing extending to a subterranean formation. The production casing is suspended from the protective casing at a downhole location in order to reduce loading at the wellhead. Also disclosed are means for supporting other tubular goods within the well rather than at the wellhead.

4 Claims, 1 Drawing Figure




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WELL COMPLETION SYSTEMS

This application is a division of application Ser. No. 57,636, filed July 23, 1970.

BACKGROUND OF THE INVENTION

This invention relates to well completions and more particularly to completion systems for wells which extend through permafrost zones of the earth.

Permafrost is encountered in arctic oil producing regions such as those found in northern Canada and on the North Slope of Alaska. Permafrost is a frozen ground mass which underlies the surface tundra and which remains perenially at a temperature of 32° F. or less. In most areas the permafrost has a thickness within the range of about 800 to 1500 feet, although it may vary from only a few hundred feet or less to as much as 2000 feet.

The presence of permafrost poses serious difficulties in regard to the completion and production of wells in arctic regions. One particularly hazardous problem is presented by the tendency of the permafrost to melt in the vicinity of the production wells. Curde oil as it is recovered from a production well is at an elevated temperature, typically on the order of 160° F. Thus, in the absence of appropriate meliorative procedures, the operation of a production well will result in progressive melting of the permafrost with the passing of time. Such thawing is particularly serious in the upper 50 to 200 feet of the permafrost zone This portion of the permafrost contains a significant amount of so-called "free ice." As this melts, the resulting decrease in volume causes subsidence of the permafrost zone which may result in damage to casing strings and other components of the well completion system.

Various techniques may be employed to lessen the likelihood of subsidence in the permafrost zone and attendant damage to the well completion equipment. For example, insulation may be provided about appropriate tubing or casing strings in order to prevent or at least delay thawing of the permafrost. In addition, the well may be provided with refrigeration equipment in order to achieve this same result. Another technique involves the provision of one or more shear connections in casing strings within the permafrost zone. Thus, as subsidence occurs, these joints are sheared to avoid stresses in other parts of the completion system.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a new and improved well completion technique system wherein a significant portion of the casing load in the well is supported downhole so as to reduce the deleterious effects of subsidence within the permafrost zone. The well system of the present invention comprises an outer conductor casing and a protective casing within the conductor casing which extends downwardly from the wellhead into the permafrost zone. In addition, the well is provided with a production casing extending through the protective casing to a subteranean formation such as an oil reservoir. A lower section of the production casing is suspended from the protective casing by means of suitable support means located at a downhole location within the protective casing. Thus, most of the weight of the production casing is supported within the well rather than at the wellhead. Preferably, the lower section of the production casing is supported at a depth either below the permafrost zone or, if within the permafrost zone, at a depth of at least 500 feet from the wellhead. At this depth the permafrost contains little or no free ice. Thus, if the permafrost should thaw at this depth, little or no subsidence results. The production casing is provided with selectively releasable connecting means at a downhole location below the conductor casing and above the support means for allowing an upper section of the production casing to be selectively disconnected from a lower section thereof. Thus the upper section may be withdrawn in order to facilitate installation of heat barrier means in the annulus between the production and protective casings while leaving the lower section in place.

DESCRIPTION OF THE DRAWING

The drawing is an illustration partly in section showing a well completed in accordance with the present invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS

With reference to the drawing, there is illustrated a well **10** which extends from a wellhead **12** at the earth's surface to a subterranean formation **14** which is productive of oil and/or gas. As shown, the well extends through an overburden including a layer of tundra **16**, a permafrost zone **17**, and an unfrozen section **18**.

The well is equipped with an outer casing or conductor pipe **20** which extends from the wellhead **12** a relatively short distance into the permafrost zone. This casing conventionally is cemented from its total depth to the surface of the well to provide a cement sheath **22**. As the well is drilled it is provided with progressively smaller casing strings including, as shown, a surface casing **24**, a protective casing **25**, and a production casing **26** which extends from the wellhead to formation **14**. The upper portion of casing **25** is enlarged, as shown, in order to provide sufficient clearance for the installation of a heat barrier between casings **25** and **26**. For example, refrigeration coils may be implaced between these casings or insulation may be wrapped around the upper section of casing **26**. The well also is equipped with a tubing string **28** which extends within production string **26** for the flow of fluids between formation **14** and the surface. The wellhead **12** is equipped with valved flowlines **30**, **31**, and **32** for the tubing **28**, the tubing annulus **29**, and the production casing annulus **33**, respectively, in order to provide for the egress or ingress of fluids. The production casing **26** is cemented as indicated by reference character **34** and is provided with perforations **35** which define an open production interval within formation **14**.

Well **10** may be operated in any suitable mode. For example, the well may be produced through the tubing annulus **39**, with tubing **28** left available as a "kill string" in the event it becomes necessary to pump fluid down the well in order to kill the well. Alternatively, fluids from formation **14** may be produced through the tubing string in which case the tubing annulus **29** may be closed with a suitable downhole packer (not shown). The well also may be employed as a dual-zone producer in the event the well penetrates two producing formations, In this case, casing string **26** may be perforated opposite an upper producing formation (not shown) and a packer set in the tubing annulus **29** between the two formations. The lower formation then

may be produced through the tubing string and the upper formation through the annulus **29.**

It is to be recognized that the completion components thus far described are merely exemplary and that the well may be completed by other techniques consistent with the practice of the present invention. For example, rather than providing a production interval by means of perforations **35,** as shown, the casing string **26** may be set and cemented to the top of the formation **14.** Thereafter, the well may be drilled deeper into formation **14** in order to provide an "openhole" completion.

As noted previously, thawing of the permafrost zone is accompanied by subsidence which is particularly pronounced in the upper free-ice section of the permafrost zone. Such subsidence results in increased compressive stresses within the various casings employed in completing the well. For example, should the permafrost zone melt adjacent casings **20** and **24,** frictional engagement between the subsiding ground mass and these casings will exert a downward force on the casings. This force, in addition to the columnar load on the casings due to their own weight and also the weight of equipment supported thereon, will increase the compressive stress in these casing strings ultimately to the point where buckling may occur.

In accordance with the present invention, the problems associated with such subsidence are alleviated by suspending the greater portion of production casing **26** from the protective casing **25** by means of a downhole support means **38.** Thus, the load of the lower section of the production casing below support means **38** is transferred to casing **25** at the level of the support means and from there through the surrounding cement to the adjacent formation. Where the support **38** is located within the permafrost zone, as shown, it is desirable to position it below the free-ice section where little or no subsidence will occur from thawing of the permafrost. Preferably, the support will be located at a depth of at least 500 feet from the wellhead in order to ensure that it is well below the free-ice section. Alternatively, particularly where the permafrost zone is relatively thin, the support **38** may be positioned in the unfrozen section **18** of the overburden below the permafrost zone.

Above support **38,** production casing **26** is provided with a normally closed circulating valve **39** and a releasable connection **40** such as back-off joint **40.** Connection **40** will enable withdrawal of the upper portion of casing **26** without disturbing the lower section suspended from support **38.**

In addition to supporting the production casing downhole, it is preferred to likewise support a lower section of the protective casing at a downhole location. Thus, a second support **41,** which is located above support **38,** is employed to suspend a lower section of protective casing **25** from the surface casing **24.** Thus, all tension loading carried by the protective casing below the support **41** is transferred through the surface casing and surrounding cement to the adjacent ground mass.

Supports **38** and **41** may be of any suitable type and normally will take the form of "liner hangers" such as are conventionally employed in supporting liners within wells. The liner hangers may incorporate packers which when set provide a positive fluid seal between the adjacent casings to prevent fluid flow past the hanger.

Preferably, the casings **24** and **25** are only partially cemented in order to lessen the compressive stresses induced in these casings by subsiding permafrost. Thus, protective casing **25** is provided with a cement sheath **42** which extends from below to above the support **38.** Normally cement sheath **42** will extend from the total depth of casing **25** to a position above support **41,** as shown. Similarly, surface casing **24** is provided with a cement sheath **44** which extends from below support **41** and terminates above this support. The annuli **46** and **48** above the cement sheaths are loaded with a liquid in order that the permaforst will not seize a purchase if subsidence occurs. Normally a thixotropic liquid such as gelled oil or drilling mud will be used to load the annuli. Such use of a thixotropic liquid is especially beneficial with respect to annulus **48** which is open to the adjacent ground mass since it reduces fluid loss from the annulus. If drilling mud is employed, sufficient salt should be added to bring its freezing temperature to a level well below 32° F., e.g., to 15° F.

Since the oil produced through casing string **26** and/or tubing string **28** is at a high temperature, these strings will tend to undergo thermal expansion relative to protective casing **25.** This effect will be particularly pronounced where the annulus **33** is provided with heat barrier means such as insulation or refrigeration. It is preferred to compensate for this by providing the wellhead with a stuffing box **50** between the upper sections of casings **25** and **26.** Stuffing box **50** functions to seal the annulus between casings **25** and **26** while at the same time allowing for relative longitudinal movement between these casings at the wellhead. In addition, by this arrangement, the weight of the upper part of casing **26** is carried by support **38** rather than at the wellhead **12.**

The tubing string **28** and production casing **26** will undergo little or no thermal expansion relative to one another. Thus, it is preferred to suspend tubing **28** from the production casing **26** at the wellhead by means of a surface support **52.** By this arrangement, the weight of tubing **28** as well as the upper portion of casing **26** is carried at downhole support **38** to avoid these loads being transferred to the wellhead. In addition to providing a surface support for tubing **28,** it is preferred to support the tubing in casing **26** at a depth at least as great as support means **38.** Thus, a lower section of tubing **28** is suspended from casing **26** by means of a downhole support **56.** By this arrangement only the section of tubing **28** above support **56** is carried by the upper section of the production casing in compression.

What is claimed is:

1. In a well extending from a wellhead through a permafrost zone of the earth to an underlying subterranean formation, the combination comprising:

an outer conductor casing within said well extending downwardly from the wellhead,

a protective casing within said conductor casing extending downwardly from the wellhead into said permafrost zone,

a production casing within said protective casing extending from the wellhead through said permafrost zone to the subterranean formation,

support means at a downhole location within said protective casing and below the top of said permafrost zone for suspending a lower section of said production casing from said protective casing, and

selectively releasable connecting means in said production casing at a downhole location below said conductor casing and above said support means for allowing an upper section of said production casing to be selectively disconnected from a lower section of said production casing whereby said upper section may be withdrawn from said well while leaving said lower section in place.

2. The system of claim **1** wherein said support means for said lower section of production casing is located at a depth of at least 500 feet.

3. The system of claim **1** wherein said support means is located below the free ice section of said permafrost zone.

4. In a well extending from a wellhead through a permafrost zone of the earth to an underlying subterranean formation, the combination comprising:

an outer conductor casing within said well extending downwardly from the wellhead,

a protective casing within said conductor casing extending downwardly from the wellhead through said permafrost zone to a location below said permafrost zone,

a production casing within said protective casing extending from the wellhead through said permafrost zone to the subterranean formation,

support means within said protective casing for suspending a lower section of said production casing from said protective casing at a location below said permafrost zone, and

selectively releasable connecting means in said production casing at a downhole location below said conductor casing and above said support means for allowing an upper section of said production casing to be selectively disconnected from a lower section of said production casing whereby said upper section may be withdrawn from said well while leaving said lower section in place.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. **3,760,876** Dated **September 25, 1973**

Inventor(s) **ELMO M. BLOUNT, ET. AL.**

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover sheet insert -- The portion of the term of this patent subsequent to Oct. 3, 1989, has been disclaimed. -- .

Signed and sealed this 21st day of January 1975.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents