May 13, 1969 W. P. McCOMB 3,443,641

METHOD AND APPARATUS FOR RECOVERY OF LIQUIDS FROM A WELL BORE

Filed Feb. 27, 1967

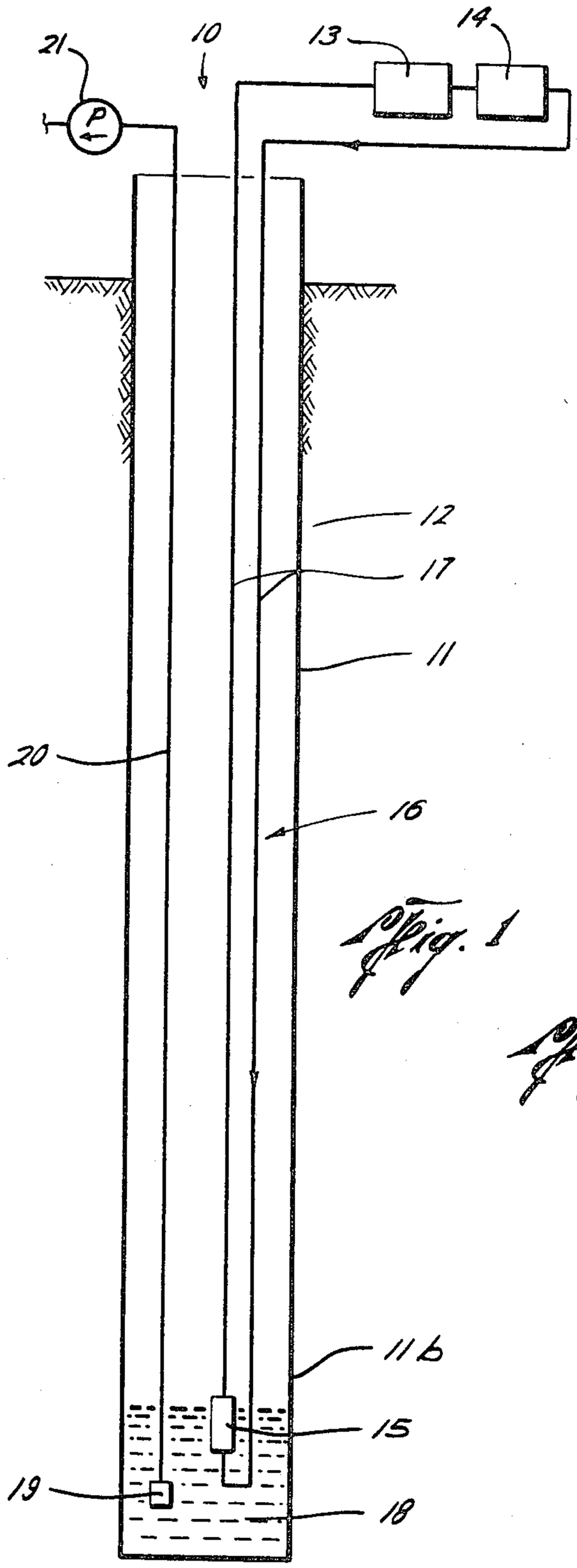


Fig. 1

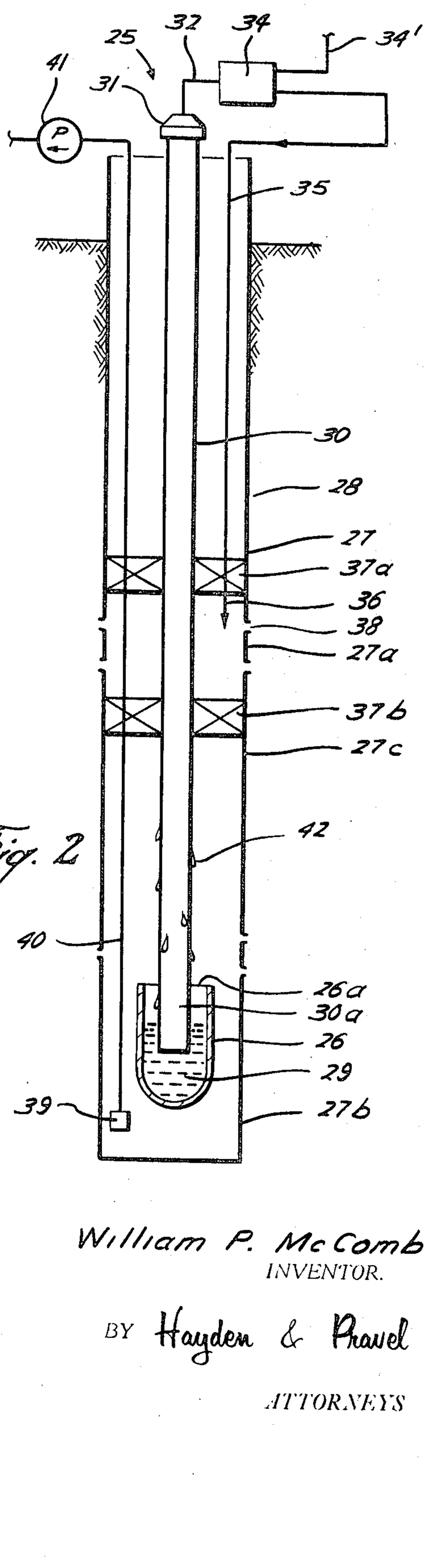


Fig. 2

William P. McComb
INVENTOR.

BY Hayden & Pravel

ATTORNEYS

United States Patent Office

3,443,641

Patented May 13, 1969



3,443,641

# METHOD AND APPARATUS FOR RECOVERY OF LIQUIDS FROM A WELL BORE

William P. McComb, late of Box 1291, Conroe, Tex. 77301; Austin B. McComb, administrator of said W. P. McComb, deceased

Filed Feb. 27, 1967, Ser. No. 618,939

Int. Cl. E21b *43/16*

U.S. Cl. 166—302

5 Claims

## ABSTRACT OF THE DISCLOSURE

A method and apparatus for recovery of liquids and vapors from a well bore including positioning a compressor means and a condensor means adjacent the well bore and positioning an evaporation means in the well bore to cool and condense a portion of the vapors in the well bore into liquids. The compressor means, condensor means, and evaporator means are connected together to form a refrigeration cycle which causes a portion of the vapors in the well bore to condense as well as causing the higher temperature vapors and liquids in the surrounding higher pressure formation to move toward the cooled well bore for removal of the liquids and vapors by suitable means.

In another related embodiment, a vessel or container filled with refrigerant is positioned in the well bore with a tubular member positioned in one end of the vessel. The tubular member is cooled by continuously removing the refrigerant from the vessel by a compressor means positioned adjacent the well bore and liquid gas is taken from the compressor and inserted back into the adjacent earthen formations. The cooled tubular member causes vapors in the well bore to condense thereon, which condensed liquid then drips downwardly into the vessel providing a continuous refrigerant for said vessel. The cooled vessel condenses vapors in the well bore into liquids which are thereafter removed by a suitable means such as a valve and pump means.

## BACKGROUND OF THE INVENTION

### *Field of the invention*

This invention relates to a new and improved method and apparatus for recovery of liquids from a well bore and more particularly to a new and improved method and apparatus including the use of a refrigeration cycle positioned in well bore to condense vapors in the well bore into liquids so that they may thereafter be removed by a suitable valve and pump means.

### *Summary of the invention*

It is an object of the present invention to provide a method for recovery liquids from a well bore comprising the steps of positioning a compressor means and condensor means adjacent the well bore, positioning an evaporator means in the well bore, connecting each of the means to each other to form a refrigeration cycle, condensing vapors in the well bore into liquids adjacent the evaporator means and removing the liquids from the well bore by a suitable valve and pump means.

Yet another object of the present invention is to provide a new and improved method for recovery of liquids from a well bore comprising the steps of positioning a compressor means adjacent the well bore, inserting or positioning refrigerant in an open end vessel or container to cool the vessel, positioning the container in the well bore, positioning a tubular member in the well bore and cooling the tubular member with the refrigerant in the container wherein the refrigerant is continuously removed upwardly



though the tubular member by a compessor positioned adjacent the well bore thereby causing liquid vapors in the well bore to condense into liquids on the tubular member and move downwardly into the container, and condensing vapors in the well bore adjacent the container into liquids so that said liquids may be removed by any suitable means from the well bore.

Yet still another object of the present invention is to provide a new and improved apparatus for recovering liquids from a well bore including a vessel or container positioned in the well bore and having a refrigerant positioned therein to cool the container; a tubular member having an upper and lower end positioned in the well bore with said lower end being positioned in the container; a compressor positioned adjacent the well bore for removing the liquid refrigerant from the vessel upwardly though the tubular member to thereby cool the tubular member to cause vapors in the well bore to become condensed into liquids on the tubular member to thereby enable the condensed liquids to move or drop downwardly into the container so that they may be continuously removed by the compressor, said compressor means being used to return the liquid gas to the formation adjacent the well bore wherein the cooled container causes vapors in the well bore to become condensed in liquid form adjacent said container and wherein the liquid gas returned to the formation from the compressor means causes liquids in the adjacent higher temperature and higher pressure formations to move toward the cooled, lower pressure well bore adjacent said container; and further including a means for removing liquids in the well bore adjacent said container.

### *Brief description of the drawings*

FIG. 1 illustrates an embodiment of the invention describing a refrigeration cycle positioned in an adjacent the well bore with means for removal of liquids from the well bore; and

FIG. 2 is an illustration of an alternative embodiment of the present invention illustrating a container or vessel positioned in a well bore having a tubular member positioned at one end in said vessel and with said other end mounted adjacent a compressor effecting a continuous refrigeration cycle to enable liquids in the well bore to be removed by any suitable means.

### *Description of the preferred embodiments*

Attention is directed to FIG. 1 wherein the present invention is generally illustrated by the numeral **10** and is illustrated as being positioned in a well bore **11** surrounded by earthen formations **12**. A compressor means and condensor means **13** and **14**, respectively, are positioned adjacent the well bore and an evaporator means **15** is positioned in the well bore to form a refrigeration cycle which moves in the direction of the arrows **16**. The evaporator means **15** cools the adjacent well bore and the vapor in the evaporator means **15** is moved upwardly through the compressor **13** and into the condensor **14** to be continuously returned to the evaporator means **15** by the conduits **17** connecting each of the compressor means, condensor means, and evaporator means to each other. It is, of course, to be understood that a suitable refrigerant is used in the conduit lines **17** for cooling the well bore adjacent the evaporator means **15**.

As the well bore **11***b* adjacent the evaporator means **15** is cooled, a portion of the vapors forced into the well bore **11***b* by the adjacent higher temperature and higher pressure earthen formation are condensed into liquids **18** because of the change in temperature. It is to be understood that the well bore **11** usually has a lower pressure in the adjacent formations because of the hole or bore itself and that the evaporator means **15** cools the well

bore so that it has a lower temperature than the adjacent higher temperature formation.

As liquids **18** are condensed in the well bore **11***b*, a valve means **19** is provided for continuously removing the liquids **18** and vapors therefrom by providing a conduit **20** communicating with a suitable pump **21** for removal of the liquids **18** and vapors from said bore to any suitable pipe line (not shown) or storage means (not shown).

In the alternative embodiment as illustrated in FIG. 2, the invention is generally designated by the numeral **25**. A vessel or container **26** is positioned in a well bore **27** which is surrounded by earthen formation **28**. An initial refrigerant **29** is placed or positioned in the vessel **26** for cooling of the vessel. A tubular member **30** is positioned in the well bore and is illustrated as having a lower end **30***a* positioned in an opening **26***a* of the vessel. The upper end of the tubular member **30** is swedged or tapered at **31** to be connected to a compressor conduit line **32**. The compressor conduit line **32** is connected at the other end to a compressor means **34** positioned adjacent the well bore **27**. As further illustrated in FIG. 2, a conduit line **35** extends from the compressor **34** downwardly into the well bore **27** and terminates at **36** between a plurality of inflatable packers **37***a* and **37***b* mounted between the tubular member **30** and well bore **27** which isolate a segment **27***a* of the well bore from the remainder of the well bore. **27**. As will be brought out hereinafter, suitable perforation holes **38** are provided for communicating the well bore hole with the surrounding earthen formations, if needed.

A valve means **39** is positioned in the well bore **27** adjacent the vessel **26** and is connected to a conduit **40** which extends upwardly through the packers **37***a* and **37***b* to suitable pumping means **41** which is well known in the art.

In the operation of the embodiment disclosed in FIG. 2, the initial liquid refrigerant **29** positioned in the vessel **26** is drawn upwardly as a vapor and partially as a liquid through the tubular member **30** and into the compressor means **34** by passing through the taper **31** and conduit line **32**. As the refrigerant **29** is moved upwardly, the tubular member **30** is cooled which causes the portion of the well bore **27***c* adjacent the tubular member to become cooled, thereby causing vapors in the well bore adjacent the segment **27***c* to become cooled to thereby enable vapors to become condensed into liquid form on the tubular member **30**. The liquid **42** moves downwardly into the vessel or container **26** to provide an additional refrigerant and is thereafter continuously removed from the vessel by the compressor means **34**.

The compressor means **34**, after converting the vapors into compressed gas, moves a portion of the liquid gas through the line **35** down to the isolated well bore segment **27***a*. The liquids then flow out into the adjacent earthen formation through the perforation holes **38**. It is to be understood that the perforation holes **38** are only necessary if the well bore segment **27***a* is surrounded by casing or other tubular members. It is also to be understood that the liquid gas not returned to the formation through conduit **35** is transported to a storage area (not shown) through conduit **34'**.

As the container or vessel **26** is continuously cooled by the refrigerant **29** and liquid **42**, vapors in the well bore segment **27***b* become condensed into liquids and are thereafter removed by the valve means and pump means **39** and **41**, respectively, by communicating such means with the conduit line **40**.

Since the well bore segment **27***b* is of a lower temperature and at a lower pressure than the surrounding earthen formation, then heat removed from the well bore segment **27***b* will be replaced by heat from the surrounding earthen formation system. As the heat supplied by liquids and vapors from the earthen formation system moves into the lower pressure and lower temperature well bore segment **27***b*, such vapors are converted or condensed into liquid form to become removed by the valve means and pump means **39** and **41**, respectively, as is well known in the art.



Further, as the liquid gas is returned to the earthen formation adjacent the segment **27***a*, this causes the earthen formation and the liquids contained therein to flow or move in the direction of the lower pressure well bore which thereby increases the volume of liquid collecting in the well bore segment **27***b*.

It is, of course, to be understood that the conduit line **35** may be inserted in other well bores upstream (not shown) in the same formation from the well bore **27** to cause similar flooding or washing as hereinabove described.

This invention relates to a new and improved method and apparatus for recovering liquids from a well bore utilizing a continuous refrigerant cycle to continuously cool the well bore to cause vapors in the well bore to become condensed into liquids for their continuous removal by a suitable means.

I claim:

**1**. A method for recovering liquids from a well bore surrounded by earthen formations comprising the steps of:

(a) positioning a compressor means adjacent the well bore;

(b) positioning an initial liquid refrigerant in an open ended vessel which cools the vessel;

(c) positioning the open ended vessel in the well bore with its open end facing upwardly;

(d) positioning a tubular member in the well bore;

(e) removing said initial liquid refrigerant from said vessel through said tubular member and into said compressor means, thereby cooling gaseous vapors in the well bore with the cooled tubular member, condensing the gaseous vapors into liquid gas on the tubular member which causes the condensed gas to move downwardly into the open ended vessel;

(f) continuously removing the liquid from the vessel through the tubular member and into the compressor means, thereby cooling the vapors in the well bore and formation adjacent the cooled vessel, and condensing the cooled vapors adjacent the vessel into liquids; and

(g) positioning means in the well bore adjacent the vessel for withdrawing the liquids from the well bore.

**2**. The method as set forth in claim **1** including the steps of returning the condensed vapors from the compressor means to the earthen formations adjacent the well bore which thereby causes higher temperature vapors and gases in the formation to move toward the well bore.

**3**. The method as set forth in claim **1** including the steps of:

(a) isolating a segment of the well bore with a plurality of inflatable packers; and

(b) returning condensed vapors from the compressor means to the earthen formations adjacent the isolated segment of the well bore which thereby causes vapors and gases in the higher temperature earthen formations to move toward the well bore.

**4**. The method as set forth in claim **1** including the step of returning condensed vapors from the compressor means to another well bore which thereby causes higher temperature liquids and vapors in the formation to move toward the cooled vessel for removal thereof by the means for withdrawing the liquids from the well bore.

**5**. An apparatus for recovering liquids from a well bore including:

(a) a container having an open top positioned in the well bore having an initial refrigerant positioned therein to cool said container;

(b) a tubular member having an upper and lower end positioned in the well bore, said lower end being positioned in the container;

(c) a compressor means positioned adjacent the well bore for removing the initial liquid refrigerant from the vessel up through the tubular member which

thereby cools the tubular member to cause a portion of the vapors in the well bore to become condensed as a liquid on the tubular member and wherein the condensed liquid moves down said tubular member and into said container to be used as a refrigerant and become continuously removed by the compressor means;

(d) means for returning said condensed liquid from said compressor means to the formation adjacent the well bore wherein said cooled container causes vapors in the well bore to become condensed in liquid form adjacent said container and wherein the liquid gas returned to the formation from the compressor means causes liquids in the adjacent higher temperature and pressure formations to move toward the cooled, lower pressure well bore adjacent said container; and



(e) means for removing liquids in the well bore adjacent said container.

**References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 1,812,267 | 6/1931 | Lewis | 166—39 X |
| 2,588,296 | 3/1952 | Russell | 166—57 |
| 2,765,850 | 10/1956 | Allen | 166—39 |
| 3,004,601 | 10/1961 | Bodine | 166—39 |


CHARLES E. O'CONNELL, *Primary Examiner.*

I. A. CALVERT, *Assistant Examiner.*

U.S. Cl. X.R.

166—57