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Erb

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[54] **METHOD AND ASSEMBLY FOR CONTROLLING BLOW-OUTS IN OIL WELLS**

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

[58] **Field of Search** 166/57, 63, 302; 175/17; 251/1; 137/604

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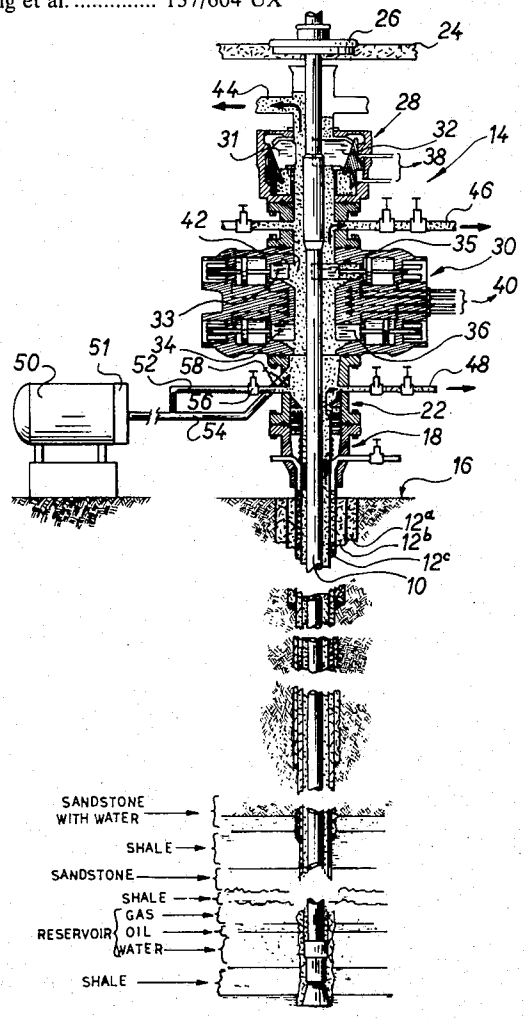
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[57] **ABSTRACT**

The disclosure herein describes a new method of sealing off wells, such as those producing oil and gas in the event of a blowout; the method consists in tapping the well-head with a branch line connected to a supply of liquid carbon dioxide or nitrogen under pressure. The introduction of CO_2 or nitrogen into a high-pressure oil rig-pipe has a double purpose; first, if introduced in sufficient quantity, it freezes the pipe and, secondly, in being mixed with the flammable and combustible fluid, it renders the fluid inert, i.e., non-flammable and non-combustible.

1 Claim, 1 Drawing Figure



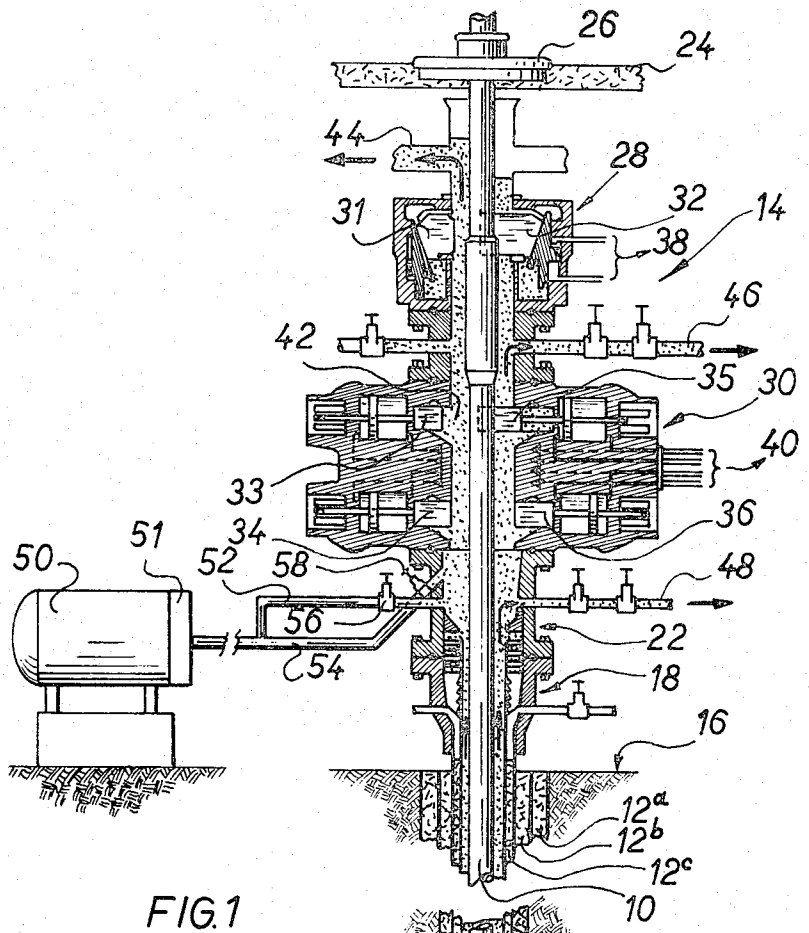
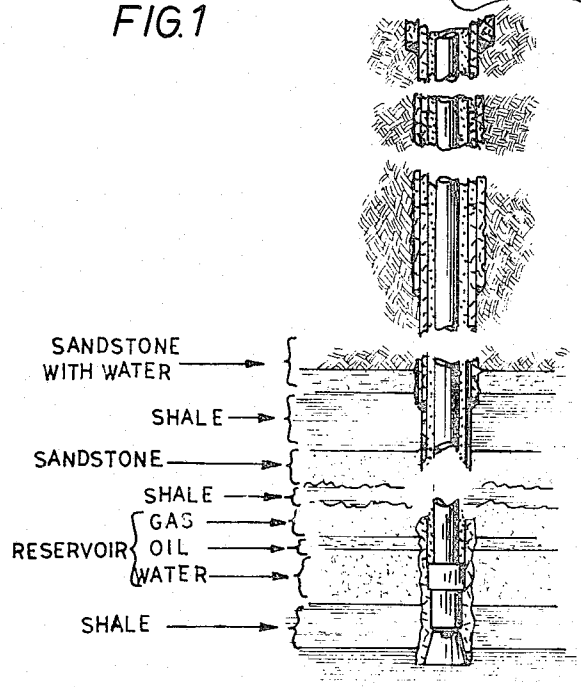

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12a
12b
12c
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FIG. 1


SANDSTONE WITH WATER
SHALE
SANDSTONE
SHALE
RESERVOIR
GAS
OIL
WATER
SHALE

METHOD AND ASSEMBLY FOR CONTROLLING BLOW-OUTS IN OIL WELLS

The present invention relates to a method of sealing off wells, such as those producing oil and/or gas, in the event of a blowout.

In the oil or gas extracting field, the drilling is carried out at surface under complete control and safety. From the moment when a reservoir is penetrated while drilling, until the end of its productive life, a well is always vulnerable and can get out of control. Great care must be taken to ensure that large or small leaks occurring at surface or down below ground or water (on offshore drilling) can be noticed immediately and blowout preventers be operated as quickly as possible.

Presently, well-heads are provided with mechanical blowout preventers of the sleeve type and/or of the double-ram type which are operated by hydraulic controls; the rams are shaped to fit the drill pipe and, when actuated, are moved across the bore of the well to make a seal around the pipe. However, due to human and mechanical failure, these preventers are not always operated in time to prevent the blowout and, unfortunately, uncontrolled eruptions of gas and oil are still occurring. The fluid pouring out of the oil well under high pressure is combustible and flammable and may be easily ignited by flame or combustion creating a fire at the head of the pipe or at a fracture along the pipe. However, oil well fires are still being extinguished by means of explosions which are set as close as possible near the center of flame to thereby create a vacuum serving to put out the fire. In addition to being hazardous, this fire extinguishing method requires a considerable amount of man-hours and it is well known that, when a fire develops on an oil rig, it costs millions of dollars in lost oil and gas production as well as equipment and fire fighting expenses, including pollution and loss of life.

Broadly, it is an object of this invention to provide a method for sealing off wells in the event of a blowout; the method consists in tapping the well-head with a branch line connected to a supply of an expandable refrigerant, such as liquid carbon dioxide or nitrogen under pressure.

The present invention provides on oil wells a chemical blowout preventer which replaces or supplements the mechanical blowout preventers already in use. The introduction of carbon dioxide or nitrogen into a high-pressure oil rig-pipe has a dual function; first, if introduced in sufficient quantity, it freezes the pipe forming a block of ice to seal the exit of erupting gas and oil and, secondly, in being mixed with the flammable and combustible fluid flowing, it renders this fluid inert, i.e., non-flammable and non-combustible.

It is also an object of this invention to provide an assembly which can be tapped to an oil rig-pipe, whether under water or under ground, and which is very effective in rapidly blocking the eruption of gas and oil and in rendering the gas and oil inert. Installing an assembly made in accordance with the present invention prior to a fire, practically, if not totally, eliminates these types of fire from becoming uncontrollable disasters.

The physical properties of CO_2 for oil rig fire application are as follows:

Density liquid = 63.39 lb/ft^3 at 0°F.
Density gas = 0.1234 lb/ft^3 at 32°F.
Melting point = −69.9°F., 75.1 psi
Latent heat of fusion = 85 BTU/lb at 69.9°F.

Carbon dioxide will create 556 cubic feet of carbon dioxide gas from one cubic foot of liquid carbon dioxide at 69.9°F., 75.1 psia. The latent heat of fusion is 85 BTU per pound at 69.9°F. Assuming an actual well fire is producing 28,000 cubic feet of natural gas and 10.4 barrels of oil per minute, an output of over 4,000 million thermal units of heat would be created causing outside temperatures to be around 250°F. The pressure of the oil in the well pipe is at a pressure of 2,000 psi or more and the temperature thereof is in the range of 180°F. or above; upon introducing carbon dioxide liquid at 0°F. in the well pipe, it can easily be calculated that it would require 55 cubic feet of liquid carbon dioxide pumped into the well which would equal the sum of 330 gallons per minute. The liquid carbon dioxide, upon entering the oil at this rate, would instantly create 30,800 cubic feet of carbon dioxide gas; allowing an additional 10% of carbon dioxide gas due to the temperature of the oil, a total of about 34,000 cubic feet of carbon dioxide gas is obtained. Thus, the ratio of natural gas and oil to carbon dioxide is approximately 1:1.

The storage of flammable liquid in industry produces a serious fire hazard. The liquid may reach a temperature above its flash point or it may be subjected to conditions under which it becomes hazardous from a fire standpoint. Although steps have been taken to minimize the effect of a possible fire or explosion, little attention has been paid to eliminate conditions which favour the formation of a flame. The hazards of flammable liquids are determined by several properties, chiefly among which are flash points, explosive or flammable limits at explosive range. The flash point of the liquid is the temperature at which gives off a vapour sufficient to form a combustible mixture with the air near the surface of the liquid or within the vessel used. By combustible mixture is meant a mixture of vapour and air within the explosive range that is capable of burning without further addition of heat. Some evaporation takes place below the flash point temperature, but the vapourization rate is not sufficient to support combustion. Such vapours will continue to burn as long as the source of ignition is not removed. With most flammable liquids, gases and solids, there is a minimum and maximum vapour-air mixture below or above which the spreading of the flame will not occur upon ignition. These vapour-air mixture limits are known as the lower and higher explosive limits and are usually expressed in terms of percentage by volume of gas or vapour in air. In other words, a mixture below the lower explosive limit is too lean to explode and a mixture above the upper explosive limit is too rich to explode. Explosive limits are always based upon normal atmospheric pressure and temperatures. There are, of course, variations in explosive limits with pressure-temperature combinations other than standard conditions. The explosive range includes all concentrations of vapour-air mixtures in which flash and flame travel will occur when ignited. It is actually the difference between a lower and higher explosive limit. Many common flammable liquids have very wide explosive range.

Carbon dioxide, when added to the vapour space, dilutes the air and takes the mixture out of the explosive range. Since only a fraction of the air is displaced by carbon dioxide, the cost of using carbon dioxide is economical and practical. Carbon dioxide compares favourably with nitrogen since in most cases two vol-

umes of nitirogen are required to obtain the same results as one volume of carbon dioxide. As an example, to make gasoline vapours non-flammable, 91.6 cubic feet of nitrogen must be added to each 100 cubic feet of air in the vapour while only 40.8 cubic feet of CO_2 are needed.

It has been established from past research and tests that the ratio of carbon dioxide necessary to extinguish a fire successfully, is in the range of 33% carbon dioxide to 1 cubic foot of gas creating the fire. Therefore, it is assumed that the safety factor of the present system has a ratio of 3 parts carbon dioxide to 1 part of fuel.

Hence, if there is 34,000 cubic feet of carbon dioxide introduced into the oil well per minute which is producing 28,000 cubic feet and 10.4 barrels of oil per minute, it can be easily seen that, with the ratio of fire extinguishing properties of carbon dioxide being 3:1 the oil well fire must extinguish itself within the first minute. It can therefore be further seen that the present system applies to any oil well fire of any scale or magnitude.

Other objects of the invention will become apparent from the following description and the accompanying drawing of an exemplary form of the invention, wherein:

FIG. 1 is a schematic illustration of an assembly used to carry out the method of the present invention and being mounted to an oil well rig.

Referring to FIG. **1**, there is shown an exploitory well where a reservoir rock containing gas, oil and water has been penetrated by a drill pipe **10** shown enclosed in a series of casings **12** and extending through a well-head **14** installed above ground level **16.** The well-head **14** includes a first casing head **18** anchored to an inner cement casing **12c** and of a casing hanger **22** bolted above the casing head **18.** Disposed below the derrick floor **24** and table **26** of the rig, mechanical blowout preventers such as those shown at **28** and **30** are commonly used; these are usually removed once the tubing run production well-head (or "Christmas tree" as referred in the trade) is installed on the completed well. The function of these blowout preventers is to prevent a flow through the well by positively closing in the well-head. Blowout preventers **28** and **30** respectively include rams **31, 32** and rams **33, 34, 35, 36** which are operated by independent controls (not shown) via suitable hydraulic conduits **38** and **40** respectively. The rams are shaped to fit the drill pipe **10** and are adapted to be moved (one of which is shown at **35** in the closed position) across the core **42** of the well to make a seal around the drill pipe. Mud is pumped from a tank (not shown) downwardly through the drill pipe and is sucked upwardly via core **42** with the rock cuttings collected at the drill bit level. Mud returns to shakers (not shown) via conduit **44**; two lines **46** and **48** are also provided to feed mud to mud pressure controls before being returned to the mud shakers.

The present invention provides an additional preventing device on exploratory wells, i.e., wells which are in the process of drilling, as well as on development wells, i.e., completed wells which are producing oil and/or gas. This is achieved by introducing in core **42** an expandable refrigerant under pressure, such as liquid carbon dioxide or nitrogen. The refrigerant is contained in a tank **50** which is located at a safe distance from the well-head and is connected thereto by means of one or more lines **52** and **54** which have their ends communicating, via valves **56** and **58,** with core **42** of the well. There are many advantages in using CO_2 in comparison with nitrogen or similar refrigerant; carbon dioxide is non-poisonous, easy to handle and to transport, available everywhere at a moderate cost and readily stored in commercial containers. Furthermore, as explained above, three volumes of nitrogen are required to obtain the same results as of one volume of carbon dioxide. Although not shown, the operation of valves **56** and **58** are manual or automatically controlled by means similar to those used for the mechanical blowout preventers **28** and **30.** Tank **50** includes a section **51** which receives a pump to pump carbon dioxide under pressure, a compressor to maintain the CO_2 in liquid form and an automatic sensory unit for the operation of the closure valve means and for the introduction of CO_2 in the well.

In operation, when the occurrence of a blowout is manifested and detected by suitable detecting means, the valve **56** (and/or valve **58**) is opened and the liquid CO_2 under pressure in tank **50** is introduced in the core **42.** Immediately, the CO_2, upon entering the core **42,** expands into the gaseous phase and freezes the rock collecting mud or the oil and gas vapour to form a block of ice thereby making a seal around the drill pipe to plug the egress of oil and gas vapour resulting from the blowout. The present method has a dual function: in addition to being a blowout preventer, introducing liquid CO_2 in the well renders the gas and oil flowing through the well inert in the event that the blowout cannot be prevented due to faulty operation of the detecting means or for any other human or mechanical failures. The pressure and velocity of oil and gas flowing up the well in the event of a blowout normally ranges between 1,000 and 2,500 psi and can obtain a height of 1,000 feet or more. In order to apply the above method to a well, it is preferable to tap the CO_2 line into core **42** at angle. The principle for tapping at angle is to utilize the pressure and velocity of the flammable liquid housed in the pipe in order to create a vacuum in the CO_2 branch line to allow a calculable amount of CO_2 to be introduced into the main line without hinderance by pressure. The branch line **54** may be disposed at an angle of 15° to 75° along the line of flow; however, most satisfactory results are obtained between 30° and 45°. Therefore, when introduced in sufficient quantity, CO_2 mixes with the flammable and combustible fuel that are the oil and gas present in the blowout and reacts with it to render it non-flammable and non-combustible thereby eliminating the danger of a blowout from bursting into flames.

A great advantage may be obtained if a blowout assembly similar to the one illustrated in FIG. **1** is installed permanently on a completed well as a safety device. It is established that a fire developing on an oil rig costs millions of dollars in lost oil and gas production and fire fighting expenses. By installing the present system prior to a fire as a safety device on oil well rigs, this may practically eliminate all oil well fires from becoming uncontrollable disasters. Furthermore, the system shown in FIG. **1** may well be buried, for example, 8 to 10 feet under ground or it may be installed below water on offshore drilling rigs at approximately 30 feet below water. The reason for burying the assembly or for installing it under water, is that, if an oil rig exploded in such a manner as to cause any damage to any valve or line on the surface, problems would be created causing

the ineffectiveness of carbon dioxide introduction into the well pipe.

It is also within the purview of this invention to introduce the expandable refrigerant down the drill pipe of an exploitory well to thereby form a plug at any location in the well. As an example, carbon dioxide may be pumped down the drill pipe at a certain rate of flow and, once stopped, it begins its freezing process thereby creating an ice plug freezing off the annulus. This may be achieved by pumping in after the CO_2 an alcohol substance which will not freeze and by subsequently pumping in mud over the alcohol substance. If this plug is placed at a given depth in the well, the chances of ground fracture due to excessive pressure on the plug are considerably reduced.

Although the invention has been described above in relation to one specific form of the invention, i.e., its application to oil wells, it can be seen that it may be applied to other uses such as normally horizontally extending pipe lines in inside or outside plants. It is therefore wished to have it understood that the present invention is not limited in interpretation except by the terms of the following claims.

The embodiments of the invention in which an exclusive property or priviledge is claimed are defined as follows:

1. A method of sealing off an exploitory well for the production of oil and gas, said well having a well-head including a core through which extends a drill pipe, comprising the steps of introducing by pumping down the drill pipe liquid carbon dioxide at a given rate of flow to a desired height in said drill pipe; pumping in said drill pipe above said carbon dioxide an alcohol substance; and pumping in said drill pipe over said alcohol substance mud to thereby prevent the egress of oil and gas resulting from the blowout and to prevent ground fracturing adjacent the well.

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