United States Patent Office 3,286,778
Patented Nov. 22, 1966

3,286,778

METHOD FOR MINIMIZING THE OCCURRENCE OF FIRES DURING WELL DRILLING OPERATIONS

John Gordon Jackson, Denver, Colo., assignor to Well Completions Inc., Denver, Colo., a corporation of Colorado

No Drawing. Filed July 13, 1962, Ser. No. 209,755
5 Claims. (Cl. 175—69)

This invention relates to a method for minimizing the occurrence of fire during the drilling of wells, and particularly, during drilling with air and other gases.

Gas drilling of oil wells, that is, drilling with the use of air or other gas as the circulating medium rather than drilling mud, is now an accepted procedure in the drilling industry. Air, being a mixture of gases is referred to herein as a gas, the latter term including a single gas or a mixture of gases. Among the many advantages of gas drilling is the fact that bit life is increased by as much as one and one-half times and drilling times are reduced by a factor of 2 to 5 under ordinary conditions. In accordance with this procedure air or other gas is circulated through the well during drilling to perform the function of drilling mud. Circulation is usually accomplished by forcing the air or other gas under pressure into the well through the drill pipe and bit and when reversing its travel to the well surface between the outside of the drill pipe and the bore hole; however, the circulation route can be reversed. A dual passage drill stem can be used, and other methods may be used to introduce the gas into the well. The main function of the circulating gas is, of course, to remove drilling and other foreign material from the well.

One of the disadvantages attendant to the use of air drilling is the fact that the hazard of fire in the well during drilling is significantly increased. The principal reason for this increase when air is used as the drilling gas is that such use results in the introduction of oxygen in amounts sufficient to support combustion when a gas flow is encountered in the well. The oxygen content of air is around 18 percent and it is established that air containing about 12 percent or more of oxygen will support combustion under atmospheric conditions.

Combustible and explosive gases present in oil wells which ordinarily cause fires or explosions when mixed with the correct proportion of oxygen and hydrocarbon gases or mixtures thereof. The most commonly occurring of these, of course, is methane. In addition, certain combustible solid materials such as lignite may constitute some of the surface of the bore hole. While the agency causing ignition of the combustible material is not definitely established, it is believed that heat generated by friction between the drill string and the surface of the bore hole, and sparks resulting from contact of the drill or other metal equipment with rocks may be sources of ignition. While the number of fires occurring in oil wells is relatively small in comparison to the number of wells drilled, the damage from a single fire may be extremely large. This is true because it may become necessary to "fish" the bit if the drill string is severed or the well may be lost, either of these occurrences resulting in a large financial loss in the way of equipment, time and labor. This emphasizes the importance of the availability of a method for the prevention of oil well fires.

Accordingly, it is a principal object of this invention to provide a method for minimizing the occurrence of fires in wells during air drilling thereof which method is safe, effective, and economically feasible.

The invention in its broadest aspects comprises maintaining by various means the oxygen content of the gaseous medium, in wells being drilled, below that necessary to support combustion under the temperature and pressure conditions existing in the well.

The temperature and pressure existing in bore holes during drilling vary and are often higher than atmospheric temperature and pressure. These higher temperatures and pressures result in a reduced amount of oxygen being required to support combustion. Accordingly, the amount of inert material introduced into the gas stream must be sufficient to reduce the oxygen content of the gaseous medium in the bore hole below that necessary to support combustion. This amount can be readily calculated as the variants necessary for the calculation are well known. In practice, conditions are adjusted such that an excess of inert material is used to insure that inert conditions are achieved in the bore hole.

The invention will be illustrated by an application in which compressed air is used as the circulating medium during drilling to replace mud. It is not limited to this application as it is equally applicable when other gases or mixtures of gases are used, particularly, if the gas mixture includes oxygen. As is well known, the rate of introduction of compressed gas into a well during drilling is measurable and controllable. It is thus a simple operation to calculate the amount of inert material necessary for introduction into a measured quantity of compressed air to reduce the oxygen content thereof below that necessary to support combustion and meter this amount into the gas stream before it enters the well. The inert material when introduced may be in solid, liquid or gaseous form, and covers a wide range of materials, one requirement being that it not have a prohibitively deleterious effect on the drilling equipment.

When a gas is used as the inert material, it is cleaned and dehydrated when necessary before introduction into the compressed air stream. The gas used preferably should have a higher density than air, should be non-explosive, non-combustible, and otherwise inert so that it does not produce a corrosive effect on the drilling equipment. In practice, sufficient quantities of inert gases are mixed for re-cycling into the well, consisting of air and inert material, and this mixture re-cycled continuously with replenishment as necessary. Re-cycling is practiced because of economic considerations. Obviously when the economic situation warrants it, a single inert gas rather than air, or a mixture of such gases, may be used where more effective fire prevention is required. The invention includes the maintenance of the gaseous medium in the well in the required state of inertness not only by introduction of an inert material itself but also by the formation of such a material in situ. An example of this is the formation of an inert gas in situ from materials introduced into the well.

A preferred gas, where the economics of the situation will permit its use, is carbon dioxide. This gas is heavier than air, is inert, can be inexpensively manufactured, and is easy to handle. The slight amount of carbonic acid which might be formed from contact of this gas with moisture in the well can be economically inhibited. Other gases which may be used are helium, argon, nitrogen, other inert gases, and mixtures thereof. Natural gas and exhaust gases have been used effectively in the process. These latter two gases contain moisture and other components which result in corrosion of equipment and they must be carefully cleaned, dehydrated and conditioned before use.

It is to be understood that the term "gas" or "gaseous medium" as used in this specification and claims means not only a single gas but mixtures of gases, and includes air. The term "inert material" as used herein means

material which is non-combustible and non-explosive and will not support combustion. The term "circulating medium" includes drilling mud, gas, gaseous medium and other materials circulated through the well during drilling to remove drillings and other foreign material from the well. When the oxygen content of a gaseous medium is "below that required to support combustion" as the expression is used herein, it is meant that the oxygen content is below the amount ordinarily accepted as necessary for supporting combustion, this amount being about 12 percent for air under atmospheric conditions. By "fire retardant" or "fire retardant material" is meant material which has the property of blanketing out fires and is commonly used for that purpose. Examples of such materials are disclosed in U. S. Patent No. 2,858,895. The term "exhaust gas" includes engine exhaust gases from internal combustion engines.

When solids are used as the inert material they are used in the form of finely divided powder in which the particle size is ordinarily not over 50 microns in diameter. A wide variety of solid materials may be used. The solid material may be introduce into the gas stream by means of conventional solids injection devices such as that disclosed in U. S. Patent No. 2,907,480. The amount of solids to be introduced is readily calculable and can be metered into the gas stream by conventional metering techniques or machines such as that referred to above. The extremely small particle size and the introduction of the particles into a high velocity gas stream results in a suspension of the finely divided particles in the air stream. Solid materials which have been successfully used are materials such as dibasic ammonium phosphate, powdered soda ash, borax and various other borates, particularly, calcium containing borates. Other materials which may be used are alkali and alkaline earth metal carbonates and other ammonium compounds, such as, ammonium chloride and ammonium sulphate.

Soda ash or a mixture of borax and soda ash, and sodium calcium borate used alone, have been used to good effect as the solid materials to minimize the occurrence of fires during well drilling operations. In these applications the solid materials having a particle size of about 50 microns were introduced into the gas stream at the rate of about 5 to about 35 pounds per hour. The volume of the air stream varied from about 1500 standard cubic feet per minute to about 5000 cubic feet per minute at pressures varying from 250 p.s.i.g. to 750 p.s.i.g. This amounts to a ratio of about .000017 to .00039 pound of inert material per standard cubic feet of air. The pressure will, of course, not affect the amount of inert material per volume of air which is added but only the rate of addition. In applications of the invention like the above solids are introduced into a fixed volume of air until the correct mixture is obtained and the mixture continuously recirculated in a closed system which includes the bore hole with replenishment of solid material as necessary. The closed system includes conventional apparatus at the surface for removal of borings and conditioning by removal of unwanted moisture and other undesirable materials.

The preferred solid material to be suspended in the gas stream is a fire retardant material such as soda ash, sodium calcium borate, ammonium phosphate and other equivalent materials, as these materials have a fire retardant effect through coating of the surfaces of the drill pipe and the bore. The coating of certain combustible substances in the bore wall, such as lignite, with fire retardant material results in additional fire protection. These finely divided materials also have a fire retardant effect on the combustible gases present when mixed with them. Other borates which may be used are calcium borate and mixtures thereof with sodium-calcium borate, and borates occurring in mineral form, such as, colemanite, elexite and mixtures thereof.

The solid material introduced is not restricted to material which itself reduces the oxygen content of the gaseous medium but includes materials which may interact with each other or under the influence of heat to form inert gases, which in turn reduce the oxygen content of the gaseous medium in the well to the desired amount. For example, carbonates, such as, sodium bicarbonate and others can be introduced which will decompose under the action of heat or interaction with dilute acid to release carbon dioxide. For example, a soluble acid salt and bicarbonate of soda or soda ash can be introduced simultaneously in which case the soluble acid salt will react with slight amounts of water present to form acid which will in turn react with the bicarbonate of soda to produce carbon dioxide. Frothing agents may also be introduced with the inert material.

Liquids, including suspensions and emulsions, may also be used in the required amounts as the inert medium. Such liquids are preferably introduced in the form of aerosols. For example, they can be introduced in the air stream by piston type injection pumps. A liquid such as carbon tetrachloride may be used, this liquid being inert and nonreactive with metal drilling equipment so that it does not produce corrosion solutions of inert materials which react under heat to release inert gas may be used. Other inert liquids and mixtures thereof may be used. The aerosol formed by introduction of the liquid into the high velocity gas stream would of course be a suspension of the liquid in the air stream.

The invention is not limited to the introduction of inert materials only in the compressed gas stream for oxygen control purposes, but includes introduction of these materials along with other materials for other purposes, such as, frothing agents, wetting agents, agents for moisture control and for other purposes.

It is seen from the above discussion that a method has been provided for minimizing the occurrence of fires in wells which is effective and highly compatible with gas drilling. The method, in which both gas and solid materials have been used as the inert materials, has been effectively used with gas drilling and has significantly reduced the incidence of down-hole fires in oil and gas wells in which it has been used.

The invention is not limited to the particular inert materials and proportions disclosed herein, as these are given for the purpose of illustration only and other equivalent materials and varying proportions may be used.

It is therefore to be understood that various modifications and changes may be made in the construction and arrangement of parts of the present invention without departing from the spirit and scope thereof as defined by the appended claims.

What is claimed is:

1. The method of minimizing the occurrence of fire during drilling of wells wherein air is used as the circulating fluid, which method comprises: Introducing into the circulating air materials which react to form a sufficient amount of an inert gas to reduce the oxygen content of the air below that which will support combustion.

2. The method of claim **1** in which said materials decompose under heat to form the inert gas.

3. The method of claim **2** in which one of said materials is sodium bicarbonate.

4. The method of claim **1** in which said materials are carbonates of sodium and a soluble acid salt which reacts with water in the bore hole to form an acid.

5. The method of minimizing the occurrence of fires during well drilling operations in which air is used as a circulating fluid which comprises; injecting into the air before it enters the well, a finely divided inert solid material selected from the group consisting of alkali metal carbonates, alkaline earth metal carbonates, dibasic ammonium phosphate, ammonium chloride, ammonium sulphate, and borates of calcium, in an amount conforming

to a ratio of about .000017 to .00039 pound of inert material per standard cubic feet of air.

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

D. H. BROWN, *Assistant Examiner.*