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METHOD OF DRILLING WELLS WITH GAS

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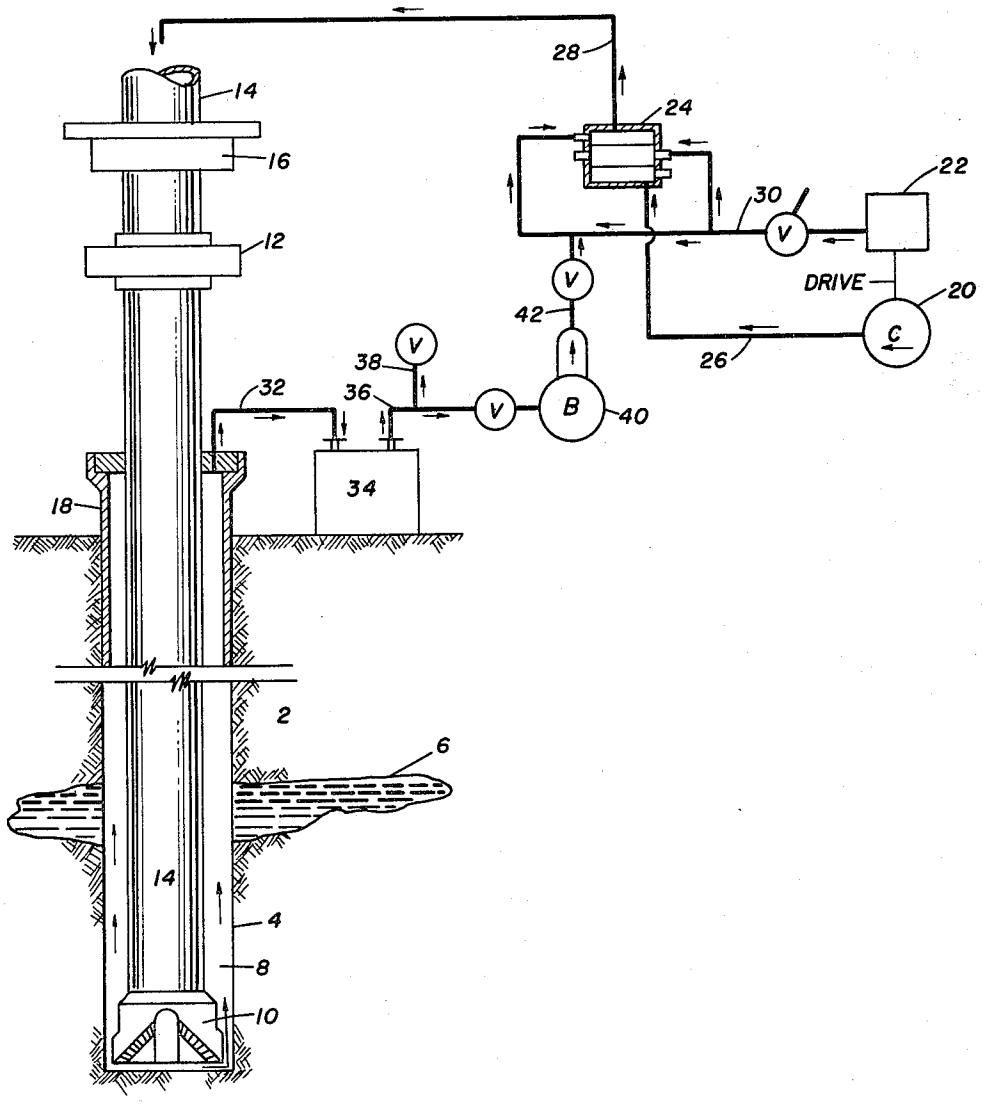

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METHOD OF DRILLING WELLS WITH GAS

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This invention relates to an improved rotary air-drilling technique. More particularly, this invention relates to a method for preventing agglomeration of powdery cuttings when drilling through strata which contain water.

In the rotary drilling of wells by means of a gasiform drilling fluid, such as compressed air or natural gas, water frequently flows into the well-bore from water-containing strata penetrated by the well, because the pressure of the gasiform drilling fluid is not sufficient to hold the water back in the pores of the formation. Even where the gas pressure is sufficient to prevent the flow of water into the well, water enters the stream of drilling fluid from within the pores of water-containing rock as the rock is ground into small pieces during the drilling operation. The presence of water within the well is deleterious because it wets the powdery cuttings and causes them to "ball" together into lumps that are too large to be carried from the well by the gas stream. These lumps tend to clog the bit and stick the drill pipe.

Conventionally, natural gas under high pressure is introduced into the hollow drill stem, passes downward to the drill bit, and then upward through the annulus around the drill stem to carry the cuttings from the well-bore. Where natural gas under high pressure is not available, air is often pressurized by means of compressers and introduced into the drill stem for the same purpose. In general, any gas available in quantity and under pressure can be used for the same purpose. However, whatever gas is employed, wetting of the powdery cuttings causes agglomeration and inadequate removal of the cuttings from the well-bore at practical fluid flow rates and pressures. The use of foaming agents to alleviate this problem has met with less than complete success.

The drawing is a schematic view illustrating a well being drilled according to one of the methods of the invention.

Now, in accordance with this invention, an improved gas-drilling method is provided which avoids the difficulties commonly encountered when using conventional gas-drilling techniques to cut through water-bearing strata. In this improved method, the gasiform drilling fluid is heated sufficiently to vaporize water entering the well from strata penetrated by the well. The drilling-fluid stream will then carry the water in the form of superheated steam from the well along with the dry cuttings. In practicing this invention, the heat content of the gasiform drilling fluid, which is dependent upon the amount and temperature of the drilling fluid, must be at least equal to the amount of heat required to warm the water from formation temperature to vaporization temperature, plus the latent head of vaporization of the water. The partial pressure of water vapor in the drilling fluid will depend upon the absolute pressure at the point of water entry, and upon the relative flow rates of drilling fluid and entering water.

The hot compressed gas used in the method of this invention may be provided in any of several different ways, depending upon the nature of the gas employed and practical field considerations. In a typical air-drilling operation where air is circulated at a rate of 500 standard cubic feet per minute, the amounts of water that can be vaporized by heating the air to various temperatures in accordance with this invention are shown as follows:

Table I

Air temperature (° F.):	Water vaporized (bbl./day)
219	5
236	10
257	20
294	50
333	100

Air circulating at rates less than 500 standard cubic feet per minute would have to be heated to higher temperatures, and air circulating at more than 500 standard cubic feet per minute could be used at lower temperatures.

Approximately the same relationships will be found to exist where natural gas is the drilling fluid. Where natural gas is available under pressure from convenient sources, it has been common practice to utilize the gas as a gasiform drilling fluid, the gas, after circulating through the well, usually being flared as it leaves the flow line. In accordance with this invention, the heat necessary to warm the inlet gas before entering the drilling string is conveniently provided by indirect heat exchange from the combustion products of the flared exit gases from the well-bore. This can most readily be accomplished by means of a conventional, tube-type heat exchanger. It is also possible to dilute the inlet gases to the well by admixture with combustion products of the exit gases to provide a hot gasiform mixed fluid which can be introduced into the drill string. It is preferred, however, to heat the inlet gas by indirect heat exchange, for the reason that the combustion products already contain large quantities of water vapor.

Where the gasiform drilling fluid is air, the air will ordinarily be warmed to a certain extent in the mechanical compression thereof, which is necessary to raise the air to a practical pressure, such as 500 p.s.i., as is conventional in air drilling. The warmed air is then further heated by indirect heat exchange with the combustion products of some suitable fuel, or with the hot exhaust of the prime mover which is used to compress the air. Ordinarily, the gasiform fluid will be heated to about 250 to 1000° F., depending upon the extent of water influx, the drilling fluid flow rate, and the anticipated convection losses.

Referring specifically to the drawing, formation 2 has drilled therethrough well 4 which penetrates water producing strata 6. Water from this strata enters annulus 8 making drilling with drill bit 10 highly inefficient. Well 4 has completed well equipment 12, drill pipe 14 and rotary equipment 16 by which drill pipe 14 is given rotational movement. Casing 18 communicates to annulus 8 and encompasses drill pipe 14. Now in accordance with one embodiment of this invention a gasiform fluid is compressed in compressor 20 driven by prime mover or diesel engine 22 having its exhaust directed through two way valved conduit 30 to either heat exchanger 24 or the atmosphere. The gasiform fluid is slightly heated due to compression and is passed into heat exchanger 24 by means of conduit 26. The heated high pressure fluid passes out of heat exchanger 24 via conduit 28 and is injected into hollow drill pipe 14 and past drill bit 10 into annulus 8 where it vaporizes accumulated water entering the well 4 from water producing strata 6. As the gasiform fluid, entrained solids and steam rise through annulus 8 they pass through casing 18 through conduit 32 into settling tank 34 where the solid materials are removed from the fluid stream, and if desired water and water vapor removed from the gasiform fluid. The gasiform fluid leaves settling tank

34 via conduit 36 and is either flared to the atmosphere through valved conduit 38 or is fed into boiler 40 where it is ignited to provide hot combustion products which are fed to heat exchanger 24 by means of valved conduit 42. It will be obvious that precautions, within one's ordinary engineering skill, will need to be taken to prevent exhaust from prime mover 22 entering boiler 40 and combustion products from valved conduit 42 entering the exhaust manifold of prime mover 22.

As a specific example of the method of this invention, in the rotary drilling of a well-bore using compressed air at a rate of 500 standard cubic feet per minute, a weeping-shale formation is encountered which produces water at the rate of 50 barrels per day. Agglomeration of the cuttings is found to occur, with resulting sticking of the drilling string. In accordance with this invention, the compressed air is heated to a temperature of 500° F. by passing the air in indirect heat exchange with the exhaust of the compressor prime mover. This heated air is then introduced to the tubing string in the conventional manner. The effluent gases from the well bore are found to be at a temperature of about 220° F. and substantially saturated with water vapor. The tendency of the drill string to stick is found to be alleviated. About 70 percent of the temperature drop in the well is due to heat transfer to the formation, and about 30 percent is used to vaporize the water.

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

1. In the rotary drilling of a well-bore through a water-bearing subterranean formation, while employing gas as a drilling fluid, the improvement comprising heating the gas to a temperature in the range of 250 to 1000° F. before passing it down the drilling string, the amount and temperature of said gas being sufficient to vaporize any water entering the well-bore from the strata penetrated by it.

2. The method in accordance with claim 1 including the step of compressing the gasiform fluid in a mechanical compressor, and in which the fluid is heated by passing the fluid in indirect heat exchange with the hot exhaust of a prime mover employed to drive said compressor.

3. The method in accordance with claim 1 in which said gasiform fluid is natural gas, including the step of burning a portion of the spent gas after it leaves the well-bore to form hot combustion products, said gas before entering the drilling string being heated by indirect heat exchange with said combustion products.

4. In the rotary drilling of a well-bore through a water-bearing formation, while employing natural gas as a drilling fluid, the improvement comprising heating the natural gas, prior to passing it down the drilling string, the amount and temperature of said gas being sufficient to vaporize any water said natural gas contacts within said well-bore, whereby influx water in said well-bore is vaporized and removed in vapor form.

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