

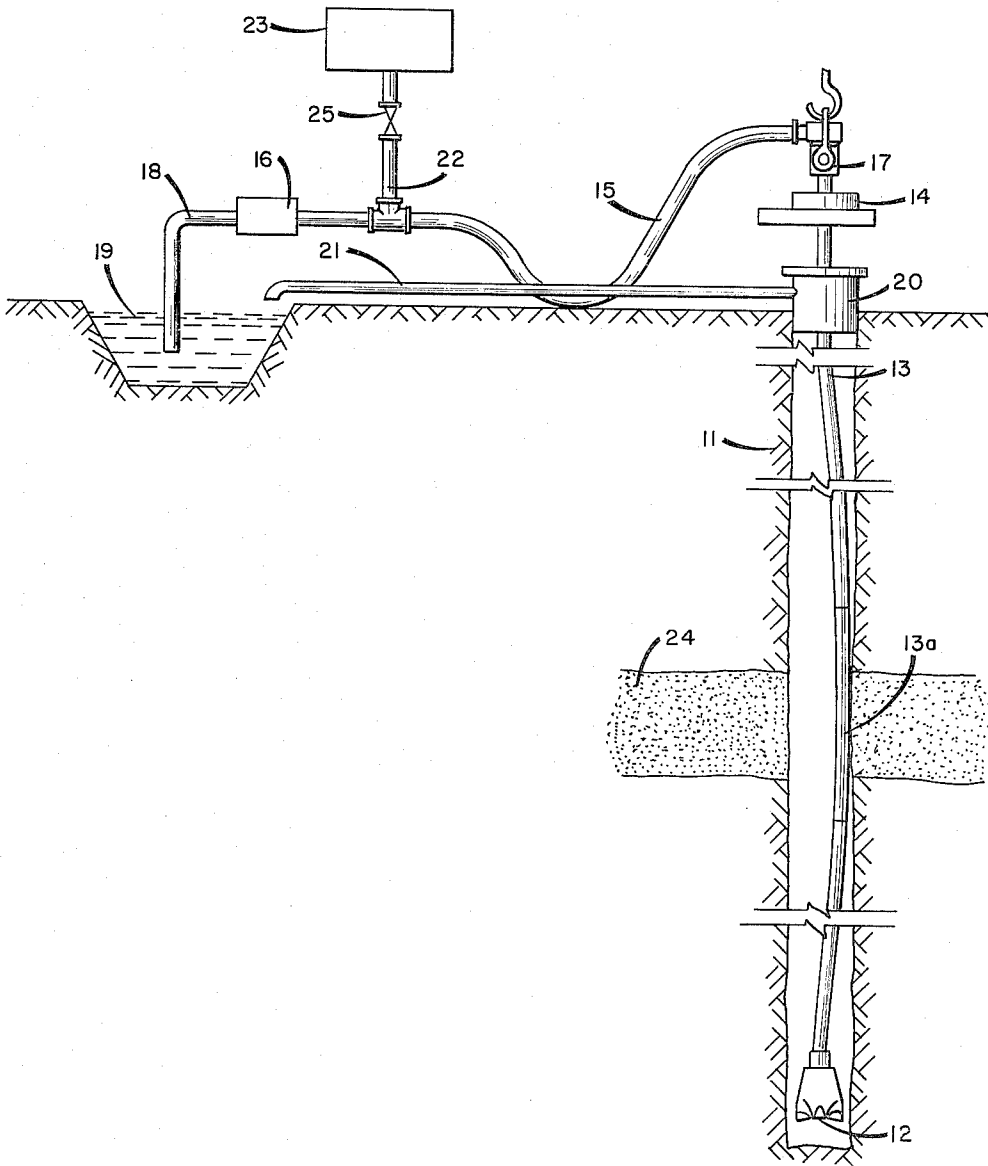
April 19, 1966

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3,246,696

METHOD OF FREEING PIPE STUCK IN A WELL

Filed Oct. 25, 1963



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1

3,246,696

**METHOD OF FREEING PIPE STUCK IN A WELL**  
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Filed Oct. 25, 1963, Ser. No. 318,915

5 Claims. (Cl. 166—46)

This invention relates to a method of freeing a pipe string stuck in a well, and particularly it relates to an improved method for freeing a drill string stuck against the wall of a well by the differential pressure between the drilling mud and the formation.

In rotary drilling operations using a drilling fluid containing finely divided solids, or drilling mud, the drill pipe frequently becomes stuck and cannot be rotated or removed from the bore hole. In a well where the pressure of the mud column is substantially higher than the formation pressure, a pressure differential occurs. Normally, this pressure differential is carried by the mud filter cake on the wall of the well. If the formation behind the mud filter cake is permeable and the pressure differential is abnormally high, an object, such as a pipe string, may contact and isolate a portion of the filter cake so that the pressure differential is transferred to the pipe string which is held against the wall of the bore hole with a force great enough to cause the pipe string to become stuck in the well. Generally, such differential sticking of the pipe tends to occur where there is a permeable formation into which a flow of filtrate passes from the filter cake so that filtrate is lost and a heavy mud cake is formed and builds up around the section of drill pipe which contacts the wall of the well. Such differential sticking most often occurs when the pipe is allowed to remain stationary in the well, even for short periods of time, such as when drilling is stopped for connection, repairs, etc. Generally, the longer the drill string is motionless, the more force is required to free it because of the increased filter cake-pipe friction and contact area resulting from the loss of filtrate from the isolated portion of the filter cake and the resultant shrinkage. The degree to which differential sticking occurs depends upon a number of factors, such as mud weight, the permeability of the formation, the area of contact of the pipe with the mud cake, fluid loss, properties of the mud, the time that the pipe remains in contact with the thickened filter cake, etc.

Heretofore, a large number of different techniques have been proposed for freeing pipe stuck in a well by differential pressure. Typically, it has been proposed to spot oil or water in the well to wet the pipe, to apply a coating to the pipe, to add surface-active agents to the oil to improve the speed of wetting, to wash over with oil or water, to jar the pipe loose by impact or to displace the drilling mud in the annulus. Methods proposed for preventing differential sticking have included the use of special drill collars to reduce the contact area, varying the type drilling mud, the use of additives in the drilling mud and varying the differential pressure by employing low density drilling muds. Much work has been done and much has been written concerning differential sticking. For example see the paper by E. L. Haden and G. R. Welch, "Techniques for Preventing Differential Pressure Sticking of Drill Pipe," presented at Southern District API, Shreveport, Louisiana, March 10, 1961; and by P. H. Monahan and M. R. Annis, "Differential Pressure Sticking—The Effect

2

of Oils and Special Additives on Sticking Coefficients," presented at Southern District API, New Orleans, Louisiana, March 7, 1963. However, such techniques require the use of special apparatus in the well, require the addition of expensive materials to the drilling mud or require expensive and time-consuming operations conducted at the well and oftentimes produce uncertain results. Differential pressure sticking of drill pipe remains a serious operational problem.

The general object of this invention is an improved method of freeing differentially stuck pipe in a well, which method is rapid, reliable and inexpensive and which causes a minimum disruption of scheduled events in the drilling program. Briefly, differentially stuck pipe in a well is freed by circulating a gasified drilling fluid in the well when differential sticking occurs.

In accordance with the present invention, there is provided an improved method of freeing a pipe string stuck in a well by differential pressure wherein a bore hole is formed in the earth and a pipe string placed in the bore hole, followed by circulating a drilling fluid containing finely divided solids in the well to contact a low-pressure permeable formation causing a filter cake to be deposited on the wall of the well and contact the pipe string to cause it to become stuck therein. A gasified circulating fluid is introduced into the well to reduce the pressure differential from the bore hole to the permeable formation to a value at which the pipe may then be readily freed.

Aerated or gasified drilling fluids, such as clear water, oil or muds have been used in the drilling art for various purposes. Where large volumes of drilling mud are lost into highly porous and permeable formations which accept both the fluid and the suspended finely divided solids, such fluid loss is referred to as lost circulation. Aeration of drilling muds has been proposed as a method of preventing lost circulation in a well. In such instances, a filter cake does not build up on the wall of the well, since the solids move into the formation, rather than plastering the surface.

The present invention will be better understood by reference to the following description of the invention and to the accompanying drawing which illustrates typical apparatus employed in the practice of the present invention.

Referring to the drawing, a well bore hole 11 is drilled into the earth by means of a drill bit 12 secured to the lower end of a string of drill pipe 13 which is rotated in the bore hole from the surface by means of a conventional rotary table 14, typically mounted on a platform (not shown) on a derrick (not shown) for handling the drilling equipment. A hose 15 connects mud pump 16 to the top of the hollow drill string by means of a swivel joint 17 through which a drilling mud, such as a suspension of clay in water having a suitable density and viscosity, is passed downwardly through the drill string and the drill bit into the well bore. The suction line 18 from the pump 16 is immersed in a mud pit 19 and a mud discharge line 21 connects the wellhead 20 with the mud pit. Connected into the discharge line 15 of the pump 16 is line 22 from a pressured source of gas, such as air compressor 23, providing a sufficient quantity of air at a pressure suitable to gasify the drilling mud in the well as herein-after described.

In the practice of the invention a gas such as air, natural gas, carbon dioxide, nitrogen, or other suitable gas is in-

jected into the drilling fluid in the well under pressure to reduce the hydrostatic pressure in the well bore and thereby reduce the differential pressure from the well bore to the low-pressure, permeable formation causing differential sticking of the pipe in the hole. The gas may be supplied by one or more compressors or pressure tanks or field gas of suitable pressure may be used. Preferably air is used, and is supplied by a suitable air compressor.

Typically, during normal drilling operations, the drilling mud is pumped from the mud pit by pump 16 through mud line 15 and swivel 17 down the hollow drill stem where it is discharged through the bit 12 positioned near the bottom of the bore hole 11. The drilling mud returns upwardly through the annulus between the drill string and the wall of the bore hole 11 and is discharged at the surface through conduit 21 back into the mud pit. During the course of drilling into the earth, permeable, relatively low-pressure formations such as a fresh water sand 24 may be encountered. When the drill pipe is permitted to remain stationary for a short period of time, such as required for making up a connection or making repairs, a thick drilling-mud filter cake may be formed on the wall of the well bore in contact with drill collar 13a where the drill string passes through such a formation. The differential pressure between the pressure of the drilling mud and that of the formation forces the pipe against the built-up filter cake and the friction therebetween causes the pipe to become stuck in the hole so that it cannot be removed or rotated.

Advantageously, when the above differential sticking occurs, air from compressor 23 is passed by way of valve 25 and air line 22 into the drilling mud to aerate the drilling mud. The aerated drilling mud is passed down the drill string and upwardly into the annulus between the drill string and the wall of the well to reduce the pressure of the drilling fluid in the well. The air may be injected into the drilling mud in slugs or continuously over a longer period of time. For shallow to medium depth wells, air at about 350-500 p.s.i. may be employed while for deeper wells, e.g., about 10,000 feet or more, an air pressure of about 1500 p.s.i. or greater may be employed. Generally, it is advantageous to inject the air into the mud at the well surface, such as by operating mud pump 16 and continuously injecting air into the pump discharge line so that aerated mud is passed down the hole to displace the mud in the annulus.

The ratio of gas-to-mud may be varied over a wide range, depending upon the extent to which it is necessary to lower the mud pressure in the well to reduce the differential pressure to a value at which the pipe is readily freed. A relatively small amount of air, as low as about 5 percent by volume of the aerated mass may be sufficient; and comparatively, large amounts of air as great as about 80 to 90 percent by volume of the aerated mass may be employed. Typically, when the drill pipe becomes stuck, the mud pump 16 is slowed down and the drilling mud is cut with air supplied from compressor 23 at an increasing rate until the differential pressure is reduced by an amount sufficient to enable the stuck pipe to be freed. During the freeing operation the pipe string may be placed in tension, compression or torque, and/or worked in a normal manner. Upon breaking the pipe loose, the drilling of the well may then be resumed.

Of course, the present method may be employed to free casing, tubing or wash pipe stuck in a well as a result of differential pressure while drilling a well, while repairing casing in a well, or while salvaging casing in an abandoned well. For such uses a circulating fluid, such as drilling mud or other suitable fluids may be circulated in the well, with the gaseous fluid utilized to reduce the differential pressure as described herein. In some instances it may be advantageous to employ reverse circulation, i.e., injecting the gasified fluid into the annular space between the stuck pipe and the well bore, rather than using conventional circulation as described above.

The following example illustrates the effectiveness of the present invention. During the drilling of a well having a total depth of 5,696 feet, the drill pipe became differentially stuck at approximately 1,150 feet when drilling was halted for a bit change. The total length of the drill string was 1,963 feet, with 813 feet being 6¼-inch drill collars and 1,150 feet being 4½-inch drill pipe. It was indicated that the pipe was stuck at the top of the drill collars, opposite a porous sand. Native mud, having a density of 10.6 pounds per gallon was being used as a drilling fluid. The drill pipe was worked in an attempt to free it, and both oil and acid were spotted for approximately one and one-half days, without success in freeing the pipe. Subsequently, a 400 c.f.m., 350 p.s.i.g. air compressor was connected into the mud line standpipe and the air compressor and mud pump started, with discharge rates of 100 c.f.m. and 3.5 b.p.m., respectively. Circulation was established and the flow rates of the air and mud were increased until the returns had become quite frothy, indicating the mud column was approaching minimum weight. Within two hours the drill pipe was fished free without any further complications and the drilling of the well was resumed.

From the foregoing description, it is readily seen that the present invention provides an economical and efficient method of freeing pipe differentially stuck in a well which provides definite advantages over the methods heretofore proposed by the prior art.

I claim:

1. In a well operation wherein a pipe string is placed in a borehole formed in the earth traversing a permeable formation and a circulating fluid containing suspended finely divided solids is circulated in said borehole until a filter cake has been deposited on the wall of said borehole to contact said pipe string and cause said pipe string to become differentially stuck thereagainst, the improved method of freeing said stuck pipe string which comprises: injecting a gaseous fluid into a circulating liquid, circulating the resulting gasified liquid in said borehole to effectively reduce the differential pressure between the fluid therein and said permeable formation, working said pipe string in said borehole while circulating said gasified liquid to effectively free said stuck pipe string, and maintaining the interior of said drill pipe string in unobstructed fluid communication with the annulus between said pipe string and the borehole wall while circulating gasified liquid and working said pipe string.

2. In the well drilling art wherein a drill string having a drill bit positioned at its lower end is rotated to form a borehole in the earth and a drilling fluid containing finely divided solids is circulated under pressure in the resulting well, through the drill string and the annulus between said drill string and the wall of said well, to contact a permeable formation traversed thereby and having a pressure lower than said drilling fluid pressure, the pressure differential between said drilling fluid and said formation causing a filter cake to form on the wall of said well in contact with said drill string to cause said drill string to become differentially stuck in said well, the improved method of freeing said stuck drill string comprising: injecting a gaseous fluid into said drilling fluid and circulating the resulting gasified drilling fluid in said well to effectively reduce said differential pressure, working said drill string in said well while circulating said gasified drilling fluid to effectively free said stuck drill string, and maintaining the interior of said drill string in unobstructed fluid communication with said annulus while circulating the gasified drilling fluid and while working said drill string.

3. The method of claim 2 wherein said drilling fluid comprises a suspension of clay in water.

4. A method of claim 2 wherein said gaseous fluid is air.

5. The method of claim 2 wherein said gaseous fluid is admixed with said drilling fluid at the earth's surface and

5

the resulting gasified drilling fluid is circulated down said drill string and up the annular space between said drill string and the wall of said well.

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6

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