United States Patent [19]

Hall

[11] **3,756,317**

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[54] **METHOD FOR CRYOGENICALLY FREEING DRILLING PIPE**

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[52] **U.S. Cl.** **166/254,** 166/301, 166/57, 166/302

[51] **Int. Cl.** **E21b 31/02**

[58] **Field of Search** 166/57, 301, 302, 166/250, 254

[56] **References Cited**

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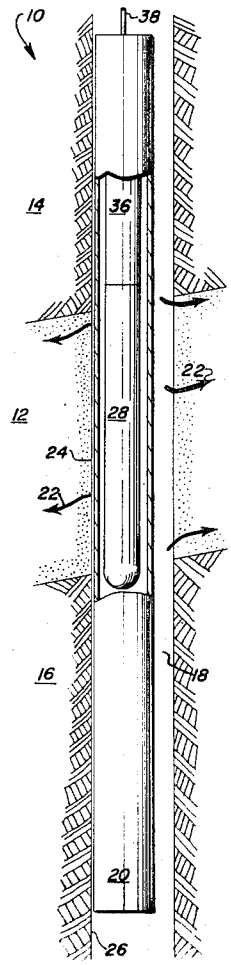
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Primary Examiner—Stephen J. Novosad
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[57] **ABSTRACT**

A method of freeing drilling pipe in a well bore which has become stuck or seized through a differential pressure condition within the bore wherein a torque is maintained on the drill pipe, the zone of differential pressure determined within rough limits, a cryogenic tool or carrier is positioned so as to correspond generally to the zone, the tool then being actuated and forming a thin, temporary ice or frozen sheath between the bore hole and drill pipe thus losing a substantial portion of the bore hole permeability and consequent differential pressure, the torque and/or heat applied to the drill pipe breaking the "sheath" and continuing rotation of the pipe.

6 Claims, 3 Drawing Figures



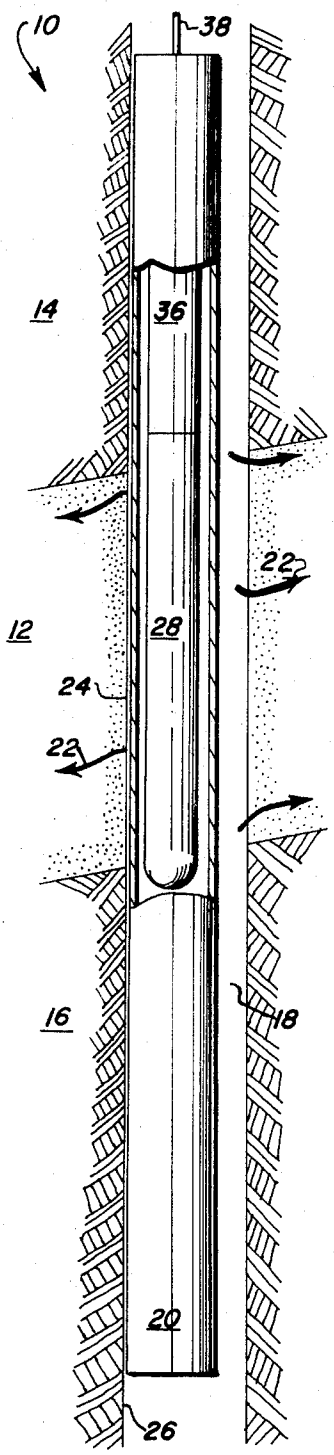


Fig. 1

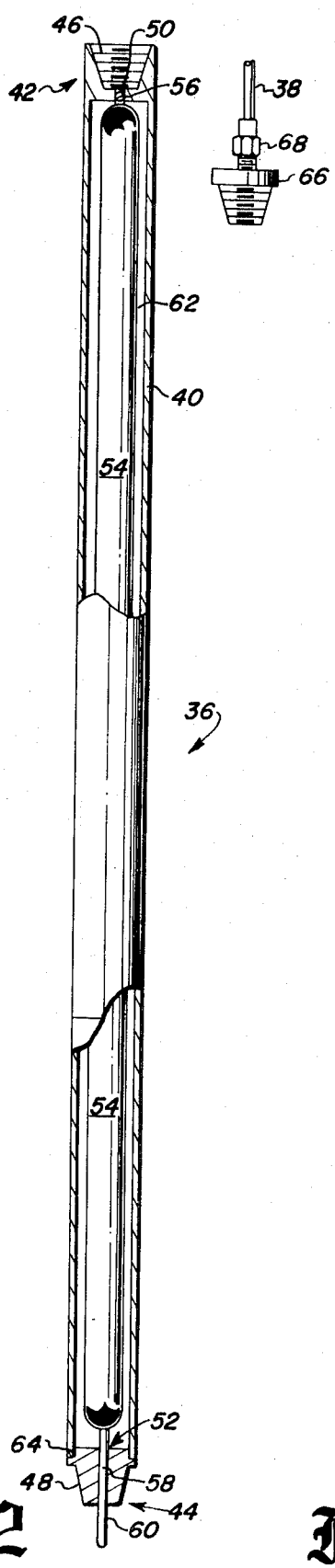


Fig. 2

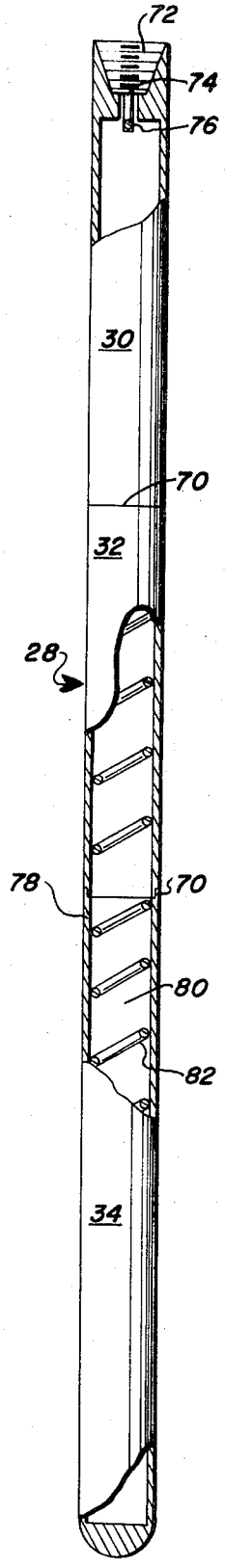


Fig. 3

METHOD FOR CRYOGENICALLY FREEING DRILLING PIPE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to methods and apparatus for freeing stuck pipe in well bores, and more particularly to freeing drilling pipe within a well bore which has been rendered inoperative through a pressure differential between the well bore and the associated drilling equipment and media therein and a porous subterranean formation through which it passes or is being passed.

Such differential pressure is a relatively common occurrence in bore holes, and is particularly troublesome in deep wells which must of necessity pass through varying strata. The condition is perhaps best described in U.S. Pat No. 2,956,626 issued Oct. 18, 1960 to Elmer D. Hall, and will not be detailed any more specifically herein.

2. Description of the Prior Art

With the exception of the above identified patented method, the prior art has for years relied almost exclusively on two methods. The first was to "wash over" that portion of the casing which was stuck in order to free it; the second a "jarring" method employing generally mechanical special purpose devices generally called "jars" attached below the drill collar and above a "spear" or equivalent fishing device, the jars being provided with, for example, a clutch arrangement designed to release or trigger at a pre-set force resultant from the drill pipe.

Both of these methods have in general the same disadvantages, the first requiring extensive time periods in that the "stuck" portion was located, the drill pipe cut or backed off (if possible) above the upper limit, retrieved, a second casing of larger diameter than the drill pipe lowered to the break-off point and then maneuvered over the stuck pipe, the casing then being rotated while circulation is maintained to wash-over the stuck portion and free it from the bore hole wall, the casing is then withdrawin and a cutter tool attached to it, then it is again maneuvered over the new freed but uncoupled drill pipe, this procedure being repeated until the drill string is recovered. A basic disadvantage of this method beside the tremendous time and effort involved is of course that the secondary casing may well become stuck through the same differential pressure causing the initial stoppage and if the drill pipe "sticks" coming up or going down, the portion below the uncoupling point is almost invariably lost or damaged beyond repair. The use of jars, although having many advantages over the above method, is still quite time-consuming, and still normally requires removal of the drill pipe section, locating disjointed section, cutting, threading or other mechanical interlock, etc.

The above noted patent method, although an improvement over the prior methods has disadvantages inherent in its use, the most notable being the physical force required to force the tool down the casing and the scoring or abrasion resultant therefrom.

It is, of course, known that refrigeration or freezing may be employed to aid in drilling or "working" relatively unstable formations. For example, U.S. Pat. No. 2,193,219 to C. P. Bowie et al. wherein a well bore is continuously frozen in order to prevent heaving and sloughing; McNamer U.S. Pat. No. 3,301,326 employs

continuous freezing processes to selectively increase permeability and porosity; Huff U.S. Pat. No. 3,424,254 which freezes bore holes to prevent sloughing and seepage; and Maguire U.S. Pat. No. 3,612,192 also establishing a frozen boundary within the formation to prevent sloughing.

However, none of these prior art patents attempts or can overcome the problem to which the present invention is directed.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a method of economically and quickly freeing drill pipe from any portion of a well bore wherein the drill pipe has become stuck due to pressure differential between the drilling fluid in the bore hole and a zone of lower hydrostatic pressure to which the pipe has become adhered;

It is another object of the invention to provide an economical, easily utilized tool for temporarily cryogenically neutralizing differential pressure at a low pressure zone subject to differential pressure;

A further object of the invention is a method for nullifying the suction tending to hold a drill pipe against a portion of the wall of a bore hole occasioned by the differential pressure resultant from a zone of relatively low porosity;

The above, and further objects and advantages of the invention are accomplished through the lowering of a freeze tool having means for containing a cryogen through a drill casing, the tool having means for the selective release of the contained cryogen, positioning the tool in substantial conformity with the low pressure zone to which the pipe or casing is adhered, releasing the cryogen to thereby temporarily freeze or change the wall characteristics of the bore hole substantially at the surface thereof and adjacent the contact surface between it and the casing, torquing or otherwise applying a movement force to the drill pipe to break it away from the surface to which it is adhered, removing the freeze tool and continuing with the drilling operation.

The above, and other objects and advantages of the invention will become apparent to those skilled in the art when taken in conjunction with the description of a preferred embodiment of the invention, and the following drawings wherein:

FIG. 1 is a sectional elevational view of the device of the present invention employed to free a drill pipe within a bore hole from a porous, low pressure portion of the bore hole surface to which it has become adhered through differential pressure;

FIG. 2 is an elevational view, partially in section, of the device of the present invention; and

FIG. 3 is an elevational view partially in section, of the freeze tool of the present invention broken into its constituent parts.

DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

Referring now to the drawings, FIG. 1 is a partial cross-sectional view through an earth formation 10 having a permeable horizon 12 therein, the porous, low pressure strata 12 adjacent relatively impermeable strata 14, 16, bore hole 18 penetrating the formation at least through the impermeable portion 14 and extended into or through permeable, low pressure zone 12, casing or drill pipe 20 being run through bore hole

18 into the low pressure zone 12. A drilling fluid, not shown, is circulated within bore hole 18 during the drilling process, and since permeable zone 12 has a lower hydrostatic pressure than the drilling fluid as indicated by arrows 22 showing "flow," the drill pipe will be attracted to and become lodged against that portion 24 of the bore hole wall 26 passing through zone 12.

Since the force or adhesive effect of such a condition may well be of an order of several hundred thousand pounds, the impossibility of continued drilling operation is manifest since casing 20 can not be moved in any direction. Prior attempts to overcome the condition once the casing has become stuck have relied primarily on brute force or on secondary or supplementary drilling procedures as previously indicated.

According to the present invention, a "freeze tool" 28 of a diameter to be received within drill pipe 20 and which may comprise multiple sections 30, 32, 34 (only one of which is shown in FIG. 1) is positioned within casing 20 and attached to a cryogenic tanker 36 (which may also comprise multiple sections only one of which is shown in FIG. 1) and lowered by any conventional means such as cable 38 to the stuck portion of the drill pipe corresponding to bore hole wall portion 24 in low pressure zone 12 (which zone may be located by conventional means). The freeze tool 28 is comprised preferably of the necessary number of sections to overlap impermeable zones 14, 16 above and below zone 12 and may obviously be varied in length. Freeze tool 28, as subsequently explained, is then caused to assume cryogenic temperatures by the release of a cryogenic liquid thereinto from tanker 36, which causes the fluid on or very near the surface 24 of bore hole 26 to freeze, forming an ice sheath of quite narrow thickness and limited duration at the interface between drill pipe 20 and wall portion 24, rendering wall portion 24 impervious or substantially impermeable. A normal drilling torsion, or other means, which may be continuously applied, then operates readily to break any drill pipe-to-ice bond in the absence of the differential pressure, thus freeing the drill pipe. Freeze tool 28 and the associated tanker sections 36 are then recovered and normal operations resumed. The operation is accomplished without the necessity of raising, lowering, cutting, modifying or otherwise altering the casing already run down the bore hole, drilling operations may continue immediately, and the tremendous advantages inherent therein will be immediately appreciated.

Referring now to FIG. 2 which is an elevational sectional view of a tanker section 36, it will be apparent that the tanker sections comprise a tubular pipe-like member consisting of an outer pressure hull or wall 40 closed at the top and bottom 42, 44 respectively. Tanker sections 36 may be provided with coupling means, here shown as female threads 46 and mating male threads 48 respectively for attachment of one section to another, the ends also being provided with probe receiving orifices 50, 52 respectfully. Section 36 carries within it a cryogenic liquid gas container or flask 54 which flask is provided with communication means to adjacent tanker sections, in the preferred embodiment herein illustrated shown as a probe receiving valve fitting 56 positioned within upper probe orifice 50, and a transfer tube 58 extending through orifice 52 and provided with probe 60 operative to actuate valve 56. An insulating space 62 is provided between flask 54 and tanker wall 40 which is herein shown as a void, although it is obvious insulative materials may be employed therein if desired. In most instances, an insulation void is sufficient to prevent a high boil rate of the cryogen from the heat normally encountered in the drilling fluids employed, particularly since the operation is of relatively short duration. Tanker sections 36 may also be provided obviously with coupling means 64 to facilitate loading of flasks 54. As will also be apparent, transfer tube 58, probe 60 and valve 56 may be integral with tanker section 36 rather than flask members 54 if desired.

Cap member 66 having a securing means 68 attachable to cable 38 may be employed for positioning the device, although it will be obvious that any conventional means may readily be adapted.

FIG. 3 shows a freeze tool 28, the tool illustrated as comprising an upper section 30, one intermediate section 32 and a closure section 34, the sections coupled at 70. Freeze tool 28 has a mating fitting 72 on its upper section 30, fitting 72 in this instance being provided with probe receiving opening 74 in which is received a command transfer valve 76 such as shown for example, in pages 24, 25, 27, and 89 of Automatic Switch Company Catalog No. 28, 50–56 Hanover Road, Florham Park, New Jersey. Freeze tool 28 comprises cylindrical wall 78 and a void or expansion chamber 80.

In operation, the depth and extent of the low pressure formation 12 are determined, a freeze tool 28 is made up comprising an adequate number of sections 30, 32, 34 to substantially coincide with the length of formation zone 12, the tool 28 then being positioned within the drill pipe, a sufficient number of the tanker or carrier elements 36 are attached thereto as determined will be required based on the length of tool 28 and the temperature of the formation, the tanker and tool are lowered to the portion of the casing seized, torque is applied to casing 20 and the cryogenic liquid gas released through the command transfer valve 76 so that it dumps or flows to tool 28 by gravity or through its normal expansion pressure. On expansion of the cryogen into the cylinder or void 80 of tool 38, sufficient heat is drawn from drill pipe 20, drilling fluid and the portion 24 of bore hole wall 26 to form a thin "sheath" of frozen material at the interface of the drill pipe and bore portion 24 (extending into the zone 12 a small distance of course) to render the wall impermeable for a short time along the area of contact of drill pipe and wall 24. Since there is a torque on the pipe, the moment the low pressure zone loses all — or at least a substantial amount — of its differential pressure due to the loss of permeability, the drill will begin to rotate and be free of the wall. The carriers and freezing tool are then recovered by being pulled up and disconnected, while the drill pipe will quickly lose any ice or low temperature to the surrounding drilling fluid. An artificial "melting" means here shown as interiorly positioned heating coils 82 may of course be employed to assure that any ice sheath formed is melted first at the casing-formation interface rapidly, thus obviating any difficulty which might be engendered in breaking the bond between the casing and frozen wall while still maintaining the impermeable nature of the formation wall. Where such heater coils are employed, obviously energizing means, leads and connectors (not shown) may be employed as necessary.

Liquid nitrogen has been determined to be an excellent cryogen in the above method due to its availability

and other economic factors, but obviously any liquid gas may be employed. Non-return valves will effectively prevent expansion of the gas during the positioning operation from exceeding pressure limits by relieving excessive pressure.

It is noted that where the terms "ice," "frozen" and "ice sheath" are employed, they are intended to encompass any transitional phase of the affected material which substantially reduces the permeability of low pressure formation **12** at the contact portion thereof with drill pipe **20** of a sufficient degree to reduce the pressure differential momentarily to permit the pipe to break loose. Obviously, because of the composition of a particular drilling fluid, the material formed may not be technically "ice," nor may the drilling fluid along the contact area actually have to "freeze" since many fluids may increase in viscosity as to effectively seal the contacted portion of the low pressure formation without actually achieving a transformation to the solid state.

Having thus described my invention, I Claim:

1. A method for freeing drill pipe seized in a bore hole at a low pressure formation zone by the differential pressure between that zone and the media within the bore hole, comprising:

A. determining the location and extent of the low pressure zone;

B. withdrawing sufficient heat from the surface of the low pressure zone in contact with the drill pipe to momentarily reduce the permeability of said surface and thus the differential pressure throughout a substantial portion of its length; and

C. applying a force to the drill pipe to break it free of the surface during the period of reduced differential pressure.

2. The method defined by claim **1** wherein said step for withdrawing heat comprises:

A. lowering a selectively actuatable heat transfer means slideably within the drill pipe;

B. positioning the heat transfer means so that at least a portion thereof substantially coincides with the determined location and extent of the low pressure zone;

C. selectively cryogenically cooling temporarily that portion of the heat transfer means which coincides with the low pressure zone to thereby alter the viscosity of any fluid in the contact area of the pipe-low pressure zone a sufficient amount to materially reduce the differential pressure thereof thereby permitting the applied drill pipe force to overcome the remaining differential pressure.

3. The method defined by claim **2** wherein said selective temporary cooling is continued until the fluid in and adjacent the contact area of the pipe-low pressure zone freezes.

4. The method defined by claim **1** wherein said step for withdrawing heat comprises:

A. positioning a heat transfer means slideably within the drill pipe;

B. lowering the heat transfer means through the drill pipe at its ambient temperature;

C. positioning a first portion of the heat transfer means so that it substantially coincides with the drill pipe-low pressure zone interface;

D. selectively actuating the heat transfer means so that the first portion thereof causes a rapid cooling at and adjacent the drill pipe-low pressure zone interface;

E. terminating the cooling when the drill pipe breaks free of its adhesion to the bore hole wall; and

F. retrieving the heat transfer means.

5. The method defined by claim **4** wherein said rapid cooling is continued until the interface of the pipe-low pressure zone forms an ice sheath.

6. A method for freeing casing seized in a bore hole by the differential pressure resultant from the casing contacting a permeably low pressure formation within the bore hole comprising:

A. determining the location and extent of the low pressure formation;

B. assembling a freeze tool of sufficient length to substantially coincide with the extent of the permeable low pressure formation;

C. attaching thereto a liquified gas carrier and insulating means of sufficient volume to cause the freeze tool on application to change the character of the surface of the low pressure formation where contacted by the casing to a relatively impermeable condition;

D. lowering the freeze tool and carrier as a unit within the casing;

E. locating and positioning the assembled freeze tool within that portion of the casing substantially corresponding to the low pressure formation;

F. transferring liquified gas from the carrier and insulating means to the freeze tool;

G. rapidly expanding the transferred liquified gas within the freeze tool to cause the tool to withdraw heat from the drill pipe, the intermediate area and material, and low pressure formation immediately adjacent at least the casing surface seized;

H. applying a torque to the casing during said heat withdrawal step;

I. continuing said heat withdrawal until a frozen or substantially impervious sheath is formed momentarily on the casing contacted low pressure formation bore hole wall substantially reducing the differential pressure and releasing the torqued casing; and

J. retrieving the carrier and freeze tool units.

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