Sept. 22, 1970 W. L. HILL 3,529,684

HORIZONTAL NOTCHING TOOL

Filed May 10, 1968

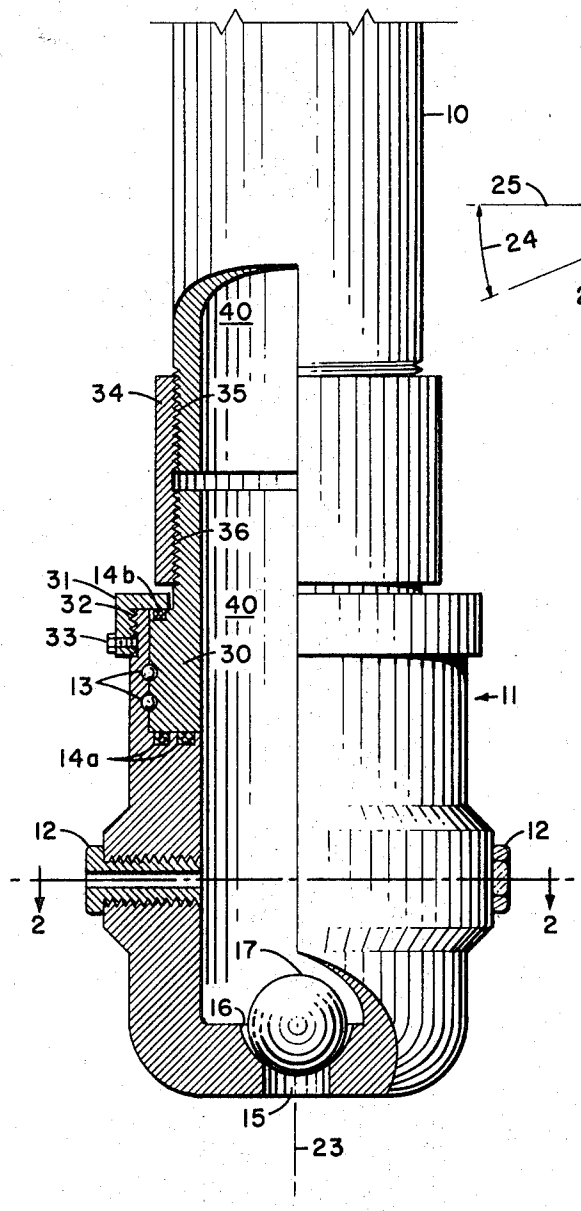


FIG. 1

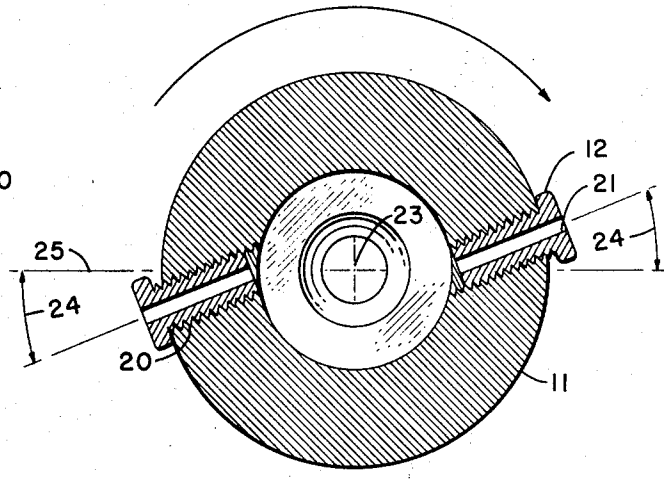


FIG. 2

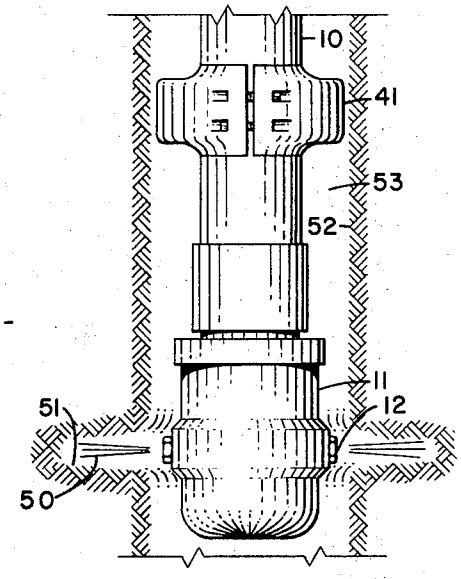


FIG. 3

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HORIZONTAL NOTCHING TOOL

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U.S. Cl. 175—422 1 Claim

ABSTRACT OF THE DISCLOSURE

A perforating apparatus rotatably attached to the terminus of a well string and comprising a plurality of jets mounted at an angle so that when the perforating fluid is forced down the well string and out the jets, the perforating apparatus will rotate, cutting a disc-shaped perforation normal to the axis of the well bore.

BACKGROUND OF THE INVENTION

In the design and initiation of hydraulic fracture treatments in subterranean formations, it is often necessary to create a horizontally oriented fracture. Rock stresses, tectonic forces, formation depth and lithological factors in a particular formation affect, to a large extent, the direction that a fracture may take. Therefore, normal perforating techniques, due to the aforementioned factors, may or may not aid in forming a horizontal fracture.

The only known method which will insure a horizontal fracture is to form a 360° horizontal notch in the formation. Various methods are presently being used to perforate the formation in a horizontal plane to form such a notch. The patent to R. W. Brown, et al., No. 3,130,786, discloses a plurality of jets oriented in a horizontal plane. Each jet will, however, erode a single hole into the formation, rather than a 360° notch, so that when the fracturing fluids are applied, it is doubtful that a symmetrical horizontal fracture will result. Other patents, such as the patents to T. E. Quick, No. 3,081,828 and No. 2,720,381, disclose a means for forming a 360° perforation by rotating a jet manually wherein the jet is coupled to the drill pipe and the entire drill pipe is rotated to effect the 360° horizontal perforation. The latter patents, however, would not be satisfactory unless the bore hole is perpendicular, or at least substantially perpendicular. Any offset whatsoever would cause the drill pipe to bind when manually rotated. Further, if the drill string is excessively long, manual rotation would be nearly impossible.

SUMMARY OF THE INVENTION

This invention comprises a rotating head journaled on the end of a string of drill pipe. The rotating head has a plurality of jets, mounted at an angle with the radius of the rotating head, so that when perforation fluid is forced down the drill pipe and out the jets, a rotational force is imparted to the head, causing the head to rotate. The abrasive fluid is forced out of the jets at high velocity, forming a 360° notch in the formation.

This invention has several advantages over the devices of the prior art in that the bore hole can have a dog leg and still permit the head to rotate, since the drill string itself does not need to be moved once the head is properly positioned adjacent the formation to be perforated. The perforation tool also includes a ball valve which will permit easy entry and withdrawal of the drill string and will likewise permit cleaning of the head and drill string after the perforation operation is complete.

It is therefore an object of this invention to form a 360° horizontal perforation without necessitating the rotational movement of the drill string holding the perforation tool.

It is a further object of this invention to incorporate means for removing and inserting the drill string having the perforation tool attached thereto, without the problem of flotation, or loading, caused by fluid within the pipe.

Other objects and advantages of the invention will be evident from the following detailed description, when read in conjunction with the accompanying drawings which illustrate the invention.

BRIEF DESCRIPTION OF THE FIGURES

Referring to the figures in detail:

FIG. 1 is a partial sectional side view of the perforating tool;

FIG. 2 is a top sectional view taken through line 2—2 of FIG. 1; and

FIG. 3 is a cross sectional portion of a bore hole showing perforation tool in operation.

Referring to all of the figures, but in particular to FIGS. 1 and 2, a drill string **10** has attached thereto a perforating head generally referred to as **11**. Perforating head **11** essentially consists of a plurality of jets **12**, bearings **13**, a plurality of seals **14**–A and **14**–B, and a ball valve **15**. Ball valve **15** consists of a seat **16** and a ball **17** which should have a density greater than the material being pumped down the well bore. Jets **12** are removably attached to head **11** by means of threads **20** (see FIG. 2). The opening **21** of jets **12** is likewise in a plane perpendicular to the axis **23** of head **11** and at an angle **24** with the radius **25** of head **11**. In the preferred embodiment of this invention, angle **24** is 22°. It is obvious, however, that the angle can vary, depending upon the characteristics desired. A more detailed explanation will be given at a later point in the specification.

Head **11** is attached to mounting portion **30** by means of a collar **31** which can be secured to head **11** by a plurality of threads **32**. A seat screw **33** anchors the collar **31** in place and prevents accidental rotation during operation of the device. Mounting portion **30** is attached through to drill string **10** by collar **34**, using threads **35** to attach collar **34** to the drill string and threads **36** to attach collar **34** to mounting portion **30**. Both drill string **10** and mounting portion **30** have an opening **40** used for the passage of perforating fluid. Attached to drill string **10** is a centralizer **41** (see FIG. 3), which is here shown to be the type used to alleviate wear on a drill string; however, other forms of centralizers can be used so long as sufficient clearance is permitted around the centralizer **41** to provide fluid passage either through or around it.

The perforator is operated by lowering the drill string head **11** secured through collar **34** to drill string **10**, into the well bore. Normally, ball **17** in ball valve **15** is removed from the drill string during the lowering process. Ball valve **15** will then be free to permit the entry of fluids into the interior **40** of drill string **10**. Since the fluids are free to enter the drill string, the air which would normally be trapped therein will be permitted to escape, thereby eliminating flotation problems. Once the jets **12** are positioned adjacent the stratum to be perforated, ball **17** is dropped into opening **40**. Since the ball **17** is slightly more dense than the fluid in the well bore, the ball will drop through the fluid to seat **16** of valve **15**. The ball can be put into the opening **40** by any well known means (not shown), such as, for example, a pair of valves communicating with opening **40**. In this procedure, the ball is inserted between the first and second valves, with the second valve closed (the second valve being adjacent opening **40**). The top of first valve is then closed and the second valve opened, permitting the ball to fall through the valve opening and into the drill string opening **40**. The above is a standard technique for inserting objects into a drill string and is so well known that it

is not shown in the drawing. Perforation of the strata adjacent the head **11** is accomplished by forcing an abrasive slurry down well string **10** through opening **40** into head **11** and out the openings of jets **12**. Since jets **12** are at an angle **24** with the radius **25**, a torque will be applied to head **11**, causing rotation in the direction of the arrow shown in FIG. 2. Head **11** is journaled on mounting portion **30** through a plurality of bearings **13**; therefore, head **11** is free to rotate about mounting portion **30**, causing jet **21** to subscribe a 360° arc. The perforating fluid **50** (see FIG. 3) will be forced out of the jet nozzles and against the strata opposite the jets, causing eroding away of the strata, forming a disc-shaped perforation **51**. Stabilizer **41** may be used when necessary to maintain a clearance between the jets **21** and the wall **52** of the well bore. If head **11** were laying too heavily upon well bore **52**, rotation of head **11** might be prevented by excessive friction. On substantially perpendicular holes, stabilizer **41** will probably not be needed since the jets would soon erode away any material that would cause the jets **12** to "hang up." When the perforation is complete, fluid is reversed in the well bore, that is, it is pumped down the annulus **53** of the well bore and up valve **15**, causing ball **17** to leave seat **16** and travel up the opening **40** in drill pipe **10**. The ball can be removed from valve **15** using a procedure reverse to that used for inserting the ball and may be flushed into a fluid tank. Once the ball is removed, the drill string can be removed with ease since the fluids inside the drill string will flow freely out of the opening **15**, preventing excessive weight, due to the liquid column form building up during removal of the drill string **10**. Reverse flow has a second advantage in that it will tend to clean the perforation fluid from the head **11** and drill string **10**, since clear liquid will be pumped up the drill string thereby preventing sand and other sediments from settling out of the perforation fluid.

The preferred embodiment shown in the drawings has only two jet nozzles **12**. It is obvious that a single jet nozzle or more than two jet nozzles can be incorporated and stay fully within the teachings of this invention. An angle of 22° was likewise stated as being preferred; however, the angle should be sufficient to cause adequate rotation of head **11** under the pressure and flow conditions during perforation. Therefore, if the pressure within the opening **40** is increased, additional torque will be created by jet **12** and the angle **24** can be reduced conversely if the pressure on opening **40** is reduced. A reducing torque will be developed by jet **12** on head **11**; therefore, the angle **24** will need to be increased. The main criterion of angle **24** is that it develops sufficient torque to prevent rotational stoppage of head **11** during the perforation process. Likewise, while the ball valve **15** is highly desirable, for ease of operation, it is fully understood that the perforation tool could be manufactured without the ball valve, particularly where the depth of perforation is fairly shallow. Further, one form of bearings has been shown. It is obvious that other methods of journaling head **11** in mounting portion **30** can be used. Likewise, a simplified version of seals **14A** and **14B** is shown. More complex or modified seals can be used in order to prevent the high pressure abrasive fluid from damaging bearings **13**. These modifications are well within the ability of those skilled in the art and are likewise fully within the scope of this specification and claims.

Changes may be made in the combination and arrangement of elements as heretofore set forth in this specification and shown in the drawings; it being understood that changes may be made in the embodiments disclosed without departing from the spirit and scope of the invention as defined in the following claim:

What is claimed is:

1. A perforating apparatus for a well bore comprising a tubular drill string, a mounting portion on one end of said drill string, a cup-shaped rotating head means having a longitudinal axis, collar means rotatably mounted over said mounting portion and secured to the open end of said cup-shaped rotating head means, tubular jet means having an axial opening therethrough, means for mounting said tubular jet means through the wall of cup-shaped rotating head means such that the axis of the opening through said jet means lies on a plane perpendicular to the axis of said cup-shaped rotational head means and at an angle to a radius of said cup-shaped rotational means, such that a fluid forced through the opening in said jet means will cause a force to be developed around the axis of said cup-shaped means, causing said cup-shaped head means to rotate about said longitudinal axis, a ball valve means located in the bottom of said cup-shaped rotational head means, and a centralizing means attached about said drill string in close proximity to said cup-shaped rotational head means.

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