

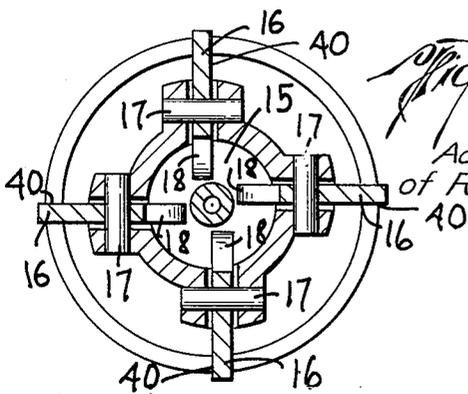
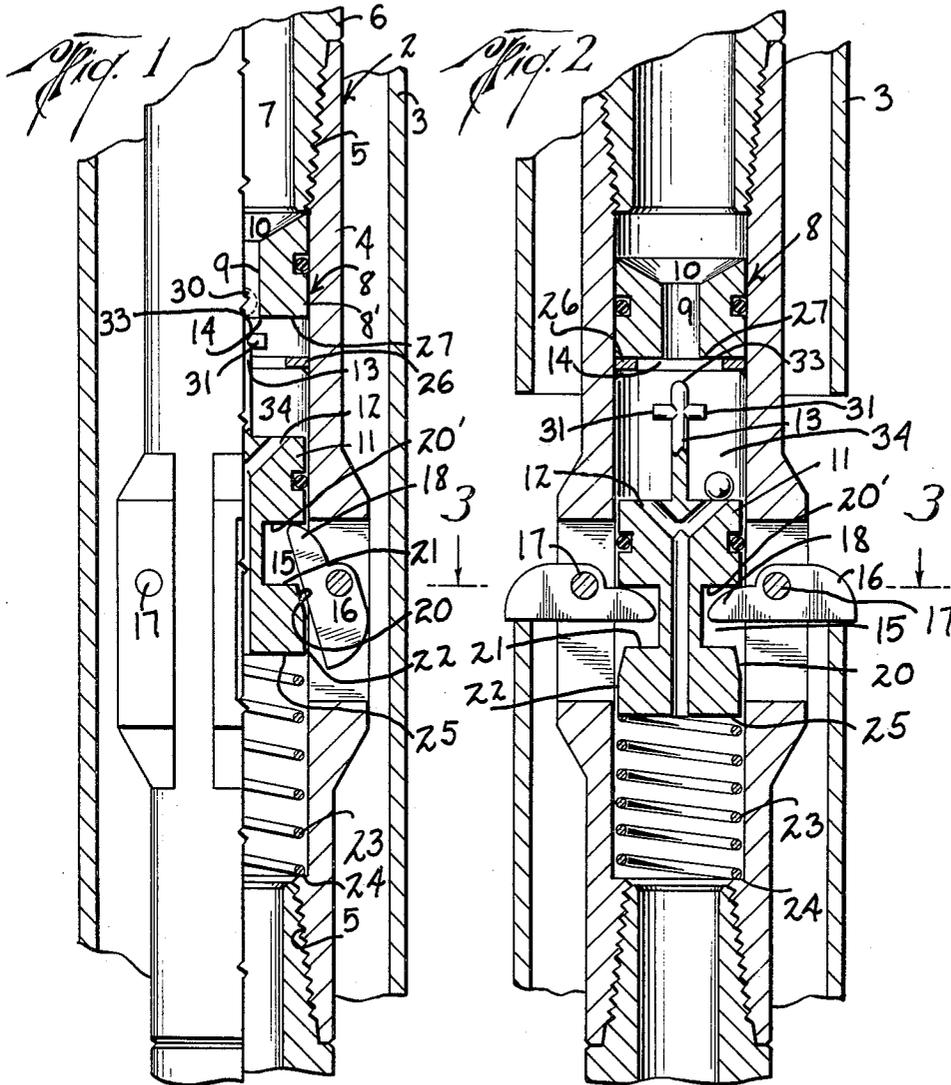
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PIPE CUTTER AND MILLING TOOL

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PIPE CUTTER AND MILLING TOOL

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1 Claim. (Cl. 166—55.8)

The present invention relates to a cutter and milling tool adapted to be lowered into a pipe in a well and to cut the pipe by rotation of the tool.

Various types of cutters have been proposed and are in use at the present time for cutting well pipe in situ in a well bore. Those devices which have been heretofore proposed and are used to cut pipe which employ hydraulically actuated means to effect the cutting are disadvantageous in that as the tools are lowered into the well bore normal circulation of mud fluid is greatly restricted by the device in the well, or in some instances the circulation may be completely cut off as the device is being lowered into the well and used.

In the drilling of oil and gas wells a mud laden fluid is injected into the drilling string and circulated down through the drilling string to be discharged at the lower end thereof and into the well bore whereupon it is circulated up through the well bore to the earth's surface. This circulation of drilling fluid is desirable and necessary to accomplish successful drilling operations, and it is extremely important to endeavor to maintain normal circulation of the drilling of fluid during all stages of the drilling of the well. If, for some reason or other, it becomes necessary to greatly restrict the rate of circulation, or to completely cut it off for even a short period of time, there is a very great danger that such restriction of the mud flow will cause the particles in the mud laden fluid to settle out in the well bore. The settling of the constituents of the mud stream may cause the drill string to become stuck in the well bore thereby necessitating a "fishing" operation to try to remove the stuck portion of the well pipe from the well bore.

The present invention provides a hydraulically operated cutting tool for cutting pipe in situ in a well, which is constructed and arranged so that it will aid in maintaining substantial normal flow through the tool as it is being lowered into the well pipe on a well string thereby overcoming the above mentioned difficulties.

Still a further object of the present invention is to provide a hydraulically operated milling and cutting tool, including piston means adapted to normally accommodate fluid flow through the device when it is inactivated and not in use, which piston means is constructed and arranged so that the ports therein may be closed off, and the piston means thereafter moved by hydraulic pressure longitudinally of the body of the milling tool to move cutters to accomplish the cutting and milling operation on the pipe in the well.

Yet a further object of the present invention is to provide a combined milling and cutting tool wherein piston means are provided in the body and include ports therethrough to accommodate flow of drilling mud when the tool is not in operation, which piston means also normally retains the cutter on the device in an activated position, but which is operable to move the cutter to an activated position by the application of fluid pressure, said piston means being so constructed and arranged to release the hydraulic pressure against the cutters when the cut on the pipe has been completed.

Other objects and advantages of the present invention will become more readily apparent from a consideration of the following description and drawings, wherein:

FIG. 1 is a partial longitudinal sectional view, show-

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ing the tool of the present invention in inactivated position but ready to begin a cut on a pipe;

FIG. 2 is a longitudinal sectional view somewhat similar to FIG. 1 and showing the relationship of the components of the mechanism after the cut on the pipe has been completed; and

FIG. 3 is a sectional view on the line 3—3 of FIG. 2 to better illustrate the details of construction of the present invention.

Attention is directed to FIG. 1 of the drawings, wherein the cutter tool is illustrated generally by the numeral 2 and is shown as having been lowered into a well pipe 3 for cutting thereof.

The tool 2 includes a body 4 which is of a size to be inserted into the pipe 3 and to be lowered therethrough to the desired elevation in the well at which the pipe 3 is to be cut. The body 4 is provided with suitable means such as threads 5 at each end thereof, whereby the tool may be connected into a well string for lowering into the well bore.

The well string shown at 6 is provided with a bore 7 for conducting drilling fluid therethrough to be circulated outwardly and into the well bore at the lower end of the well string, whereupon the well fluid is circulated up through the well bore to the surface of the earth.

It is extremely desirable in the drilling of oil and gas wells that the circulation of drilling fluid in the well bore be maintained in all stages of the drilling operations to inhibit settling of particles of mud from the fluid in the well, which settling might cause the drilling tools or other tools in the well bore to become stuck therein, thereby necessitating what is termed a "fishing" operation to recover the stuck pipe from the well bore.

The present invention provides a tool in which circulation of drilling fluid may be maintained at a substantially normal rate as the tool is being lowered into the well bore, thereby inhibiting the possibility of the tool sticking in the well. Heretofore, a problem encountered with using hydraulically operated cutter tools has been that their construction necessitated cutting off, or greatly reducing the circulation of the drilling fluid in the well bore as the tool is lowered into the well bore to such an extent that the impaired or eliminated flow of the drilling mud greatly increased the possibility of the tool becoming stuck by settling mud particles through the well string and the cutting tool supported thereon.

The construction of the present invention overcomes this difficulty in that as the tool is lowered into the well, normal circulation can be maintained to inhibit sticking of the well pipe by settled fluids in the circulating drilling mud; however, when it is desired to effect a cutting operation on the pipe within the well, means are provided for utilizing the hydraulic pressure of the circulating drilling fluid to move the cutters into active position whereby a cutting operation may be performed upon the pipe. Thereafter, the device automatically returns to its original position whereupon circulation may be continued through the pipe and tool connected therewith.

As shown in the drawings, a piston means is illustrated generally at 8 which piston means includes the spaced upper and lower pistons 8' and 11, respectively. FIG. 1 illustrates the position of the upper piston 8' and the lower piston 11 as the tool is lowered into the well pipe to the desired position as which a cut is to be made in the pipe. In order to accommodate substantially normal fluid flow of the drilling mud through the bore 7 of the well string 6 above and below the tool 2, suitable fluid conducting means are provided for conducting the fluid through the tool so that it will not operate against the piston means to actuate the cutter means, which actuation will be described more in detail hereinafter. As shown in the drawings, a fluid conducting port means is pro-

vided at 9 in the upper piston 8' and port means 12 are provided in the lower piston 11 so that the fluid from the bore 7 in the well string 6 above the tool 2 may pass through the tool without effecting movement or travel of the piston means 8 within the tool. The port 9 and the port 12 act as fluid by-pass means to in effect conduct the drilling fluid through the tool without acting upon the pistons on the one hand, and without substantially restricting the flow of the fluid through the tool on the other hand, which overcomes the problems discussed hereinafore relative to hydraulically operated cutter tools.

The lower piston 11 includes a projection 13 which extends upwardly and terminates adjacent the lower end 14 of fluid conducting means or fluid by-pass port means 9 in piston 8', as shown in FIG. 1 of the drawings. The projection 13 serves as a means to aid in effecting movement of the piston means generally denoted at 8 whereby the cutters may be moved outwardly relative to the body to effect a cut in the well pipe 3, and such projection also serves as a means for returning the piston means 8 to its initial position within the tool body 4.

The piston 11 includes the annular recess 15 into which extends the projection 18 on the rear end of the cutters 16. The annular recess 15 in cooperation with the rearwardly extending portions or projections 18 on the cutters 16 cooperate to effect outward movement of the cutters 16 in order to engage the well pipe 3 to effect a cut therein, and the recess 15 as well as the rearwardly extending portions 18 also cooperate to retract the cutters 16 back into the tool after the well pipe 3 has been cut. The initial retracted position of the cutters 16 is more clearly illustrated in FIG. 1 of the drawings and it is to be noted that an annular tapered portion 20 is provided at the lower end of the recess 15, and the tapered portion extends between the lower surface 21 of the recess 15 and the outer surface 22 of the piston 11 as shown in FIG. 1 of the drawings. The tapered surface or portion 20 serves as a means to further aid in guiding the cutters 16 as they move outwardly into engagement with the well pipe and also aid in guiding the cutters 16 into their retracted position after the cut in the well pipe has been performed.

The cutters 16 are pivotally mounted on the pin 17 in the body 4 of the tool. Any suitable number of cutters 16 may be used and as shown in the drawings, four cutters are provided in the tool. The cutters 16 are circumferentially spaced about the tool body 4 and arranged so that they are equal distance apart.

In order to maintain the cutters in retracted position within the body 4 as the tool is lowered into the well, spring means 23 is provided which rest on the shoulder 24 in the lower end of body 4 and which abuts the lower end 25 of the piston 11, such spring means tending to urge piston 11 to the position illustrated in FIG. 1 of the drawings. In this position the rearward extension 18 on the cutters 16 is adjacent the tapered portions or surface 20 at the lower end of the recess and by the upper wall 20' of the recess to aid in retaining the cutters 16 retracted within the body 4 of the tool 2. The spring 23 is of sufficient strength to urge the piston 11 upwardly and to maintain it in the position shown in FIG. 1 of the drawings, even though well fluids are being circulated downwardly through the bore 7 of the drilling string 6 and passed through the bore 9 and bore 12 in the piston 11. However, spring means 23 will compress when the fluid conducted port or passage means 9 and 12 has been closed off to accommodate movement or travel of the piston means 8 within the body 4 whereupon the cutters 16 may be rotated out of the body 4 and into engagement with the well pipe 3.

Any suitable means may be utilized to shut off fluid flow so that the fluid pressure within the bore 7 becomes effective against the piston means 8 to move the piston means 8 longitudinally of the body to cause the cutters 16 to rotate outwardly. As shown in the drawings, this means assumes the form of a ball 30 which may be low-

ered or dropped through the bore 7 of the well string 6. The top surface 10 of the piston 8' is tapered which serves to guide the closing means into the fluid conducting passage or port means 9 whereupon the closing means, shown in dotted line in FIG. 1 as being in the form of a ball 30, will come to rest on top 33 of the projection 13. This closes off flow of drilling mud through the body 4 of the tool 2, whereupon the pressure of the drilling fluid is exerted against the piston 8' to effect travel thereof longitudinally of the body 4. Laterally extending pins or members 31 are provided adjacent the upper end of the projection 13 and span the fluid conducting port or passage means 9 so that the lower end 27 of piston 8' will engage such members to effect movement of piston 11 as piston 8' moves longitudinally of the body 4. As the piston means 8 moves longitudinally of the body, the top surface 20' of annular recess 15 engages the rear projection 18 of each cutter 16 and rotates each of the cutters out of the body. As the cutters are rotated out of the body, the well string 6 and the tool 4 are also rotated which moves the cutters about the inner periphery of the well pipe 3 which is to be cut. It seems obvious that continued downward movement of the piston means 8 will continue to urge the cutters 16 outwardly and as rotation of the tool is effected, the well pipe 3 will be cut.

Of course, after the cut in the well pipe has been completed, it is desirable to continue circulation of the drilling mud in order to inhibit sticking of the well pipe within the well and to this end, a stop 26 is provided in the body 4 which is adapted to engage the lower end 27 of the piston 8' which stops longitudinal travel of the piston 8' within the body 4 after the cutters have been rotated substantially to their final position as shown in FIG. 2 of the drawings. Of course, at this time the means 30 still retains the fluid conducting passage means 9 closed off and in order to re-establish circulation, such fluid conducting passage means must be opened up. This is accomplished by the fluid pressure acting against the closing off means 30, which in turn moves the piston 11 downwardly relative to the piston 8' which is now resting on stop 26 until sufficient clearance has been provided between the upper end 33 of projection 13 and the lower end 14 of port 9 in piston 8' so that the ball 30 may fall out of the fluid conducting port means 9 and into the chamber 34 to rest on the top of piston 11 as shown in FIG. 2 of the drawings. When this occurs, the fluid conducting means 9 is thereupon opened to receive fluid flow therethrough, whereupon the fluid may be conducted through the passage 12 in the lower piston 11.

After the ball means 30 has moved to the position shown in FIG. 2 of the drawings, the spring means 23 will thereupon move piston 11 to its initial position relative to piston 8' as shown in FIG. 1 of the drawings.

While it is believed that the operation of the invention is apparent by reason of the foregoing description, to further amplify and describe, it will be assumed that the device as shown in FIG. 1 of the drawings is connected to a well string 6 and has been lowered to a predetermined level within the well bore at which it is desired to cut the well pipe 3. The piston 11 and the piston 8' are in the initial position as shown in FIG. 1 of the drawings, and spring means 23 serves to retain such piston means 8 in this initial position. The fluid conducting means 9 in piston 8' and the fluid conducting means 12 in piston 11 serve as by-pass means for the drilling fluid, whereby the drilling fluid may be circulated in the bore 7 of the well string 6 above the tool body 4, downwardly through the tool to be discharged in the bore 7 of the well string 6 below the tool. Thus, as the tool is lowered into the well bore, substantially normal circulation may be maintained, since the fluid conducting means 9 and 12 may be of a maximum size to offer the minimum resistance to fluid flow through the tool body 4.

When the elevation in the well pipe 3 has been reached at which it is desired to effect a cut, suitable means must

be provided for closing off communication through the tool body 4 during the cutting operation. Any suitable means may be provided for this purpose, and as shown in the drawings, such means assumes the form of a ball 30 which is dropped or lowered into the bore 7 of the well string 6, whereupon it moves into the fluid conducting passage 9 to rest on the top 33 of the projection 13. This closes off the fluid flow through the tool and thereafter the fluid pressure acts against piston 8' so as to move the piston means 8 longitudinally of the body 4 against tension in the spring 23. As piston means 8' moves longitudinally of the body, the bottom 27 thereof will engage the laterally extending members 31 on projection 13, thereby effecting a movement of the piston 11 along with the movement of piston 8'. Stop 26 within the body 4 engages the bottom 27 of the piston 8' after a desired amount of movement of piston 8' to prevent further movement of such piston, and at this time, the close off means 30 is still within the fluid conducting passage means 9. Also, the cutters 16 are engaged by the top 20' of the annular recess 15 in piston 11 and rotated out of the body as piston 11 moves longitudinally of the body, so that such cutters engage the well pipe 3 and upon rotation of the well pipe 6 will cut the well pipe 3 as shown in FIG. 2 of the drawings.

In order to release the cutters 16 to return them to retracted position within the body 4, the fluid pressure against piston means 8 must be relieved, and this is accomplished when piston 11 travels an additional amount in the body 4 until sufficient clearance has been provided between the end 33 of projection 13 and the bottom 27 of piston 8' to accommodate movement of the ball 30 out of passage 9, therebetween and into the chamber 34. At this time, the spring means 23 will act against the piston 11 to return the piston and cutters 16 to their retracted position within the tool body 4 so that the tool and well string may be lifted out of or removed from the well bore.

From the foregoing description it can be appreciated that a tool construction is provided wherein circulation is maintained as the well tool is lowered into the well to inhibit sticking of the well string or the tool in the well bore. Additionally, the fluid pressure is utilized to release the cutters from the cut portion of pipe and also an automatic signal means is provided for signalling to the operator that the well pipe has been cut. For example, it is obvious that pump pressure will increase during the cutting operation, but when piston 11 has moved sufficiently to permit the closing off means 30 to move into chamber 34, the resistance to flow will be decreased, and pump pressure accordingly will also decrease.

Particular attention is also directed to the fact that the cutting surfaces 40 of each of the cutters 16 are arranged on the center line of the tool body which aids in imparting a greater cutting force through the cutters to the pipe. Heretofore, cutters in well cutting tools have been mounted so that the cutting face thereof is on a chord of the tool body, rather than on a diameter, or the center

line thereof. It can be appreciated that when the cutters are mounted on the center line of the tool as shown in FIG. 3 of the drawings, rather than on the chord, a greater cutting effort may be exerted by the cutters against the pipe to be severed.

As the piston 11 moves longitudinally of the body 4 to assume its initial position therein, the members 31 will engage the bottom 27 of piston 8' and also move it to its initial position as represented in FIG. 1 of the drawings.

Broadly the invention relates to a tool for cutting the pipe in place in a well bore, and particularly to a tool which maintains restriction to fluid flow therethrough at a minimum as the tool is lowered into the well bore, but which tool uses the pressure of the mud fluid to effect a cut and to signal to the operator that a successful cut has been made in the pipe.

What is claimed is:

A pipe cutter and milling tool including an elongated body of a size to be inserted into a pipe in a well, a pair of spaced upper and lower pistons slidably mounted in said body, there being port means in said pistons for conducting fluid flow therethrough, means adapted to be lowered into the pipe in the well for closing off said port means whereby fluid flow through said upper piston is closed off, a projection on said lower piston terminating adjacent said upper piston port means whereby when said means for closing off said port means is lowered into the well, it rests on said projection and said upper piston thereby becomes responsive to the fluid to move said lower piston longitudinally of said body, a cutter pivoted on said body and engaged by said lower piston means whereby movement of said lower piston rotates said cutter out of said body and into cutting position, spring means normally retaining said lower piston in position in said body to maintain said cutter retracted but adapted upon the application of fluid pressure to said upper piston when the ports therein have been closed to accommodate movement of said lower piston longitudinally of said body, stop means in said body to limit the longitudinal movement of said upper piston, said lower piston movable by fluid pressure after said upper piston has stopped and until said means lowered to close off said port in said upper piston has cleared said upper piston port means by movement of said lower piston whereby fluid flow may continue through said port means, and said spring means thereafter urging said lower piston to its initial position to aid in retracting said cutter engaged thereby.

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