This invention relates in general to hydraulic drill bits and to method of drilling. In particular, this invention relates to hydraulic drill bits of the rotary type for use in the oil well drilling industry, wherein fluid or drilling mud under high pressure will drill the hole and be directed entirely through said drill bit so that it is ejected at or ahead of the mechanical cutting edge of the drill bit.

In the past, oil wells have been bored into the earth by means of various different types of drill bits which are rotated to mechanically bore downwardly into the earth. These bits are usually provided with small openings or passages therein which terminate rearwardly of the mechanical cutting edges. Drilling mud under pressure is usually directed through said passages so that the material cut away is eventually washed upwardly and removed from the bored hole. Each of the various types of present conventional drill bits mechanically bores into the earth to loosen the material which is subsequently washed upwardly by means of the drilling mud which is forced through the passages which terminate rearwardly of the mechanical cutting edges.

One of the principal objects of the present invention is to provide a hydraulic drill bit designed for hydraulically drilling into the earth by utilizing substantial quantities of drilling mud under high pressure. This pressure is of sufficient force to hydraulically penetrate the earth formation being drilled, which pressure is obtained by using a variable variable pressure pump such as that described in my co-pending application Serial No. 304,935, filed August 18, 1952, now U.S. Patent No. 2,789,515, dated April 23, 1957.

Another object of the present invention is to provide a drill bit having a passage means therein for the drilling material to terminate at or otherwise of the mechanical cutting edges of the drill bit. Another object is to provide a hydraulic drill bit of the type described wherein the drilling mud opening in said bit is provided with a floating pipe which ejects said drilling mud under high pressure at a point forwardly of said cutting edges and automatically feeds forwardly as the forward to discharge edge of the pipe is worn away by the abrasive drilling mud. Another object is to provide an automatic feed arrangement which utilizes the force of the drilling mud which enters the drill bit for keeping the discharge end of the pipe constant distance from the mechanical cutting edges regardless of the wear caused by the drilling mud. Another object is to provide a self-cleaning pipe which will not become clogged.

Still another object is to provide a new method of drilling wherein the actual primary drilling is accomplished by hydraulic means and the mechanical cutting edges of the drill bit are provided merely to grind or chop up the material already bored out or removed so that it can be moved upwardly out of the hole by the drilling mud and to give form to or preserve the gauge of the hole.

These and other objects and advantages will become apparent hereinafter.

The present invention is embodied in a hydraulic drill bit having an opening for drilling mud under high pressure, said opening positioned at or ahead of the mechanical cutting edge of the drill bit. The invention is also embodied in a method of hydraulically drilling a hole and subsequently grinding the material cut away so that it can be washed upwardly with ease.

The invention also consists in the parts and in the arrangements and combinations of parts hereinafter described and claimed. In the accompanying drawings which form part of this specification and wherein like numerals refer to like parts wherever they occur:

Fig. 1 is a longitudinal cross-sectional view of a hydraulic drill bit embodying the present invention.

Fig. 2 is a horizontal cross-sectional view taken along the line 2-2 of Fig. 1.

Fig. 3 is a side elevational view thereof.

Fig. 4 is a longitudinal cross-sectional view of a modified form of hydraulic drill bit embodying the present invention.

Fig. 5 is a side elevational view of the modified bit shown in Fig. 4, and

Fig. 6 is a vertical cross-sectional view of still a further modification of a drill bit embodying the present invention.

Referring now to the drawings in detail, it will be seen that the embodiment of the invention which has been illustrated comprises a hydraulic drill bit 1 having an upper portion or collar 2 with a threaded shank 3 thereon for attachment to a drill collar or drill stem 4 in the usual manner. The bit 1 is provided with depending mechanical teeth 5 extending downwardly therefrom and terminating in mechanical cutting edges 6. The bit 1 is provided with a central opening 7 having a countersink 8 therein with a shoulder 9 therebetween having a small radius 10 thereon to reduce strain. A smooth bore 11 is provided below or forwardly of the countersink 8 for slidably receiving a pipe 12 having an opening 13 therein forming all or a portion of the passage 14 which extends completely through the bit 1.

The pipe 12 is provided with an upper collar 15 having an upper annular surface 16 with outwardly extending projections 16a thereon with vertical slots 17 between said projections 16a. The collar 15 is also provided with a key 19 adapted to fit into a corresponding groove 19 in the countersink 8 so that said pipe 12 will rotate with said bit 1. The pipe 12 has a body portion 20 extending downwardly from said collar 15 which terminates in an annular bottom edge 21 which is subject to extreme wear from the earth formation and the escape of the high pressure drilling mud. The bore 11 is provided with a circumscripting groove 22 having a seal 23 therein for preventing the passage of drilling mud between said pipe and the wall of said bore. An annular chamber or cavity 24 is formed in the countersink 8 outside of the pipe 12 and between the collar 15 and shoulder 9. The slots 17 connect said cavity 24 with the countersink 8 above said collar 15 so that no drilling mud can become entrapped in said cavity 24 thereby preventing the pipe 12 from moving or operating as intended. The pipe 12 is also provided with internal vanes 25 which are intended to break up the earth formation that might otherwise enter therein during the drilling operation.

In operation, the hydraulic drill bit 1 is suitably secured to the lower end of a drilling pipe 4 and is rotated thereby. When not in contact with the bottom of the hole, the pipe 12 hangs downwardly from the drill bit 1 with the collar 15 in substantial abutting relation with the shoulder 9. As the pressure fluid or drilling mud is directed through and against the pipe 12 and against the material to be drilled, the pipe 12 adjusts itself in said drill bit until an equilibrium position is attained.
In this equilibrium position, the bottom edge 21 of the pipe 12 is slightly below the cutting edges 6 of the drill bit as best shown in Fig. 1. Drilling mud is directed through passage 14, that is, through the counterbore 8 and opening 13 within the pipe 12, at a pressure sufficient to hydraulically disintegrate the earth formation and bore downwardly into the earth through rock and any other material that might be present. Thereafter, the drilling mud is forced laterally outwardly from the pipe 12 after accomplishing its hydraulically drilling action. This constant movement of material which includes the drilling mud and the bored material, under high pressure gradually wears the lower edge 21 of the pipe 12 away, but the drilling mud acting upon the upper annular surface 16 of the collar 15 forces the pipe 12 downwardly to compensate for wear so that the bottom edge 21 of the pipe 12 remains at a distance below the mechanical cutting edges 6.

The drilling mud with drilled material therefrom moves upwardly as shown by the arrows in Fig. 1, primarily in the space 26 between the mechanical cutting means and to some extent in the annular space 27 to the top of the well, into the mud pits. The numeral 28 refers to the wall of the hole being drilled which is slightly larger than the width of the bit. After the mud with the removed material thereon passes laterally beyond the wall of the pipe 12 it is subjected to the mechanical cutting or grinding of the teeth or cones which may be provided. As illustrated, the present invention can be used with several different types of drill bits, including those bits 1 which have only two relatively large teeth 5 as shown in Figs. 1-3, those bits 1a which have several cones 29 thereon each having a plurality of relatively small teeth 30 as shown in Figs. 4 and 5, and those bits 1b which have a plurality of blades 31 such as shown in Fig. 6. With any type of drill bit, the opening or passage 14b for the drilling mud should terminate at or have its discharge end at the mechanical cutting edge thereof, or forwardly thereof as when the pipe 12 is used. Whenever the pipe 12 is found to be desirable, it should preferably be suitably mounted so that it utilizes the force of the incoming drilling mud so as to automatically feed it forwardly to maintain the discharge end 21 thereof at a predetermined distance forwardly of the mechanical cutting edges 6. This is accomplished by carefully determining the diameter of the opening within the pipe, the effective area of the top surface of the collar 15 at the end of the pipe 12, and the amount of hydraulic pressure necessary to bore through the particular rock formations being drilled.

For most types of drilling, satisfactory results will be obtained if the effective area subject to the force of the drilling mud is substantially equal to the area of the top of the pipe 12. That is, referring now to Fig. 2, the area of the annular surface 16 plus the area of the opening of the vanes 25 should be the same as the open area 13 of the pipe 12.

Under present conditions, the pipe 12 need not be of the floating type but may be provided with threads 32, as shown on the pipe 12a in Fig. 4, which cooperate with threads 33 in the lower portion of the central opening 7a. With this arrangement, no counterbore 8 is necessary since the collar 15 has been eliminated. Thus, the passage 14a which extends completely through the bit 1a is of uniform diameter. Of course, the cooperating threads 32 and 33 are merely one simple form for rigidly securing the pipe 12a to the bit 1a and other means may be used if desired.

With the type of bit 1b as shown in Fig. 6, a plurality of blades 31 extending angularly through the teeth or blades 31 have their lower edges 35 positioned at the cutting edges 6b of the teeth 31. This type of bit 1b is usually provided with two or more teeth 31, each of which may be provided with one or more holes 34. A threaded socket 36 is provided for receiving the externally threaded pin 37 of a drill stem 38.

Obviously, the hereinbefore described hydraulic drill bit admits of considerable modification without departing from the invention except as defined in the claims. Therefore, I do not wish to be limited to the precise arrangements shown and described.

What I claim is:

1. A hydraulic drill bit having a bore and a counterbore rearwardly thereof for receiving substantial quantities of drilling fluid under high pressure, said drill bit having at least one mechanical cutting edge for breaking up material which has been hydraulically bored, a pipe slidably mounted in said bore and having a discharge end positioned forwardly of said mechanical cutting edge, said discharge end having a bottom edge positioned in a plane substantially perpendicular to the longitudinal axis of said hydraulic drill bit, said pipe positioned to force said drilling fluid against the bottom of the hole being drilled, said pipe having a bore of substantially uniform cross-section, said pipe having a collar thereon slidably in said counterbore, said collar having at least one opening therein for establishing communication between said counterbore and the space between said counterbore and said pipe forwardly of said collar, means for locking said pipe and said drill bit against relative rotation, said hydraulic drill bit confining the hydraulic pressure against the bottom of the hole being drilled.

2. A hydraulic drill bit having a bore and a counterbore rearwardly thereof for receiving substantial quantities of drilling fluid under high pressure, said drill bit having at least one mechanical cutting edge for breaking up material which has been hydraulically bored, a pipe slidably mounted in said bore and having a discharge end positioned forwardly of said mechanical cutting edge, said discharge end having a bottom edge positioned in a plane substantially perpendicular to the longitudinal axis of said hydraulic drill bit, said pipe positioned to force said drilling fluid against the bottom of the hole being drilled, said pipe having a bore of substantially uniform cross-section, said pipe having a collar thereon slidable in said counterbore, means for locking said pipe and said drill bit against relative rotation, said hydraulic drill bit confining the hydraulic pressure against the bottom of the hole being drilled.

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