June 3, 1941. A. W. KAMMERER 2,244,537

WELL DRILLING BIT

Filed Dec. 22, 1939

Fig. 1.

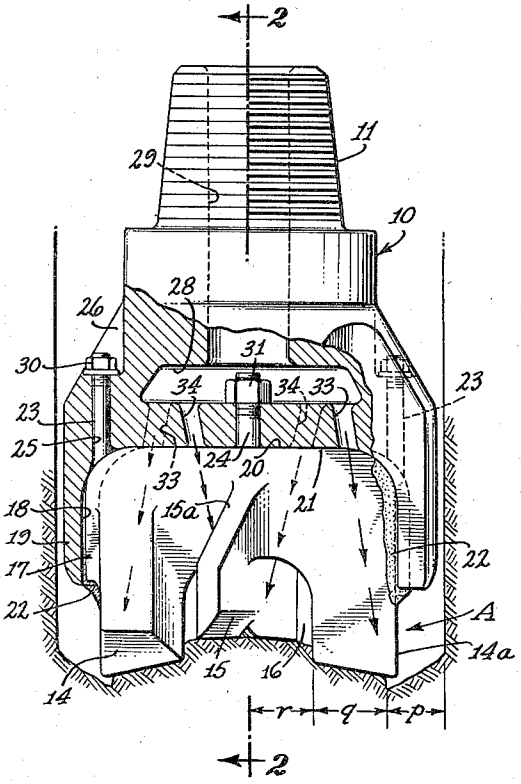
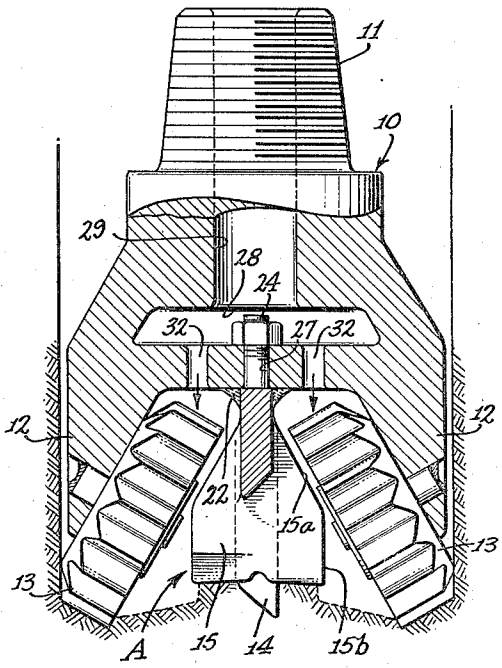


Fig. 2.



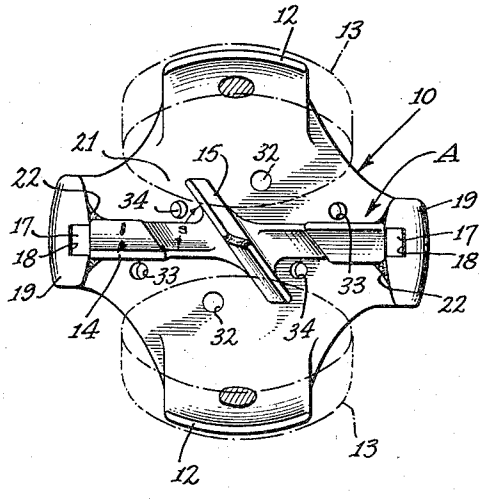


Fig. 3.

Inventor

ARCHER W. KAMMERER,

By Bernard Kriegel

Attorney

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WELL DRILLING BIT

Archer W. Kammerer, Fullerton, Calif.

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20 Claims. (Cl. 255—71)

This invention relates to earth boring tools, and more particularly to drilling bits used in the rotary drilling of wells.

In the rotary method of drilling oil wells and the like, it is usual practice to remove relatively soft earth formations by employing a drag or blade type of bit. As drilling proceeds, the outer reaming edges of the cutter blades become worn to progressively greater extents, with attendant decrease in the effective diameter of the bit, resulting in the production of a downwardly tapering, undersized hole, which must be brought to the required diameter throughout its entire length either by a reamer or another bit before drilling of the hole to greater depths can continue. It has heretofore also been difficult to drill a straight, vertical hole with a drag bit, especially when heavy drilling weights are imposed on the bit for the purpose of making more rapid progress through the formation.

It is, accordingly, an object of the present invention to provide an improved rotary drill bit embodying blade or drag types of cutters, the bit being capable of forming a hole of the required diameter throughout its useful drilling life without loss of gauge on the blade or drag cutters as drilling proceeds.

It is a further object of the invention to provide an improved rotary drill bit having its cutting elements designed and arranged to inherently drill a vertical hole, and to bring a hole which has deviated back to the vertical.

While drag bits are effective in removing soft earth formations, they are comparatively ineffective in making progress through hard formations. Strata answering this latter description can be removed by bits having rolling cutters, but this type of bit will not function adequately in soft formations. Another object of the invention is, therefore, to provide an improved composite rotary drilling bit having both drag and roller cutters, capable of efficiently drilling both soft and hard formations, and of making relatively rapid progress through formations that are not suited for removal by either drag or roller cutters alone.

Still another object of the invention involves the provision of a composite drag and roller bit of sturdy construction, in which the cutters are readily replaceable, permitting reemployment of the main bit body for a plurality of runs.

Another object of the invention is to arrange the cutters of a drill bit in such a manner as to facilitate their cleaning by the drilling fluid and the removal of cuttings from the hole bottom.

This invention possesses many other advantages and has other objects which will become apparent from a consideration of the embodiment shown in the drawing accompanying and forming part of the present specification. This form will now be described in detail to illustrate the general principles of the invention, but it is to be understood that such detailed description is not to be taken in a limited sense, since the invention is best defined in the claims appended hereto.

Referring to the drawing:

Figure 1 is an elevational view of a drill bit, parts being removed for purposes of clarity, and other portions being shown in section.

Figure 2 is a longitudinal section taken generally along the line 2—2 of Figure 1, and

Figure 3 is a plan view of the drill bit, as seen from the bottom of Figure 1.

The example of the invention disclosed in the drawing includes a main body or shank 10 having the usual threaded, tapered pin 11 at its upper end for attaching the bit to a tubular string of drill pipe (not shown), by means of which the bit can be rotated from the surface of the hole, in a well-known manner. Depending downwardly from the main body is a pair of opposed legs 12, 12 rotatably carrying side or gauge toothed cutters 13, 13 whose purpose is to remove the outer portions of the formation material and to maintain the hole to its required diameter. It is preferred that these cutters 13, 13 rotate on anti-friction bearings, and that their mounting be such as to permit their replacement without damage to the main body of the shank, enabling reemployment of the latter member for a plurality of runs. While the specific anti-friction bearing and detachable mounting for the side roller cutters form no part of the present invention, reference is made to United States Patent No. 2,145,573, patented January 31, 1939 in the name of John T. Phipps, as illustrative of one arrangement that can be used. It is to be understood, however, that other rotatable mountings for the side or gauge cutters can be utilized without departing from the present invention.

The formation material within the annulus p cut by the side rollers is removed by cutters of the drag or blade type. These cutters form part of an assembly A and are preferably rigid or integral with respect to each other, consisting of outer drag cutters 14, 14 and inner drag cutters 15, 15 disposed at an angle s to the former, with intervening openings or spaces 16 provided

therebetween for purposes of cleaning both the cutting portions of the drag assembly A and the bottom of the hole, in a manner more specifically described hereinafter. The upper portions 15a of the inner cutters are bevelled to clear the side cutters.

The drag cutter assembly A is securely attached to the main body or shank 10 of the bit by having its reduced ends 17, 17 slidably fitting within grooves or guideways 18, 18 formed lengthwise in the inner faces of legs 19, 19 depending from the main bit body, and preferably integral therewith. The drag cutter assembly A is inserted into the main body with its ends 17 sliding within the guideways 18 until its upper surface 20 abuts the underside 21 of the bit shank. This drag assembly can then be integrated with its cooperable legs 19 by welding fillets 22 between the legs and the outer drag cutters 14, both along the inner side surfaces of the legs and along their undersurface. Because of this arrangement of parts, drilling weight imposed on the drag assembly is transmitted directly between the upper surface 20 of the drag cutter and the undersurface 21 of the main bit body, while the driving effort or torque is transmitted directly between the sides of the grooves or guideways 18 and the reduced end 17 engageable therewith. In this manner, a functionally integral drag bit construction is provided, in which removal of the drag cutters and their replacement is accomplished through the simple expedient of burning away or otherwise removing the welded fillets 22.

Another mode of securing the drag cutter assembly A rigidly to the main body 10 of the bit is to secure outer studs 23, or an intermediate stud 24, or both, to the upper portion of the drag cutter assembly, the outer studs extending upwardly through holes 25 at the sides of the shank with their ends positioned within recesses or pockets 26 formed in the inclined portions of the body, while the central stud 24 extends upwardly through a hole 27 in the shank and into a fluid passageway or chamber 28 communicating with a central passageway 29 extending through the body and its upper threaded pin 11. The various studs are securely held in place, as shown in Figure 1, by the nuts 30 threaded onto the outer studs within the pockets or recesses, and by a nut 31 threaded onto the central stud and bearing against the bottom of the fluid chamber 28. This latter nut can readily be assembled on its cooperative stud by inserting it through the central fluid passageway 29 and by employing a suitable wrench.

The two modes of rigidly securing the drag cutter to the main bit body can both be utilized in a single bit construction, or one may be employed in preference to the other, depending upon the particular drilling conditions prevailing within the hole.

The drag or cross cutter assembly A is disposed between the side cutters 13 with its central plane substantially at right angles to the axes of rotation of the side cutters. The outer drag cutters 14 are of such width as to cut an annulus *q* on the bottom of the hole, with the outermost end portions 14*a* of these cutters each having a radius at least equal to and preferably slightly greater than the radius of the inner circumference of the annulus of material *p* removed by the side roller cutters. Similarly, the central portion *r* of the formation material is removed by the inner drag cutters 15, which have a radius at least equal to and preferably slightly greater than the radius of the inner circle traced by the outer drag cutters. It is to be noted further that the lowermost toothed portions of the side roller cutters 13 lead or are positioned ahead of the outer drag cutters 14 in a downward vertical direction by a material extent, and that the bottom contacting portions of the outer drag cutters 14 also lead the bottom contacting portions of the inner drag cutters 15. Because of this arrangement, the roller cutters are relied upon to remove the outer annulus *p* of formation material and to keep the hole to its requisite diameter. But in view of the fact that these cutters lead and overlap the path traced by the outer drag cutters 14, the outermost end portions 14*a* of the latter do not operate upon the formation at all, and consequently are prevented from wearing and losing their gauge. The similar leading and overlapping by the outer drag cutters 14 of the inner drag cutters 15 prevents the ends 15*b* of the latter from operating upon the formation and their loss of gauge. Thus, wear on the drag cutters 14, 15 is concentrated at their bottom formation engaging surfaces, while reliance is placed on the roller cutters 13 to keep the hole to gauge throughout the drilling life of the bit, which experience shows is accomplished very effectively.

The cutting portions of the bit and the hole bottom are kept clean by means of a plurality of fluid passages or nozzles communicating with the fluid chamber 28 within the main body of the bit. The side cutters 13 are cleaned by the direct impact on their teeth of fluid issuing from the nozzles 32. The cutting surfaces of the outer drag cutters or blades 14 are cleaned by fluid issuing from the outer set of nozzles 33, disposed on the leading side of these cutters (as regards the rotational direction of the bit) and inclined upwardly and inwardly to the axis of the bit. The inner cutter blades 15 are kept clean by fluid issuing from the nozzles 34 positioned in advance of their cutting surfaces and adapted to direct fluid at an angle onto these surfaces, because of the inclination of the nozzle axes in the opposite direction to that of the nozzles 33 for cleaning the outer blades. The fluid issuing from these nozzles 33, 34 will not only clean the drag cutters, but it also has practically a direct impact upon the cuttings at the bottom of the hole to remove them to the surface of the bore and leave the bottom free from cuttings, under which conditions the cutters can penetrate most effectively.

It has been found that drilling by this type of bit is enhanced if the inner drag cutters 15 are disposed at an angle *s* to the outer drag cutters 14 and trail them by no more than 90 degrees, and preferably by an acute angle. This not only assists in the removal of the formation material, but also provides the openings 16 between the outer and inner blades through which the cuttings can pass, and through which they can be flushed by fluid issuing from the inner set of nozzles 34. The direction of fluid discharge from these nozzles and the acute angle *s* of the inner cutters with respect to the outer cutters serves to move the drilling mud and cuttings partially through these openings from where they are caused to pass outwardly and upwardly to the surface of the bore.

The progressive leading of the cutters 13, 14, 15 not only maintains the hole to gauge and

eliminates side wear on the drag cutters, but it also results in the formation of a high center at the bottom of the hole, which assists its breakdown and is conducive to straight hole drilling, and also to bringing a deviated hole back to the vertical. In this connection, the ability of the bit to produce a vertical hole is enhanced if the bottoms of the drag cutters **14**, **15** are inclined slightly upwardly and inwardly, as shown in the drawing.

Thus, I have developed a drilling bit capable of drilling a full gauge, straight hole, and in which the detritus is removed from both the cutter surfaces and the hole bottom to allow maximum drilling progress. The composite character of the bit permits it to make rapid progress in soft formations and material progress in the hard formations, while strata of intermediate characteristics can be removed more effectively and rapidly than with drag bits or rock bits alone.

I claim:

1. A drill bit, including a main body, side roller cutters rotatably carried by said body, a drag assembly secured to said main body and having inner and outer cutters disposed at an angle to each other, said roller cutters extending below said outer cutters and said outer cutters extending below said inner cutters.

2. A drill bit, including a main body, side roller cutters rotatably carried by said body, a drag assembly secured to said main body and having spaced inner and outer cutters disposed at an angle to each other, said roller cutters extending below said outer cutters and said outer cutters extending below said inner cutters, the maximum effective radius of the outer cutters being at least equal to the radius of the innermost portion of the annular path traced by said side cutters, and the maximum effective radius of said inner cutters being at least equal to the minimum radius of said outer cutters.

3. A drill bit, including a main body having a pair of depending legs, side roller cutters rotatably carried by said legs, a second pair of legs depending from said body between said first-mentioned pair, a drag assembly secured to and between said second pair of legs, said assembly comprising outer blade cutters and inner blade cutters disposed at an angle to said outer cutters.

4. A drill bit, including a main body having a pair of depending legs, side roller cutters rotatably carried by said legs, a second pair of legs depending from said body between said first-mentioned pair, a drag assembly secured to and between said second pair of legs, said assembly comprising outer blade cutters adapted to trace an annular path and inner blade cutters adapted to act upon the central portion of a hole bottom within said annular path, said inner cutters trailing said outer cutters by an angle of no more than 90 degrees.

5. A drill bit, including a main body, side roller cutters rotatably carried by said body, a drag assembly secured to said body with its central plane substantially at right angles to the axes of rotation of said side cutters, said assembly comprising outer blade cutters and inner blade cutters trailing said outer cutters by acute angles and being in spaced relation to said outer cutters.

6. A drill bit, including a main body, opposed side roller cutters carried by said body for rotation about axes disposed inwardly and downwardly of the bit axis, a drag assembly secured to said body with its central plane substantially at right angles to the axes of rotation of said side cutters, said assembly comprising outer blade cutters and inner blade cutters disposed at an angle to said outer cutters and in spaced relation thereto, each of said inner cutters having a portion bevelled in an upward and inward direction and lying adjacent said side cutters.

7. A drill bit, including a main body having a pair of depending legs, opposed side roller cutters carried by said legs for rotation about axes inclined inwardly and downwardly to the bit axis, a second pair of opposed legs depending from said body between said first-mentioned pair, a drag assembly secured to and between said second pair of legs with its central plane substantially at right angles to the rotational axes of said side cutters, said assembly comprising outer blade cutters and inner blade cutters trailing said outer cutters by acute angles and in spaced relation thereto, each of said inner cutters having an upper portion bevelled in an upward and inward direction of lying adjacent the inner faces of said side cutters.

8. A drill bit as defined in claim 7, said roller cutters extending below said outer cutters, and said outer cutters extending below said inner cutters.

9. A drill bit, including a main body, side roller cutters rotatably carried by said body, said body comprising a plurality of depending legs disposed between said cutters, a drag assembly positioned between and received within grooves in the inner faces of said legs, and means for detachably securing said assembly to said body.

10. A drill bit, including a main body, side roller cutters rotatably carried by said body, said body comprising a plurality of depending legs disposed between said cutters, a drag assembly positioned between and attachable to said legs, and means for detachably securing said assembly to said legs.

11. A drill bit, including a main body, side roller cutters rotatably carried by said body, said body comprising a pair of depending legs disposed between said cutters, a unitary drag assembly positioned between and slidably received within longitudinal grooves in the inner faces of said legs, and means for detachably securing said assembly to said body.

12. A drill bit, including a main body having a pair of depending legs and an undersurface between said legs, side roller cutters rotatably carried by said body between said legs, a unitary drag assembly abutting the undersurface of said body and positioned between and slidably received within longitudinal grooves in the inner faces of said legs, and means for securing said assembly rigidly to said body.

13. A drill bit, including a main body having a pair of depending legs and an undersurface between said legs, side roller cutters rotatably carried by said body between said legs, a unitary drag assembly abutting the undersurface of said body and positioned between and attachable to said legs, and means for securing said assembly rigidly to said legs.

14. A drill bit as defined in claim 12, said means comprising welding material integrating said assembly to said legs.

15. A drill bit as defined in claim 12, said means comprising a plurality of studs fixed to said assembly and extending upwardly through holes in said body, and nuts on said studs for fixedly securing said assembly to said body.

16. A drill bit as defined in claim 11, said means comprising a stud fixed to each end of the drag assembly and extending upwardly through a hole in the body into a recess provided in the outer surface of said body, and a nut within said recess threaded on each stud.

17. A drill bit, including a main body, side roller cutters rotatably carried by said body, a drag assembly fixed to said body and extending between said side cutters, said assembly comprising depending outer cutters and inner cutters disposed at an angle to said outer cutters and in spaced relation thereto, said body having a plurality of openings for directing cleaning fluid on said inner and outer cutters, the openings for said outer cutters having their lines of discharge inclined downwardly and outwardly, and the openings for said inner cutters having their lines of discharge inclined downwardly and inwardly.

18. A drill bit, including a main body, side roller cutters rotatably carried by said body, a drag assembly fixed to said body and extending between said side cutters, said assembly comprising depending outer cutters adapted to trace an annular path and inner cutters trailing said outer cutters by an acute angle and adapted to trace a path within said annular path, said inner and outer cutters being in spaced relation to provide longitudinal openings therebetween, said body having a plurality of passages for directing cleaning fluid on the leading faces of said inner and outer cutters, the lines of discharge of said passages for said inner cutters being inclined downwardly and inwardly.

19. A drill bit, including a main body having a pair of depending legs, peripherally toothed side roller cutters rotatably carried by said legs and adapted to trace an annular path on the bottom of a bore hole being produced, a second pair of legs depending from said body between said first-mentioned pair, drag cutters secured to said second pair of legs to trace a path within said annular path, the teeth of said roller cutters extending below the lower cutting edges of said drag cutters.

20. A drill bit, including a main body, peripherally toothed side roller cutters rotatably carried by said body and adapted to trace an annular path on the bottom of the bore hole being produced, a pair of legs depending from said body between said side roller cutters, drag cutters secured to said pair of legs to trace a path within said annular path, the teeth of said roller cutters extending below the lower cutting edges of said drag cutters.

ARCHER W. KAMMERER.