Dec. 4, 1962 A. B. HILDEBRANDT 3,066,750

DRILL BITS

Filed March 2, 1959 2 Sheets-Sheet 1

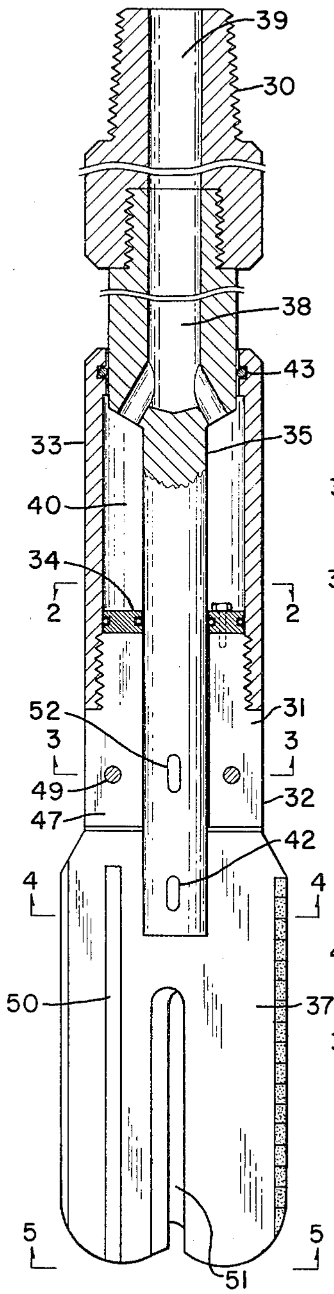

FIG. 1

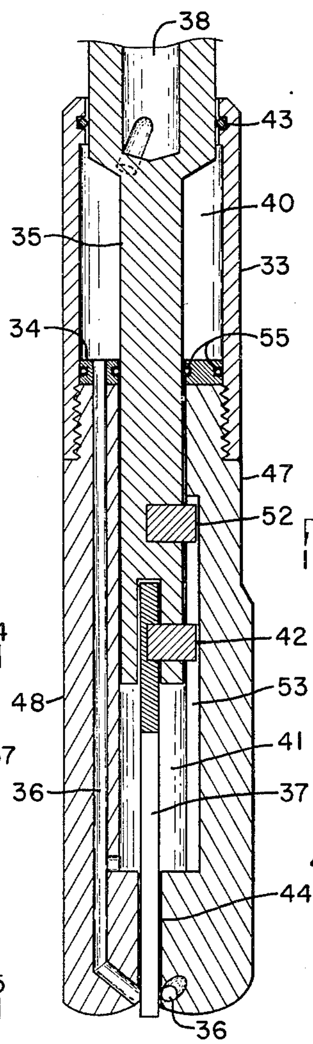

FIG. 6

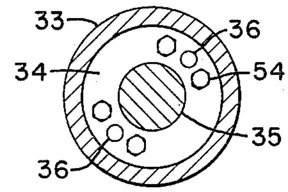

FIG. 2

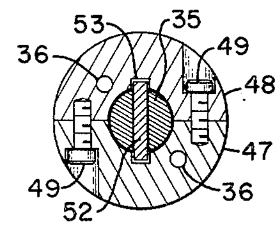

FIG. 3

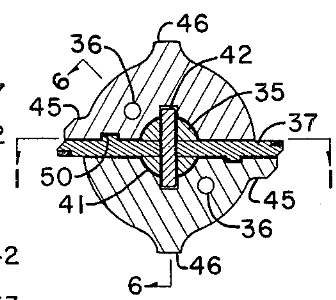

FIG. 4

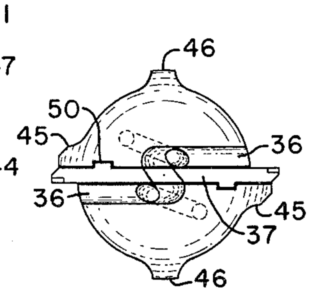

FIG. 5

Alexander B. Hildebrandt Inventor

By James A. Reilly Attorney

DRILL BITS

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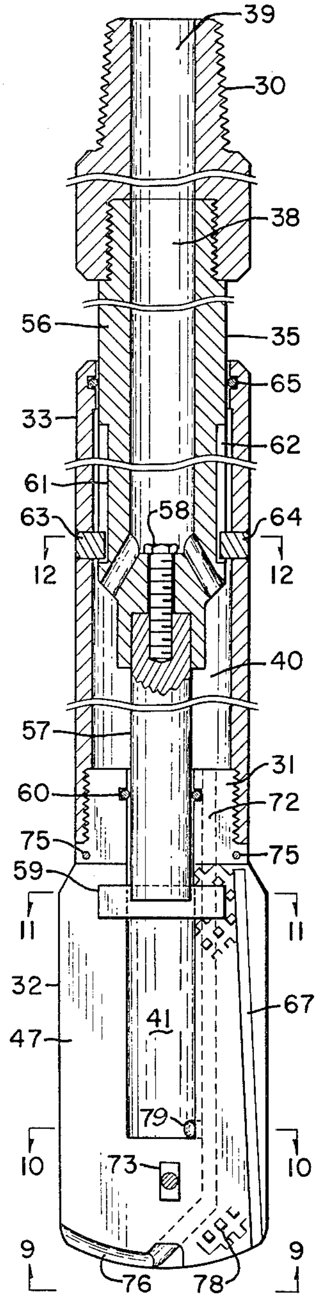

FIG. 7

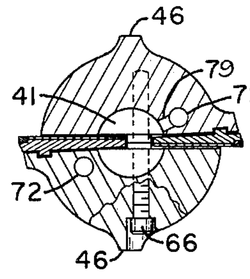

FIG. 10

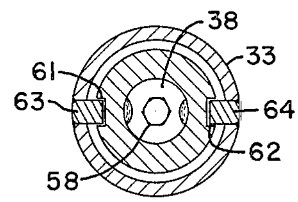

FIG. 12

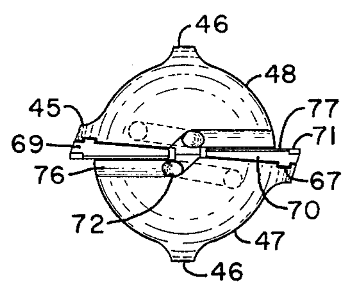

FIG. 9

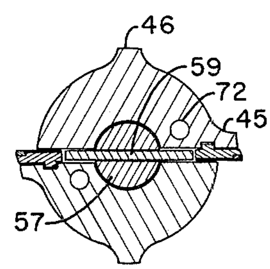

FIG. 11

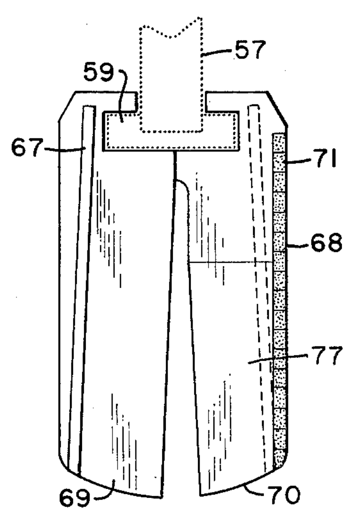

FIG. 8

Alexander B. Hildebrandt Inventor

By James A. Reilly Attorney

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3,066,750
DRILL BITS

Alexander B. Hildebrandt, Tulsa, Okla., assignor to Jersey Production Research Company, a corporation of Delaware

Filed Mar. 2, 1959, Ser. No. 796,708
11 Claims. (Cl. 175—329)

The present invention is broadly concerned with the art of drilling boreholes in the earth and more especially with improved drill bits for use in such drilling. The drill bits of the invention are particularly characterized by having cutter elements which are readily replaceable and possess long operating lives. In operation, the bits automatically renew the cutting surfaces of their cutter elements and thereby make for substantially continuous drilling.

A wide variety of drilling systems have been used or suggested for drilling boreholes in the earth. For example, in rotary drilling it is conventional to rotate and apply loads to a bit by means of a string of pipe which extends from the bit up the borehole to the surface of the earth. Bits that are used for this and other systems include roller bits, drag bits, ring bits, etc. Water, air, or other drilling fluid is passed down through the drill pipe and then through special ports or courses in the bit to carry cuttings from the bit through the borehole annulus to the earth's surface.

It has been possible with conventional bits of the types described above to drill to considerable depths. For example, in the petroleum industry, it is not unusual to drill holes 10,000 feet or more in depth in the search for oil. While such performance is commendable, it is unfortunately also very expensive.

A substantial portion of the expenses incurred in earth drilling is caused by the fact that the drill bits now employed must frequently be replaced. For example, in moderately hard abrasive formations, a conventional drag or roller bit may drill from about 200 to 300 feet before requiring replacement. This means that, in drilling a borehole of say 10,000 feet or more, a very substantial number of bits must be used. In rotary drilling systems, it also means that the entire string of drill pipe must be removed from the borehole each time a bit has to be replaced. The cost of the bits themselves, then, is only a part of the total costs occasioned by bit wear. Furthermore, the cost of the bits becomes a progresively smaller part of the total cost the deeper drilling operations go. When operating at great depth, it is the cost of changing bits—rather than the cost of the bits themselves—that becomes the more important item.

It is therefore a primary object of the present invention to reduce present drilling costs by providing drill bits that have improved operating lives and thereby require less frequent replacement. It is a further object of the invention to provide long-life bits which are simple and inexpensive in construction and adapted for use with conventional drilling systems. It is also an object of the invention to provide bits which automatically renew the cutting surfaces of their cutter elements as they become worn.

These and related objects of the invention will be expressly discussed or readily apparent in the description that follows. The objects are realized by the use of a bit having one or more cutters which are mounted within the body of the bit, and in extensible relation therewith. As the cutter elements become worn, they advance automatically in relation to the body of the bit and thereby continuously present fresh cutting surfaces.

The bits of the invention may be better understood by reference to the attached drawing in which:

FIGURE 1 is a longitudinal, partially sectioned view of a preferred embodiment of the invention.

FIGURE 2 is a section taken along the lines 2—2 of FIGURE 1.

FIGURE 3 is a section taken along the lines 3—3 of FIGURE 1.

FIGURE 4 is a section taken along the lines 4—4 of FIGURE 1.

FIGURE 5 is a bottom view of the apparatus in FIGURE 1.

FIGURE 6 is a section taken along the lines 6—6 of FIGURE 4.

FIGURE 7 is a longitudinal view in partial section of an especially preferred embodiment of the invention showing the bit body less the cutter elements.

FIGURE 8 is a view of the cutter elements as they would be arranged in the apparatus of FIGURE 7.

FIGURE 9 is a bottom view of the apparatus shown in FIGURE 7.

FIGURE 10 is a section taken along the lines 10—10 of FIGURE 7.

FIGURE 11 is a section taken along the lines 11—11 of FIGURE 7.

FIGURE 12 is a section taken along the lines 12—12 of FIGURE 7.

Referring first to FIGURES 1 through 6, the bit shown there includes blade-like cutter element 37 housed within body member 31 and in a slidable relation therewith. Member 31 in turn includes shoe-like member (or shoe) 32 and cylindrical extension 33. Also included in FIGURES 1 through 6 are ring member 34, rod 35, and passageways or courses 36.

Referring in detail first to rod 35, this member is threaded or otherwise adapted at its upper end to be connected to suitable bit-driving means. It is also provided at its upper end with passageway 38 which serves to convey drilling fluid from a drill string or other source to the interior of the drill bit proper. Thus, passageway 38 is shown to interconnect the passageway 39 in coupling 30 to the annular space 40 defined between the rod 35 and extension member 33.

The lower end of rod 35 is smaller in diameter than its upper end; and it telescopes within shoe 32 through ring 34 and elongated recess 41 in a piston-cylinder relationship. The lower end of rod 35 engages cutter element 37 and is keyed thereto by means of key 42. Key 42 and key 52 also engage the keyway 53 in body member 31 and thereby act to transmit torque loads therebetween.

The lower end of extension member 33 is threaded to shoe 32, and its upper end engages the upper enlarged portion of rod 35 in a sliding, telescoping relation. An O-ring 43 or equivalent sealing means insures a fluid-tight seal between these members.

Shoe 32 in FIGURES 1 through 7 is an elongated, substantially cylindrical member provided with a longitudinal slot 44 at its lower end to receive and support cutter element 37. It is conveniently split longitudinally into two halves 47 and 48 held together by screws 49 and threaded member 33. As mentioned above, it is also recessed at 41 to receive rod 35. It is also provided with flange-like members 45 which help support element 37. Other flange-like members 46 act more or less as centralizers.

In connection with flange-like members 45 and 46, it is important to note that these members must give shoe 32 a smaller lateral dimension than that of cutter element 37; otherwise, these members tend to have a reaming—rather than a mere centralizing—effect within a borehole.

The lower end of shoe 32 may be surfaced with abrasive particles such as diamonds, tungsten carbide, etc. Such particles, however, should be within the path swept by the cutter elements. The entire bottom of the shoe may also be cast to contain tungsten carbide or other abrasive material.

The lower end surface of shoe 32 is preferably rounded and provided with water courses so that fluid discharging from passageways 36 flows swiftly across the bottom of a borehole—and changes direction (i.e., up the borehole annulus) with a minimum of flow restriction. As shown particularly in FIGURES 1, 5, and 6, the passageways 36 terminate in the form of grooves or recesses formed in the lower surface of shoe 32 which cause drilling fluid to sweep directly across each leading or cutting edge of cutter element 37. In this way, cuttings formed by the cutter element are carried away and swept up through the borehole annulus in an efficient manner.

Ring 34 is secured to the top of shoe 32 by screws 54. Seals 55 guard against leakage of fluid around the ring.

As will be apparent from FIGURES 1 through 6, body member 31 is thrust downward against the bottom of a borehole by virtue of its own weight and also by virtue of hydraulic forces existing within the borehole. The amount of this downward thrust may be readily regulated by regulating the weight of the body member, the cross-sectional area of ring 34, and the pressure drop developed as fluid passes through passageways 36. It is important, however, that the total downward thrust on body member 31 be sufficient to hold this member against the bottom of a borehole without any substantial wear of its bottom surface. Experiments have shown that a downward thrust of about 500 to 1000 pounds is usually adequate for the purpose. If the bottom surface of member 31 is provided with a hard abrasive material, heavier loadings on this member may be used. However, any substantial wear of the member should be avoided.

While it is essential that the lateral dimension of body member 31 (including its flange-like members 45 and 46) be less than the lateral dimension of cutter element 37, it is equally essential that it be sufficient in size to buttress cutter element 37 and enable it to resist torsional and other stresses and forces. Body member 31 may be constructed of any suitable material; however, it is preferably constructed of alloy steels which are tough and resistant to abrasion. Its surface portions may be hardened or otherwise treated to be more wear-resistant.

To help stabilize the position of cutter element 37 within body member 31, both are preferably longitudinally splined or slotted as at 50.

Cutter element 37 has been discussed in part in connection with body member 31 and its component shoe 32. Further pursuant to the cutter element, this member may be constructed of a variety of materials such as steel alloys. It is preferred that the cutting faces or surfaces of the cutter element be surface-hardened or provided with hard particles of abrasive materials such as tungsten carbide to promote a more efficient drilling action. The portions of the cutter element cutting to gage (i.e., the longitudinal cutting surfaces or edges) should be harder and more wear-resistant than the central portions of the element. For example, diamond or tungsten carbide inserts may be embedded along the outer edges of the element.

In the embodiment of the invention shown in FIGURES 1 through 6, cutter element 37 is provided with a longitudinally and centrally disposed slot 51. The purpose of the slot is to reduce the high stresses in the cutter element that would otherwise tend to exist there.

The particular embodiment of the invention shown in FIGURES 1 through 6 is a drawing, substantially to scale, of a bit actually designed and used to drill a five-inch diameter borehole. The actual bit was connected through coupling 30 to a length of drill pipe. The drill pipe, in turn, was rotated and loaded by means of conventional rotary drilling equipment. The leading faces of the cutter element 37 were coated with tungsten carbide in the form of "Tube Borium." Cast inserts of diamond and tungsten carbide particles were soldered along the gage edges (i.e., longitudinal edges) of the cutter element.

When initially assembled and lowered within a borehole, the apparatus of FIGURES 1 through 6 is substantially in the condition illustrated. Then, assuming that the apparatus is powered by conventional rotary drilling equipment, drilling mud or other suitable drilling fluid is pumped down the drill string and through passageways 39 and 38 into the space 40. Both the cutter element 37 and the body member 31 should be touching the bottom of the borehole before drilling is started. The fluid within space 40 exerts a downward thrust upon ring 34 and also flows through passageways 36 to discharge across the lower cutting surface of cutter element 37. The bit, the drill string, and related equipment are rotated within the borehole; and the cutter element is loaded by applying weight from the drill pipe to an extent sufficient to penetrate whatever formation or rock surface is being encountered.

As will be reasonably apparent, the action of the bit shown in FIGURES 1 through 6 is substantially as follows. First, the entire bit comprising body member 31 and cutter element 37 is rotated in conjunction with the drill string or other driving member. The body member serves: (1) to transmit torque from the rotary driving means directly to the cutting edges of the cutter element; (2) to transmit and direct drilling fluid to the bottom and across the face of the blade in a fixed position regardless of the wear on the cutter element; (3) to support the cutter element in compressional loading and to drive the cutter element at points close to the cutting action, thus permitting the use of relatively thin blade-like members for this purpose.

Expressed otherwise, the downward thrust on body member 31 is only that necessary and sufficient to cause this member to ride along the bottom surface of a borehole without causing any substantial wear of this member. The loading on cutter element 37, on the other hand, is regulated at a value necessary and sufficient to penetrate a fraction of an inch within the rock underlying the borehole bottom. Thus, the lower end of the cutter element automatically and continuously presents only that portion of its length which corresponds to the depth of cut desired. The depth of cut, in turn, is controlled and regulated in a conventional manner by adjusting the load imposed by the bit-driving means. Furthermore, as cutter element 37 becomes worn as a result of its drilling action, it merely moves downward within body member 31 and thereby automatically and continuously presents a fresh cutting edge.

The longitudinally disposed cutting surfaces or edges of cutter element 37 in effect perform a gage-reaming action. In this connection, the entire length of these surfaces or edges should provide this effect. In other words, these cutting edges or surfaces should be substantially parallel to the longitudnial axis of the drill bit and equidistant therefrom. These surfaces or edges—like the leading face of each cutter element—should, furthermore, be surface-hardened or otherwise treated to make them abrasion-resistant. And, if inserts of abrasives such as diamond or tungsten carbide are embedded within these surfaces or edges, the abrasives should be relatively fine in size. In the case of diamond particles, fine rather than large particles have been found to provide the better performance in a reaming capacity. Diamond particles ranging in size from about 20 to 42 mesh have been used with success. Other sizes, of course, may be more desirable in some instances—viz., depending upon the nature of the rock being drilled.

In actual test operations, a bit of the type shown in FIGURES 1 through 6 gave performance substantially superior to a conventional drag-type bit. Each bit drilled a five-inch diameter borehole, and each was rotated at a speed of 100 r.p.m. under a 9000-pound load. Fresh water was used as the drilling fluid in each instance, 100 gallons per minute being circulated for the bit of the invention—and some 130 gallons per minute for the conventional bit. The net downward thrust on the shoe of the bit of the invention was maintained at about 800 pounds.

Two separate runs were made for the conventional bit; and an average penetration rate of about 50 feet per hour was obtained. Total depths of about 160 feet and 220 feet were realized. In the latter case, the bit was drilling about one-quarter inch under-gage at the completion of the test, indicating that this depth was somewhat beyond the practical depth for the bit.

In a test of the bit of the invention, an alloy steel cutter element in the shape of a blade ⅜" thick, 5" wide, and 8½" long (with an effective working length of about 3") was employed. The face of the blade was coated with "Tube Borium," a commercially available preparation of small tungsten carbide particles dispersed in a softer steel matrix. The gage was supported by tungsten carbide and diamond inserts. Using this cutter element, it was possible to drill at penetration rates as great as about 120 feet per hour and to a total depth of about 1350 feet. The gage of the hole was reduced only ⅛ inch, and some three inches of blade were worn away in drilling to depth, thereby demonstrating the practicability and utility of the bit.

Referring next to FIGURES 7 through 12, the embodiment of the invention shown there employs the same basic principles as the embodiment shown in FIGURES 1 through 6. Certain of the components have, however, been altered somewhat, as will be apparent in the following description.

The bit in FIGURES 7 through 12 includes rod member 35, which in this instance comprises an upper section 56 and a lower section 57 held together by means of screw 58. Passageway 38 conveys fluid from a source such as the passageway 39 in coupling 30 into the annular space 40 between the rod 35 and the cylindrical extension 33.

The lower end of rod 35 enters within the recess 41 defined by the internal surfaces of the two halves 47 and 48 of the shoe portion 32 of bit body member 31. A rectangularly shaped plate member 59 attached as by welding to the lower end of rod 35 engages recesses in the cutter elements 69 and 70 as indicated particularly in FIGURE 8. Plate member 59 is free to slide up and down along with the cutter elements between the two halves of shoe 32. The lower section 57 of rod 35 is also free to move up and down within the recess 41. An O-ring 60 or equivalent sealing means effects a fluid-tight seal between section 57 of rod 35 and recesss 41 of shoe 32.

Two longitudinal splines 61 and 62 formed in the side wall of the upper section 56 of rod 35 receive matching keys or splines 63 and 64, respectively, which are attached rigidly to extension member 33. Thus, means are provided for transmitting torque from rod 35 to bit body member 31 through the latter's cylindrical extension member 33. An O-ring 65 or equivalent means provides a fluid-tight sliding seal between the upper end of extension member 33 and the upper section 56 of rod 35.

Referring in some detail to shoe 32, this member—as explained earlier—conveniently comprises two halves or portions 47 and 48. These two portions—while basically similar to corresponding portions identified by the same legends in FIGURES 1 through 6—are also different from those portions in some respects. For example, the face or surface of each portion backing up a cutter element is preferably provided with a grilled or other tortuous-like surface 78. It has been found that a surface of this character enables drilling fluid to penetrate between the cutter elements and the shoe and thereby dislodge cuttings or other solid materials from this region.

Screw 66 inserted and threaded between portions 47 and 48 helps to hold these portions rigidly together when assembled. The cap of the screw may be spot-welded to the shoe to prevent its being loosened or disengaged during operation of the bit.

It will be especially noted that the splines 67 on the shoe 32 and on the cutter elements 69 and 70 (see FIGURE 8) are inclined rather than longitudinally disposed like the corresponding splines 50 in the embodiment of FIGURES 1 through 6. While the splines 67 can, of course, readily be made parallel to the axis of the bit shown in FIGURES 7 through 12, it is preferred that they be inclined slightly to compensate for any gage wear of the bit. In other words, should the longitudinally disposed cutting surfaces 68 of cutter elements 69 and 70 become worn in operation, such wear may be automatically compensated for by outward lateral movement or expansion of the cutter elements. Generally speaking, such wear appears to be relatively small; but, if it should occur, inclination of the splines 67 may be used to overcome the effects of such wear. The inclination of the splines may also be varied to suit the character of the rock being drilled. It should be noted at this point that the angle of inclination has been exaggerated in the drawing for the sake of clarity.

In regard to the longitudinal or gage cutting surfaces or edges 68 of elements 69 and 70, it is essential—as previously discussed in connection with FIGURES 1 through 6—that these be substantially parallel to and equidistant from the longitudinal axis of the bit. In this way, the entire lengths of these surfaces or edges effect a reaming action, and gage wear is greatly minimized.

As shown in FIGURE 8, it is preferred that one of the cutter elements 69 and 70 be wider than the other and extend almost to the axis of the bit—i.e., the center line of the borehole. A good cutting action at the center of the hole is thereby assured without undue loading of this cutter element. At the same time, it is preferred that the other cutter element—i.e., cutter element 70—not extend entirely to the center of the borehole. The outer portions of the laterally disposed cutting edges of the cutter elements tend to wear faster than the inner portions; and this configuration helps to make for more uniform over-all wear.

It is further preferred that the leading face of each cutter element, and the leading portion of each longitudinal cutting surface or edge 68, be surface-hardened or provided with especially hard or abrasive material to promote cutting efficiency and minimize cutter wear. For example, when using steel alloys for the cutter elements, it has been found desirable to coat the leading face of the cutter elements with a layer of abrasive 77 (e.g., tungsten carbide in the form of "Tube Borium") and to provide the cutting surfaces or edges 68 with cast diamond and tungsten carbide particle inserts. These inserts are available commercially. As mentioned earlier, diamond particles used in this service should be relatively small in size.

The lateral edges of the two cutter elements 69 and 70 have been found in practice to assume a shape or contour corresponding roughly to that shown in FIGURE 8. In fabricating these cutter elements, then, it has become the practice to provide them with an initial profile or contour of this nature. The initial shape of the lower surface of the shoe 32 and cutter elements 69 and 70 has also been found to be a factor in controlling the contour of the cutter elements. Generally speaking, the laterally outer portions of the cutter elements should be made more wear-resistant than the inner portions. The wedged shape of the elements in the drawing is helpful in this connection, and it also helps in supporting the inserts 71.

As in the previous embodiment of the invention, the embodiment of FIGURES 7 through 12 is provided with passageways 72 in the bit body member for conveying and discharging drilling fluid along the cutting surfaces of the cutter elements. Furthermore, as indicated in FIGURE 7, these passageways extend down through the bit body member and discharge in a direction approximately along the lower surface of the bit body member.

To help stabilize the two lower ends of the portions 47 and 48 of the shoe 32, a block 73 may be mounted therebetween. Conveniently, screw 66 may be threaded through this block. Port 79 is provided to interconnect recess 41 with one of the passageways 72 to flush this area and prevent solids accumulation. Alignment pins 75 or the like may be used to facilitate assembly of the portions of the bit body member.

The bit of FIGURES 7 through 12 operates in essentially the same manner as the bit in FIGURES 1 through 6. Thus, a downward thrust is imposed upon the cutter elements from any suitable bit-driving means through rod 35. A downward thrust on the bit body member is again effected by a combination of the weight of this member together with differential hydraulic forces existing at the bottom of the borehole. Thus, when the bit is rotated as by means of conventional rotary equipment, cutter elements 69 and 70 are driven into the bottom of a borehole, while the shoe 32 of the bit body member rotates and rides against the bottom of the borehole. By keeping the shoe against the bottom of the borehole, the exposure of the cutter elements its automatically and continuously kept consistent with the desired depth of cut by controlling he load on these elements at the surface of the earth. Furthermore, the discharge of drilling fluid from pasageways 72 and along the grooves 76 cut in the lower surface of the shoe maintain a very effective and continuous cleaning action.

FIGURES 7 through 12 illustrate, approximately to scale, a bit of the invention which was used in actual drilling tests and compared with a conventional roller bit. The actual bit of the invention, however, had straight splines in place of the inclined splines 67. Each bit had an effective drilling diameter of 6¾ inches, the conventional bit being a Hughes OSC type bit. The bit of the invention possessed cutter elements which tapered in thickness from about 3⁄16″ near their center portion to 9⁄16″ on the gage edge. They were about 13″ long, with an effective or usable cutting length of about 6″.

In comparing the conventional bit with the experimental bit, comparable operating conditions were employed. The load on the roller bit was maintained at about 15,000 pounds, with a drilling fluid circulation rate of about 200 gallons per minute. Under these conditions, two such bits were used to drill to a depth of 700 feet. The first of the bits lasted about 535 feet.

In operating the bit of the invention, a load of about 15,000 pounds was maintained on the cutter elements and a load of about 1500 pounds on the bit body member. A drilling fluid circulation rate of about 200 gallons per minute was again employed. The bit in this instance drilled a total of 950 feet at average penetration rates of about 45 feet per hour. The average penetration rate of the conventional bits was about 35 feet per hour.

While the foregoing description has been concerned with two embodiments of the invention, it is to be understood that the invention is not limited to these specific embodiments. Numerous variations and modifications within the spirit and scope of the invention will be readily apparent to persons skilled in the art. For example, it is apparent that the bit may be driven by downhole power sources such as mud turbines and the like. Such sources are usually supported from a drill string, but they may also be anchored to the wall of the borehole on occasion. It is also apparent that various means may be employed to indicate when the usable length of the cutter element has been expended. A substantial decrease in penetration rate is, of course, one such indication.

The inner edges of the cutter elements of the embodiment of the invention shown in FIGURES 7 through 12 are parallel to the splines 67. If the splines in this embodiment are made parallel to the axis of the bit, it

will be apparent that the inner edges of the cutter elements should also be parallel to the bit axis.

In summary, then, the invention pertains to an improved drag-type drill bit in which the body of the bit serves as a housing for one or more blade-like cutter elements extending radially from the axis of the bit. The cutter elements in operation extend longitudinally beyond the lower end of the body of the bit to terminate in cutting edges which perform a basically drilling action. They also extend laterally beyond the body of the bit to terminate in cutting edges which perform a reaming action. Both the cutter elements and the body of the bit are urged against the bottom of a borehole, the cutter elements under a load sufficient to penetrate the underlying rock, and the body of the bit under a load sufficient to contact the bottom of the borehole without causing any substantial wear thereof. The body of the bit and the cutter elements are rotated in unison, the body of the bit serving to support the cutter elements—especially near the drilling and reaming edges. Passageways or courses within the body of the bit convey drilling fluid across the cutting edges in a pattern designed to encounter minimum flow resistance and to effect maximum cleaning action.

An additional and important aspect of the invention is the fact that it enables relatively thin blade-like members to be used as cutting elements in a drag-type bit. The elements are arranged within the bit so that their flat surfaces lie transverse to the direction of the cutting action—i.e., to the direction of rotation of the bit. The leading surface or face of each element is surface-hardened or coated with a thin layer of very hard material. The resulting structure, then, is a cutter element in which a relatively soft material such as steel is used to back up a relatively hard material such as tungsten carbide. The soft material appears to wear away faster than the hard material and inherently provide the cutter element with a cutting edge of undiminished sharpness throughout its entire operating life.

The term "relatively thin" in the preceding paragraph naturally has a somewhat variable meaning, depending upon several factors. For example, in the case of a bit drilling a 12-inch diameter hole, it is contemplated that blade thicknesses up to about one inch may be used at the outer extremity of the element. On the other hand, blade thicknesses of the order of 3⁄16″ are contemplated for use at the inner extremity of the element. These dimensions, of course, are merely typical ones; and considerable variation in them is possible, depending upon rock hardness, rock type, etc. A major or critical feature about the cutter elements is the fact that they may be kept substantially constant in their thickness—and relatively thin—throughout their effective or usable lengths. Thus, the cutter elements provide a substantially constant penetration rate throughout their lives—assuming, of course, a rock or formation of a homogeneous nature is being penetrated by the elements.

The invention claimed is:

1. A rotary drill bit which comprises:

a supporting member including means for connecting said bit to a conduit for drilling fluid; said supporting member containing a longitudinal passage for transmitting drilling fluid downwardly from said conduit;

an elongated blade-like cutter element coupled to and depending from said supporting member in fixed axial relationship, said cutter element including a transverse drilling edge;

a body member supported by and co-rotatable with said supporting member and cutter element, said body member being axially slidable with respect to said supporting member and cutting element, said body member containing a longitudinal passage for the discharge of drilling fluid from within said supporting member to a point beneath said body member and a longitudinal slot within which said cutter element extends downwardly, and said cutter element bearing against the lateral surface of said body member within said slot;

and means for urging said body member downwardly with respect to said supporting member and cutter element in response to hydraulic force exerted by drilling fluid circulated downwardly through said supporting member and body member while permitting upward movement of said body member as said drilling edge wears away.

2. A bit as defined by claim 1 wherein abrasive particles are embedded in the lower surface of said body member.

3. A rotary drill bit which comprises:

an elongated supporting member provided with means near the upper end thereof for connecting said member to a rotary drill string and with means near the lower end thereof for coupling said member to a blade-like cutter element, said supporting member containing a longitudinal passage for transmitting drilling fluid downwardly from said drill string;

an elongated blade-like cutter element coupled to and depending from said supporting member in fixed axial relationship, said cutter element having a longitudinal reaming edge and a transverse drilling edge;

an elongated body member co-rotatable and axially slidable with respect to said supporting member and cutter element and depending from said supporting member in coaxial relationship, said body member containing a longitudinal slot within which said cutter element extends downwardly and a longitudinal passage through which drilling fluid may be transmitted from said supporting member to a discharge port in the lower surface of said body member, said passage in said body member extending through an internal shoulder against which hydraulic force may be exerted to hold said body member downwardly with respect to said supporting member and cutter element, and said cutter element bearing against the lateral surface of said body member within said slot and extending outwardly from said slot to expose said reaming edge and downwardly below said body member to expose said drilling edge.

4. A bit as defined by claim 3 wherein a plurality of blade-like cutter elements are coupled to said supporting member and extend downwardly within longitudinal slots in said body member at spaced points about the periphery of said body member.

5. A bit as defined by claim 3 wherein said body member and said cutter element are provided with mating splines inclined to the longitudinal axis of said bit for moving said cutter element outwardly as said body member moves upwardly with respect to said cutter element.

6. A bit as defined by claim 3 wherein diamonds are embedded in the lower surface of said body member.

7. A bit as defined by claim 3 wherein lateral passageways are provided in the lower surface of said body member to control flow of fluid discharged beneath said body member.

8. A rotary drilling tool which comprises:

an elongated supporting member provided with means near the upper end thereof for connecting said member to the lower end of a drill string and with means near the lower end thereof for coupling said member to the upper end of a blade-like cutter element, said supporting member containing a longitudinal passage extending from the upper end of said member to a port intermediate the ends of said member;

an elongated blade-like cutter element coupled to and depending from said supporting member in fixed axial relationship, said cutter element having an outer longitudinal reaming edge and a lower transverse drilling edge;

a hollow body member mounted on and co-rotatable with said supporting member, said body member being axially slidable with respect to said supporting member and cutter element, said body member forming an annular chamber about said supporting member about said port in said supporting member, said body member containing a longitudinal slot within which said cutter element bears against the lateral surface of said body member as said tool is rotated and from which said reaming and drilling edges of said cutter element extend beyond said body member, and said body member containing a passageway which extends from said chamber to a discharge port in the lower surface of said body member.

9. A rotary drill bit comprising in combination:

an elongated supporting member having an upper section including means for coupling said bit to a rotary drill string and a lower section including means for coupling blade-like cutting elements to said supporting member, said upper section containing an axial fluid passage for transmitting drilling fluid downwardly from said drill string;

blade-like cutter elements having longitudinal reaming edges and transverse drilling edges at the lower ends thereof, said cutter elements being coupled to said lower section of said supporting member in fixed axial relationship and extending below said lower section of said supporting member;

a body member including a lower shoe mounted upon and axially slidable with respect to said cutter elements, said body member containing longitudinal and radial slots from which said reaming and drilling edges of said cutter elements extend outwardly beyond said body member and within which said cutter elements bear against the lateral surfaces of said body member, a fluid passage in said body member communicating with said passage in said supporting member and having an outlet in the lower surface of said shoe, and an internal shoulder upon said body member against which fluid pressure may be exerted to hold said body member in a downward position adjacent said drilling edges of said cutter element.

10. A bit as defined by claim 9 wherein the faces and reaming edges of said cutter element are hard surfaced with tungsten carbide.

11. A bit as defined by claim 9 wherein diamonds are embedded in the reaming edges of said cutter elements.

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