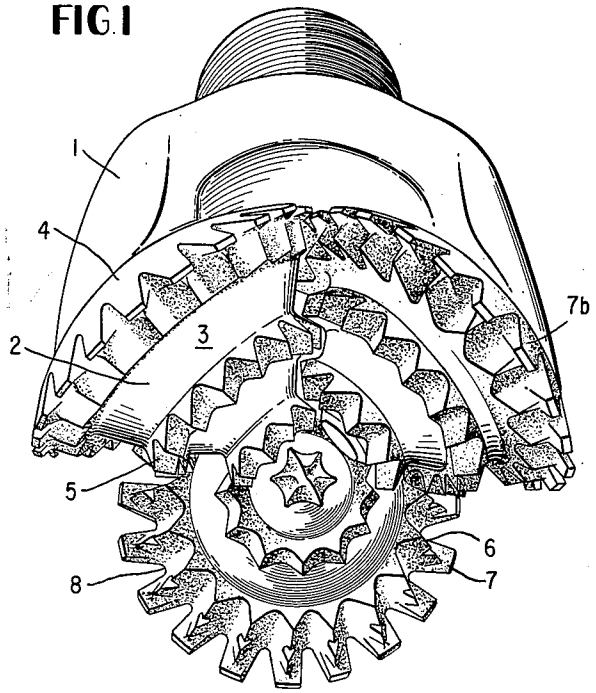
Sept. 24, 1963 D. V. DAVIS 3,104,726

ROTARY BIT STABILIZING STRUCTURE

Filed Feb. 9, 1962

FIG. 1



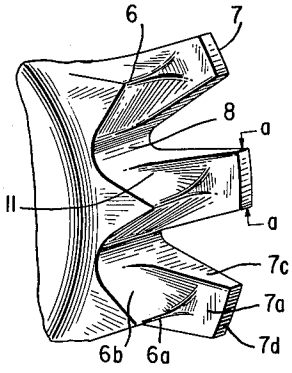


FIG. 2

FIG. 3

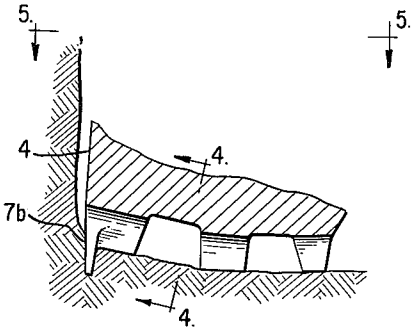
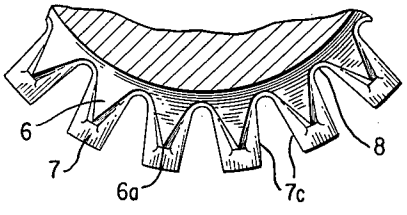


FIG. 4



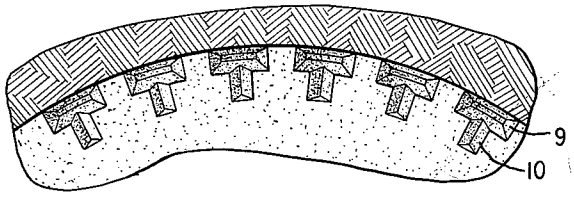


FIG. 5

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ROTARY BIT STABILIZING STRUCTURE

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This invention relates to an improved rotary bit which is structurally characterized by means which stabilize the bit during its cutting action and counteract lateral movement tendencies.

In drilling bore holes with rotary bits which include a plurality of rolling cutters, substantial difficulty has been encountered in preventing lateral bit movement. This problem has been found to be particularly acute when drilling in formations such as shale, where the bedding planes of the formation have been inclined relative to the drilling axis. In practice, it has been found that where formations are encountered having a bedding direction of extreme or near vertical inclination, a vertically directed drilling bit will tend to drill parallel to the bedding direction, its original vertical orientation notwithstanding. This tendency for a bit to move parallel to a bedding direction has been found to be especially troublesome where inclined bore holes are being drilled whose axes are only slightly inclined with respect to the plane of bedding. Even where formation bedding planes have been encountered which are only slightly out of perpendicular relationship with a drilling axis, there has been noted some tendency for bits to deviate from their original inclination to assume an orientation perpendicular to the formation. This problem of bit deviation tendency has also been found to be compounded and made more severe when operating with unusually heavy weight imposed upon the bit.

Recognizing the need for a stabilized drill bit which could be reliably employed for either conventional or inclined bore hole drilling, it is the principal object of this invention to provide an improved structure for a rotary bit rolling cutter which will counteract lateral deviation tendencies.

It is a further object of this invention to provide a stabilized bit structure which will readily accommodate the circulation of conventional drilling fluids and not tend to become clogged during drilling.

It is an additional object of the invention to provide an improved bit structure which is structurally resistant to abrasion, fluid cutting action and mechanical wear.

It is also an object of the invention to provide an improved rotary bit structure which will achieve an improved and particularly efficient cutting action.

To accomplish the foregoing objects, there is presented through this invention an improvement in each of the rolling cutters incorporated in a rotary bit. The improvement comprises a plurality of cutting teeth circumferentially spaced about the outer end of the lateral peripheral faces of each of the cutters and a plurality of circumferentially spaced, stabilizing elements. The stabilizing elements project beyond the cutting termini of the cutting teeth for engagement with the base of a well bore in advance of the cutting teeth. In the preferred embodiment the cutting teeth and stabilizing elements are combined in integral, combination cutting and stabilizing means circumferentially spaced about the lateral periphery of each cutter. Each such means includes a generally wedge-shaped cutting portion tapering outwardly to a cutting terminus and a generally web shaped stabilizing portion projecting beyond the cutting terminus, for engagement with the base of a well bore in advance of the cutting portion. The stabilizing portion, in its preferred form, is generally elongate in cross section with the elongate, cross sectional direction thereof being generally aligned with the rolling direction of the cutter. The cutting portion is integrally merged with the stabilizing portion so that the cutting terminus extends transversely of the elongate cross sectional direction of the stabilizing portion.

The apparatus of this invention will now be described with reference to the preferred embodiment, as illustrated in the application drawings in which:

FIGURE 1 is a perspective view of a rotary bit embodying the improved rolling cutter structure;

FIGURE 2 is a partial, perspective view of the outer end portion of the cutter, showing a plurality of spaced combination cutting and stabilizing means;

FIGURE 3 is a partial, vertical section taken through the rolling cutter positioned for cutting action in the base of a well bore;

FIGURE 4 is a sectional view taken along the lines 4—4 of FIGURE 3; and

FIGURE 5 is a cross sectional view of a bore hole shown in FIGURE 3, taken along the lines 5—5 of FIGURE 3 with the cutter removed so as to reveal the cutting pattern formed by the combination cutting and stabilizing means.

In the preferred embodiment of the improved drilling structure, illustrated in FIGURE 1, a rotary bit 1 is provided with three, generally conical, rolling cutters 2. The axes of rotation of the rolling cutters 2 converge toward and are inclined relative to the longitudinal axis of the bit 1 as is conventional in the rolling cutter type of bit. Each rolling cutter 2 includes a lateral peripheral face 3 and an outer end face 4. On each lateral face 3 there are provided cutting means which include conventional, rolling cutter teeth 5 which are adapted to engage the base of a well bore for drilling action.

Disposed about the outer end of each lateral face 3 are a plurality of circumferentially spaced cutting teeth 6. Associated with each cutting tooth 6 is a stabilizing element 7. Each stabilizing element, as shown in 1 and 2, is generally elongate in cross section, particularly in the portion projecting beyond cutting tooth 6. From the drawings it is readily apparent that the elongate cross sectional direction of the stabilizing element 7, labeled *a*—*a* in FIGURE 2, is generally aligned with the rolling direction of the circumference of the rolling cutter 2.

Each stabilizing element 7 projects substantially beyond the cutting edge or terminus 6*a* of its associated cutting tooth so as to be engageable with the base of a well bore in advance of its associated tooth. This advance engagement of the stabilizing element 7 is shown more clearly in the partial vertical cross sectional view of FIGURE 3. As is readily apparent, through the disposition of the stabilizing elements 7 about the outer end of the lateral, peripheral faces 3 of each cutting element 2 carried on the bit 1, the stabilizing elements 7 of the bit will form an annular track pattern around the base of the well bore which is characterized by spaced indentations deeper than those formed by the cutting teeth on the remainder of the bit.

Each of the stabilizing elements 7, as illustrated, is

provided with planar inner side faces 7*a* and planar outer side faces 7*b* which are generally parallel with the elongate cross sectional direction *a*—*a* and taper outwardly. Further, each element 7 preferably includes planar edge faces 7*c*, which are generally perpendicular to the side faces 7*a* and 7*b* and also taper outwardly. As shown most completely in FIGURE 2, the edge faces 7*c* and the side faces 7*a* and 7*b* intersect a planar generally rectangular face 7*d* on the outer tip of the element 7.

By reference to FIGURES 2 and 3, it will be seen that, in the preferred arrangement, mutually facing edge faces 7*c* on adjacent stabilizing elements 7 define smooth continuations of the outer end faces 4 of the rolling cutters 2, with which they are associated. These continuations, while substantially planar with the faces 4 may be moderately inclined or curved in respect thereto. It is contemplated that the outer side faces 7*b* will be hardened to resist abrasion and wear. One method of achieving such hardening is to plate the outer side faces 7*b* with 20 to 30 mesh tungsten carbide.

Each associated cutting tooth 6 and stabilizing element 7 may be considered as a combination cutting and stabilizing means. Adjacent means are separated by an outwardly diverging opening terminating at a root portion 8. Each such means includes the generally wedge-shaped cutting tooth or portion 6 which tapers outwardly to a cutting terminus 6*a* and the generally web shaped stabilizing portion or element 7 which projects substantially beyond the cutting terminus 6*a*. Although portion 6 and portion 7 of each combination cutting and stabilizing means comprise separate elemental portions of the means, they are integrally and smoothly merged, as shown in the application drawings. The cutting portion or tooth 6 merges smoothly with the stabilizing portion or element 7 so that the cutting terminus 6*a* extends transversely to the elongate cross sectional direction *a*—*a* of the stabilizing portion 7. As illustrated, terminus 6*a* extends substantially at a right angle to the median plane of stabilizing portion 6. Thus, as is apparent, a transverse cross section through each such combination cutting and stabilizing means in the vicinity of the cutting terminus 6*a* would provide a generally T-shaped configuration. This configuration is revealed in the track pattern formed by the combination cutting and stabilizing means as shown in FIGURE 5. The track of each individual combination cutting and stabilizing means includes a deeply indented elongate portion 9, aligned with the circumferential periphery of the base of the well bore, and a lesser indented portion 10 extending generally radially of the well bore base.

The smoothly merging character of the tooth portion 6 and stabilizing portion 7 of each combination cutting and stabilizing means is shown most clearly in FIGURE 2. The side faces 6*b* of each tooth portion 6 are smoothly merged with the inner side face 7*a* of the associated stabilizing portion 7 at curved junction 11. Similarly, the bases of the edge faces 7*c* of the stabilizing portion 7 are substantially aligned with the bases of contiguous side faces 6*b* and smoothly merged with root portions 8.

As shown in FIGURE 3, each stabilizing element or portion 7, when directed fully downward so as to become fully engaged with the base of a well bore, is substantially aligned with the longitudinal axis of the bit and with the well bore. Preferably, in this position, each portion 7 has its median plane aligned with the bit axis. Generally, however, it is sufficient if the line of force applied to the bit, when translated laterally to the position of the stabilizing portion, passes downwardly through and within the stabilizing portion 7.

The improved roller cutter structure heretofore described provides several substantial operational advantages. Its principal advantage resides in a bit stabilizing effect which deters lateral bit deviation during drilling. The stabilizing portions 7 engage the base of a well bore with their elongate cross sectional direction transverse to bore hole radii. In this manner, maximum surface resistance is provided by the stabilizing portions against lateral bit sliding or skidding. The uniform disposition of the stabilizing portions 7 about the bit insures a substantially symmetrical disposition of stabilizing forces. Because the portions 7 enter the base of a well bore in substantial axial alignment with the direction of applied force, axial progression of the bit, without lateral deviation, is further insured.

The unique structure of the stabilizing portions 7 particularly facilitates the circulation of drilling fluid and prevents the accumulation of agglomerated formation debris which would tend to clog the rolling cutters so as to impede drilling action and possibly induce lateral bit deviation. The stabilizing elements are individually spaced with their mutually facing edge faces 7*c* extending to the root portion 8 between adjacent cutting teeth 6. In this way there is no interference with the normal circulation of drilling fluid through the space between adjacent cutting teeth on the roller cutter. In defining smooth, substantially planar continuations of the outer end face of the rolling cutters, the stabilizing elements 7 avoid the forming of structural projections between the cutter end and the side of a well bore which might tend to impede the circulation of drilling fluid.

Several factors in the structure of the stabilizing elements or portions 7 contribute to mechanical strength. The outward taper of the edges 7*c* and the side faces 7*a* and 7*b* minimize the tendency of chipping or fracturing which might occur at the outer corners of the projecting ends of the stabilizing portions. The integrally merged character of the cutting tooth portion 6 and stabilizing portion 7 provides a mutually reinforcing effect for these components. The substantial alignment of the stabilizing elements, when fully engaged with the base of a well bore, with the longitudinal axis of the bit confines the direction of applied force within the body of the stabilizing portion so as to minimize bending or deflection tendencies. With the bit axis, i.e., direction of applied force, aligned with the median plane of the portion 7, stress is uniformly distributed on face 7*a* to further reduce corner wear and fractures. The hardened nature of the outer face 7*d* minimizes abrasive wear.

Of equal significance are the structural attributes of the improved rolling cutter which contribute to the reduction in abrasive and fluid cutting wear. The substantially continuously planar nature of the outer end faces 4 and outer faces 7*b*, avoids projections which would be vulnerable to abrasion and fluid cutting action. The smoothly merged nature of the stabilizing portions 7 and the cutting tooth portions 6 similarly avoids the formation of sharp corners which would be vulnerable to the effects of fluid induced cutting or abrasion. The extending of the edge faces 7*b* to the root portions 8 provides maximum size openings between adjacent stabilizing portions so as to minimize the velocity of circulating fluid passing therebetween and thus minimize abrasion and fluid cutting tendencies.

In addition to the foregoing, the structure of the stabilizing elements 7 contributes to optimum cutting action. The overall tapered nature of the stabilizing portions 7 and the alignment of their elongate, cross sectional direction with the rolling direction of their respective cutters, facilitates penetration of the outer extremities of the stabilizing portions 7 and additionally facilitates their emergence from track portions 9. The hardened character of the outer side faces 7*b* promotes a self-sharpening of the edges of the stabilizing portions 7 which facilitates penetration of the outer extremities of stabilizing portions 7 as well as the shearing action performed by these portions on the side of a well bore.

In comparative field tests it has been determined that a roller bit as illustrated in this application will drill materially faster than conventional roller cutter type rotary

bits. In comparative tests made thus far, conventional rolling cutter, roller bits drilled an average of approximately 55 feet in a 20 hour period, while the bit featured in this application averaged approximately 110 feet in a 12 hour period. Thus, whereas the conventional bits averaged approximately 2.8 feet per hour, the bit featured in this application averaged approximately 9.2 feet per hour.

It is readily apparent that the essential characteristic of this invention resides in spaced, stabilizing elements which project outwardly beyond roller cutter, cutting teeth to engage the base of a well bore in advance of the teeth. Stabilizing action as achieved in the present invention would not result, for example, from conventional webs employed between cutting teeth on roller cutters, which webs do not project beyond these teeth. It is equally apparent that optimum bit stabilizing action, as achieved with the structure of this invention would not result where a continuous, circumferentially projecting, web was employed. Such a continuous web would not tend to penetrate the base of a well bore as readily as the discrete projecting stabilizing elements 7, as described in this application. Such a continuous web structure would not provide the deterrence afforded by the structure featured in this application, against lateral bit deviations. Additionally, if such a projecting continuous web were coplanar in nature, it would engage the base of a well bore at an angle mis-aligned from the direction of force applied to the bit so as to be vulnerable to deflection and breakage. Additionally, and of particular consequence, such continuous webs would impede the circulation of drilling fluid, particularly where sticky shale formations were encountered. This impedance to the flow of circulating fluid would materially, adversely affect bit cutting action possibly to the extent of inducing bit deviation.

While the invention has been described with reference to a preferred embodiment, it is apparent that it is not limited to the precise bit, cutting tooth, or stabilizing element configurations illustrated. The overall scope of the invention is deemed to be defined in the appended claims.

I claim:

1. In a rotary bit, including a plurality of rolling cutters rotatably mounted thereon, with the axis of rotation of said cutters converging toward, and being inclined relative to, the longitudinal axis of said bit and the lateral faces of said cutters having cutting means adapted to engage the base of a well bore, the improvement in each cutter comprising: a plurality of cutting teeth circumferentially spaced about the outer end of the lateral face of each of said cutters; and a plurality of circumferentially spaced stabilizing elements, each of said elements being individually associated with one of said cutting teeth and projecting beyond a cutting terminus thereof for engagement with the base of a well bore in advance of said teeth; each said cutting tooth being generally wedge-shaped and terminating in a said cutting terminus adapted to engage a well bore base; each said stabilizing element having inner and outer side faces disposed transversely of the terminus of its associated cutting tooth and edge faces aligned transversely of said side faces, each such edge face being spaced from an edge face of an adjacent stabilizing element, each of said stabilizing element further including a well bore base engaging face at its extremity extending transversely of said side and edge faces; said stabilizing elements being disposed in relation to their respectively associated cutting teeth so that each cutting tooth terminus, when in engagement with a well bore base, is disposed between the outer side face of its associated stabilizing element and the axis of rotation of said rotary bit, with said outer side faces of said stabilizing elements being disposed about the outer end of the lateral face of the rolling cutter with which they are associated so as to be positioned substantially at the outer periphery of said rotary bit when in engagement with a well bore base.

2. The improvement in a rolling cutter for a rotary bit as described in claim 1, wherein each of said rolling cutters has a generally conical lateral face; wherein each of said stabilizing elements is generally elongate in cross section with the elongate, cross-sectional direction thereof being generally aligned with the rolling direction of its respectively associated cutter; wherein each of said stabilizing elements has side faces extending generally parallel with said elongate, cross sectional direction and tapering outwardly; wherein each of said stabilizing elements has edge faces extending generally perpendicular to said side faces and tapering outwardly; and wherein, on each of said stabilizing elements, said edge faces and side faces intersect a generally planar, well bore base engaging face on the outer extremity thereof.

3. The improvement in a rolling cutter for a rotary bit as described in claim 1, wherein all adjacent stabilizing elements have mutually facing edge faces extending to the root portion between the cutting teeth associated with said adjacent elements.

4. The improvement in a rolling cutter for a rotary bit as described in claim 1, wherein each of said stabilizing elements, when fully engaged with the base of a well bore, is substantially aligned with the longitudinal axis of said bit.

5. The improvement in a rolling cutter for a rotary bit as described in claim 2, wherein all adjacent stabilizing elements have mutually facing edge faces extending to the root portion between the cutting teeth associated with said adjacent elements; wherein said outer side faces of said elements are made resistant to abrasion; and wherein each of said stabilizing elements when fully engaged with the base of a well bore, is substantially aligned with the longitudinal axis of said bit.

6. In a rolling cutter for a rotary bit, the improvement comprising: a plurality of combination cutting and stabilizing means circumferentially spaced about the lateral periphery of said cutter, each said means including a generally wedge-shaped cutting portion tapering outwardly to a cutting terminus and a generally web shaped stabilizing portion projecting beyond said cutting terminus for engagement with the base of a well bore in advance of said cutting portion, said stabilizing portion being generally elongate in cross section with the elongate, cross sectional direction thereof being generally aligned with the rolling direction of said cutter; said cutting portion being integrally merged with said stabilizing portion with said cutting terminus extending transversely of the elongate cross sectional direction of said stabilizing portion; said cutting terminus of each cutting portion being adapted to engage a well bore base; each said stabilizing portion having inner and outer side faces defining the elongate sides of said stabilizing portion cross section and disposed transversely of the terminus of its associated cutting portion and edge faces aligned transversely of said side faces, each such edge face being spaced from an edge face of an adjacent stabilizing portion, each said stabilizing portion further including a well bore base engaging face at its extremity extending transversely of said side and edge faces; said stabilizing portions being disposed in relation to their respectively associated cutting portions so that each cutting terminus, when in engagement with a well bore base, is disposed between the outer side face of its associated stabilizing portion and the axis of rotation of the rotary bit on which said rolling cutter is mounted, with said outer side faces of said stabilizing portions being disposed about the outer end of the lateral periphery of the rolling cutter with which they are associated so as to be positioned substantially at the outer periphery of said rotary bit when in engagement with a well bore base.

7. The improvement in a rolling cutter for a rotary bit as described in claim 6 wherein said stabilizing portion, when fully engaged with the base of a well bore, is sub-

stantially aligned with the direction of force applied to said bit.

8. The improvement in a rolling cutter for rotary bit as described in claim 7; wherein the base of said cutting portion and the base of said stabilizing portion are substantially aligned; wherein said stabilizing portion has side faces generally parallel with said elongate, cross sectional direction and tapering outwardly; wherein said stabilizing portion has edge faces generally perpendicular to said side faces and tapering outwardly; and wherein said edge faces and said side faces intersect a generally planar, well bore base engaging face on the outer extremity of said stabilizing portion.

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