

May 28, 1963

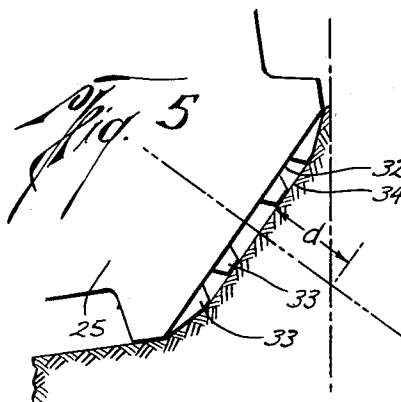
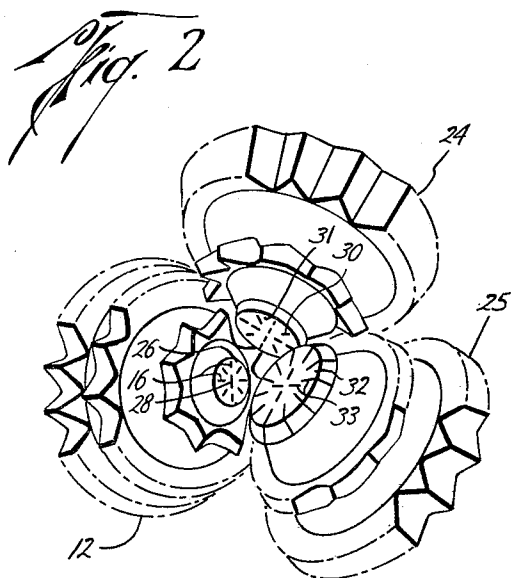
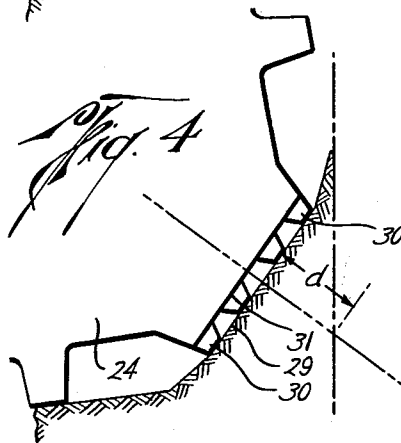
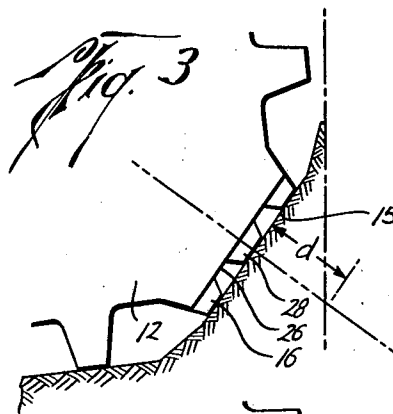
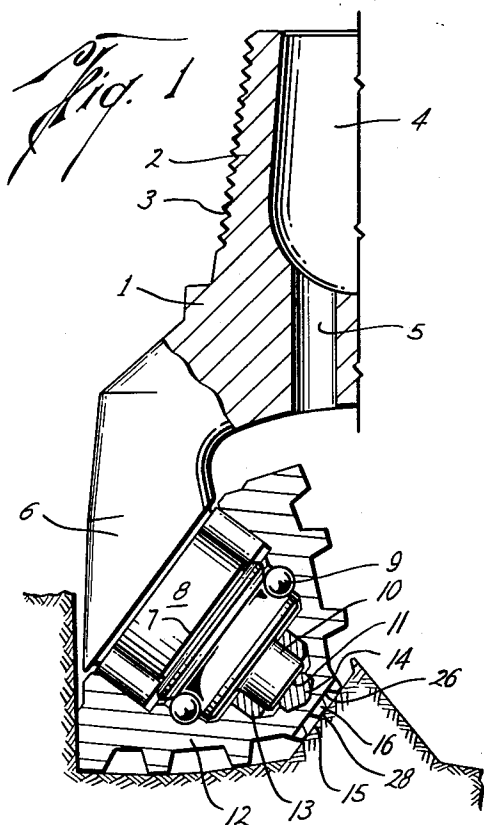
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DRILL BIT WITH IMPROVED CORE DESTROYING MEANS

Filed Oct. 5, 1960

3 Sheets-Sheet 1



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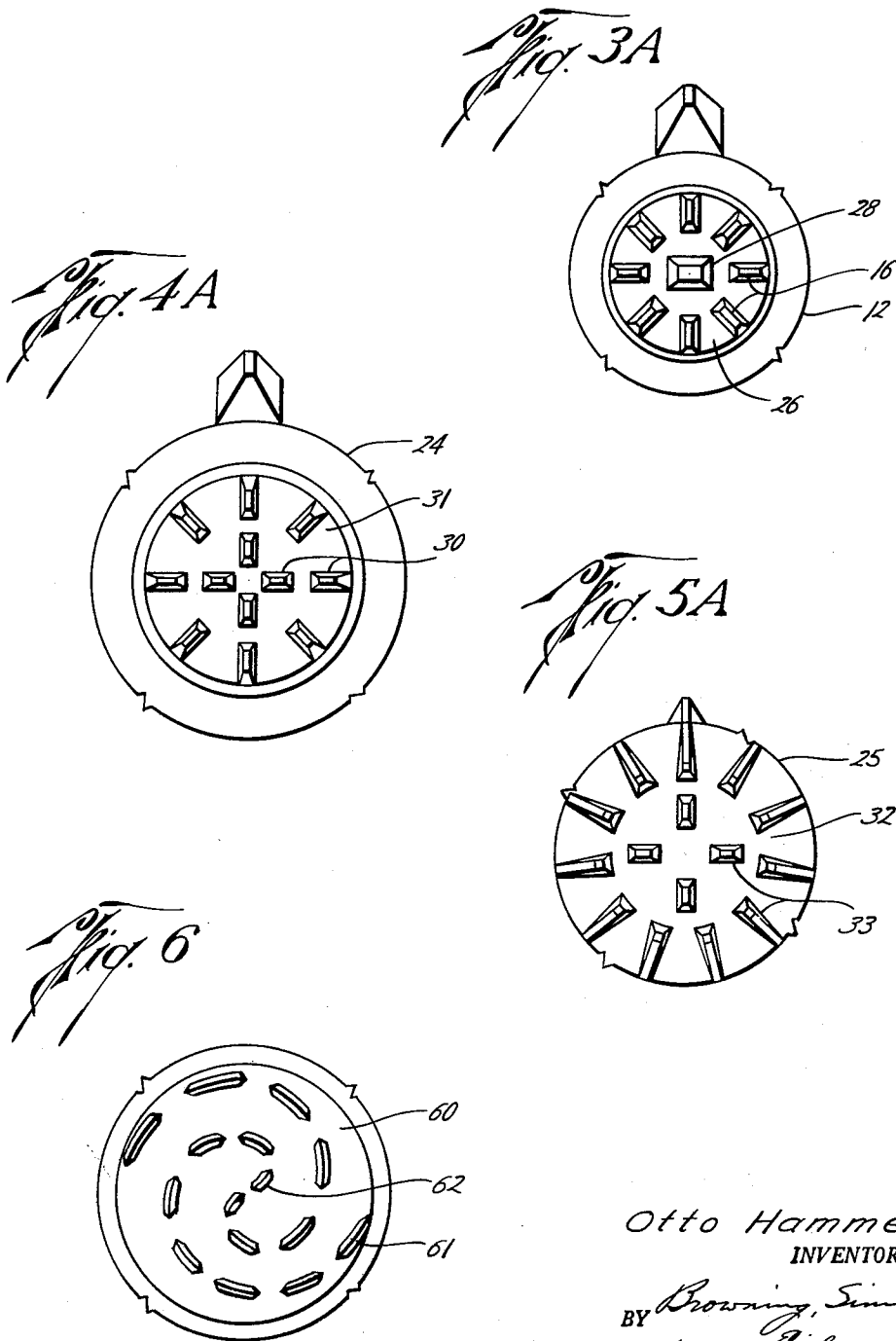
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DRILL BIT WITH IMPROVED CORE DESTROYING MEANS

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3 Sheets-Sheet 2



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DRILL BIT WITH IMPROVED CORE DESTROYING MEANS

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3 Sheets-Sheet 3

Fig. 7

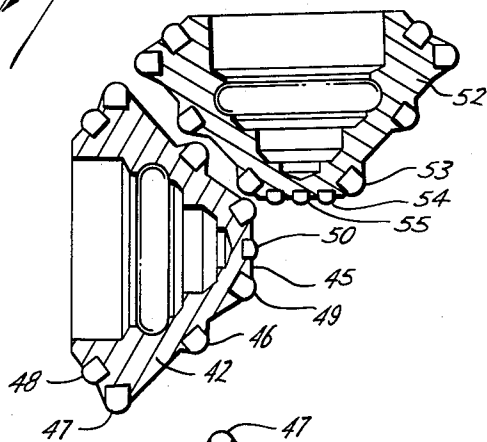


Fig. 8

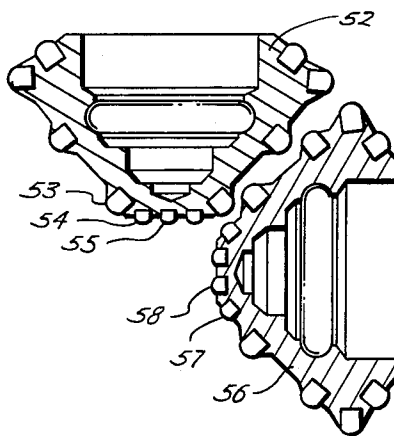


Fig. 9

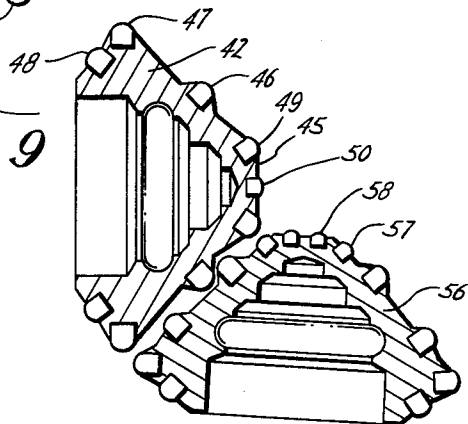


Fig. 7A

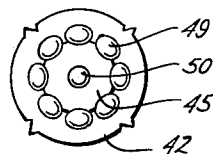


Fig. 8A

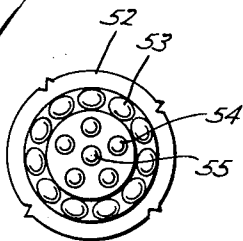
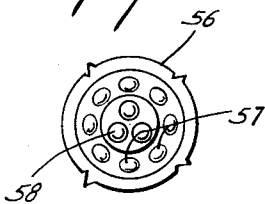


Fig. 9A



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3,091,300
**DRILL BIT WITH IMPROVED CORE
DESTROYING MEANS**

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5 Claims. (Cl. 175-333)

The present invention relates to drill bits and more particularly has reference to that type of drill bit adapted to drill in earth formations by rotary motion of the bit, and to a rotary cutter adapted to form a part of such bit.

It is well known that in the drilling of holes in earth formations by the rotary drilling method, one of the more difficult portions of the hole to drill is that portion substantially at the center of the hole and closely adjacent thereto, because at such locations there is little transverse motion of the cutters of the bit with respect to the formation when such cutters are formed and mounted on the bits in the usual fashion. One of the most common types of drill bits employed in the rotary drilling of wells in earth formations is the type employing one or more cutters which are generally conical in outer contour and which are ordinarily mounted with their bases radially outermost with respect to the axis of rotation of the drill bit and with their nose ends or smaller ends closest to the center of the bore hole. Such cutters are also customarily mounted on axes which extend downwardly and inwardly with respect to the bit axis so that the conical sides of the cutters will roll on the bottom of the hole against the formation with a more or less true rolling action. The outer or gauge forming surface of the cone bearing against the formation produces a thrust on the cone in a radially inward direction. This produces a bearing problem requiring a bearing capable of taking this thrust. It has been customary, in order to provide for drilling of the formation at and near the center of the hole, to provide for one of the cutters to have an elongated nose portion extending to or even past the center of the hole. However, such elongated nose portion is necessarily of very small cross section in a plane transverse to its axis and can only be provided with a few teeth. The result is that it is difficult to make such a nose portion strong enough so that it will not be damaged during the drilling operation and difficult to provide bearing capacity for the cutter having such an elongated nose portion, such that the drilling forces exerted on the nose portion will be adequately supported. Neither does such a nose portion provide any outward radial thrust which would assist in overcoming the inward radial thrust from the gauge surface action. Finally, it is in many cases impossible to provide sufficient teeth on such a nose portion so that an adequate number of contacts with the central portion of the hole will be made to provide a proper cutting action.

It is, therefore, one of the objects of this invention to provide a drill bit in which the central portion of the hole may be subjected to adequate cutting action without necessity for an elongated nose on any cutter.

Another object is to provide a drill bit which will provide adequate cutting action adjacent the center of the bottom of a hole without necessity for a cutter portion of such small cross section that it will be of doubtful strength.

Another object of this invention is to provide a cutter of the character described which will provide a greater number of cutter teeth engaging the central portion of the bottom of a hole with a cutting action than has been possible with designs heretofore employed.

Another object of this invention is to provide a drill bit of the character described in which all of the cutters of a multi-cone drill bit have teeth thereon adapted to

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engage the formation adjacent the center of the bottom of a hole being drilled.

Another object is to provide a drill bit of the character described in which adequate bearings can readily be provided for the portions of the cutters adapted to drill the formation adjacent the center of the bottom of a hole.

Another object is to provide a bit with cones whose action on the center portion of the formation will partially or entirely counteract the radially inward thrust resulting from the action of the gauge forming surfaces of the cones.

Other objects and advantages of this invention will become apparent from the following description taken in connection with the accompanying drawings wherein are set forth by way of illustration and example certain embodiments of this invention.

In the drawings:

FIG. 1 is a fragmentary portion of a drill bit constructed in accordance with this invention, a portion of the body thereof being broken away and shown in longitudinal cross section to illustrate the interior thereof, and the single cutter included in this figure being shown in longitudinal cross section, the cutter being illustrated in operative position with respect to the formation at the bottom of a hole being drilled so as to illustrate the drilling action of the cutter adjacent the center of the bottom of such hole;

FIG. 2 is a diagrammatic bottom plan view of a three-cone cutter bit constructed in accordance with this invention, the shapes of the nose portions of the cutters and of the cutter teeth thereon adapted to cut the formation adjacent the center of the bottom of a hole being drilled being shown merely by lines indicating the cutting crests of such teeth; and the exemplary disposition of rows of teeth for cutting the outer portions of the bottom of the hole being shown only by lines outlining such rows;

FIGS. 3, 4 and 5 are diagrammatic fragmentary views in vertical cross section through the central portion of the bottom of a hole being drilled and showing respectively the action on the formation of the nose portions of the cutters of a bit constructed in accordance with this invention;

FIGS. 3A, 4A and 5A are enlarged scale end elevations of the nose portions only of the respective cutters shown in FIG. 2, the portions of the cutters other than the noses or inner end portions being broken away;

FIG. 6 is a view similar to FIGS. 3A, 4A, and 5A but illustrating a modified arrangement of cutter teeth having elongated crests on the inner end of a cutter, skewed so as to lie at an inclination to a radial line therethrough.

FIGS. 7, 8 and 9 are mutually similar fragmentary views each showing in section along a plane through the axes of two adjacent cutters, said two of the cutters of a three-cone bit and illustrating the manner in which the teeth thereof interfit in such plane, these cutters being provided with teeth of the so-called insert or compact type;

FIGS. 7A, 8A and 9A are views similar to FIGS. 3A, 4A and 5A but illustrating the nose portions of the respective cutters in FIGS. 7, 8 and 9.

The term "teeth" is intended to include cutting elements formed of hard metal compacts, diamonds, or the like.

This invention, by providing rotating cutters with blunt ends having teeth directed axially of the cutter adjacent the rotational axis of the bit, and by arranging those ends to rotate in engagement with and cut away and form a conical upper end surface on the core which without such cutting would be left at the center of the hole, provides for cutting such core with a shearing, scraping and chipping action of a considerable number of teeth, instead of by a pivoting action of only one or two teeth. Also, by providing such cutters with such blunt ends of

different diameters although on cutters of identical lengths, one cutter nose may be made large enough to cut substantially the entire top of the core while the others cut portions of the top of the core where the cutting action of the larger cutter nose is at least efficient. Furthermore, the reaction forces from engagement of the blunt noses of all the cones consist of thrusts radially outwardly from the bit axis and thus tend to balance the inward thrust from the engagement of the base end gauge cutting surfaces of the cones with the outer wall of the hole.

Referring now in more detail to the drawings, the numeral 1 designates a bit body which may be of any conventional construction having a threaded pin 2 on its upper end provided with external threads 3 for the purpose of connecting it to the lower end of a drill stem. This upper end portion of the bit body is hollowed out in conventional fashion as illustrated at 4 so as to provide for the flow of drilling fluid from the drill stem through the bit body and out through the fluid flow openings 5. It is to be understood that this upper portion of the bit body is conventional in nature and that various types of bit body may be employed in a bit constructed in accordance with this invention.

Likewise, in conventional fashion the bit body 1 is provided with any desired number of downwardly extending cutter supporting legs 6 at intervals around its outer circumference, and each of these legs at its lower end has a downwardly and inwardly extending cutter bearing shaft 7 providing races for suitable bearings such as the roller bearings 8 adjacent the outer end of the shaft, the ball bearings 9 intermediate the ends of the shaft, and a friction bearing 10 on the nose of the shaft as well as provision for a thrust bearing surface 11 on the end of the shaft. The employment of roller and ball bearings in the positions illustrated is conventional and it will be understood that other types of bearings may be employed in place of the friction radial bearing 10 and thrust bearing 11 if found more desirable for any particular application of the bit.

It will be understood that FIG. 1 illustrates only one cutter of what may be, and is here disclosed as, a plural cutter bit, conventional except as to the nose portions of the cutter or cutters. The most common form is the tri-cone bit more diagrammatically illustrated in bottom plan view in FIG. 2. It is to be considered that FIG. 1 has other cutters of which the cutter 12 shown in FIG. 1 is exemplary in general but from which they will differ in certain features as will be presently described.

The cutter 12 is adapted to be locked in place on the cutter bearing shaft 7 by means of the ball bearings 9 in a well-known conventional manner and may be provided with a sufficiently large counterbore adjacent its nose to receive a hard bearing insert 13 adapted to engage the radial friction bearing surface 10 on the shaft. Likewise, it may be provided with a recess in the extreme nose portion for the purpose of receiving a thrust bearing insert 14 adapted to engage the frictional bearing surface 11 on the nose of the shaft 7.

The teeth along the generally conical sides of the cutter 12 may be conventionally arranged but, in accordance with this invention, the axis of this cutter and other cutters of the same bit terminate short of the bit axis. This cutter has on its inner end a series of teeth 16 whose crests, when the cutter rotates, will generate a surface 15 which is shown as extending substantially at right angles to the cutter axis. This surface does not have to be at right angles to a cutter axis as it may vary in shape from a flat surface, but should be a surface of rotation about the cutter axis and have its elements extending at a greater angle to the cutter axis than the cutter axis does with the bit axis so that in operation that portion of the surface 15 which lies above the cutter axis will extend upwardly and toward the bit axis.

This surface 15 should extend toward the cutter axis at an angle greater than that at which the normally conical side surfaces of the cutter extend toward the cutter axis, so that the cutter will have a blunt nose on which the cutter teeth 16 are formed for the purpose of cutting the formation adjacent the center of the bottom of the hole as will now be described.

The arrangement of teeth on the sides of the cone 12 and of the other cones of the same bit are substantially the same as in a conventional bit and cut an annulus on the bottom of the bore hole, this annulus covering all except a small circular area in the center of the hole. If this central area were not cut, then as the drilling on the annular area proceeded, there would be formed in the center of the hole a column of uncut material commonly called a core. The conventional manner of disposing of this core and preventing it from building up so as to interfere with and butt against the ends of the cutters as the drilling proceeds is to provide one of the cutters with an elongated nose portion that extends substantially to or in some instances past the axis of the bore hole, and which has teeth extending in all radial directions from the nose portion of such cutter to cut away the core.

In accordance with this invention, such an elongated nose portion is done away with and instead each of the cutters is provided with a blunt end on which are formed the end teeth or core cutting teeth such as 16 extending and having cutting portions presented in a substantially axial direction with respect to the axis of the cutter. The core cutting teeth present axially directed cutting extremities whose aggregate area on a cutter is less than the aggregate area by which said extremities are separated. This is clearly shown in FIGS. 3A, 4A, 5A, 6, 7A, 8A and 9A. The effect is that of a series of cutting teeth separated by spaces providing relief rather than an interrupted wear surface. When these end teeth come in contact with the core left by the ordinary cutting teeth on the sides of the cutters, the rolling action of the cone on the bottom of the bore hole causes these end teeth to shave or shear across the sloping top and sides of the short conical core along an incline extending upwardly and inwardly toward the center of the bore hole so as to effect its complete destruction. One cutter should have end teeth which collectively extend far enough from the cutter axis to substantially destroy the core. Preferably the end teeth on all cutters of a bit should generate and cut on the same conical or similar surface on the core. Therefore, the cutting portions of correspondingly positioned end teeth on every cutter of a bit should be the same distance from the center of rotation of the bit measured along the axis of the cutter in each case. This will prevent one or more cutters from absorbing all the cutting load on the core. Also, since the end teeth of a single cutter cut only a narrow path in a vertical plane along one side of the core at any instant, the end teeth of each cone should be arranged so that a diametrical path of substantial width cannot be located across any cutter nose without encountering one of said teeth. This also is apparent in all of FIGS. 3A, 4A, 5A, 6, 7A, 8A and 9A.

However, with the end teeth so located, it is not possible, in a bit with more than two cutters, to have the end teeth of two adjacent cutters both of such radial extent relative to the cutter axis that they will cut substantially to the center of the core, because they would interfere with each other. In accordance with this invention, the end teeth of one cutter are made of an extent to cut substantially to the center of the core while those of the adjacent cutters are made of sufficiently lesser extent to avoid interference with such one cutter or each other. Furthermore, the cutters with end teeth of such lesser extent will have such teeth of different radial extent from each other to avoid interference between them. The result is as shown in FIG. 2 with the largest nose cutter and teeth cutting the entire surface of the core, the next larger cutting only a portion of the core over which the teeth

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of the first-mentioned cutter cut, and the third cutting only a portion of the core over which the teeth of the other two cutters cut.

When these end teeth are arranged as illustrated in FIGS. 1 to 5, inclusive, and have crests which are elongated and extend in radial directions with respect to the rotational axis of the cutter, they will move laterally so that they have a cutting action on the sloping surfaces of the core and will continually shave off the material from such sloping surfaces. However, this lateral movement is modified by the continuous rotation of the cutter about its axis and the axis of the bit so that instead of a simple scraping action, there is a compound action of scraping, shearing and chipping which is constantly changing in nature with respect to any given end tooth, depending on its rotational position on the cutter axis.

Referring more in detail to FIGS. 2, 3, 4, 5, 3A, 4A and 5A which are illustrative of some of the various actual tooth forms which may be employed on the inner ends of the cutters, of which FIG. 1 shows a partial cross section, there is shown a three-cone bit having cutters 12, 24 and 25. The series of core cutting end teeth 16 on cutter 12 have elongated crests which are arranged in radial directions with respect to the axis of the cutter 12. In the center of the blunt end 26 of this cutter is a single end tooth having an elongated crest as shown at 28, the crest being disposed substantially along a diameter at the end 26. This single end tooth will cut the center of the core slope and the teeth 16 and 28 together will cut a path on each side of the center of the core slope.

The cutter 24 is provided with teeth 30 which will generate a larger diameter surface 29 as compared with the surface 15 generated by the nose teeth on the cutter 12, but like the cutter 12 this cutter 24 has the end teeth 30 with elongated crests, each being arranged substantially in a radial direction and spaced about the outer zone of the blunt end 31. In the central portion of this blunt end, more than a single tooth is required because of the larger area of this end as compared with the end 26. Hence, four such elongated teeth are illustrated, these likewise being arranged with their crests extending radially and their inner ends disposed closely adjacent the axis of the cutter 24. These four teeth cut the uncut formation remaining between the teeth 16 and 28 of cutter 12, and with the other teeth 30 will cut a path wider than but centered along the same center of the core shape as the path cut by the cutter 12.

The cutter 25 is similar to the other two but has a still larger blunt inner end 32 with end teeth adapted to cut a substantial distance along the sloping sides of the core so as to in effect complete its destruction. These end teeth have elongated crests extending radially as shown at 33, with these teeth disposed adjacent the outer periphery of the blunt end 32. In addition, closer to the center of the blunt end 32 there are four similar end teeth likewise radially arranged. These teeth will generate the surface 34, and the innermost thereof will cut the formation left uncut between the inner and outer rows of teeth 30 on cutter 24.

It will be apparent that in a bit with the cutters having blunt ends with teeth thereon as illustrated in FIGS. 2, 3, 4, 5, 3A, 4A and 5A, the core will be disposed of as the bit advances by the end teeth on the blunt ends of all three cutters cutting along a single conical or inclined surface. Cutter 25, having the largest blunt end will cut over the entire conical surface in the center of the hole. Cutter 24 will cut a narrower annular path spaced from the center and bottom of such conical surface. Cutter 12 will cut a still narrower annular path intermediate the limits of the path cut by cutter 24. The surfaces generated by all three sets of nose or end teeth are the same distance from the central axis of the bit measured along the respective axes of the cutters, so that all cutters will be required to perform work on the conical core at the same time. Thus, substantially

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all of the teeth on the blunt ends of these three cutters will move around the core in taking the cut in such a fashion that each tooth will generate the conical surface on the core and move along the core in a direction transverse to the crest of the tooth, but with the compound action above described.

It would be preferable from the standpoint of cutting the core, that all the blunt ends be large. However, to avoid interference with each other and cut close to or entirely the center of the core, blunt ends of different diameters are necessary. The ends of these three cutters of different diameters will interfit as shown in FIG. 2 and not interfere with each other even though one cuts substantially to the central axis of the bit and all cut on the same conical surface.

FIGS. 3A, 4A and 5A illustrate the tooth structures of FIGS. 1 to 5 somewhat more in detail. It will be understood that these tooth structures will be selected according to the known tooth structures most suitable for the particular formation being drilled. It is well known that in drilling soft formations of a certain character, chisel-shaped sharp crested teeth are employed, while in certain formations not quite so soft more of a crushing action is required. FIGS. 3A, 4A and 5A illustrate teeth which are somewhat blunt.

In FIGS. 7, 8, 9, 7A, 8A and 9A there is shown still another form of cutter having teeth of the character known as insert or compact teeth. The bit body and bearing shafts for these cutters may be the same as those illustrated in FIG. 1 and no additional description thereof will be given at this point. However, the cutters are somewhat different. On the left-hand cutter body 42 illustrated in FIGS. 7 and 8 there is a blunt end 45 similar to the blunt end 26 of FIG. 1. However, the teeth on the sides or conical surfaces of this cutter are not formed from the mother metal of the cutter body and then hardened or hard surfaced as is the case in FIG. 1, but instead are formed by embedding inserts of hard material such as tungsten carbide or the like as illustrated at 46 and 47. The inserts 47 cut substantially at the outer edge of the bottom of the hole, and the inserts 48 which are provided in the shank of the bit body serve to assist the inserts 47 in maintaining the gauge of the hole.

In the blunt end 45 of this body 42 there are provided a number of teeth formed of such inserts, those at 49 being located around the margin of the blunt end and a single such insert at 50 being located centrally with respect to the axis of rotation of the cutter.

In similar fashion, the cutter body 52, of which only the blunt end and nose portion is illustrated, has cutting teeth inserts 53 located on its conical sides, with one circularly arranged group of insert teeth 54 and one central insert tooth 55 in the blunt end or nose portion of the cutter.

The cutter body 56, of which likewise only the nose portion is illustrated, has teeth formed of inserts 57 located in the conical sides thereof and a symmetrically arranged group of three inserts forming teeth 58 located in the blunt end thereof.

In the case of this bit arrangement the cutter 56 has the smallest blunt end, the cutter 42 next, and the cutter 52 the largest blunt end. In each case the action of cutting the core will be similar to that described in connection with FIGS. 1 to 5, inclusive, except that with this form of cutter the cutting is done by more impact and pressure than by chipping and actually cutting. However, the scraping movement of each cutting tooth across the sloping upper surface of the core will in every case be similar to that described in connection with FIGS. 1 and 2.

FIGS. 7, 8 and 9 each show two only of the cutters of a three-cutter bit, each figure being along the plane of the axes of the two cutters, in order to show how each cutter interfits, and does not interfere, with the other two cutters.

With reference to FIG. 6 there is illustrated a still further modification which will be found highly advantageous in connection with certain types of formation. The blunt end 60 on the cutter of which only the nose portion is shown in this figure has sharp crested teeth such as above described, but instead of being arranged in radially disposed positions as in the previously described cutters, these are skewed, and, in the form shown, are arranged in spiral rows, two spiral rows being shown in this figure. The outer teeth 61 of these spiral rows are preferably somewhat longer along their crests than the inner teeth 62 of these rows. However, in each instance the crest of the tooth extends along the length of the spiral row. The effect of this arrangement is that when this cutter nose rotates the cutting crest will move across the formation of the core with a motion which is partly transverse to the cutting crest but which also has a component in a direction longitudinally of the cutting crest so as to produce a shaving or shearing action with a slight sawing effect. The efficiency of such a movement in cutting is well known and this novel arrangement of cutting teeth tends to produce the desired effect.

While described and illustrated as applied to a three-cutter bit, it will be apparent that this invention is applicable to bits with any number of cutters. Also, the teeth or cutting elements can be of any conventional material such as diamonds, tungsten carbide, or other substance or any combination thereof.

It will also be apparent that in each form illustrated the cutting action of the inner end teeth will produce a thrust reaction on the cutter which will be directly opposed to the thrust reaction on the cutter resulting from the cutting action of the gauge forming teeth. These will thus tend to balance each other and reduce the thrust bearing capacity required for the cutter.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. In a drill bit comprising a hollow body having a connection for a drill stem at its upper end and a cutter carrying leg extending downwardly from a predetermined position on its circumference, a downwardly and inwardly extending cutter bearing on said leg adjacent its lower end, and a generally frusto-conical cutter, with cutter teeth on its outer conical surface, journaled on said bearing and disposed with its larger end radially outermost from the bit axis, the improvement which comprises said cutter terminating at its inner extremity short of the bit axis and cutting teeth on said extremity directed axially of the cutter with cutting extremities separated from each other by relief areas, the cutting extremities having an aggregate area exposed axially of the cutter less than the aggregate area separating the cutting extremities which cutting extremities in rotation define a surface whose elements form a greater angle with the cutter axis than the cutter axis does with the bit axis for engaging the core which would be left by the other teeth of said cutters at the center of a bore being drilled by said bit.

2. A drill bit improvement as set forth in claim 1 in

which at least part of the cutter teeth on said cutter inner extremity have elongated crests disposed at an angle to the direction of motion of the teeth across a core formation to cut the same with a motion having at all times sidewise and endwise components of the teeth across the formation as they engage the same.

3. A drill bit improvement as set forth in claim 1 in which at least part of the cutter teeth on said cutter inner extremity have elongated crests arranged in spiral rows with the crests extending longitudinally of the rows.

4. In a drill bit comprising a hollow body having a connection for a drill stem at its upper end and a plurality of cutter carrying legs extending inwardly from predetermined spaced positions on its circumference, a downwardly and inwardly extending cutter bearing on each of said legs adjacent its lower end, and a generally frusto-conical cutter with cutter teeth on its outer conical surface journaled on each bearing and disposed with its larger end radially outermost from the bit axis, the improvement which comprises each cutter terminating at its inner extremity short of the bit axis and cutting teeth on each such inner extremity directed axially of the cutter and having cutting extremities which in rotation define a surface whose elements form a greater angle with the cutter axis than the cutter axis does with the bit axis for engaging the core which would be left by the other teeth of said cutters at the center of a bore being drilled by said bit, the effective cutting extremities of corresponding ones of said axially directed teeth of different cutters being located equidistant from the rotational axis of the bit measured parallel to the cutter axis, whereby the cutting teeth of all cutters will in rotation operate on the same surface of the formation, and the end cutting teeth on certain of said cutters being of less radial extent with respect to their cutter axis than are the end cutting teeth on other of said cutters, whereby interference between the end cutting teeth on adjacent cutters will be avoided.

5. In a drill bit comprising a hollow body having a connection for a drill stem at its upper end and a cutter carrying leg extending downwardly from a predetermined position on its circumference, a downwardly and inwardly extending cutter bearing on said leg adjacent its lower end, and a generally frusto-conical cutter, with cutter teeth on its outer conical surface, journaled on said bearing and disposed with its larger end radially outermost from the bit axis, the improvement which comprises said cutter terminating at its inner extremity short of the bit axis and cutting teeth on said extremity directed axially of the cutter and having cutting extremities which in rotation define a surface whose elements form a greater angle with the cutter axis than the cutter axis does with the bit axis for engaging the core which would be left by the other teeth of said cutters at the center of a bore being drilled by said bit, said axially directed teeth being arranged with at least one cutting tooth interrupting every diametrical path across the inner extremity of such cutter so that at all times at least one tooth will be in cutting engagement with such core.

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