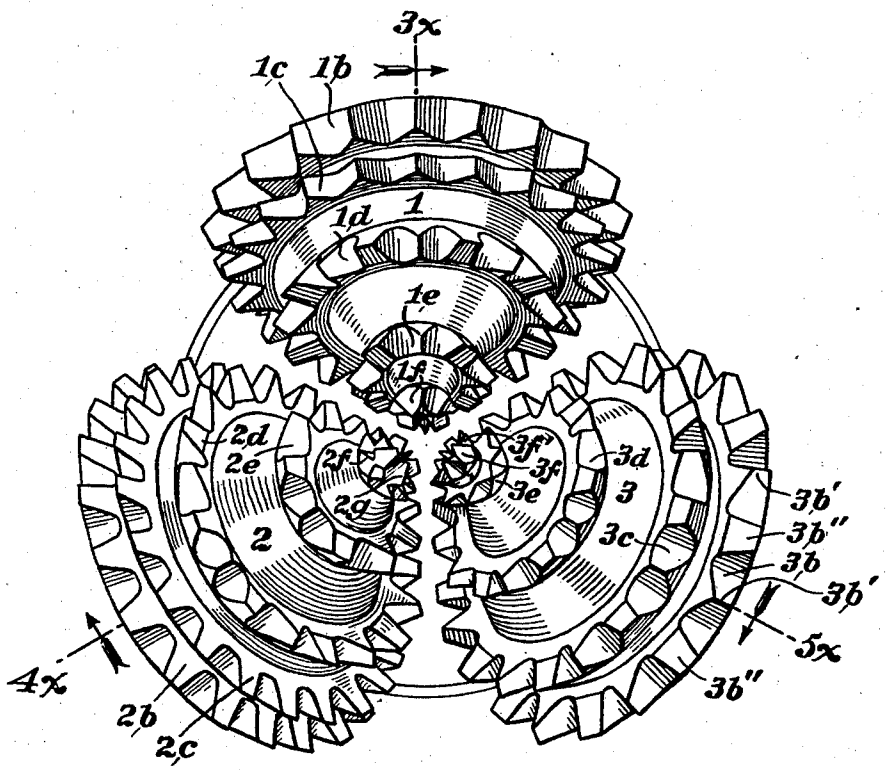
May 17, 1938. C. E. REED 2,117,679

EARTH BORING DRILL

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Fig. 1.



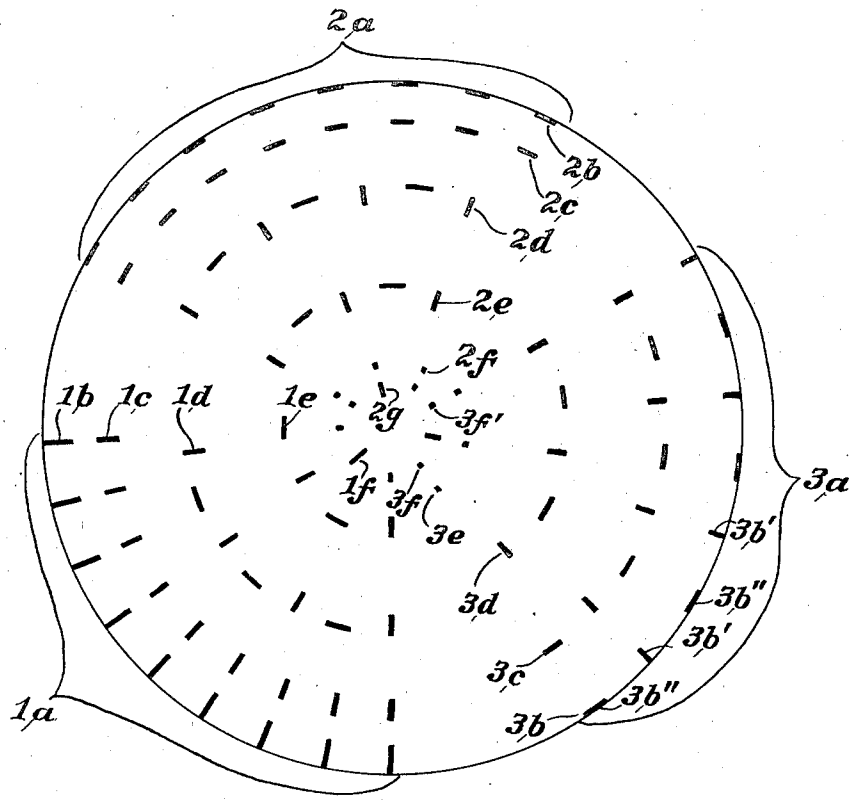
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Fig. 2.



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Fig. 3.

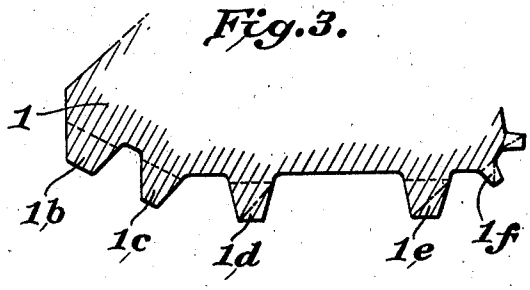


Fig. 4.

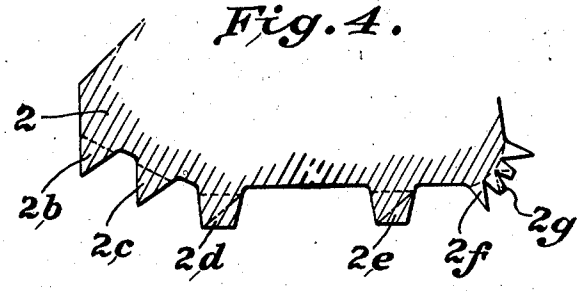
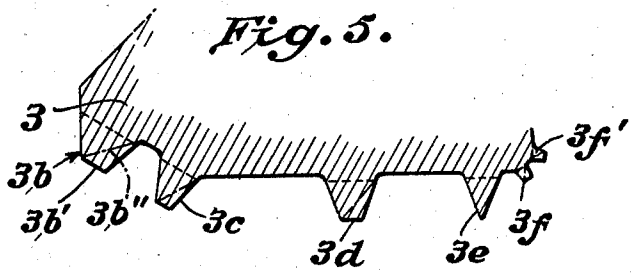


Fig. 5.



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Patented May 17, 1938 2,117,679

UNITED STATES PATENT OFFICE

2,117,679

EARTH BORING DRILL

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Application December 27, 1935, Serial No. 56,399

16 Claims. (Cl. 255—71)

It has been found in practical field use of rotary earth boring bits that in earth formations which are cut rapidly by roller cutters a surprisingly small total amount of teeth edge is required in proportion to the area of bottom to be disintegrated. Cutter teeth in conventional bits up to now have largely remained of the old, inverted V-type with the cutting edges, or crests disposed in planes radial to the cutter axis. Such teeth are individual short lengths of edge running radially of the drill. In certain earth formations such radially disposed crests of the several rows of teeth on one cutter make radial grooves in the bottom of the bore hole, thus forming radial ridges in the earth, which ridges are about as high as the teeth are deep in the cutter shell. The relation between the bottom surfaces of the cutters and the earth then becomes that of a gear, and the drill cutters "ride" on the ridges formed in the bottom of the hole. The frictional contact of such "gear" relation greatly retards penetration of the teeth into the formation and slows down drilling speed. The individual tooth penetration per revolution of bit head is only four one-hundredths of an inch, with drill making 12 ft. per hour at 60 R. P. M. and this penetration is mostly in the bottom of the grooves in the bottom of the bore hole. For rubbing off of the ridges at the bottom of the bore hole, reliance was had upon contact of the smooth portions of the periphery of the cutters with said ridges.

In shales of the characteristic "toughness" permitting radial and annular ridges to arise in the bottom surface of the hole, the flanks, meaning the sloping sides, of the teeth of conventional cutters slip or rub frictionally on the sides of the ridges and penetrate the earth formation very slowly because the resistance of the formation is enough to prevent the formation breaking readily under the very limited number of teeth at any one time contacting the bottom, and the teeth work into the formation making grooves, the sloping sides of the teeth rubbing off only very fine particles of the formation. The teeth are said to "ride" the formation, meaning the sides of the teeth bear on the sides of the ridges formed. The cutting edges of the teeth remain sharp. Wear marks on the teeth show plainly on the sloping sides of such teeth when withdrawn from such formations.

This invention has for one object an arrangement of cutting edges for preventing such gear relationship from arising. Another object is the provision of teeth for digging into the side slopes of any such ridges that tend to rise in the bottom of the hole to thereby assist in breaking up such ridges, so that speedy drill penetration may take place.

In the drawings:

Fig. 1 is a bottom plan view of the drill showing three frustoconical cutters and arrangement of the teeth thereon.

Fig. 2 is a diagram of the impressions made by the cutters of Fig. 1 on the bottom of the bore hole, the inclination of the two cutting zones of each cutter being ignored, and the drill rotated through only a part of a revolution so as to bring enough teeth in contact to show the sequence of impressions.

Fig. 3 is a section on the line 3*x* of cutter 1, the next rearward teeth being projected upon the plane of the section and being shown in dot and dash lines.

Fig. 4 is a section on the line 4*x* of cutter 2, the next rearward teeth being projected upon the plane of the section and being shown in dot and dash lines.

Fig. 5 is a section on the line 5*x* of cutter 3, the next rearward teeth being projected upon the plane of the section and being shown in dot and dash lines.

The invention is particularly adapted to three cone bits and is here shown in this relation. It is well known that two cone bits have a decided tendency to run tangent to the circular path of the rows of teeth, which tendency causes the bits to wabble or run eccentric to the axis of rotation of the drill, whereas the three cone bits, being better balanced have practically no tendency to run eccentric and do have tendency to run concentric to axis of rotation, hence the rows of teeth on three cones in conventional forms of drills more readily become "geared" to the radial grooves and ridges of the bottom surface of the bore hole when the characteristics of the formation permit such ridges to form. The present tooth arrangement minimizes this tendency to three cone cutters to become "geared" to the ground.

For purpose of illustration the invention is here applied to a cone type cutter having two separately tapered cutting surfaces, the apex of one surface, if extended, being far to one side of the axis of rotation of the drill. This relation is shown in Figs. 3, 4 and 5 which show the cutters as having a base zone and an apex zone inclined relative to each other. Such cutters are called non-true-rolling cones, the teeth thereon having a twisting, slipping action in contact with

the earth, giving a scraping action in normal operation.

These cutters are indicated generally in Fig. 1 by the numerals 1, 2 and 3. The impressions formed by the teeth of these cutters on the bottom of the hole are indicated at 1*a*, 2*a* and 3*a* respectively.

It will be noted that the rows of teeth upon the base zone of each cutter are spaced relatively close together, while the rows of teeth upon the apex zone are spaced wide apart. Preferably, the distance between the rows of teeth on the apex zone as measured at the base of the groove between these rows is at least two times the crest length of the individual tooth. As shown in Fig. 3, the distance between row 1*d* and row 1*e*, as thus measured, is approximately three times the crest length of a tooth on either row.

According to this invention, in some of the rows of teeth, substantially every other tooth has a length of cutting edge positioned at an angle to each adjacent tooth.

It will be noted, for instance, taking the circumferential row of cutter teeth marked 3*b*, that certain of the teeth 3*b'* have the cutting edges at their crests running in a direction from apex to base of the frustoconical body, or in other words these edges or crests lie in planes radial to the axis of the cutter.

Interspersed with these teeth 3*b'* are the teeth 3*b''* whose edge crests lie in planes transverse to the axis of the cutter so that said crests run in a general direction circumferentially of the cutter.

All of these teeth are four sided with oppositely disposed sides in convergent relation so that the teeth are of substantially pyramidal shape but with edge like crests or tops. The length of this crest line is shorter than the length of any one of the lines defining the base of the tooth.

On cutter 3 the circumferential rows of teeth 3*c* and 3*d* have teeth substantially like those just described on row 3*b* with the crest of each tooth running in a direction nearly at a right angle to the direction in which run the crests of the adjacent tooth. It will be noted that the teeth on row 3*e* are all brought to a point. In row 3*f* the teeth between the radial crests are brought to a point 3*f'* instead of being brought to a circumferentially disposed crest. The resulting impression of cutter 3 is shown in Fig. 2 at 3*c*.

The teeth which are similar in their adjacent circumferential rows may be in line with each other in a direction from base to apex on one cutter and out of line with each other on another cutter. In cutter 3 the corresponding teeth are in line with each other, that is, they lie generally in the same radial plane.

The teeth at the base zone of the cutter 3 have the alternating relation of radial and circumferential crests described, but this is not an essential. As shown on cutter marked 2, the teeth in rows 2*b* and 2*c* on the base zone have crests all running in a direction circumferentially of the cutter. On cutter marked 1 the teeth in rows 1*b* and 1*c* of the base zone have crests running in a direction in planes radial to the vertical axis of the drill.

On the apex zones of the cutters it similarly is not necessary that all circumferential rows of teeth have alternately arranged radially and circumferentially disposed crests. It has been noted that the teeth of row 3*e* on cutter 3 are all brought to a point and that row 3*f* included teeth having points. On cutter 2 this same general relation is present as the teeth in row 2*f* are all brought to a point and the teeth in row 2*g* include both points and radial crests, as best shown at 2*a* in Fig. 2. On cutter 1, however, all the teeth forming rows on the apex zone, namely rows 1*d*, 1*e* and 1*f* have the alternate arrangement of radial and circumferential teeth, as is clear from Fig. 2 at 1*a*.

It should be observed that the rows of teeth on the several cutters together disintegrate the entire hole bottom and that except for the base zone teeth and those at the extreme apex, the rows cut separate paths on the hole bottom. Thus, rows 1*f*, 2*g* and 3*f* substantially track each other. The rows 2*f*, 3*e*, 1*e*, 2*e*, 3*d*, 1*d*, 2*d*, cut successively outward paths up to the path cut by the teeth on the base zones of the cutters.

To obtain best results it is desirable that each path upon the bottom of the hole which is directly disintegrated by teeth, be acted upon by both radially and circumferentially disposed crests. If the path is passed over by a row of teeth on a single cutter the teeth in that row should include both radial and circumferential crests. For this reason row 3*d* which cuts its own individual path, includes both radial and circumferential crests. However, if the path is passed over by rows of teeth on several cutters it is immaterial whether the teeth in the row on one cutter include both crests arrangements. Thus, considering the rows 1*c* and 2*c* which track substantially the same path, it is made possible that row 1*c* have all radially disposed crests and that row 2*c* have all circumferentially disposed crests. The teeth in row 2*c* break up the ridges which the teeth in row 1*c* tend to form.

The effect of the alternate arrangement of relatively short lengths of cutting edges is to rapidly and effectively break down any ridge tending to form. In this invention the cutting edges of the individual teeth may be spaced relative to each other so that excessive distance from one edge to another edge in the same circumferential row is avoided and at the same time more metal removed between individual edges, so that the total of all actual contacting teeth is less than in the conventional tooth form and arrangement and the friction contact of smooth portions of the periphery of the cutters with the bottom is avoided or eliminated, therefore more and faster drill penetration of the earth formations is secured under any given weight on the drill, and as all teeth have short, sharp crests and relatively wide, broad bases, the teeth are each individually strong and do not break in operation. The slipping tendency of a non-true rolling cone employing this invention utilizes the one tooth to plow into the ridge formation, if it tends to rise, or into the bottom of the hole in a circumferential direction of the cutter, and the following tooth disposed crosswise, having radially positioned cutting edge, the cutter meets less resistance to its twisting tendency of the radial edges wedging off particles of formation, and thus ridges of earth formation capable of setting up the "geared" relationship do not form and faster drilling penetration or speed results.

It will be apparent to those skilled in the art that many variations respecting individual teeth proportions and exact position in sequences around the cone or in any one row radially, or in respect to the relationship of all cutters considered together in the drill, may be made within the spirit of the invention which contemplates broadly reducing the total of all cutting edges

proportional to the area to be disintegrated without increasing the frictional contact of untoothed portions of the cutter periphery and arrange the cutting edges in rows having some teeth positioned substantially at right angles to others and alternately, either in respect of teeth or of rows as arranged on the drill.

I claim:

1. In an earth boring drill having a rotary toothed cutting organization made up of at least three frusto-conical roller cutters disposed at the bottom of the drill about the vertical axis thereof, each cutter rotating about an axis inclining downwardly and inwardly towards the vertical axis of the drill, and having two separately tapered toothed cutting areas, the apex of one of said areas of each cutter, if extended, being far to one side of the vertical axis of the drill, said cutting organization having teeth whose crests extend in planes substantially radial to the vertical axis of the drill, and other teeth whose crests extend in planes substantially perpendicular to planes first mentioned, said other teeth tracking and alternating in position in the same circumferential row with the teeth first mentioned, substantially as described.

2. An earth boring drill according to claim 1 in which each frusto-conical roller cutter has its teeth differently disposed in relation to the disposition of the teeth on the other cutters, substantially as described.

3. In an earth boring drill having a rotary toothed cutting organization made up of at least three frusto-conical roller cutters disposed at the bottom of the drill about the vertical axis thereof, each cutter rotating about an axis inclining downwardly and inwardly towards the vertical axis of the drill, and having two separately tapered toothed cutting areas, the apex of one of said areas of each cutter, if extended, being far to one side of the vertical axis of the drill, said cutting organization having teeth whose crests extend in planes substantially radial to the vertical axis of the drill, and other teeth whose crests extend in planes substantially perpendicular to planes first mentioned one of the frusto-conical cutters having all of the teeth of one of its areas in a plurality of rows with their crests extending in the radial planes mentioned, and having teeth whose crests extend alternately in radial and perpendicular planes disposed in rows on said other area, substantially as described.

4. In an earth boring drill having a rotary toothed cutting organization made up of at least three frusto-conical roller cutters disposed at the bottom of the drill about the vertical axis thereof, each cutter rotating about an axis inclining downwardly and inwardly towards the vertical axis of the drill, and having two separately tapered toothed cutting areas, the apex of one of said areas of each cutter, if extended, being far to one side of the vertical axis of the drill, said cutting organization having teeth whose crests extend in planes substantially radial to the vertical axis of the drill, and other teeth whose crests extend in planes substantially perpendicular to planes first mentioned one of the frusto-conical roller cutters having all of the teeth of one area in a plurality of rows with crests extending in said perpendicular planes, and having teeth whose crests extend alternately in radial and perpendicular planes disposed in rows on said other area.

5. In an earth boring drill, a plurality of frusto-conical roller cutters, said cutters having each a plurality of toothed areas, the teeth of one area lying in spaced apart circumferential rows with the crests of some of said teeth extending in planes radial to the axes of the cutters, and others of said teeth on said area having their crests extending in planes perpendicular to the axes of said cutters, the teeth whose crests are in radial planes on one cutter non-tracking similarly disposed teeth on another cutter, and the teeth whose crests are in planes perpendicular to the axis non-tracking similar teeth on another cutter substantially as described.

6. An earth boring drill comprising a plurality of frusto-conical cutters, each having teeth lying in spaced apart individual circumferential rows, some of the teeth having crests extending in planes radial to the axis of the cutter on which they are mounted, and other teeth having crests extending in planes perpendicular to the axis of the cutter upon which they are mounted, said teeth in said radial and perpendicular planes tracking each other, substantially as described.

7. An earth boring drill according to claim 6 in which said tracking teeth are upon the same cutter.

8. An earth boring drill according to claim 6 in which said tracking teeth are upon separate cutters.

9. An individual frusto-conical roller cutter for an earth boring drill having two separately tapered cutting areas thereon, individual teeth arranged on said areas in individual rows, some of said teeth having crests extending in planes perpendicular to the axis of the cutter and in the same individual row with other teeth having crests extending in planes radial to the axis of the cutter.

10. An individual frustoconical roller cutter having two separately tapered cutting areas thereon and having individual teeth on said areas arranged in circumferential rows, the teeth in each row on one of said areas having crests which alternately extend in planes radial and perpendicular to the cutter axis, and the rows on the other area being spaced apart at least twice the length of a tooth crest in an adjacent row.

11. In an earth boring drill, a plurality of frustoconical cutters, each having circumferential spaced apart rows of teeth, some of said teeth on each cutter having crests lying in radial planes, and other teeth on each cutter substantially tracking the teeth last mentioned and having crests extending in planes substantially perpendicular to the radial planes in which the crests first mentioned lie to break down the ridges formed by the radial crests, said first mentioned teeth being arranged in alternating relation to said other teeth substantially as described.

12. In an earth boring drill, three approximately frusto-conical roller cutters uniformly spaced about the lower end of the drill, each cutter having a base toothed cutting area inclined to an apex cutting area, and individual teeth arranged on said apex area in a circumferential row lying wholly in a plane substantially perpendicular to the axis of the cutter, with some of said teeth of the row having crests in planes radial to the axis of the cutter and others of said teeth of the row having crests in planes intersecting radial planes of said cutter.

13. In an earth boring drill, a plurality of approximately frusto-conical roller cutters spaced about the lower end of the drill, each cutter having a base toothed cutting area inclined to an apex cutting area, and individual teeth on the base cutting area, some of which track teeth on the

other cutters, and teeth having cutting edges extending in planes radial to the cutter axis and positioned on the said apex area in rows non-tracking rows on the other cutters in which some teeth edges are positioned in planes intersecting planes radial to cutter axis.

14. A rotary toothed cutter organization for earth boring drills comprising three frusto-conical toothed rollers arranged about the vertical axis of the drill on axes inclining downwardly and inwardly towards said vertical axis, each of said cutters having a toothed base cutting area and a toothed apex cutting area, the teeth of the base area of one cutter having two circumferentially extending rows of teeth the crests of which extend in planes radial to the cutter axis, the base area of another cutter having teeth in circumferential rows with their crests in planes perpendicular to the axis of said cutter, the base area of the third cutter having circumferential rows of teeth with the crests of some of them extending in planes radial to the axis of the cutter and the crests of others of said teeth extending in planes perpendicular to the axis of the cutter, the apex portions of said cutters having teeth the crests of some of which extend in planes radial to the axis of their respective cutters and the crests of others of said teeth of said apex areas extending in planes perpendicular to the axis of their respective cutters, substantially as described.

15. An individual frusto-conical roller cutter having individual teeth arranged thereon in circumferential rows, the teeth in one of said rows having crests extending in planes radial to the axis of the cutter, and in planes perpendicular to the axis of said cutter, the teeth having crests extending in said radial planes alternating with teeth whose crests extend in said perpendicular planes.

16. An earth boring drill comprising a bit head, a plurality of roller cutters mounted thereon, each cutter having widely spaced circumferential rows of cutting teeth on its periphery, the rows of teeth on one cutter being adapted to roll over annular areas at the bottom of the bore hole, passed over by the spaces between the rows on another cutter, one or more of said rows comprising a set of teeth having crests extending circumferentially of the row alternating with a set of teeth having crests extending transversely to the crests on the first-mentioned set of teeth.

CLARENCE E. REED.