Dec. 7, 1943. J. A. ZUBLIN 2,336,335

ROTARY HAMMERING BIT

Filed Aug. 13, 1942 2 Sheets-Sheet 1

Fig. 1.

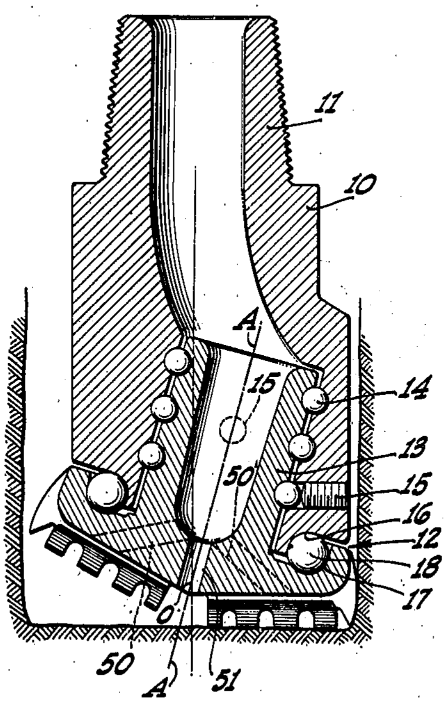


Fig. 2.

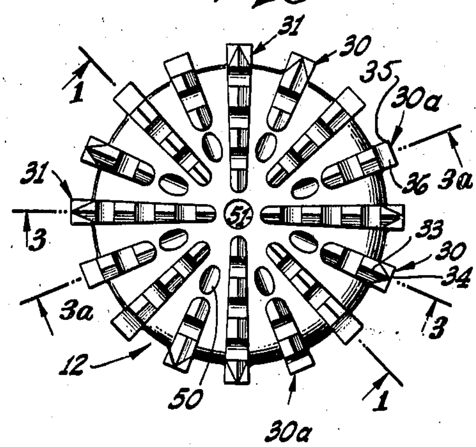
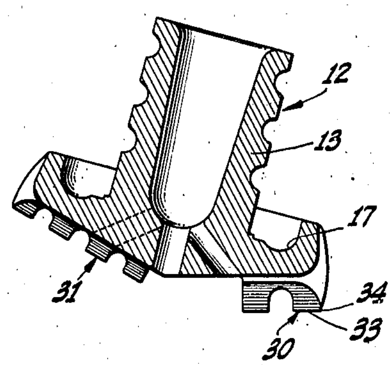


Fig. 3.



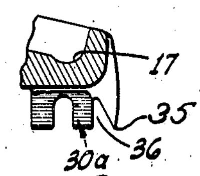


Fig. 3a.

Fig. 4.

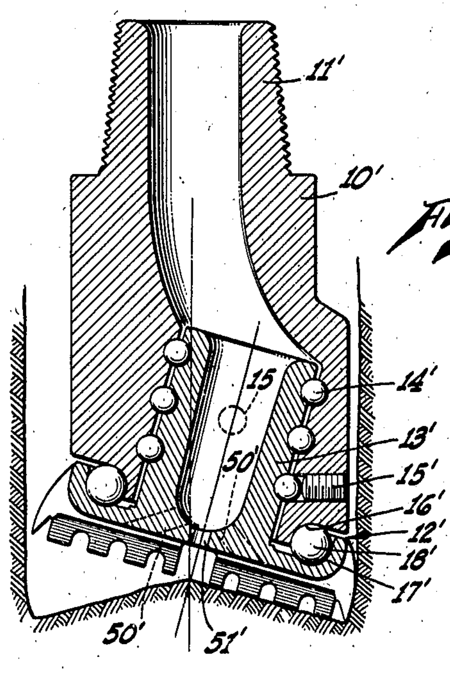


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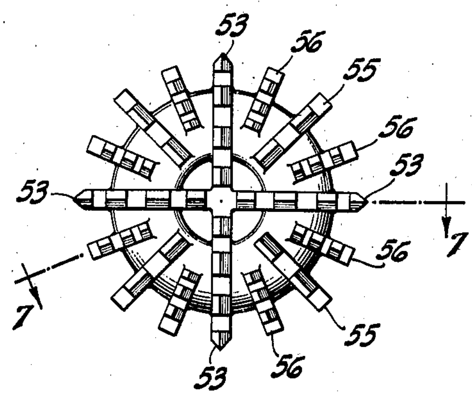
Fig. 6.



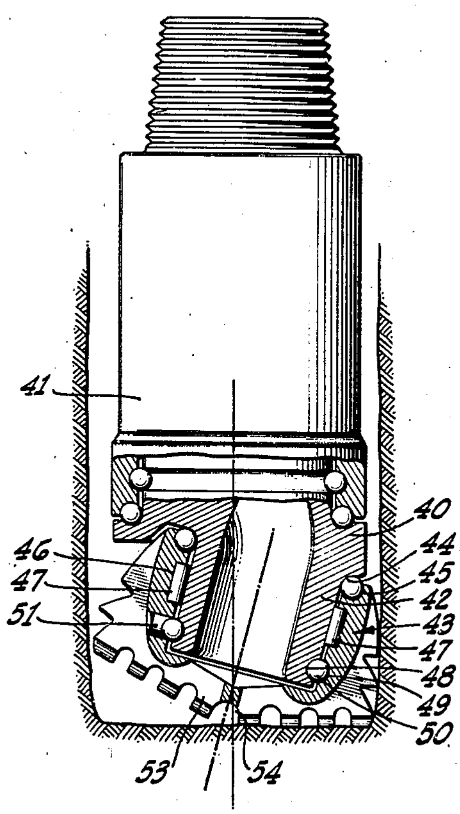


Fig. 5.

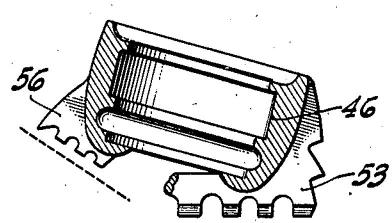


Fig. 7.

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ROTARY HAMMERING BIT

John A. Zublin, Los Angeles, Calif.

Application August 13, 1942, Serial No. 454,690

6 Claims. (Cl. 255—71)

The present application deals more particularly with the formation of a cutter for producing the effect described in my copending application, Serial No. 454,689, filed August 13, 1942, entitled "Method and means for rotary drilling." The principle involved in that and in this application is the attainment of a sufficient impact or blow on the formation by the teeth as they engage the same. A single cutter is provided with teeth which engage the formation as the cutter rolls about the bottom of the bore being produced. Due to the fact that the toothed body is not a continuous smooth surface, but is on the contrary more or less star shaped, it can be readily seen that when two adjacent teeth are in contact with the hole bottom, the cutter will be in a lower position than when only a single tooth is in contact with the formation. Thus as the cutter rolls from tooth to tooth, it is lifted and dropped. This lifting and dropping of the bit, together with the drill collar and the lowermost portion of the drill pipe, requires an acceleration of the lifted and dropped mass. Such acceleration can cause the penetration of the teeth into the formation. The net result is that instead of penetrating merely by the weight imposed upon the teeth, the teeth are actually hammered into the formation.

It can be appreciated that the distance through which the bit and its associated parts are lifted has a considerable effect upon the degree of hammering action on the formation. Thus for a given rotational speed, if the bit can be caused to rise and drop a greater distance than has been previously done, the hammering effect will be much greater. The distance through which the bit is raised and dropped through operation of the bit is dependent upon the number of teeth on the cutter, the angle of inclination of the cutter to the axis of rotation of the bit, and the distance between the teeth. Thus a bit having a minimum number of teeth would be raised and dropped a greater distance if these teeth were near the periphery rather than near the center of rotation of the bit.

In the drilling of wells by the rotary method, the most difficult portion of the formation to remove is that in the zone adjacent the wall of the bore produced. This is because the formation in that position is supported not only by its attachment to the formation directly beneath the bottom of the bore, but also by its attachment to the walls of the bore. Another reason for the difficulty in removing formation from the outermost zones of the circular well bottom is the fact that a zone of a given width obviously covers more area if near the periphery of the well bottom than if near the center thereof.

It is proposed to design a cutter which will impart to the portion of a formation which is most difficult to remove the greatest impact attainable at a given speed of rotation. Taking into consideration the fact that a given number of teeth equally spaced about the cutter axis will lift and drop the bit the greatest amount if these teeth are nearest the periphery, and taking into account the fact that the formation is most difficult to remove from the parts of the well bottom engaged by the periphery, it is proposed to have cutting teeth near the periphery of the cutter. As a supplement to this, it is also proposed to so form the teeth that they will have a cutting effect which is greater than that which has been hitherto achieved.

With the above brief explanation in mind, it is an object of the present invention to provide a drilling bit, the teeth of which will have a maximum impact upon the formation.

It is a further object of the present invention to provide a drilling bit which will have the greatest cutting effect upon the part of the hole bottom which is most difficult to remove.

It is a further object of the present invention to provide a drilling bit which will have the greatest cutting effect near the periphery of the bore produced.

It is a further object of the invention to provide cutting elements which will most effectively attack the formation in the corner between the walls of the bore and the bottom of the bore.

It is a well known fact that if a pattern can be produced on the bottom of a bore being drilled, the pattern can be removed with less energy than that required to produce it. This is because a pattern leaves upstanding portions in the formation which can be readily knocked off by the teeth of the cutter. However, the production of a pattern oftentimes interferes with the operation of a bit for the reason that the teeth of the cutter tend to gear themselves to the pattern and ride around without obliterating the pattern or cutting any deeper. This has led to the development of various types of bits in which the object to be attained seems to be the prevention of the production of any pattern. It is proposed, in one type of bit about to be described, to produce a pattern, the pattern being produced by the most effective teeth, and to then attack the upstanding portions of the pattern by what might be termed secondary or auxiliary teeth which need not be as effective as the primary or most powerful cutting teeth.

It is, therefore, a further object of the present invention to produce a drilling bit which will produce a pattern with one of two sets of teeth, and attack the upstanding portions of the pattern with another set of teeth.

The above described pattern producing bit need not, and in fact preferably does not, produce a pronounced pattern over the entire hole bottom. The pattern is preferably produced in the outermost zone of the hole bottom, which as has been explained above, is the most difficult part of the formation to remove. The central portion of the hole bottom can be removed in the normal way.

It is, therefore, a further object of the present invention to produce a bit in which a pattern is formed in the outermost portions of the bore by one set of teeth, the upstanding portions of which pattern are attacked by secondary teeth.

The production of a pattern in the outermost region of the bottom of the well bore, and the removal of upstanding portions of that pattern can be accomplished by the use of teeth set with their edges in two different planes or surfaces. Thus, the teeth which form the pattern should have their cutting edges below the teeth which are intended to attack the upstanding portions of the pattern. As it was pointed out that these two actions preferably should take place in the outermost portion of the hole bottom, and as the hammering effect is most efficiently generated by teeth which are near the periphery of the cutter, it becomes evident that the main teeth should extend inwardly from the periphery only part of the way to the center, and that the auxiliary teeth may extend from the periphery to a point considerably beyond the innermost ends of the main teeth. However, there is possible a variation on this construction. When a bit is rotated at a high rotational speed, e. g., by a turbine at the lower end of the drilling string, the tooth action is not so critical. It is then possible to have the main cutting teeth extend to points quite close to the axis of rotation of the cutter, while the auxiliary teeth extend from the periphery to points considerably short of the axis of the cutter.

Referring now to the drawings:

Figure 1 is a longitudinal section through the center of one form of bit embodying the present invention;

Figure 2 is a bottom view of the cutter shown in Figure 1;

Figure 3 is a section of the cutter of Figure 2, taken on line 3—3 thereof;

Figure 3*a* is a fragmentary section of the cutter of Figure 2, taken on line 3*a*;

Figure 4 is a longitudinal section of another form of bit embodying the present invention;

Figure 5 is a partial longitudinal section of still another form of bit embodying the present invention;

Figure 6 is a bottom view of the cutter employed in the form of bit shown in Figure 5; and,

Figure 7 is a section along line 7—7 of Figure 6.

The bit shown in the present application comprises essentially a shank member which is secured to the drilling string, and a cutter mounted for rotation on this shank member about an axis which is inclined with respect to the axis of rotation of the bit shank. Referring particularly to Figure 1, a shank member **10** is provided with a pin **11** for connection to the drill collar and the rest of the drilling string. On this shank is mounted a cutter **12**. This cutter is mounted on this shank by means of a stem **13**, which projects from the cutter body into a bore in the shank. One or more races are provided in the shank and in the stem **13**, to contain the balls **14** which act as bearings between the shank and the cutter stem. These balls also serve to retain the cutter in place and to carry a considerable portion of the thrust. These balls may be inserted through holes in the shank which are afterwards closed by means of plugs **15**. The plug for the uppermost row is in the part of the shank cut away.

In order to hold the cutter body against both radial and axial movement a bearing is provided between the body of the cutter and the body surface of the shank. This bearing has been shown as being in the form of a combination thrust and radial bearing, the shape of the races **16** and **17** adapting this bearing to this type of service. The balls **18** in this bearing have been shown as being of considerably larger diameter than the balls in the previously mentioned bearings and they, therefore, can carry a considerably greater load. The cutter thus rotates about the axis A—A, which intersects the axis of the bore at point O.

The teeth on the body of the cutter are shown in detail in Figures 1, 2, 3 and 3*a*. As shown in Figure 2, the teeth are radially disposed, and have a plurality of notches cut in their length which serve to decrease the total length of cutting edge in contact with the formation at any one time, thus increasing the depth of penetration.

As shown in Figure 3, the teeth have two different levels. Thus tooth **30** extends further from the surface of the body than the tooth **31**. It will also be noted that the cutting edge of tooth **30** is considerably shorter than the cutting edge of tooth **31**. Thus tooth **30** extends from the periphery of the cutter to a point considerably short of the axis of the cutter. Tooth **31**, on the other hand extends almost to the axis of the cutter. In the present instance what might be termed the high or main teeth **30** alternate with the low or secondary teeth **31**. It may be sometimes desirable to alter this arrangement, depending upon the particular type of formation encountered.

In order to assure a complete coverage of the formation by the teeth, all of the teeth **30** have their notches so disposed that an unnotched portion of each adjacent main tooth falls opposite a notched portion of another main tooth. There is no portion of the formation within the zone intended to be covered by the teeth **30** that is not covered by any one tooth or its neighbor. A similar scheme is employed for the secondary teeth **31**. In order to more fully carry out this scheme of alternating unnotched and notched portions on the teeth and in order to provide a type of tooth which will clear the corner between the bottom of the well bore and the wall of the bore, both teeth **30** and **31** alternate with a tooth of the structure shown in Figure 3*a*. The tooth **30** has a cutting edge **33** which extends to the end of the tooth. Peripheral cutting edge **34** merges with this radial cutting edge. This is the form of tooth shown in Figure 3. However, the tooth **30*a***, as shown in Figure 3*a*, has a peripheral edge **35** which is formed by a notch in the body of the tooth. The same form of alternation of the tooth ends may be practiced with the teeth **31**.

The form of tooth shown in Figure 3 is particularly useful in clearing away the formation at the corner above described. It will be noted that the edge **34** can be made quite thin, as it and the edge **33** mutually support each other.

The above description is of the preferred embodiment of the present invention. In Figures 5, 6 and 7 there is shown a modified form of cutter which is particularly useful in a bit which has a high rotational speed. This high rotational speed may be attained by the use of a turbine such as that illustrated in my copending application, Serial No. 454,691 filed August 13, 1942, for a turbine rotary bit. In Figure 5, no constructional details of the turbine are shown, the shank **40** being driven by turbine means within the body **41**. This shank **40** has a pin **42** formed on its lowermost end which supports a cutter **43** for rotation about an axis at an angle to the axis of the bit as a whole. A bearing is formed by races **44** and **45** respectively in the shank and in the cutter body. This bearing is so formed that it will resist upward and radial movement of the cutter, but will not prevent downward movement of the cutter on the pin. A race **46** in the body of the cutter serves to hold roller bearings **47** which are adapted to resist radial movement of the cutter. In order to hold the cutter in place when it is out of contact with the bottom, a pair of races **48** and **49** are cut in the shank and cutter respectively to receive balls **50**. These balls may be inserted through an opening in the cutter body which is afterwards closed by a plug **51**. It will be noted that the bearings formed by the balls **50** serve to prevent axial movement of the cutter in either direction, and they thus serve to lock the cutter securely in place.

The teeth on this type of bit may be the same as those shown in Figures 1 to 3. However, this type of cutter can employ a little different type of tooth formation as shown in the figures. Teeth **53** extend substantially entirely across the cutter. Of course a notch **54** at the center of the cutter is present. Other notches are placed at intervals along the length of the teeth for the same reason as the notches in the preferred form of device. Intermediate these teeth **53** are teeth **55** set at the same level but extending inwardly only to the edge of the water circulation opening.

These teeth **53** and **55** are intended to act as the main cutting teeth of the device; that is, they act in a manner exactly the same as the short teeth **30** of the preferred form. Intermediate these teeth is a series of secondary teeth **56**. It will be noted that these teeth **56** lie in a surface which is above the surface passing through the main teeth **53** and **55**.

The ends of the teeth may be formed in the same manner as the teeth in the preferred form. However, it is possible to utilize teeth which have a substantially radial cutting edge without the peripheral edge shown in Figure 2. Thus the four main teeth crossing the water circulation opening have been illustrated as formed in this fashion. The same alternation between teeth may be practiced in this form of device as was practiced in the preferred form.

The action of both types of cutter should now be clear. The main teeth in both forms, that it, teeth **30** and teeth **53** and **55** project from the body of the cutter so that they would be the only teeth in contact with the hole bottom if the hole bottom were flat or conical. Thus, as the bit rotates, the cutter, in rolling from tooth to tooth, is lifted and dropped as described in my co-pending application mentioned above. It will be appreciated that the lifting and dropping of the form shown in Figure 2 is through a much greater distance than is true in the form of Figure 5, because the teeth extend radially to a point closer to the axis of the bore in the form shown in Figure 5. This is compensated by the fact that the cutter in the form of Figure 5 is rotated at a comparatively high speed.

The wide spacing of the main teeth might result in the formation of a pattern on the bottom of the bore. The secondary teeth are intended to break up this pattern. It is understood that the secondary teeth can readily knock off upstanding portions of the pattern as they come in contact with them, as an upstanding portion can be readily broken off, as compared to the difficulty of forming the notches defining such upstanding portion. Thus, the secondary teeth require, comparatively speaking, no impact.

In the figures described, the axis of the cutter and the axis of the bit intersect at a point above the formation. This produces a slight scraping action of the cutter over the formation. It may be desirable to provide a bit which has a true rolling motion over the formation. This type of bit has been shown in Figure 4. The details of this bit are exactly the same as those of the bit shown in Figure 1, and the corresponding parts have therefore been indicated by primed numerals. The cutter shown in Figure 4 is flat rather than conical, but this is merely to assure that the bore produced will be of the same diameter as the diameter of the cutter. Other details of construction are exactly as shown in Figure 1.

The forms shown in Figures 1 and 4 are intended to operate with drilling fluid in the usual manner. However, it is desired to have the drilling fluid issue from the cutter in such a direction that it has the maximum efficiency in cleaning the teeth of the bit and the formation. For this reason, the water passages **50** are provided from the hollow stem to points distributed over the face of the cutter. A central opening **51** may also be provided. It will be noted that the openings **50** pierce the body of the cutter at points between the teeth, and thus the issuing streams efficiently wash the teeth, and, when the teeth are in contact with the formation, also wash the formation.

It is to be clearly understood that the above description and the drawings are intended to be illustrative of the present invention and should not be taken as limiting the scope of the present invention, which is best apprehended by the appended claims.

I claim:

1. In a cutter for a gyrating bit, a plurality of teeth each having a cutting edge extending toward the axis of rotation of said cutter and a peripheral cutting edge on its outer end, some of said teeth each having the first mentioned cutting edge intersecting the corresponding peripheral cutting edge, others of said teeth each having a gap between the first mentioned cutting edge and the corresponding peripheral cutting edge.

2. In a cutter for a gyrating bit, a plurality of teeth, each having a cutting edge extending toward the axis of rotation of said cutter and a peripheral cutting edge on its outer end, alternate teeth each having the first mentioned cutting edge intersecting the corresponding peripheral cutting edge, the remaining teeth each having a gap between the first mentioned cutting edge and the corresponding peripheral cutting edge.

3. A gyratory bit cutter having a series of teeth with their cutting edges lying in a surface of revolution having its axis coincident with the axis of rotation of the cutter and lying in planes

passing through said axes and a second series of teeth with their cutting edges lying in a similar surface of revolution about the same axis and lying in planes passing through said axis, said second surface being axially spaced from said first surface, and a single tooth of the first series lying between each adjacent pair of teeth of the second series.

4. A gyratory bit cutter having two series of radiating teeth with cutting edges, a single tooth of the first series lying between each adjacent pair of teeth of the second series, the cutting edges of all teeth of the first series lying in a surface of revolution about an axis coincident with the axis of rotation of the cutter and the cutting edges of all teeth of the second series lying in a similar surface of revolution about the same axis, said surfaces of revolution being axially spaced from each other.

5. A gyratory bit cutter having a working face provided with two series of teeth having cutting edges, the cutting edges of all teeth of the first series lying in a surface of revolution about an axis coincident with the axis of rotation of the cutter and extending from the periphery of said working face toward the axis of rotation of the cutter but terminating a substantial distance from said axis, and the cutting edges of all teeth of the second series lying in a similar surface of revolution about the same axis and extending from the periphery of said working face toward and in close proximity to the axis of rotation of the cutter, the teeth of the first series alternating with teeth of the second series, said surfaces of revolution being axially spaced from each other.

6. A gyratory bit cutter having a working face provided with a large central opening for discharge of drilling fluid and two series of radiating teeth having cutting edges, a single tooth of the first series lying between each adjacent pair of teeth of the second series, the cutting edges of all teeth of the first series lying in a surface of revolution about an axis coincident with the axis of rotation of the cutter and the cutting edges of all teeth of the second series lying in a similar surface of revolution about the same axis, said surfaces of revolution being axially spaced from each other, and at least some of the teeth of one of said series being united at their inner ends to bridge said large central opening.

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