Dec. 29, 1964 M. VAGINS ETAL 3,163,246

ROCK DRILL BIT

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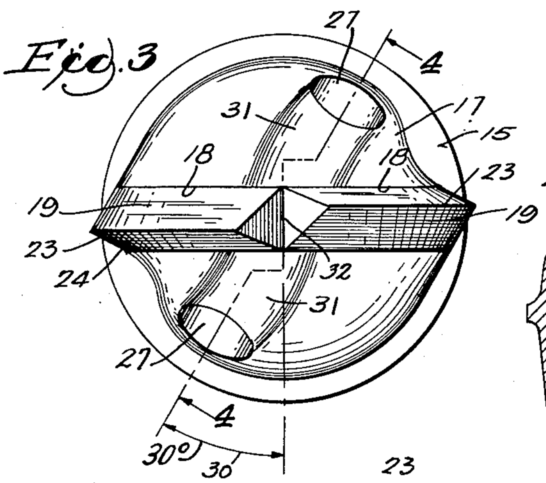
FIG. 3



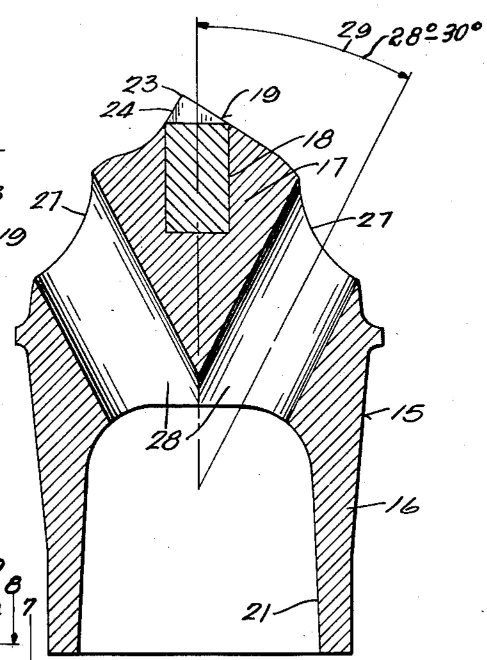


FIG. 4

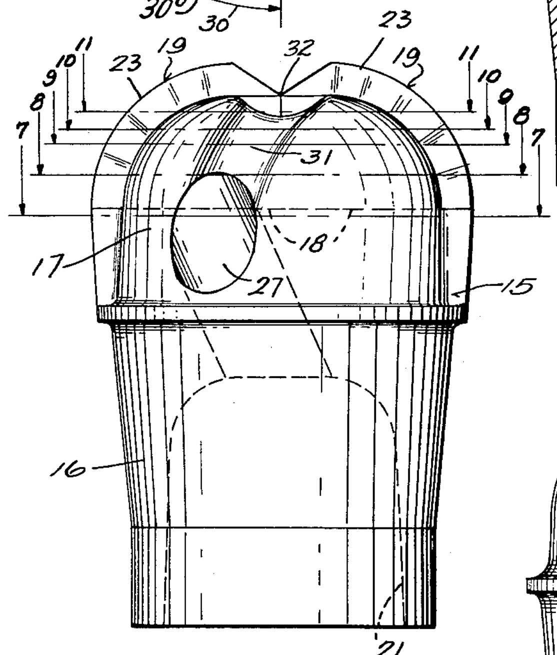


FIG. 1

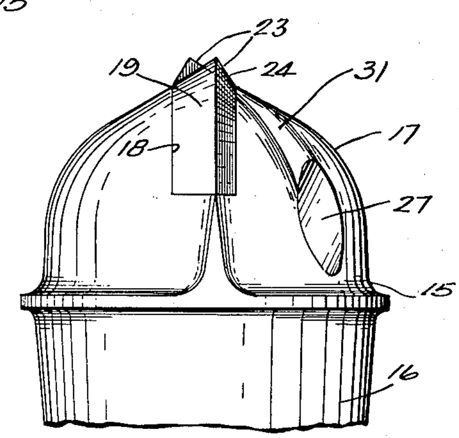
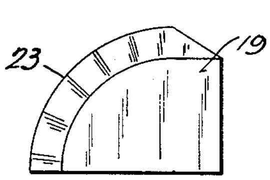


FIG. 2



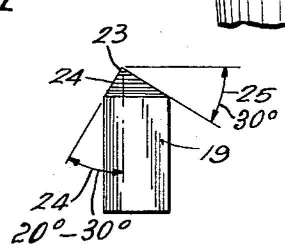


FIG. 5 FIG. 6

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ROCK DRILL BIT

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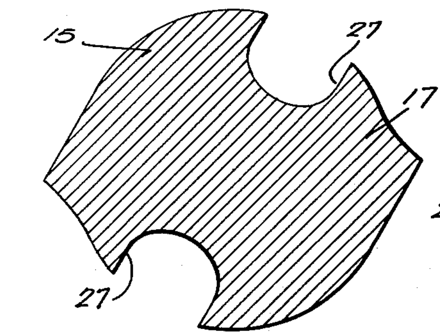

Fig. 7

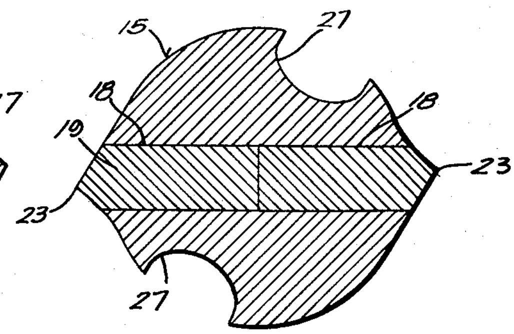

Fig. 8

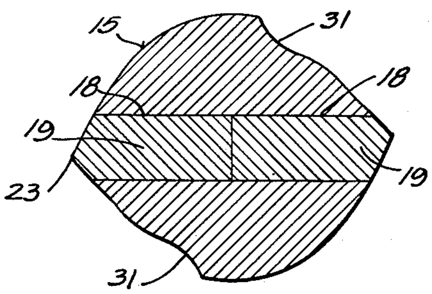

Fig. 9

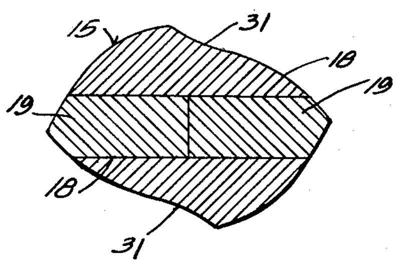

Fig. 10

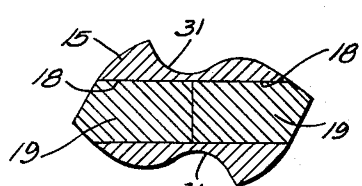

Fig. 11

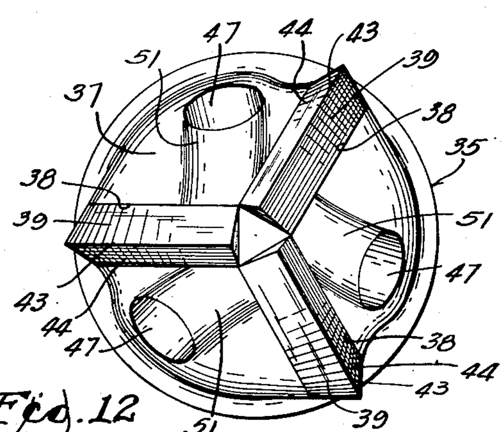

Fig. 12

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3,163,246
ROCK DRILL BIT

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6 Claims. (Cl. 175—410)

The present invention relates generally to improvements in the art of rock drilling and relates more particularly to the provision of an improved rock drill bit suitable for use with either rotary or percussive drills and also particularly adapted for rotary-percussive operation.

In the drilling of rock, the majority of operations presently employ either a percussive drill or a rotary drill dependent upon the types of rock encountered. Normally, percussive drilling is employed for hard rock, such as granite, and for extremely abrasive softer rock, such as sandstone; and rotary drilling is used on soft types of rock, such as shale. In the percussion method, apparatus is used which performs constant percussion blows against the rock with the boring member or bit being backed off between blows and rotated or indexed slightly to a new striking position. On the other hand, the rotary type employs apparatus in which a constant and uninterrupted rotation is imparted to the bit which is retained under pressure and in constant contact with the rock.

While both the percussion drilling method and the rotary drilling method have been in widespread use for many years, neither of these modes can drill very hard rock types or extremely abrasive rock types at a high rate of penetration without the application of high power inputs and large applied thrusts wihch, in turn, results in added down time due to drill-steel failure and excessive bit wear. Furthermore, since specialized drilling machinery is required for each type of drilling with vastly different bits being used in each instance, the investment in equipment necessary in order to operate satisfactorily under varying conditions as well as the costs resulting from down time for changing drills are undesirably high.

Accordingly, in fairly recent years, it has been proposed to combine the percussion method of drilling with the rotary method. This type of drilling operation is commonly referred to as a rotary-percussion method, and in exploiting the same, the drilling tool or bit is rotated constantly with sufficient thrust applied so that the mode of action of the bit cutting edges, charcteristic of rotary drilling is attained, while being simultaneously subjected to a constant series of percussion blows. However, the rotary-percussion method of drilling has thus far enjoyed only limited success due to the fact that the drilling machines have been relatively large and cumbersome and therefore incapable of operations in restricted areas. Furthermore, conventional bits of the type used in rotary drilling as well as those used with ordinary percussion apparatus have not proven adaptable for combined rotary-percussion operations, and the redesigned bits heretofore proposed for rotary-percussive drilling have likewise not been entirely satisfactory.

For example the bit shown and described in United States Patent No. 2,294,004, dated August 25, 1942, is of one-piece construction with the wings formed integral with the body and radiating outwardly from the apex of the head along spiral or helical paths which virtually precludes the use of wear resistant cutting inserts as a practical matter due to the complicated, if not impossible, machining operations which would be necessitated. Thus, in order that the one-piece bits of Patent No. 2,294,004 have any wear resistance whatsoever to the impacts resulting from rotary-percussive drilling, they must be formed

in their entireties of selected metals specially treated and machined at relatively high and prohibitive cost.

Another type of bit heretofore proposed for rotary-percussion operation is shown and described in United States Patent No. 2,507,221, dated May 9, 1950, wherein the cutting wing or contact edge is formed separately of the body of a wear resistant material and in which flushing holes are provided in the head. However, the symmetrical angles of the cutting elements of this type of bit on opposite sides of their apices have proven inefficient for rotary-percussive drilling, and the sharp terminal portions of the wings have been found to deteriorate rapidly due to extreme impact forces in these areas. Furthermore, the placement of the flushing holes in relation to the cutting inserts is relatively ineffectual in cooling the inserts, and these bits have therefore not proven entirely satisfactory for combined rotary-percussion drilling.

United States Patent No. 2,756,967, dated July 31, 1956, shows and describes another type of rotary-percussion drill bit which recognizes some of the shortcomings of the prior tools, and this bit has enjoyed a fair degree of success. However, the wings of this bit again terminate in sharp angular corners at the periphery of the head, and since the greatest rates of bit wear occur near the outer gage of the bit due to the fact that the amount of rock broken out per unit length of bit edge increases in proportion to the radial distance from the axis of rotation, these corner portions are subjected to the greatest force and friction in use and consequently cause a shortened wear life. Also, the relatively sharp angularity of the mating portions of adjacent surfaces of the head of this prior bit have been found to create fatigue points, and the means for cooling the cutting elements still leaves something to be desired.

It is therefore an object of the present invention to provide an improved bit for rotary-percussion drilling which obviates the disadvantages and objections attendant prior tools intended for similar use.

Another object of this invention is to provide a rotary-percussion drill bit which has a cutting head of hemispheroidal shape and wherein the cutting elements or wings are curved in a plane which includes the axis of the bit so as to increase the length of cutting edge per unit increase in radial distance from the axis of rotation to equalize the amount of rock broken by all portions of the cutting edges per unit distance advance of the drill and tending to equalize the wear of the cutting edges over their entire lengths, thus resulting in maximum operating efficiency and long life.

Still another object of the invention is to provide an improved bit of the rotary-percussion type which has a body and cutting edges so designed as to eliminate sharp fatigue points and points of stress concentration, and which is moreover provided with extremely effective flushing and bit edge cooling, all aiding in prolonging the bit life.

An additional object of the present invention is to provide an improved rotary-percussion rock drill bit wherein the head is provided with cutting elements formed of a material possessing high impact strength and having smoothly contoured mating steel surfaces to minimize critical stresses and early fatigue failures.

These and other objects and advantages of the invention will become apparent from the following detailed description.

A clear conception of the construction of a typical rotary-percussion drill bit embodying the improvements constituting the present invention may be had by referring to the drawings accompanying and forming a part of this specification wherein like reference characters designate the same or similar parts in the several views.

FIG. 1 is a side elevation of a typical embodiment of the invention as applied to a two-bladed or double-wing removable drill bit body;

FIG. 2 is a fragmentary side elevation taken from another side of the same drill bit;

FIG. 3 is a view taken from the working end of the drill bit of FIG. 1;

FIG. 4 is a vertical transverse section through the bit taken along the line 4—4 of FIG. 3;

FIG. 5 is a side elevational view of one of the cutting elements removed from the head of the bit;

FIG. 6 is an end view of the cutting element or insert of FIG. 5 as taken from the inner end of the same;

FIG. 7 is a transverse section through the bit taken along the line 7—7 of FIG. 1;

FIG. 8 is a transverse section taken along the line 8—8 of FIG. 1;

FIG. 9 is a transverse section taken along the line 9—9 of FIG. 1;

FIG. 10 is a similar section taken along the line 10—10 of FIG. 1;

FIG. 11 is another transverse section taken along the line 11—11 of FIG. 1; and

FIG. 12 is an end view of a somewhat modified drill bit embodying the invention but provided with three blades or wings.

While the invention has been shown and described herein as being especially applicable to a rotary-percussion drill bit having a tapered shank portion and formed in a particular manner of certain specified materials, it is not intended or desired to thus unnecessarily limit the scope or utility of the improvements by reason of such restricted embodiments; and it is also contemplated that certain specific terminology used herein shall be given the broadest possible interpretation consistent with the disclosure.

Referring to FIGS. 1 to 11 of the drawings, the improved rotary-percussion rock drill bit shown therein as embodying the invention comprises, in general, a unitary body **15** having a shank portion **16** terminating at one end in a hemispheroidal head **17** provided with at least one groove **18** traversing the head from the bit apex to the region of the greatest circumference of the head, and at least one cutting element or insert **19** secured within the groove **18** in a suitable manner, as by soldering, brazing or welding, so that the cutting elements each have an impact portion **23** extending from their respective grooves. The shank **16** is formed with a tapered socket **21** for reception by the drill rod of a drilling machine, but other means for attachment of the bit to the drill rod may be utilized.

The drill bit body **15** may be forged in a customary manner, and the curved cutting elements which are all identical may be fabricated of a material having great impact strength such as tungsten carbide having a relatively large cobalt content. As shown, the cutting elements **19** are curved in the plane which includes the axis of the bit and the longitudinal planes within which the cutting edges lie throughout the length thereof are all parallel to the axis of the bit. The groove **18** for receiving the cutting elements **19** may conveniently be designed so that the cutting elements may be of segmental shape approximating a quadrant of a circle as shown in FIG. 5, and the arcuately curved cutting edges **23** of each of the cutting elements **19** should preferably be formed with a negative rake angle **24** of between twenty and thirty degrees and with a relief angle **25** of approximately thirty degrees, these angles having been found to afford the most satisfactory drilling and strength requirements. Also, the bit must not have any abrupt changes in cross section in the immediate vicinity of the cutting edges since such abrupt changes in the configuration tend to lead to a fatigue condition resulting in the shortening of the drilling life of the bit.

The bit body is also provided with flushing holes **27** equal in number to the number of cutting elements **19**, and the placement and formation of these holes **27** is extremely important in prolonging the life of the bits and their cutting elements. To form the flushing holes **27**, conduits **28** are punched in the head **17** during fabrication thereof, such conduits **28** extending through the head from the inner end of the tapered socket **21** to the exterior of the head at an inclined angle relative to the bit axis as shown in FIG. 4. The angles **29** at which the conduits should preferably be formed with respect to the bit axis approximate twenty-eight to thirty degrees, and thus form openings **27** in the head which are of oblong shape in the direction of the bit axis so as to closely follow the curvature of the extending wear portions **23** of the cutting elements **19**. In addition, each of the flushing holes **27** should be placed as close as possible to the rake angle side of the cutting edge of its adjacent cutting element **19** as shown in order to obtain the best possible cooling results and chip clearance during operation, and it has been found that an offset of approximately thirty degrees from the bit centerline as shown at **30** in FIG. 3 gives excellent results in a two-bladed bit.

To augment the cooling effect and chip clearance obtained by proper formation and placement of the flushing holes **27** as above described, the bit head **17** is additionally formed with spiral or helical recesses or chipways **31** extending from each of the flushing holes **27** to the apex of the head **17** on the rake angle side of each of the adjacent cutting elements. Thus, the placement of the flushing holes **27** coupled with the spiral formation of the chipways or recesses **31** insures turbulent air flow in the vicinity of the cutting edges **23** of the inserts **19** by inducing a spiral flow pattern and forcing the flushing fluid into a turbulent vortex around the cutting edges. The unsymmetrical placement of the flushing holes **27** so that they are closer to the rake angle side of the adjacent cutting element also helps create the turbulent vortex of fluid flow and consequent reduction in bit edge temperatures during cutting operations, and this enhancement of the heat transfer pattern is extremely important to long bit life. The placement of the flushing holes and the patterning of the recesses **31** is illustrated most vividly in FIGS. 7 to 11 inclusive which reflect the shape of the bit head along various transverse areas thereof.

While the improvements have been shown and described with specific reference to a two-bladed bit, they may be utilized with similar advantages in bits which have more than two cutting blades or wings, and FIG. 12 illustrates a three-bladed bit of the present improved design. Again, in the three-bladed construction, the head **37** of the bit **35** is provided with equally spaced grooves **38** traversing the head from the apex thereof to the region of its greatest circumference in planes lying parallel with the bit axis; and a cutting element **39** formed of a material possessing high impact strength is suitably secured, as by brazing, soldering or welding, within each of the grooves **38**. Each of the cutting elements **39** has a wear surface or cutting edge **43** extending outwardly from the hemispheroidal head, and each of these wear surfaces is curved in the plane which includes the axis of the bit so as to follow the contour of the head. Also, the three-bladed head shown in FIG. 12 is provided with a plurality of flushing holes **47** formed in a manner similar to that described with respect to the two-bladed head, and each of these holes **47** is placed adjacent to the rake angle side **44** of a cutting element **39**. Again, a turbulent flow of the flushing fluid in a spiral pattern may be induced by forming the head **35** with spiral or helical recesses **51** extending from each of the flushing holes **47** to the apex of the head at the rake angle side of the adjacent cutting element.

The improved drill bits have been subjected to extensive tests, and the results of these tests have been extremely satisfactory and have indicated that extremely efficient drilling is accomplished with the life of the bits being prolonged to a considerable extent. The bits were found to start their holes with ease and with very little tendency to walk away or slip from their initial starting positions. Furthermore, the bits have been shown to run remarkably cool and drill at an excellent rate of penetration. No flushing difficulties have been encountered with these bits even when drilling at a rapid rate, and rock removal is accomplished easily without evidence of choking.

While the bits illustrated herein have the wings thereof formed as a pair of special carbide steel inserts possessing high impact strength and secured as by soldering or brazing within grooves formed in the hemispheroidal head, these wings 19, 39 may be formed integral with the head which may then be specially treated to increase the impact strength thereof. Also, in bits having only one pair of wings as in FIGS. 1 to 11 inclusive, the wings may either be formed of two separate end abutting segmental inserts, as shown, or a single semi-circular insert may be used, and in either case, the continuous nature of the oppositely directed end-abutting or one-piece wings imparts strength and rigidity to the bit since the shocks are more equally disbursed across the wings in operation and torque is more effectively absorbed. In addition, by tapering the wings at their abutting portions or at the bit apex as at 32, the life of the inserts or cutting elements may be prolonged since the effectiveness of the turbulent vortex formed by the flushing ports 27 and recesses 31 which terminate at the apex is enhanced. It should also be understood that additional flushing holes may be provided if found desirable, and the bits shown and described may be used effectively either with a drilling system wherein cuttings are removed from the hole by means of vacuum drawn through the bit and drill steel or by pressure projected through the steel and the bit.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

We claim:

1. A rotary-percussion rock drill bit comprising, a unitary body having a shank portion terminating at one end in a hemispheroidal head provided with at least two equally spaced wings formed with cutting edges extending outwardly from said head and traversing the head from the apex thereof to the region of its greatest circumference in longitudinal planes which lie parallel with the bit axis, said wings each being curved in the plane which includes the axis of the bit so as to follow the contour of the head and being tapered inwardly from their outer cutting edges toward each other and toward the apex of said head.

2. A rotary-percussion rock drill bit according to claim 1, wherein the cutting edges of said wings each have a

negative rake angle of from twenty degrees to thirty degrees and a relief angle of approximately thirty degrees.

3. A rotary-percussion rock drill bit according to claim 1, wherein the cutting edges of said wings each have a rake angle side and a relief angle side, and the body is formed with conduits providing fluid flushing holes extending therethrough to the exterior of the head and equal in number to the number of wings, each of said flushing holes terminating closer to the rake angle side than the relief angle side of a wing, and the head being formed with outwardly open recesses extending from each of said flushing holes to the apex of said head adjacent the tapered portions of the wings.

4. A rotary-percussion rock drill bit according to claim 3, wherein the conduits formed in the body are inclined relative to the bit axis whereby the terminal portions of the flushing holes form openings in the head which are of oblong shape and closely follow the curvature of the adjacent wings.

5. A rotary-percussion rock drill bit according to claim 3, wherein the recesses formed in the head extend along an approximately spiral path on the rake angle side of the adjacent wing from the terminal end of each of the flushing holes to the apex of the head.

6. A rotary-percussion rock drill bit comprising a unitary body having a shank portion terminating at one end in a hemispheroidal head provided with a groove diametrically traversing the head from the apex thereof to the region of its greatest circumference in a plane lying parallel with the bit axis, and a pair of end-abutting cutting elements formed of a material possessing high impact strength secured within said groove and having impact portions extending from the groove to provide oppositely directed wings having outer cutting edges and each curved in the plane which includes the axis of the bit so as to follow the contour of the head, the abutting ends of said cutting elements being tapered toward each other and toward the apex of said head to provide a transverse recess.

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