

[54] **SOFT FORMATION INSERT BITS**

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Related U.S. Application Data

[63] Continuation of Ser. No. 794,515, Jan. 28, 1969, abandoned.

[52] U.S. Cl. 175/374, 175/353

[51] Int. Cl. E21c 13/00

[58] Field of Search. 175/376, 377, 353, 374

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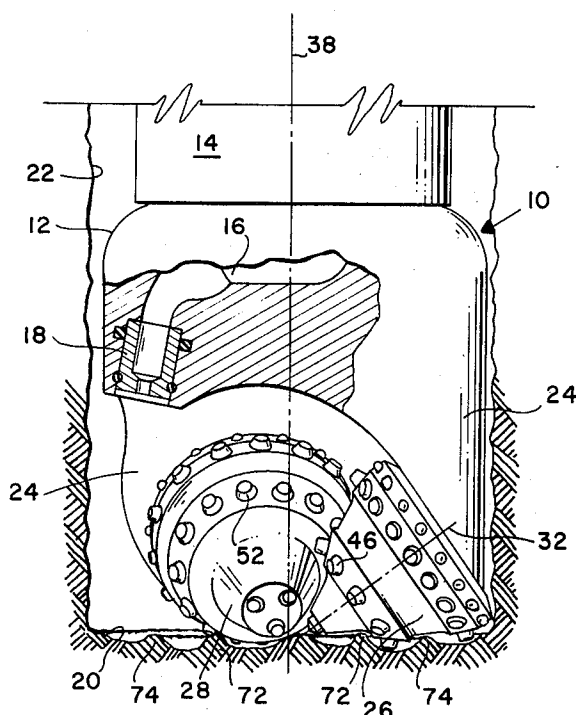
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[57]

ABSTRACT

A rotary drill bit is disclosed that is utilized in forming a well bore or the like. The rotary drill bit includes a bit body having three arms journaling three generally conical cutter members. Each of the cutter members is provided with a plurality of annular rows of outwardly projecting, circumferentially-spaced inserts. The inserts are constructed from a material such as tungsten carbide and project from the surface cutter members for a considerable distance. The spacing of the annular rows is such that a substantial quantity of the bottom of the well bore is not subjected to the downward impression of the inserts as the bit is rotated in the well bore. The cutter members are arranged in such a manner that the axes thereof do not intersect each other nor do they intersect the axes of rotation of the bit.

8 Claims, 7 Drawing Figures



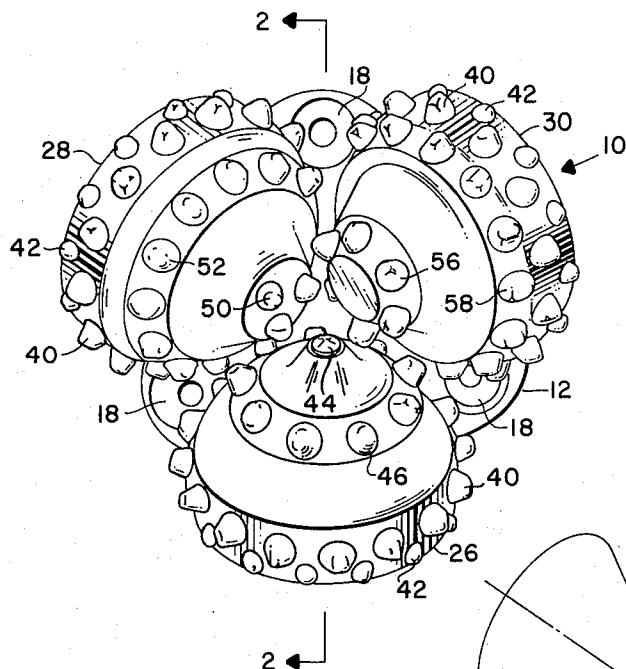


FIG. 1

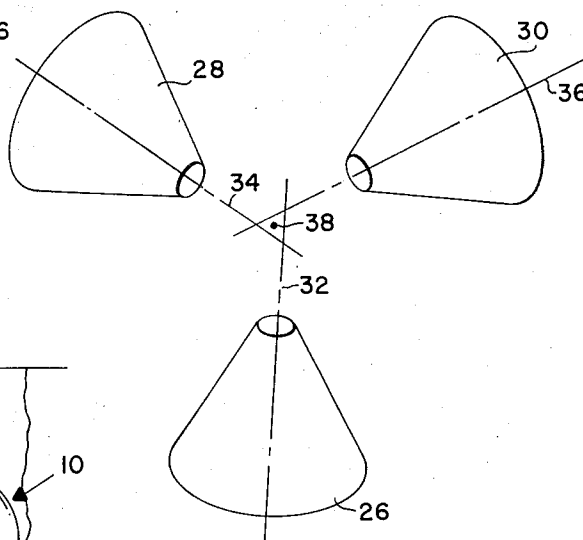


FIG. 3

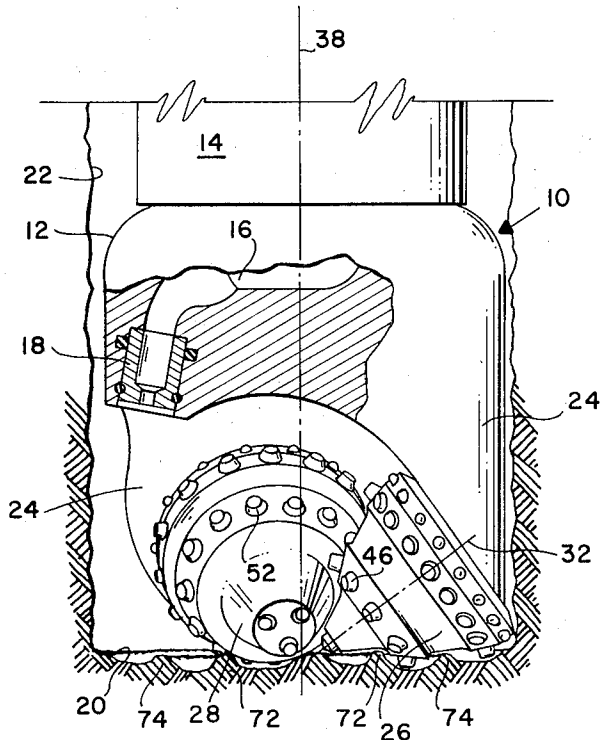


FIG. 2

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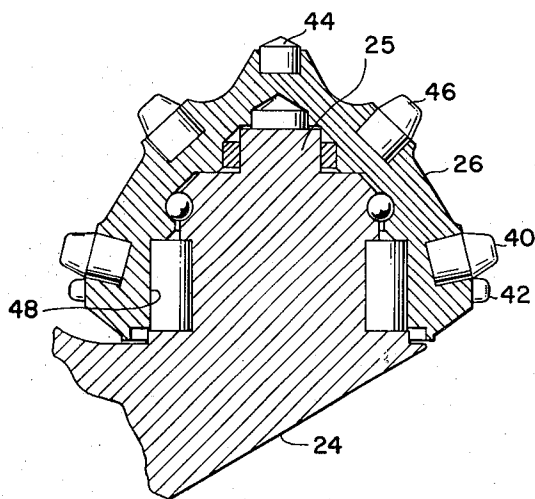


FIG. 4

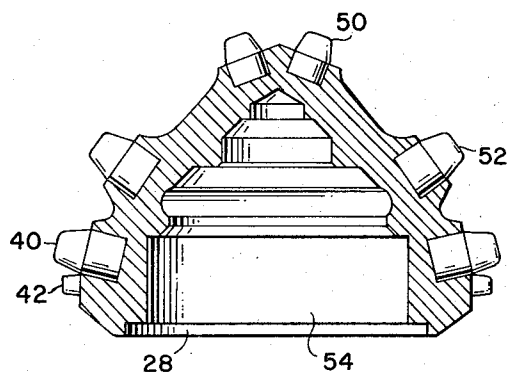


FIG. 5

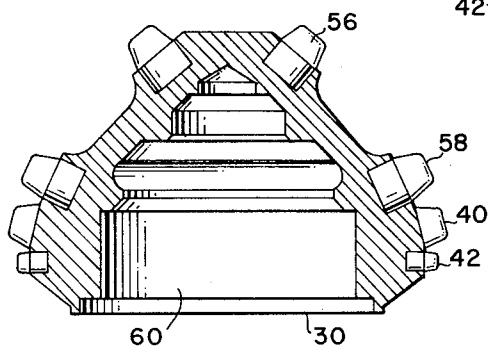


FIG. 6

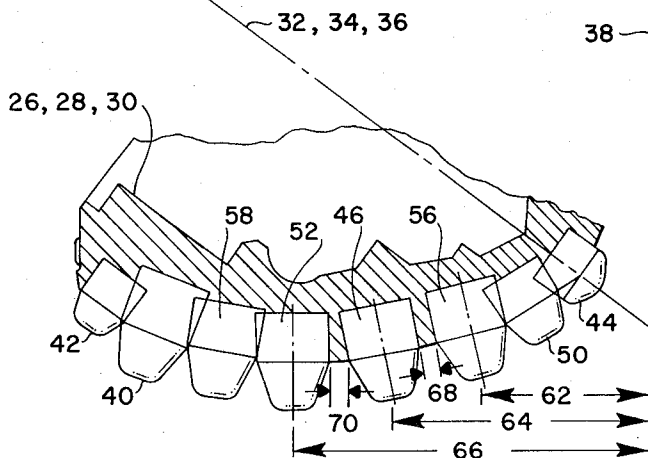


FIG. 7

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SOFT FORMATION INSERT BITS

is a continuation of application Ser. No. 794,515, filed Jan. 28, 1969, now abandoned.

BACKGROUND OF THE INVENTION

The use of insert-type drill bits for drilling extremely hard formations has been known in the oil industry for many years. In these bits, the inserts project from the surface of the cutter members for a very small distance. It has been thought over the years that the relatively brittle inserts would break if they were extended for any significant distance from the surface of the cutter members.

Also, the cutter members of such bits have been positioned on axes that intersect the rotational axis of the bit so that a substantially true rolling situation exists. With true rolling action, scuffing of the inserts, which will contribute to breakage of the inserts, is virtually eliminated.

On occasion, the insert bits have been utilized in relatively soft formations, but such attempts have resulted in a very low penetration rate. The low penetration rate is believed to be due to the relative plasticity of the softer formations which will not disintegrate upon impact as will the more friable, harder formations. It is also believed that the lack of projection of the inserts, the quantity of well bore bottom that is left uncut and the lack of scuffing action of the insert-type bits contribute to the lower penetration rate of the insert-type bits when used in the soft formations.

It has also been known in the industry to utilize bits having cutter members provided with relatively large teeth that are milled on the cutter member. In these bits, the large teeth and offset of the cutter members provide a cutting action that is more efficient in removing the relatively soft formations as the well bore is drilled therethrough. With such bits, it has not been possible to provide uncut bottom due to the tendency of the milled or integrally formed teeth to wear away and prematurely break off as a result of erosion as the teeth flanks engage the uncut bottom. It is known that in certain instances, providing a greater amount of uncut bottom increases the rate of penetration of the bit. The increased penetration is highly desirable provided that the uncut bottom can be removed without severely decreasing bit life due to erosion damage to the teeth.

SUMMARY OF THE INVENTION

This invention provides an improved rotary drill bit for forming a well bore or the like wherein the bit comprises: a bit body having an axis of rotation, an upper end connected with a drill string for rotating the bit, and three downwardly projecting arms, each of the arms including an inwardly and downwardly inclined shaft defining an axis of cutter member rotation, none of the axes intersecting any other of the axes; first, second and third cutter members of generally conical configuration, each of the cutter members being journaled on a respective one of the shafts and having a nose and a base, the base defining the well bore gage or diameter; and, a plurality of an outwardly projecting, circumferentially spaced inserts located in annular rows in each of the cutter members for engaging the bottom of the well bore.

It is one object of this invention to provide an improved rotary drill bit for use of soft formations that is more efficient and will have a longer operating life than the previously known drill bits for use in soft formations.

Another object of this invention is to provide an improved drill bit having extremely hard, inserts located in the cutter members for use in soft formations.

A further object of the invention is to provide a rotary drill bit having extremely hard inserts that extend from the surface of the cutter members for a considerable distance and are arranged in annular rows providing a substantial quantity of uncut bottom whereby the bit preforms more efficiently in soft formations.

Still another object of the invention is to provide an improved rotary drill bit having cutter members provided with extended annular rows of extremely hard inserts wherein the cutter members have axes that do not intersect any other cutter member axis or the axis of rotation of the bit whereby the bit will have a considerable quantity of uncut bottom, relatively deep penetration due to the extended teeth, and a scuffing action that will efficiently remove the formation as the drill bit is rotated in the well bore.

The foregoing and additional objects and advantages of the invention will become more apparent as the following detailed description is read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1, is a bottom view of a drill bit constructed in accordance with the invention.

FIG. 2, is a view, partly in cross-section and partly in elevation, taken substantially along the line 2—2 of FIG. 1.

FIG. 3, is a schematic view illustrating the relationship of the axes of the cutter members of the bit of FIG. 1.

FIG. 4, is an enlarged cross-sectional view of a cutter member utilized in the bit of FIG. 1.

FIG. 5, is an enlarged cross-sectional view of another cutter member utilized in the bit of FIG. 1.

FIG. 6, is an enlarged cross-sectional view of still another cutter member utilized in the bit of FIG. 1.

FIG. 7, is a superimposed view of a portion of the cutter members illustrated in FIGS. 4, 5, and 6 showing the bottom profile of a portion of a well bore bottom as the drill bit is rotated in the well bore.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing and to FIGS. 1 and 2 in particular, shown therein and generally designated by the reference character 10 is a drill bit constructed in accordance with the invention. As illustrated, the drill bit 10 includes a bit body 12 connected at its upper end to the lower end of a drill string 14.

The bit body 12 includes a cavity 16 that extends through the upper end of the body 12 providing communication for drilling muds or the like passing downwardly through the drill string 14 into the nozzles 18. The restricted nozzles 18 are arranged to direct the flow of the drilling mud into engagement with the bottom 20 of the well bore 22.

Depending from the body 12 are three substantially identical arms 24. The lower end portion of each of the arms 24 is provided with a conventional shaft and bearings 25 (See FIG. 4). Each arm 24 rotatably supports a generally conical cutter member. The cutter members are designated by the reference characters 26, 28 and 30. The cutter members 26, 28, 30 will be described more fully in connection with the descriptions of FIGS. 4 through 7.

The shafts carrying the cutter members 26, 28 and 30 define axes of rotation 32, 34 and 36 respectively, about which the cutter members rotate. It will be noted in FIG. 2 that the axes of rotation are tilted downwardly and inwardly at an angle of approximately 36 degrees. As can be seen in FIG. 1 and more clearly in FIG. 3, axes 32, 34 and 36 do not intersect nor do they intersect the axis of rotation 38 of the bit 10.

The direction of rotation of drill bits is in a clockwise direction as seen from above so that the threads making up the various joints of the drill string 14 are constantly tightened by the forces exerted as the drill string 14 rotates the bit 10 about the axis 38. Since FIG. 1 and FIG. 3 are bottom views of the bit 10, the direction of rotation as seen therein will be counterclockwise. The axes, 32, 34 and 36 of the cutter members are offset slightly to the right of the axis of rotation 38 of the bit as is clearly shown in FIG. 3. Offsetting the cutter member rotational axes provides a scuffing action as the cutter members 26, 28 and 30 rotate about the bit rotation axis 38 in engagement with the bottom 20 of the well bore 22.

As shown in the drawings, each of the cutter members 26, 28 and 30 includes a nose portion that is oriented toward the bit rotation axis 38 and a base that is positioned at the intersection between the wall of the well bore 22 and the bottom 20 thereof. In fact, the cutting action of the base defines the diameter of the well bore 22.

Each of the cutter members 26, 28 and 30 also includes two staggered annular rows of inserts 40 and 42 that are located adjacent to the base of each cutting member. The inserts 40 and 42 cut the intersection between the well bore wall and the bottom thereof. The annular rows of inserts 40 and 42 are generally referred to as "gage rows."

The cutter member 26 (See FIG. 4) includes a nose insert 44 that is located in the nose of the member 26 and functions to cut away the formation near the center of the well bore 22. Between the nose insert 26 and the gage rows 40 and 42, the cutter member 26 includes an annular row of inserts 46 that is generally referred to as an intermediate row. The cutter member 26 also includes a cavity 48 that is configured to receive the shaft and bearings 25 rotatably supporting the cutter member 26.

Cutter member 28, which is shown in cross section in FIG. 5, includes a plurality of nose inserts 50 that aid in removing the formation adjacent the center line of the well bore 22. Between the nose inserts 50 and the gage inserts 40 and 42, the cutter member 28 is provided with an annular row of intermediate inserts 52. The cutter member 28 also includes a bore 54 that is configured to receive the shaft and bearings 25 (See FIG. 4) for rotatably supporting the cutter member 28 on one of the arms 24.

The cross sectional view of FIG. 6 illustrates the structure of the cutter member 30. As shown therein, the cutter member 30 has a first annular row of intermediate inserts 56 located relatively near the nose and a second annular row of intermediate inserts 58 located between the inserts 56 and the gage row inserts 40 and 42. As is true in the cutter members 26 and 28, the cutter member 30 includes a bore or recess 60 configured to receive the shaft and bearings 25 (See FIG. 4) that rotatably mount the cutter member 30 on one of the arms 24.

The partial view of FIG. 7 is a composite of the lower portion of the cutter members 26, 28 and 30 superimposed to illustrate the coverage of the well bore bottom 20 by the annular rows of inserts located in the cutter members. FIG. 7 also illustrates the radial spacing of the annular rows of the inserts to attain "uncut bottom" as the bit 10 is rotated in the well bore 22.

As clearly shown in FIG. 7, the annular row of intermediate inserts 56, which is carried by the cutter member 30, is located a radial distance 62 from the bit axis of rotation 38. Similarly, the annular intermediate row of inserts 46, mounted in the cutter member 26, is located a radial distance 64 from the bit axis of rotation 38 and the annular row of intermediate inserts 52, which are mounted in the cutter member 28, is located a radial distance 66 from the bit axis rotation 38. While the dimension lines of radial distances 62, 64 and 66 are offset in FIG. 7 to more clearly illustrate their length, they are preferably measured from a common point on the bit axis of rotation 38.

It will be noted that the radial distance 66 is greater than the radial distance 64 by a quantity that is greater than the thickness of any of the intermediate inserts. Also, the radial distance 64 is greater than the radial distance 62 by a quantity that is greater than the thickness of any of the intermediate inserts. Thus, there is provided between the inserts 46 and 56 a space 68 and there is provided between the inserts 46 and 52 a space 70, which spaces 69 and 70 are not engaged by any of the inserts in the bit 10.

As the bit 10 rotates, annular portions 72 and 74 of the bit bottom 20 shown in FIG. 2 correspond to the spaces 68 and 70, respectively, and are not engaged by the downward impression of any of the inserts. Thus, there will be a percentage of the well bore bottom 20 that is uncut. Preferably, the combined area of the cutter members not covered by annular rows of inserts and thus, the uncut bottom will be between six and thirteen percent of the surface area of the cutter members or bottom that is located between the nose and base of the cutter members. The uncut annular portions 72 and 74 will, as they reach a predetermined height above the bottom of the well bore 22 be broken away by the scuffing action of the inserts located adjacent thereto. As previously mentioned, the scuffing action is due to the offset of the axes 32, 34 and 36 of the cutter members 26, 28 and 30, respectively, relative to the bit axis of rotation 38.

The material used in forming the inserts that are mounted in the cutter members 26, 28 and 30 is preferably a tungsten carbide or similar material that is extremely hard. It will be noted in the various figures of the drawing that the inserts protrude from the surface of the cutter members for a relatively large distance

compared to the protrusion of inserts from the surface of previously known insert-type cutter members. It is preferred that the inserts, at least the inserts 46, 52, 56 and 58, project from the surfaces of their relative cutter members for a distance of between one quarter of an inch and nine sixteenths of an inch. The distance that the inserts protrude is governed to a great extent by the thickness or diameter of the insert and the size of the bit in which the inserts are used. It is also preferred that the inserts be provided with a wedge-shaped exposed end portion as shown in the drawings. However, the inserts may also be frusto-conical or rounded.

OPERATION OF THE PREFERRED EMBODIMENT

The drill bit 10 is preferably utilized in the drilling of the well bore 22 through formations that are generally referred to in the drilling industry as the harder soft formations and the softer medium formation such as shales, gypsum, salt, lime, shaley lime, and other formations of similar hardness and drilling difficulty.

In use, the drill bit 10 is connected with the lower end of the drill string 14 and lowered into the well bore 22 until the cutter members 26, 28 and 30 engage the bottom 20. Upon engagement with a bottom 20 of the well bore 22, the drill string 14 is rotated, rotating the bit 10 therewith. As the bit 10 rotates about the bit axis of rotation 38, each of the cutter members 26, 28 and 30 rotate about its axis of rotation 32, 34 and 36, respectively.

During the rotation of the bit 10, the annular rows of inserts come into engagement with the formation and, due to the force exerted downwardly on the bit 10, the inserts are impressed into the formation thereby cutting or chipping away the bottom 20. Since the cutter members are not true rolling, that is, their axes do not intersect the bit axis of rotation 38, the inserts slide for a short distance along the bottom 20 of the well bore 22. The sliding or scuffing action helps to disintegrate the uncut annular portions 72 and 74 of the bottom 20 as previously mentioned.

During the course of conducting performance tests in actual oil wells, bits constructed in accordance with the foregoing consistently out performed both tooth-type bits and standard hard formation insert-type bits that were utilized in drilling offset wells through the same formations. The data shown below in tabular form is a comparison of footage and penetration rates between the bit-types utilized in the performance tests.

Comparative Bit Performance Tests

Well Bit Type	No. 1 Fig. 1	1st Offset Medium Formation-Tooth-Type	2nd Offset Medium Formation-Tooth-Type
Number of Bits	1	8	7
Total Footage, Ft.	1760	1692	1640
Total Drilling Time, hrs.	65	70	58
Penetration Rate ft/hr	27.1	24.2	28.3
Well Bit Type	No. 2 FIG. 1	1st Offset Hard Formation-Tooth-Type	2nd Offset Insert-Type
Number of Bits	1	6	1
Total Footage, Ft.	758	730	796
Total Drilling Time, hrs.	44	45	79
Penetration Rate ft/hr	17.3	16.1	10.2

Well Bit Type	No. 3 FIG. 1	Offset Insert-type
Number of Bits	1	2
Total Footage, Ft.	1527	1723
Total Drilling Time, hrs.	61	98
Penetration Rate ft/hr	25.2	17.6

In the tables, it can be seen in the first test well that one bit constructed in accordance with the invention out-performed 8 tooth-type bits in the first offset well and 7 tooth-type bits in the second offset well. In the second well, the bit of FIG. 1 outperformed 6 hard formation tooth-type bits in the first offset well and had a considerably better rate of penetration than the insert-type bit used in the second offset well. In the third well, the bit of FIG. 1 drilled almost as much footage as two insert-type bits at a rate of penetration that was almost twice that attained by the bits used in the offset well.

From the foregoing, it should be apparent that a bit constructed in accordance with the invention is more efficient than any previously known bit for penetrating the particular formations for which the bit is intended. In fact, the tests clearly show that a single bit constructed in accordance with this invention outperformed several bits of previously known design in penetrating comparable footages in comparable formations.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A rotary drill bit for forming a well bore or the like, said bit comprising:

a bit body having an axis of rotation, an upper end connectable with a drill string for rotating said bit, and three downwardly projecting arms, each said arm including an inwardly and downwardly inclined shaft defining an axis of cutter rotation, none of said axes intersecting any other of said axes;

first, second and third cutter members of generally conical configuration, each of said cutter members being journaled on a respective one of said shafts and having a nose and a base, said base being oriented generally toward the wall of the well bore; and,

a plurality of outwardly projecting, circumferentially-spaced inserts located in annular rows in each said cutter member for engaging the bottom of the well bore with the inserts of at least one annular row of each cutter member projecting from the surface of the respective cutter member a minimum of one-fourth of an inch.

2. The drill bit of claim 1 wherein said inserts projecting at least one-fourth of an inch have a wedge-shaped exposed end portion.

3. The drill bit of claim 1 wherein the inserts of at least one annular row of each cutter member project from the surface of the respective cutter member between one-fourth and nine-sixteenth of an inch.

4. A rotary drill bit for forming a well bore or the like, said bit comprising:

a bit body having an axis of rotation, an upper end connectable with a drill string for rotating said bit, and three downwardly projecting arms, each said

arm including an inwardly and downwardly inclined shaft defining an axis of cutter rotation, none of said axes intersecting any other of said axes;

first, second and third cutter members of generally conical configuration, each of said cutter members being journaled on a respective one of said shafts and having a nose and a base, said base being oriented generally toward the wall of the well bore; and,

a plurality of outwardly projecting, circumferentially-spaced inserts located in annular rows in each said cutter member for engaging the bottom of the well bore, wherein at least one of said annular rows of inserts is mounted in each said cutter member between said nose and base defining an intermediate row in each said cutter member, said intermediate rows being located on said cutter members at a different radial distance from said bit axis of rotation by more than the thickness of one of said intermediate row inserts, said radial distance being measured perpendicularly to and from a common point on said bit axis of rotation to each of said intermediate rows with the net surface area between said intermediate rows on said cutter members being between six and thirteen per cent of the total surface area between the nose and base of all of said cutter members.

5. The drill bit of claim 4 wherein the inserts in said intermediate rows project from the surface of said cutter members by at least one-fourth of an inch.

6. The drill bit of claim 5 wherein the projecting end portion of each of said intermediate row inserts is wedge-shaped.

7. A rotary drill bit for forming a well bore or the like, said bit comprising:

a bit body having an axis of rotation, an upper end connectable with a drill string for rotating said bit, and three downwardly projecting arms, each said arm including an inwardly and downwardly inclined shaft defining an axis of cutter rotation, none of said axes intersecting any other of said axes;

first, second and third cutter members of generally conical configuration, each of said cutter members being journaled on a respective one of said shafts and having a nose and a base, said base being

oriented generally toward the wall of the well bore; a plurality of outwardly projecting, circumferentially-spaced inserts located in annular rows in each said cutter member for engaging the bottom of the well bore;

the annular rows of inserts in said first cutter member include an intermediate row disposed between a nose insert and a row of gage inserts that are located adjacent said base with said intermediate row inserts projecting from the surface of said cutter member between one-fourth and nine-sixteenths of an inch and at least a portion of said intermediate row inserts having a wedge-shaped, exposed end portion;

the annular rows of inserts in said second cutter member include an intermediate row disposed between a row of nose inserts and a row of gage inserts, the intermediate row in said second cutter member being spaced from a said bit axis of rotation by a greater distance than said intermediate row in said first cutter member by at least the thickness of one of said intermediate row inserts with said intermediate row inserts projecting from the surface of said cutter member between one-fourth and nine-sixteenths of an inch and at least a portion of said intermediate row inserts having a wedge-shaped, exposed end portion; and,

the annular rows of inserts in said third cutter member include first and second intermediate rows disposed between the nose of said cutter member and a row of gage inserts, one of said intermediate rows in said third cutter member being spaced from said bit axis of rotation by a distance less than the intermediate row in said first cutter member by at least the thickness of one of said intermediate row inserts with said intermediate row inserts projecting from the surface of said cutter member between one-fourth and nine-sixteenths of an inch and at least a portion of said intermediate row inserts having a wedge-shaped, exposed end portion, whereby one or more annular portions of the well bore bottom are not subjected to the downward impression of inserts thereon.

8. The drill bit of claim 7 wherein the net surface area between said intermediate rows on said cutter member is between six and thirteen per cent of the total surface area between the nose and base of all of said cutter members.

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