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[54] **IMPREGNATED DIAMOND BIT**
34 Claims, 3 Drawing Figs.

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[50] Field of Search **175/329,**
330, 379, 403, 404; 125/39

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ABSTRACT: A rotary formation drilling core bit, including an impregnated portion containing diamonds dispersed in a matrix, the inner part of the impregnated portion having a step disposed axially inwardly of the bit face and in which surface-set diamonds are disposed to create formation cuttings flushed laterally outwardly across the full face of the bit to abrade and effect its resharpening by exposing additional diamonds. The rise between the step and bit face has circumferentially spaced ribs for creating cuttings also flushed across the bit face, the flow of flushing liquid being facilitated by the spaces between the ribs.

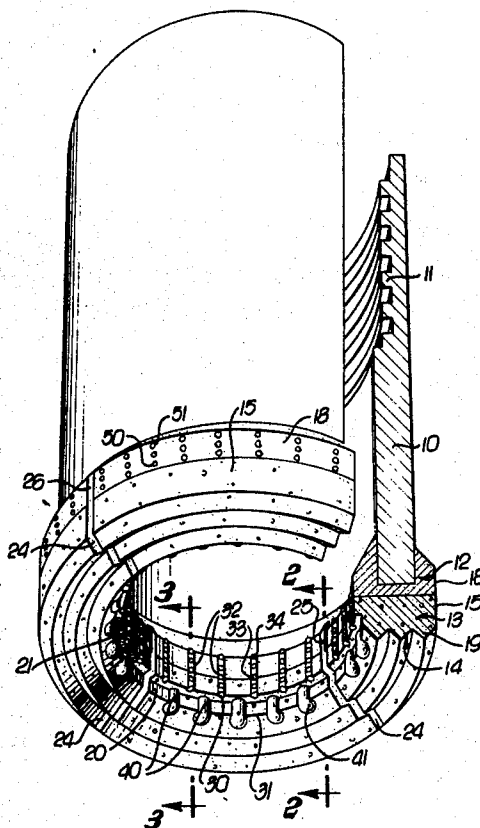


FIG. 1.

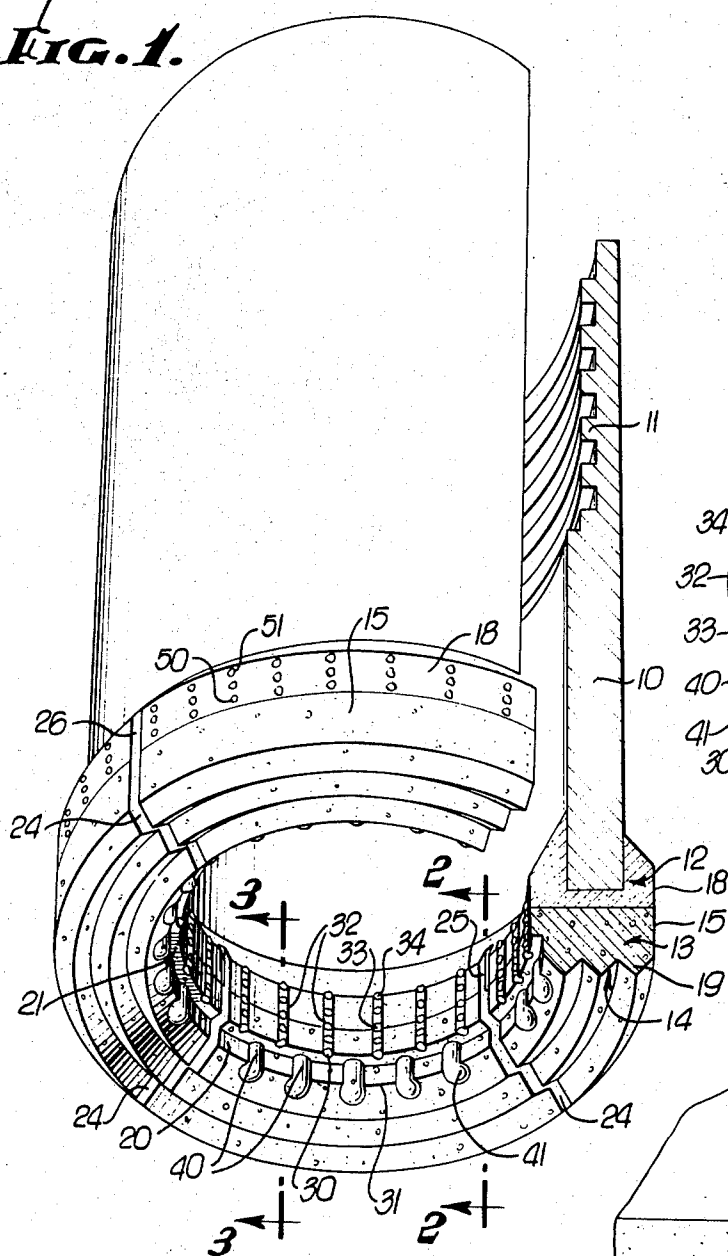


FIG. 2.

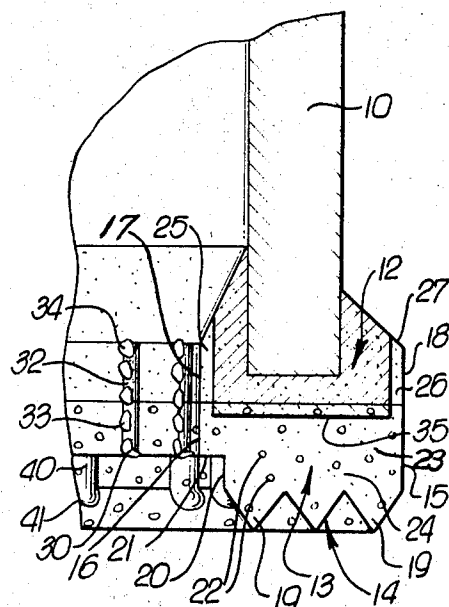
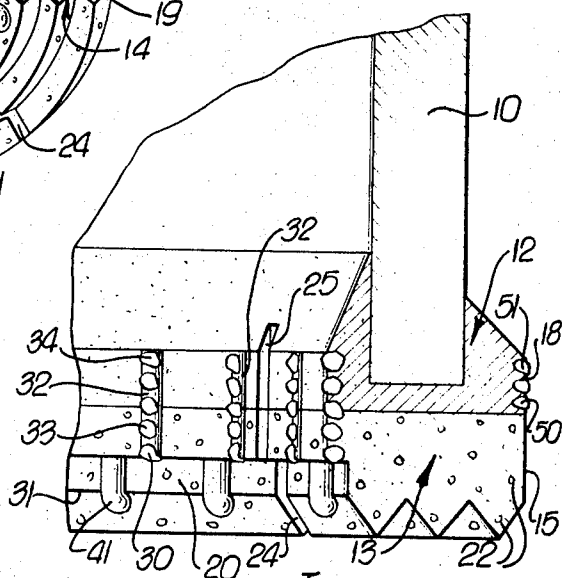


FIG. 3.



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IMPREGNATED DIAMOND BIT

The present invention relates to rotary formation drilling bits, and more particularly to bits containing diamonds as dominant cutting elements.

Diamond bits of the impregnated type have diamonds dispersed in a matrix. As the bit drills the formation, it is desirable for its matrix to wear away across the entire bit face to expose additional diamonds for the performance of a cutting action on the formation, until the entire impregnated portion of the bit is consumed, the cutting life of the bit then being at an end.

Heretofore, diamond impregnated bits have ceased drilling or cutting the formation despite the fact that a large impregnated portion still remained. In core bits, their failure to continue drilling is due to the absence of continuous self-sharpening of the bit face at the region adjacent to its inside diameter. The result is rapid wear at such portion of the impregnated bit to the extent that no diamonds remain at such portion for cutting the formation. The entire bit ceases drilling despite the presence of a large impregnated bit volume extending laterally outwardly from such worn inner portion to the outside diameter of the bit. Not only does the rapid wear of the inner bit portion cause the entire bit to cease drilling, but the inner ends of the bit waterways provided in its impregnated portion are covered and closed by the formation, preventing flushing liquid from passing therethrough to the exterior of the bit for the purpose of cooling and cleaning the bit and conveying the cuttings from the drilling region upwardly around the bit exterior and toward the top of the hole being drilled.

Thus, prior art diamond impregnated bits have a relatively short, useful life, requiring replacement although the bits still possess a large diamond impregnated portion. As noted above, bit wear does not occur uniformly across the bit face, but predominantly at its region adjacent the bit inside diameter. Accordingly, a large portion of the bit is not consumed, but instead is wasted, resulting in large economic loss, which is enhanced by the time required to make round trips in a bore hole for the purpose of changing drill bits.

The dominant wear at the inside diameter region of the bit is due to such region not being self-sharpening. The self-sharpening action occurs as a result of cuttings formed by the bit acting as an abrasive on the matrix in which the diamonds are embedded, progressively wearing it away to continuously expose additional diamonds for action upon the formation. Abrasive cuttings have been present at the intermediate and outer portions of the bit face, which are resharpened, but such resharpened portions are prevented from cutting the formation by the innermost bit face portion which has been worn to the extent of becoming devoid of diamonds, and which can do nothing more than slide against the formation without cutting it, much in the nature of an axial thrust bearing.

With the present invention, an impregnated diamond bit is provided which is self-sharpening in its region adjacent to its internal diameter, as well as at all other regions across the face of the bit. Cuttings are formed in the formation being drilled, which are flushed across the inner portion of the bit face, the abrasive action of the cuttings on the bit matrix effecting sharpening of such inner portion. The abrasive formation cuttings are carried across the entire bit face to produce a sharpening action across its entire area. Thus, the impregnated portion of the bit wears substantially uniformly across the entire bit face, the bit remaining in a self-sharpened and useful condition until substantially the entire impregnated mass is consumed. As a result, the bit has a long useful life, being capable of drilling a greater depth of hole at a faster rate and in a more economical manner. When the impregnated bit portion is substantially entirely consumed, its waterways are shut off or greatly restricted by the formation, advising the operator at the top of the bore hole that the bit should be replaced by his noting a considerable rise in pump pressure at the top of the hole.

In general, the present invention includes the provision of a step at the inside diameter of the impregnated bit portion, in which individual diamonds are surface-set in spaced relation

to one another. These diamonds, which are usually larger than the diamonds in the impregnated region of the bit, produce cuttings that are flushed across the inside diameter of the bit face, such cuttings acting as an abrasive upon the matrix and progressively exposing the diamonds embedded therein. The cuttings formed by the surface-set diamonds combine with the cuttings formed by the exposed diamonds in the face of the impregnated bit to be flushed in greater number across the face of the bit toward the bit outside diameter, effecting a continuous resharpening of the entire bit face. The impregnated bit portion preferably has ribs projecting laterally inwardly from the rise of the step, which also produce cuttings and form passages therebetween for drilling fluid to carry the cuttings toward the outer bit face, the cuttings and flushing fluid continuing to flow laterally outwardly across the entire bit face. Waterways are also provided in the bit face from the inside diameter to the outside diameter of the bit, cuttings being flushed through such waterways, as well as across the bit face between the waterways. These waterways are substantially as deep as the impregnated portion of the bit. When such portion is virtually all consumed, the formation at the outside diameter of the bit will shut off flow through the waterways, the sudden increase in fluid pressure signalling the operator that the bit is at the end of its useful life.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense.

Referring to the drawings:

FIG. 1 is an isometric projection of an impregnated diamond bit embodying the invention, a portion being broken away and disclosing a longitudinal section through part of the bit;

FIG. 2 is an enlarged section taken along the line 2-2 on FIG. 1; and

FIG. 3 is an enlarged section taken along the line 3-3 on FIG. 1.

The specific embodiment of the invention illustrated in the drawings is a core bit for cutting a core in a bore hole. It includes a tubular bit shank 10 having an upper threaded box 11 for suitable attachment to a core barrel or a tubular drilling string (not shown). The bit shank has its lower end extending into a backing matrix 12 of annular form and suitably secured thereto, as by being fused thereto in a furnace at an appropriate temperature. The backing matrix is secured to an annular impregnated diamond bit portion 13, as by being fused thereto in a furnace at the same time that the steel shank 10 is fused to the backing matrix 12.

The impregnated portion 13 is of a suitable height or depth, having a lower face 14 of any suitable shape, which terminates at the outer cylindrical gauge surface 15 of the bit, and also at the inner cylindrical gauge surface 16 of the bit. The backing matrix 12 has inner and outer cylindrical gauge surfaces 17, 18 that are the same as the inner and outer gauge surfaces 16, 15, respectively, of the impregnated bit portion 13.

As noted above, the face 14 of the bit can be made of any suitable shape, depending upon the particular type of formation being drilled. As specifically disclosed, it includes a plurality of concentric generally V-shaped annular ribs 19, the outer rib terminating at the outer gauge 15 of the impregnated matrix 13, the inner rib terminating at the rise 20 or inner cylindrical wall that extends upwardly to a step 21 formed in the impregnated bit portion, this step continuing to the inside diameter or inner gauge 16 of the impregnated bit portion.

The impregnated bit portion 13 consists of a mixture of diamond particles 22 and a matrix 23, the diamonds being of a suitable mesh and being dispersed throughout the entire volume of the matrix. Substantially radial circumferentially spaced waterways 24 extend through the diamond im-

pregnated portion from its inner gauge surface 16 to its outer gauge surface 15, the depth of the waterway across the face of the bit being substantially the same as the height of the impregnated portion, that is, substantially to the backing matrix 12, the inner end of each inner waterway communicating with a longitudinal waterway 25 that continues through the backing matrix 12 and being open at its upper end; whereas, the outer end of each waterway 24 communicates with a longitudinal or vertical outer waterway 26 extending upwardly through the backing matrix 12 and having an outlet opening 27 at its upper end. Thus, a flushing liquid can flow downwardly through the steel shank 10, as between it and an inner core barrel (not shown), downwardly through the inner waterways 25 and laterally through the waterways 24, and thence through the outer waterways 26, as well as flowing laterally along the inner gauge surfaces 17, 16 and laterally across the face 14 of the bit between the waterways 24. During such lateral flow across the face 14 of the bit and through the waterways, the flushing fluid carries cuttings therewith, the cuttings also being flushed from the bit face 14 into the waterways 24 and then upwardly through the longitudinal, external waterways 26 to the region above the backing matrix 12 for continued upward movement around the steel shank 10 and the tubular drilling string (not shown) to the top of the well bore, in a known manner.

As noted above, cuttings have not been available at the face 14 of the bit adjacent its internal diameter for producing an abrasive action on the matrix 23 at such region, resulting in considerable wear at the inner face portion of the bit, considerably shortening the useful life of the bit. In the present case, the step 21 is provided in the bit, diamond cutting elements 30 being set in the face of the step with the required exposure, these diamonds being circumferentially spaced from one another. During the drilling action, the impregnated bit portion 13, as well as the surface-set diamonds 30, are producing cuttings, the fluid flowing downwardly along the inside of the shank 10 passing along the inner gauge 17, 16 of the bit to carry the cuttings formed by the surface-set diamonds 30 longitudinally along the rise 20 and then laterally across the face 14 of the bit, the cuttings produced by the impregnated face also being flushed laterally outwardly across the face of the bit, all of the cuttings acting as an abrasive against the bit face to gradually wear away the matrix 23 surrounding each diamond 22 and exposing the diamonds in the impregnated bit portion for the performance of the cutting action against the bottom of the bore hole.

Thus, the surface-set diamonds 30 produce cuttings, and such cuttings will be carried by the flushing liquid laterally outwardly across the innermost portion or corner 31 of the face 14 of the bit, combining with the cuttings produced by the face of the bit itself for self-sharpening action upon all areas of the bit face, from its inner gauge to its outer gauge. The cuttings are also flushed from the face of the bit into the waterways 24 to reduce the extent of regrinding of cuttings by the face of the bit, the cuttings in the waterways being flushed therethrough to the outer gauge 15 and then upwardly through the longitudinal waterways 26 into the annular space between the wall of the bore hole and the steel shank and drilling string thereabove.

To enhance the flow of the circulating fluid toward the drilling face, longitudinal ribs 32 are formed in both the backing matrix 12 and the impregnated bit portion 13. Additional diamonds 33 or tungsten carbide chips 34, or both, can be embedded in such ribs. Surface-set diamonds 33 are preferably contained in each rib 32 substantially to the same extent as the base or bottom 35 of each waterway 24, so that as the step 21 is worn away through loss of diamonds 30 therein, additional diamond cutting elements 33 will be available for insuring the continuous production of cuttings at the inner portion of the bit for movement across the inner corner 31 of the face of the bit, insuring that such inner corner, and regions adjacent thereto, are resharpened, as well as the remainder of the face 14 of the bit.

The inwardly projecting longitudinal ribs 32 and the diamonds 33 or tungsten carbide chips 34 set therein produce a core that is slightly less in diameter than the inside diameter of the inner gauge 16, 17 of the impregnated bit portion 13 and of the backing matrix 12. As a result, space exists between the ribs 32 through which the flushing or circulating fluid can pass to the step 21, across the step and then along the rise 20 to the inner edge 31 of the face of the bit, the fluid then flowing laterally outwardly across the bit face to its outer gauge surface 15.

To insure the flushing of cuttings across the inner edge 31 of the bit face, so that such inner edge portion will be resharpened, together with the remainder of the bit face, circumferentially spaced longitudinal ribs 40 extend laterally inwardly from the rise 20 of the impregnated portion, these ribs being integral with and formed together with the impregnated portion 13 and having diamonds embedded in the matrix. These ribs 40 produce a diameter of core which is slightly less than the diameter across the rise 20, thus creating waterways or passages through which the cuttings and flushing fluid produced by the surface-set diamonds 30 can flow across the inner edge 31 and adjacent portions of the face 14 of the bit. The ribs 40 also extend longitudinally beyond the face 14 and then slightly across the face, forming circumferentially spaced cutting portions or protuberances 41 that will cut against the bottom of the bore hole, these cuttings also being effective for producing a sharpening action on the inner portion 31 of the face of the bit, and also being flushed with other cuttings across the face of the bit to effect its resharpening.

To insure the cutting of the bore hole to full gauge, diamonds 50 or tungsten carbide chips 51, or both, are surface-set in the outer gauge portion 18 of the backing matrix 12. As disclosed, several rows of diamonds 50 and tungsten carbide chips 51 are embedded in such gauge portion, the diamonds preferably being in the lowermost row. If not entirely in such lowermost row, at least there are some diamonds in such lowermost row, inasmuch as they have a longer cutting life than the tungsten carbide chips. Thus, if the outer gauge 15 of the impregnated portion 13 were to cut a slightly undergauge hole as the drilling proceeded, the diamonds 50 and tungsten carbide chips 51 in the backing matrix 12 would reach the hole to its required diameter.

The diamonds 50 and tungsten carbide chips 51 need not necessarily be set in separate planes normal to the bit axis. They can, if desired, be set in helical fashion around the outer gauge portion 18 of the backing matrix.

As the bit becomes worn during drilling of the bore hole, it is found that the lateral outermost part of the impregnated portion 13 wears to a greater extent than the remainder of the drill bit. Although the wear across the entire face of the bit is found to be substantially uniform from its inside diameter 16 to its outside diameter 15, the outermost region does, as indicated above, wear to a greater extent, such that when the impregnated portion 13 has been almost entirely consumed, the formation will then extend across the outer ends of the waterways 24 and will shut off the flow therethrough; that is to say, it will prevent communication between the radial waterway portions 24 and the longitudinal waterways 26 in the outer gauge 15, 18 of the bit. When the flow is shut off, which occurs suddenly, the circulating pressure rises suddenly and will thereby advise the operator that the bit is worn out and requires replacement.

I claim:

1. In a rotary drill bit: a body structure having a lower impregnated portion comprising a mixture of cutting elements and a matrix in which said elements are embedded, said impregnated portion having a drilling face adapted to engage the bottom of the hole in which the bit is operating and a fluid passage extending longitudinally through said body structure and opening into said drilling face, said impregnated portion having an inner step adjacent to said fluid passage above said drilling face, and individual cutting elements embedded in said step and adapted to engage the bottom of the hole.

2. A rotary drill bit as defined in claim 1; said impregnated portion having waterways extending from said fluid passage to the periphery of said impregnated portion.

3. A rotary drill bit as defined in claim 1; said cutting elements of said impregnated portion being diamonds.

4. A rotary drill bit as defined in claim 1; said individual cutting elements being diamonds.

5. A rotary drill bit as defined in claim 1; said cutting elements of said impregnated portion being diamonds; said individual cutting elements being diamonds.

6. A rotary drill bit as defined in claim 1; said impregnated portion having a longitudinal rise extending between said step and drilling face, said impregnated portion including circumferentially spaced ribs extending laterally inwardly from said rise.

7. A rotary drill bit as defined in claim 1; said impregnated portion having a longitudinal rise extending between said step and drilling face, said impregnated portion including circumferentially spaced ribs extending laterally inwardly from said rise, said ribs having protuberances overlapping and integral with that portion of said drilling face adjacent to said rise and extending below said drilling face portion.

8. A rotary drill bit as defined in claim 1; said impregnated portion having a longitudinal rise extending between said step and drilling face, said impregnated portion including circumferentially spaced ribs extending laterally inwardly from said rise, said ribs having protuberances overlapping and integral with that portion of said drilling face adjacent to said rise and extending below said drilling face portion, said cutting elements of said impregnated portion being diamonds, said individual cutting elements being diamonds.

9. A rotary drill bit as defined in claim 1; said impregnated portion having a longitudinal rise extending between said step and drilling face, said impregnated portion including circumferentially spaced ribs extending laterally inwardly from said rise, said ribs having protuberances overlapping and integral with that portion of said drilling face adjacent to said rise and extending below said drilling face portion, said cutting elements of said impregnated portion being diamonds, said individual cutting elements being diamonds, said impregnated portion having waterways extending from said fluid passage to the outer periphery of said impregnated portion.

10. In a rotary drill bit: a body structure having a lower annular impregnated portion comprising a mixture of cutting elements and a matrix in which said elements are embedded, said impregnated portion having an inner gauge surface, an outer gauge surface, and a drilling face adapted to engage the bottom of the hole in which the bit is operating, said body structure having a fluid passage extending along said inner gauge surface and opening into said drilling face, said impregnated portion having a step extending laterally outwardly from said inner gauge surface and disposed above said drilling face, and circumferentially spaced individual cutting elements embedded in said step and adapted to engage the bottom of the hole.

11. A rotary drill bit as defined in claim 10; said impregnated portion including circumferentially spaced longitudinal ribs extending laterally inwardly of said inner gauge surface.

12. A rotary drill bit as defined in claim 10; said impregnated portion including circumferentially spaced longitudinal ribs extending laterally inwardly of said inner gauge surface, said ribs being aligned with and extending upwardly from said individual cutting elements, said individual cutting elements extending laterally inwardly of said inner gauge surface.

13. A rotary drill bit as defined in claim 10; said impregnated portion including circumferentially spaced longitudinal ribs extending laterally inwardly of said inner gauge surface, said ribs being aligned with and extending upwardly from said individual cutting elements, said individual cutting elements extending laterally inwardly of said inner gauge surface, and individual cutting elements embedded in said ribs.

14. A rotary drill bit as defined in claim 10; said cutting elements of said impregnated portion being diamonds, said individual cutting elements being diamonds.

15. A rotary drill bit as defined in claim 10; said cutting elements of said impregnated portion being diamonds, said individual cutting elements being diamonds, said impregnated portion including circumferentially spaced longitudinal ribs extending laterally inwardly of said inner gauge surface, said ribs being aligned with and extending upwardly from said individual cutting elements, said individual cutting elements extending laterally inwardly of said inner gauge surface.

16. A rotary drill bit as defined in claim 10; said impregnated portion having waterways extending from said inner gauge surface to said outer gauge surface.

17. A rotary drill bit as defined in claim 10; said impregnated portion having waterways extending from said inner gauge surface to said outer gauge surface, the bases of said waterways being above said step and located substantially at the upper end of said impregnated portion.

18. A rotary drill bit as defined in claim 10; said cutting elements of said impregnated portion being diamonds, said individual cutting elements being diamonds, said impregnated portion including circumferentially spaced longitudinal ribs extending laterally inwardly of said inner gauge surface, said ribs being aligned with and extending upwardly from said individual cutting elements, said individual cutting elements extending laterally inwardly of said inner gauge surface, said impregnated portion having waterways extending from said inner gauge surface to said outer gauge surface, the bases of said waterways being above said step and located substantially at the upper end of said impregnated portion.

19. A rotary drill bit as defined in claim 10; said impregnated portion having a longitudinal rise extending between said step and drilling face, said impregnated portion including circumferentially spaced ribs extending laterally inwardly from said rise.

20. A rotary drill bit as defined in claim 10; said impregnated portion having a longitudinal rise extending between said step and drilling face, said impregnated portion including circumferentially spaced ribs extending laterally inwardly from said rise, said ribs having protuberances overlapping and integral with that portion of said drilling face adjacent to said rise and extending below said drilling face portion.

21. A rotary drill bit as defined in claim 10; said impregnated portion having a longitudinal rise extending between said step and drilling face, said impregnated portion including circumferentially spaced ribs extending laterally inwardly from said rise, said impregnated portion including circumferentially spaced longitudinal ribs extending laterally inwardly of said inner gauge surface, said longitudinal ribs being aligned with and extending upwardly from said individual cutting elements, said individual cutting elements extending laterally inwardly of said inner gauge surface.

22. A rotary drill bit as defined in claim 10; said impregnated portion having a longitudinal rise extending between said step and drilling face, said impregnated portion including circumferentially spaced ribs extending laterally inwardly from said rise, said impregnated portion including circumferentially spaced longitudinal ribs extending laterally inwardly of said inner gauge surface, said longitudinal ribs being aligned with and extending upwardly from said individual cutting elements, said individual cutting elements extending laterally inwardly of said inner gauge surface, said cutting elements of said impregnated portion being diamonds, said individual cutting elements being diamonds.

23. A rotary drill bit as defined in claim 10; said impregnated portion having a longitudinal rise extending between said step and drilling face, said impregnated portion including circumferentially spaced ribs extending laterally inwardly from said rise, said impregnated portion including circumferentially spaced longitudinal ribs extending laterally inwardly of said inner gauge surface, said longitudinal ribs being

drilling face adjacent to said rise and extending below said drilling face portion, said longitudinal ribs being aligned with and extending upwardly from said individual cutting elements, said individual cutting elements extending laterally inwardly of said inner gauge surfaces, said cutting elements of said impregnated portion being diamonds, said individual cutting elements being diamonds.

34. A rotary drill bit as defined in claim 10; said body structure comprising a shank, and a backing matrix between said shank and impregnated portion and secured thereto, said backing matrix having outer and inner gauge surfaces conforming to said outer and inner gauge surfaces, respectively, of said impregnated portion, said impregnated portion and backing matrix including circumferentially spaced longitudinal ribs extending inwardly of said inner gauge surfaces, said impregnated portion having a longitudinal rise extending

between said step and drilling face, said impregnated portion including circumferentially spaced ribs extending laterally inwardly from said rise, said last-mentioned ribs having protuberances overlapping and integral with that portion of said drilling face adjacent to said rise and extending below said drilling face portion, said longitudinal ribs being aligned with and extending upwardly from said individual cutting elements, said individual cutting elements extending laterally inwardly of said inner gauge surfaces, said impregnated portion having waterways extending from said inner gauge surface to said outer gauge surface of said impregnated portion, the bases of said waterways being above said step and located substantially at the upper end of said impregnated portion, said cutting elements of said impregnated portion being diamonds, said individual cutting elements being diamonds.

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