Dec. 24, 1946. E. F. ASTON 2,412,939

CORE DRILL

Filed June 25, 1945 2 Sheets-Sheet 1

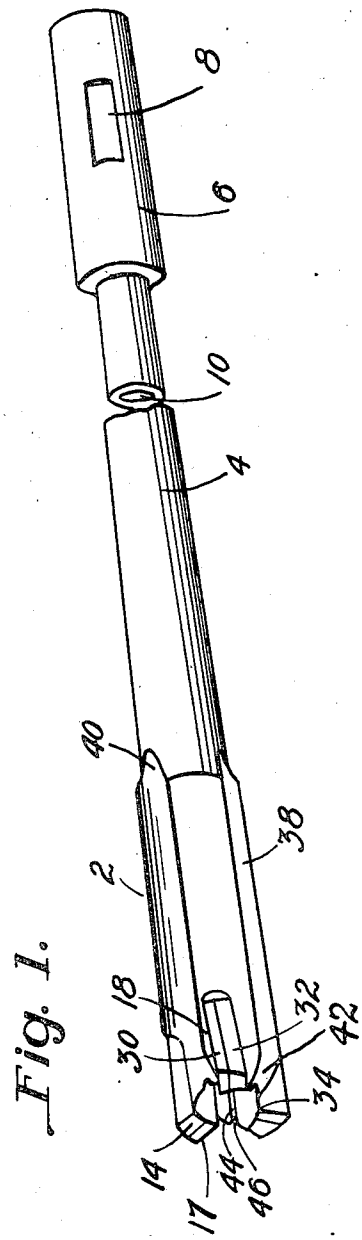

Fig. 1.

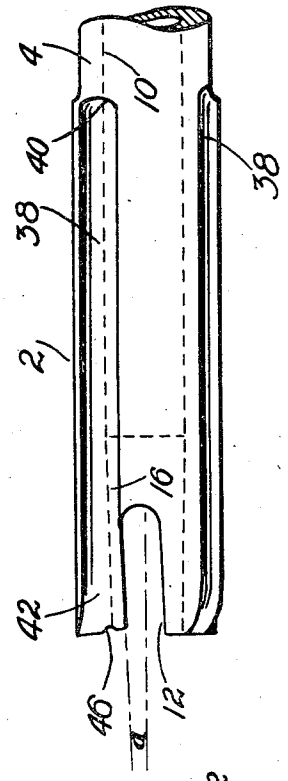

Fig. 3.

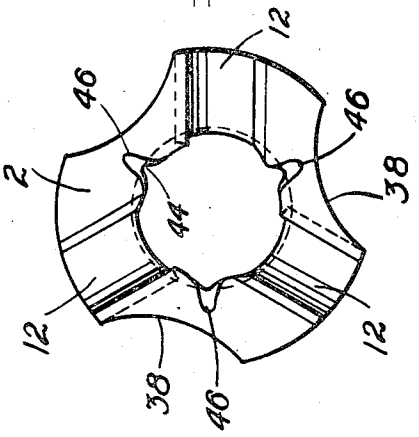

Fig. 2.

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CORE DRILL

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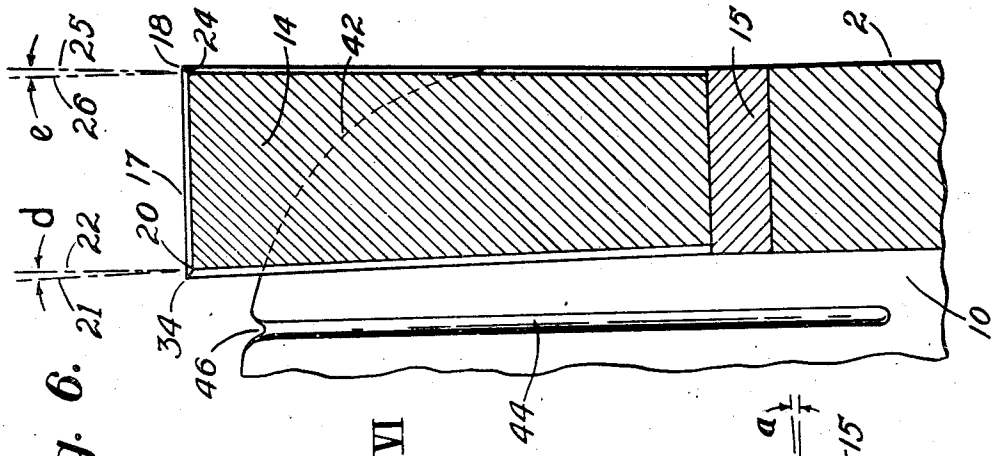

Fig. 6.

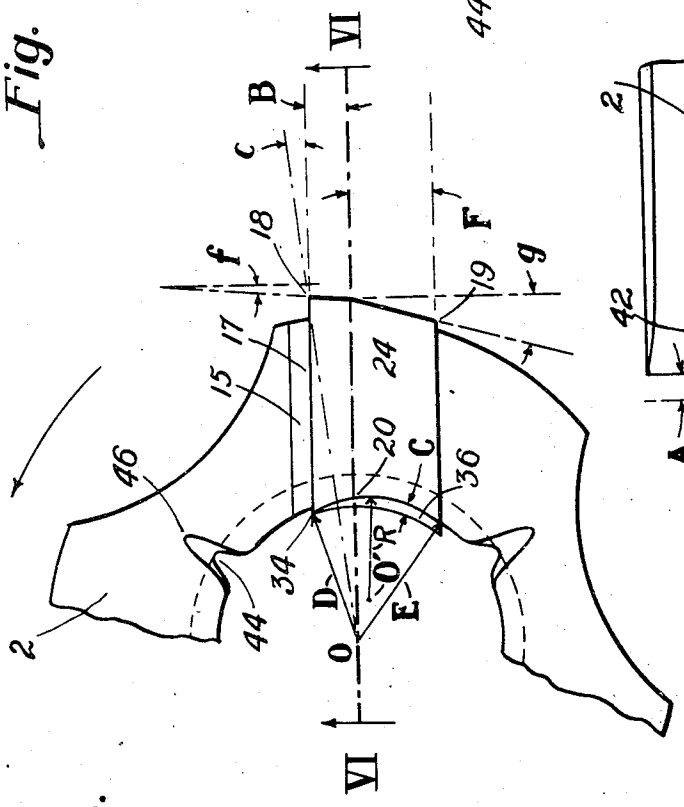

Fig. 4.

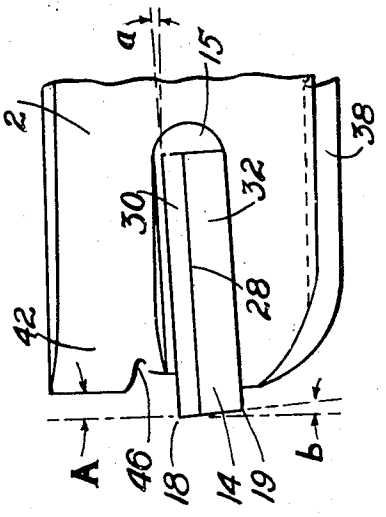

Fig. 5.

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UNITED STATES PATENT OFFICE

2,412,939

CORE DRILL

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Application June 25, 1945, Serial No. 601,406

9 Claims. (Cl. 77—69)

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This invention relates to an improved core drill of the type which produces a hole in material by forming an annular kerf and thus removing a solid core therefrom.

The invention has among its objects the provision of a core drill of improved design which makes feasible the drilling of hard materials, such as water-hardened armor plate.

A further object of the invention is the provision of a core drill having cutting bits so oriented that they are protected from cracking and spalling, and so that the chips cut thereby are removed from the zone of cutting by being forced to the outer periphery of the drill, thereby preventing binding at the core and consequent breaking of the drill.

These and further objects of the invention will become more fully apparent in the following disclosure.

Although the core drill of the present invention may be used to advantage in the cutting of holes in various types of materials, such as iron and steel articles, it displays perhaps its maximum advantages in the drilling of hard materials, such as water-hardened armor plate, for the purpose of removing therefrom an integral test core. When using prior art core drills for this purpose, failure thereof has been so frequent that it has not been possible as a regular commercial practice to secure test cores of the hardened armor plate in this manner. Failure of the prior art drills in such operation has been mainly of two types. Frequently the cutting bits, which are made of hard rather brittle material such as tungsten, carbide, shatter or spall. The drills also frequently became fouled by the chips cut, thereby becoming bound either at the core or the outer periphery thereof, and often ultimately breaking as a result.

The present invention makes possible the practice of drilling hard materials, of which water-hardened armor plate is typical, for the purpose of securing integral test cores. The core drill of the present invention possesses a long life in such arduous service, and overcomes the difficulties experienced with prior art drills outlined above. In general, the drill overcomes shattering and spalling of the bits by a novel arrangement of such bits to provide them with proper clearances and rakes to avoid unduly high localized pressures thereon, and overcomes binding of the drill in the kerf by a particular distribution of chip receiving and coolant conducting grooves, thereby preventing the chips from fouling the drill.

The invention will be more readily understood by consideration of the accompanying drawings, in which:

Figure 1 is a view in perspective of the core drill of the present invention;

Figure 2 is an enlarged end view of the bit holder of the core drill;

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Figure 3 is an enlarged view in elevation of the bit holder of the core drill;

Figure 4 is an enlarged end veiw of a portion of the core drill;

Figure 5 is an enlarged view in elevation of a portion of the cutting head of the drill; and

Figure 6 is a view in cross section through the cutting head of the drill, the section being taken along the line VI—VI in Figure 4.

The core drill of the present invention consists generally of a cutting head 2 having a diameter substantially equal to the outer diameter of the annular kerf to be cut, an elongated drill shank 4 having a diameter somewhat less than that of the cutting head, and an enlarged chuck-engaging portion 6 having a flatted portion 8 thereon for engagement with the drill driving and holding means of the chuck. The drill is provided with an axial bore 10 therethrough, such bore providing for the reception of the core of material cut by the drill and for the introduction through the rear end thereof of a suitable coolant, lubricant, or of compressed air for the forcing of the chips to the outer periphery of the kerf. In the core drill shown, the cutting head 2 is provided with three equally spaced bit receiving seats 12, at the forward end thereof, in which cutting bits 14 of hard material, such as tungsten carbide, are retained by means of brazing metal 15 on the sides and bottoms thereof which bonds them to the bit holder.

As shown more particularly in Figure 3, the end of bore 10 at the outer end of the cutting head is tapered slightly at 16 toward the outer end of the cutting head so as to provide adequate clearance between the core of material cut and the inner walls of bore 10. Bit receiving seats 12 are milled into the outer end of the cutting head in such angular relationship with respect to the axis of the drill, and the bits are positioned in the seats when being brazed therein, so that they have a small angle of negative axial rake *a* as shown in Figures 3 and 5. The direction of rotation of the drill is in the direction of the arrow in Figure 4 and from the bottom to the top in Figures 1, 3, and 5. Each of bits 14 is of such dimensions relative to the length of the seat and is finished ground after being mounted in the bit holder so that the forward cutting end thereof projects a material distance A from the outer end of the bit holder. The outer cutting edge of each bit is also provided with a small clearance angle *b* as shown in Figure 5.

In order to provide each of the cutting bits with a suitable angle of negative radial rake in accordance with the present invention, each of the bit receiving seats 12 is positioned as shown in Figure 4 so that the center of the bit lies somewhat below the radial line parallel with its forward and rearward edges. As shown in Figure 4, the outer corner of the outer leading cutting edge

18 axially of bit 14 is located a small distance B above the radial line which coincides with section line VI—VI, distance B being somewhat less than the distance F from such radial line to the trailing outer edge 19 of the bit. As a result of such location of the bit, the bit is disposed in the bit holder with a negative radial rake measured by the small angle *c* between a radial line from the axis O of the drill through the outer corner of the edge 18 of the drill, in the plane of the paper in Figure 4, and a line, also in the plane of the paper in that figure, coinciding with the forward cutting edge 17 on the end face thereof.

In order to provide the bits with clearance on both their inner and outer axial cutting faces, they are provided with the clearances on the sides thereof more clearly shown in Figure 6. As shown in that figure, the cutting bits are ground so that they have a radial thickness decreasing from the outer cutting face thereof in a direction toward the rear of the bits. The clearance angle *d* from the bit face on the inside along a longitudinal axis of the drill may be measured between line 21 through the point 20, at the point at which section line VI—VI cuts the outer face of the bit, line 21 contacting the inner face of the bit and lying in an axial plane, and the line 22, which is a line parallel to the axis of the drill and lying in an axial plane. The clearance angle from the bit face on the outside in an axial plane may similarly be measured between the line 25 running through the point 24, which is the point on the outer face of the bit which is cut by section line VI—VI, line 25 lying along the outer face of the bit and in an axial plane, and the line 26 likewise running through point 24, parallel to the axis of the drill and in an axial plane. As a result of such clearances the inner and outer cutting edges of the bit are relieved from contact with the inner and outer walls of the kerf except at the outer cutting face of the bit.

The outer cutting face of the bit is further provided with two lands 30 and 32, the first or leading land 30 being of less extent than the second or trailing land, and being disposed at an angle *f* with respect to a line at right angles to the radius coinciding with the section line VI—VI, angle *f* being appreciably smaller than the angle *g*, at which the second land is disposed to such line. The junction between the two lines is in the form of a straight line 28, as shown in Figure 5.

The inner axial cutting face of each bit is provided with the proper amount of clearance, as shown in Figure 4, where the leading cutting edge 34 of such inner face is shown projecting toward the axis O a distance D, which is less than the distance E from such axis to the trailing edge 36 by a distance C. Such clearance is produced, after the bits have been mounted in the bit holder, by the introduction of a small right circular cylindrical grinding wheel of radius R within the bore of the drill with its axis O' parallel to the axis of the drill but displaced slightly below the radial line coinciding with section line VI—VI. It will be obvious that such offsetting of the grinding wheel will produce the curved inner face of the bit as shown, in which the leading cutting edge projects inwardly a distance greater than does the trailing cutting edge. Although such ground curved inner face is shown in the particular core drill illustrated as extending over the full extent of the inner axial face of the bit, it is obvious that in some designs proper clearance will be afforded between the leading and trailing edge when the curved ground surface extends only part of the way back from the leading to the trailing edge.

The bit holder is provided on the cutting head thereof with three longitudinal external chip clearance grooves or flutes 38 of relatively large radius, such grooves being equally spaced circumferentially of the head and positioned between the bit receiving seats with the trailing end of each groove located close to the leading or cutting edge of each bit so that chips cut by each bit may be received directly into the groove. The chip clearance grooves 38 are radiused at the point 40 where the enlarged cutting head is joined to the shank 4 of reduced diameter. Each groove 38 is flared circumferentially on the cutting head and deepened radially at the forward end 42 thereof, as indicated in Figures 1 and 3, so that chips cut by each bit are thrown outwardly away from the core and into the chip clearance groove forward of each particular bit. The cutting head is further provided with three internal longitudinal coolant grooves 44, as shown in Figures 1, 4, and 6, to carry coolant, lubricant, compressed air, or combinations of them axially of the cutting head past the core down to the zone of cutting. The forward end of each coolant groove is notched at 46, as shown in Figures 4 and 5, in order to insure the escape of such fluid from the grooves into the working zone, whence it progresses upwardly through the chip clearance grooves, carrying chips with it.

The use of the negative angle of axial rake has been found to reduce greatly the tendency of the cutting bits to break. This is probably due to the fact that the relatively brittle tungsten carbide tends to snap when pushed into the work rather than being dragged along it. The radial negative rake results in suitable travel of the chips outwardly where provision is made for their reception in the chip clearance groove. The amount of radial negative rake must be carefully chosen, however, since too great an angle of negative radial rake forces the chips to the outside of the drill at so great a rate so that the volume of chips may exceed the capacity of the chip clearance grooves to accommodate them, so that the chips will bind between the drill and the wall of the hole.

As a specific example of a core drill made in accordance with the present invention, the following dimensions of a typical drill employed for the drilling of water-hardened armor plate are given. It is to be understood, however, that numerous variations are possible, depending upon the type of the material to be drilled, the size of the outer bore, and the size of the core, etc. In such typical drill, which removes a ¼ inch diameter core, the diameter of the head 2 and of the outer wall of the kerf is ⅝ inch and the diameter of the bore 10 of the drill is $\frac{5}{16}$ inch. Zone 16, which extends inwardly one inch from the outer end of the cutting head, is tapered in an amount of ¾ inch per foot, which is equivalent to 3° 35'. The bits employed are tungsten carbide having when mounted but before grinding, a thickness of ⅛ inch, a width of ¼ inch in the direction radial of the drill, and a height of ½ inch, axially of the drill.

The axial projection A of each bit is $\frac{3}{64}$ inch, the negative axial rake angle *a* is 3°, the negative radial rake angle *c* is 5° 21', clearance angle *b* from the outer cutting edge is 3°, clearance angle *d* at the inner axial edge is 1° 47½', clearance angle *e* at the outer axial edge is 30', the amount

of clearance C of the inner leading edge of each bit is .008 inch. Such clearance is produced by the use of a 3/16 inch diameter R right circular cylindrical abrasive wheel mounted with the center O' 1/64 inch below the radial line coinciding with the section line VI—VI. The width B of the first land on the outer axial cutting face of the bit is 3/64 inch and the width F of the second is 5/64 inch. The angle *f* of the first land with respect to the line at right angles to the radius is 3°, and the angle *g* with respect to such line is 10°.

Having thus fully disclosed the core drill of the present invention, what I desire to claim is the following.

I claim:

1. A core drill comprising an elongated hollow shank, a hollow cutting head positioned on the forward end of the shank coaxially thereof, said cutting head having a longitudinal bore therethrough and a plurality of substantially equally spaced longitudinally extending chip clearance grooves on the exterior thereof, the cutting head having a plurality of cutting portions thereon, said cutting portions being spaced substantially equally both circumferentially of the exterior surface and radially of the bore, one such cutting portion being positioned between each successive pair of grooves, said cutting portions having end cutting and inner and outer axial cutting faces, the cutting portions being so disposed on the head as to cut an anular kerf of a diameter at least slightly in excess of the diameter of the head and to cut an integral core of the material being drilled having a diameter at least slightly less than the diameter of the bore through the head, the forward cutting edge of the outer axial cutting face being disposed with respect to the axis of the head so that it has a small angle of negative axial rake and the forward cutting edge of the end cutting face being so disposed as to have a small angle of negative radial rake.

2. A core drill comprising an elongated hollow shank, a hollow cutting head positioned on the forward end of the shank coaxially thereof, said cutting head having a longitudinal bore therethrough and a plurality of substantially equally spaced longitudinally extending chip clearance grooves on the exterior thereof, the chip clearance grooves at the forward working end of the cutting head being flared circumferentially, the cutting head having a plurality of cutting portions thereon, said cutting portions being spaced substantially equally both circumferentially of the exterior surface and radially of the bore, the forward substantially radial cutting faces of the cutting portions communicating directly with the flared forward end of the adjacent forward chip clearance groove, one such cutting portion being positioned between each successive pair of grooves, said cutting portions having end cutting and inner and outer axial cutting faces, the cutting portions being so disposed on the head as to cut an annular kerf of a diameter at least slightly in excess of the diameter of the head and to cut an integral core of the material being drilled having a diameter at least slightly less than the diameter of the bore through the head, the forward cutting edge of the outer axial cutting face being disposed with respect to the axis of the head so that it has a small angle of negative axial rake and the forward cutting edge of the end cutting face being so disposed as to have a small angle of negative radial rake.

3. A core drill comprising an elongated hollow shank, a hollow cutting head positioned on the forward end of the shank coaxially thereof, said cutting head having a longitudinal bore therethrough and a plurality of substantially equally spaced longitudinally extending chip clearance grooves on the exterior thereof, the chip clearance grooves at the forward working end of the cutting head being flared outwardly and deepened radially, the cutting head having a plurality of cutting portions thereon, said cutting portions being spaced substantially equally both circumferentially of the exterior surface and radially of the bore, the forward substantially radial cutting faces of the cutting portions communicating directly with the flared forward end of the adjacent forward chip clearance groove, one such cutting portion being positioned between each successive pair of grooves, said cutting portions having end cutting and inner and outer axial cutting faces, the cutting portions being so disposed on the head as to cut an annular kerf of a diameter at least slightly in excess of the diameter of the head and to cut an integral core of the material being drilled having a diameter at least slightly less than the diameter of the bore through the head, the forward cutting edge of the outer axial cutting face being disposed with respect to the axis of the head so that it has a small angle of negative axial rake and the forward cutting edge of the end cutting face being so disposed as to have a small angle of negative radial rake, said cutting head having a plurality of longitudinally extending lubricant-receiving grooves in the forward end of the bore therethrough, said grooves being located at substantially equal distances around the periphery of the bore.

4. A core drill comprising a bit holder including an elongated hollow shank and a hollow cutting head on the forward end of such shank coaxially thereof, said cutting head having a longitudinal bore therethrough and being provided with a plurality of longitudinally extending chip clearance grooves on the exterior thereof, said grooves being spaced substantially equally about the periphery of the head, the forward ends of such grooves being flared circumferentially, the forward end of the cutting head being provided with a plurality of cutting head receiving seats, one of each of such seats being positioned adjacent each chip clearance groove, said seats being disposed generally longitudinally of the cutting head and generally radially of the bore, a hard metal cutting bit secured in each such seat so that they all lie at substantially the same radial distance from the axis of the bore, each cutting bit having an end cutting face and inner and outer axial cutting faces, the forward cutting edge of the outer axial cutting face being so disposed with respect to the axis of the cutting head as to have a small angle of negative axial rake and the forward cutting edge of the end cutting face being so disposed with respect to a radial plane parallel thereto as to have a small angle of negative radial rake.

5. A core drill comprising a bit holder including an elongated hollow shank and a hollow cutting head on the forward end thereof and coaxial therewith, the cutting head having a longitudinal bore therethrough, the bore through the cutting head tapering slightly toward the axis of the bore from a point some distance to the rear of the cutting end in a direction toward the working face of the cutting head, said cutting head having a plurality of longitudinally extending chip clearance grooves substantially equally spaced on the exterior thereof, the for-

ward end of each chip clearance groove being flared circumferentially, said cutting head being provided with a plurality of cutting bit receiving seats, one of each of such seats being located between each successive pair of chip clearance grooves, each such seat being disposed generally longitudinally of the cutting head and generally radially thereof, a hard metal cutting bit secured in each seat so that the forward radial cutting face thereto communicates directly with the flared portion of its adjacent forward chip clearance groove, each bit having an end cutting face and inner and outer axial cutting faces, the bits being so disposed on the cutting head as to cut an annular kerf of at least slightly greater diameter than the cutting head and to cut an integral core of the material being drilled having a diameter at least slightly less than that of the bore of the cutting head at the forward end thereof, the forward cutting edge of the outer axial cutting face being so disposed with respect to the axis of the cutting head as to have a small angle of negative axial rake, and the forward cutting edge of the end cutting face of each bit being so disposed with respect to a radial plane parallel to such edge as to have a small angle of negative radial rake.

6. A core drill comprising a bit holder including an elongated hollow shank and a hollow cutting head on the forward end thereof and coaxial therewith, the cutting head having a longitudinal bore therethrough, the bore through the cutting head tapering slightly toward the axis of the bore from a point some distance to the rear of the cutting end in a direction toward the cutting end, said cutting head having a plurality of longitudinally extending chip clearance grooves substantially equally spaced on the exterior thereof, the forward end of each chip clearance groove being flared circumferentially, said cutting head being provided with a plurality of cutting bit receiving seats, one of each of such seats being located between each successive pair of chip clearance grooves, each such seat being disposed generally longitudinally of the cutting head and generally radially thereof, a hard metal cutting bit secured in each seat so that the forward radial cutting face thereof communicates directly with the flared portion of its adjacent forward chip clearance groove, each bit having an end cutting face and inner and outer axial cutting faces, the bits being so disposed on the cutting head as to cut an annular kerf of at least slightly greater diameter than the cutting head and to cut an integral core of the material being drilled having a diameter at least slightly less than that of the bore of the cutting head at the forward end thereof, the forward cutting edge of the outer axial cutting face being so disposed with respect to the axis of the cutting head as to have a small angle of negative axial rake, and the forward cutting edge of the end cutting face of each bit being so disposed with respect to a radial plane parallel to such edge as to have a small angle of negative radial rake, the forward tapered portion of the bore through the cutting head being provided with a plurality of substantially equally spaced longitudinally extending lubricant receiving grooves, each groove communicating with a generally radial notched portion in the end of the bit holder to insure the escape of lubricant therefrom.

7. In the core drill set out in claim 1, each cutting portion being provided with a plurality of longitudinally extending lands on the outer axial cutting face thereof, the land adjacent the leading outer axial cutting edge having a smaller clearance angle than the land rearwardly thereof, the outer axial cutting face tapering toward the axis of the cutting head and the inner axial cutting face tapering away from such axis in an axial direction away from the cutting face of the head so that the cutting portion is relieved from contact with the outer circumference of the kerf and with the core except at the forward cutting end of the tool.

8. In a core drill set out in claim 4, each cutting portion being provided with a plurality of longitudinally extending lands on the outer axial cutting face thereof, the land adjacent the leading outer axial cutting edge having a smaller clearance angle than the land rearwardly thereof, the outer axial cutting face tapering toward the axis of the cutting head and the inner axial cutting face tapering away from such axis in an axial direction away from the cutting face of the head so that the bit is relieved from contact with the outer circumference of the kerf and with the core except at the forward cutting end of the tool.

9. A core drill comprising a bit holder including an elongated hollow shank, a hollow cutting head on the forward end thereof and coaxial therewith, the cutting head having a longitudinal bore therethrough, the cutting head having a diameter substantially larger than that of the shank, the cutting head being provided with a plurality of longitudinally extending substantially equally spaced chip clearance grooves on the exterior thereof, the forward ends of such grooves being flared circumferentially and deepened radially, said cutting head having a plurality of substantially eually spaced bit receiving seats, one of each of such seats being located between each successive pair of chip clearance grooves, each seat being located generally longitudinally of the cutting head and generally radially thereof, a hard metal cutting bit secured in each such seat so that the forward cutting face of each bit communicates directly with the flared forward end of its adjacent forward clip clearance groove, each cutting bit having an end cutting face and inner and outer axial cutting faces, the bits being so disposed on the head as to cut an annular kerf of at least slightly greater diameter than the head and to cut an integral core of the material being drilled having a diameter at least slightly less than that of the bore through the head, the forward cutting edge of the outer axial cutting face of each bit being so disposed relative to the axis of the cutting head as to have a small angle of negative axial rake and the forward cutting edge of the end cutting face being so disposed with respect to a radial plane parallel to such edge as to have a small angle of negative radial rake, the outer and inner axial cutting faces of each bit being relieved from contact with the outer wall of the kerf and from the core cut thereby except at the forward cutting end thereof, the forward portion of the bore through the cutting head being provided with a plurality of substantially equally spaced lubricant-receiving grooves which communicate at their forward ends with the forward flared ends of the chip clearance grooves.

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