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ROCK DRILL WITH SOCKET HAVING A CURVED SURFACE

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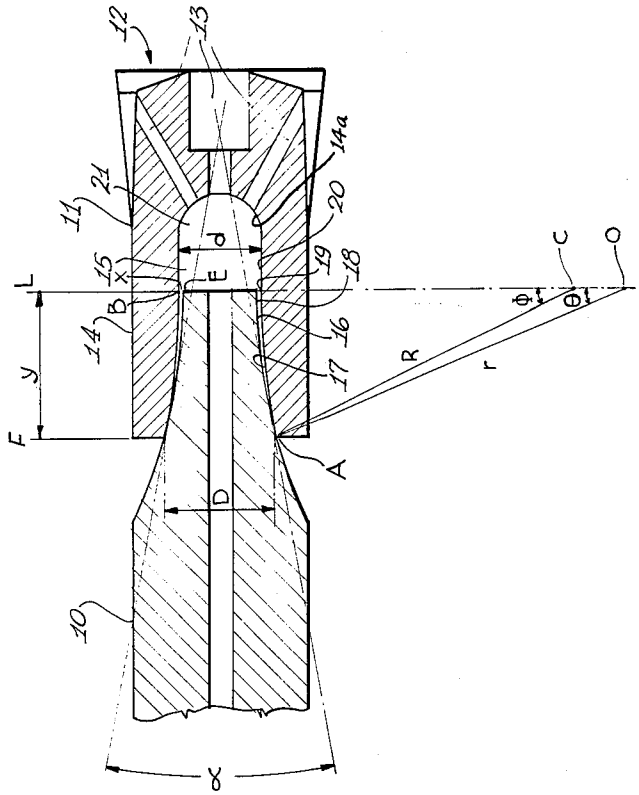

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ROCK DRILL WITH SOCKET HAVING A CURVED SURFACE

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This invention relates to rock drill bits and drilling assemblies and other structures where transmission of a force through a demountable joint is required.

A conventional push-on type of drill bit comprises a cutting head and a rod-receiving socket portion having a skirt with an interior linearly tapered surface section and usually a second surface section of approximately constant diameter, and a dome. The rod for use with such a bit has a linearly tapered end section of complementary dimensions for engagement with the tapered surface section of the bit skirt. These conventional bits have a limited life due to operational failures which most frequently are radial fractures in the skirt ("ring-offs") and, to a lesser extent, radial failures through the base of the dome and the water hole in the cutting head.

It has been determined that the use of linear tapers results in a large hoop stress discontinuity with resulting tensile forces which cause fatigue failures in the conventional bits.

It is an object of this invention to provide a drill bit and rod assembly which will result in reduced hoop stress discontinuity with consequent less failure incidence and increased operational life.

The invention will be described with reference to the accompanying drawing, the single figure of which is a sectional elevation of a bit and rod assembly in accordance with the invention.

Referring to the drawing, **10** is a drill rod and **11** a bit in accordance with the invention.

The bit **11** has a cutting head **12** with water holes **13** and a skirt **14** having an interior cylindrical surface **14***a* forming a socket **15** for reception of the tapered end **16** of the rod **10**.

In accordance with the invention, the interior or rod-seating surface portion **17** of the bit skirt is of a curved tapered contour, and the complementary surface **18** of the rod end **16** is of a nearly mating curved tapered contour. It is quite desirable that, as shown, there be a smooth tangential transition of the surface portion **17** to the surface portion **19** of the constant diameter section **20** of the skirt leading to the dome **21** in order that there be no abrupt change in hoop stress at the root.

It will be apparent that the entire cylindrical surface **14***a* of the skirt **14** and comprising the surfaces **17** and **19** and dome **21**, constitutes the entire longitudinal extent of the socket. The interior cylindrical surface **14***a* of the skirt is fundamentally circular in cross-section throughout its extent and has a longitudinal axis of symmetry. As previously indicated, the surface portion **17** is curved in the longitudinal section thereof. The surface **14***a* has a maximum diameter of successively decreasing degree from the mouth throughout the entire longitudinal extent of such surface.

It will be apparent that the provision of such surfaces **17** and **18** on the bit and rod makes possible an arrangement of such surfaces whereby true tangential separation of rod and bit is possible. It will be recognized that the provision of a theoretically ideal rod shape is impractical, since it would be confined to one specific load for each shape, and the configuration chosen must be tolerant of production variables. However, there is illustrated in the figure the geometry of one configuration

using nearly mating radii which is satisfactory for practical purposes and which approximates most closely to the ideal.

It is emphasized that there are many other geometrical configurations that are satisfactory, including one with nearly mating surfaces of opposite signs to those illustrated and nearly mating surfaces of non-constant radii of both signs. A concave radius on the rod and a convex radius on the bit are defined as those illustrated in the figure.

In the drawing,

F is a plane lying normal to the longitudinal axis of the bit and in which lies the socket mouth end of the bit.

L is a plane lying normal to the longitudinal axis of the bit and in which occurs the juncture of surfaces **17** and **20**.

$AC=R$=radius of rod surface **18**.
$AO=r$=radius of bit surface **17**.
$BE=x$=root clearance.
$FL=y$=length of tapered section of bit.
D=diameter of mouth.
d=diameter of surface **19**.
α=mouth angle.

It will be apparent that, if the radii AC and AO were identical, the root clearance BE would be zero. This arrangement would of course be impractical since it is intolerant of production variables.

Considering triangle AOC,

$$\text{Sin } \phi = r/R \text{ Sin } \theta \qquad \text{(I)}$$

Since $BE=BC-EC$,

$$BE=R-r+r \text{ Cos } \theta - R \text{ Cos } \phi \qquad \text{(II)}$$

With ϕ obtained from (I), the root clearance is therefore

$$x=r \text{ Sin } \theta . \tan \phi/2 - r (1-\text{Cos } \theta) \qquad \text{(III)}$$

It will be observed that the mouth angle α equal 2θ.

The following table gives by way of example suitable dimensional characteristics of curved taper bits in accordance with the invention, based upon a mouth diameter (D) of 0.875 inch.

TABLE I

Examples of dimensions for curved taper bits

y (in.)	r (in.)	α	d (in.)
1.125	4.0	32°40′	0.549
1.125	5.0	26°	0.619
1.125	6.0	21°36′	0.663
1.25	5.0	28°58′	0.557
1.25	6.0	24°1′	0.611
1.25	7.0	20°34′	0.649
1.25	8.0	17°58′	0.679
1.375	5.0	31°56′	0.489
1.375	6.0	26°30′	0.555
1.375	7.0	22°40′	0.603
1.375	8.0	19°48′	0.637
1.375	9.0	17°34′	0.667
1.50	6.0	28°58′	0.493
1.50	7.0	24°46′	0.549
1.50	8.0	21°36′	0.591
1.50	9.0	19°12′	0.623
1.50	10.0	17°16′	0.649

In one form of standard bit, the taper length (y) is 1.25 inches with a value for d of 0.65 inch. It is not desirable to use values of d significantly above this figure, as the consequent reduction of section may result in failures on a pseudo-buckling basis. The value of d cannot be reduced excessively, as the necessary resultant reduction in rod tip diameter may be impossible on some rods due to non-axiality of the water hole. The choice of dimensions giving a high mouth angle (α) is not desirable, as the interference forces holding the bit onto the rod

will be lower, with the consequent possibility of the bit becoming detached on withdrawal from the drill hole.

The following table gives values of the rod radius (R) necessary for given root clearances between the bit and the rod for bit dimensions which appear most suitable. The root diameter of the rod is obtained by simple subtraction of the clearance from the values of *d* given in Table I.

TABLE 2

Examples of values of rod radius and root diameter for most suitable clearances and bit dimensions

Taper Length *y* (in.)	Bit Radius (in.)	Root Clearance (in.)	Rod Radius (in.)	Rod Root Diameter (in.)
1.125	6.0	0.0018	5.90	.6594
		0.0037	5.80	.6556
		0.0099	5.50	.6432
		0.0218	5.00	.6194
1.25	7.0	0.0017	6.90	.6456
		0.0034	6.80	.6422
		0.0088	6.50	.6314
		0.0191	6.00	.6108
1.25	8.0	0.0013	7.90	.6764
		0.0021	7.80	.6738
		0.0066	7.50	.6658
		0.0143	7.00	.6504
1.375	7.0	0.0020	6.90	.5990
		0.0041	6.80	.5948
		0.0107	6.50	.5816
		0.0233	6.00	.5564
1.375	8.0	0.0015	7.90	.6340
		0.0031	7.80	.6308
		0.0081	7.50	.6208
		0.0173	7.00	.6048
1.375	9.0	0.0012	8.90	.6646
		0.0024	8.80	.6622
		0.0063	8.50	.6544
		0.0134	8.00	.6402
1.5	8.0	0.0018	7.90	.5874
		0.0037	7.80	.5836
		0.0097	7.50	.5716
		0.0207	7.00	.5496
1.5	9.0	0.0014	8.90	.6202
		0.0029	8.80	.6172
		0.0075	8.50	.6080
		0.0160	8.00	.5910
1.5	10.0	0.0012	9.90	.6466
		0.0023	9.80	.6444
		0.0060	9.50	.6370
		0.0127	9.00	.6236

Due to the curved nature of the contact between rod and bit, the use of the usual brass shim is rather impractical, but zinc spraying of the contacting surface of the bit may be used provided suitable dimensional changes are made in the bit and/or rod to compensate.

It should be observed that in the case considered the radius centre of the rod is in line with the end of the rod, while that of the bit is at a distance from the open end equal to the length of the taper section.

The data given in the tables is given by way of example for one configuration for one specific drill size; similar data for other sizes can readily be computed using the relations given.

As given in Table 2, the taper length is 1.125 to 1.50 inches, the bit radius 6 to 10 inches and the root clearance 0.010 to 0.050 inch.

The expression "root clearance" as employed in the appended claims means the radial clearance between the mating surfaces of rod and bit in the assembly at the root or small diameter section of such surfaces.

While the foregoing description has been directed mainly to drilling assemblies, it will be understood that the basic principals involved are equally applicable to any other structure involving the transmission of a force through a demountable joint.

I claim:

1. A drilling device comprising a drill bit having a cutting head and a rod receiving skirt defining a socket, said skirt having an interior cylindrical surface constituting the entire longitudinal extent of said socket and an edge defining the mouth of said socket, said surface being fundamentally circular in cross-section throughout its extent and having a longitudinal axis of symmetry, said surface being curved in the longitudinal section thereof and having a maximum diameter at said mouth and a diameter of successively decreasing degree from said mouth throughout the entire longitudinal extent of said surface.

2. A drill bit as defined in claim **1**, said curved surface being convex.

3. A drill bit as defined in claim **1**, said curved surface being of constant radius.

4. A drill bit comprising a cutting head and a skirt defining a socket, said skirt having an interior cylindrical surface constituting the entire longitudinal extent of said socket and an edge defining the mouth of said socket, said surface having a longitudinal axis of symmetry and being circular in cross-section throughout its extent, said surface having a constant diameter portion remote from said mouth and a second portion extending from said constant diameter portion to said mouth, said second portion being curved in the longitudinal section thereof on a radius the center of which lies in a plane normal to said longitudinal axis and in which occurs the juncture of said surface portions, said surface having a maximum diameter at said mouth and a diameter of successively decreasing degree from said mouth throughout the entire longitudinal extent of said surface.

5. A drill bit as defined in claim **4**, the length of said curved surface being 1.125 to 1.50 inches, and said radius of curvature being 6 to 10 inches.

6. A drill bit as defined in claim **5**, said curved surface having a daimeter of about 0.549 to 0.679 inch.

7. A drilling assembly comprising a drill bit having a cutting head and a skirt defining a socket, said skirt having an interior cylindrical surface constituting the entire longitudinal extent of said socket and an edge defining the mouth of said socket, said surface having a longitudinal axis of symmetry and being circular in cross-section throughout its extent, said surface having a constant diameter portion remote from said mouth and a second portion extending from said constant diameter portion to said mouth, said second portion being curved in the longitudinal section thereof on a radius the center of which lies in a plane normal to said longitudinal axis and in which occurs the juncture of said surface portions, said surface having a maximum diameter at said mouth and a diameter of successively decreasing degree from said mouth throughout the entire longitudinal extent of said surface, and a rod having an end portion the surface of which is curved in the longitudinal section thereof on a constant radius, said rod surface being of gradually decreasing diameter towards the adjoining end of said rod, the diameter range of said second surface portion of said socket being approximately the same as that of said rod end portion surface.

8. A drilling assembly as defined in claim **7**, the center said radius of curvature of said rod end portion surface lying in the diametral plane of said adjoining end of said rod, said curved surface of said socket having a root clearance with respect to said rod end portion surface.

9. A drilling assembly as defined in claim **8**, said root clearance being in accordance with the formula

$$r \text{ Sin } \theta . \tan \frac{\Phi}{2} - r(1 - \text{Cos } \theta)$$

where r is said radius of curvature of said bit surface section, θ is the angle of r with said plane of juncture, and Φ is the angle of said radius of curvature of said rod surface with said diametral plane.

10. A drill bit comprising a cutting head and a rod-receiving skirt having a rod-engageable interior surface, said surface having a dome section constituting the inner end thereof, and an outer end defined by the edge of said skirt, said surface being circular in cross-section throughout its extent and having a longitudinal axis of symmetry, the portion of said surface adjoining said dome section being of constant diameter, and the remaining portion of

said surface being curved in the longitudinal section thereof, and having a gradually increasing diameter from a minimum diameter at the juncture with said constant diameter portion to a maximum diameter at said outer end.

11. A joint assembly comprising a first member having a skirt defining a socket, said skirt having an interior cylindrical surface constituting the entire longitudinal extent of said socket and an edge defining the mouth of said socket, said surface having a longitudinal axis of symmetry and being circular in cross-section throughout its extent, said surface having a constant diameter portion remote from said mouth and a second portion extending from said constant diameter portion to said mouth, said second portion being curved in the longitudinal section thereof on a radius the center of which lies in a plane normal to said longitudinal axis and in which occurs the juncture of said surface portions, said surface having a maximum diameter at said mouth and a diameter of successively decreasing degree from said mouth throughout the entire longitudinal extent of said surface, and a second

member having an end portion of the surface of which is curved in the longitudinal section thereof on a constant radius, said second member surface being of gradually decreasing diameter towards the adjoining end of said second member, the diameter range of said second portion of said socket surface being approximately the same as that of said second member surface.

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