March 17, 1964 J. D. MEDLOCK ETAL 3,125,174

ROCK BIT WITH REPLACEABLE AIR COURSE

Filed Feb. 9, 1961 2 Sheets-Sheet 1

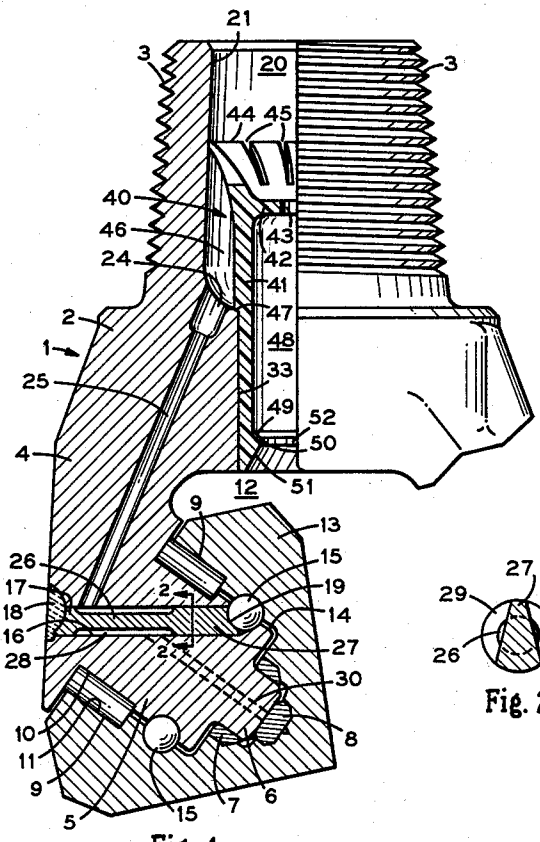


Fig. 1

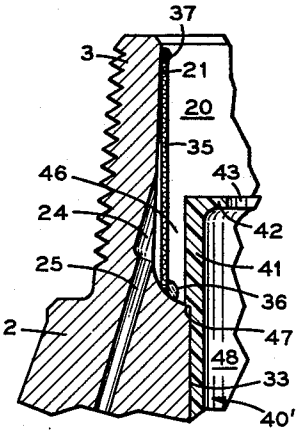


Fig. 3

Fig. 2

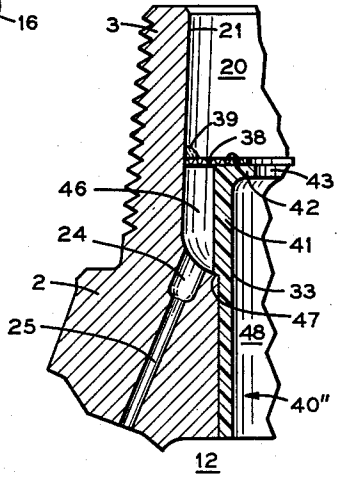


Fig. 4

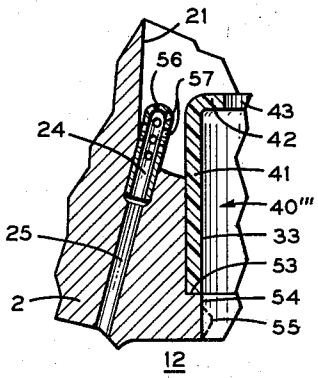


Fig. 5

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ROCK BIT WITH REPLACEABLE AIR COURSE

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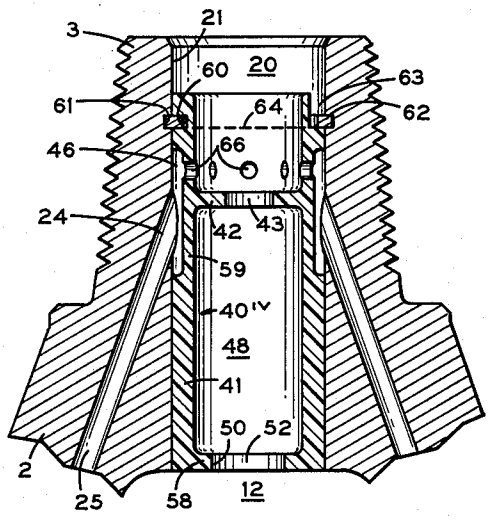


Fig. 6

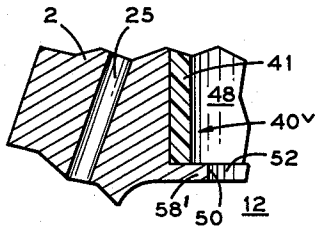


Fig. 9

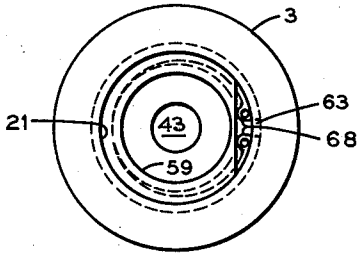


Fig. 7

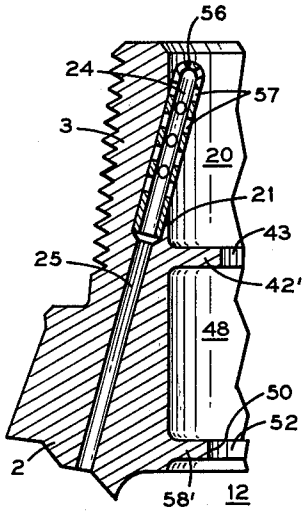


Fig. 10

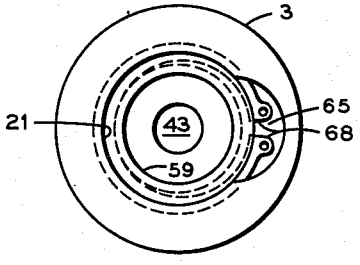


Fig. 8

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3,125,174

ROCK BIT WITH REPLACEABLE AIR COURSE

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Filed Feb. 9, 1961, Ser. No. 88,160
19 Claims. (Cl. 175—337)

The present invention deals with rock bits of the rolling cutter type, and more particularly with those rock bits utilizing air or another gas, frequently laden with water or another liquid, as the flushing and cleaning medium. Such a bit is attached to a hollow drill stem through which the gas is pumped to the bit and thereafter through a number of passages in the bit to the bottom of the hole. Some of these passages divert part of the gas to the bearing spaces between the rolling cutters and their associated shafts to cool these elements and to keep such spaces cleared of foreign matter and abrasion products, the balance of the gas being passed directly through other passages in the bottom of the bit head to impinge either on the exterior of the cutters or directly on the formation being drilled, or a combination of both.

In the prior art, it has been customary to provide one or more such passages at or near the bit axis for the direct air flow, such passages being commonly known in the art as "drilled air courses." When an air stream passes through such air courses at the flow rate necessary to carry away the cuttings produced by the action of the bit, there is frequently severe erosion of the cutter cutting structure.

Since a typical modern bit has three cones interfitting so closely as to leave no gaps except toward the bit periphery, such erosion could not be avoided by reorienting the centrally disposed air courses. Other expedients were adopted, e.g., moving the air courses to locations near the bit periphery in the gaps between the cutters, thus converting the structure to what is now commonly called a "jet" bit. Jet bits do not present the same erosion problems, but they are more difficult to manufacture and consequently are more expensive than drilled air course bits.

It is the primary purpose of the present invention to provide a rock bit of the rolling cutter type in which a gas may be passed axially and centrally from the cavity in the hollow bit head to the bottom of a formation borehole with little or no erosion of the rolling cutters mounted below the head of such bit, but with adequate clean-up of the formation cuttings.

Another purpose is to provide such a bit in which portions of the gas stream are diverted into the bearing spaces between the rolling cutters and their shafts, such gas thereby flushing and cooling the bearing surfaces, and in which means are provided to prevent the introduction of particulate material with the gas passing into the bearings.

Another difficulty with the prior art drilled air courses relates to changeovers in such air courses dictated by changes in drilling conditions and available equipment. When such changes require a reduction in orifice size, a sleeve must be inserted in each hole, a simple but nevertheless somewhat time-consuming procedure. On the other hand, when the orifice size must be increased, it is generally necessary to ship the bit to a machine shop for "re-working," i.e., reaming out the original air courses to a larger diameter.

It is a further object of the present invention to provide a bit having the previously mentioned advantages and also having the advantage of replaceability of that part of the bit defining the air course. Stated in different words, that part of the bit through which air or other gas flows may be removed and replaced with a different but

similar member to change one or both of the flow rate of the gas and the pressure drop through the bit.

In arriving at the present invention, it was first determined that the cutter erosion characterizing prior art bits did not result from the introduction of abrasive particles with the air entering the bit from the drill string, but rather was the result of turbulence in the air after its passage through the bit. Such air leaves the bit and strikes the rolling cutters and the bottom of the borehole with considerable velocity. Cuttings and rock dust are picked up by this violent air and recirculated with various turbulent trajectories in the spaces between the cutters, bit head and borehole bottom before such air and its load pass into the annulus around the bit and upwardly through the annulus surrounding the drill string. When such turbulent air collides with the high velocity air emerging from the drilled air courses of the bit, in the space between the bottom of the bit head and the cutters, the recirculating rock cuttings and rock dust are violently projected downward on the top surfaces of the cutters. The action is similar to sand blasting, and the result is an accelerated wearing of the cutting structure, particularly toward the center. The effect is most pronounced with the more abrasive formations.

Although prior art air bits were designed with the tacit assumption that extremely high velocity air was required at the bottom of the borehole, the theory underlying the present invention discards such assumption and substitutes the idea that efficient entrainment and asportation of cuttings can be accomplished with lower velocity air. In comparing the behavior of the bits of the present invention with that of prior art bits which satisfactorily accomplish the bottom flushing and cleaning function, the important criterion is to maintain about the same mass flow rate.

Continuing such comparison, it seemed apparent that air bits of the present invention could be developed from the older drilled air course bits simply by providing a single large air course at the axis, larger than either a single prior art air course or the combined multiple air courses in cross-sectional area. This would virtually eliminate any pressure drop through the bit and would make it possible to use a pump of reduced pressure capacity while maintaining the same mass flow rate.

While a bit thus modified would be practicable with a sealed bearing bit, it could not be used to furnish the air for air-cleaned and lubricated bearings such as those employed with bits of the present invention. Experience with such air-cleaned and lubricated bearings indicates that a minimum pressure drop over the bit of 15 p.s.i. is required, and that 20 to 30 p.s.i. or higher is preferable. To provide such a pressure drop through the bearing structure, it is of course necessary to provide the same drop in the passageways used to supply air directly to the bottom of the hole.

It thus became apparent that the bits of the present invention should have about the same pressure drop through the bit as those of the prior art, and should deliver volumes of air at about the same rate, but with lower linear velocities of the emerging gas stream at the axial positions where such streams contact the cutter surfaces. It was determined that this must be accomplished by causing rapid divergence of the central airstream at some point downstream from the high pressure area where a portion is diverted to the bearing ports, and it is accordingly an object of the present invention to provide a bit which will cause a rapid divergence of the central airstream. Such divergence must be large compared with the substantially non-divergent emergent airstreams of prior art bits to avoid the abrasion wearing characteristic of prior art bits. Stated in other words,

an object of the present invention is to provide a rock bit with a central air flushing passageway in which there is considerably less abrasion of the cutting structure than with comparable prior art bits under the same conditions.

The explanation below of the manner of accomplishing this object and those mentioned above will be apparent to those skilled in the art from a consideration of the drawings attached hereto, in which:

FIGURE 1 is a partially sectioned elevation of a rock bit of the present invention complete with one cone, it being understood that there may be two, three or more similar cones,

FIGURE 2 is a partial cross section on lines 2—2 of FIGURE 1, showing a detail of the ball loading bore and ball plug therein to illustrate the air passage therebetween,

FIGURE 3 is a partial section, similar to that of FIGURE 1, of an alternate embodiment which includes an alternate optional structure for avoiding the introduction of particulate material into the bearing ports,

FIGURE 4 is another partial section like that of FIGURE 3 showing another optional alternate structure for keeping particles out of the bearings, and also an alternate nozzle shape,

FIGURE 5 is a partial section showing still another alternate screen structure, together with alternate nozzle structures,

FIGURE 6 is a partial section of a bit head showing a means for retaining a nozzle in an unstepped head passageway, and also showing a modified form of exit orifice,

FIGURE 7 is a partial top view of the FIGURE 6 embodiment,

FIGURE 8 is similar to FIGURE 7 but with an axial groove cut into the bit pin rather than the nozzle,

FIGURE 9 is a partial section similar to FIGURE 6 but with a downstream orifice formed in the bit head, and

FIGURE 10 illustrates a bit head with two orifices formed in a bit head.

Turning to FIGURE 1, the rock bit indicated generally at 1 includes a head 2 having an upwardly extending tapered pin or shank 3 for attachment to the corresponding box in the lower end of a drill stem member such as a drill pipe, drill collar or sub (not shown).

Depending from head 2 are one or more downwardly extending legs 4, from each of which a shaft or bearing pin 5 extends generally inwardly. Such bearing pin 5 is cylindrical and stepped to provide a pilot pin 6, the surfaces of which are especially treated to obtain wear resistant surfaces. Each of the members 7 and 8 facing pilot pin 6 is force fitted into the indicated recesses in the cutter 13. A roller bearing is provided by rollers 9 mounted in registering annular grooves 10 and 11 in bearing pin 5 and cutter 13, respectively, and a ball bearing is provided by balls 15 mounted in similar registering annular grooves. All of such recesses and grooves may be considered as enlarged parts of the bearing gap 14. The cutter is originally mounted with rollers 9 in place, after which balls 15 are loaded through ball loading opening 16 to lock the cutter in place. The escape of balls 15 is avoided by inserting ball plug 17 in opening 16 until the contoured end 19 is flush with the corresponding groove in bearing pin 5, after which the position of ball plug 17 is secured by welding it to leg 4 with weld metal 18.

It should be noted that a flow passage is provided between balls 15 and the portion of ball plug 17 underlying the downward terminus of fluid passageway 25 extending from the main opening 20 in pin 3. Such flow passage is provided by the annular gap 28 surrounding reduced diameter portion 26 of ball plug 17 and the axially contiguous spaces 29 between ball loading bore 16 and the wedge shaped portion 27 of ball plug 17 (see FIG. 2). An alternate passageway which may be substituted or used in addition is indicated by the dashed passageway 30. Many other alternate passageways may be used to furnish air for the bearings. It is not necessary to utilize opening 16, but the latter is conveniently available.

No cutting structure has been shown on the surface of cutter 13 because the present invention is not concerned with or limited to any particular cutting structure. It is to be understood that some such structure is provided and that it may take many forms, e.g., integral teeth or inserted wear resistant compacts of the type introduced to the trade in rock bits now known by the Hughes Tool Company trademark "Hugheset."

The number and shape of the cutters may vary, but typically there are three conical cutters, as in the three cone bits sold to and known in the trade under the Hughes Tool Company trademark "Tri-Cone." Such conical cutters are disposed uniformly around the bit axis and define a space 12 lying above cutters 13 and below the bottom of bit head 2. It is into this space that the major flow of air is discharged from the main opening 20 of hollow pin 3.

Returning to FIGURE 1, it can be seen that the bottom of bit head 2 has been machined out as a large center borewall 33, into which is inserted the air course nozzle generally indicated as 40. This nozzle includes as major parts the cylindrical wall 41, upper orifice plate or transverse member 42 defining orifice 43, and flared bearing port screen or skirt 44 provided with slots 45 to allow air to pass into gap 46 between the bore 21 of the pin and nozzle 40, and thence through ports 24 of fluid passageways 25. Slots 45 are sufficiently narrow to prevent all but very small particles from entering ports 24, e.g., ⅛ inch.

While the flared bearing port screen 44 is not indispensable, it does protect against the introduction of trash through bearing ports 24 in the event that water or some other formation fluid rises through the nozzle, carrying with it cuttings or other comminuted material, as is particularly likely to happen when the air supply is shut off.

When screen 44 is used, it need not necessarily be provided with slots 45 around the complete periphery of the nozzle, as shown, but may be limited to one or more slots in the vicinity of each bearing port. The number of slots is somewhat arbitrary, so long as a sufficient number are provided to insure essentially a zero pressure drop from above the nozzle to gap 46, but the preferable construction is to space slots 45 uniformly and frequently about the entire periphery of the upper edge of the nozzle. This construction makes it possible to use a nozzle having a greater outside diameter in its uninstalled position than the inside diameter of the bore 21 at the height of contact, thereby providing a small force normal to such borewall which resists upward movement of the nozzle, normally not likely because it is held down by the downwardly flowing air. For the same reasons, it is preferable to spring the webs of material between gaps 45 in inserting the nozzle rather than making the maximum flare slightly less than the diameter of borewall 21 to provide a filtering gap therebetween.

Nozzle 40 is secured against downward movement by a step or shoulder 47 abutting against the corresponding corner of borewall 21. At and just above such point, the nozzle wall 41 must be thick enough to withstand substantially the full pressure drop across the nozzle, from gap 46 to the main opening 48 of the nozzle.

Near the bottom of bit head 2 a second transverse member is formed as nozzle wall 41 converges at surface 49, extends over a short straight portion 50 defining a wide orifice 52 of only slightly smaller diameter than that of the main opening 48, and finally diverges at surface 51. The relatively wide orifice converging-diverging nozzle thus formed is not essential, and the nozzle may take the alternate form 40″ indicated in FIGURE 4, in which the main opening 48 does not change in cross-sectional area at the lower end of the nozzle. Although the discharge from the FIGURE 4 embodiment diverges rapidly and

prevents rapid cone erosion as effectively as that using a discharge nozzle, as in FIGURE 1, there is some experimental evidence that a low pressure region is formed in the bottom end of the main opening **48**. Such low pressure would tend to suck in cuttings and dust which would abrade the wall **41** and the bottom of head **2**.

FIGURE 3 illustrates an embodiment of the present invention in which the nozzle **40'** does not include a flared bearing port screen similar to element **44** of FIGURE 1, but is similar in other respects. In this embodiment, particulate materials may be prevented from entering ports **24** by a screen **35** secured in place by tack welding at **36** and **37**. Screen **35** may be in short circumferential sectors, each covering a single bearing port **24**, but is more conveniently a single cylindrical piece.

Although the structure of FIGURE 3 does not provide against upward movement of nozzle **40'**, it is apparent that such movement may be prevented in many ways. The nozzle may be cemented in by adhesives, but preferably is held by means permitting ready replaceability, e.g., a split retaining ring engaging matching circumferential grooves in borewall **33** and the outside of nozzle wall **41**, as shown in Payne, U.S. Patent 2,855,182.

FIGURE 4 is similar to FIGURE 3 except as mentioned above and except that in FIGURE 4 a flat screen **38** is disposed on top of orifice plate **42**, and is secured in place by any suitable means such as tack welding **39** securing it to borewall **21**. Screen **38** may either completely fill the cross-section of opening **20**, as indicated, or may be annular, overlying only gap **46**.

In the drawings, the cross hatching for nozzle **40** and its variants indicates a synthetic plastic, and a wide range of thermosetting and thermoplastic resins may be used in forming the nozzle. Plastic pieces are preferred because they can be produced cheaply, but there is no physical requirement barring the use of metals, such as steel and aluminum, or other appropriate materials. The nozzle need only be able to retain its shape with pressures up to a maximum of the order of 150 p.s.i.g. and with a modest temperature rise, e.g., to 300° F.

It is believed to be apparent that the nozzles described above are easily removeable through main opening **20** in pin **3**. The FIGURE 4 embodiment is somewhat of an exception when screen **38** is tack welded at **39**, but the use of such screen is not mandatory. Furthermore, such screen when used need not necessarily be secured to borewall **21**, but may be secured instead to the nozzle. Such removability is to be preferred to a structure in which the nozzle is more permanently secured in place, as by welding, because it is frequently necessary to make field changeovers.

Many modifications of the nozzle structure shown are possible without departing from the basic innovation of disposing an orifice plate at a considerable distance upstream from the discharge passage at the bottom of the bit head. The removable nozzle may be terminated at some distance above the latter position, as indicated in FIGURE 5, a shoulder **53** being provided in the bit head passage by making such passage step to a smaller bore **54**, at the same time providing for a flush fit between the bore of the removable piece and the bore of the bit head. When the lower, large orifice is to be used, it may be machined as a part of the bit head when the air course is drilled, as indicated by the dashed outline **55** thereof in FIGURE 5.

FIGURE 5 also illustrates an older form of bearing port screen **56** which may be used when desired. Screen **56** is essentially a tube having its outer end closed and pierced with a number of flow holes **57**.

In laboratory tests with the nozzle **40** exhausting into the atmosphere, the bore of main opening **48** was $2\frac{15}{16}$", orifice plate **42** was ⅛ inch thick, upper orifice **43** was $1\frac{3}{16}$" in diameter at an axial distance of $3\frac{7}{8}$" from the lower end of the nozzle. At the lower orifice **52** cross sectional angles with the axis of the nozzle were 45° for converging surface **49** and 30° for diverging surface **51**. The axial distances of these surfaces were ¾" for surface **49**, ⅛" for surface **50** and 1" for surface **51**. The diameter of lower orifice **52** was 2 inches.

The nozzle as thus constructed was tested with air at 30 p.s.i.g., the air containing sufficient water to render the discharge stream visible. The flow rate measured at the higher pressure was 815 cubic feet per minute (c.f.m.), and the included plane angle between the divergent extremities of the discharge was 26°. Decreasing the distance between the lower end of the nozzle and upstream orifice **43** to $2\frac{7}{8}$" (slightly less than the bore of passage **48**) caused the discharge stream to narrow to an essentially straight, high velocity stream.

Such results were contrasted with those obtaining from prior art devices by delivering the same type of air through a thick plate (about 2") orifice of a uniform $1\frac{3}{16}$" diameter. With the same 30 p.s.i.g. pressure drop over the plate, the upstream flow rate was 900 c.f.m. and the included plane angle of the discharge was only 7°. The high velocity of the discharge was not significantly reduced up to 6 inches from the discharge exit by modifying the straight through bore to provide a converging entrance, a diverging exit, or both.

Field tests were also run with the FIGURE 1 embodiment and with the prior art drilled air course bits, both drilling through the same levels of the same medium hard iron ore formation and both otherwise identical 9-inch (gage) bits which are sold and known to the trade as the Hughes Tool Company's "W7R" bits, as listed and described in its current catalogue 23. Both bits were used with a pressure drop of 32–35 p.s.i.

In the FIGURE 1 embodiment, the replaceable nozzle was of synthetic plastic, had an upper orifice **43** of $2\frac{1}{32}$" diameter, ⅛ inch axial length, located $3\frac{1}{16}$" above the bottom of the bit head, and a lower orifice **52** of 1 inch diameter, ⅛ inch axial length, located ⅜ of an inch above the bottom of the bit head. The diameter of the main opening **48** was $1\frac{3}{16}$". This bit drilled 1834 feet at 55 ft./hr., 60–80 r.p.m. and 20–40,000 lb. weight on bit, before dulling to the point of unprofitable drilling. Examination of the dull bit disclosed even wear over the cutting structure of each of the three cones.

The standard prior art bit (W7R) had three ½" diameter holes of uniform section drilled centrally through the bottom of the bit head. This bit drilled only 557 feet at 53 ft./hr., at the same weight and rotary speed, before dulling to the point of unprofitable drilling. Examination disclosed that the teeth of the heel rows on each cutter were still capable of further drilling but that the cutting structures toward the center of all three cutters, including the entire spearpoint of the No. 1 cutter, had been completely eroded away by blast effect. Similar comparative runs with the FIGURE 1 embodiment resulted in runs of 2333 feet and 2903 feet while the nearest competitive bit made only 1215 feet.

In using the replaceable nozzle of the present invention, it may become necessary to provide for changes in flow rate, pressure or both. This is most easily accomplished by replacing the entire nozzle with one in which the only important difference is the size of the upstream orifice. As an example, assume that a particular bit equipped with a nozzle provided for a 32 p.s.i. pressure drop and an air flow of 800 c.f.m. has been cleaning bottom satisfactorily in a particular formation.

With a change in formation, it then becomes necessary or desirable to increase the flow rate with the same pressure drop. This is provided for by changing to a nozzle having a larger upstream orifice. If, on the other hand, the change is to be to a higher pressure at the same flow rate (all flows being in volume on the high pressure side), the area of the upstream orifice must be decreased. When both the flow rate and pressure drop are to be increased or decreased together, a change may or may not be necessary, depending on the relative extent of the changes.

A number of generalizations have been deduced as a

result of further experiments with the FIGURE 1 embodiment. No minimum for the diameter of main opening **48** with respect to the diameter of upstream orifice **43** has been determined, but the former should in general be at least twice the latter. The axial distance of the upper orifice **43** from the bottom of the bit head should be at least equal to the diameter of main opening **48**, for otherwise the discharge stream fails to diverge or diffuse to the extent desired.

Finally, the area of the downstream orifice **52**, when used, should be equal to or greater than about 1.5 times the area of upstream orifice **43**, for as this ratio is decreased the discharge stream gradually converges. As previously noted, the downstream orifice **52** is not essential and may be eliminated by projecting the bore of main opening **48** to the bottom of the bit head. The only apparent disadvantage of so doing is to introduce some turbulence and erosion at the bottom of the main opening (but no erosion of the cutter surfaces). When the nozzle structure of FIGURE 5 is employed, such erosion of borehole **54** and the adjacent metal at the bottom of the bit head is not particularly harmful, as the large masses of metal involved cannot be seriously weakened prior to normal dulling of the cutter structure through chipping and grinding of the borehole formation.

It should also be noted that the lower orifice, when used, need not include either converging surface **49** or diverging surface **51**, as essentially the same discharge is obtained with a sharp edged ring plate of the types indicated in FIGURES 6 and 9. In FIGURE 6, a thin ring plate **58** extends across the lower end of the nozzle **40^{IV}** and has a bore **50** defining wide orifice **52**, while in FIGURE 9, the thin ring plate **58'** is a part of the bit head. In FIGURE 9 the ring plate **58'** is not removable with the nozzle **40^{V}**, but furnishes support against downward axial movement thereof. Apparently any benefit in performance obtained through the use of a restricted opening at the bottom of the bit head, whether shaped as in FIGURE 1 or simply straight through as in FIGURES 6 and 9, results from a consequent division of the pressure drop over the nozzle between the upstream orifice **43** and the downstream orifice **52**. The bulk of this drop is across the upper orifice, but the small drop over the lower orifice prevents the backflow of air into the central opening **48** and thus prevents the asportation of abrasive cuttings to that region.

The corollary proposition is also apparently true, i.e., the upstream orifice plate may either be bored to form a simple orifice or may be shaped in the manner of the lower orifice plate of FIGURE 1.

FIGURES 6 through 9 also illustrate alternate means for securing the replaceable nozzles **40^{IV}** and **40^{V}** against axial movement. Some such means is necessary in the FIGURE 6 embodiment because there is but one straight through opening **20** of bore **21** in bit head **2**, but it is apparent that the retaining means of FIGURES 6–8 can be used with the embodiments of FIGURES 1–5 previously described. In FIGURE 6 the upper part of the nozzle is necked down to wall **59** to provide gap **46** around bearing ports **24**, wall **59** extending above plate **42**. A groove **60** is provided in this upwardly extending part of wall **59**, registering with a similar groove **61** in borewall **21** of pin **3**. A flexible split ring fastener **62** is seated in grooves **60** and **61** to prevent axial movement in either direction.

An axial groove **63** is provided in the periphery of wall **59**, extending from the top surface to radial groove **60**, to permit the insertion of a compressive tool in assembly and disassembly. Such a tool has points fitting into the indicated holes in nibs **68** of the split ring (see FIG. 7), and is used to compress the ring and withdraw it from engagement in groove **61**, the nozzle then being removable with the ring.

FIGURE 8 illustrates an alternate means for insertion of the compressive tool, through an axial slot **65** in the bore-wall **21** of pin **3**, extending into radial slot or groove **61**.

It is apparent that the nozzle **40^{IV}** of FIGURE 6 may have an alternate upward termination which eliminates groove **60**, as indicated by the dashed line **64** in FIGURE 6. With such construction, ring **62** prevents only upward movement of the nozzle, and some means must be provided to prevent downward movement, e.g., the construction of FIGURE 9. The construction of FIGURE 9 is the same as that of FIGURE 6 except that the lower orifice **52** is formed in a thin plate **58'** extending from bit head **2**. Lower plate **58^{I}** may be used as a mere retainer for nozzle **40^{V}** of FIGURE 9; in this event the opening through thin plate **58^{I}** is increased to a diameter that provides a seat for the nozzle **40^{V}** but that does not restrict the gas flow.

In the embodiments of FIGURES 6–9, air at the upstream pressure is supplied to the bearing ports **24** through a multiplicity of passages **66** through wall **59**. These passages are sufficiently spaced and sufficiently numerous that they may be of relatively small size, e.g., ⅛ inch diameter, and thus serve as the screen to prevent particulate material from entering gap **46** and bearing ports **24**.

FIGURE 10 has been included simply to demonstrate that the upstream thin orifice plate **42'**, as well as the exit orifice plate **58'** may be integral with bit head **2**. While such construction sacrifices the ready replaceability of the earlier described embodiments, it does embody the broadest inventive concept, that of a thin plate upstream orifice over which essentially the full pressure drop takes place. In this embodiment, screening of the bearing air may be accomplished through inserted screens **56**, as described in connection with FIGURE 5, or equivalents.

What is claimed is:

1. A rolling cutter rock bit suitable for use with gaseous flushing media comprising a head section with an upwardly extending shank suitable for connection to a drill string, said head and shank having an axially extending and coextensive central passageway therethrough, at least one leg extending downwardly from said head, a bearing pin thereon extending generally inwardly beneath said passageway, a rolling cutter rotatably mounted on said bearing pin to define therewith a bearing gap, passage means in said head, leg and bearing pin extending from said bearing gap to a bearing port in said central passageway, and a member extending generally transverse said passageway upstream from the exit end thereof, said member having at least one restricted orifice therethrough and being supported from the wall of said passageway to divide the passageway into a high pressure zone and a low pressure zone, said low pressure zone lying downstream from said member and above the exit end of the passageway, said member being secured to said wall against at least downward movement with respect thereto and to prevent the flow of flushing fluid into said low pressure zone except through said orifice, and said bearing port being in communication with said high pressure zone.

2. The rock bit of claim 1 in which said transverse member is disposed upstream from the exit end of said central passageway an axial distance at least about equal to the bore thereof.

3. The rock bit of claim 2 in which the bore of said central passageway is at least about twice the bore of the orifice in said transverse member.

4. The rolling cutter rock bit of claim 1 which includes a second member extending transverse the central passageway adjacent the exit end thereof, said second member having a second restricted orifice therethrough and being secured to the wall of the passageway to block said passageway except for said second orifice, said second orifice being sufficiently larger than said first orifice that a small but measurable fraction of the total pressure drop over the bit occurs thereover.

5. The rock bit of claim 4 in which the area of said

second orifice is at least about 1.5 times the area of said first orifice.

6. The rock bit of claim 5 in which the first orifice is disposed upstream from said exit end of said central passageway an axial distance at least equal to about the bore of said passageway.

7. The rock bit of claim 6 in which the bore of said head passageway is at least about twice the bore of said first orifice.

8. The rolling cutter rock bit of claim 1 in which the head portion of the central passageway is of smaller bore than the shank portion thereof and in which said transverse member is a part of a removable nozzle slidably inserted in and secured to the wall of said passageway against at least downward movement therefrom, said nozzle extending into said shank portion of the passageway to define with the wall thereof an annular gap contiguous with said bearing port, said nozzle consisting essentially of a hollow cylinder and said transverse member having at least one orifice therethrough, said transverse member extending across the opening in said cylinder to block any flow therethrough except through the orifice of said member, said cylinder serving to support the transverse member from the wall of said passageway and having an outside diameter essentially equal to the bore of the passageway.

9. The rock bit of claim 8 in which said nozzle extends to about the bottom of the head portion of the passageway and said nozzle wall has an outside stepped surface defining a shoulder engaging the intersection of the walls defining the shank and head portions of said passageway.

10. The rock bit of claim 8 in which the head portion of said passageway is stepped to a lesser diameter to define a shoulder and the lower end of said nozzle butts flush against said shoulder, and in which there is included a second member extending transverse said passageway, adjacent the exit end thereof and below said shoulder, said second member being integral with the wall of the passageway and having a second restricted orifice therethrough, said second orifice being sufficiently larger than the first orifice that a small but measurable fraction of the total pressure drop over the bit occurs thereover.

11. The rock bit of claim 10 in which said first transverse member is located an axial distance above the bottom end of said passageway an axial distance at least about equal to the bore of said passageway.

12. The rock bit of claim 11 in which the bore of said passageway is at least about twice the diameter of said plate orifice.

13. The rolling cutter rock bit of claim 8 in which said removable nozzle includes an upwardly and outwardly flaring skirt above said transverse member extending from said wall, the uppermost edge of said skirt contacting the wall of said passageway and said skirt containing a multiplicity of slots extending axially from its top, said slots being of sufficient width and number to screen comminuted particles from said bearing port without an appreciable pressure drop.

14. The rolling cutter rock bit of claim 13 in which said removable nozzle includes a second member transverse said passageway adjacent the exit end thereof, said second transverse member being secured to said cylinder of the nozzle and having a second restricted orifice therethrough, said second orifice being sufficiently larger than the first orifice that a smaller but measurable fraction of the total pressure drop over the passageway occurs thereover.

15. The rock bit of claim 14 in which the area of said downstream orifice is at least about 1.5 times the area of said upstream orifice.

16. The rock bit of claim 15 in which said upstream orifice plate is located an axial distance from the exit end of said pasageway at least about equal to the bore thereof.

17. The rock bit of claim 16 in which the bore of said large passageway is at least about twice the diameter of said upstream orifice.

18. The rolling cutter rock bit of claim 1 in which said passageway is of essentially uniform bore from the top end to the exit end and in which said transverse member is a part of a removable nozzle slidably inserted in and secured to the wall of said passageway against at least downward movement therefrom, said nozzle consisting essentially of a tubular wall having an outside diameter essentially equal to the bore of said passageway and said transverse member secured to said wall upstream from said exit end to block the flow of fluid through said nozzle except through the orifice of such member, said wall being necked down in the vicinity of said bearing port to define with the wall of said passageway an annular gap contiguous with said bearing port, said openings being provided to join said annular gap to the space overlying said transverse member.

19. In a rolling cutter rock bit of the type prefaced in claim 18, the removable nozzle as therein set forth which includes a second transverse member extending across said nozzle wall adjacent the lower end thereof, said second transverse member having an orifice therein larger than the orifice in said upstream transverse member and smaller than the bore of said passageway.

References Cited in the file of this patent

UNITED STATES PATENTS

1,151,014	Humason	Aug. 24, 1915
1,256,694	Hughes	Feb. 19, 1918
1,816,203	Behnke	July 28, 1931
1,896,250	Scott	Feb. 7, 1933
2,279,129	Pennington	Apr. 7, 1942
2,329,745	Crook	Sept. 21, 1943
2,661,932	Woods	Dec. 8, 1953
2,751,196	Smith	June 19, 1956
2,783,971	Carle	Mar. 5, 1957
2,814,464	Pike et al.	Nov. 26, 1957
2,861,780	Butler	Nov. 25, 1958
2,880,970	Swart	Apr. 7, 1959