May 5, 1970 E. M. GALLE 3,509,952

PASSAGEWAY EXTENSION FOR DRILLING TOOLS

Filed Dec. 11, 1968 4 Sheets-Sheet 1

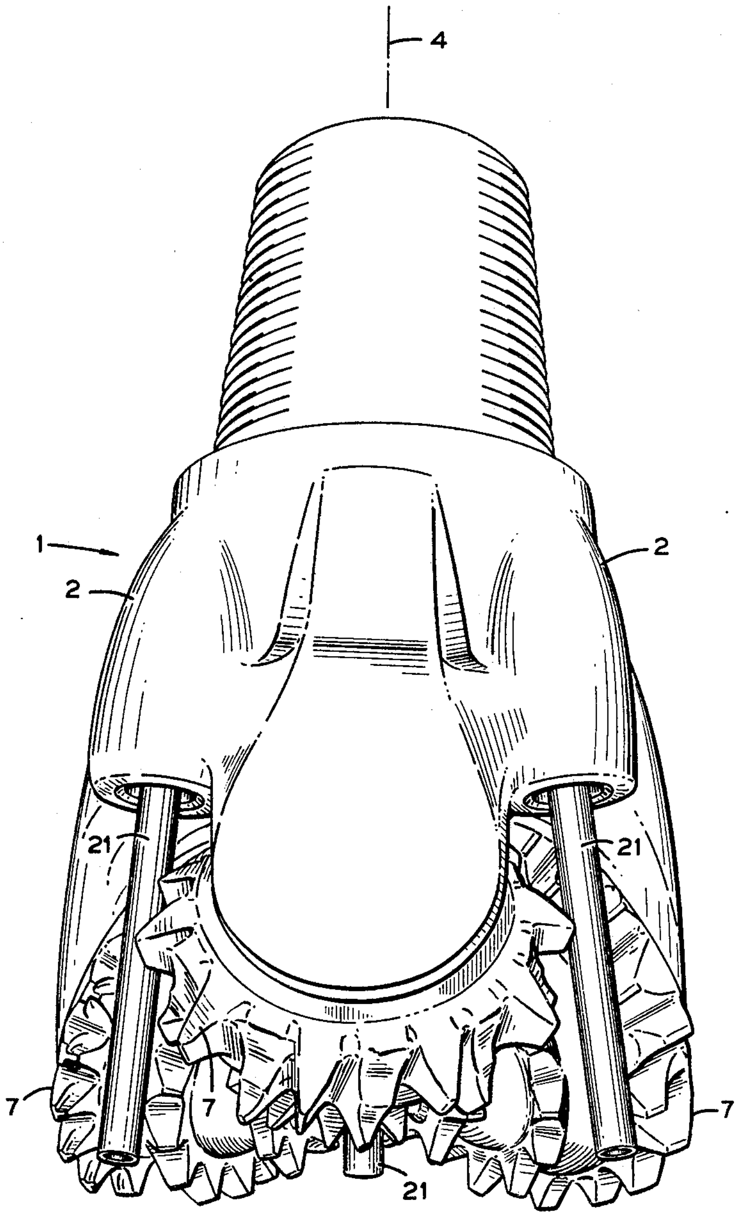

FIGURE 1

EDWARD M. GALLE
INVENTOR.

BY Roy H. Smith, Jr.
ATTORNEY

PASSAGEWAY EXTENSION FOR DRILLING TOOLS

Filed Dec. 11, 1968 4 Sheets-Sheet 2

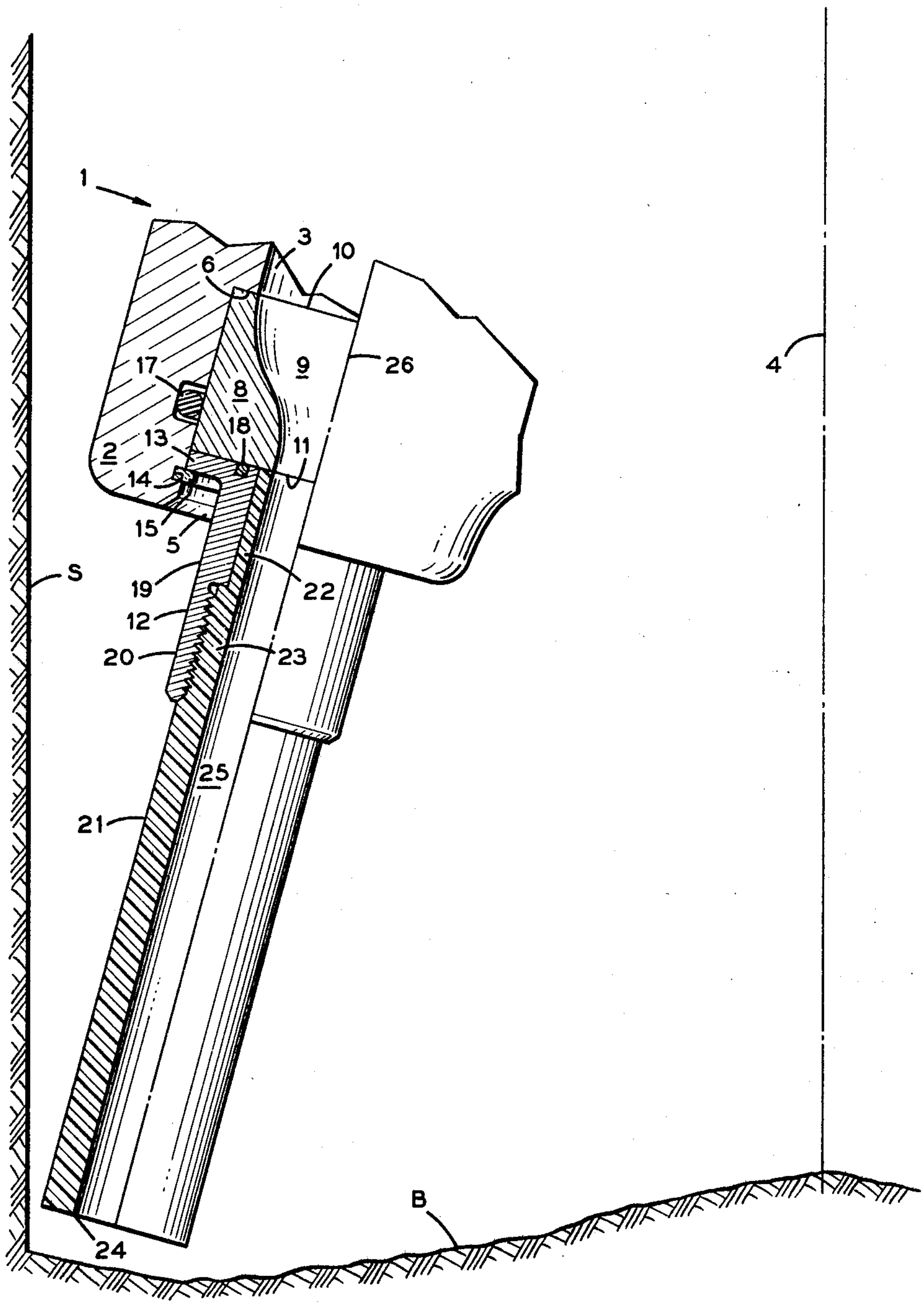

FIGURE 2

EDWARD M. GALLE
INVENTOR.

BY Roy H. Smith, Jr.
ATTORNEY

May 5, 1970 E. M. GALLE 3,509,952

PASSAGEWAY EXTENSION FOR DRILLING TOOLS

Filed Dec. 11, 1968 4 Sheets-Sheet 3

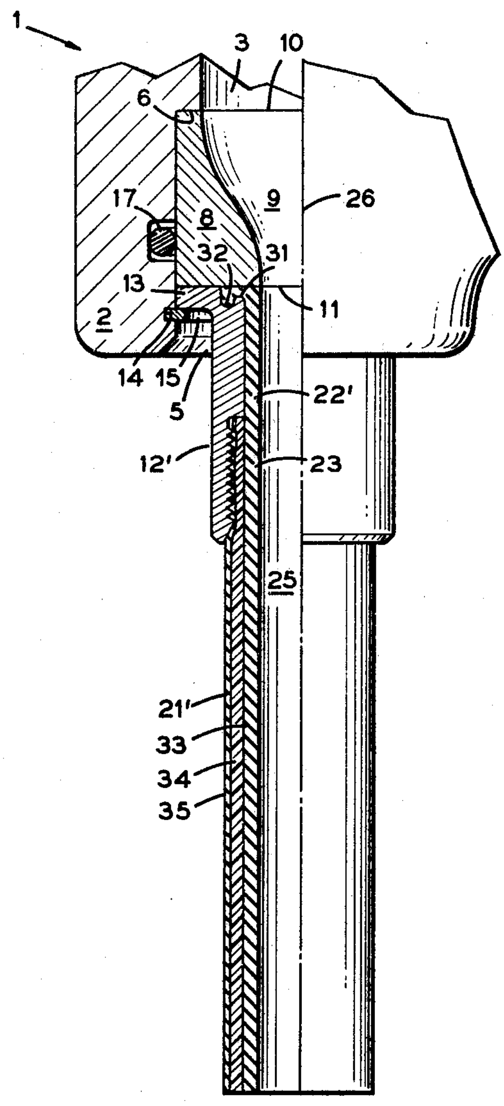

FIGURE 3

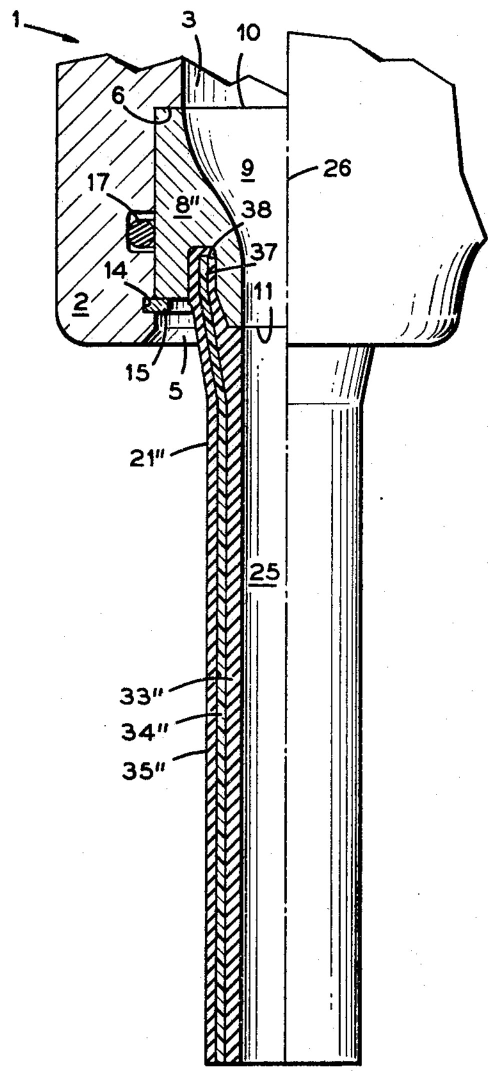

FIGURE 4

EDWARD M. GALLE
INVENTOR.

BY Roy V. Smith, Jr.
ATTORNEY

PASSAGEWAY EXTENSION FOR DRILLING TOOLS

Filed Dec. 11, 1968 4 Sheets-Sheet 4

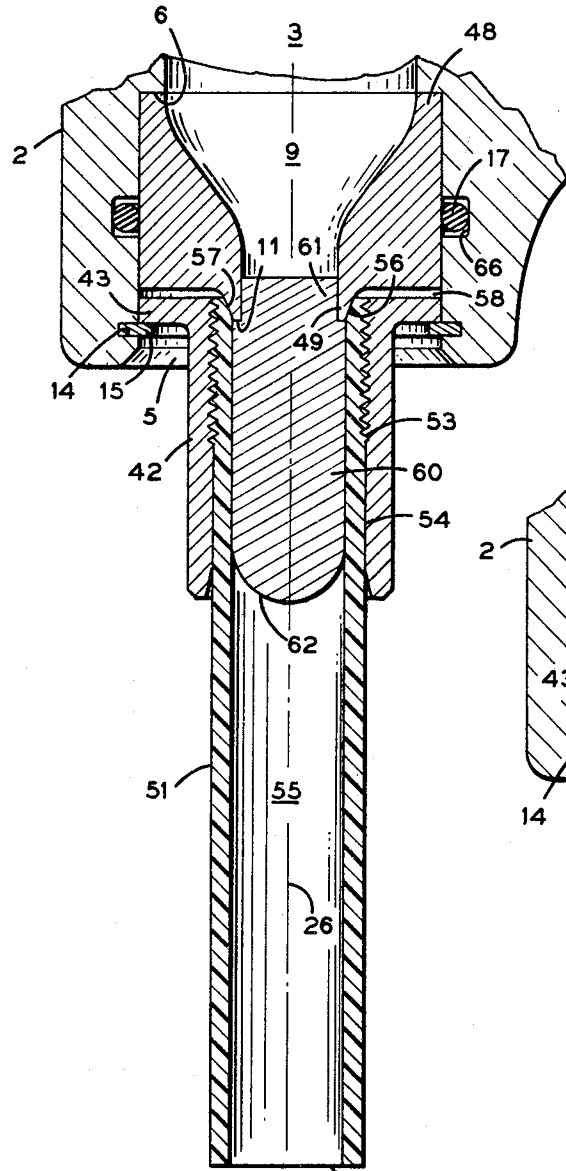

FIGURE 5

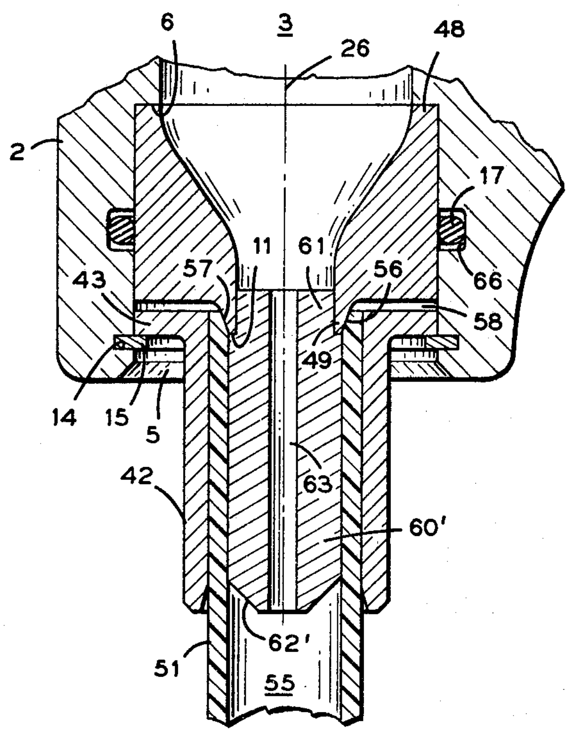

FIGURE 6

EDWARD M. GALLE
INVENTOR.

BY Roy H. Smith, Jr.
ATTORNEY

United States Patent Office

3,509,952

Patented May 5, 1970

1

3,509,952

PASSAGEWAY EXTENSION FOR DRILLING TOOLS

Edward M. Galle, Houston, Tex., assignor to Hughes Tool Company, Houston, Tex., a corporation of Delaware

Continuation-in-part of application Ser. No. 588,458, Oct. 21, 1966. This application Dec. 11, 1968, Ser. No. 798,840

Int. Cl. E21b 9/08

U.S. Cl. 175—339 19 Claims

ABSTRACT OF THE DISCLOSURE

Discloses a passageway extension in the form of a flexible conduit attached to and depending from the exit orifice of a drilling fluid passageway of a jet rock bit. The object is to conserve the energy of the fluid stream until it impinges on the bottom of the hole, and accordingly the flexible conduit is extended quite close to the bottom of the hole, as close as 1/4 inch. The conduit preferably has a uniform bore equal in size to the exit orifice of the jet nozzle to which it is attached, as a sealed and coaxial extension, both to avoid turbulence and minimize the downward force on the extension. Flexible materials such as rubbers and resilient plastics are used so that the conduit will give way to rock shelves and large rock cuttings, but will thereafter snap back to its original form and position. The conduit is disposed below the nozzle rather than the reverse to insure that destruction of the conduit will not cause loss of the nozzle.

This application is a continuation-in-part of application 588,458, filed Oct. 21, 1966, now abandoned.

The present invention lies in the general field of drilling tools, especially earth and rock penetrating tools, and deals more particularly with improvements whereby a drilling fluid is circulated through various drill bits.

Probably from the very infancy of well drilling a fluid has been used to cool the drilling tool, and from the start of rotary drilling such a fluid has been circulated through the drill bit and back up to the surface to carry away the cuttings. The commonest drilling fluid is one with a water base, and clear water is often used with many advantages over drilling fluids or muds containing various additives such as clays, barites or other weighting materials, and various chemicals. While the primary purposes of the drilling fluid are still cooling of the bit and carrying the cuttings formed by the bit to the surface, the various additives enable the drilling fluid to form gels that hold cuttings in suspension even when circulation of the fluid is stopped, increase the specific gravity and hydrostatic pressure of the mud column and thus hold formation fluids in place, consolidate loose or caving formations by forming a filter cake on the walls of the hole, prevent water from the drilling fluid from intruding into hydrophilic shale formations which tend to swell and cave in the wall of the hole, prevent the loss of drilling fluid into porous formations, lubricate the drill pipe and other drilling equipment, prevent corrosion, and promote settling of the cuttings and sand in the surface settling pits.

Another function frequently served by the drilling fluid involves the disposition of the passageways in the bit relative to its cutting structure. Until the latter part of the 1940 decade most such passageways were disposed so that the emergent stream impinged on the cutters to keep them from becoming fouled with formation cuttings that tend to agglomerate into hard, sticky masses that get into the spaces behind and above the cutters of the bit and impede the progress of the tool. These passageways

2

were typically of uniform bore, and were of such size that with the ordinary circulation rates the drilling fluid leaving the passageway normally had a velocity of less than 100 feet per second. Most of the energy of this stream was expended in cleaning the bit, and the stream struck bottom with its velocity and kinetic energy further reduced by mixing with the turbulent fluid surrounding the cutters. It should be noted that a higher fluid velocity would increase the likelihood of eroding the cutters, particularly when the drilling fluid contained any abrasive material.

In the late 1940's there occurred a development in which less emphasis was placed on cleaning the cutters and more stress was laid on increased fluid velocities. The drilling fluid passageways in the bit were relocated so that the fluid stream did not impinge on the cutters, and shaped nozzles were provided in the passageways to accelerate the drilling fluid to much higher velocities, 300 to 400 feet per second. The nozzles were located above the cutters but were placed close to the periphery of the bit, between adjacent cutters. This development was eminently successful because it caused considerable improvement in drilling rates, and led to widespread acceptance of the modified structure, known generally as the "jet" bit. The present invention, while useful with the older, uniform bore fluid passageways upon relocating them so that the emergent stream does not strike the cutting structure, is particularly useful with jet bits.

The major disadvantage of jet bits as presently made is that the jet stream still loses a considerable portion of its energy before reaching bottom, largely by turbulent mixing with the circulating fluid already present at the bottom of the hole. It is the principal purpose of the present invention to remove or reduce such disadvantage, i.e., the purpose is to provide a means for conserving most of such energy in the jet stream until it hits the bottom of the hole.

Another object is to provide a device to be added to any drilling fluid passageway which terminates above or behind the forwardly located cutting structure of a drill bit so that the added device will receive the drilling fluid from the pasageway and delived it at a location adjacent such cutting structure without substantial loss of energy.

A subsidiary object is to provide a combined jet drilling structure which includes passageway means in a drill bit, a nozzle or orifice member in the passageway having a restriction, orifice or convergent passageway which accelerates the drilling fluid and passes it from its downstream end at a relatively high velocity, and an added member in fluid flow communication with such restriction, orifice or convergent passageway that receives the fluid flow from such exit and conveys it forwardly therefrom and discharges it in the immediate vicinity of the bottom of a hole with little or no loss of velocity and energy.

The present inventor is aware that others have performed a certain amount of experimental work aimed at accomplishing the above purposes. The structure they utilized, however, differs from that disclosed and claimed herein in that in their experimental structure the converging nozzle, which theretofore had usually been located in a bit passageway terminating several inches above the bottom of the bit, was relocated much closer to the bottom of the bit, between the most advanced teeth of the cutters. This extended nozzle was connected to the bit by a rigid metal tube having a relatively large cross section, at least equal to the cross section of the upstream end of the nozzle passageway.

Such experimental structure has several disadvantages, not the least of which is the expense of providing the parts mentioned and adapting them for connection to the rock bit. The pressure differential between the inside and outside of the connecting tube is quite high, and the downward force exerted on the tube by the moving fluid and tending to blow it off the bit is also quite high, dictating a strong tube firmly secured to the bit. Such a tube is readily broken or battered out of shape by unavoidable collisions with the formation during operation, or when running the bit in or pulling it out of the hole. When it is broken off, the drilling fluid velocity is necessarily reduced because it will thereafter flow through the relatively wide bit passageway rather than the restricted nozzle passageway.

It is a further object of the present invention to provide a nozzle extension which minimizes or avoids the enumerated disadvantages of such experimental structure. More specifically, the present invention proposes to provide structure which will convey the drilling fluid from a rock bit or other drilling tool to a point closely adjacent the bottom of a borehole with minimum loss of energy through a conduit subject to a low pressure differential between the circulating drilling fluid moving through the conduit and the fluid outside the conduit and also subject to a low downward force exerted by the fluid on the conduit and tending to blow it off the bit, and in which said conduit is sufficiently flexible and resilient that it is not easily broken off or battered out of shape by contact with rock formations or large cuttings. It is also an object of the invention to avoid relocating the convergent nozzles, leaving them essentially in their customary locations several inches above the bottom of the bit. Another object is to provide such a conduit so joined to a prior art nozzle that if the conduit is unavoidably broken off, the nozzle will remain intact and operate as heretofore to deliver a high velocity stream of drilling fluid, although passing it from the bit several inches above bottom. It is also proposed to make such conduit of relatively small size and of relatively inexpensive materials, and to secure it to the bit by means requiring a minimum of parts and process steps, thus keeping the cost of the improvement to a reasonable level.

Such objects are achieved in the present case by an added member which may be most simply described as a flexible hose or conduit attached to the exit end of the nozzle passageway and extending forwardly to an end lying only slightly behind the most advanced portions of the cutting structure. While the passageway in this conduit may have various shapes, the shape preferred is a uniform bore equal to that of the exit end of the nozzle passageway, the conduit preferably being sealingly secured to the bit so that its bore is coaxial with the nozzle passageway and forms an extension thereof. The material defining the bore should be one which has good abrasion resistance as well as being flexible, because drilling fluids frequently are somewhat abrasive, especially at the velocities imparted to it by the nozzle.

Making the conduit opening equal to that of the exit end of the nozzle or orifice minimizes erosion of the tube due to turbulence of the abrasive fluid. Placing the tube or conduit downstream of the nozzle or orifice rather than the reverse greatly reduces the internal pressure experienced by the tube, thus making many materials and constructions available which could not be used if the pressure force were higher. In addition, placing the tube downstream of the nozzle allows a much smaller diameter tube to be used, thus allowing the tube to extend fully to the forward end of the cutting structure without interfering with the cutters of the rock bit.

It is also important to make the conduit of flexible material, as it is frequently exposed to collisions with rock shelves when the bit is being run into a hole. When the bit is operating on bottom, the forward portion is very likely to be jarred by contacts with large pieces of formation that have been torn loose, or even by large rock teeth in the bottom pattern. If the conduit were made of brittle material like tungsten carbide, the conduit would easily be broken off. If it were made of tougher but nevertheless rigid material such as steel, it would be jarred and hammered on by repeated contacts with rock until in many cases it would be battered out of shape and ultimately broken off. Examples of suitably flexible materials are various rubbers and plastics.

In some situations it has also been found highly desirable to dispose in the flexible conduit a temporary plug which either completely blocks any reverse flow between the nozzle and conduit, or rather severely restricts such flow. The plug prevents flattening and inversion of the conduit as the bit to which it is secured is being lowered to the bottom of a borehole through drilling fluid and suspended cuttings which increase in pressure at greater depths. The temporary plug is blown out of the conduit when the bit reaches bottom and the mud pumps are turned on, and means are preferably furnished to secure it against movement up into the drill string during its trip to the bottom of the hole.

While this invention can probably be readily understood by a written description alone, a few embodiments are illustrated in an attached drawing. It is to be understood that these illustrations are just that and no more, and are not intended in a limitaing sense. The figures show only uniform bore flexible conduits secured to jet bits with now conventional converging nozzles, but it is believed to be apparent that the bit passageways could be of uniform bore, and that the bore of the conduit could be somewhat diverging or converging.

In the drawing:

FIG. 1 is a perspective view of a typical jet rock bit in operating position at the bottom of a borehole, showing the flexible conduit of the present invention aiding such bit in directing a jetstream between the rolling cutters directly to the bottom of the hole,

FIG. 2 shows in vertical cross section a portion of a vertically oriented bit having a convergent nozzle and a conduit made of a single material secured underneath the nozzle by a flanged metal adapter, the conduit being held in the adapter by threading and adhesives,

FIG. 3 is similar to FIG. 2 but utilizes a shoulder engagement between conduit and adapter to avoid the use of adhesives,

FIG. 4 illustrates a form of the invention in which no adapter is used and the conduit is secured directly to the nozzle,

FIG. 5 illustrates in longitudinal section an embodiment including temporary plug which is present in the assembly only when the bit is being tripped into the hole, and

FIG. 6 is a similar section of a plugged embodiment, differing from the FIG. 5 form in that a through opening is provided for the temporary plug.

FIG. 1 illustrates a rock bit **1** disposed in the customary operative position in which it is used in drilling a vertical borehole. As can be seen from the figure, conduits **21** are secured to and extend downwardly from nozzle bosses **2**, passing between cutters **7** and terminating just above the bottom of the hole. If the reader visualizes the drilling fluid filling all available space in the hole and entirely surrounding the jetstreams, and recalls that in the prior art this fluid is constantly being turbulently mixed with the jetstreams, he will readily appreciate the saving in jetstream energy by conducting the fluid streams through the conduits to the bottom of the hole. The conduits of the invention form protective shields for the jetstreams, enabling them to preserve their high energy identities until the moment they are delivered on bottom.

In FIG. 2 a portion of bit **1** is shown in its typical operating position with respect to the bottom B and sidewall S of a drilled hole. The nozzle boss **2** of the bit and passageway **3** through the boss are typically slightly inclined with respect to the axis of rotation **4** of the bit so that the stream leaving the passageway is directed forwardly and somewhat outwardly, toward the intersection of bottom B and sidewall S. The lower end of passageway **3** is typically counterbored at **5** to provide a shoulder **6** against which nozzle **8** abuts, this arrangement having the advantage of securing the nozzle against upward movement. The counterbore also makes it possible to size the diameter of the upper end **10** of nozzle passageway **9** so that it is equal to the non-counterbore part of passageway **3**, thus providing for smooth flow into the nozzle.

In the assembly an adapter **12** is provided with an outturned flange **13** of a diameter approximately equal to that of counterbore **5**, so that it is received fairly snugly therein. A groove **14** is formed in the wall of counterbore **5** to receive a split snap ring **15** at a location below the lower end of nozzle **8** about equal to the thickness of flange **13**. When snap ring **15** is added to the assembly it snaps into place so that part of it extends into groove **14** and part of it underlies the flange, thus clamping the flange to the nozzle and holding the assembly to the bit. O-rings **17** and **18** are respectively located in grooves in passageway **5** and in the top of adapter **12** to insure against leakage of drilling fluid around the nozzle and between the nozzle and the adapter.

Adapter **12** has an upper portion **19** of smaller inside diameter than that of a lower portion **20**, and conduit **21** is similarly contoured on its outer surface to extend into such portions of the adapter. The uppermost end **22** of the conduit is secured to upper end **19** of the adapter by bonding with suitable adhesives, while its lower portion **23** is threaded into the counterbored and tapped lower end **20** of the adapter.

As illustrated, lowermost end **24** of conduit **21** extends quite close to the bottom B of the hole, e.g., about ¼ inch. It is preferably made with a uniform bore equal to that of exit end **11** of nozzle passageway **9**; and is disposed so that conduit passageway **25** and nozzle passageway **9** are coaxial about nozzle center line **26**, with such passageways butted together in end-to-end relationship. When conduit **21** strikes an obstruction, its flexible construction permits it to deflect and bounce back to the illustrated position without permanent damage. Should it be completely turn loose by unforeseen circumstances, nozzle **8** will operate as heretofore without loss of function, and the only damage suffered will be the energy loss in colliding with the turbulent drilling fluid circulating at the bottom of the hole. By contrast, if a structure in which passageway **3** were extended to the bottom of the hole and terminated with a nozzle **8** were to be broken off, the remaining fluid passageway would be of the full diameter of passageway **3** and there would be a sharp drop in fluid velocity.

In FIG. 3 the modification illustrated differs only slightly from that of FIG. 2, principally in that the upper end **22'** of the conduit **21'** has an outturned lip or flange **31** which is integral with conduit **21'** and is received in the illustrated corresponding annular groove **32** in the upper surface of adapter **12'**. This construction not only eliminates the need for bonding the conduit to adapter **12'**, but also avoids the use of a separate O-ring. Lip **31** acts in itself as a seal ring to prevent drilling fluid from leaking between the lower end of the nozzle **8** and the upper end of adapter **12'**. The FIG. 3 embodiment is also different in that conduit **21'** is made in laminations of layers (or plies), an innner layer **33** which is both flexible and abrasion resistant, e.g., a urethane elastomer, an intermediate ply of flexible braided materials, e.g., interwoven polyester or nylon filaments, and an outer flexible member **35** of such material as rubber or a urethane elastomer. These three layers or plies are suitably bonded together in the same manner that plies are bonded together in pneumatic tires or hoses used in conveying hydraulic fluids, grits used in sand blasting, and the like.

In FIGS. 2 and 3 the nozzle and conduit may be assembled to the bit utilizing the existing snap ring **15** and snap ring groove **14**. The only change required over the structure shown in FIG. 3 of Payne, 2,855,182, for example, is in the length of the nozzle. In the Payne structure the snap ring **15** butts directly against the bottom of the nozzle to keep it secured in the boss passageway. In the present structure the nozzle may either be made somewhat shorter or may be otherwise reduced in length to accommodate flange **13** of the adapter **12** or **12'** (or the same length nozzle may be used in a deeper counterbore).

In the FIG. 4 embodiment, on the other hand, no such adapter is utilized and the nozzle **8'** is of its prior length and is held in place by direct contact with snap ring **15**. The upper end **37** of conduit **21''** is elongated and extends into a deep annular groove **38** formed in the lower end of nozzle **8''**, where it is secured to the nozzle by conventional bonding techniques. The various illustrated plies **33''**, **34''**, **35''** of the FIG. 4 embodiment may be of the same materials as in FIG. 3. Again the construction avoids the need for a separate seal between the nozzle and the conduit.

In the FIG. 5 embodiment a flexible conduit **51**, which again may be of several plies, is threaded at **53** and bonded or vulcanized at **54** to an encircling adapter **42** having the form of a sleeve terminating at its upper end with an outturned flange **43**. Conduit **51** presses against the lower end of nozzle **43**, at **56**, forming a fluid seal. Nozzle **48** is constrained against upward movement by the shoulder **6**, formed by providing the counterbore **5** in fluid passageway **3** of nozzle boss **2**. As in the other embodiments, flange **43** of adapter **42** is held in place by snap ring **15** in groove **14** of the counterbore, and an O-ring **17** is provided in a separate groove **66** to prevent leakage between nozzle **48** and the wall of counterbore **5**.

The embodiment of FIG. 5 differs from those previously described in including a temporary plug member **60** disposed in the upper portion of the bore **55** of conduit **51**. The fit of plug **60** to the wall of bore **55** is a fairly tight fit, sufficient to prevent the plug from falling out as a result of accidental jars, but not so tight as to resist movement downwardly to the lower end **54** of conduit **51** when the mud pumps are turned on.

To prevent upward movement of the plug under the influence of a negative pressure gradient, as when the bit is being run into the hole, an upper stop of some sort must be provided. In the FIG. 5 embodiment such a stop is provided by the downwardly projecting lip **49** of nozzle **48**, together with making the diameter **55** of conduit **51** slightly larger than the diameter of the exit orifice **11** of the nozzle passageway **9**. This construction enables lip **49** to project slightly into passageway **55** to furnish the desired stop. An upper part **61** of plug **60** is necked down to fit into the minimum diameter straight section of the nozzle passageway **9** just above exit orifice **11**, as shown, but the plug could terminate without such neck, at the exit orifice **11**.

It should also be noted that the depending lip **49** of nozzle **48** has a downwardly converging outer surface **56** which sealingly compresses the upper or entrance end of flexible conduit **51**. The axial dimensions of the nozzle **48** and adapter flange **43** are selected so that a small axial gap **58** appears between these two elements, and the only contact between them is between the outer surface **56** of lip **49** and the uppermost portion **57** of the inside diameter surface defining passageway **55** of the conduit. When, during a drilling operation, fluid is being pumped downwardly through the nozzle passageway **9** and into the passageway **55** of conduit **51**, this configuration results in a superior seal because the downward pressure force on the nozzle is transmitted to the conduit over the small area of contact at the nozzle lip, concentrating the force to obtain a highly loaded sealing force.

The lower end **62** of the plug **60** is preferably tapered or rounded, as shown, to promote ready rejection of the plug through tube **51** at the proper time. Illustrated are a downwardly convex configuration in FIG. 5 and a chamfered lower termination **62'** in the FIG. 6 modification. Otherwise the FIG. 6 assembly differs from the FIG. 5 embodiment only in utilizing a plug **60'** having a restricted passageway **63** therethrough, and in securing tube **51** and adapter to each other only by bonding or vulcanizing.

The two embodiments just described (FIGS. 5 and 6) are particularly useful in those situations wherein conditions in the hole are likely to plug the flexible conduit with cuttings, when lowering the bit in the hole. When such unplanned plugging occurs, it apparently takes place at the exit end of the conduit. As the bit is lowered, if no temporary plug member is used, the drilling fluid already present in the wellbore rushes upwardly through the conduits and on into the drill string, carrying suspended cuttings with it. Apparently a fairly large cutting becomes stuck in the lower end of the conduit, other cuttings fill in the gaps between the first cutting and the conduit wall, and mud materials fill in the smaller voids to completely block the conduit passageway and seal it off from the surrounding fluid.

As the bit is lowered further, into regions of the wellbore containing higher pressure fluids, the pressure difference between the fluid outside the bit and the low pressure fluid inside the bit increases, and the flexible conduit collapses and flattens. On some occasions it has also inverted, i.e., the tube or conduit becomes turned inside out and the lower portion of the tube is thrust up inside its upper end and into the nozzle. When this has happened, all nozzles may become so tightly plugged that no circulation of the drilling fluid can be started when the mud pumps are turned on. Such an undesirable event has the twin disadvantages that the conduits are not serving their intended function and that a trip to the bottom of the hole has been wasted, as there is nothing that can be done to restore circulation without first pulling the bit to the surface to unplug the nozzles.

In the FIG. 5 embodiment the conduit **51** is prevented from becoming flattened and inverted by pre-plugging it with the temporary plug **60**, preferably in the upper portion of the conduit, as shown. The portion of conduit passageway **55** underlying plug **60** is filled with fluid at the same pressure as the fluid surrounding the conduit, so there is no net force tending to flatten the flexible tube. Also, since there is no flow through the tube while lowering the assembly, there is little tendency for cuttings to collect in and plug the passageway **55**. Even if this should happen, however, it is extremely unlikely that such cuttings and temporary plug **60** would not be ejected downwardly as the mud pumps are started—because there is no restricting or flattening of the conduit to prevent the downward movement of such cuttings.

The use of temporary plugs **60** in all nozzles of a bit furnishes an incidental advantage in that they serve as "float plugs." See U.S. Pat. 3,189,107 of the present inventor, which discloses several forms of float plugs and enumerates their various advantages, chief of which is that the empty drill string can be lowered to bottom with less wear and tear on the supporting surface equipment by taking advantage of its buoyancy.

However, as mentioned in the same patent there is some risk of drill stem collapse when float plugs are used in extremely deep wells. To prevent this from happening, the present invention may incorporate various of the prestressed float plugs disclosed in the patent, suitably modified for mounting in the flexible conduits hereof. Alternately, the plug **60′** of FIG. 6, provided with the flow passage **63** therethrough, will reduce the tendency of drill string collapse.

It will be apparent that either or both of the features disclosed in FIGS. 5 and 6—the temporary plug pumped out when circulation is started and the depending lip of the nozzle—may be provided in the various other embodiments. It will also be apparent that various other means could be used to prevent upward movement of the temporary plug, e.g., any member overlying the plug and extending into the flow passageway but not subtracting greatly from its cross-section.

An assembly like that of FIG. 3 was tested for abrasion resistance by circulating water which contained a small quantity of abrasives for 20 hours, the result being that no significant erosion was observed. The orifice or exit of the nozzle was ⅜ inch in diameter, the pressure

drop over the nozzle under these conditions was 1500 pounds per square inch (p.s.i.) and the velocity was approximately 430 feet per second. The inner layer **33** of the conduit was .050 inch thick and was made of a polyurethane rubber having a hardness of 80 durometer (Shore A), the intermediate strength braid **34** was .050 inch thick and made of interwoven nylon filaments, and the outer ply **35** was of polyurethane rubber .020 inch thick.

Getting the jet stream to impinge directly on bottom without loss of velocity and energy is very important. In many cases 40% or more of the initial energy can be saved in this manner, and this additional energy has a direct influence on the drilling rate and economy of operation.

The largest benefit from having a higher velocity stream on bottom is a more efficient removal of cuttings. The high energy stream digs into the mixture of filter cake and cuttings which tends to accumulate on bottom, tearing it up and carrying it off so that the cutters work directly on the rock and not on the filter cake. To some extent the jet stream is also enabled to remove rock directly, particularly in the softer shale formations.

As previously mentioned, the preferred form of the invention utilizes a flexible conduit of smooth, uniform bore of a size equal to that of the exit end of the nozzle passageway, as illustrated in the drawing. This limits the pressure drop over the conduit to that resulting from wall friction, e.g., only about 120 p.s.i. when circulating 100 g.p.m. of water through a ⅜ inch diameter bore of a polyurethane tube 4½ inches long, and thus there is little tendency for the conduit to burst (which would not be true if the nozzle were located at the bottom end of the conduit). This construction also limits the force tending to blow the tube off the bit, e.g., 13 pounds for the dimensions and conditions mentioned.

What is claimed is:

1. In a drilling tool having cutting members on its forward end and a drilling fluid passageway through the tool disposed to direct a stream of fluid through the tool toward a point adjacent said cutting members, such passageway terminating in an exit end spaced rearwardly from said cutting members, the improvement comprising a flexible conduit sealingly secured to said drilling tool and extending forwardly from said exit end of the drilling fluid passageway and terminating adjacent said cutting members, said conduit having a fluid flow passage therethrough in fluid flow communication with the passageway of said tool and having sufficient flexibility in composition and construction that it will be pushed to one side when encountering obstacles and will thereafter spring back to assume its original shape and position.

2. In the improved drilling tool of claim **1**, a flexible conduit as therein described having a fluid flow passage therethrough of an approximately uniform cross-section throughout its length.

3. In the improved drilling tool of claim **2**, a flexible conduit as therein described in which said uniform bore is of approximately the same cross-section as the exit end of said drilling fluid passageway of the drilling tool.

4. In a drilling tool having a forward end, a rearward end and an intermediate point, a plurality of cutting means secured to the tool and extending forwardly to said forward end with spaces between adjacent cutting means, and at least one drilling fluid passageway extending through the tool from its rearward end to said intermediate point and there terminating in an exit end of restricted area, such passageway being disposed to direct a stream of fluid from its exit end forwardly between adjacent cutting means, the improvement comprising a flexible conduit member sealingly secured to said drilling tool and extending from said intermediate point approximately to said forward end, said flexible conduit being disposed in fluid flow communication with said drilling fluid passageway and having a through passage disposed approximately in end-to-end and coaxial relationships with said passageway.

5. The improved drilling tool of claim 4 in which said conduit is of approximately uniform bore throughout its length.

6. The improved drilling tool of claim 5 in which said bore of the conduit passage is approximately equal in cross-section to the cross-section of the exit end of the tool passageway.

7. In a drilling tool equipped with cutters on its forward end with spaces between adjacent cutters and at least one drilling fluid passageway extending forwardly from its rearward end and terminating in an exit end at a point intermediate said ends and spaced rearwardly from said cutters, said passageway being disposed to emit and project a stream of drilling fluid forwardly between adjacent cutters, the improvement comprising the combination of a nozzle member secured in said passageway at the exit end thereof, said nozzle terminating forwardly in a restricted orifice, and a flexible conduit member sealingly secured to said tool and extending forwardly from said restricted orifice of the nozzle to a point between and adjacent the foremost ends of a pair of said cutters, said conduit having a passage therethrough for drilling fluid with its rearward end in fluid flow relationship with said nozzle orifice, said conduit passage being approximately of a uniform bore substantially the same in cross-section as said nozzle orifice.

8. In a jet rock bit having a number of cutters disposed at its forward end, at least one drilling fluid passageway extending through the bit and terminating at a lower end spaced rearwardly from said cutter members, said passageway being disposed so that if projected forwardly it would pass between two adjacent cutters, and a flow control member disposed in the lower end of said passageway, such member terminating forwardly in a discharge orifice of restricted area, the improvement comprising a flexible conduit secured to said bit and having a through opening extending from said discharge orifice in fluid flow and sealing relation therewith to a point between a pair of adjacent cutters and approximately to the most forward parts thereof, said conduit opening being of about the same cross-sectional size as said discharge orifice and approximately uniform over its length.

9. The improved rock bit of claim 8 in which said flexible conduit is bonded directly to said flow control member.

10. The improved rock bit of claim 8 in which said flexible conduit has its upper end sealingly butted against the lower end of said flow control member and is secured in place by a flanged adapter surrounding said conduit, the flange of said adapter being outturned and being received and supported in the lower end of said passageway below said flow control member.

11. As a subcombination, a nozzle member adapted to be sealingly seated in the lower end of a drilling fluid passageway of a rock bit and a flexible conduit member sealingly secured to one end of said nozzle members, said members both having flow passages therethrough disposed in approximately coaxial and end-to-end relationships, said nozzle member having a restricted orifice in its passage and said conduit member having an approximately uniform bore substantially equal in cross-section to the cross-section of said orifice.

12. The subcombination of claim 11 in which one end of said nozzle member has an annular groove surrounding said orifice and said conduit member has its upper end sealingly and supportingly received in said groove.

13. In a drilling tool having cutting members on its forward end and a drilling fluid passageway through the tool disposed to direct a stream of fluid through the tool toward a point adjacent said cutting members, such passageway terminating in an exit end spaced rearwardly from said cutting members, the improvement comprising a flexible conduit sealingly secured to said drilling tool and extending forwardly from said exit end of the drilling fluid passageway and terminating adjacent said cutting members, said conduit having a fluid flow passage therethrough in fluid flow communication with the passageway of said tool, and a temporary plug disposed in said flexible conduit to prevent flow therethrough, said plug being restrained against upward movement into said nozzle and being expellable downwardly from the flexible conduit under the influence of a positive pressure difference.

14. The improved drilling tool of claim 13 in which said temporary plug is disposed in the upper portion of the flexible conduit.

15. The improved drilling tool of claim 14 in which said plug is disposed so that it also projects upwardly into said passageway of the tool.

16. In a drilling tool having cutting members on its forward end and a drilling fluid passageway through the tool disposed to direct a stream of fluid through the tool toward a point adjacent said cutting members, such passageway terminating in an exit end spaced rearwardly from said cutting members, said tool including jet nozzle defining the lower portion of said passageway, the improvement comprising a reduced diameter, annular lip depending from the lower end of said nozzle and defining the exit end of said drilling fluid passageway, and a flexible conduit secured to said drilling tool and extending forwardly from said exit end of the drilling fluid passageway and terminating adjacent said cutting members, said conduit having a fluid flow passage therethrough in fluid flow communication with the passageway of said nozzle and tool, and said conduit making sealing contact with the annular lip of the nozzle.

17. The improved drilling tool of claim 16 in which said exit orifice of the nozzle and tool passageway is of smaller cross-section than the passage through the flexible conduit, and said lip projects at least partially into said passage.

18. The improved drilling tool of claim 16 which includes a temporary plug member secured in said flexible conduit.

19. The improved drilling tool of claim 16 in which the temporary plug member is disposed in the upper end of the flexible conduit and includes a necked down upper portion projecting into said nozzle.

References Cited

UNITED STATES PATENTS

2,745,647	5/1956	Gilmore	175—422 X
2,966,949	1/1961	Wepsala	175—393 X
3,048,231	8/1962	Beck	175—393
3,112,800	12/1963	Bobo	175—422 X
3,189,107	6/1965	Galle	175—393
3,207,241	9/1965	Neilson	175—340
3,363,706	1/1968	Feenstra	175—422 X

CHARLES E. O'CONNELL, Primary Examiner

R. E. FAVREAU, Assistant Examiner

U.S. Cl. X.R.

175—422