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US 4878548 A US 4427221 A

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(54) Abstract Title
Nozzle assembly for a rotary drill bit

(57) A nozzle assembly for a rotary drill bit comprising a nozzle (24) for retention in a socket (25), wherein the nozzle (24) is characterised by projections (30) which are engagable with open-ended recesses (31) in a side wall of the socket (25). Once the nozzle (24) has been received in the socket (25), locking elements such as grub screws (36, fig. 5), may be engaged within inlet portions (32) of the recesses (31) in order to retain the projections (30) in the recesses (31). Further retention recesses may be provided transversely from the open-ended recesses, into which the projections may be urged. Resilient means located between the projections and the walls of the recesses, then urge the projections against the walls to retain them in place. This arrangement provides a nozzle (24) whose overall diameter is not significantly larger than the nozzle aperture itself, for example, the maximum outer cross-dimension of the nozzle may be no greater than 70% larger than the cross-dimension of the nozzle aperture. This enables the nozzle assembly to be employed in situations where space is limited. A rotary drill bit may be provided with a nozzle assembly characterised by a maximum cross-dimension and a smaller minimum cross-dimension, the nozzle assembly being orientated so that the maximum cross-dimension is generally aligned with the length of at least one blade.

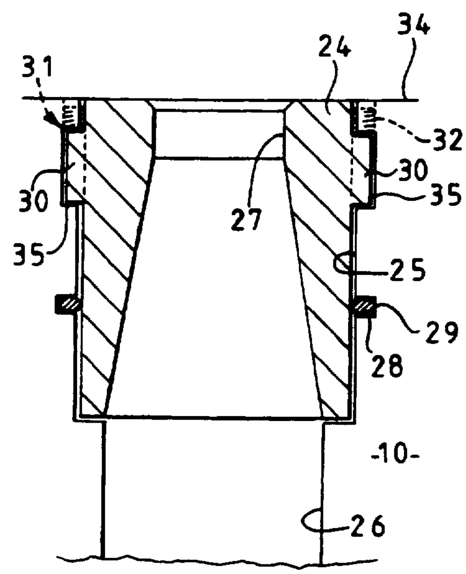

FIG 4

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG 1

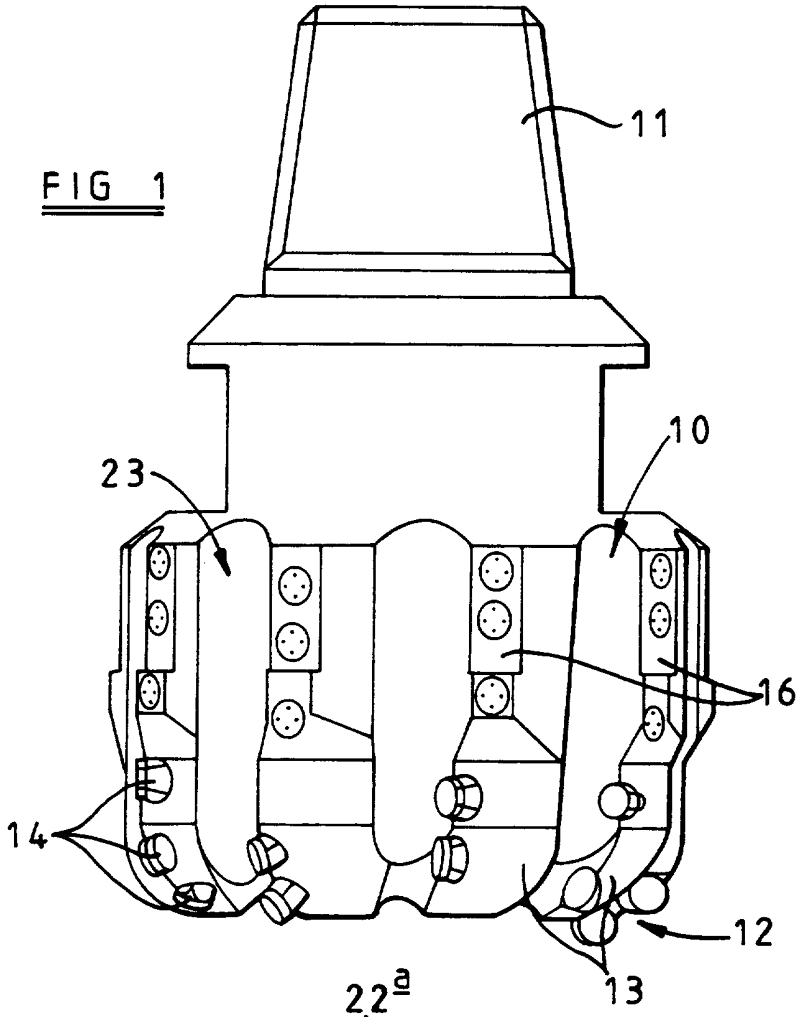
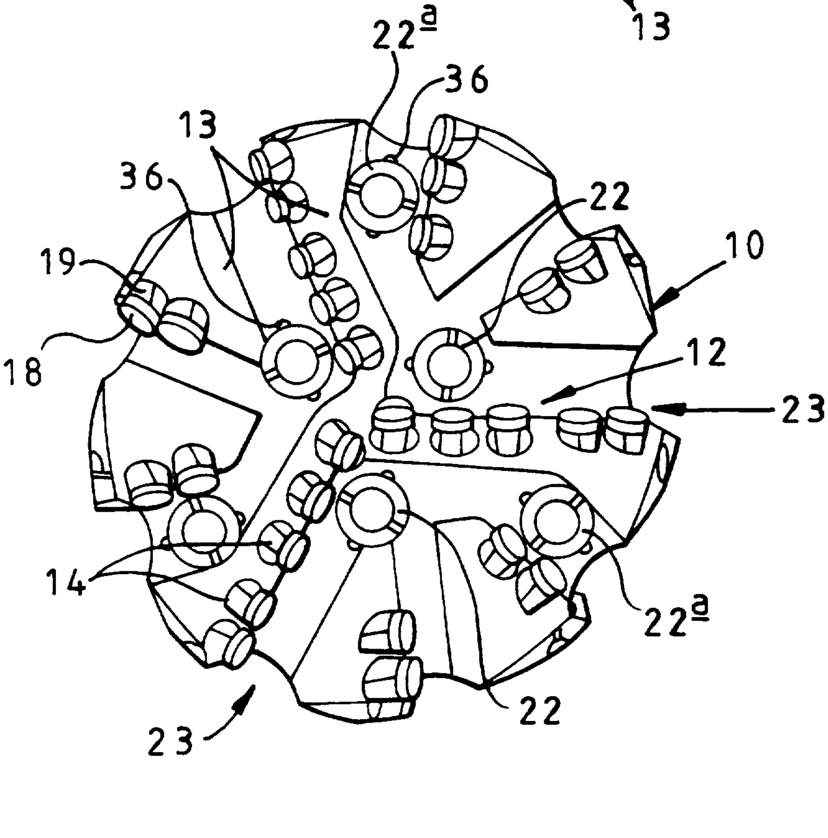


FIG 2



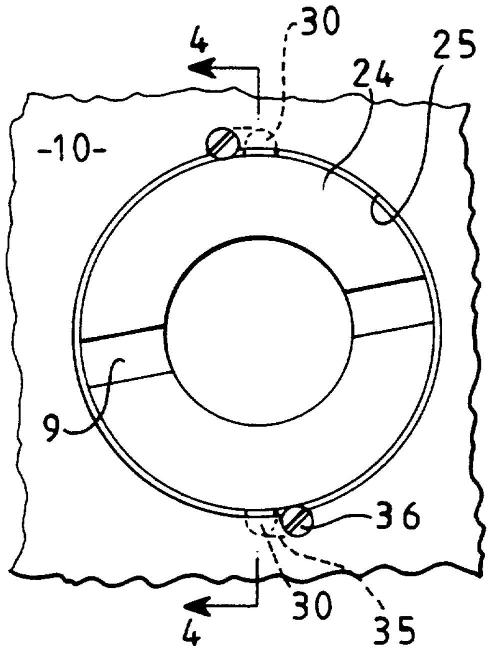


FIG 3

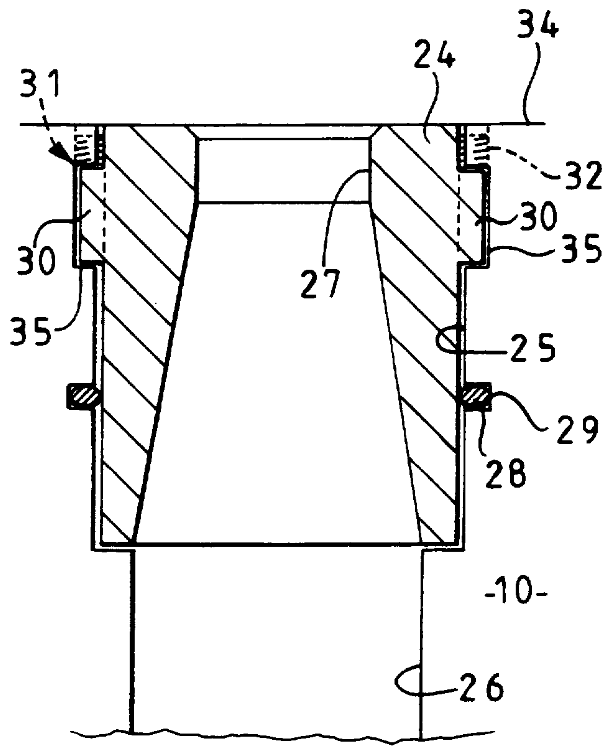


FIG 4

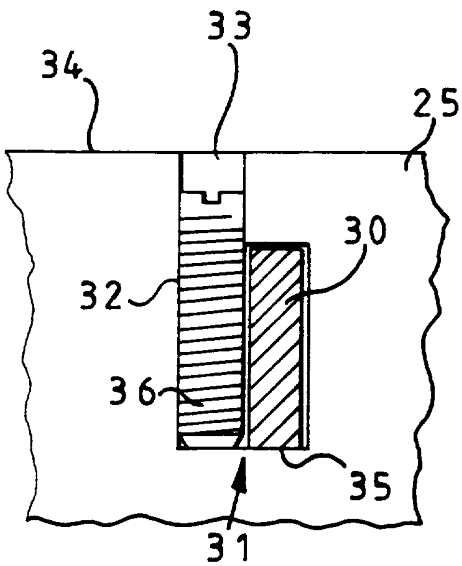


FIG 5

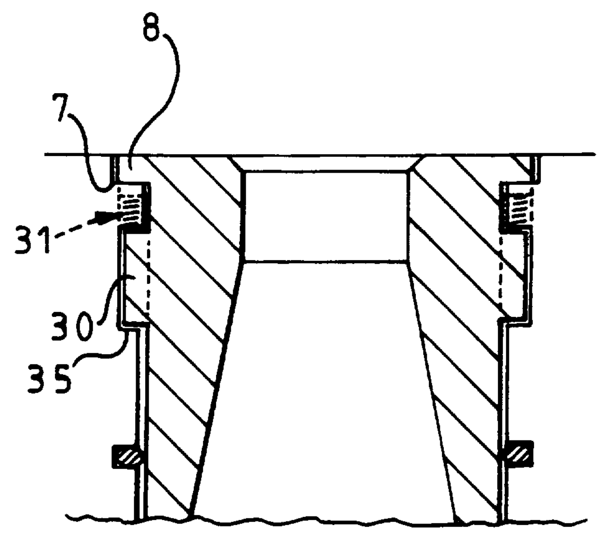


FIG 6

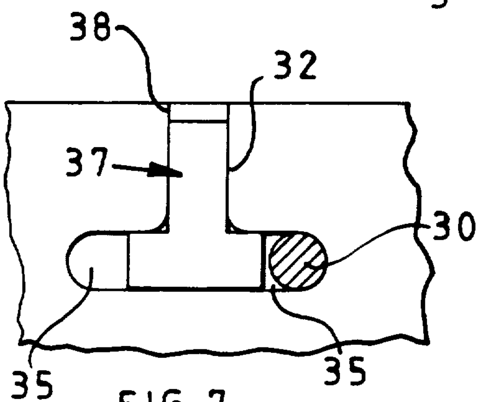


FIG 7

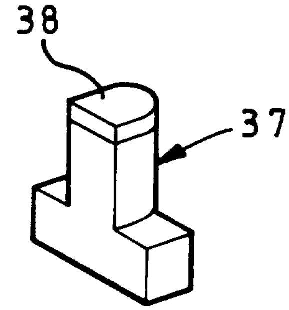


FIG 8

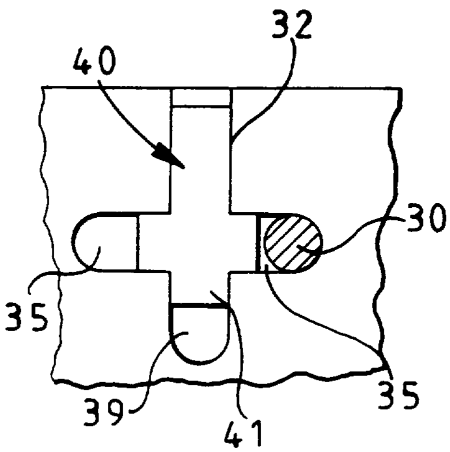


FIG 9

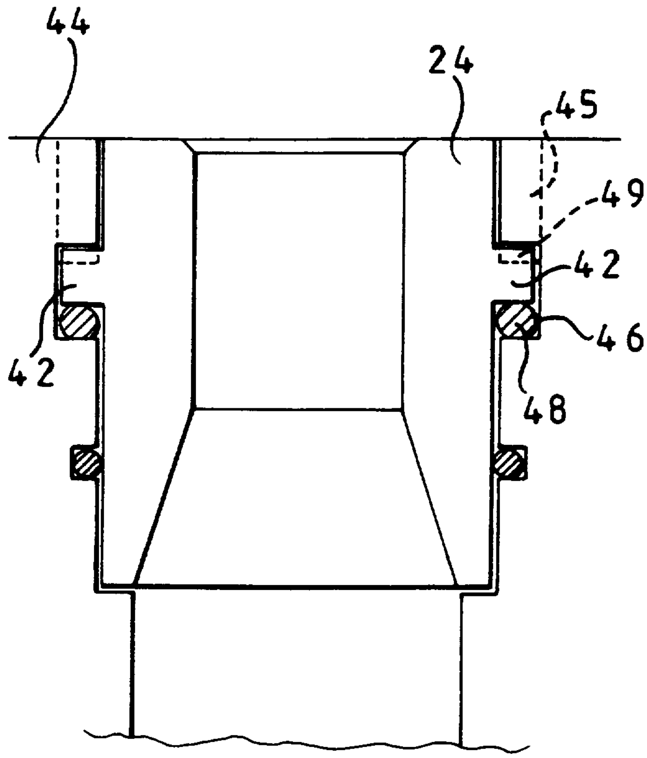


FIG 10

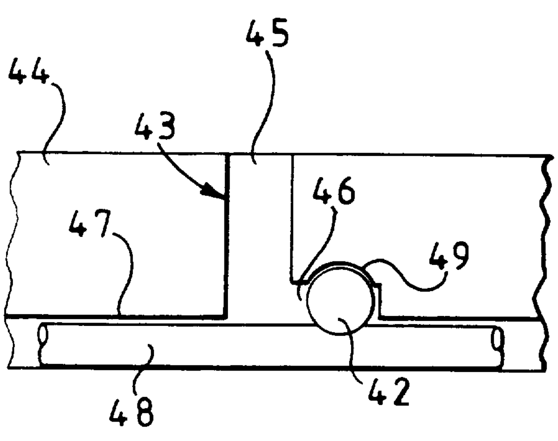


FIG 11

"A Nozzle Assembly for a Rotary Drill Bit"

The invention relates to nozzle assemblies for rotary drill bits for drilling holes in subsurface earthen formations.

One common type of drill bit is a drag-type drill bit comprising a bit body having an external surface on which are mounted a plurality of fixed cutting elements. For example, the cutting elements may comprise preform elements in the shape of a circular or part-circular tablet having a front cutting face of polycrystalline diamond or other superhard material bonded to a substrate of less hard material, such as tungsten carbide. The cutting elements are either directly mounted in sockets on the bit body or are mounted on tungsten carbide posts or carriers which are, in turn, mounted in sockets on the bit body.

Another type of drill bit, for drilling holes in harder formations, is a roller-cone drill bit in which a plurality of rolling cutter bodies, usually three, are rotatably mounted on respective inwardly and downwardly extending spindles spaced equally apart around the bit body. Each rolling cutter body carries a plurality of hard cutting inserts for engagement with the formation being drilled, the cutters rotating against the formation as the cutter body rotates.

In each case, the drill bit is formed with an internal passage through which drilling fluid is delivered under pressure to nozzle assemblies mounted at the surface of the bit body. Drilling fluid delivered under pressure through the nozzles serves to cool and clean the cutters and to carry away the cuttings upwardly to the surface through the annulus between the drill string and the formation.

In such drill bits it is desirable to mount the nozzles removably in the bit body. since there are many different factors which determine what size of nozzle aperture will give the best performance during drilling. It is therefore necessary that the nozzles shall be removable so that the appropriate size of nozzle may be selected and fitted according to the particular drilling conditions. Commonly this is achieved by providing each nozzle with an external screw thread whereby it may be screwed into a correspondingly threaded socket in the bit body. However, in order to provide the required erosion resistance, the nozzles must be formed from tungsten carbide or similar hard material and since this is difficult to machine, the external thread for the nozzle has usually been provided on a separate steel sleeve which is brazed to the carbide of the nozzle. The threaded socket, into which the nozzle is screwed, also may comprise a separate internally threaded steel sleeve mounted in a socket in the bit body. In such an arrangement it is necessary to take further steps to protect the steel sleeve from erosion. Consequently, screw-threaded nozzle assemblies are generally of significantly larger diameter than the nozzle aperture itself and this may lead to difficulty in locating the nozzles on the bit body, particularly in the case of drag type drill bits where space may be limited, particularly near the central axis of the bit where the cutters tend to be closely packed.

It has been proposed to replace the screw threaded fitting of nozzles by a type of snap fitting where a non-circular part of the nozzle passes through a similarly shaped mouth of a socket and the nozzle, once in the socket, is rotated to bring projecting portions of the non-circular part beneath an undercut within the socket. A compression spring is provided within the socket to urge the nozzle upwardly against the overhanging part of the undercut so as to retain the nozzle against rotation. A nozzle assembly of this type is shown in US Patent No. 4878548, and US Patents Nos. 4185781 and 4438884 show spray nozzles of similar design, although not specifically intended for use in rotary drill bits.

A disadvantage of such arrangements, when used in drill bits, is the complexity of the structure, due for example to the necessity of providing some form of spring means within the assembly. Also, due to the nature of the retaining structure the diameter of the complete nozzle assembly is still significantly greater than the diameter of the nozzle aperture itself, again making it impracticable to employ such assemblies in situations where space is limited.

The present invention sets out to provide improved forms of nozzle assembly which may be simple to manufacture, which comprises few components, which locate the nozzle positively but removably in the assembly and, most importantly, where the overall diameter of the nozzle assembly is little greater than the diameter of the nozzle aperture itself, thus enabling the assembly to be located in spaces which would be insufficient for prior art constructions of nozzle assembly.

According to one aspect of the invention there is provided a nozzle assembly for a rotary drill bit comprising a nozzle for retention in a socket by means of a fitting comprising at least one external projection on the nozzle which is engageable within an open-ended recess in the wall of the socket, there being provided a removable locking element which is engageable within the open end of the recess, after the projection has been introduced into the recess, in order to retain the projection in the recess.

The socket and recess may be formed directly in the body of the drill bit, or may be formed in a separate member for inclusion in the bit body.

Preferably said fitting is a bayonet fitting, where the recess in the wall of the socket comprises an inlet portion leading from the open end of the recess into the socket, and a retention portion extending transversely with respect to the inlet portion. For example, the inlet portion may extend generally longitudinally of the socket, and the retention portion may extend generally circumferentially of the socket. The inlet portion may continue to extend into the socket beyond the retention portion.

With such a bayonet fitting the nozzle may be engaged within the socket by first inserting the nozzle longitudinally in the socket, the projection on the nozzle passing along the inlet portion of the recess, and then partly rotating the nozzle in the socket so that the projection enters the retaining portion of the recess.

The recess may include a second retention portion which extends generally circumferentially of the socket on the opposite side of the inlet portion to the first said retention portion. In this case the nozzle may be rotated in either direction to secure the bayonet fitting.

The removable locking element may be threadedly retained in the recess; for example it may comprise a grub screw. In this case the portion of the recess in which the locking element is retained may be generally U-shaped in cross-section, but only the rounded part thereof being internally screw-threaded.

Alternatively the locking element may be frictionally retained within the recess.

For example, the element may be formed from an elastic material, such as rubber or an elastomeric polymer, which is compressed as it is introduced into the recess, so as to engage the sides of the recess frictionally and resiliently.

In the case where the fitting is a bayonet fitting, the elastic retaining element may include a first part engageable within the inlet portion of the recess and a second part engageable within the retention portion of the recess. In the case where the recess includes two retention portions on opposite sides of the inlet portion, the elastic retaining element may include two second parts for engagement within the two retention portions of the recess respectively. In the case where the inlet portion continues to extend into the socket beyond the retention portion or portions, the first portion of the elastic retaining element may include a further part for engagement within said extension of the inlet portion.

In any of the above arrangements at least a part of the retention element which is exposed at the mouth of the recess is preferably formed of an erosion-resistant material, such as tungsten carbide. For example, the element may have an end cap of such material secured to it.

According to a second aspect of the invention, there is provided a nozzle assemble for a rotary drill bit comprising a nozzle for retention in a socket by means of a bayonet fitting comprising at least one external projection on the nozzle which is engageable within an open-ended recess in the wall of the socket, the recess comprising an inlet portion leading from the open end of the recess into the socket, and a retention portion extending transversely with respect to the inlet portion, resilient means being located between the projection and a wall of the retention portion of the recess, when the projection is located in said retention portion, to urge the projection against the opposite wall of the retention portion, thereby to tend to retain the projection in the retention portion.

Preferably said opposite wall of the retention portion is formed with a subsidiary recess into which a part of the projection is urged by said resilient means.

Preferably also, said opposite wall of the transverse retention portion of the recess, against which the projection is urged by the resilient means, is the wall which is nearest to the open end of the recess.

Said resilient means may comprise a body of elastomer.

The body of elastomer may be located adjacent said one wall of the retention portion of the recess, so as to be compressed by the projection as the projection passes along said retention portion, away from the inlet portion of the recess.

Preferably the body of elastomer extends across the end of the inlet portion of the recess which is adjacent the retention portion, whereby the projection on the nozzle engages and compresses part of the elastomer before being introduced into the retention portion.

In a preferred embodiment, the body of elastomer comprises an O-ring which is retained in an annular groove which extends around the wall of the socket, a stretch of said groove being coincident with the retention portion of said recess in the wall of the socket.

Any of the above arrangements where the projection on the socket is retained in the recess by resilient means may be used in combination with a removable locking element of any of the kinds previously referred to.

The following is a more detailed description of embodiments of the invention, by way of example, reference being made to the accompanying drawings in which:

Figure 1 is a side elevation of a typical drag-type drill bit incorporating nozzle assemblies according to the present invention,

Figure 2 is an end elevation of the drill bit shown in Figure 1, showing the nozzle assemblies,

Figure 3 is a plan view, to a larger scale, of one form of nozzle assembly in accordance with the invention,

Figure 4 is a cross-section on the line 4-4 of Figure 3,

Figure 5 is a diagrammatic section showing the bayonet fitting by which the nozzle is held in position,

Figure 6 is a similar view to Figure 4 of a modified arrangement,

Figure 7 is a similar view to Figure 6 of an alternative construction,

Figure 8 is a perspective view of the locking element shown in Figure 7,

Figure 9 is a further view, similar to Figures 6 and 7, showing a further form of locking element,

Figure 10 is a similar view to Figure 4 of an alternative embodiment of the invention, and

Figure 11 is a diagrammatic section showing the bayonet fitting in the arrangement of Figure 10.

Figures 1 and 2 show a typical full bore drag bit incorporating nozzle assemblies according to the invention. The bit body 10 is machined from steel and has a shank formed with an externally threaded tapered pin 11 at one end for connection to the drill string. The operative end face 12 of the bit body is formed with a number of blades 13 radiating from the central area of the bit, and the blades carry cutter assemblies 14 spaced apart along the length thereof. The bit has a gauge section including kickers 16 which contact the walls of the borehole to stabilise the bit in the borehole.

Each cutter assembly 14 comprises a preform cutting element 18 mounted on a carrier 19 in the form of a post which is located in a socket in the bit body. Each preform cutting element is in the form of a circular tablet comprising a facing table of superhard material, usually polystyrene diamond, bonded to a substrate which is normally of cemented tungsten carbide. The rear surface of the substrate is bonded to a suitably orientated surface on the post 19.

A central passage (not shown) in the bit and shank delivers drilling fluid through inner nozzles 22 and outer nozzles 22a in the end face of the bit body. Drilling fluid emerging under pressure through the inner nozzles 22 flows outwardly along the channels between the blades 13, cooling and cleaning the cutters 14 and carrying the cuttings removed from the formation being drilled outwardly to junk slots 23 in the gauge section. The drilling fluid then passes upwardly through the junk slots and the annulus between the drill string and the sides of the borehole to the surface, where the drilling fluid is filtered before being pumped back down the drill string to the bit.

The outer nozzles 22a are located nearer the outer periphery of the drill bit and are orientated so that at least the majority of drilling fluid emerging under pressure through the nozzles 22a initially flows inwardly along the channels in which the outer nozzles are located, although there may also be some outward flow directly to the adjacent junk slots. The inward flow of drilling fluid from the outer nozzles 22a thus is directed towards the inner nozzles 22 so as to join with the outward flow from those inner nozzles.

Figures 3-5 show in greater detail the construction of one form of each nozzle assembly 22 or 22a.

Referring to these figures, each assembly comprises a generally cylindrical nozzle 24 fitted within a corresponding cylindrical socket 25 formed in the bit body 10 and communicating, through a passage 26, with the aforementioned central passage in the drill bit.

The nozzle 24 is formed from cemented tungsten carbide and has a central passage 27 of circular cross-section through which the drilling fluid flows in use. The nozzle is a close sliding fit in the socket 25, an elastomeric sealing ring 28 being located in an annular groove 29 extending around the socket so as to sealingly engage the outer surface of the nozzle 24.

The nozzle 24 is retained in the socket 25 by two diametrically opposed bayonet fittings. Each bayonet fitting comprises an elongate projection 30 of rounded cross-section integrally formed on the outer surface of the nozzle 24 which cooperates with an L-shaped recess 31 (see Figure 5) formed in the interior wall surface of the socket 25. The recess 31 is similar in cross-sectional shape to the projection 30, so that the projection may slide smoothly along the recess.

As best seen in Figure 5, the recess 31 includes an inlet portion 32 which extends generally axially of the socket 25, away from an open mouth 33 of the recess which is formed in the surface 34 of the bit body adjacent the socket. The recess 31 also comprises a retention portion 35 which extends at right angles to the inlet portion 32 so as to extend circumferentially of the socket 25.

The nozzle 24 is introduced axially into the socket 25, with the two projections 30 on the nozzle aligned with the mouths 33 of the two diametrically opposed recesses 31. The projections 30 thus pass downwardly along the inlet portions 32 of the recesses. When the nozzle is fully received within the socket, each projection 30 lies opposite the circumferential retention portion 35 of the recess so that the projection may then be introduced into the retention portion by rotating the nozzle clockwise.

The curved part of the wall of the inlet portion 32 of the recess is internally threaded so that, after the nozzle has been fitted into its socket, using the bayonet fitting, a threaded grub screw 36 may be screwed into the inlet portion 32. The grub screw seals off the end of the retention portion 35 of the recess, as best seen in Figure 5, so as to retain the projection 30 within that portion of the recess and thus lock the nozzle into its socket.

The head of the grub screw 36, which may be formed with a slot or a cross-shaped or hexagonal socket for manipulating purposes, may be disposed below the level of the surface 34 of the bit body, as shown. This may shield the head of the grub screw from erosion by the drilling fluid flowing over the surface of the bit body, and the circular recess above the grub screw may fill with debris. However, the grub screw, or the head portion thereof, is in any case preferably formed from an erosion-resistant material.

The nozzle 24 is thus positively and securely retained within the socket 25 and yet may readily be removed or replaced by unscrewing the grub screw 36 and releasing the bayonet fitting. A slot 9 is formed in the outer surface of the nozzle so that it may be rotated by an appropriate tool.

The only part of the nozzle assembly which extends beyond the diameter of the nozzle 24 itself are the small recesses 31 and grub screws 36. Since the recesses 31 may be formed directly in the material of the bit body forming the wall of the socket 25, the space demanded by the assembly is at a minimum and allows the nozzle to be fitted in a comparatively small space, when compared with prior art nozzle assemblies.

Although it is preferred, for the maximum saving of space, that the recesses 31 should be formed directly in the wall of the socket in the bit body, the invention also provides arrangements where the recesses 31 and O-ring groove 29 are formed in the internal surface of a preformed cylindrical sleeve which is in turn secured within a socket in the bit body.

In order to make the maximum use of the saving of space, the nozzles are so orientated that their maximum cross-dimension, i.e. the distance between the outer extremities of the projections 30, is aligned with the adjacent blade, i.e. is aligned with the length of the channel in which the nozzle is located, as may be seen from Figure 2. This means that the minimum cross-dimension of the nozzle extends across the channel and between adjacent blades, thus allowing the greatest possible diameter of nozzle assembly which will fit in the limited space.

Typically, by use of the present invention, the maximum cross-dimension of the nozzle assembly as a whole may be no more than 70% larger than the diameter of the nozzle aperture itself, while the minimum cross-dimension of the nozzle assembly (i.e. the outer diameter of the basic nozzle 24) need be no more than about 50% larger than the diameter of the nozzle aperture itself. Typically, for a nozzle aperture of 11.11mm the diameter of the nozzle (i.e. the minimum cross-dimension) need be only 16.4mm, i.e. the nozzle diameter is about 47.6% greater than the aperture diameter. The maximum cross-dimension of the nozzle, taking into account the projections 30, may be 18.4mm, i.e. about 65.6% larger than the diameter of the nozzle aperture.

In the modified arrangement shown in Figure 6, the outer part of the nozzle 24 is formed with a continuous peripheral outer flange 8 which is a close fit in a correspondingly shaped annular rebate 7 formed in the bit body around the outer end of the socket 25. The grub screws 36 are, in this case, shorter than in the arrangement of Figure 4 so as to lie beneath the rebate 7. The peripheral flange 8 then protects the grub screws 36 against erosion or detachment.

In order to fit the grub screws in position, the flange 8 is formed with apertures (not shown) which can register with the openings 33 through which the grub screws are introduced. The retention portion 35 of the bayonet recess is then longer, in the circumferential direction, than in the arrangement of Figures 4 and 5 so that, after the grub screws have been fitted, the nozzle may be rotated clockwise by a further distance to bring the apertures in the flange 8 out of register with the openings 33. Alternatively, the flange 8, instead of being integral with the nozzle 24, may comprise a separate annular ring which is secured by suitable means within the rebate 7 after the grub screws 36 have been placed in position.

In the alternative arrangement shown in Figure 7, the recess 31 of each bayonet fitting is provided with two retention portions 35 extending in opposite directions from the lower end of the inlet portion 32 of the recess. In this case the nozzle may be rotated in either direction, clockwise or anti-clockwise, after having been introduced axially into the socket 25, so as to pass into one or other of the two retention portions 35.

In this arrangement the locking element for retaining the projection 30 in the recess is a generally T-shaped element 37 formed from natural or synthetic rubber, or any other suitable elastomeric material. The element 37 is compressed and forced into the inlet portion 32 of the recess until it reaches the bottom, where the arms of the T-shape open out and are squeezed into the retention portions 35 of the recess. The combination of the T-shape of the element 37 and its resilient compression serves to retain the element in the recess 31. In order to protect the element 37 from erosion there is bonded to the upper end of the T-shape a tablet 38 of erosion-resistant material, such as tungsten carbide, which is shaped to fill the U-shaped mouth 33 of the recess.

Figure 9 shows diagrammatically a further modification where the inlet portion 32 of the recess is extended downwardly beyond the two retention portions 35, as indicated at 39. In this case the elastomeric locking element 40 is generally cross-shaped so as to provide a limb 41 which extends into the extension 39 for added security.

In the arrangements of Figures 7-9 the elastomeric locking elements may be removed from the recesses, when it is desired to remove the nozzle, by digging them out with a sharp implement or perhaps by burning them out, the tungsten carbide cap, where such is provided, first having been removed in each case.

Although the invention has been described in relation to a particular form of drag-type drill bit, as previously mentioned the invention is applicable to nozzle assemblies for any other type of drill bit, including natural diamond bits and roller cone bits.

In all of the arrangements of Figures 3-9, the fitting is a bayonet-type fitting where each projection 30 is first inserted axially in an inlet portion 32 of the recess in the wall of the socket, and the nozzle is then rotated so that the projection passes into a transverse retention portion 35 of the recess. In a modified arrangement, not shown, the transverse retention portion of the recess is omitted and each projection simply comprises a single straight inlet portion corresponding to the inlet portion 32 of the bayonet arrangements. When the socket has been fully inserted, so that each projection lies at the bottom of its associated recess, a threaded grub screw, or other locking device, is introduced into the recess so as to retain the projection at the bottom of the recess, and hence retain the nozzle in the socket. Such arrangement simplifies the machining of the recess in the wall of the socket. Preferably when the grub screw or other form of locking device is fully inserted into the recess, it engages the projection on the nozzle so as to hold it firmly against the bottom of the recess.

Figures 10 and 11 show a further alternative arrangement in accordance with the present invention. In this case the nozzle 24 is of generally similar configuration to the nozzle of the previously described arrangements, and is integrally formed with diametrically opposed projections 42 each of which cooperates with a corresponding L-shaped recess 43 formed in the interior wall surface 44 of the socket.

As in the previous arrangements the recess 43 comprises an inlet portion 45 and a transverse retention portion 46. In this case the retention portion 46 is coincident with a stretch of an annular groove 47 which extends around the wall of the socket 44 and locates an O-ring 48.

As may be seen from Figure 11 the retention portion 46 is of greater width than the O-ring groove 47 so that after the projection 42 on the nozzle has been introduced into the inlet portion 45 of the recess, it may be passed along the retention portion 46 by compression of the O-ring. The upper wall of the retention portion 46 is formed with a subsidiary recess 49 so that when the projection 42 reaches the end of the retention portion it is snapped into engagement with the subsidiary recess 49 by the resilience of the O-ring. This serves to retain the projection in the recess and hence retain the nozzle in its socket.. Preferably the diameter of the O-ring is such that it is still is slightly compressed when the projection 42 is fully engaged in the subsidiary recess 49.

After insertion of the socket the inlet portion 45 of the recess may be closed by a grub screw or other form of locking element, such as those described in relation to Figures 7-9, to provide added security against escape of the projection 42 from the recess.

Although an O-ring provides a convenient form of resilient element for retaining the projection in the recess, a similar effect may be achieved by providing a shorter length of elastomer, or other resilient means, only within the bottom of the inlet and retention portions of the recess 43. In a further modified arrangement, the resilient means may be mounted on the underside of each projection 42, so as to move with the projection, instead of being mounted on the wall of the recess.

CLAIMS

1. A nozzle assembly for a rotary drill bit comprising a nozzle for retention in a socket by means of a fitting comprising at least one external projection on the nozzle which is engageable within an open-ended recess in the wall of the socket, there being provided a removable locking element which is engageable within the open end of the recess, after the projection has been introduced into the recess, in order to retain the projection in the recess.

2. A nozzle assembly according to Claim 1, wherein the socket and recess are formed directly in the body of the drill bit.

3. A nozzle assembly according to Claim 1, wherein the socket and recess are formed in a separate member for inclusion in the bit body.

4. A nozzle assembly according to any of the preceding claims, wherein said fitting is a bayonet fitting, where the recess in the wall of the socket comprises an inlet portion leading from the open end of the recess into the socket, and a retention portion extending transversely with respect to the inlet portion.

5. A nozzle assembly according to Claim 4, wherein the inlet portion extends generally longitudinally of the socket, and the retention portion extends generally circumferentially of the socket.

6. A nozzle assembly according to Claim 5, wherein the inlet portion continues to extend into the socket beyond the retention portion.

7. A nozzle assembly according to any of Claims 4 to 6, wherein the recess includes a second retention portion which extends generally circumferentially of the

socket on the opposite side of the inlet portion to the first said retention portion.

8. A nozzle assembly according to any of the preceding claims, wherein the removable locking element is threadedly retained in the recess.

9. A nozzle assembly according to Claim 8, wherein the removable locking element comprises a grub screw.

10. A nozzle assembly according to Claim 9, wherein the portion of the recess in which the locking element is retained is generally U-shaped in cross-section, only the rounded part thereof being internally screw-threaded.

11. A nozzle assembly according to any of Claims 1 to 7, wherein the locking element is frictionally retained within the recess.

12. A nozzle assembly according to Claim 11, wherein the element is formed from an elastic material which is compressed as it is introduced into the recess, so as to engage the sides of the recess frictionally and resiliently.

13. A nozzle assembly according to Claim 12, wherein the elastic material is rubber or an elastic polymer.

14. A nozzle assembly according to Claim 12 or Claim 13, wherein the fitting is a bayonet fitting, and wherein the elastic locking element includes a first part engageable within an inlet portion of the recess and a second part engageable within a retention portion of the recess.

15. A nozzle assembly according to Claim 14, wherein the recess includes two retention portions on opposite sides of the inlet portion, and the elastic locking element includes two second parts for engagement within the two retention portions of the recess

respectively.

16. A nozzle assembly according to Claim 14 or Claim 15, wherein the inlet portion continues to extend into the socket beyond the retention portion or portions, and the first portion of the elastic locking element includes a further part for engagement within said extension of the inlet portion.

17. A nozzle assembly according to any of the preceding claims, wherein at least a part of the retention element which is exposed at the mouth of the recess is formed of an erosion-resistant material.

18. A nozzle assembly according to Claim 17, wherein the erosion-resistant material is tungsten carbide.

19. A nozzle assembly according to Claim 17 or Claim 18, wherein the retention element has an end cap of erosion-resistant material secured to it.

20. A nozzle assemble for a rotary drill bit comprising a nozzle for retention in a socket by means of a bayonet fitting comprising at least one external projection on the nozzle which is engageable within an open-ended recess in the wall of the socket, the recess comprising an inlet portion leading from the open end of the recess into the socket, and a retention portion extending transversely with respect to the inlet portion, resilient means being located between the projection and a wall of the retention portion of the recess, when the projection is located in said retention portion, to urge the projection against the opposite wall of the retention portion, thereby to tend to retain the projection in the retention portion.

21. A nozzle assembly according to Claim 20, wherein said opposite wall of the

retention portion is formed with a subsidiary recess into which a part of the projection is urged by said resilient means.

22. A nozzle assembly according to Claim 20 or Claim 21, wherein said opposite wall of the transverse retention portion of the recess, against which the projection is urged by the resilient means, is the wall which is nearest to the open end of the recess.

23. A nozzle assembly according to any of Claims 20 to 22, wherein said resilient means comprise a body of elastomer.

24. A nozzle assembly according to Claim 23, wherein the body of elastomer is located adjacent said one wall of the retention portion of the recess, so as to be compressed by the projection as the projection passes along said retention portion, away from the inlet portion of the recess.

25. A nozzle assembly according to Claim 23 or Claim 24, wherein the body of elastomer extends across the end of the inlet portion of the recess which is adjacent the retention portion, whereby the projection on the nozzle engages and compresses part of the elastomer before being introduced into the retention portion.

26. A nozzle assembly according to any of Claims 23 to 25, wherein the body of elastomer comprises an O-ring which is retained in an annular groove which extends around the wall of the socket, a stretch of said groove being coincident with the retention portion of said recess in the wall of the socket.

27. A removable nozzle assembly for a rotary drill bit comprising a nozzle, having a nozzle aperture, for retention in a socket in the drill bit, the nozzle having a maximum outer cross-dimension which is no greater than 70% larger than the maximum cross-

dimension of the nozzle aperture.

28. A nozzle assembly according to Claim 27, wherein the nozzle comprises a generally cylindrical body having retaining means projecting outwardly therefrom, the diameter of the cylindrical body being no greater than 50% larger than the maximum cross-dimension of the nozzle aperture.

29. A nozzle assembly according to Claim 27 or Claim 28, wherein the nozzle aperture is circular.

30. A rotary drill bit comprising a bit body having an end face formed with a number of upstanding blades extending outwardly away from a central area thereof, a plurality of cutters mounted on the blades, and at least one nozzle assembly mounted on the bit body having a maximum cross-dimension and a smaller minimum cross-dimension, the nozzle assembly being so orientated on the bit body that the maximum cross-dimension thereof is generally aligned with the length of at least one adjacent blade.

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): B2F (FJB)
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Int Cl (Ed.6): B05B 15/06
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F16L 37/08, 37/24, 37/248, 37/252

Other: Online: WPI
Internet: http://www.patents.ibm.com/ibm.html

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 0 795 681	(Avimo Ltd) - see whole document, especially lines 49-116 of page 2, and figs. 1-3.	1-5
Y	EP 0 716 261 A1	(INDA...) - see whole document, especially abstract and figs. 1 and 2.	1-5
Y	US 5 253 716	(Wallace) - see whole document, especially fig. 5.	1-5
Y	US 4 878 548	(Eastman Christensen) - see whole document, especially fig. 1.	1-5
A	US 4 427 221	(Reed Rock) - see whole document.	-

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