(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 669 449 A2**

(12) # EUROPEAN PATENT APPLICATION

(21) Application number : **95300879.4**

(51) Int. Cl.^{6} : **E21B 10/60**

(22) Date of filing : **13.02.95**

(30) Priority : **24.02.94 GB 9403544**

(43) Date of publication of application : **30.08.95 Bulletin 95/35**

(84) Designated Contracting States : **BE DE**

(71) Applicant : **CAMCO DRILLING GROUP LIMITED**
Hycalog
Oldends Lane
Industrial Estate
Stonehouse, Gloucestershire GL10 3RQ (GB)

(72) Inventor : **Fuller, John Michael**
1A The Hazels,
Park Road
Nailsworth, Gloucestershire GL6 0HW (GB)

(74) Representative : **Carter, Gerald et al**
Arthur R. Davies & Co.
27 Imperial Square
Cheltenham, Gloucestershire GL50 1RQ (GB)

(54) **Nozzle structure for rotary drill bits.**

(57) A nozzle structure for use in a rotary drill bit comprises an inner portion (36) which is formed with a passage through which, in use, drilling fluid may pass, and an outer portion (38) formed with an external screw thread (39) whereby the nozzle structure may be screwed into a corresponding internally screw threaded socket in a drill bit. At least the screw threaded outer portion (38) of the nozzle structure is formed from solid infiltrated matrix material so as to be resistant to erosion and damage. The inner and outer portions may be separate, integral or secured together.

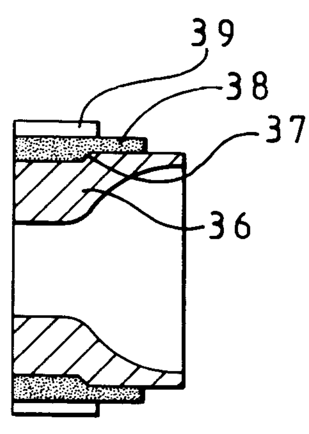

FIG 5

EP 0 669 449 A2

The invention relates to rotary drill bits for use in drilling or coring deep holes in subsurface formations, and in particular relates to nozzle structures for use in such bits.

The invention is applicable to nozzle structures for many different types of drill bit, including drag-type drill bits and roller cone bits.

The invention is, for example, applicable to rotary drag-type drill bits of the kind comprising a bit body on which are mounted a plurality of cutting elements for cutting or abrading the formation being drilled, and an inner passage for supplying fluid to one or more nozzle structures mounted at the external surface of the bit. The nozzle structures are so located that drilling fluid emerging from the nozzles flows past the cutting elements, during drilling, so as to cool and clean them.

In such bits the cutting elements may be in the form of so-called "preform" cutting elements, being in the shape of a tablet, usually circular, having a hard cutting table formed of polycrystalline diamond or other superhard material and bonded to a less hard substrate, for example of cemented tungsten carbide.

The bit body may be machined from metal, usually steel, sockets being machined in the bit body, some to receive the nozzle structures and some to receive studs or posts on which the cutting elements themselves are mounted. In an alternative form of construction the bit body may be formed by a powder metallurgy process. In this process a hollow mould in the configuration of the bit body, or a part thereof, is packed with powdered material, such as tungsten carbide, which is then infiltrated with a molten metal alloy, such as a copper alloy, in a furnace so as to form a hard solid infiltrated matrix. (The term "solid infiltrated matrix" will be used herein to refer to the whole solid metallic material which results from the above process, i.e. tungsten carbide or other hard metal powder surrounded by solidified alloy which has been caused to flow, when in the molten state, into the mass of hard metal powder. The term "matrix" is the term commonly used for such material in the drill bit industry, notwithstanding the fact that, in strict metallurgical terms, it is the infiltration alloy alone which forms a matrix, in which the hard metal particles are embedded.)

There are many different factors which determine what size of nozzle aperture will give the best performance during drilling, so that it is desirable to permit different sizes of nozzle to be selected and fitted to a given drill bit according to the particular drilling conditions. In order to achieve this, it is the normal practice for the outer part of each nozzle structure to be externally screw threaded so that it may be screwed into or out of an internally threaded socket provided in the bit body. In bit bodies formed of steel the internal screw thread may be readily machined in the socket during manufacture. Where the bit body is moulded, however, the internal screw thread will usually be formed by use of a suitably shaped refractory former which is fitted within the mould, in view of the difficulty of machining an internal screw thread directly into the matrix material from which the bit body is formed.

In order to render the nozzle resistant to erosion by the drilling fluid flowing through and past it, the nozzle itself must be formed from an erosion-resistant material and it is therefore usually formed from cemented tungsten carbide. (As is well known, this is formed by submitting a mass of tungsten carbide and cobalt particles to very high pressure and temperature in a suitably shaped mould.) Because of the extreme hardness of the cemented tungsten carbide, an accurate screw thread cannot readily be machined on the external surface of the nozzle itself. Hitherto, therefore, it has been the practice to hold the nozzle in position in the bit body by a separate annular retaining element having an external screw thread, machined in steel, which engages the internal screw thread in the bit body, the retaining element having an annular shoulder which bears against the nozzle, as the retaining element is screwed into the bit body, and clamps the nozzle between the annular shoulder and an annular abutment at the bottom of the socket within which the nozzle is retained.

In such known arrangements the whole annular retaining element may be formed from steel. However, steel is highly subject to erosion in the downhole environment with the result that after prolonged use of the drill bit the retaining element may become eroded away to an extent whereby it becomes impossible to remove the element, and hence to replace the nozzle, or in extreme cases the retaining element may be eroded away to such an extent that the nozzle becomes detached from the drill bit.

In order to overcome this erosion problem, it has been proposed to form the annular retaining element in two annular parts which are brazed or otherwise secured together: a steel part formed with the external screw thread to engage the screw thread on the bit body, and a manipulating part which is formed from cemented tungsten carbide and which overlies and protects the steel part from erosion. While this may reduce the problems associated with erosion, the tungsten carbide, being comparatively brittle, is liable to damage as a result of axial or torsional impacts to which it may be subjected in the field. Consequently, the tungsten carbide manipulating part may become cracked or broken, making it again difficult or impossible to remove the securing element, and possibly also exposing the steel part of the element to the eroding effect of the drilling fluid.

The present invention sets out to provide a novel form of nozzle structure where the above-mentioned disadvantages may be overcome.

According to the invention there is provided a nozzle structure for use in a rotary drill bit comprising an inner portion which is formed with a passage through which, in use, drilling fluid may pass, and an outer portion formed with an external screw thread whereby the nozzle structure may be screwed into a corresponding internally screw threaded socket in a drill bit, at least the screw threaded outer portion of the nozzle structure being formed from solid infiltrated matrix material (as hereinbefore defined).

The inner portion may be formed, at least in part, from cemented tungsten carbide, or it may also be formed from solid infiltrated matrix material as will be described.

The outer portion may be separately formed from the inner portion. In this case the outer portion may be secured to the inner portion by welding, brazing, shrink-fitting, adhesive or chemical bonding, or by mechanical fixing or interlock. In such arrangements the axial location of the outer portion with respect to the inner portion is preferably such that, when the nozzle structure is fitted to a drill bit, the outer portion does not project beyond the inner portion in a direction away from the drill bit.

When the inner and outer portion of the nozzle structure are secured together in this fashion, the nozzle structure forms a single unit for fitting to the bit body.

Alternatively, the outer portion of the nozzle structure may be separate from the inner portion and shaped to inter-engage with the inner portion in such manner as to prevent axial separation of the two portions in one direction and to permit their axial separation in the opposite direction. In this case, the inner portion of the nozzle assembly is first located in the socket in the bit body, and the outer portion is then screwed into the socket to serve as a retaining element to retain the inner portion in the socket.

In an alternative arrangement according to the invention the outer portion may be integral with the inner portion. For example the inner portion may comprise a solid preformed body of material around which the solid infiltrated matrix material of the outer portion is formed, so that the outer portion is bonded to the inner portion by the infiltration material. Alternatively the inner and outer portions of the nozzle structure may comprise portions of a single body of solid infiltrated matrix material.

The invention includes within its scope a drill bit comprising a bit body on which are mounted a plurality of cutting elements for cutting or abrading the formation, and an inner passage for supplying drilling fluid to one or more nozzles structures at the external surface of the bit body, at least one of said nozzles being of any of the forms referred to above and according to the invention.

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 drill bit of a kind to which the invention is applicable,

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

Figures 3 and 4 are axial sections through prior art nozzle structures, and

Figures 5-8 are axial sections through nozzle structures according to the present invention.

Referring to Figures 1 and 2, the bit body 10 is typically machined from steel and has a threaded 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 cutters 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. A central passage (not shown) in the bit body delivers drilling fluid through nozzles 17 in the end face 12 in known manner to clean and cool the cutters.

In the particular arrangement shown, each cutter 14 comprises a preformed cutting element 18 mounted on a carrier in the form of a post 19 which is located in a socket in the bit body. Each preform cutting element is usually circular and comprises a thin facing table of polycrystalline diamond bonded to a substrate of tungsten carbide. However, it will be appreciated that this is only one example of the many possible variations of the type of bit to which the invention is applicable, including bits where the cutting elements are mounted directly on the bit body instead of being mounted on posts.

As previously mentioned, it is desirable for the nozzles 17 to be readily removable from the bit body. In order to achieve this, each nozzle is part of a nozzle structure which is in screw threaded engagement within a socket in the bit body, which socket communicates with the aforementioned central passage for drilling fluid. Slots 20 are formed in the end of each nozzle structure to permit its engagement by a tool whereby the nozzle structure may be removed.

Figure 3 shows in greater detail one typical form of prior art nozzle structure.

In this arrangement the nozzle structure comprises an inner nozzle portion 21 formed from cemented tungsten carbide. The inner portion 21 is annular in shape, being provided with a central passage 22 which converges as it leads, outwardly of the drill bit, from an inlet 23 to an outlet 24 through which the jet of drilling fluid under pressure emerges during drilling.

The nozzle 21 is received in the socket in the bit body and bears against an annular shoulder (not shown) on the bit body surrounding a passage which delivers fluid to the inlet 23 of the nozzle. In order to retain the nozzle 21 in the bit body, the nozzle structure includes a separately formed outer retaining element 25.

The retaining element 25 is machined from steel and is formed with an external screw thread 26 which threadedly engages the internal screw thread in the socket in the bit body. The annular retaining element 25 is also formed with the aforementioned transverse slots 20 to receive a tool whereby the retaining element 25 may be screwed into and out of the socket in the bit body.

As previously mentioned, such prior art nozzle structures suffer from the disadvantage that the outwardly facing parts of the steel retaining element 25 are subject to erosion by the abrasive drilling fluid flowing through the passage 22 in the nozzle and washing over the exterior of the drill bit during drilling. Such erosion may wear away the projecting parts of the retaining element 25 which define the slots 20 making it difficult or impossible to unscrew the retaining element 25 should it be wished to change the nozzle. In extreme cases the retaining element 25 may be eroded away to such an extent that the nozzle 21 may fall out leading to drastic deterioration in the performance of the drill bit.

In an effort to overcome this problem an alternative prior art construction has been employed as shown in Figure 4. In this arrangement the retaining element 27 is formed in two parts: an annular part 28 formed with an external screw thread 29 which threadedly engages the internal screw thread in the socket in the bit body 30, and an outer annular part 31 having an outwardly projecting flange 32 which is received in an annular recess 33 surrounding the mouth of the socket in the bit body. The two parts 29 and 31 of the retaining element are brazed together and as the element is screwed into the socket the nozzle 34 is clamped between the part 31 and an annular surface 35 in the bit body.

The part 28 of the retaining element is machined from steel so that it may be readily formed with the screw thread 29, whereas the outer part 31 is moulded from cemented tungsten carbide so as to resist erosion and protect the steel part 28.

While such a nozzle structure is less susceptible to erosion damage than the arrangement of Figure 3, the brittle nature of the cemented tungsten carbide 31 means that the outer part is liable to fracture as a result of the impacts, particularly torsional impacts, to which it is likely to be subjected in the field. Once the outer part 31 has broken not only may it be difficult to unscrew the retaining element, but the steel part 28 may be exposed to erosion and consequent damage.

Figure 5 shows one form of nozzle structure according to the present invention. In this case the nozzle 36 forms the inner portion of the nozzle structure and is moulded from cemented tungsten carbide. The nozzle has smaller and larger diameter portions connected by an inclined annular step 37 on its outer surface. The nozzle is surrounded by an outer retaining element 38 the internal surface of which is stepped to correspond to the external surface of the nozzle 36, and the outer surface of which is formed with a screw thread 39. The retaining element 38 is separately formed from the nozzle 36 and is formed from solid infiltrated matrix material by the process previously described. That is to say, the element is moulded by packing a mass of metal particles, such as tungsten carbide particles, in a suitably shaped mould, placing the mass of particles in contact with a body of a suitable alloy, such as a copper alloy, and then placing the mould in a furnace so that the body of alloy melts and infiltrates the mass of particles to bond them together on solidification to form a solid infiltrated matrix.

Unlike cemented tungsten carbide, solid infiltrated matrix material may be readily moulded to sufficient accuracy to form the required external screw thread 39 or, if it is desired to machine the screw thread 39 on the retaining element, this may be done with greater ease than is possible with cemented tungsten carbide.

The infiltrated solid matrix material is much less susceptible to erosion than is steel, but at the same time it is less susceptible to damage by impact shocks than cemented tungsten carbide. As shown in Figure 5, the matrix retaining element 38 preferably does not extend beyond the tungsten carbide nozzle 36 in the axial direction away from the bit body so as to enhance the erosion resistance of the whole nozzle structure. The outwardly facing portions (i.e. facing to the left in Figure 5) of the retaining element 38 may be suitably shaped to receive and locate a tool for rotating the retaining element to screw it into or out of the socket in the bit body.

The retaining element 38 may be entirely separate from the nozzle 36. This has the advantage that the retaining element may be readily replaced if it becomes worn or damaged without the necessity of replacing the nozzle 36 itself. It also allows the same retaining element, if required, to be used with different nozzles, for example nozzles of different size and/or shape of internal passage.

Alternatively, the retaining element 38 may be permanently connected to the nozzle 36. This may be effected by preforming the retaining element 38 and subsequently brazing it to the nozzle 36, or the retaining element may be moulded around the preformed nozzle 36 so as to be essentially integral therewith.

Figure 6 shows a modified version of the nozzle structure of Figure 5 where a major part of the passage 40 through the nozzle structure is formed in the outer portion 41 of the structure, formed from infiltrated matrix, only a part of the passage 40 being formed in the cemented tungsten carbide inner portion 42 of the nozzle structure. In this case the outer portion 41 is brazed to the inner portion 42 or is cast around it.

Figure 7 shows a further embodiment according to the invention. This embodiment is structurally similar to the prior art arrangement of Figure 3 but, in accordance with the present invention, the retaining element 43 of the nozzle structure is formed from solid infiltrated matrix material instead of from steel as in the prior art. The matrix outer portion 43 may be separate from the nozzle 44, as in the prior art, but may if required be brazed to the nozzle or moulded around it so as to form an integral unit.

The threaded section 43a of the outer portion may be formed from matrix and integral with the rest of the outer portion 43, or it may comprise a separately formed machined steel sleeve which is bonded to the matrix material of the outer portion 43.

Figure 8 shows a further alternative form of nozzle structure according to the present invention where the whole of the nozzle structure, i.e. both the inner portion defining the passage 45 and the outer portion providing the screw thread 46, are moulded as one body of solid infiltrated matrix material. In this case the nozzle is formed with a peripheral groove 47 to receive a sealing ring.

In a further construction according to the present invention, there is provided an arrangement which is structurally similar to the prior art arrangement shown in Figure 4. In accordance with the present invention, however, the outer part 31 is formed from solid infiltrated matrix material, while the externally threaded part 28 remains formed from steel. The steel sleeve 28 may be brazed to the outer part 31. The retaining structure comprising the steel sleeve 28 and matrix outer part 31 may be separate from the nozzle 34, so as to provide a two-piece structure, or all three components may be brazed or otherwise bonded together to provide a unitary structure.

Claims

1. A nozzle structure for use in a rotary drill bit comprising an inner portion (36) which is formed with a passage through which, in use, drilling fluid may pass, and an outer portion (38) formed with an external screw thread whereby the nozzle structure may be screwed into a corresponding internally screw threaded socket in a drill bit, characterised in that at least the screw threaded outer portion (38) of the nozzle structure is formed from solid infiltrated matrix material.

2. A nozzle structure according to Claim 1, characterised in that the inner portion (36) is formed, at least in part, from cemented tungsten carbide.

3. A nozzle structure according to Claim 1, characterised in that the inner portion (36) is formed, at least in part, from solid infiltrated matrix material.

4. A nozzle structure according to any of Claims 1 to 3, characterised in that the outer portion (38) is separately formed from the inner portion (36).

5. A nozzle structure according to Claim 4, characterised in that the outer portion (38) is secured to the inner portion (36) by welding, brazing, shrink-fitting, adhesive or chemical bonding, or by mechanical fixing or interlock.

6. A nozzle structure according to Claim 5, characterised in that the axial location of the outer portion (38) with respect to the inner portion (36) is such that, when the nozzle structure is fitted to a drill bit, the outer portion does not project beyond the inner portion in a direction away from the drill bit.

7. A nozzle structure according to Claim 4, characterised in that the outer portion (38) of the nozzle structure is separate from the inner portion (36) and shaped to inter-engage with the inner portion in such manner as to prevent axial separation of the two portions in one direction and to permit their axial separation in the opposite direction.

8. A nozzle structure according to any of Claims 1 to 3, characterised in that the outer portion is integral with the inner portion.

9. A nozzle structure according to Claim 8, characterised in that the inner portion (36) comprises a solid preformed body of material around which the solid infiltrated matrix material of the outer portion (38) is formed, so that the outer portion is bonded to the inner portion by the infiltration material.

10. A nozzle structure according to Claim 8, characterised in that the inner and outer portions of the nozzle structure (Fig. 8) comprise portions of a single body of solid infiltrated matrix material.

11. A drill bit comprising a bit body on which are mounted a plurality of cutting elements for cutting or abrading the formation, and an inner passage for supplying drilling fluid to one or more nozzles structures at the external surface of the bit body, and incorporating at least one nozzle structure according to any of the preceding claims.

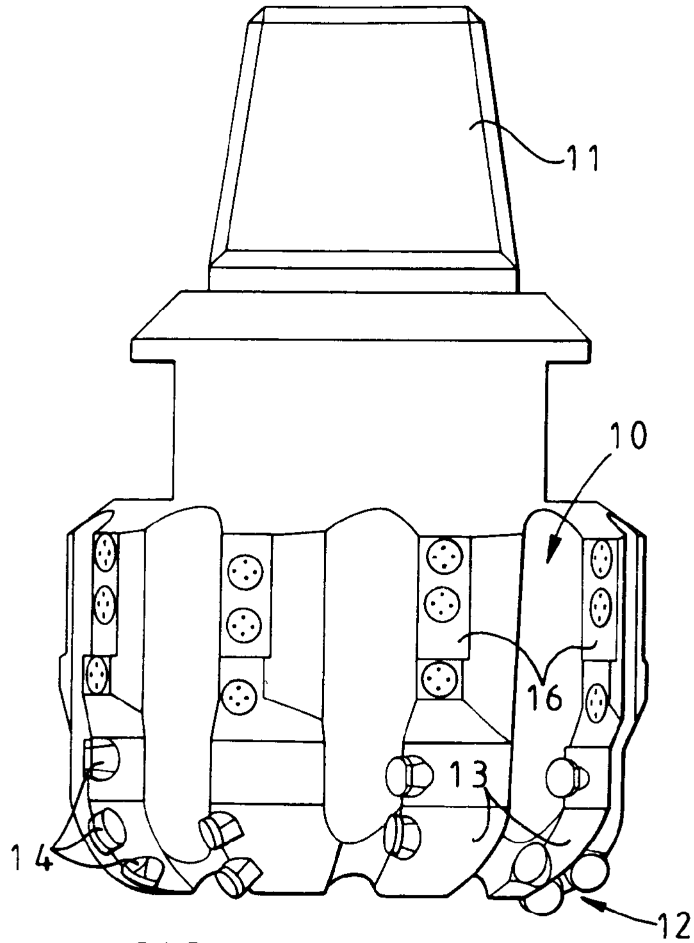

FIG 1

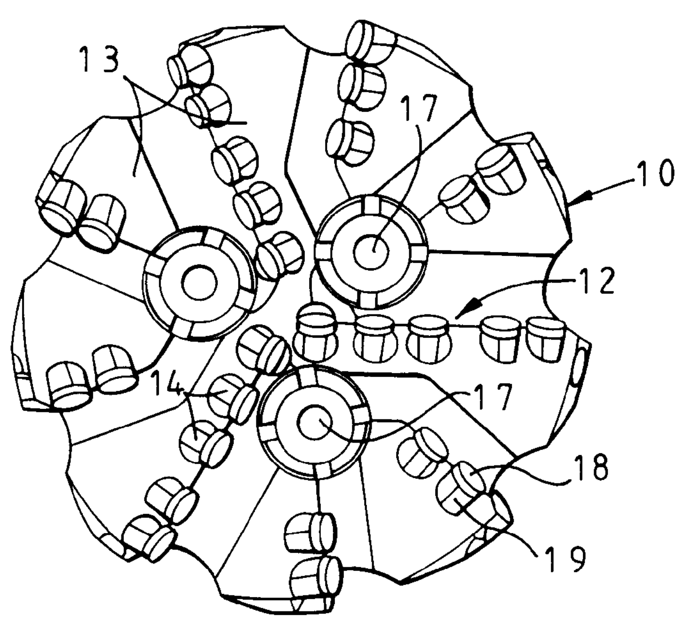

FIG 2

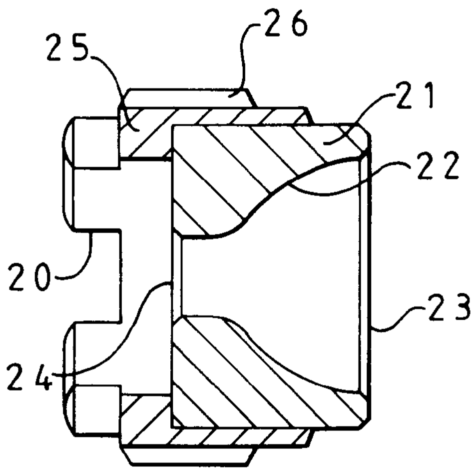

FIG 3
(Prior art)

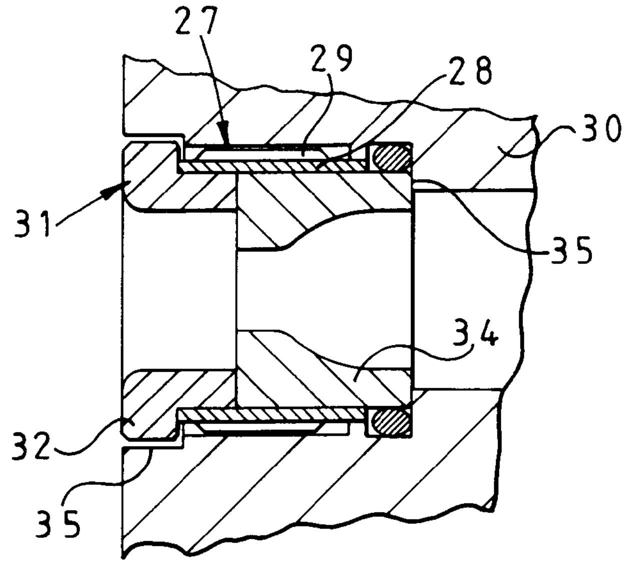

FIG. 4
(Prior art)

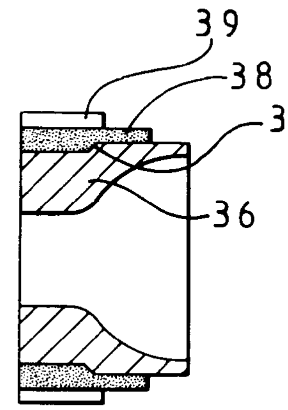

FIG 5

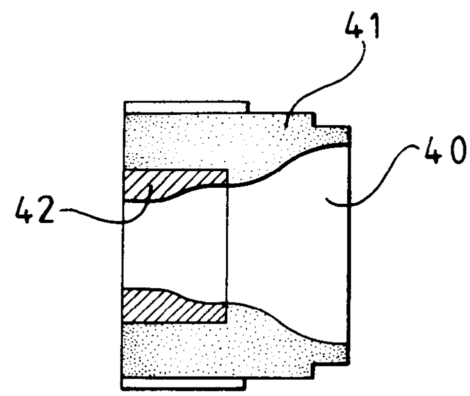

FIG 6

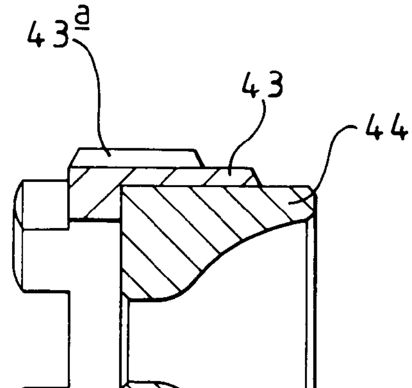

FIG 7

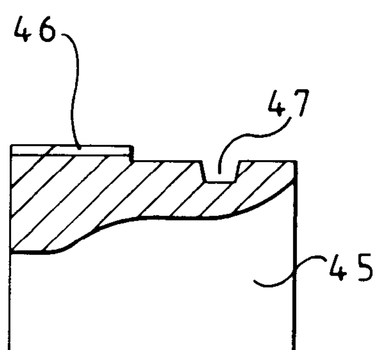

FIG 8