(12) STANDARD PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. AU 2007201848 B2

(54) Title
A nut and rock bolt assembly

(51) International Patent Classification(s)
F16B 37/00 (2006.01) ***E21D 21/00*** (2006.01)

(21) Application No: **2007201848** (22) Date of Filing: **2007.04.26**

(30) Priority Data

(31) Number	(32) Date	(33) Country
2006903413	**2006.06.26**	**AU**

(43) Publication Date: **2008.01.17**
(43) Publication Journal Date: **2008.01.17**
(44) Accepted Journal Date: **2013.05.16**

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(56) Related Art
US 4603446
US 5352065 A
US 6296429 B1
US 990581 A
US 4422196 A
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A NUT AND ROCK BOLT ASSEMBLY

ABSTRACT

A nut (1) is formed from a nut body (2) and an insert (3). An aperture (6) extends longitudinally between first and second aperture openings (7, 8) disposed on opposing first and second end faces (4, 5) of the nut body (2). The aperture (6) defines an aperture peripheral wall (9) which includes a threaded first wall portion (10) and a second wall portion (11) that has a continuous generally annular transverse cross-section tapering towards the second aperture opening (8). The insert (3) is located in and extends across the aperture (6) to inhibit passage of a rock bolt (21). The second wall portion (11) is configured to restrain the insert (3) from passing through the second aperture opening (8). When a threaded rock bolt (21) is threadingly received in the aperture (6) at a torque in excess of a predetermined torque when a torque is applied to the nut (1), the insert (3) is ejected from the second aperture opening (8) allowing passage of the rock bolt (21) through the second aperture opening (8).

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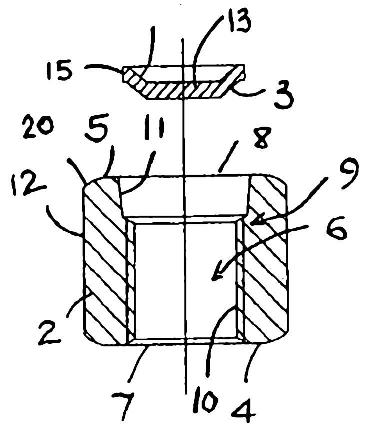

Fig. 1

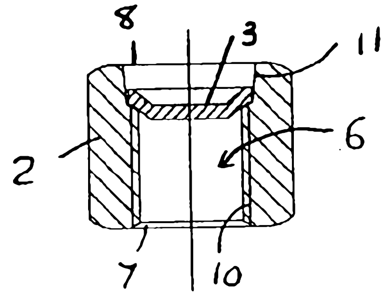

Fig. 2

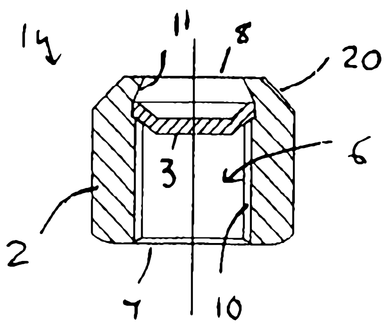

Fig. 3

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S&F Ref: 804783

AUSTRALIA

PATENTS ACT 1990

COMPLETE SPECIFICATION

FOR A STANDARD PATENT

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Invention Title:	A nut and rock bolt assembly

Associated Provisional Application Details:

[33] Country:	[31] Appl'n No(s):	[32] Application Date:
AU	2006903413	26 Jun 2006

The following statement is a full description of this invention, including the best method of performing it known to me/us:-

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A NUT AND ROCK BOLT ASSEMBLY

Technical Field

The present invention relates to the field of mining equipment, and in particular, relates to a nut for use in a rock bolt assembly used to secure the roof or wall of a mine, tunnel or other ground excavation as well as the rock bolt assembly.

Background of the Invention

A known method of installing a resin grouted rock bolt to secure the roof or wall of an underground mine, tunnel or other ground excavation involves drilling a bore hole into the rock face, inserting a two component resin filled cartridge into the bore hole and driving the cartridge toward the top of the bore hole by way of a rock bolt inserted into the bore hole. The rock bolt pierces the resin cartridge and is then rotated, thereby mixing the two component resin, allowing it to set. Once the two component resin has set, anchoring the top of the rock bolt, the rock bolt is tensioned, typically by threading a nut along the threaded lower end of the rock bolt, bearing the nut against a mine plate that engages the rock face adjacent to the bore hole opening.

To enable rotation of the rock bolt during the resin mixing phase, there has previously been proposed a nut that has a metallic disc insert positioned within a recess in the trailing end of the nut. The trailing end face of the nut is crimped at several discrete locations at the edge of the recess so as to form discrete lips extending across the recess, and thereby retain the disc insert within the nut recess. This nut is threaded onto the trailing end of the rock bolt. The rock bolt is then rotated by virtue of the drill head of the installation rig at a moderate torque. The disc insert bears against the end of the rock bolt preventing the nut from threadingly advancing along the rock bolt, resulting in the torque applied to the nut rotating the entire rock bolt assembly, thereby mixing the resin. Once the resin is set, the drill head of the installation rig is rotated at a higher torque, exceeding a predetermined "break-out" torque which is sufficient to break the insert disc out of the crimped recess, thus allowing the nut to be threadingly advanced along the rock bolt and thereby tension the rock bolt against the mine plate and rock face.

This crimped nut, however, suffers from a number of disadvantages. Firstly, the predetermined "break-out" torque is limited to relatively low torques, practically of the order of 220 Newton metres. In some applications, significantly larger "break-out" torques are desired, sometimes in the order of 400 Newton metres. This cannot however, be readily achieved utilising this nut design. As high crimping forces are applied to the edges of the nut recess, in an attempt to achieve greater "break-out" torques, the side walls of the nut flare outwards, exceeding tolerances for the "across the flats" dimension of the nut body.

High crimping forces also begin to weaken the nut body. To create the crimp, the edges of the crimping tool are designed to cut into the metal at the edge of the nut recess in order to displace the metal and thereby create the lips extending across the recess. This creates weak stress concentration points where fatigue cracking can potentially initiate and propagate throughout the nut.

Further, the specific "break-out" torque is susceptible to manufacturing tolerances, particularly variance with the concentricity of the nut recess in relation to the nut body, as well as variances in the height of the nut. In an attempt to account for these variances, the tool design for effecting the crimp is relatively complex and, as a result, more difficult and expensive to manufacture.

Object of the Invention

It is the object of the present invention to substantially overcome or at least ameliorate at least one of the above disadvantages.

Summary of the Invention

In one aspect, the present invention provides a nut comprising:

a nut body having a first end face, a second end face and an aperture for receipt of a rock bolt, said aperture extending longitudinally between a first aperture opening disposed on said first end face and a second aperture opening disposed on said second end face and defining an aperture peripheral wall, said aperture peripheral wall including a threaded first wall portion disposed adjacent said first aperture opening and a second wall portion disposed between said first wall portion and said second aperture opening, said second wall portion having a continuous generally annular transverse cross-section tapering toward said second aperture opening, said second wall portion being generally frustoconical in form;

an insert located in and extending across said aperture to inhibit passage of a rock bolt through said aperture out of said second aperture opening, said second wall portion being configured to restrain said insert from passing through said second aperture opening;

wherein said insert and said second wall portion are configured such that, in use, when a threaded rock bolt is threadingly received in said aperture via said first aperture opening and a torque in excess of a predetermined torque is applied to said nut in a direction tending to bear the rock bolt against said insert, said insert is ejected from said second aperture opening, allowing passage of the rock bolt through the second aperture opening.

Typically, said insert is in the general form of a disc.

Typically, said threaded first wall portion has a minor diameter less than the diameter of said disc.

In a further aspect, the present invention provides a rock bolt assembly comprising:

a nut as defined above;

a rock bolt having a threaded trailing end, said threaded trailing end being threadingly received in said aperture via said first aperture opening.

In a further aspect, the present invention provides a method of forming a nut comprising the steps of:

providing a nut body having a first end face, a second end face and an aperture for receipt of a rock bolt, said aperture extending longitudinally between a first aperture opening disposed on said first end face and a second aperture opening disposed on said second end face and defining an aperture peripheral wall, said aperture peripheral wall including a threaded first wall portion disposed adjacent said first aperture opening and a second wall portion disposed between said first wall portion and said second aperture opening;

locating an insert in, and extending across, said aperture;

receiving said second end face within a concave die face and forcibly engaging said concave die with a periphery of said second end face, thereby deforming said nut body inwardly towards said aperture at, and adjacent to, said second end face, deforming said second wall portion into a generally frustoconical form having a continuous generally annular transverse cross-section tapering towards said second aperture opening.

Typically, prior to engagement of said die, said second wall portion has a continuous generally cylindrical form.

In one form, said concave die has a conical or frustoconical die face.

Brief Description of the Drawings

A preferred embodiment of the present invention will now be described, by way of an example only, with reference to the accompanying drawings wherein:

Figure 1 is a cross-sectioned front elevation view of a nut body and insert.

Figure 2 is a cross-sectioned front elevation view of the nut body and insert of Figure 1, with the insert positioned in the nut aperture.

Figure 3 is a cross-sectioned front elevation view of a nut comprising the nut body and insert of Figure 2 after swaging of the nut body.

Figure 4 is an isometric view of the nut of Figure 3.

Figure 5 is a cross-sectioned front elevation view of the nut of Figure 3 in a swaging die assembly.

Figure 6 is a front elevation view of a rock bolt assembly including the nut of Figure 3.

Detailed Description of the Preferred Embodiment

Referring firstly to Figures 1 to 4, a nut 1 according to a preferred embodiment is formed from a nut body 2 and insert 3. The nut body 2 has a first end face 4, a second end face 5 and an aperture 6 extending through the nut body 2. The aperture 6 extends longitudinally between a first aperture opening 7 disposed on the first end face 4 and a second aperture opening 8 disposed on the second end face 5. The aperture 6 defines an aperture peripheral wall 9 which includes a threaded first wall portion 10 disposed adjacent the first aperture opening 7 and a second wall portion 11 disposed between the first wall portion 10 and the second aperture opening 8.

In the configuration depicted in Figures 1 and 2, the second wall portion 11 is continuous and has a generally annular transverse cross-section which tapers slightly away from the second aperture opening 8 toward the threaded first wall portion 10. The second wall portion 11, however, could alternatively be generally cylindrical or alternatively taper slightly toward the second aperture opening 8. The smallest diameter transverse cross-section of the second wall portion 11, adjacent the threaded first wall portion 10, is larger than the minor diameter of the threaded first wall portion 10 (that is, the crest diameter of the thread of the threaded first wall portion 10). Here, the diameter of the smallest cross-section of the second wall portion 11 is also slightly larger than the major diameter of the threaded first wall portion 10 (that is, the root diameter of the thread). The nut body 2, also has a standard hexagonal drive surface 12 extending about its periphery between the first and second end faces 4, 5.

The insert 3 is configured to be located in, and extending across, the aperture 6, as best shown in Figures 2 and 3. Here the insert 3 is in the general form of a circular disc made of three concentric integrally formed sections, being a flat circular central section 13, a frustoconical intermediate section 14 and an annular peripheral section 15 that is offset from the central section 13. When located in the aperture 6, the disc insert 3 sits within the recess defined by the second wall portion 11, with the peripheral section 15 of the insert 3 resting on the interface between the threaded first wall portion 10 and the second wall portion 11. The central section 13 of the insert 3 protrudes into the threaded portion of the aperture 6 defined by the threaded first wall portion 10 by virtue of the offset provided by the intermediate section 14 of the insert 3. It needs to be understood, however, that the insert may take any of various forms, as long as it can be located in and extend across the aperture so as to form a barrier, as is discussed further below.

Once the insert 3 has been located in the aperture 6, the nut body 2 and insert 3 are located in the lower die 15 of a swaging die assembly 16, as depicted in Figure 5. The nut body 2 is located in the lower die 15 with the first end face 4 located in a hexagonal recessed die face 17 formed in the lower die 15, thereby holding the nut body 2 steady. An upper die 18 having a lower concave die face 19 is positioned above the nut body 2 and lower die 15. The concave die face 19 may be of a conical form, as depicted, or alternatively frustoconical or any of various suitable concave shapes. Here the conical die face 19 has an included angle of 90°, such that the die face 19 is inclined at 45° to the second end face 5 of the nut body 2.

The upper die 18 is lowered toward the nut body 2 and further pressed down onto the second end face 5 of the nut 2. When the concave die face 19 first engages the nut body 2, it engages the periphery of the second end face 5 at each of the six corner points of the hexagonal second end face 5. The lateral force applied to each of the corner points acts to centralise the nut body 2 and lower die 15 in relation to the upper die 18. As the upper die 18 is further pressed downwardly against the periphery of the second end face 5 of the nut body 2, the conical die face 19 swages the nut body 2, deforming it inwardly toward the aperture 6 at, and adjacent to, the second end face 5. The shoulders 20 of the nut body 2 at the interface between the drive surface 12 and second end face 5 are thus deformed inwardly and flattened, and the metal between the second wall portion 11 and shoulder 20 is deformed inwardly and over the recess defined by the second wall portion

11. The greatest deformation load (and greatest deformation) occurs in the regions between each corner point of the hexagonal second end face 5, where the greatest load is applied, and the second aperture opening 8.

The resulting form of the deformed second wall portion 11, depicted in Figures 3 and 5, is of a continuous generally annular transverse cross-section which tapers towards the second aperture opening 8, which is reduced in size by the deformation process. The generally annular transverse cross-section will typically not be precisely annular, but will undulate slightly given that there is generally greater deformation of the second wall portion 11 in the region radially aligned with the corner points of the second end face 5. Whilst the process may provide the second wall portion 11 with a generally frustoconical form, various operating parameters and alternate concave shapes of the upper die face 19 may result in the second wall portion 11 tapering non-linearly toward the second aperture opening 8.

The second wall portion 11 is deformed sufficiently so as to restrain the insert 3 from passing through the second aperture opening 8 by, in the embodiment depicted, providing the second aperture opening 8 with a diameter less than the diameter of the disc insert 3.

The nut 1 so formed is then threaded onto the threaded trailing end portion 20 of a standard threaded rock bolt 21, with the threaded trailing end portion 21 being threadingly received in the aperture 6 of the nut body 2 via the first aperture opening 7. As the nut 1 is threaded along the threaded end portion 20 of the rock bolt 21, the trailing end face 22 of the rock bolt 21 bears against the central section 13 of the disc insert 3. The disc insert 3, however, inhibits the nut 1 from further advancing along the threaded end portion 20 of the rock bolt 21, thus effectively locking the nut 1 onto the rock bolt 21. This configuration of the insert 3 depicted, having the central section 13 of the insert 3 projecting into the threaded portion of the aperture 6, results in there being no contact between the insert 3 and the threads of the threaded trailing end portion 20 of the rock bolt 21, thereby avoiding damage to the threads.

The rock bolt assembly depicted in Figure 6 can be utilised to secure a rock face with the usual method utilising a two component resin. The two component resin may be mixed by rotating the rock bolt assembly by way of the drill head of an insulation rig engaging the drive surface 12 of the nut body 2 at a moderate torque, rotating the entire rock bolt assembly in unison, mixing the resin. When the resin has been allowed to set, an increased torque is applied to the nut by the insulation rig until a predetermined "break-out" torque is reached at which the load applied to the insert 3 by the end face 22 of the rock bolt 21 is sufficient to eject the insert 3 from the aperture 6 through the second aperture opening 8. Depending upon the specific configuration of the insert 3 and the second wall portion 11, this ejection may be achieved by deformation of the insert 3, outward deformation of the second wall portion 11 and/or rupture of the insert 3.

Given that the tapered second wall portion 11 provides a continuous rim restraining the insert 3, free of any significant weakening cuts, significantly higher "break-out" torques may be achieved. The higher "break out" torques are also achievable as a result of creating a greater deformation load in the second wall portion 11 in regions radially aligned with the corner points of the hexagonal second end face, corresponding to the greatest thickness of metal around the second aperture opening 8. The specific "break-out" torque may be accurately predetermined by the load applied by the upper die 18 when deforming the nut body 2. If outward deformation of the second wall portion 11 is associated with the ejection of the insert 3, the resultant outward deformation of the shoulder 20 of the nut body 2 does not cause any concern in relation to tolerance of the external dimensions of the nut body 2, given that the shoulder 20 had already been substantially inwardly deformed during the initial formation process. Further, due to the utilisation of the entire annulus of metal material around the second aperture opening 8 to restrain the insert 3, the performance of the nut is less susceptible to variances in the concentricity of the nut recess defined by the second wall portion 11. The die assembly design is also quite simple and inexpensive to fabricate, largely due to the self-centering affect provided during the pressing process.

The claims defining the invention are as follows:

1. A nut comprising:

a nut body having a first end face, a second end face and an aperture for receipt of a rock bolt, said aperture extending longitudinally between a first aperture opening disposed on said first end face and a second aperture opening disposed on said second end face and defining an aperture peripheral wall, said aperture peripheral wall including a threaded first wall portion disposed adjacent said first aperture opening and a second wall portion disposed between said first wall portion and said second aperture opening, said second wall portion having a continuous generally annular transverse cross-section tapering toward said second aperture opening, said second wall portion being generally frustoconical in form;

an insert located in and extending across said aperture to inhibit passage of a rock bolt through said aperture out of said second aperture opening, said second wall portion being configured to restrain said insert from passing through said second aperture opening;

wherein said insert and said second wall portion are configured such that, in use, when a threaded rock bolt is threadingly received in said aperture via said first aperture opening and a torque in excess of a predetermined torque is applied to said nut in a direction tending to bear the rock bolt against said insert, said insert is ejected from said second aperture opening, allowing passage of the rock bolt through the second aperture opening.

2. The nut of claim 1 wherein said insert is in the general form of a disc.

3. The nut of claim 2 wherein said threaded first wall portion has a minor diameter less than the diameter of said disc.

4. A rock bolt assembly comprising:

a nut as defined in any one of claims 1 to 3;

a rock bolt having a threaded trailing end, said threaded trailing end being threadingly received in said aperture via said first aperture opening.

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5. A method of forming a nut comprising the steps of:

providing a nut body having a first end face, a second end face and an aperture for receipt of a rock bolt, said aperture extending longitudinally between a first aperture opening disposed on said first end face and a second aperture opening disposed on said second end face and defining an aperture peripheral wall, said aperture peripheral wall including a threaded first wall portion disposed adjacent said first aperture opening and a second wall portion disposed between said first wall portion and said second aperture opening;

locating an insert in, and extending across, said aperture;

receiving said second end face within a concave die face and forcibly engaging said concave die with a periphery of said second end face, thereby deforming said nut body inwardly towards said aperture at, and adjacent to, said second end face, deforming said second wall portion into a generally frustoconical form having a continuous generally annular transverse cross-section tapering towards said second aperture opening.

6. The method of claim 5 wherein, prior to engagement of said die, said second wall portion has a continuous generally cylindrical form.

7. The method of claim 6 wherein said concave die has a conical or frustoconical die face.

8. A nut substantially as hereinbefore described with reference to Figures 1 to 5 of the accompanying drawings.

9. A rock bolt assembly substantially as hereinbefore described with reference to Figure 6 of the accompanying drawings.

10. A method of forming a nut substantially as hereinbefore described with reference to Figure 5 of the accompanying drawings.

Dated 21 March, 2012

DYWIDAG-Systems International Pty Limited

Patent Attorneys for the Applicant/Nominated Person

SPRUSON & FERGUSON

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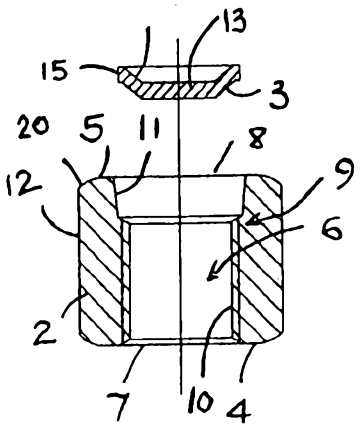

Fig. 1

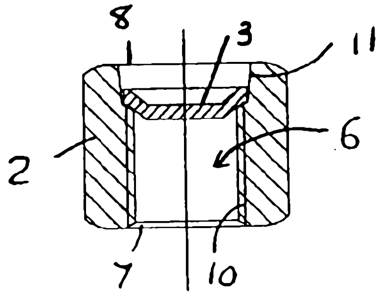

Fig. 2

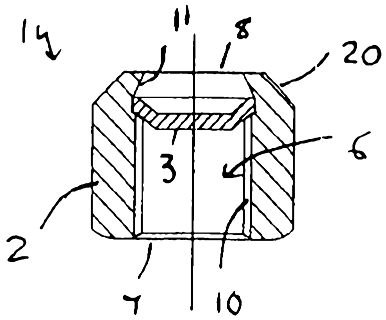

Fig. 3

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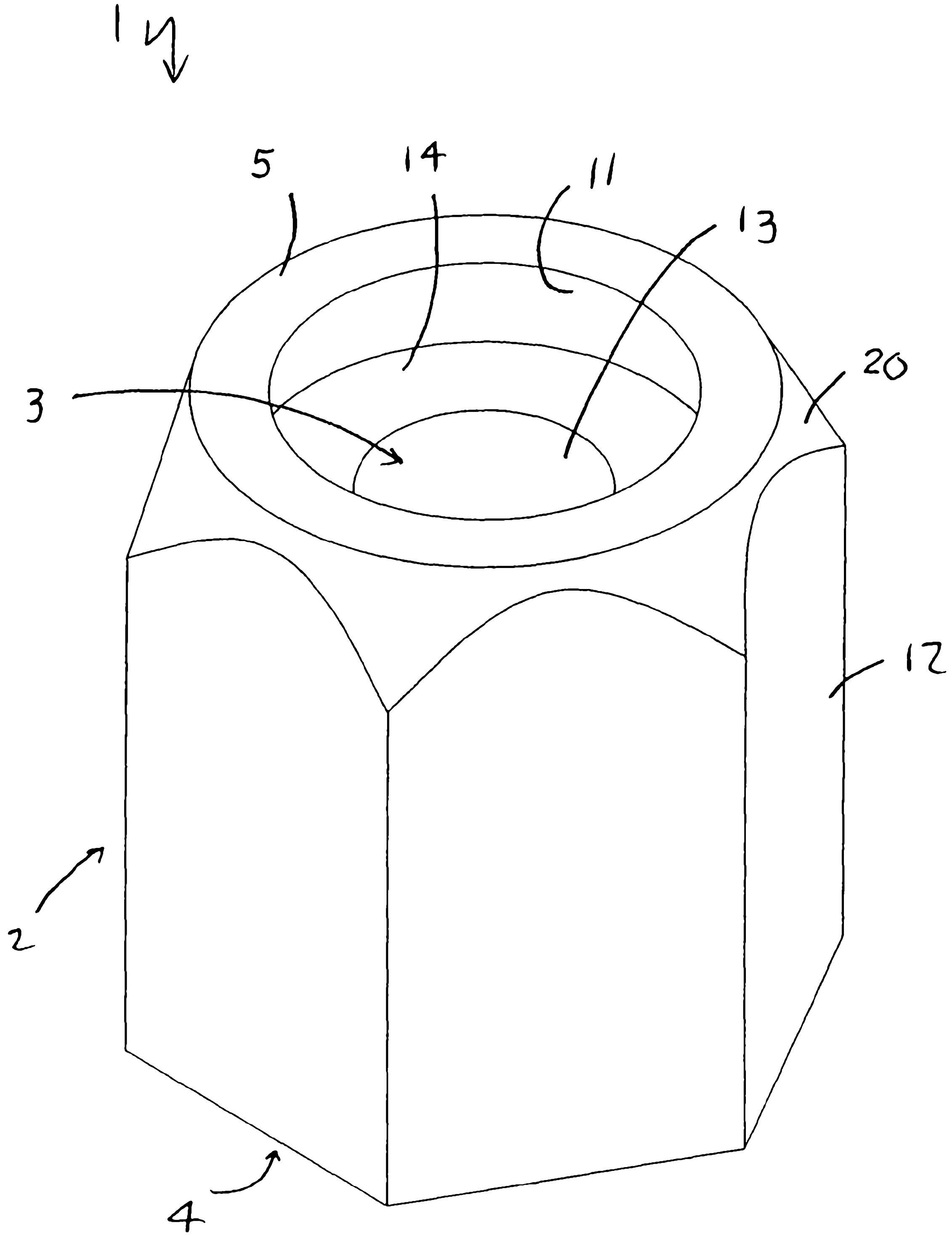

Fig. 4

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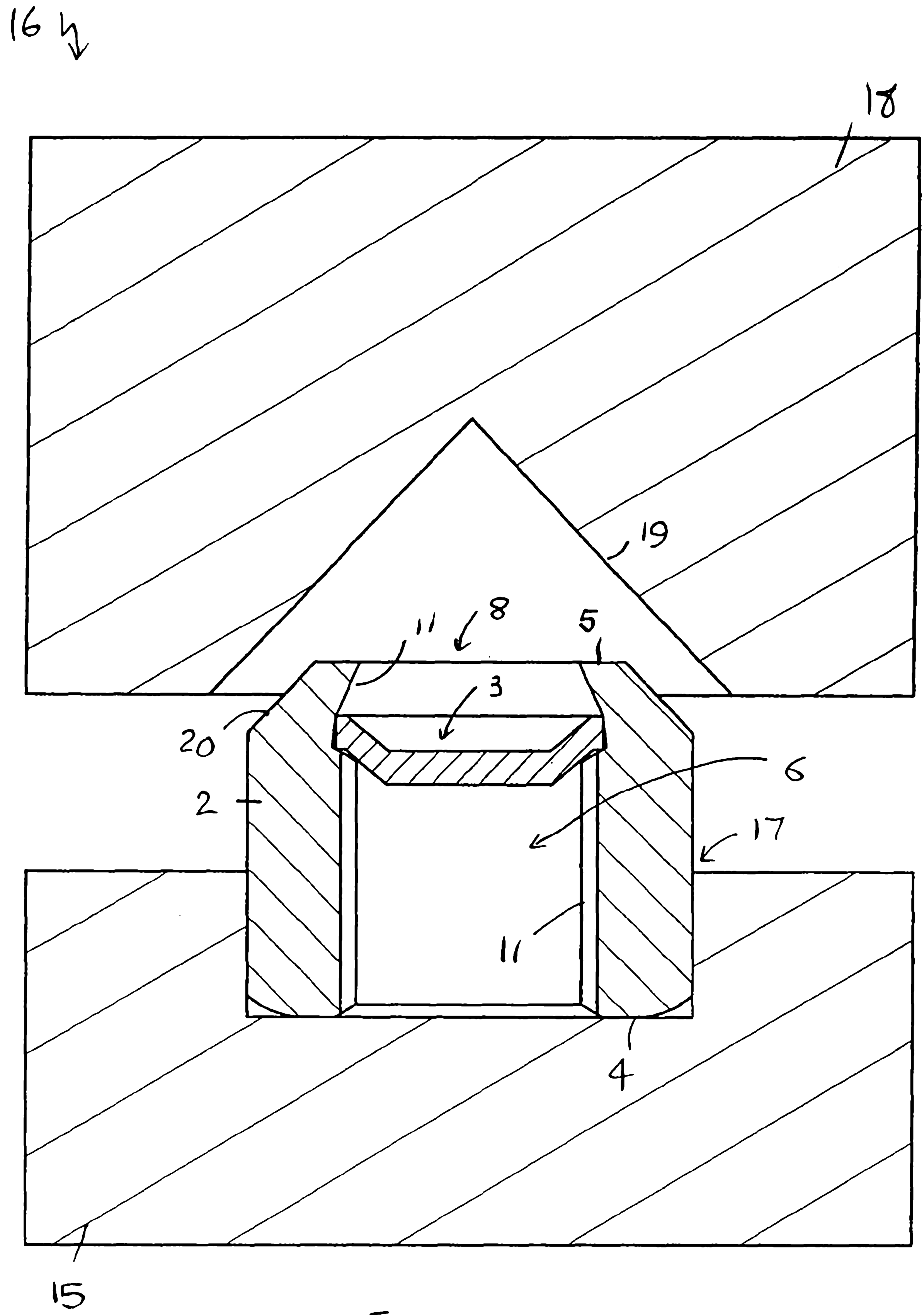

Fig. 5

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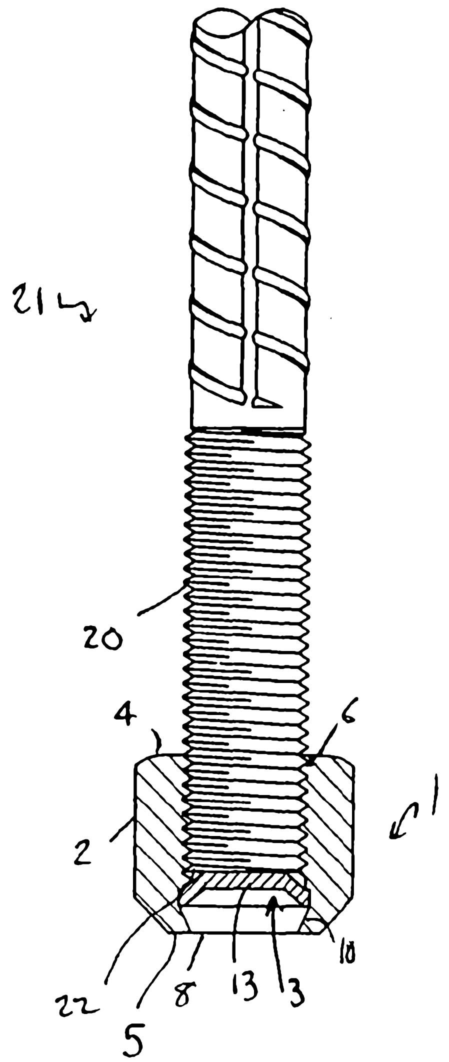

Fig. 6