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An anchor device for use in mining

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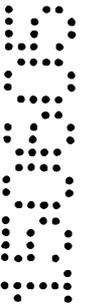
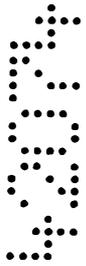
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(56) Related Art
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ABSTRACT

The present invention discloses an anchor device or friction bolt (21, 61) which takes the form of a longitudinally split hollow substantially cylindrical member (2, 62) having a cross-sectional shape which is deliberately fabricated "out-of-round". In one form a
5 longitudinally extending groove (25) of arcuate cross-sectional shape is provided. In another form the member is part semicircular and provided with two arcuate arms (65, 66) of larger radius.



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COMPLETE SPECIFICATION

FOR A STANDARD PATENT

ORIGINAL

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Invention Title: An Anchor Device For Use In Mining

Details of Associated Parent Application: 23309/01



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

AN ANCHOR DEVICE FOR USE IN MINING

FIELD OF THE INVENTION

This invention relates to an anchor device for engaging in a bore and, more particularly,
5 but not exclusively, to an anchor device for use in mining applications.

BACKGROUND OF THE INVENTION

One form of anchor device used in the mining industry is known as a friction bolt. It
comprises a longitudinally split substantially hollow cylindrical body, with a C-shaped
10 transverse cross-section and one tapered end. The C-shaped cross-section enables the
body to be radially compressed to fit within a bore such that when inserted into the bore,
compression of the body causes a radially outward force to be exerted upon the sides of
the bore to thereby anchor the bolt in place. The bolt is usually fitted with a load plate or
the like which is fixed in place by a ring secured to a free end of the bolt. The bolt is
15 driven into the hole with a succession of hammer blows. The radial compression comes
about because of the nominal external diameter of the bolt is larger than the nominal
diameter of the hole (typically by 1 mm approximately).

It has been determined by the inventor that the load bearing capacity of such a bolt is
20 limited since force transfer between the bolt and the bore has been found not to occur
around substantially all of the C-shaped cross-section. Previous perception was that the
bolt engaged the bore wall about the entire circumference of the bolt but closer analysis
by the inventor shows that the body of the bolt actually hinges about its geometric centre
when the arms are deflected inwardly to provide only a limited number of contact
25 regions: generally one region at each free end of the cross-section and another contact
region midway on the cross-section between the free ends.

OBJECT OF THE INVENTION

The present invention seeks to provide an anchor device which provides an improved force transfer between the friction bolt and the hole in the rock into which it is inserted.

5 SUMMARY OF THE INVENTION

In accordance with the present invention, there is disclosed an anchor device for frictional engagement with the interior of a hole drilled in a rock or the like, said device comprising a longitudinally split hollow substantially cylindrical member rolled from a strip of metal in which the longitudinally extending edges of said strip of metal form the side edges of
 10 the longitudinally extending slit, wherein the cross-sectional shape of said member is deliberately formed out-of-round to increase the volume of said metal elastically deformed during insertion of said device into said hole.

BRIEF DESCRIPTION OF THE DRAWINGS

15 Some embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

Fig 1 is a perspective view of a friction bolt having a tapered tip,

Fig 2 is a plan view of the bolt of Fig 1 (excluding the ring at its base),

20 Fig 3 is a transverse cross-sectional view through a hole drilled in rock or the like material,

Fig 4 is a cross-sectional view taken along the line IV-IV of Fig 1 and showing the profile of prior art circular friction bolt,

25 Fig 5 is a transverse cross-sectional view similar to Fig 3 but showing the bolt of Fig 4 inserted into the hole of Fig 3,

Fig 6 is a view similar to Fig 4 but illustrating a first form of an "out-of-round" prior art friction bolt,

Fig 7 is a view similar to Fig 6 but illustrating a second form of “out-of-round” prior art friction bolt,

Fig 8 is a view similar to Fig 5 but illustrating the bolt of Fig 6 inserted in a hole,

Fig 9 is a view similar to Fig 5 but illustrating the bolt of Fig 6 inserted in a hole,

5 Fig 10 is a view similar to Figs 8 and 9 but schematically illustrating on a large scale the situation depicted in Fig 5,

Fig 11 is a view similar to Figs 4, 6 and 7 but illustrating in transverse cross-section a friction bolt of a first embodiment,

10 Fig 12 is a schematic representation of pressure P exerted by the compressed rock bolt against the hole as a function of circumferential distance x around the hole interior,

Fig 13 is a view similar to Fig 11 but of a rock bolt of a second embodiment, and

15 Fig 14 is a graph similar to Fig 12 but in extended (linear) form and illustrating the pressure or contact force exerted by the bolt of Fig 13 against the interior of the hole.

DETAILED DESCRIPTION

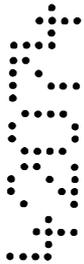
20 Referring firstly to Figs 1 and 2, a prior art friction bolt 1 is shown as comprising a body 2 terminating in a tip 3 at one end and a base 4 at the other. An annular ring 5 is welded or otherwise attached to the base 4. The body 2 is provided with a longitudinal slit 11 having side edges 9, 10. The bolt 1 is formed by rolling a strip of metal through successive rollers in order to form the body 2. The ring 5 is added thereafter.

25 As seen in Fig 3, a hole 8 having an internal generally cylindrical side wall 7 is drilled in rock 13 or other material such as mineral ores and the like. Although the side wall 7 is illustrated as being smooth, in Australia such holes are normally drilled using “button bits” which have small buttons of tungsten and therefore create a generally pitted wall surface. Further the bore of the hole is often not straight as a consequence of pressure

applied to the drill bit bending the shaft of the drill. Such holes 8 have nominal diameters of 32, 38, 45 and recently 52 mm.

5 The typical prior art friction bolt 1 is illustrated in Fig 4 and in cross-section is intended to be a perfect circle with a gap formed by the slit 11. The circle formed by the exterior of the body 2 is illustrated by a broken line in Fig 4 which notionally interconnects, or bridges between, the side edges 9, 10.

10 The outer diameter of the prior art friction bolt 1 of Fig 4 is nominally 1 mm greater than the diameter of the hole 8. Thus for 32, 38 and 45 mm diameter holes the outer diameter of the bolt 1 prior to insertion in the hole 8 is 33, 39 and 46 mm respectively. The tapered tip 3 facilitates the necessary insertion. The distance between the side edges 9, 10 is nominally 13 mm and the wall thickness of the bolt 1 is 2.3 mm for 33 and 39 mm bolts and 3.2 mm for 46 mm bolts. For a prior art 53 mm bolt the wall thickness is
15 3.6 mm.



20 Turning now to Fig 5, this drawings schematically illustrates the rock bolt 1 after insertion in the hole 8. Hitherto it has been thought that the body 2 deforms so as to reduce the outer diameter of the bolt 1 to match the diameter of the hole 8. This deformation could be either elastic or plastic – and in the latter case work hardening of the bolt 1 takes place. Thus the relationship between the external dimensions (ie the outer diameter) of the bolt 1 and the hole 8 is not hitherto been thought to be critical.



25 In addition, it was initially thought that a generally even pressure on the side wall 7 was exerted by the body 2 around the circumference of the body 2. Subsequently it was realised that the force (or pressure) exerted on the side 7 was greatest at three regions spaced from each other by approximately 120 degrees. One of these regions is opposite the slit 11 and the other two regions are adjacent, but radially spaced a little distance from, the side edges 9,10. This realization has lead to proposals that the material

constituting the side edges 9,10 could be saved by eliminating same and even changing the shape of the body 2 so long as the three zones of pressure were retained.

5 Rather than being manufactured as a perfect partial circle as illustrated in Fig 4, bolts 1 are liable to suffer either one of two defects because of their manufacturing process. These defects are illustrated in Figs 6 and 7. In the defect illustrated in Fig 6, the side edges 9, 10 protrude outside the nominal circle 15 indicated by a broken line in Figs 4 and 6. This is because the first stand of rollers in the roll forming apparatus may be either worn or mal-adjusted.

10

Conversely, the defect illustrated in Fig 7 often arises because the last stand of rollers is set too tight in an effort to avoid the result described in Fig 6. Instead the body 2 is slightly flattened as indicated in Fig 7 with opposite sides of the body 2 being “squashed” outwardly so that those sides 17, 18 exceed the diameter of the nominal circle 15.

15

Turning now to Figs 8 and 9, the result of insertion of “out-of-round” bolts 1 as illustrated in Figs 6 and 7 into the hole 8 is illustrated in Figs 8 and 9 respectively. Such bolts exhibit a reduced withdrawal force. In the case of Figs 6 and 8, the side edges 9, 10 are forced into the hole 8 but rather than bend the metal closely adjacent the edges 9, 10, instead the edges 9, 10 move towards each other and tend away from the side wall 7. This has the effect of moving the two zones of pressure adjacent the side edges 9, 10 further apart.

20

25 Similarly, as seen in Fig 9, in order to accommodate the oversize sides 17, 18 there is a tendency for the pressure exerted by the side edges 9, 10 and the base portion 19 (of the body 2 opposite the slit 11) on the side wall 7 to be reduced.

In the manner of Figs 8 and 9, Fig 10 illustrates on a larger scale the situation described above in relation to Fig 5. Thus the deformation of the bolt 1 results in the opposite sides of the body 2 flexing about the centre line 16 passing through the base 19. As illustrated in Fig 10, the bolt 1 moves so as to maximize the distance between the side edges 9, 10 and the base portion 19. This has the effect of maximizing the bending moment applied by the metal adjacent to the side edges 9, 10 to the side wall 7. Consequently the three zones of increased pressure referred to above are created.

It will be appreciated that the arrangements illustrated in Figs 8, 9 and 10 are schematic in that it is not possible to insert, say, a cigarette paper into the apparent gaps illustrated between the side wall 7 and various portions of the body 2. Instead, such gaps are intended to be indicative of a zone of reduced pressure rather than an absence of contact.

The reduced performance of the “out-of-round” bolts illustrated in Figs 6-9 relative to the “true” bolt of Figs 4, 5 and 10 indicated to the inventor that the changed shape of Figs 6-9 meant that the same volume of material was storing a lesser amount of mechanical energy as a consequence of its deformation and thus resulted in a reduced withdrawal force being exerted. Therefore in order to provide an increased withdrawal force, it was necessary to so shape an “out-of-round” bolt that its changed shape following insertion stored more mechanical potential energy. This is preferably done by firstly ensuring that the bolt is not deformed beyond its elastic limit.

A first form of such an “out-of-round” bolt 61 is illustrated in Fig 11. Below a centre line 63 the bolt 61 is rolled into a semi-circle having a radius R_1 which is one half the hole diameter D plus 1 mm. Thus the nominal circle 15 passes within the wall thickness of the body 62 of the bolt 61 below the centre line 63.

However, above the centre line 63, the body 62 is formed into two circular arcs 65, 66 each having a radius R_2 . In order to make each arc 65, 66 smoothly continuous with the

semi-circle, the centre for each radius R2 is translated along the centre line 63 relative to the centre for radius R1. The radius R2 is preferably selected so that the bolt 61 has a diameter at the side edges 69, 70 which is the hole diameter plus 2 mm. The nominal size G of the slit 71 is also increased relative to the slit size of the bolt 1 for the corresponding hole size.

In particular, the inventor has calculated that for the largest hole diameter of 52 mm instead of fabricating a bolt 1 from sheet material of 3.6 mm as previously, it is now possible to continue to use the 3.2 mm sheet material because of the enhanced physical properties of the arrangement.

The preferred dimensions in mm for the arrangement of Fig 11 are as follows.

Hole Diameter D	32	38	45	52
I.D. Lower Radius R1	14.2	17.2	19.8	22.8
I.D. Upper Radius R2	17.11	20.9	24.3	27.5
Wall Thickness T	2.3	2.3	3.2	3.2
Slit distance G	14.9	18.3	24.5	28.4

In the arrangement of Fig 11, the two arcs 65, 66 of radius R2 are stiffer than the corresponding portions of the bolt 1 and bend over a shorter distance. Thus more mechanical potential energy is stored by their deflection to fit within the hole B. Further, since the deflection is elastic, the plastic limit of the bolt 61 is not reached and the consequence is a stronger installation and a bolt 61 which is less likely to fail, particularly away from its base 4. In this connection it is thought that a possible mechanism for failure of bolts 1 hitherto is that the bolt 1, particularly adjacent the tip 3, has been plastically deformed during insertion. Thus the withdrawal force per metre of bolt is

greater near the base 4 than near the tip 3. This defect is thought to be overcome by the arrangement of Fig 11.

After insertion in the hole 8, the situation of the bolt 61 is schematically illustrated in Fig 12. The radial pressure P exerted by the bolt 61 on the side wall 7 as a function of position x around the circumference of the side wall 7 is indicated by means of a dot-dash line. The equivalent representation for the bolt 1 is indicated by a dashed line in Fig 12. It will be seen that the 3 zones of substantial pressure in Fig 12 are of a greater circumferential extend for the bolt 61 than for the bolt 1.

10

The concept described above in relation to Fig 11 can be further developed into the embodiment illustrated in Fig 13. The bolt 21 of the second embodiment has two arms 22, 23 joined by an intermediate section 24. The bolt 21 has an inset portion 25 defined by a concave section 26 of the intermediate section 24. Two laterally spaced contact portions 27, 28 are provided at either side of the inset portion 25, for engagement with the wall 7 of hole 8. The portion 25 is substantially diametrically opposite a gap or slit 52 provided between the arms 22, 23 and each contact portion 27, 28 is arranged generally opposite a respective free end 34, 35 of the arms. The contact portions 27, 28 substantially correspond to respective locations 31, 32 where the arms 22, 23 join with the section 24. The locations 31, 32 also form, or are substantially congruent with, loci 33 (indicated by dashed lines in Fig 13), about which the arms 22, 23 deflect.

20

The bolt 21 thereby provides increased contact area for engagement with the wall 29; two locations adjacent free ends 34, 35 of the arms 22, 23 and two further regions associated with the portions 27, 28. The increased contact area, as compared to the bolt 1 of Fig 1, allows for greater load bearing capacity, as reflected in experimental results, shown in Fig 14. That drawing shows a plot of contact force versus radial angle, where 180° represents the base 19 of the bolt 1 and the corresponding inset portion 24 of the bolt 21. The curves 40, 41 and 42 show sustainable contact forces about respective points 9, 10 and 19

25

of the bolt 1, while the curves 43, 44, 45 and 46 show sustainable contact forces about the free ends 34, 35 and the contact portions 27, 28, respectively.

Aside from providing an increased area of contact points, the bolt 21 also reduces the length of the arms 22, 23, as a result of introduction of the intermediate section 24, as compared to the bolt 1. This has the effect of reducing the bending moment for equivalent force application, which in turn increases the comparative load bearing limit of the bolt 21, prior to failure.

Further, it should be noted that the inset portion 25, although shown as being somewhat concave, is still reasonably flat, in order that the portion 25 does not itself function as a hinge point or section of weakness in the device. To ensure that is the case, the portion 25 is formed such that a relative angle " α ", between the loci 33 is less than, and preferably substantially less than, 90 degrees.

The above advantages may be utilized to reduce material required to produce a device having similar load bearing capabilities as the bolt 1, or alternatively provide a bolt using a similar amount of material but with enhanced load bearing characteristics.

Although the bolts 21, 61 are preferably formed as an elongate friction bolt as illustrated in Fig 1 with a tapered end and an axially extending slit 52 defined between the free ends 34, 35 of the arms 22, 23. The bolt 21 is able, however, to instead comprise only a portion of the bolt, such as the tapered tip 3 or, alternatively, be in the form of an attachment device which is simply fitted to an existing bolt or formed at an end thereof, in order to provide improved load bearing characteristics.

The comparative load bearing advantage of the device of Fig 11 or 13 results from the shape of the bolt cross-section, and the resulting location, extent and orientation of the

contact regions between the bolt and the bore wall. The bolt cross-sectional at shape functions as relatively short, stiff beam-columns. During installation then, the free ends 34, 35 of the cross-section move closer together pivoting at 33 with the arms 22, 23 maintaining the original pre-installation radii. In effect then the arms 22, 23 behave as short curved beams whereas in the prior art bolt configuration the curved sections are longer and less stiff. The curved section 25 is also quite rigid, which is the result of being of a relatively short length and having three small radii resulting from cold working of the metal during a roll forming process. The roll forming process takes the metal into the plastic or permanent deformation zone. Further, the circumferential extent of each arm of the prior art configuration is around 175 degrees whereas the equivalent circumferential extend of the bolt 21 is around 155 degrees. This reduced curvature and resulting shorter arm length means that for the same deflection during installation (since the hole diameter does not change) a greater contact force or pressure is achieved at the ends 34, 35. Thus the bending moments at the contact portions 27, 28 are greater than that achieved at the single point 19 of the prior art configuration. This is supported by Fig 14 which shows higher local stress areas at portions 27, 28. Resolving forces at the ends 34, 35 into tangential and radial components and solving for forces at 27 and 28 results in higher contact forces or pressures at contact portions 27, 28 than the equivalent at the prior art configuration at location 19. The sum of the contact forces produced by the bolt 21 is approximately 30% to 60% higher than the sum of the contact forces which are produced by prior art bolts of the same material, wall thickness and insertion depth which suit the same hole size. Accordingly, the pull-out force for a bolt formed in accordance with Figs 11 or 13 will be correspondingly higher than that for the prior art "circular section" bolts.

The foregoing describes only two embodiments of the present invention and modifications and variations may be made thereto without departing from the spirit and scope of the invention as described. For example, the side edges 9, 10 or the face ends 34, 35 can be deformed radially inwardly, if desired.

The term “comprising” as used herein is used in the inclusive sense of “having” or “including” and not in the exclusive sense of “consisting only of”.



THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. An anchor device for frictional engagement with the interior of a hole drilled in a rock or the like, said device comprising a longitudinally split hollow substantially cylindrical member rolled from a strip of metal in which the longitudinally extending edges of said strip of metal form the side edges of the longitudinally extending slit wherein the cross-sectional shape of said member is deliberately formed out-of-round to increase the volume of said metal elastically deformed during insertion of said device into said hole.
- 5
2. The device as claimed in claim 1 wherein said out-of-round shape comprises a substantially semi-circular part of first radius and two arcs each of larger radius than said first radius.
- 10
3. The device as claimed in claim 2 wherein said arcs have equal radii.
4. The device as claimed in claim 2 or 3 wherein said first radius is substantially one half of the hole diameter plus a first constant.
- 15
5. The device as claimed in claim 4 when dependent upon claim 3 wherein said equal radii are each substantially one half of said hole diameter plus a second constant, said second constant being larger than said first constant.
6. The device as claimed in claim 1 wherein said out-of-round shape comprises a longitudinally extending groove formed in said cylindrical member.
- 20
7. The device as claimed in claim 6 wherein said groove is substantially opposite said slit.
8. The device as claimed in claim 6 or 7 wherein said groove is substantially arcuate when viewed in cross-section.
9. The anchor device as claimed in any one of claims 1-8 and having a tapered tip.
- 25
10. The anchor device as claimed in any one of claims 1-9 and having a ring formed at one end thereof.

11. An anchor device for frictional engagement with the interior of a hole drilled in rock or the like, said device being substantially as herein described with reference to Fig 11 or Fig 13 or Fig 1 and Fig 11 or Fig 1 and Fig 13.

5 Dated this 4th day of May 2001

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Patent Attorneys for the Applicant

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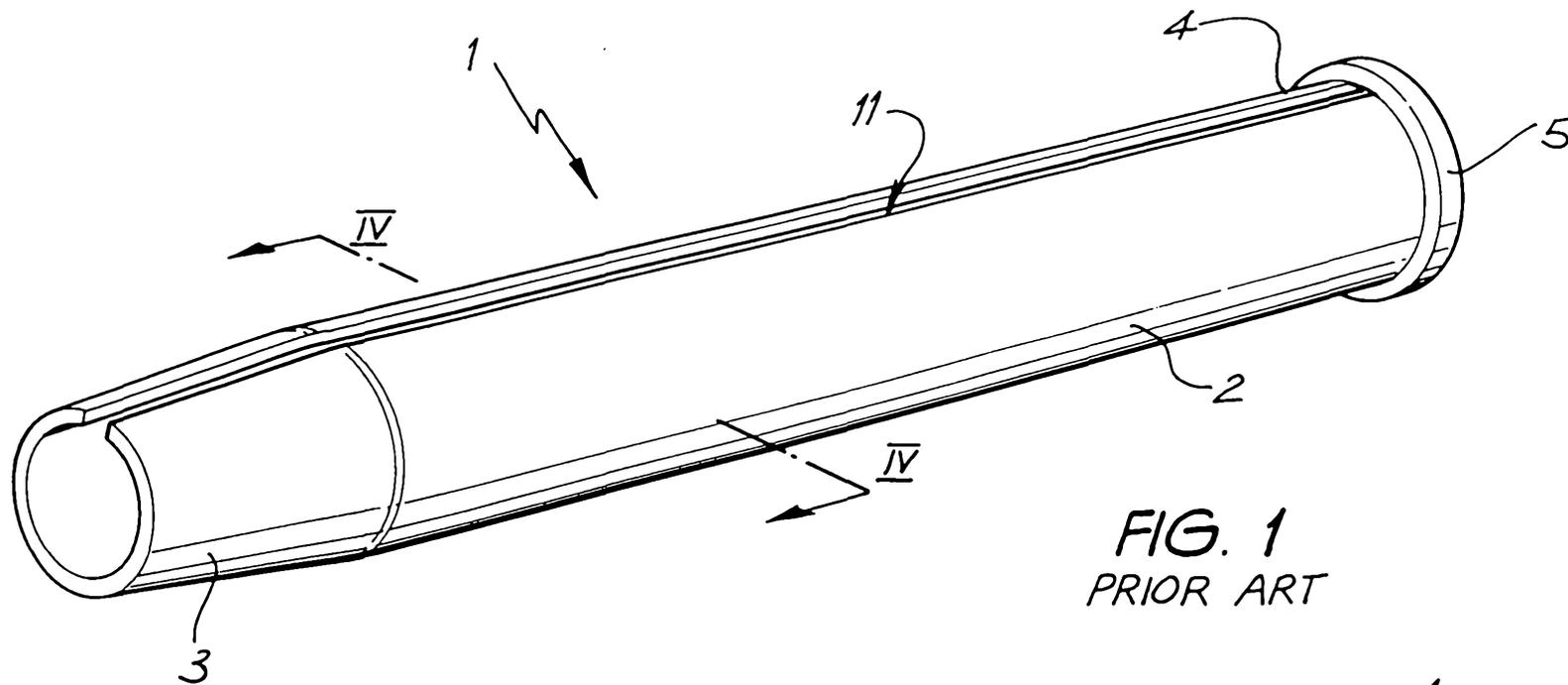


FIG. 1
PRIOR ART

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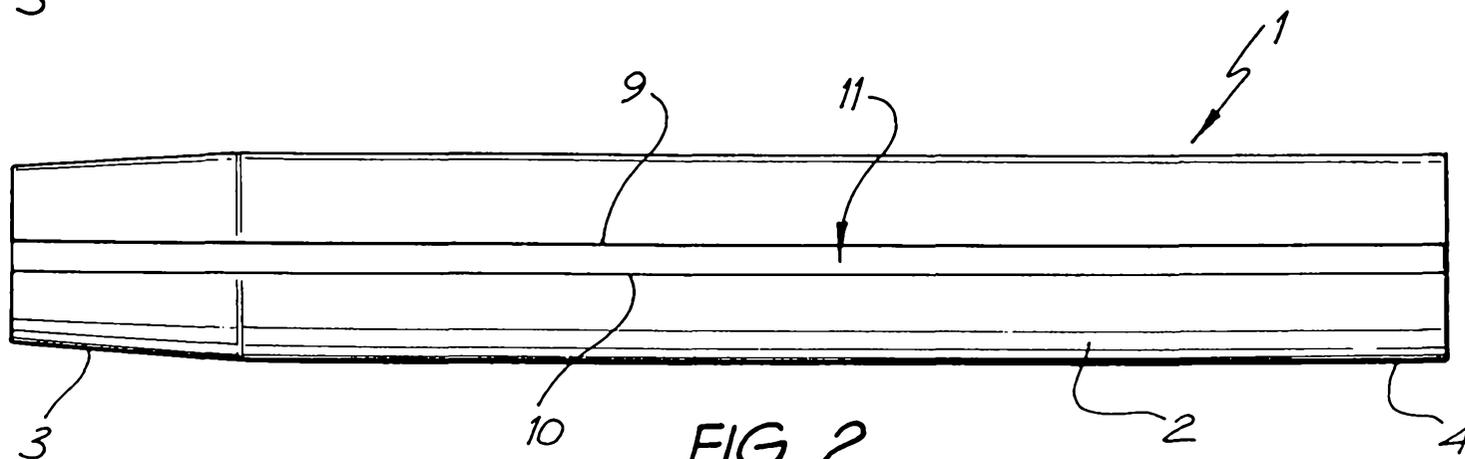


FIG. 2
PRIOR ART

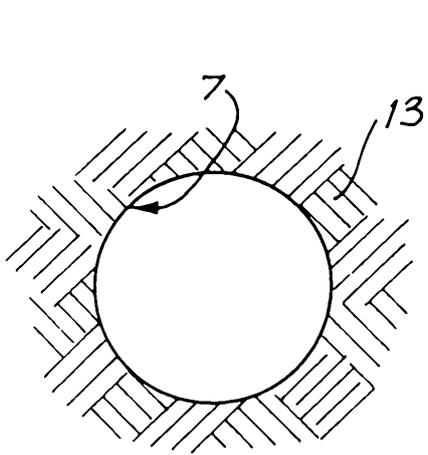


FIG. 3

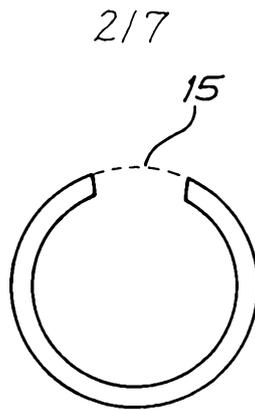


FIG. 4
PRIOR ART

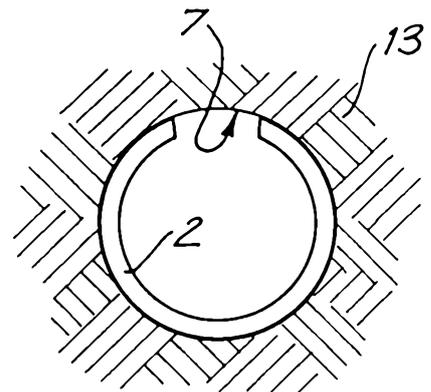


FIG. 5
PRIOR ART

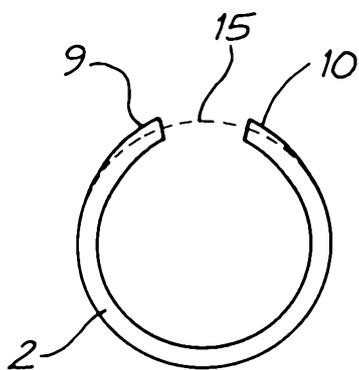


FIG. 6
PRIOR ART

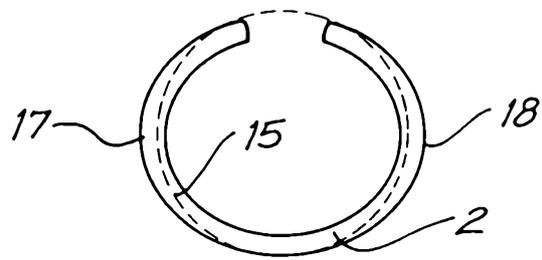


FIG. 7
PRIOR ART

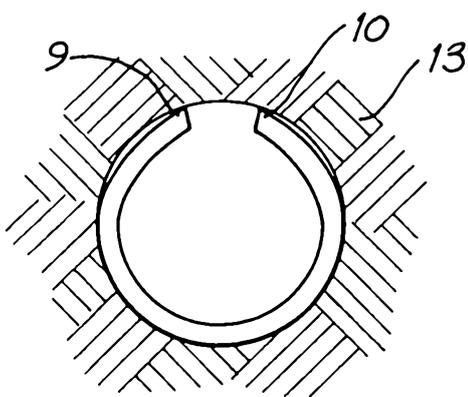


FIG. 8
PRIOR ART

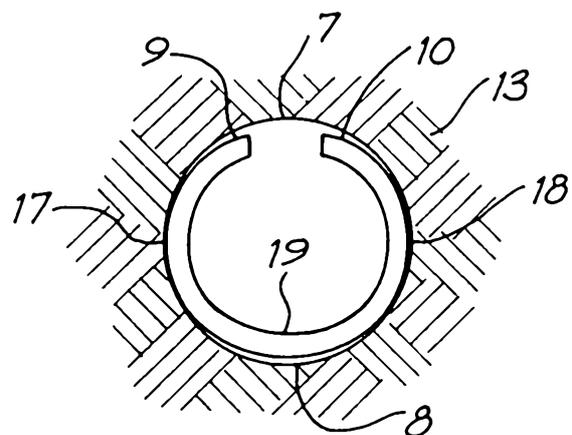
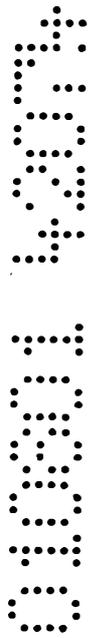


FIG. 9
PRIOR ART



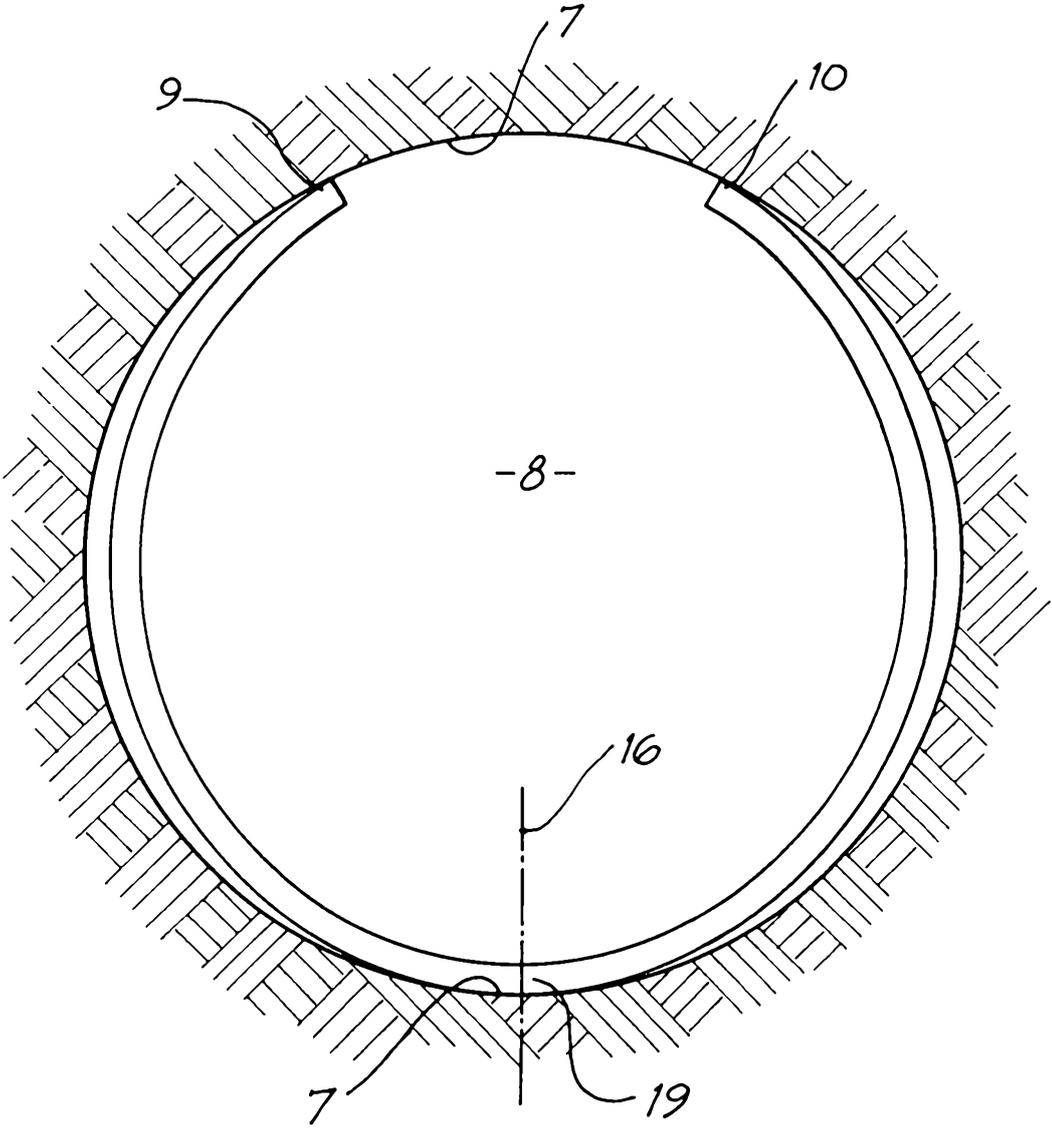


FIG. 10
PRIOR ART

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500
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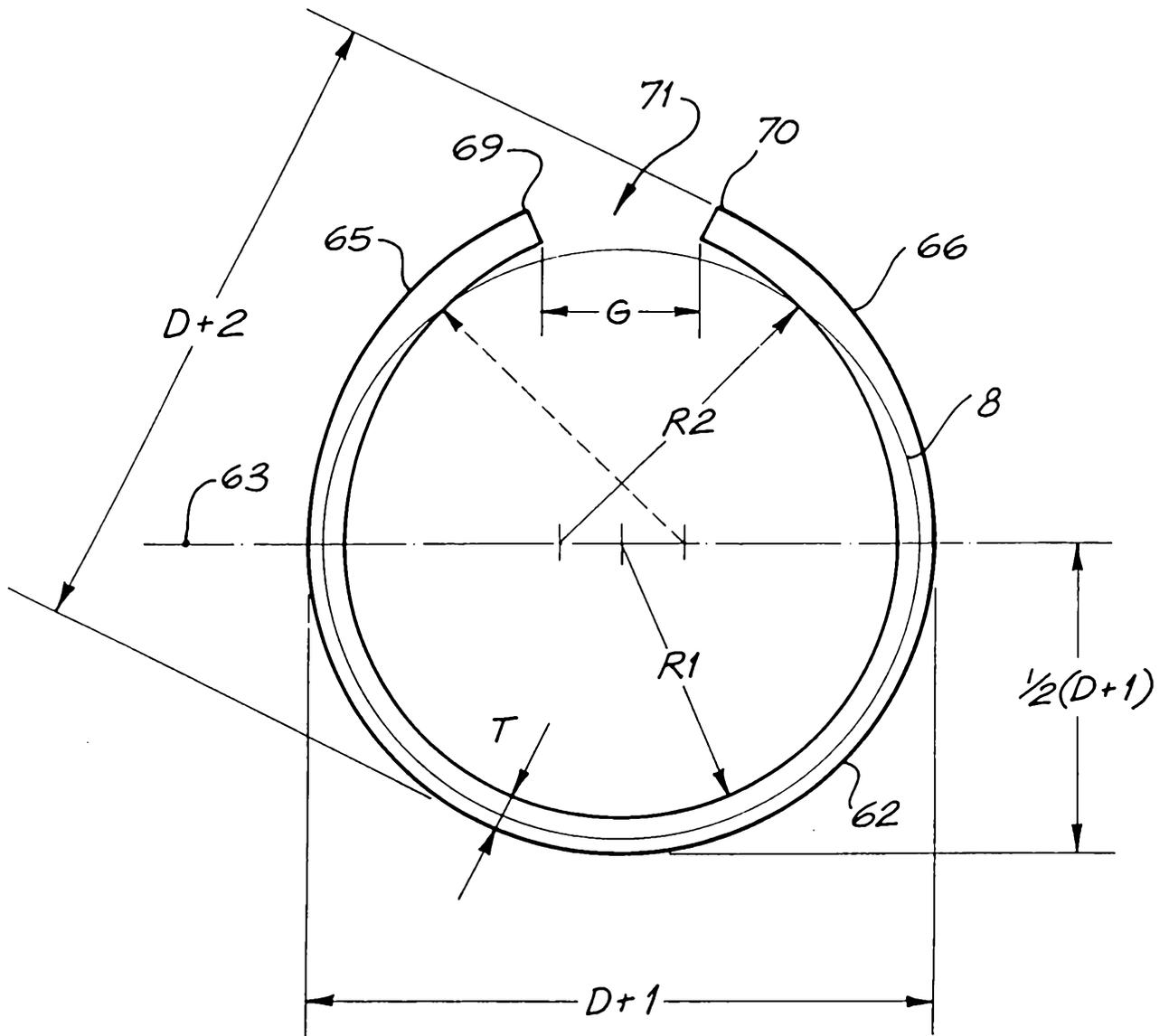


FIG. 11

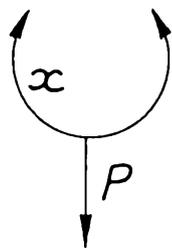
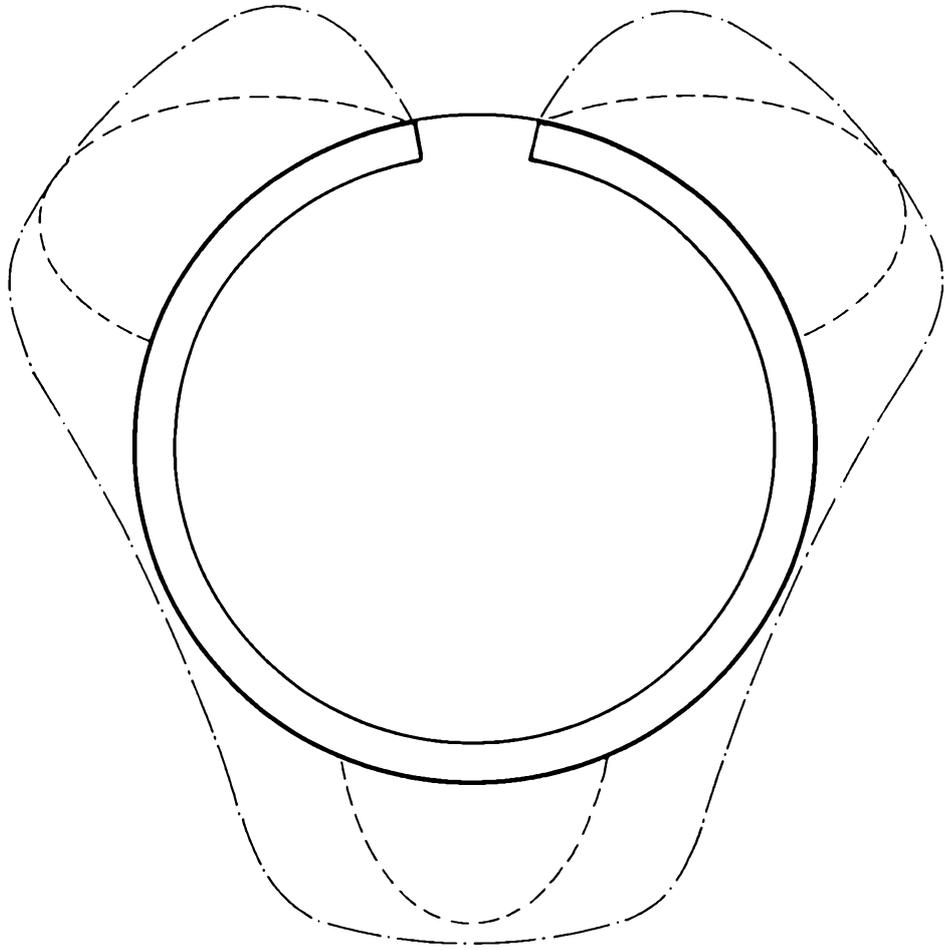


FIG. 12

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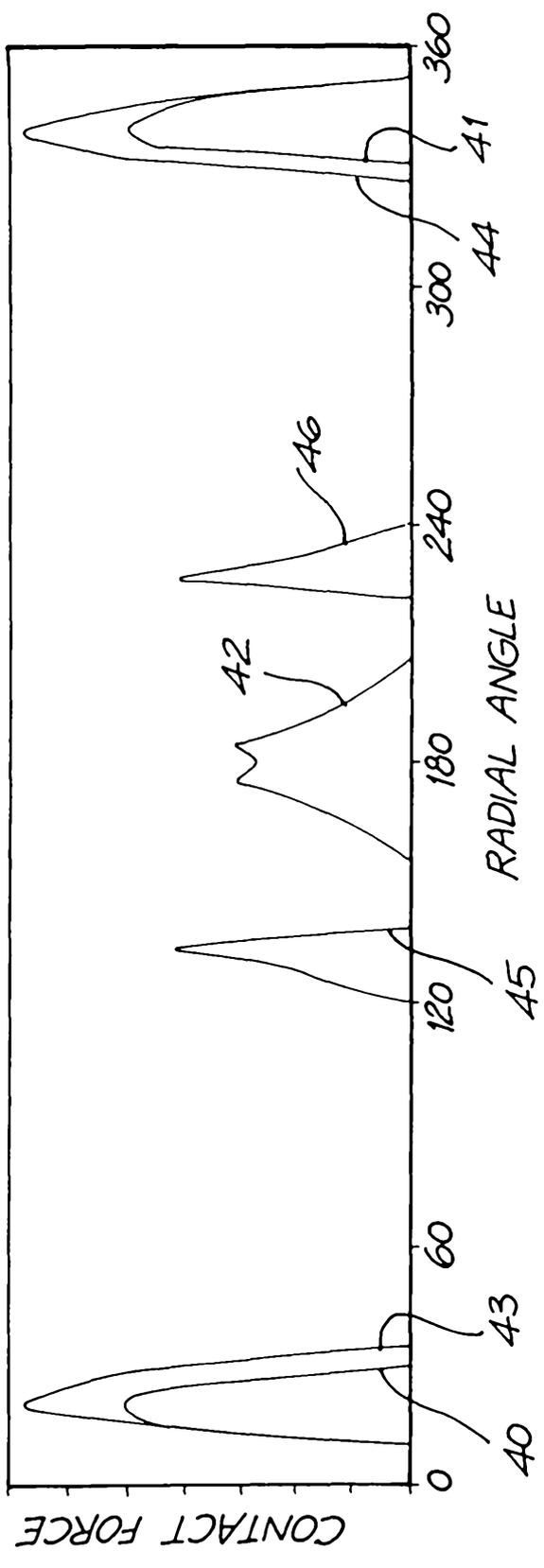


FIG. 14