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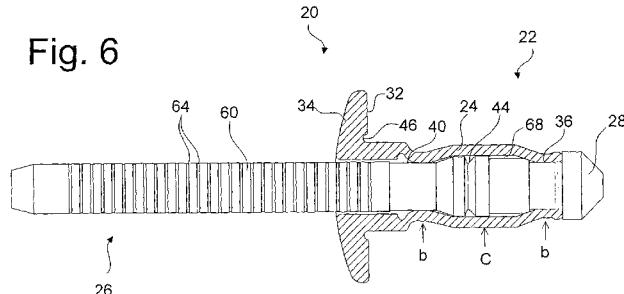
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(54) Title: BLIND FASTENER

Fig. 6



(57) Abstract: A blind fastener comprising a body (22) and a stem (26), wherein the fastener is installed in a workpiece by applying a pulling force to the body causing a bulb to form at a radially expandable section of the body, the stem of the fastener comprising two waisted regions (38, 40) of reduced diameter, such that when the body of the fastener is crimped after assembly with the stem, the body is caused to form a barrel shape, whereby clearance between the body and stem is minimised.

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Blind Fastener

This invention relates to blind fasteners, and in particular to blind
5 fasteners wherein bulbing of the fastener is caused during installation of the
fastener into a workpiece.

Blind fasteners (i.e. fasteners which can be installed by access to one
side only of the workpiece) are well known.

10

Commonly a blind fastener comprises a tubular body having an
elongated shank, a preformed radially enlarged body head at a one end (the
head end) of the body, a stem having a radially enlarged stem head at one
end, wherein the stem extends through the core of the body such that the
15 stem head is at a tail end of the body remote from the head end, and an end
portion of the stem protrudes from the head end of the body. The fastener is
inserted through aligned apertures in the workpiece comprising workpiece
members to be secured together, such that the body head abuts the near face
of the workpiece and the tail end portion of the body shank protrudes beyond
20 the remote face (the blind face) of the workpiece. An installation tool is then
used to apply an increasing pulling force to the protruding portion of the stem
relative to the body, the reaction force being supported by the body head, so
that the stem head deforms the tail end portion of the body shank radially
outwards and axially towards the body head, to form a blind bulb which abuts
25 the blind face of the workpiece. The workpiece members are thus clamped
together between the body head and the blind bulb. Usually the stem is then

broken off flush with, or slightly inside, the head of the body, at a breakneck groove preformed at the appropriate position along the stem. The breakneck breaking load is greater than the load needed to completely form the blind bulb.

5

Blind fasteners which provide a high level of static and dynamic joint strength need to develop a high retained compressive force on the workpiece, between the body head and blind bulb. Accordingly it is desirable to have a relatively large preformed body head, and also to have a relatively large contact area between the blind bulb and the blindside of the workpiece. The area of contact between the blind bulb and the blindside of the workpiece is known as the blindside footprint.

Fasteners are also known, such as those available under the trade marks STAVEX or Masterfix K-Lock, which develop multiple bulbs on installation into a workpiece, therefore allowing the fastener to cover a large grip range, i.e. to be capable of securing together workpieces having varying 'grips', i.e. varying total thicknesses of workpiece members.

20 However, during installation of a multiple bulbing fastener, each bulb will be formed at a particular point of the installation, i.e. when the fastener has been pulled relative to the sleeve by a particular amount. At certain thicknesses within the grip range of a multiple bulbing fastener, the cross-sectional area of the bulb in contact with the rear face of the fastened workpiece will be very low, and for certain 'intermediate' workpiece

thicknesses, there will be a “stand-off”, whereby minimal or no footprint is generated on the blindside of the workpiece, because installation completes before the complete formation of a particular bulb. This results in a substantial reduction in fastening strength provided by the installed fastener.

5

The above situation is illustrated in Figure 1, in which installation of the fastener 2, having a body 4 and stem 6 with a stem head 8, has completed at a particular stage wherein a bulb 10 has been formed but wherein no footprint is formed on the blindside 6 of the workpiece 14.

10

An ideal fastener would produce a single bulb on the blindside of a workpiece, to prevent the above “stand-off” situation, and would do so consistently over a large grip range.

15

Certain known fasteners such as those available under the trade marks AVIBULB and AVINOX, employ a twin tapered fastener body form which forms a single bulb on the blindside of the workpiece, to achieve a wide grip range. This form of opposing tapers, as illustrated in Figure 2, can be likened to a “barrel shape”. The tapered form is rolled onto the body 4' of the fastener 2' of Figure 2 such that the minimum inner diameter of the body 4' is approximately equal to the outer diameter of the fastener stem 6'. The body 4' is then assembled onto the stem 6' by a push-fit.

20

25

As can be seen in Figure 2, a consequence of the above design is that there is a significant amount of clearance (indicated at 12) between most

of the body 4' and the stem 6'. Clearance between the body 4' and the stem 6' is not desirable as it can lead to tilting of the stem 6 and the bulb which is formed during installation of the fastener into a workpiece.

5 A further disadvantage of such multiple bulbing fasteners as AVIBULB and AVINOX is the stem must be dimensioned such that the outer diameter is no greater than the minimum inner diameter of the rolled body to facilitate assembly of the body and stem. The pulling force for installing the fastener is therefore limited by the maximum allowable diameter of the stem 6', and the
10 shear strength offered by the installed fastener is accordingly limited.

Furthermore, a limited outer diameter of fastener stem also results in a risk of failure, i.e. breaking of the stem, at positions other than the breakneck during installation, a limited area of contact for the jaws of the
15 installation tool which can lead to jaw slippage, and a limited resistance to bending forces during fastener assembly of the fastener and during installation into a workpiece.

20 It is an aim of the present invention to overcome or at least mitigate the above problems and provide an improved blind fastener which produces a single bulb, having a large blindsight footprint, consistently over a wide grip range.

Accordingly, the present invention provides, in one aspect, a blind fastener according to claim 1 of the appended claims.

The bulb resulting from installation of the blind fastener of the present invention provides a single blindside bulb over a large grip range. In the present invention, the diameter of the stem is not restricted by the minimum inner dimension of the body before installation, and accordingly the pulling force required to install the fastener is not limited. As a stem having a greater diameter can be used, the potential for the stem breaking at a position other than the breakstem groove is reduced, the risk of installation tool jaw slippage is reduced, and the resistance to bending forces during assembly of the fastener and installation into a workpiece is increased.

The present invention therefore provides a fastener which can be reliably installed to form a fastening having a high shear strength, over a large grip range.

After crimping of the body to cause material of the body shank to enter the first and second waisted regions, a barrel shape is formed by the body shank, thereby ensuring that on installation of the fastener into a workpiece, the bulb is formed in a controlled and predictable manner. The barrel shape formed by the body shank of the present invention is improved over that of prior art embodiments as the waisted regions allow the body shank to be deformed down to a reduced diameter but the remainder of the stem to remain at a diameter greater than the waisted regions.

A tapered portion is provided leading up to at least one of the waisted regions. The tapered portion is preferably located between the breakneck groove and the second waisted region, and has the effect of 5 minimising the clearance between the internal surface of the body core and the stem outer surface. An advantage of reducing the clearance between the body and stem is that the potential for tilting of the stem or of the bulb formed during installation of the fastener into a workpiece is decreased.

10 The first waisted region may be located adjacent the stem head and the second waisted region located further away from the stem head than the second waisted region is located, such that the breakneck groove is between the first waisted region and the second waisted region.

15 A stepped portion may be provided between the first waisted region and the breakneck groove, the stepped portion having a diameter intermediate the minimum diameter of the first waisted portion and the diameter of the stem head. The stepped portion provides an increased resistance to removal of the stem from an installed fastener.

20

One or more radial projections may be provided on the stem at the first waisted region. The radial projections may have an asymmetrical triangular cross-sectional form and/or a rounded tip. The radial projections provide an increased resistance against removal of the installed fastener from a 25 workpiece into which it has been installed.

5 The body of the fastener may include an annular underhead recess, providing easier clearance of burrs around the edge of the hole in the workpiece, and an enhanced fatigue strength of the installed fastener.

10 The first waisted region may comprise a plurality of stepped portions, thereby providing an increased resistance against removal of the installed fastener from a workpiece into which it has been installed.

15 The stem of the fastener may be provided with an annular underhead recess, whereby, on installation of the fastener into a workpiece, material of the body is forced into the recess, thereby preventing "stem head entry" failure wherein the tail end of the body spills out from the stem underhead region.

20 The stem may further comprise a protruding ridge of stem material adjacent the recess. The combination of the recess and the protruding ridge act to lock the body to the stem axially in the underhead region.

25 The present invention also provides, in a further aspect, a method of manufacturing a blind fastener according to claim 14 of the appended claims. The method of manufacture includes forming a first and a second waisted region in the stem such that after the step of deforming the body, the body comprises a barrel shape, thereby minimising clearance between the body

and the stem, and thereby reducing the potential for tilting of the stem and/or the bulb of an installed fastener.

5 The step of forming the first and second waisted region may comprise rolling, and the step of deforming the body may comprise crimping.

The method may further comprise the formation of one or more radial projections on the stem at a waisted region, wherein the step of deforming the body causes the at least one radial projection to embed into the body.

10

The first waisted region may be formed into a plurality of stepped portions.

15

The manufacture of the fastener may further comprise a step of forming an underhead recess. The recess may be formed in a cold-heading step, and the ridge may be formed by rolling, wherein material displaced from the first waisted region during rolling forms a protruding ridge of stem material adjacent the recess.

20

An embodiment of the present invention will now be described by way of example and with reference to the accompanying drawings in which:

Figure 1 is a cross-sectional view of a multiple bulbing fastener in accordance with the prior art, installed in a workpiece;

25

Figure 2 is a cross-sectional view of a twin-tapered fastener in accordance with the prior art, prior to installation in a workpiece;

5 Figure 3 is a side elevation of a fastener in accordance with the present invention (with the body shown in cross-section) prior to crimping of the body, and prior to installation of the fastener in a workpiece;

Figure 4a is a cross-sectional elevation of the stem of the fastener of Figure 3;

10

Figure 4b is a detailed underhead view of the stem of Figure 4a at D;

Figure 4c is a detailed view of the pull grooves of the stem of Figure 4a;

15

Figure 5a is a longitudinal cross-sectional elevation of the body of the fastener of Figure 3;

Figure 5b is an elevation of the head end of the body of Figure 5a;

20

Figure 5c is a detailed underhead view of the body of Figure 5a;

Figure 6 is a cross-sectional elevation of the fastener of the fastener of Figure 3 after crimping of the body onto the stem and prior to installation in 25 a workpiece;

Figure 7 is a cross-sectional elevation of the fastener of Figure 3 during installation into a workpiece at the minimum end of the grip range;

5 Figure 8 is a cross-sectional elevation of the fastener of Figure 7 completely installed in the workpiece;

Figure 9 is an isometric view of the installed fastener of Figure 8 from the blindside of the workpiece;

10 Figure 10 is a cross-sectional elevation of the fastener of Figure 3 during installation into a workpiece at the maximum end of the grip range;

15 Figure 11 is a cross-sectional elevation of the fastener of Figure 10 completely installed in the workpiece;

Figure 12 is an isometric view of the installed fastener of Figure 11 from the blindside of the workpiece;

20 Figure 13 is a side elevation of an alternative embodiment of fastener in accordance with the present invention, (with the body shown in cross-section), prior to crimping of the body, and prior to installation of the fastener in a workpiece;

25 Figure 14a is a side elevation of the stem of the fastener of Figure 13;

Figure 14b is a detailed underhead view of the stem of Figure 13a at D';

5 Figure 15 is a cross-sectional elevation of the fastener of Figure 13 installed in a workpiece;

10 Figure 16 is a side elevation of an alternative embodiment of fastener in accordance with the present invention, (with the body shown in cross-section), prior to crimping of the body, and prior to installation of the fastener in a workpiece;

15 Figure 17 is a partial cross-sectional elevation of the fastener of Figure 16, after crimping of the body, and prior to installation of the fastener in a workpiece;

Figure 18a is a side elevation of the stem of the fastener of Figure 16;

20 Figure 18b is a detailed view of the stem of Figure 18a at D";

Figure 18c is a partial cross-sectional elevation of the stem of Figure 18a along the line C-C;

and

Figure 19 is a cross sectional view of the fastener of Figure 16 installed in a workpiece.

5 Referring to Figure 3, the fastener 20 comprises a body 22 and a stem 26. The stem 26 (Figure 4a) is provided with a shaft 60, an asymmetric breakneck groove 44, a stem head 28 having a conical end form, and a plurality of pull grooves 64. The body 22 (Figure 5a) is provided with a core 30, a head end 32 and a tail end 36 remote from the head end 32, and a 10 radially enlarged body head 34 at the head end 32. The body 22 is provided with an annular underhead recess 46, shown in detail in Figure 5b.

Manufacture of the fastener 20 includes rolling a first waisted region 38 and a second waisted region 40 onto the stem 26. The waisted regions 15 38, 40 have a smaller diameter than the remainder of the stem 26. The first waisted region 38 is located adjacent the stem head 28, and the second waisted region 40 is located further away from the stem head 28, beyond the breakneck groove 44, i.e. such that the breakneck groove 44 is between the first waisted region 38 and the second waisted region 40.

20

On formation of the waisted regions 38, 40, a tapered portion 70 is also formed in the stem 26, leading up to the second waisted portion 40, on the side of the breakneck groove 44. A radial projection 58 is also formed, within the first waisted region 38, and a stepped portion 66, between the first

waisted region 38 and the stem head 28. The diameter of the step 34 is intermediate the diameter of the first waisted region 38 and the stem head 28.

After the stem 26 has been formed as above, the stem 26 is inserted
5 into the core 30 of the body 22 by a push-fit (due to diameters 441 and 442 of the stem 26). As illustrated in Figures 3 and 5a, the shank 24 of the body 22 initially has a straight cylindrical form, i.e. is of an equal outer diameter along the length of the shank 24. After assembly of the body 22 onto the stem 26, the body 22 covers a portion of the stem 26, as indicated by 'A' in Figure 3. It
10 can be seen that the clearance 48 between the internal surface 72 of the body 22 defining the core 30 and the outer surface 74 of the stem 26 is minimal for most of the length of A, apart from the regions, indicated by 'B' in Figure 3, which directly surround the first and second waisted regions 38, 40 of the stem 26.

15

The body shank 24 is deformed by a twin taper crimp. The crimping is performed on the body shank 24 at regions B of Figure 3, i.e. the regions which immediately surround the first waisted region 38 and the second waisted region 40 of the stem 26. The first and second waisted regions 38, 40
20 therefore accommodate the material of the body shank 24 which is deformed by the crimping.

As a result of material of the body shank 24 entering the first waisted region 38 and the second waisted region 40, part of the body shank 24 forms
25 a "barrel shape", i.e. including two sections having a reduced diameter,

indicated by 'b' on Figure 6, and a section having a greater diameter, indicated at C on Figure 6, between the two reduced diameter sections b. As a result of the barrel shape, there is very little, or no clearance 68 between the internal surface 72 of the body shank 24 defining the core 30 and the outer 5 surface 74 of the stem 26 after crimping of the body shank 24. The tapered portion 70 provides that clearance between the internal surface 72 of the body shank 24 and the outer surface 74 of the stem 26 at the second waisted 40 is further minimised.

10 Also as a result of the crimping, radial projection 58 is caused to embed into the material of the body shank 24 which is crimped into the first waisted region 38, as illustrated in Figure 6.

15 Installation of the fastener 20 into a workpiece 50 comprising a plurality of workpiece members 52, 54 is effected in the same manner as described in the preamble in respect of prior art embodiments.

20 On installation the barrel shape of the body shank 24 ensures formation of the bulb 42 (Figures 7, 8, 10 and 11) in a controlled and predictable manner. The force applied to the stem 26 with respect to the body 22 is increased, and the bulb 42 begins to form at a predetermined pulling force.

25 At lower grip values, i.e. workpieces having a lower total thickness, the tapered portion 70 and the diameter 442 assist in formation of the bulb 42

against the rear workpiece member 54, by progressively opening out the crimped body material closest to the blindside of the workpiece 50. Therefore a "stand-off" situation, as described in the preamble, is avoided. Formation of a bulb 42 at the minimum grip value is illustrated in Figures 7 and 8. The 5 blindside footprint 56 at the minimum grip value is illustrated in Figure 9.

Once the fastener 20 has been installed in a workpiece 50, the stepped portion 66 between the first waisted region 38 of the stem 26 provides an increased resistance to removal of the stem 26 from the body 22 10 of an installed fastener.

The annular underhead recess 46 provides an enhanced fatigue strength of the installed fastened, and easier clearance of burrs.

15 Figures 10 and 11 illustrate the formation of a bulb 42 at the maximum grip value, and Figure 12 illustrates the blindside footprint 56 at the maximum grip value.

20 In an alternative embodiment, a plurality of radial projections 58' may be provided, within the first waisted region 38. This alternative fastener 20' is illustrated in Figures 12 to 15. On crimping of the body 22' onto the stem 26', the multiple projections 58' are caused to embed into the body 22' in the same manner as the single projection 58 of the above embodiment.

In further alternative embodiments, the or each radial projection 58, 58' may have an alternative cross-sectional form, such as an asymmetric triangular form, or a form having a rounded tip, or a combination of both forms.

5

Figures 16 to 19 illustrate an alternative embodiment of fastener 20" wherein the first waisted region 38" of the stem 26" comprises steps 100, 102 and 104. This embodiment further comprises a ridge 106 in the first waisted region 38" and recess 108 under the stem head 28, as illustrated in detail in Figures 18b and 18c. The ridge 106 and recess 108 are created during manufacture of the stem 26. The recess is formed in a cold heading stage, and the ridge 106 is a by-product of the rolling the first waisted region 28, i.e. it is formed by material of the stem 26" which is displaced from the step 104 during rolling.

15

In contrast with the projections 58, 58' of the previous embodiments, as illustrated in Figure 17 the ridge 106 is not caused to embed into the material of the body 22 during crimping of the body 22. Material of the body 22 is forced around the ridge 106, and into the recess 108, only during installation of the fastener 20" into a workpiece 50. As illustrated in Figure 18, material of the body 22 has been forced into the recess 108 during installation, thereby preventing "stem head entry", and between the recess 108 and the ridge 106, thereby locking the body to the stem axially in the underhead region.

25

Claims

1. A blind fastener for installation in a workpiece, the fastener comprising a body and a stem;

5

the body including a core, a head at a head end of the body, a tail end remote from the head end, and a radially expandable portion between the head end and the tail end;

10

the stem including a shaft, a radially enlarged head and a breakneck groove;

15

whereby, when the body is inserted into a suitable aperture in the workpiece and a force is applied to the body to urge the tail end of the body towards the workpiece, the reaction force is supported by the head end of the body, and the radially expandable portion of the body is thereby caused to deform radially outwards and axially towards the body head, to form a blind bulb which abuts a blind face of the workpiece and forms a blindside footprint;

20

wherein at least a first waisted region and a second waisted region are provided in an external wall of the stem, the first waisted region and the second waisted region having minimum diameters which are lower than the minimum diameter of the stem shaft,

whereby, on assembly of the fastener, the body is deformed such that material of the body enters the waisted regions thereby causing the body to comprise a barrel shape.

5 2. A blind fastener as claimed in claim 1 wherein the first waisted region is located adjacent the stem head and the second waisted region is further away from the stem head than the second waisted region is located such that the breakneck groove is between the first waisted region and the second waisted region.

10

3. A blind fastener as claimed in claim 1 or claim 2 wherein the stem further comprises a tapered portion leading up to at least one of the first waisted region and the second waisted region.

15 4. A blind fastener as claimed in claim 3 wherein the tapered portion is located between the breakneck groove and the second waisted region.

20 5. A blind fastener as claimed in any one of the preceding claims wherein the stem further includes a stepped portion between the first waisted region and the stem head, the stepped portion having a diameter intermediate the minimum diameter of the first waisted portion and the diameter of the stem head.

6. A blind fastener as claimed in any one of the preceding claims wherein one or more radial projections are provided on the stem at a waisted region.

5 7. A blind fastener as claimed in claim 6 wherein the or each radial projection has an asymmetric triangular cross-sectional form.

8. A blind fastener as claimed in claim 6 or claim 7 wherein the or each radial projection has a rounded tip.

10

9. A blind fastener as claimed in any one of the preceding claims wherein the body further comprises an annular underhead recess.

15

10. A blind fastener as claimed in any one of the preceding claims wherein the first waisted region comprises a plurality of stepped portions.

11. A blind fastener as claimed in any one of the preceding claims wherein the stem further comprises an annular underhead recess.

20

12. A blind fastener as claimed in claim 11 wherein the first waisted region further comprises a protruding ridge of stem material adjacent the recess.

13. A method of manufacturing a blind fastener, the fastener comprising a body and a stem;

5 the shell including a core, a head end, a tail end remote from the head end, and a radially expandable portion between the head end and the tail end;

the method comprising steps of;

10 forming at a first waisted region and a second waisted region in an external wall of the stem;

assembling the body onto the stem;

15 and

deforming the body such that material from the body enters the first waisted region and the second waisted region, such that after deforming of the body, the body comprises a barrel shape.

20

14. A method as claimed in claim 13 wherein the first waisted region and the second waisted region are formed by rolling.

25 15. A method as claimed in any one of claims 13 or 14 wherein the step of deforming of the body comprises crimping.

16. A method as claimed in any one of claims 13 to 15 further comprising a step of forming one or more radial projections on the stem at a waisted region such that the step of deforming the body causes the at least one radial projection to embed into the body.

5

17. A method as claimed in any of claims 13 to 16 wherein the first waisted region is formed into a plurality of stepped portions.

10

18. A method as claimed in any of claims 13 to 17 further comprising steps of forming an underhead recess in the stem.

19. A method as claimed in claim 18 wherein the step of forming the underhead recess comprises a cold-heading operation.

15

20. A method as claimed in claim 18 further comprising a step of forming a protruding ridge of stem material adjacent the recess.

20

21. A method as claimed in claim 20 wherein the step of forming the protruding ridge comprises rolling, wherein material displaced from the first waisted region during rolling forms a protruding ridge of stem material adjacent the recess.

25

22. A blind fastener for installation in a workpiece, the fastener comprising a body and a stem;

the body including a core, a head at a head end of the body, a tail end remote from the head end, and a radially expandable portion between the head end and the tail end;

5

the stem including a shaft, a radially enlarged head and a breakneck groove;

whereby, when the body is inserted into a suitable aperture in the
10 workpiece and a force is applied to the body to urge the tail end of the body towards the workpiece, the reaction force is supported by the head end of the body, and the radially expandable portion of the body is thereby caused to deform radially outwards and axially towards the body head, to form a blind bulb which abuts a blind face of the
15 workpiece and forms a blindside footprint;

wherein an underhead recess is provided under the stem head, and a protruding ridge of stem material is provided adjacent the recess, such that on installation of the fastener into a workpiece, material of
20 the body is forced into between the ridge and the recess and enters the underhead recess.

23. A blind fastener as claimed in claim 21 or 22 wherein the protruding
25 ridge of stem material is formed in a waisted region of the stem.

24. A method of manufacturing a blind fastener, the fastener comprising a body and a stem;

5 the shell including a core, a head end, a tail end remote from the head end, and a radially expandable portion between the head end and the tail end;

the method comprising a step of;

10 rolling an underhead recess onto the stem; thereby causing material displaced from the recess to form a protruding ridge of stem material adjacent the recess.

15 25. A fastener substantially as hereinbefore described and with reference to the accompanying figures.

26. A method of manufacturing a fastener substantially as hereinbefore described and with reference to the accompanying figures.

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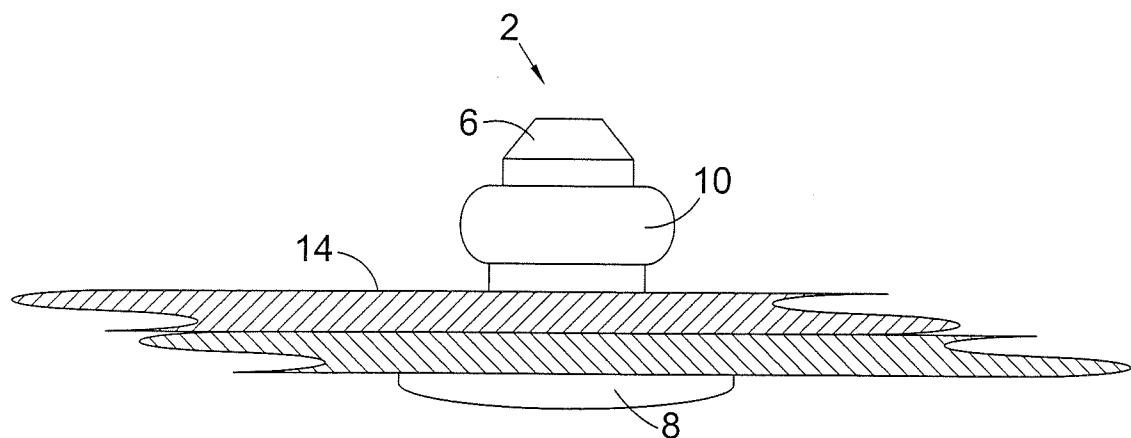


Fig. 1
PRIOR ART

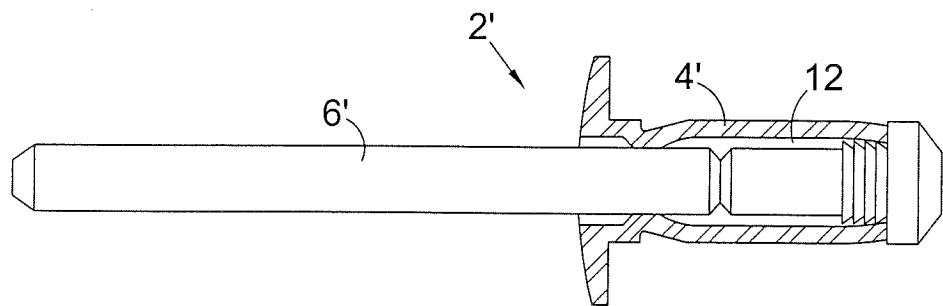


Fig. 2
PRIOR ART

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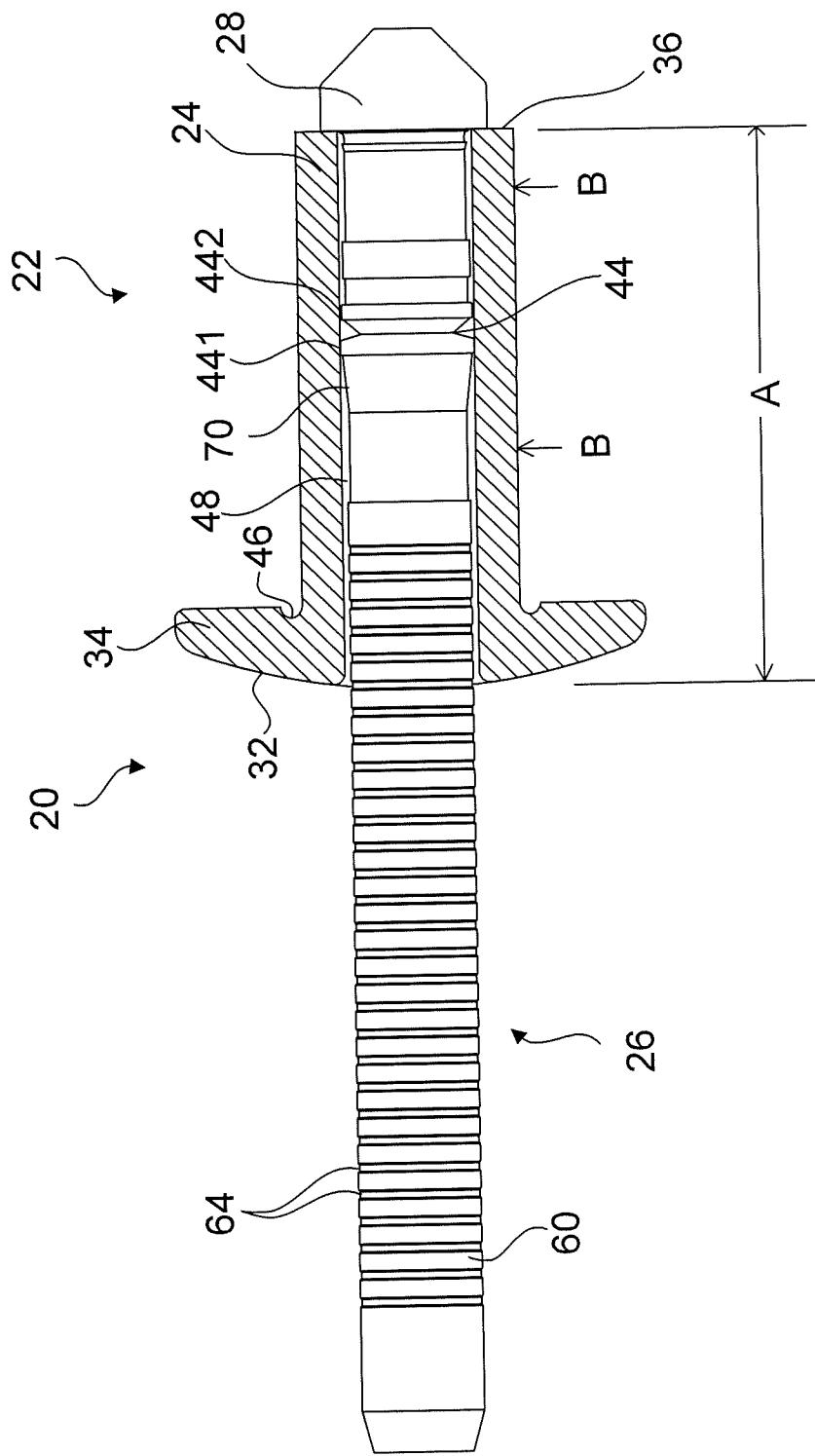


Fig. 3

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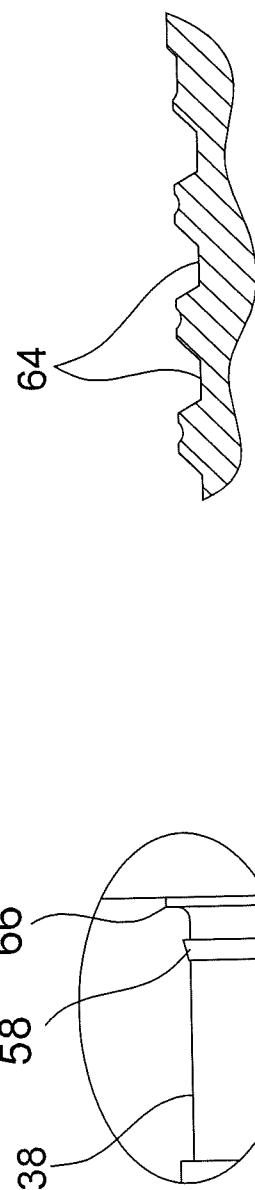
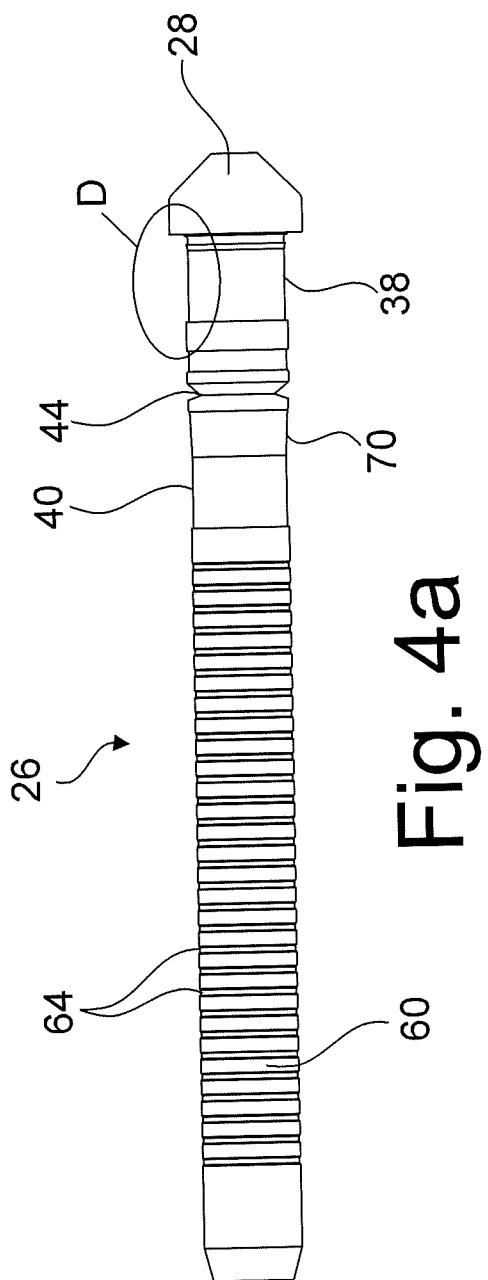


Fig. 4c

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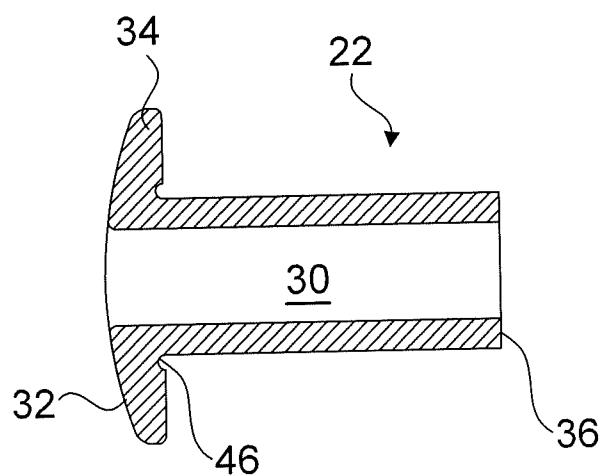


Fig. 5a

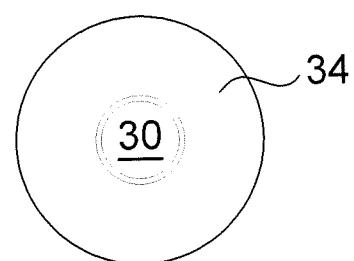


Fig. 5b

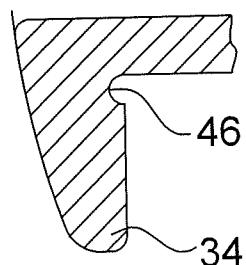


Fig. 5c

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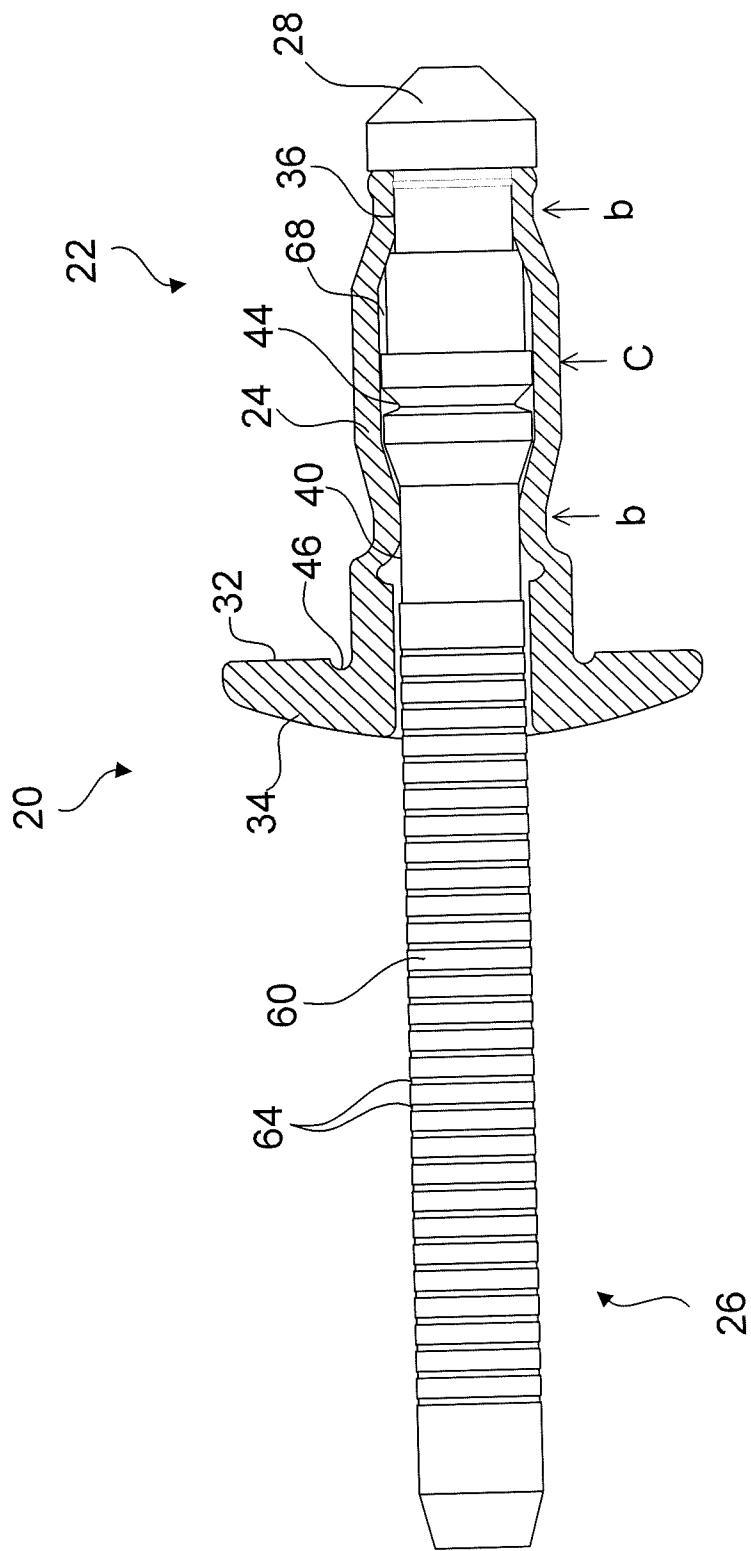


Fig. 6

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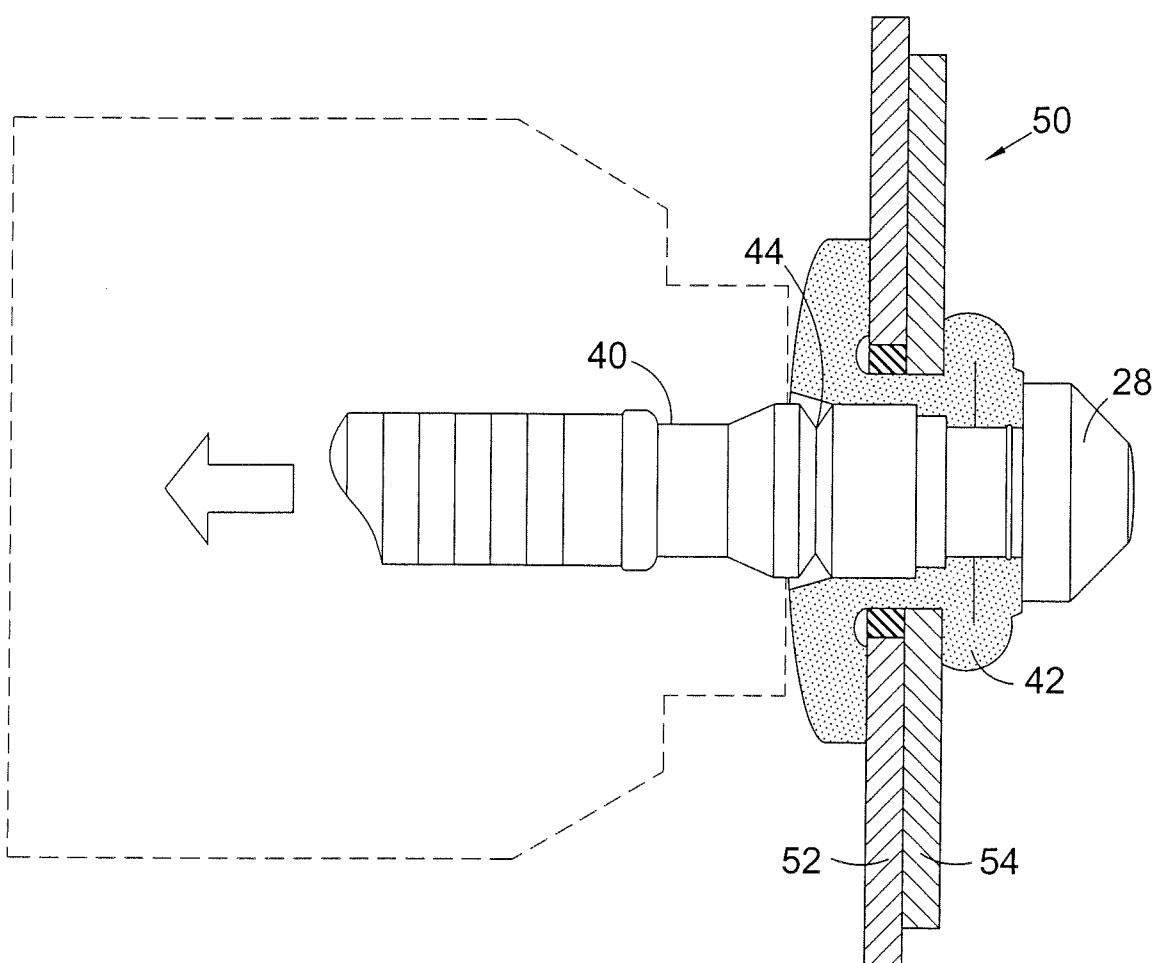


Fig. 7

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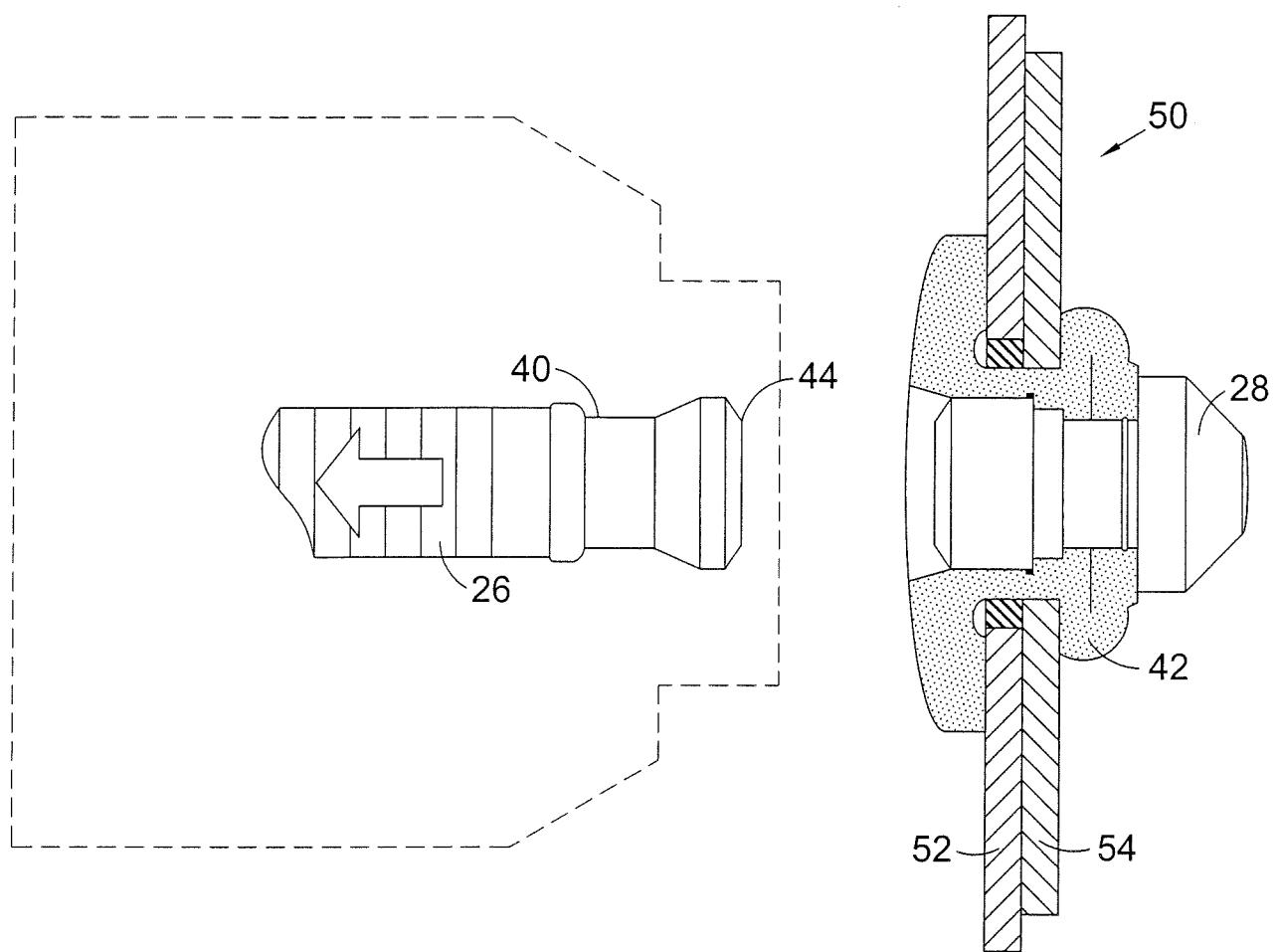


Fig. 8

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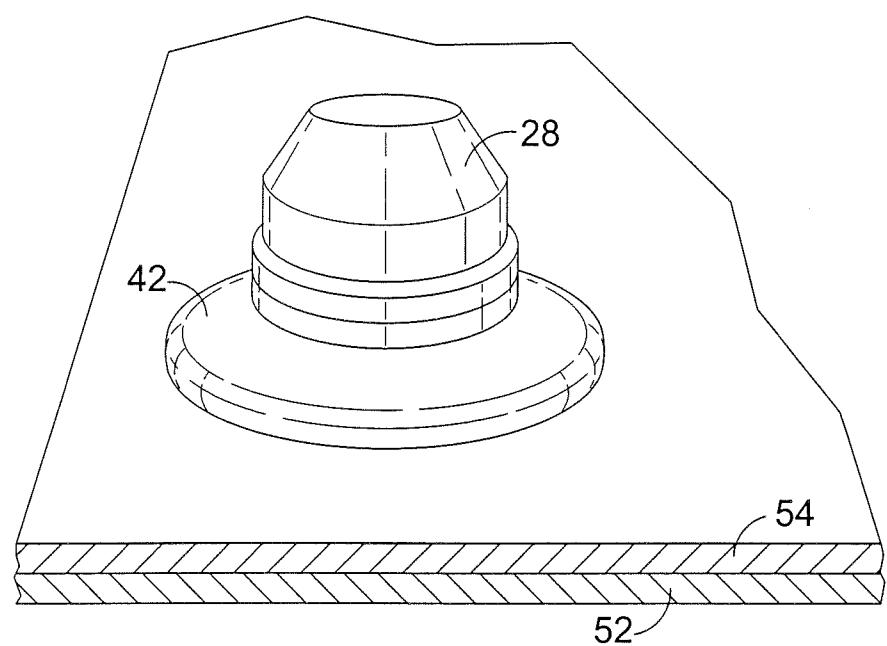


Fig. 9

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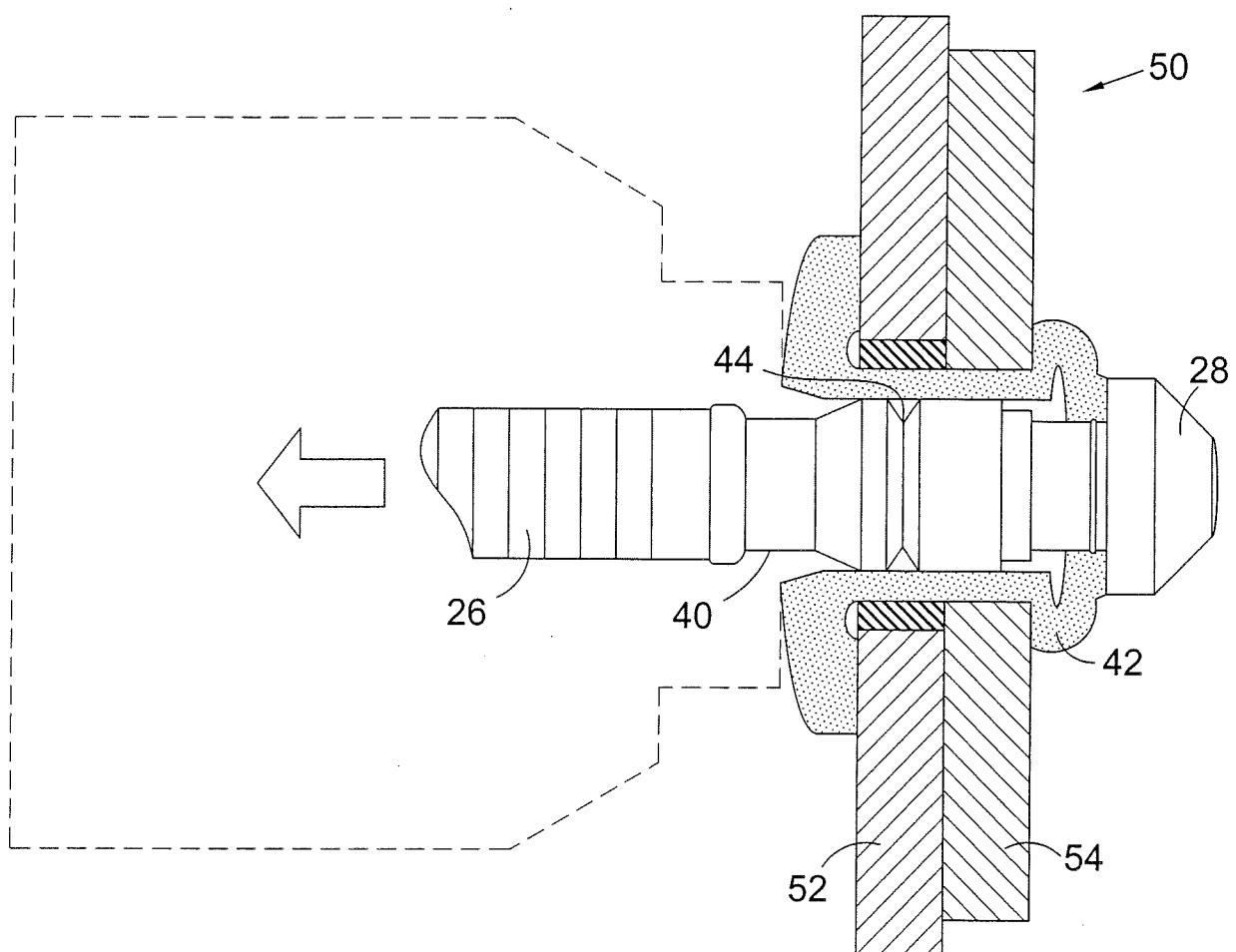


Fig. 10

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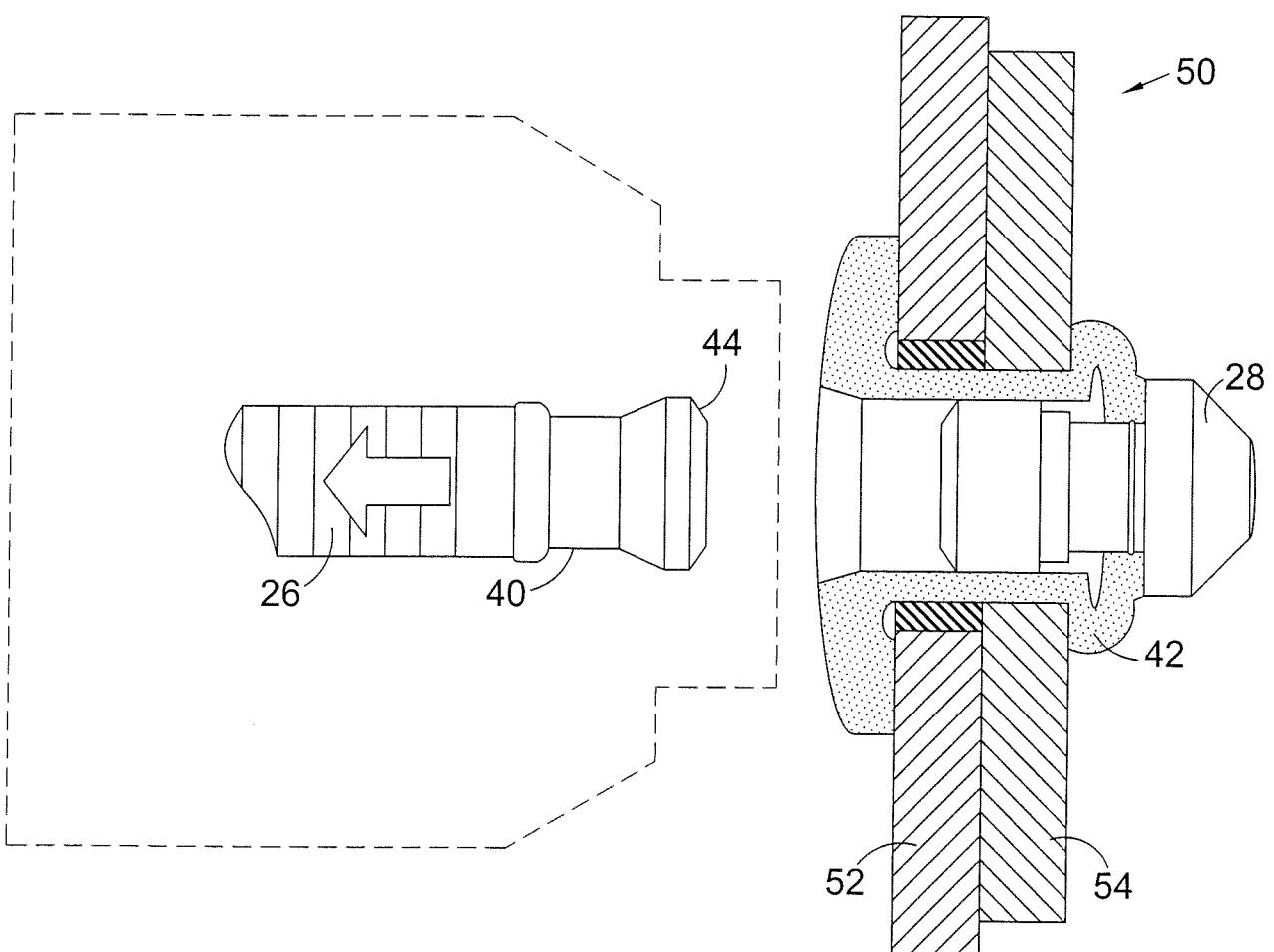


Fig. 11

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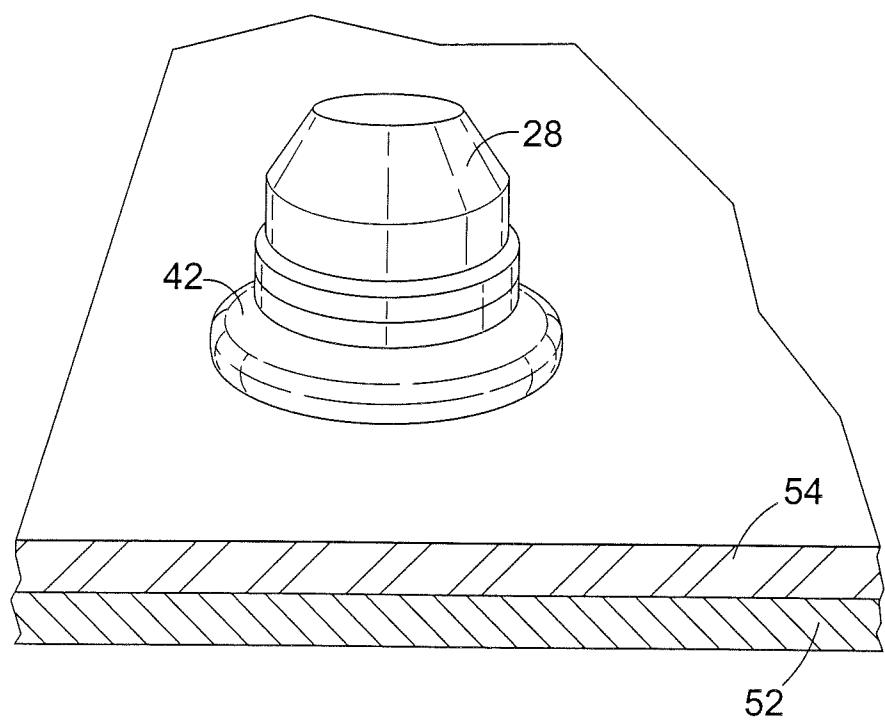


Fig. 12

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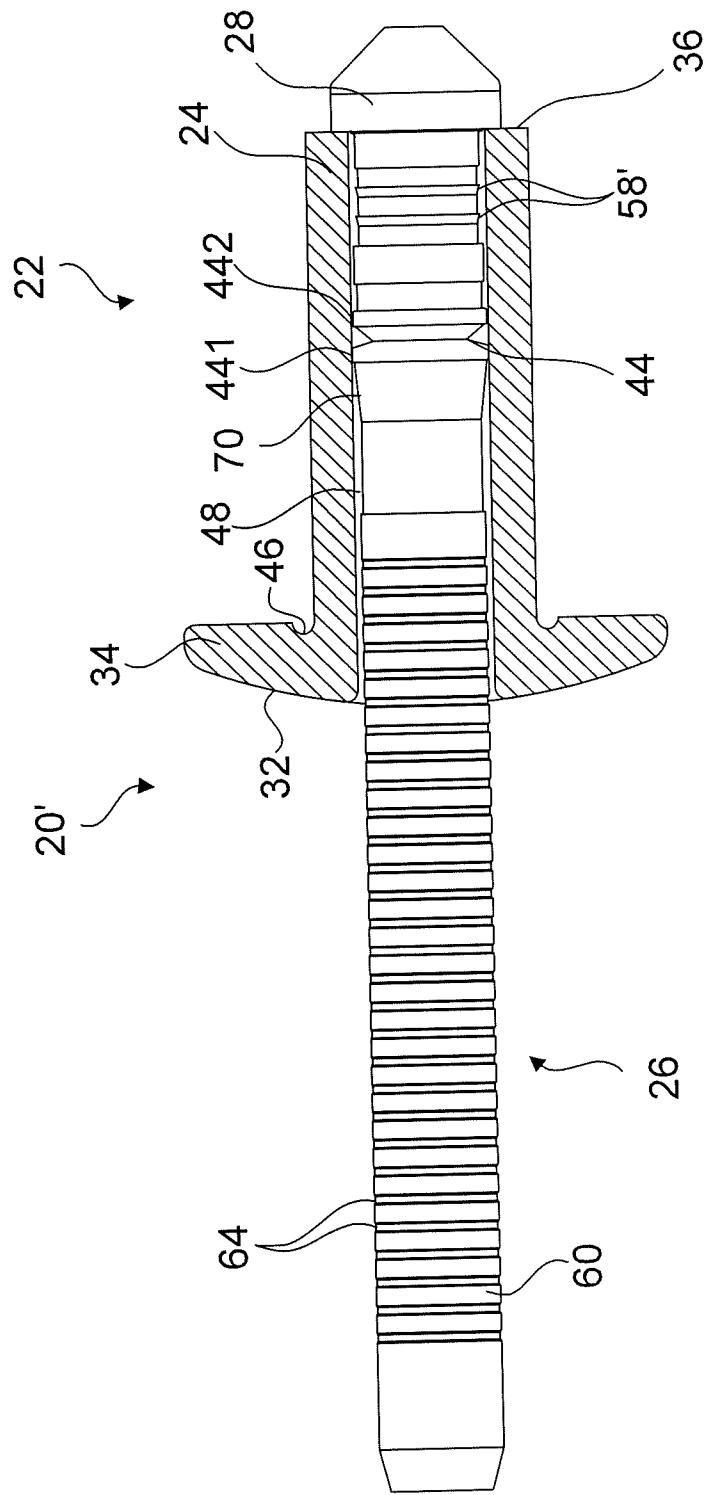


Fig. 13

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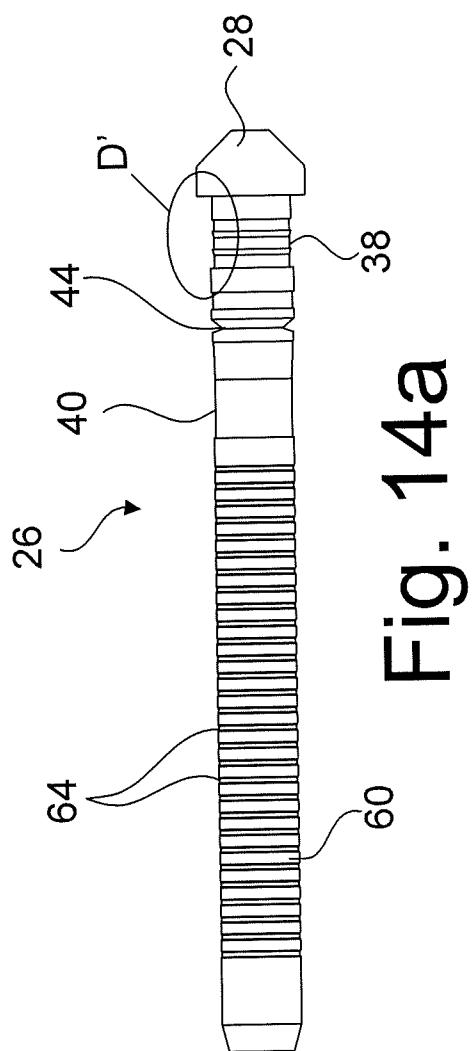


Fig. 14a

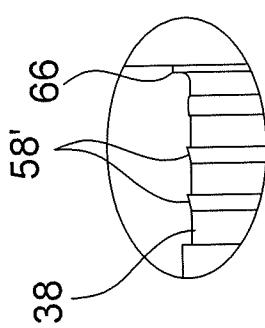


Fig. 14b

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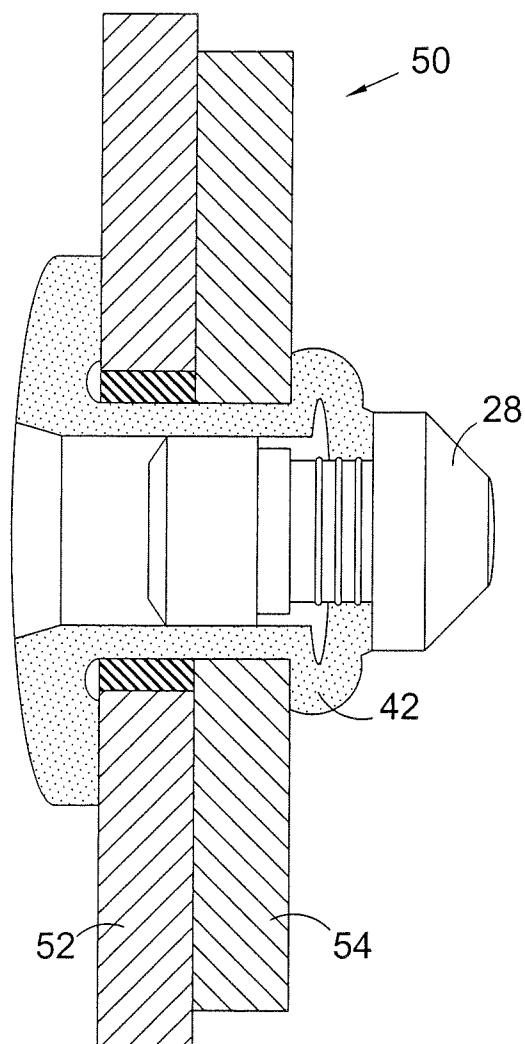


Fig. 15

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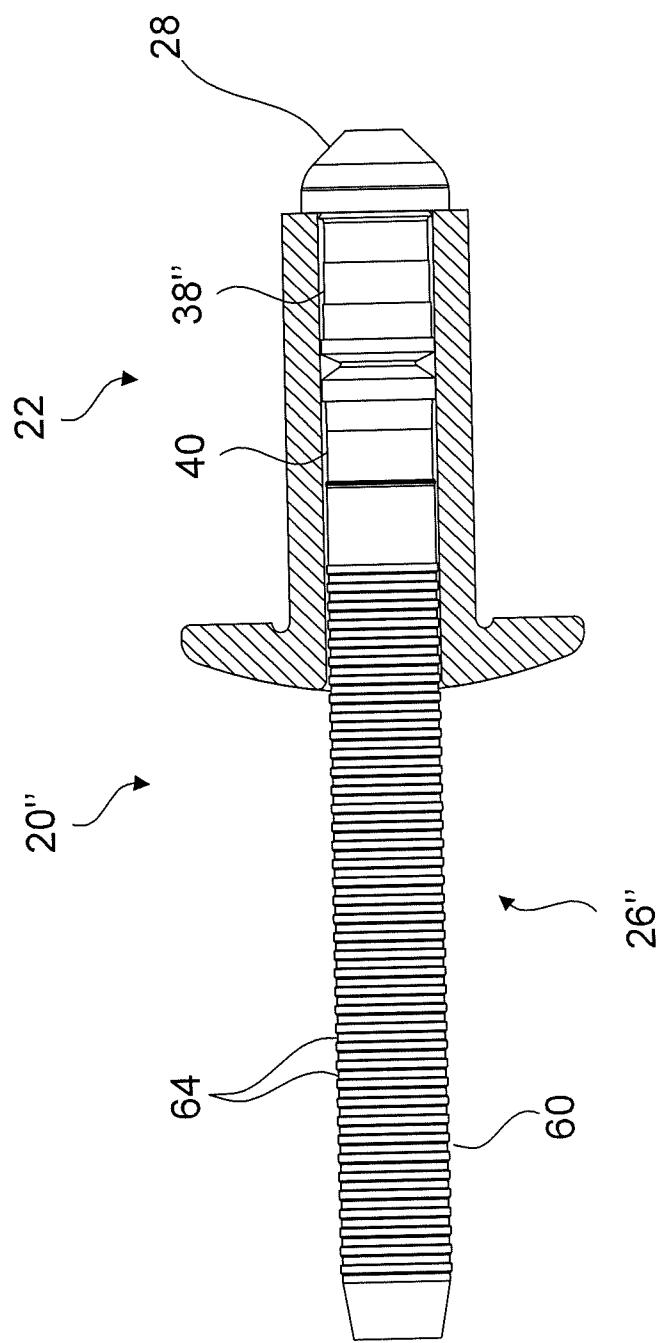


Fig. 16

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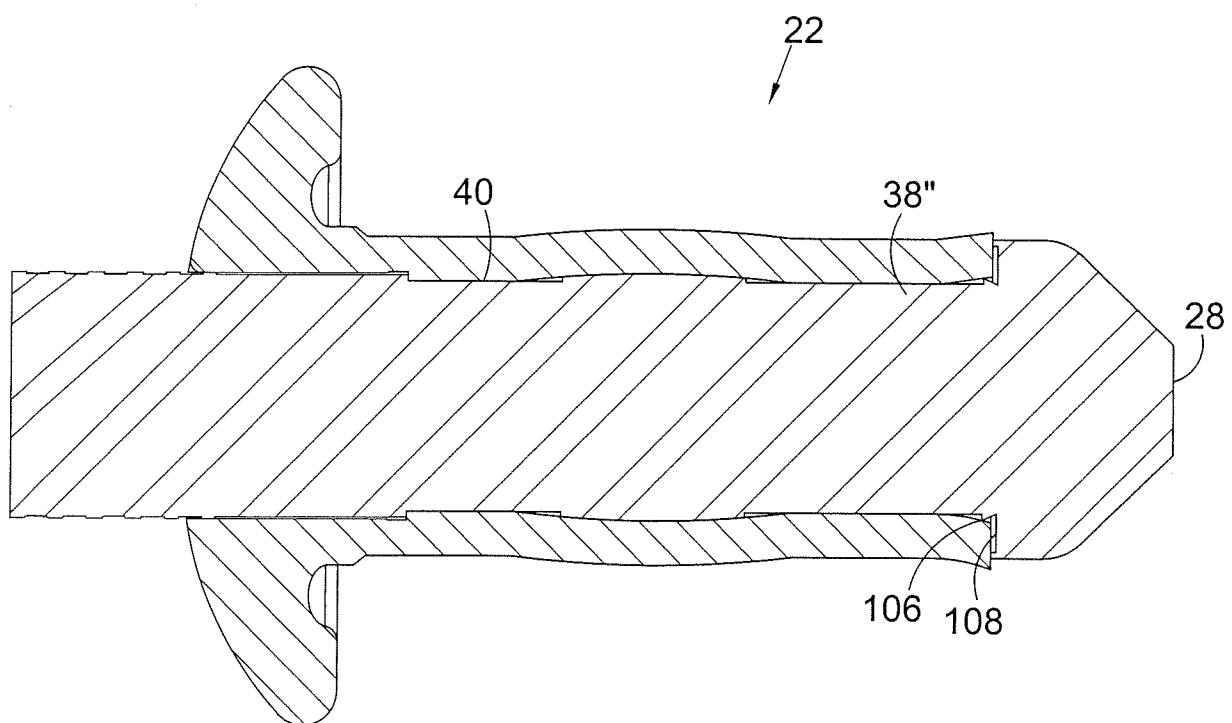
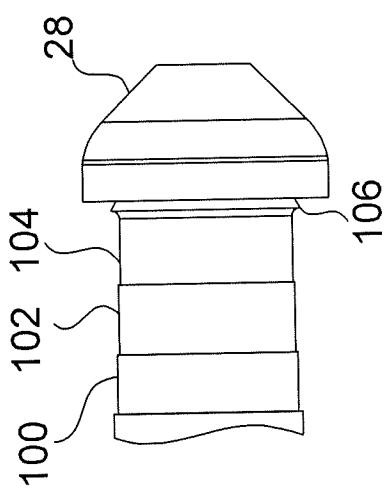
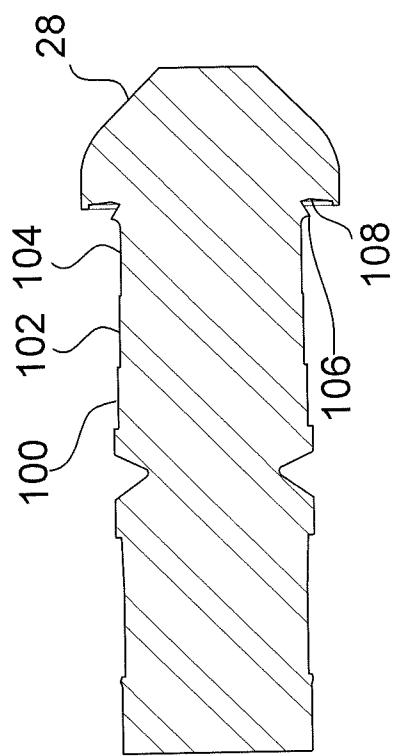
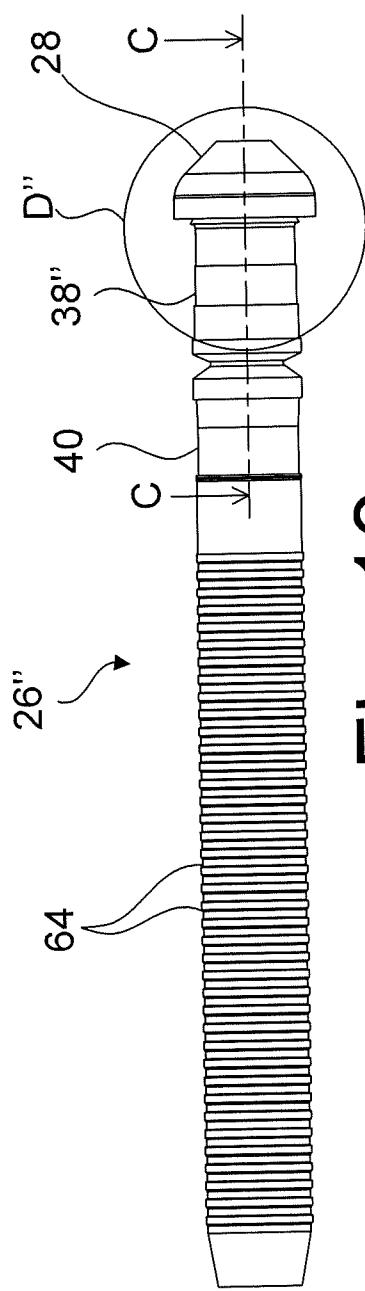


Fig. 17

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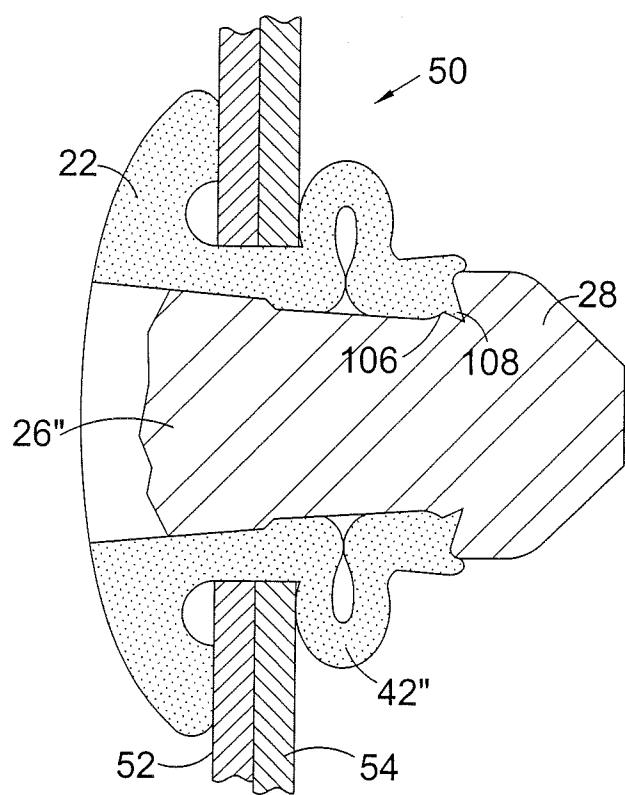


Fig. 19

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2009/050827

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16B19/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 498 617 A2 (NEWFREY LLC [US]) 19 January 2005 (2005-01-19)	1, 3-4, 13-15, 22-26
A	paragraph [0031] - paragraph [0033]; figures 6,7	2, 5-12, 16-21
X	CA 946 658 A1 (VSI CORP) 7 May 1974 (1974-05-07) page 10, line 6 - page 12, line 11; figures 4,5	1, 3-4, 22-26

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

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- *O* document referring to an oral disclosure, use, exhibition or other means
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- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search

15 October 2009

Date of mailing of the international search report

21/10/2009

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Authorized officer

Granger, Hugo

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2009/050827

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