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(54) **BLIND FASTENER**

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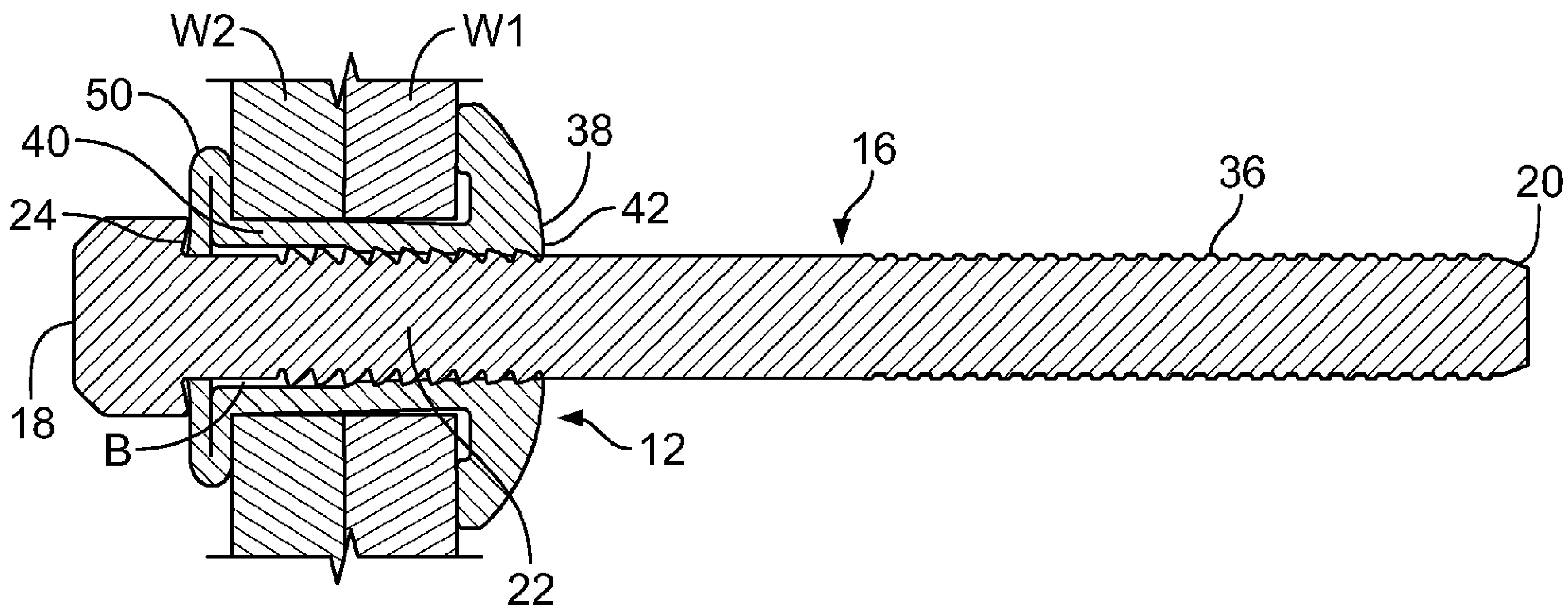
(57) **ABSTRACT**

A fastener having a pin member and a sleeve. The pin includes a head, a pin tail portion, and a locking portion with a plurality of crests and roots. Each of the crests includes a first diameter, the first diameters sequentially increase along the locking portion towards the head, while the roots include a second diameter, the second diameters sequentially decrease towards the head. The sleeve has a head and a tubular portion which is deformed into a bulb that engages a workpiece. The tubular portion of the sleeve locks onto the crests and the pintail portion of the pin member breaks off at one of the grooves located substantially flush with the head of the sleeve.



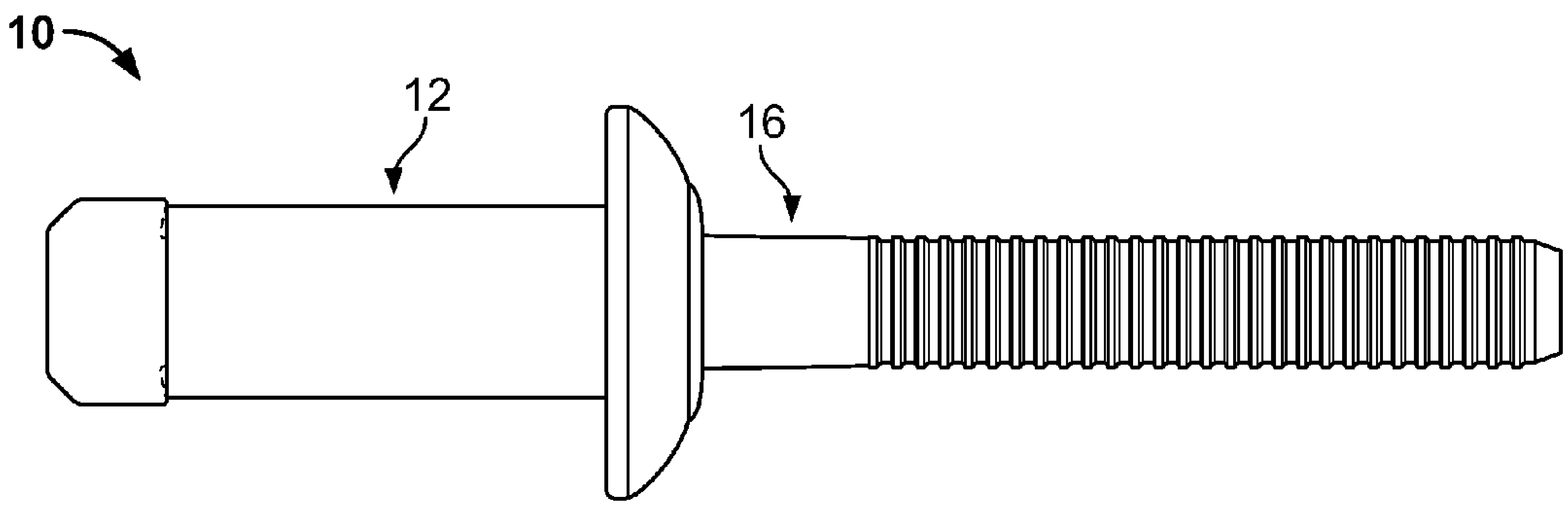


FIG. 1

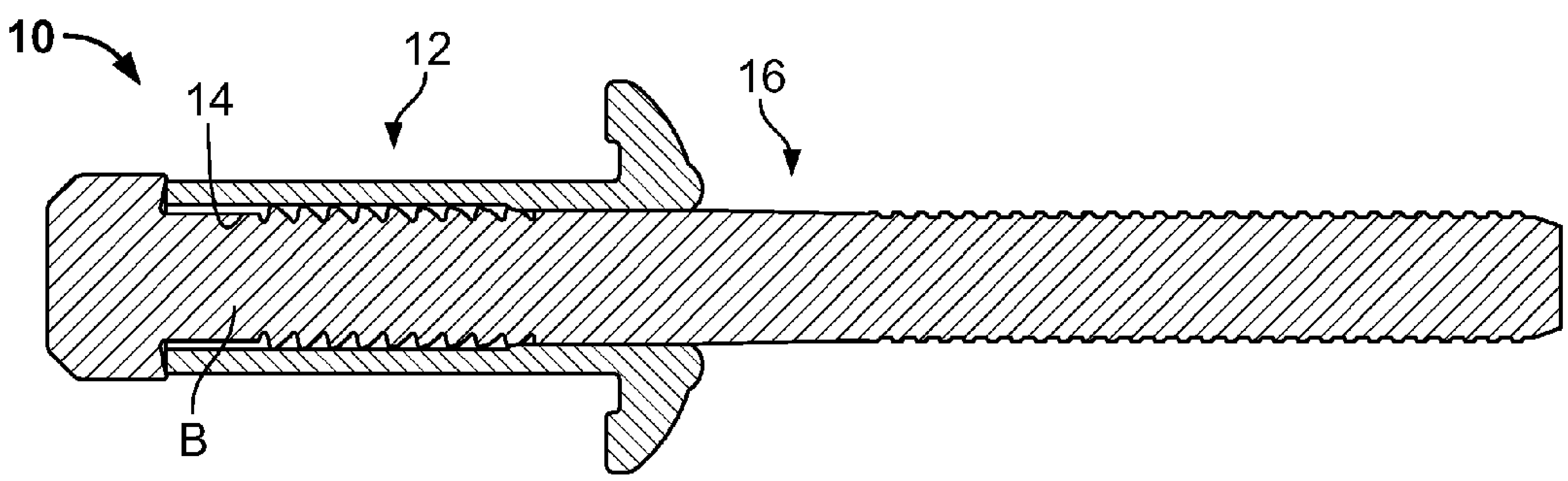


FIG. 2

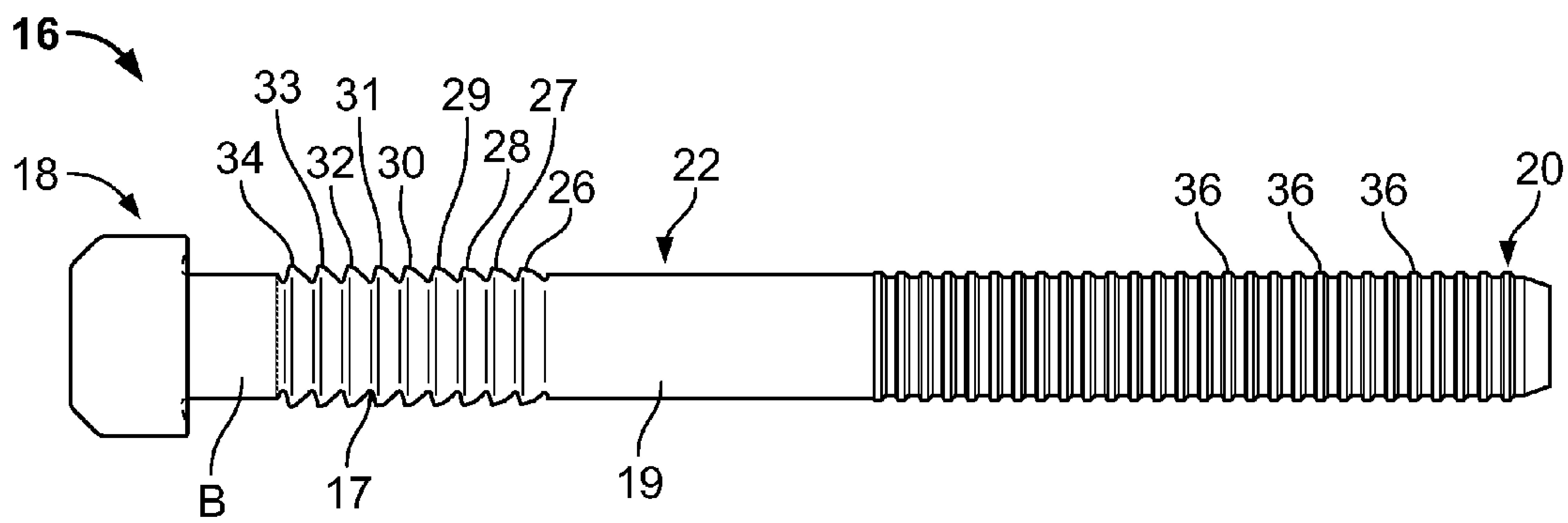

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FIG. 3

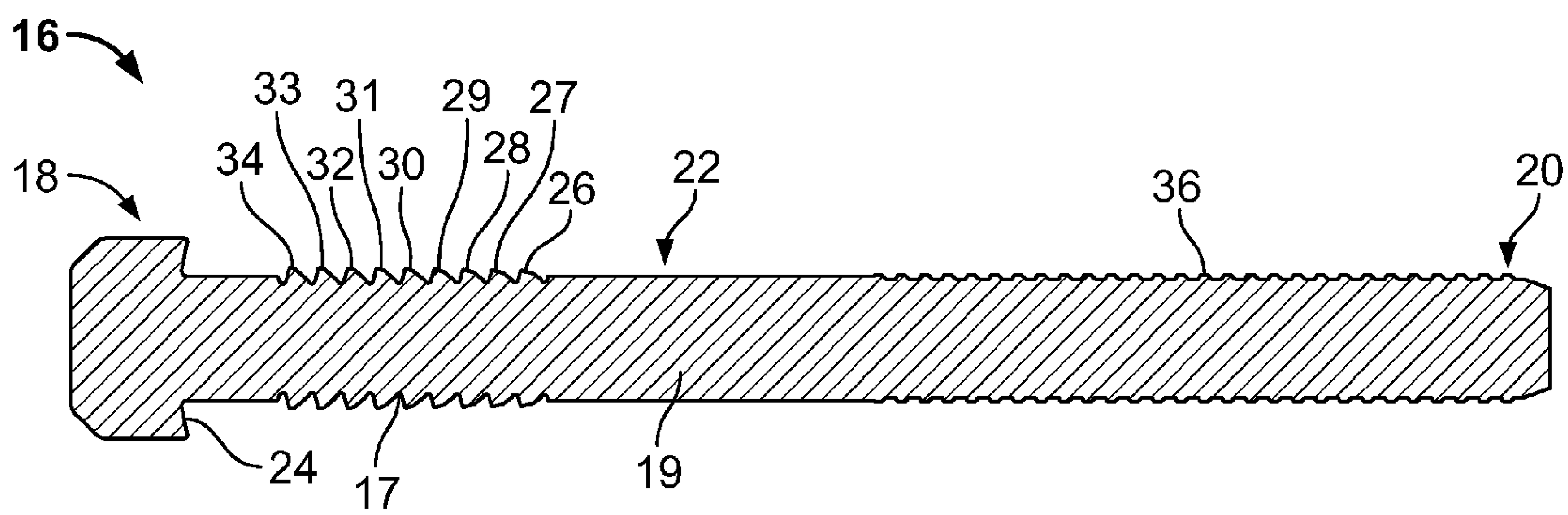
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FIG. 4

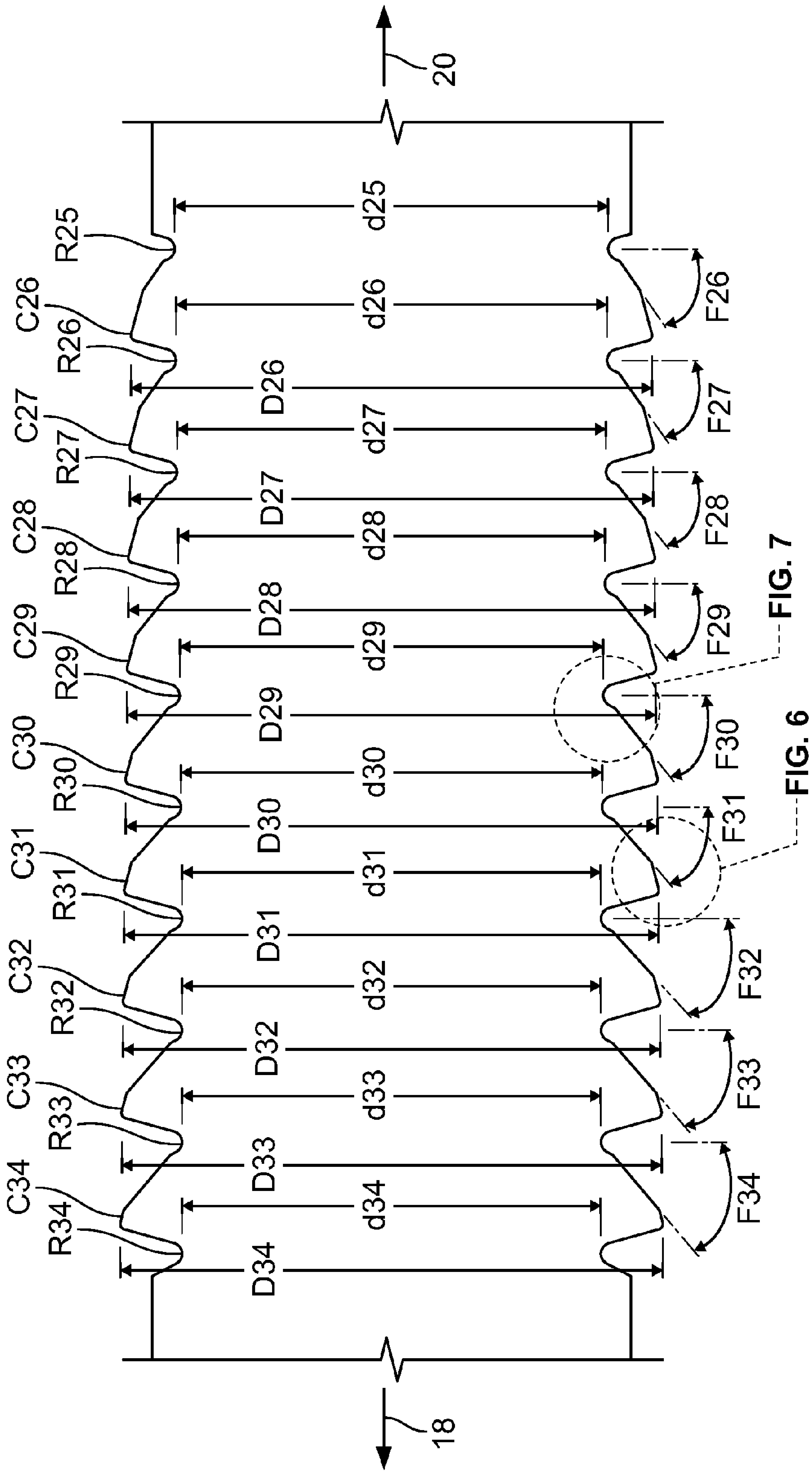
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FIG. 7
FIG. 6

FIG. 5

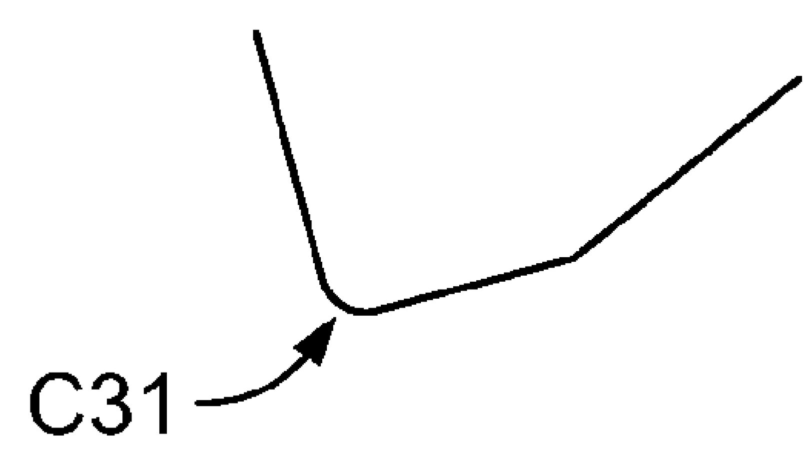

FIG. 6

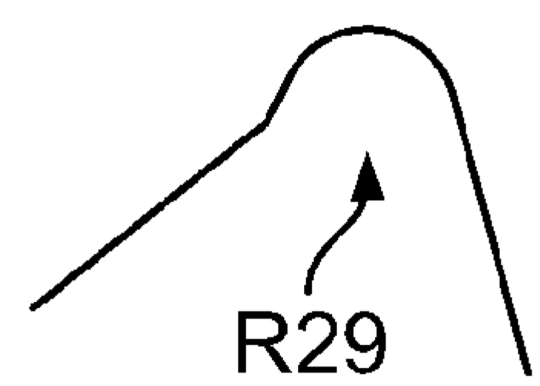

FIG. 7

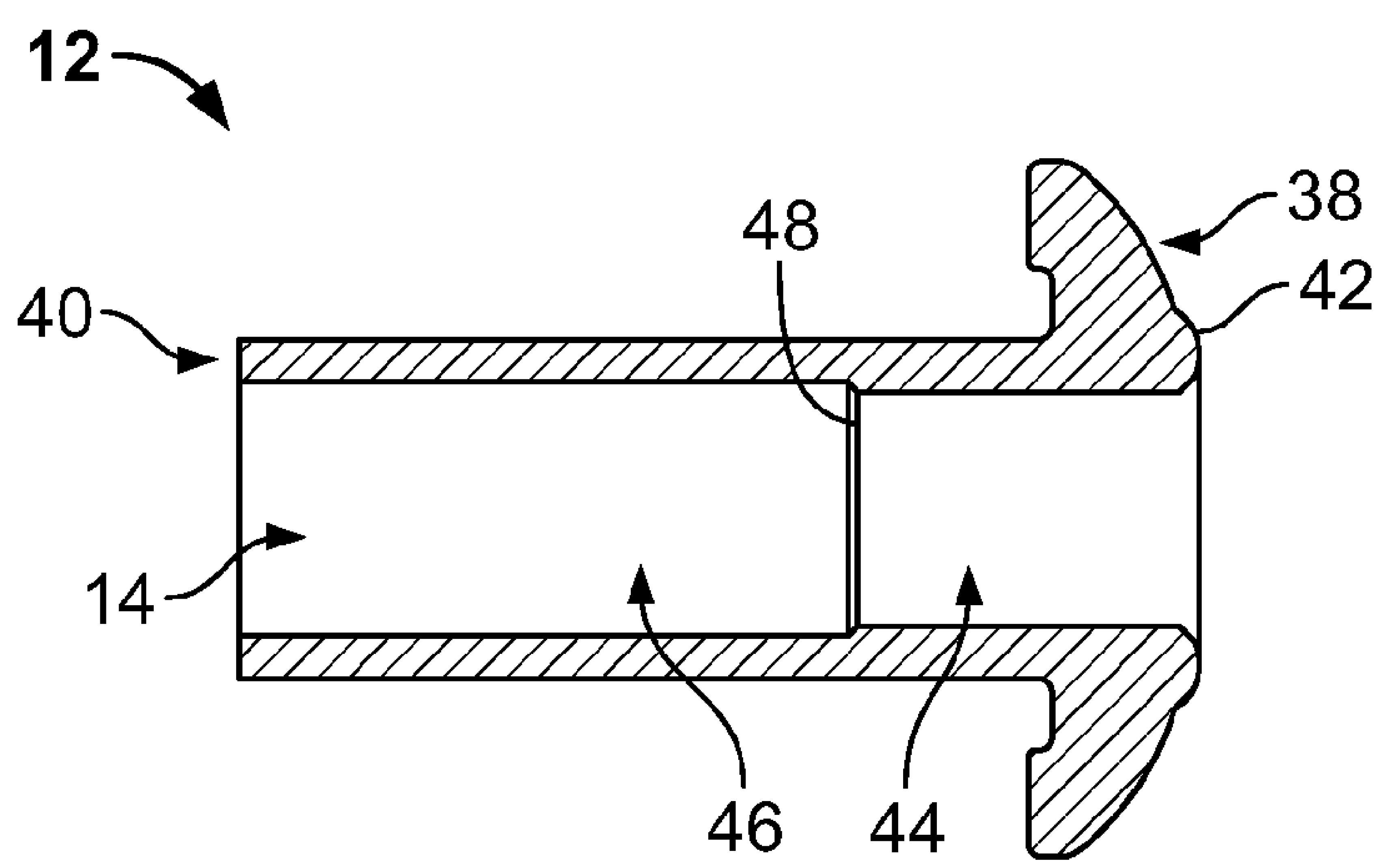

FIG. 8

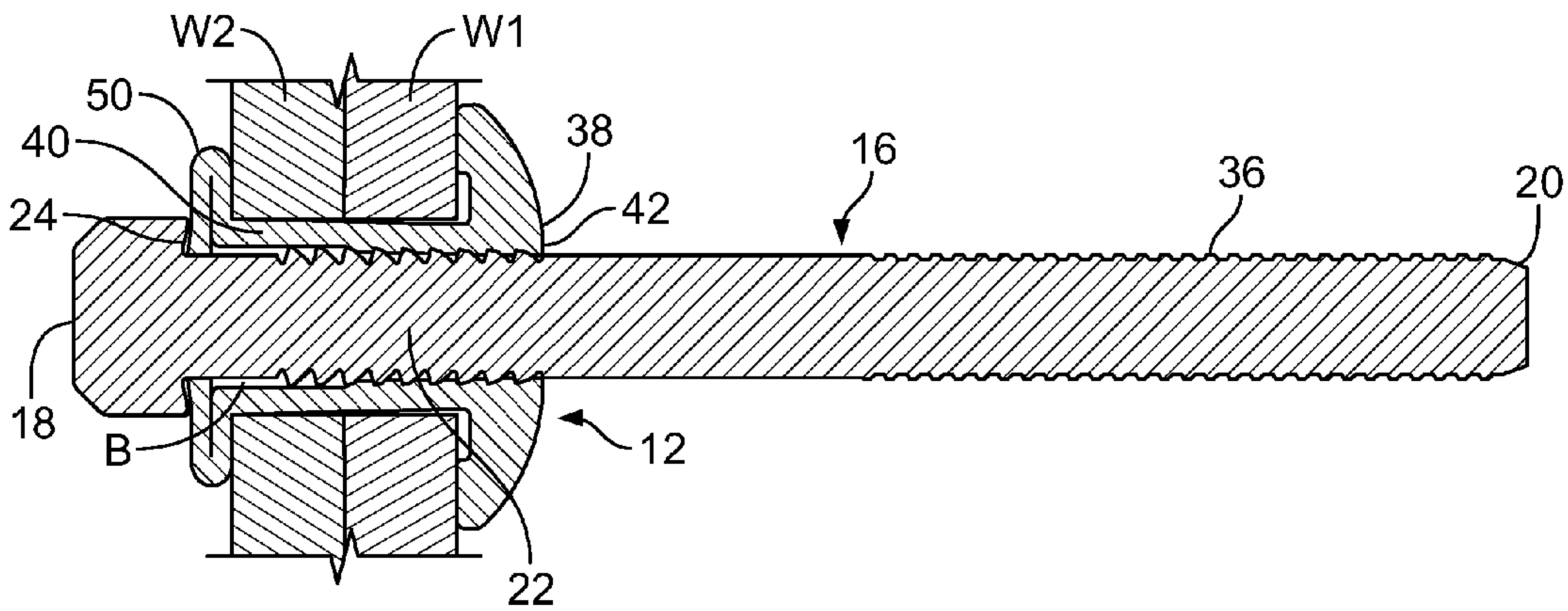

FIG. 9

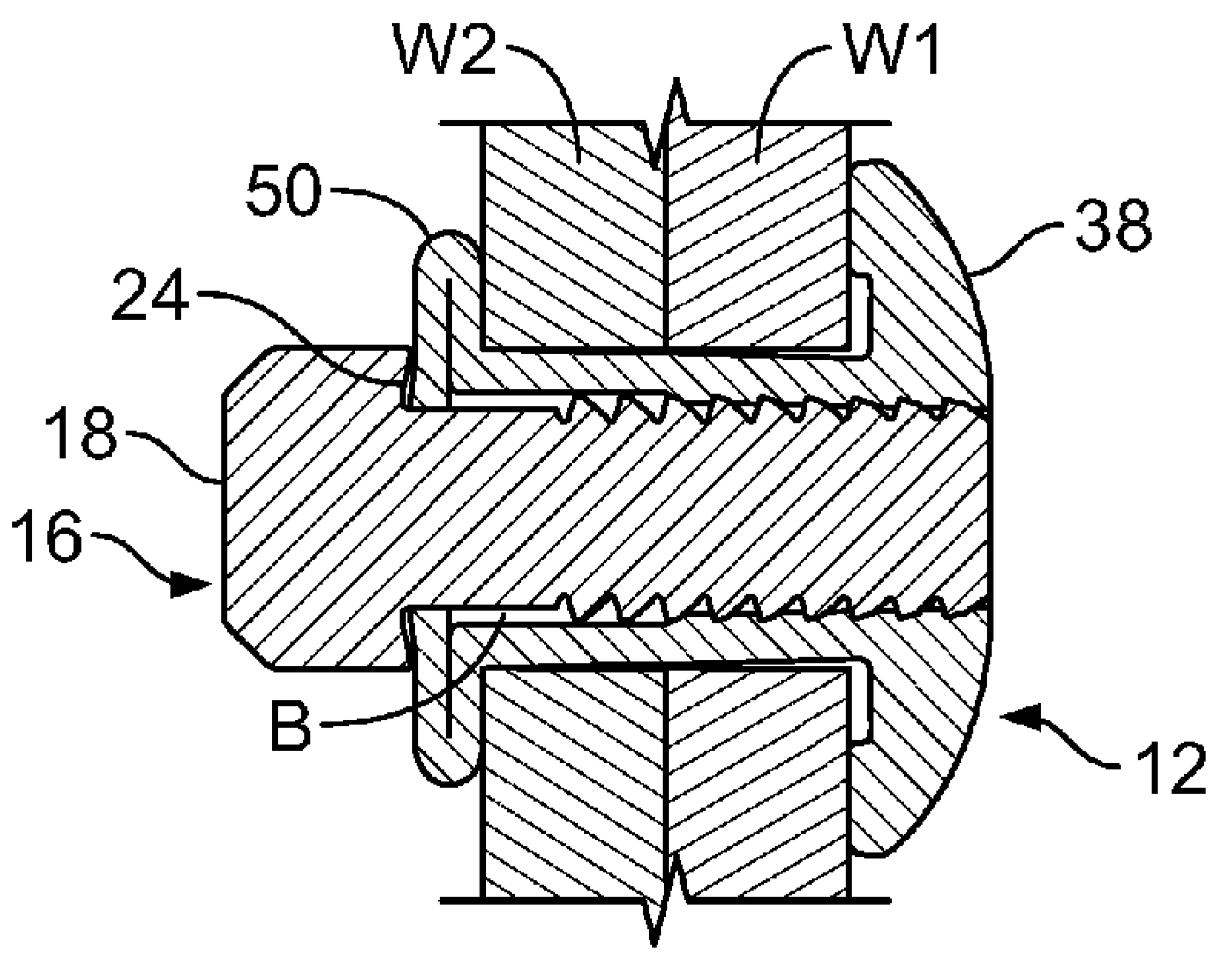

FIG. 10

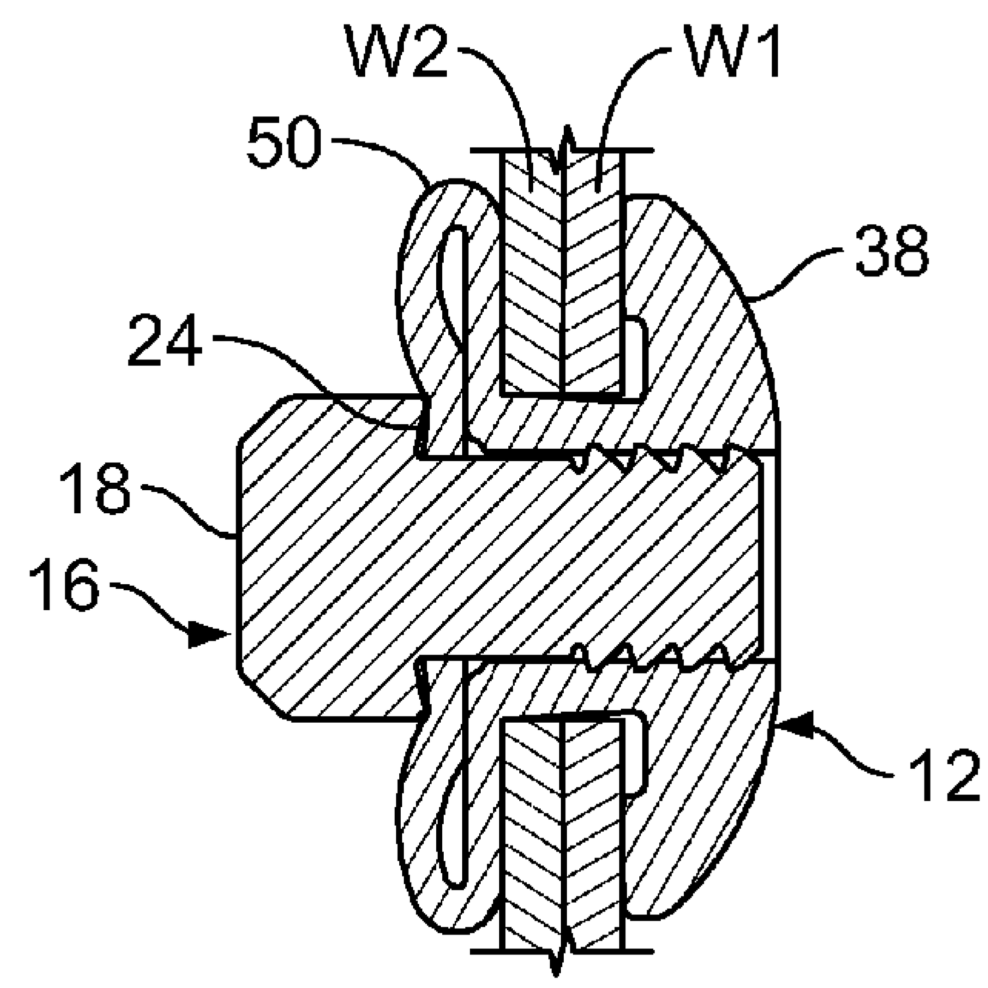

FIG. 11

BLIND FASTENER

FIELD OF THE INVENTION

[0001] The present invention relates to a blind fastener for fastening a plurality of workpieces.

BACKGROUND OF THE INVENTION

[0002] Blind fasteners are used to join workpieces when only one side of a workpiece is accessible. It is important that the fastener maintain the designed level of strength once it is installed.

SUMMARY OF THE INVENTION

[0003] In an embodiment, a fastener comprising a pin member having a first end and a second end opposite the first end, a head at the first end, a pintail portion at the second end and having a plurality of pull grooves, and a shank intermediate the head and the pintail portion, the shank having a locking portion with a first end located proximate to the head and a second end opposite the first end of the locking portion, the locking portion having a plurality of lock grooves formed by a plurality of crests and a plurality of roots, each of the plurality of crests includes a first diameter, the first diameters of the plurality of crests sequentially increase from the second end of the locking portion to the first end of the locking portion, each of the plurality of roots includes a second diameter, the second diameters of the plurality of roots sequentially decrease from the second end of the locking portion to the first end of the locking portion; a sleeve having a tubular portion with a first end a second end opposite the first end of the tubular portion, a through bore extending from the first end of the tubular portion to the second end of the tubular portion, and a head located at the first end of the tubular portion, wherein the sleeve is adapted to receive the pin member such that the shank of the pin member is inserted within the through bore of the sleeve and the head of the pin member engages the second end of the tubular portion of the sleeve member, wherein the fastener is adapted to be installed within aligned holes of a plurality of workpieces in an installed position such that the head of the sleeve engages an accessible side of one of the workpieces, and a section of the tubular portion proximate to second end of the sleeve is deformed into a bulb that engages a blind side of another of the workpieces, and wherein the pintail portion of the pin member breaks off at one of the plurality of grooves located substantially flush with the head of the sleeve.

[0004] In an embodiment, each of the plurality of crests includes a flank angle that tapers in a direction towards the head of the pin member. In an embodiment, the flank angles of the plurality of crests are sequentially steeper from the second end of the locking portion of the pin member to the first end of the locking portion of the pin member. In an embodiment, each of the plurality of lock grooves includes a barbed shape. In an embodiment, the head of the sleeve includes a cone, and wherein when the fastener is in its installed position, the cone is deformed into the through bore of the sleeve and is clamped around the pin member. In an embodiment, the pin member includes a smooth cylindrical section intermediate the head of the pin member and the locking portion of the pin member, and wherein the bulb of the sleeve is formed adjacent to the smooth cylindrical section of the pin member. In an embodiment, the head of the pin member includes a conical-shaped underside.

[0005] In an embodiment, the through bore of the sleeve includes a first bore extending from the first end of the sleeve at a location intermediate the first and second ends of the sleeve, and a second bore extending from the second end of the sleeve to the first bore, wherein an inner diameter of the second bore is greater than the inner diameter of the first bore. In an embodiment, the inner diameter of the first bore corresponds to the smallest of the first diameters of the plurality of crests of the plurality of lock grooves, and the inner diameter of the second bore of the sleeve has an interference fit on the largest of the first diameters of the plurality of crests of the plurality of lock grooves.

[0006] In another embodiment, a pin member having a first end and a second end opposite the first end, a head at the first end, a pintail portion at the second end and having a plurality of pull grooves, and a shank intermediate the head and the pintail portion, the shank having a locking portion with a first end located proximate to the head and a second end opposite the first end of the locking portion, the locking portion having a plurality of lock grooves formed by a plurality of crests and a plurality of roots, the plurality of roots including a first group of roots and a second group of roots, each of the plurality of crests includes a first diameter, the first diameters of the plurality of crests sequentially increase from the second end of the locking portion to the first end of the locking portion, each of the plurality of roots includes a second diameter, the second diameters of the first group of roots sequentially decrease from the second end of the locking portion towards the first end of the locking portion, and the second diameters of the second group of roots being equal to one another and greater than the second diameters of the first group of roots; a sleeve having a tubular portion with a first end a second end opposite the first end of the tubular portion, a through bore extending from the first end of the tubular portion to the second end of the tubular portion, and a head located at the first end of the tubular portion, wherein the sleeve is adapted to receive the pin member such that the shank of the pin member is inserted within the through bore of the sleeve and the head of the pin member engages the second end of the tubular portion of the sleeve member, wherein the fastener is adapted to be installed within aligned holes of a plurality of workpieces in an installed position such that the head of the sleeve engages an accessible side of one of the workpieces, and a section of the tubular portion proximate to second end of the sleeve is deformed into a bulb that engages a blind side of another of the workpieces, and wherein the pintail portion of the pin member breaks off at one of the plurality of grooves located substantially flush with the head of the sleeve.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] For a more complete understanding of the present invention, reference is made to the following detailed description of exemplary embodiments considered in conjunction with the accompanying drawings, in which:

[0008] FIG. **1** is a side view of a blind fastener which includes a pin member and a sleeve, and which is constructed in accordance with one embodiment of the present invention;

[0009] FIG. **2** is a cross-sectional view of the blind fastener shown in FIG. **1**;

[0010] FIG. **3** is a side view of the pin member shown in FIG. **1**;

[0011] FIG. **4** is a cross-sectional view of the pin member shown in FIG. **3**;

[0012] FIG. **5** is a side view of a section of the shank of the pin member, showing crests and roots of the lock grooves shown in FIGS. **2** through **4**;

[0013] FIG. **6** is an enlarged side view of the profile of a portion of a crest of a lock groove;

[0014] FIG. **7** is an enlarged side view of the profile of a portion of a root of a lock groove;

[0015] FIG. **8** is a cross-sectional view of the sleeve shown in FIGS. **1** and **2**;

[0016] FIG. **9** is a cross-sectional view of the blind fastener installed on a plurality of workpieces with the pintail portion of the pin member not yet detached therefrom;

[0017] FIG. **10** is a cross-sectional view of the blind fastener installed on the workpieces with the pintail portion of the pin detached from the pin; and

[0018] FIG. **11** is an illustration which is similar to FIG. **10** except the thickness of the joined workpieces is smaller.

DETAILED DESCRIPTION OF THE DRAWINGS

[0019] FIGS. **1** and **2** illustrate a blind fastener **10** (hereinafter "the fastener **10**") which is constructed in accordance with one embodiment of the present invention. In an embodiment, the fastener **10** includes a sleeve **12** having a through bore **14**, and a pin member **16** (i.e., "pin") that is adapted to be positioned within the through bore **14** of the sleeve. In an embodiment, the pin **16** is made from suitable materials known in the art, such as steel or titanium or other suitable metals and metal alloys. In an embodiment, the sleeve **12** is made from suitable materials known in the art, such as aluminum or 1010 steel, or other suitable metals and metal alloys.

[0020] Referring to FIGS. **3** and **4**, in an embodiment, the pin **16** includes a head **18** at one end, a pintail portion **20** opposite the head **18** at another end, and a cylindrical-shaped shank **22** that extends between the head **18** and the pintail portion **20**. In an embodiment, the head **18** is an enlarged head. In an embodiment, the shank **22** includes a locking portion **17** located proximate to the head **18** and having a plurality of lock grooves **26-34** extending from one end to an opposite end thereof, pull grooves **36** located on the pintail **20**, and a smooth shank portion **19** intermediate the locking portion **17** and the pintail portion **20**. In an embodiment, the lock grooves **26-34** have a constant pitch. In an embodiment, each of the lock grooves **26-34** have a barbed-shape. In an embodiment, the head **18** of the pin **16** has a cone-shaped underside **24**, for purposes that are disclosed hereinbelow.

[0021] Referring to FIGS. **5** through **7**, each of the lock grooves **26-34** includes a corresponding crest C**26**-C**34**, respectively, and a corresponding root R**25**-R**34**, respectively. FIGS. **6** and **7** illustrate embodiments of profiles of the crest C**31** and the root R**29**, respectively. Referring specifically to FIG. **5**, in an embodiment, the crests C**26**-C**34** include diameters D**26**-D**34**, respectively. In an embodiment, the diameters D**26**-D**34** of the crests C**26**-C**34** sequentially increase towards the head **18**, e.g., D**27** being greater than D**26**, D**28** being greater than D**27**, etc. In an embodiment, the roots R**25**-R**34** include diameters d**25**-d**34**, respectively. In an embodiment, the diameters d**25**-d**34** of the roots R**25**-R**34** sequentially decrease towards the head **18**, e.g., d**26** is less than d**25**, d**27** is less than d**26**, etc. In an embodiment, the diameters d**25**-d**34** of the roots R**25**-R**34** sequentially decrease towards the head **18**, e.g., d**26** is less than d**25**, d**27** is less than d**26**, etc. In an embodiment, diameters d**32**-d**34** of the roots R**32**-R**34** are constant and equal to one another and are greater than the diameters d**25**-d**31** of the roots R**25**-R**31**. In an embodiment, the constant diameters d**32**-d**34** of the roots R**32-34** establish an area along the shank **22** where it would not break during installation of the fastener **10**. In another embodiment, only diameters d**33** and d**34** are equal to one another. In an embodiment, the pin **16** includes a smooth cylindrical section B which is a gap that is located proximate the exterior surface of shank **22** that is adjacent to the head **18** of the pin **16**. In an embodiment, the section B does not include any grooves, and it facilitates the formation of a bulb (i.e., bulbing of the sleeve **12**) during the installation of the fastener **10** (see FIGS. **9** and **10**). More particularly, the section B facilities the pin **16** retention and bulb profile in the fastener **10**, as disclosed in greater detail hereinafter.

[0022] In an embodiment, the lock grooves **26-34** of the pin **16** include reverse tapers (i.e., the tapers are oriented toward the head **18** of the pin **16**). In an embodiment, the variation of the reverse tapers of the crests C**26**-C**34** is achieved by varying the angle of the flank (i.e., the flank is the side of the crest furthest away from the head **18**). Referring again to FIG. **5**, flank angles of the lock grooves **26-34**, which are denoted as F**26**-F**34**, become progressively steeper from one end of the locking portion towards the head **18**. The increases in the flank angles F**26**-F**34** enable the crests C**26-34** to have progressively larger diameters D**26**-D**34**, respectively, towards the head **18**, while the roots R**25**-R**34** have progressively smaller diameters d**25**-d**34**, respectively, towards the head **18**. Once again, in an embodiment, the diameters d**32**-d**34** have a constant diameter. In an embodiment, the reduction in root diameters d**25**-d**34** ensures that the pintail portion **20** of the pin **16** breaks substantially flush with or slightly below the head **18** of the sleeve **12** (see FIGS. **10** and **11**), so as to prevent sharp edges from protruding above the head **18**. In an embodiment, the increase in the crest diameters D**26**-D**34** provides increasing swaging pressure as the pin **16** is pulled into the sleeve **12** during installation.

[0023] Referring to FIG. **8**, the sleeve **12** includes a head **38** and a tubular portion **40**. In an embodiment, the head **38** includes a protruding cone **42**. In an embodiment, the sleeve **12** includes a first plain bore **44** and a second plain bore **46**, which are separated from one another by a bore step **48**. In an embodiment, the inside diameter of the second plain bore **46** is larger than the inside diameter of the first plain bore **44**. The inside diameter of the first plain bore **44** corresponds to the smallest diameter D**26** of the crest C**26** of the lock groove **26**. In an embodiment, the larger bore diameter of the second plain bore **46** has an interference fit on the largest crest diameter D**34**. The bore step **48** is positioned to establish the minimum grip length from under the head **38** of the sleeve **12**. (i.e., the minimum grip of the fastener). In an embodiment, the sleeve **12** can be fully annealed, end annealed or band annealed, as required.

[0024] In operation, FIG. **9** illustrates the fastener **10** positioned in aligned openings in a plurality of workpieces W**1**, W**2**, in which the head **38** of the sleeve **12** engages the accessible side of the workpiece W**1**, and the tubular portion **40** of the sleeve protrudes from the non-accessible (blind) side of the workpiece W**2**. In embodiments, the workpieces W**1**, W**2** are made of steel, aluminum, an aluminum alloy, other metals or metallic alloys, composites, or combinations thereof. The application of force is applied on the pull grooves **36** of the pin **16** by the grip of the installation tool (not shown), and by a simultaneous application of the tool's reactive force on the protruding cone **42** of the head **38** of the sleeve **12**. These forces result in the tubular portion **40** of the sleeve being driven and a section of which is deformed into a bulb **50**, which is positioned adjacent to the section B along the shank **22** and under the cone-shaped underside **24** of the head **18** of the pin **16**. The bulb **50** is adapted to engage the blind side of the workpiece W**2**. The bulb **50** improves pin **16** retention, and assists in the pin **16** breaking proximate to the head **38** of the sleeve **12** (see FIGS. **10-11**).

[0025] When the fastener **10** is completely installed, the tubular portion **40** of the sleeve **12** will lock onto the largest lock groove crests proximate to the head **18** of the pin **16** (for example, crests C**32**-C**34** when such crests have a constant diameter). This holds the pin **16** and the sleeve **12** together during use. Also, when the fastener **10** is completely installed, the sleeve **12** forms the bulb **50** evenly, assisted by the cone-shaped underside **24** of the head **18** of the pin **16**. Simultaneously, during installation, the tapered crests C**26-34** of the lock grooves **26-34** swage into the first plain bore **44** of the sleeve **12** progressively. This has the effect of creating increased friction between pin **16** and the sleeve **12**. The outside diameter of the sleeve **12** is also expanded to close the aligned opening hole clearance of the workpieces W. When the bulb **50** of the sleeve **12** is fully bulbed, the installation force will break the pin **16**. The pin **16** will break at the nearest exposed groove **26-34** to the head **38** of the sleeve **12**, and this is assisted by the protruding cone **42** of head **38** being flattened into the first plain bore **44**. The displaced material of the protruding cone **42** of head **38** of the sleeve **14**, which is displaced into the first plain bore **44**, clamps on the pin **16**, which increases the retention of the pin **16** and the fastener's **10** tensile strength.

[0026] It will be understood that the embodiments described herein are merely exemplary and that a person skilled in the art may make many variations and modifications without departing from the spirit and scope of the invention. All such variations and modifications are intended to be included within the scope of the invention as defined in the appended claims.

What is claimed is:

1. A fastener, comprising:

a pin member having a first end and a second end opposite the first end, a head at the first end, a pintail portion at the second end and having a plurality of pull grooves, and a shank intermediate the head and the pintail portion, the shank having a locking portion with a first end located proximate to the head and a second end opposite the first end of the locking portion, the locking portion having a plurality of lock grooves formed by a plurality of crests and a plurality of roots, each of the plurality of crests includes a first diameter, the first diameters of the plurality of crests sequentially increase from the second end of the locking portion to the first end of the locking portion, each of the plurality of roots includes a second diameter, the second diameters of the plurality of roots sequentially decrease from the second end of the locking portion to the first end of the locking portion;

a sleeve having a tubular portion having a first end a second end opposite the first end of the tubular portion, a through bore extending from the first end of the tubular portion to the second end of the tubular portion, and a head located at the first end of the tubular portion,

wherein the sleeve is adapted to receive the pin member such that the shank of the pin member is inserted within the through bore of the sleeve and the head of the pin member engages the second end of the tubular portion of the sleeve member, wherein the fastener is adapted to be installed within aligned holes of a plurality of workpieces in an installed position such that the head of the sleeve engages an accessible side of one of the workpieces, and a section of the tubular portion proximate to second end of the sleeve is deformed into a bulb that engages a blind side of another of the workpieces, and wherein the pintail portion of the pin member breaks off at one of the plurality of grooves located substantially flush with the head of the sleeve.

2. The fastener of claim **1**, wherein each of the plurality of crests includes a flank angle that tapers in a direction towards the head of the pin member.

3. The fastener of claim **2**, wherein the flank angles of the plurality of crests are sequentially steeper from the second end of the locking portion of the pin member to the first end of the locking portion of the pin member.

4. The fastener of claim **3**, wherein each of the plurality of lock grooves includes a barbed shape.

5. The fastener of claim **4**, wherein the head of the sleeve includes a cone, and wherein when the fastener is in its installed position, the cone is deformed into the through bore of the sleeve and clamps around the pin member.

6. The fastener of claim **5**, wherein the pin member includes a smooth cylindrical section intermediate the head of the pin member and the locking portion of the pin member, and wherein the bulb of the sleeve is formed adjacent to the smooth cylindrical section of the pin member.

7. The fastener of claim **6**, wherein the head of the pin member includes a conical-shaped underside.

8. The fastener of claim **6**, wherein the through bore of the sleeve includes a first bore extending from the first end of the sleeve at a location intermediate the first and second ends of the sleeve, and a second bore extending from the second end of the sleeve to the first bore, wherein an inner diameter of the second bore is greater than the inner diameter of the first bore.

9. The fastener of claim **8**, wherein the inner diameter of the first bore corresponds to the smallest of the first diameters of the plurality of crests of the plurality of lock grooves, and the inner diameter of the second bore of the sleeve has an interference fit on the largest of the first diameters of the plurality of crests of the plurality of lock grooves.

10. A fastener, comprising:

a pin member having a first end and a second end opposite the first end, a head at the first end, a pintail portion at the second end and having a plurality of pull grooves, and a shank intermediate the head and the pintail portion, the shank having a locking portion with a first end located proximate to the head and a second end opposite the first end of the locking portion, the locking portion having a plurality of lock grooves formed by a plurality of crests and a plurality of roots, the plurality of roots including a first group of roots and a second group of roots, each of the plurality of crests includes a first diameter, the first diameters of the plurality of crests sequentially increase from the second end of the locking portion to the first end of the locking portion, each of the plurality of roots includes a second diameter, the second diameters of the first group of roots sequentially decrease from the second end of the locking portion towards the first end of the locking portion, and the second diameters of the second group of roots being equal to one another and greater than the second diameters of the first group of roots;

a sleeve having a tubular portion having a first end a second end opposite the first end of the tubular portion, a through bore extending from the first end of the tubular portion to the second end of the tubular portion, and a head located at the first end of the tubular portion,

wherein the sleeve is adapted to receive the pin member such that the shank of the pin member is inserted within the through bore of the sleeve and the head of the pin member engages the second end of the tubular portion of the sleeve member, wherein the fastener is adapted to be installed within aligned holes of a plurality of workpieces in an installed position such that the head of the sleeve engages an accessible side of one of the workpieces, and a section of the tubular portion proximate to second end of the sleeve is deformed into a bulb that engages a blind side of another of the workpieces, and wherein the pintail portion of the pin member breaks off at one of the plurality of grooves located substantially flush with the head of the sleeve.

11. The fastener of claim **10**, wherein the second group of roots includes two of the roots.

12. The fastener of claim **10**, wherein the second group of roots includes three of the roots.

13. The fastener of claim **10**, wherein each of the plurality of crests includes a flank angle that tapers in a direction towards the head of the pin member.

14. The fastener of claim **13**, wherein the flank angles of the plurality of crests are sequentially steeper from the second end of the locking portion of the pin member to the first end of the locking portion of the pin member.

15. The fastener of claim **14**, wherein each of the plurality of lock grooves includes a barbed shape.

16. The fastener of claim **15**, wherein the head of the sleeve includes a cone, and wherein when the fastener is in its installed position, the cone is deformed into the through bore of the sleeve and clamps around the pin member.

17. The fastener of claim **16**, wherein the pin member includes a smooth cylindrical section intermediate the head of the pin member and the locking portion of the pin member, and wherein the bulb of the sleeve is formed adjacent to the smooth cylindrical section of the pin member.

18. The fastener of claim **17**, wherein the head of the pin member includes a conical-shaped underside.

19. The fastener of claim **17**, wherein the through bore of the sleeve includes a first bore extending from the first end of the sleeve at a location intermediate the first and second ends of the sleeve, and a second bore extending from the second end of the sleeve to the first bore, wherein an inner diameter of the second bore is greater than the inner diameter of the first bore.

20. The fastener of claim **19**, wherein the inner diameter of the first bore corresponds to the smallest of the first diameters of the plurality of crests of the plurality of lock grooves, and the inner diameter of the second bore of the sleeve has an interference fit on the largest of the first diameters of the plurality of crests of the plurality of lock grooves.

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