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(54) Title: LOCKBOLT FASTENING SYSTEM

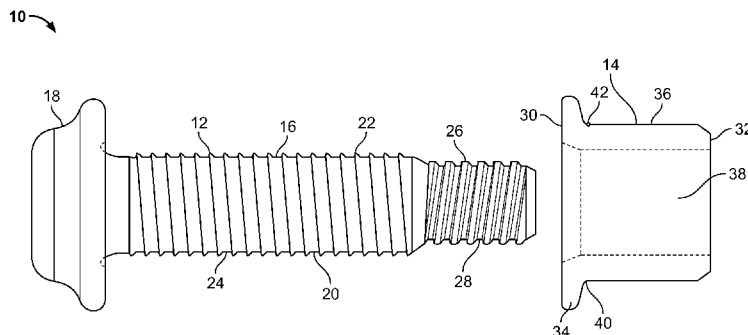


FIG. 1

(57) Abstract: A swage collar (14) includes a shank (36), a flange (34), and a through bore (38). The shank (36) includes a first end (30), a second end (32) opposite the first end (30), an outside diameter (44), and an overall length (50) between the first end (30) and the second end (32). The flange (34) extends from the first end (30) of the shank (36). The through bore (38) extends longitudinally through the shank (36) from the first end (30) of the shank (36) to the second end (32) of the shank (36). The through bore (38) defines an inside diameter (46). The inside diameter (46) and the outside diameter (44) together define a wall thickness (48) of the shank (36). The wall thickness (48) of the shank (36) is in a range of about 0.1 times the overall length (50) of the shank (36) to about 0.16 times the overall length (50) of the shank (36).



LOCKBOLT FASTENING SYSTEM

Cross-Reference to Related Application

This application relates to and claims the benefit of commonly-owned, co-
5 pending, co-pending U.S. Provisional Patent Application Serial No. 62/318,329, filed
April 5, 2016, entitled "LOCKBOLT SYSTEM WITH OPTIMIZED CLAMP AND TENSILE
STRENGTH," the content of which is incorporated herein by reference in its entirety.

Technical Field of the Invention

10 The present invention relates to fasteners and, more particularly, a lockbolt
fastening system including a pin member and a swage collar adapted to be swaged
onto the pin member.

Background of the Prior Art

15 Two-piece swaged fasteners, commonly referred to as lockbolts, are used to
secure a plurality of workpieces together. Typically, swage-type fasteners include a pin
member having lock grooves and a swage collar adapted to be swaged into the lock
grooves of the pin member by a fastener installation tool. Once installed, a swage-type
fastener should provide a high tensile strength and a high clamp load on a plurality of
20 workpieces secured together thereby.

Disclosure of the Invention

In an embodiment, a swage collar includes a shank, a flange, and a through bore, the shank including a first end, a second end opposite the first end, an outside diameter, and an overall length between the first end and the second end, the flange
5 extending from the first end of the shank, the through bore extending longitudinally through the shank from the first end of the shank to the second end of the shank, the through bore defining an inside diameter, the inside diameter and the outside diameter together defining a wall thickness of the shank, the wall thickness of the shank being in
10 a range of about 0.1 times the overall length of the shank to about 0.16 times the overall length of the shank.

In an embodiment, the wall thickness of the shank is a range of about 0.13 times the overall length of the shank to about 0.14 times the overall length of the shank. In an embodiment, the swage collar is made from either low-carbon steel or medium-carbon steel. In an embodiment, the swage collar is as-headed. In an embodiment, the swage
15 collar is thermally processed. In an embodiment, the swage collar also includes an internal fit-up tab.

In an embodiment, a swage collar includes a shank, a flange, and a through bore, the shank having a first end, a second end opposite the first end, an outside diameter, and an overall length between the first end and the second end of the shank,
20 the flange extending from the first end of the shank to a flange endpoint that is located intermediate the first end of the shank and the second end of the shank, the flange endpoint defining a swage length of the shank between the flange endpoint and the second end of the shank, the through bore extending longitudinally through the shank

from the first end of the shank to the second end of the shank, the through bore defining an inside diameter, the inside diameter and the outside diameter together defining a wall thickness of the shank, the swage length of the shank being in a range of about 5 times the wall thickness of the shank to about 7.5 times the wall thickness of the shank.

5 In an embodiment, the swage length of the shank is in a range of about 6.0 times the wall thickness of the shank to about 7.0 times the wall thickness of the shank. In an embodiment, the swage length of the shank is a range of from about 6.25 times the wall thickness of the shank to about 6.67 times the wall thickness of the shank. In an embodiment, the swage collar is made from either low-carbon steel or medium-carbon
10 steel. In an embodiment, the swage collar is as-headed. In an embodiment, the swage collar is thermally processed. In an embodiment, the swage collar also includes an internal fit-up tab.

In an embodiment, a fastener includes a pin member and a swage collar, the pin member having an elongated shank portion having a first end and a second end
15 opposite the first end, a head at the first end, a pull portion at the second end, and a plurality of lock grooves intermediate the first and second ends of the shank portion, the swage collar including a shank, a flange, and a through bore, the shank having a first end, a second end opposite the first end of the shank of the swage collar, an outside diameter, and an overall length between the first end of the shank of the swage collar
20 and the second end of the shank of the swage collar, the flange extending from the first end of the shank of the swage collar to a flange endpoint intermediate the first and second ends of the shank of the swage collar, the flange endpoint defining a swage length of the shank of the swage collar between the flange endpoint and the second end

of the shank of the swage collar, the through bore extending longitudinally through the shank of the swage collar from the first end of the shank of the swage collar to the second end of the shank of the swage collar, the through bore defining an inside diameter, the inside diameter and the outside diameter together defining a wall
5 thickness of the shank of the swage collar, the swage length of the shank of the swage collar being in a range of about 5 times the wall thickness of the shank of the swage collar to about 7.5 times the wall thickness of the shank of the swage collar.

In an embodiment, the swage length of the shank of the swage collar is in a range of about 6.3 times the wall thickness of the shank of the swage collar to about 6.6
10 times the wall thickness of the shank of the swage collar. In an embodiment, the shank portion of the pin member includes a threaded portion having a plurality of threads, and wherein the lock grooves are formed by the plurality of threads. In an embodiment, the pin member is a Class 10.9 strength level bolt. In an embodiment, the swage collar is made from either low-carbon steel or medium-carbon steel. In an embodiment, the
15 swage collar is as-headed. In an embodiment, the swage collar is thermally processed.

Brief Description of the Figures

FIG. 1 is a side elevational view of a swage-type lockbolt fastening system constructed in accordance with an embodiment of the present invention;

20 **FIG. 2** is a side cross-sectional view of a swage collar employed by the lockbolt fastening system shown in **FIG. 1**;

FIG. 3 is a side elevational view of the lockbolt fastening system shown in **FIG. 1** installed in aligned holes in a plurality of workpieces which are shown in cross-section;

FIG. 4 is a graph showing swage load as plotted against swage anvil displacement during installation of the swage-type lockbolt fastening system shown in **FIG. 1**; and

FIG. 5 is a computerized axial tomography (“CAT”) scan image showing the lock grooves of a pin member as filled by the material of the exemplary swage collar of **FIG. 1** after swaging.

Best Mode of Carrying out the Invention

Referring to **FIG. 1**, in an embodiment, a fastener **10** includes a pin member **12** and a swage collar **14** that is sized and shaped to mate with and be swaged onto the pin member **12**. In an embodiment, the pin member **12** includes an elongated shank portion **16** which terminates at one end in a head **18**. In an embodiment, the shank portion **16** includes a threaded portion **20** having a plurality of threads **22** with lock grooves **24** formed between the threads **22**. In an embodiment, the threaded portion **20** includes a single thread **22**. In another embodiment, the threaded portion **20** includes at least one lock groove **24**. In another embodiment, the threaded portion includes a single lock groove **24**. In an embodiment, the shank portion **16** includes a pull portion **26** having a plurality of pull grooves **28**. In an embodiment, the pull grooves **28** are helical grooves. In another embodiment, the pull grooves **28** are annular grooves. In an embodiment, the pull grooves **28** are formed perpendicular to a longitudinal axis of the pin member **12**. In another embodiment, the pull grooves **28** are formed obliquely to the longitudinal axis of the pin member **12**. In an embodiment, the pull grooves **28** are formed obliquely to the longitudinal axis of the pin member **12** and in an angular

direction opposite to that of the threads **22** of the threaded portion **20**. In an embodiment, the pull grooves **28** are formed obliquely to the longitudinal axis of the pin member **12** and in an angular direction the same or substantially the same as that of the threads **22** of the threaded portion **20**. In another embodiment, the pull portion **26** includes at least one pull groove **28**. In another embodiment, the pull portion includes a single pull groove **28**. In an embodiment, the pin member **12** is made from medium carbon alloy steel. In an embodiment, the pin member **12** is a Class 10.9 strength level bolt. In other embodiments, the bolt **12** can be characterized by any grade known in the art, such as, for example, Grade 2, Grade 5, Grade 8, Class 8.8, and Class 10.9. In other embodiments, the pin member **12** may be made from other suitable materials known in the art.

Still referring to **FIG. 1**, in an embodiment, the swage collar **14** includes a first end **30** and a second end **32** opposite the first end **30**. The swage collar **14** includes a circumferentially extending flange **34** at the first end **30** and a tubular-shaped shank **36** extending from the flange **34** to the second end **32** of the swage collar **14**. A through bore **38** extends from the first end **30** to the second end **32**. In an embodiment, the shank **36** includes a generally uniform, cylindrical configuration. In an embodiment, the swage collar **14** includes a curved transition area **40** between the shank **36** and the flange **34**. In an embodiment, the swage collar **14** may include an internal fit-up tab (not shown in the Figures). In another embodiment, the swage collar **14** may lack an internal fit-up tab.

In an embodiment, a point **42** is located where the shank **36** meets the curved transition area **40**. It will be apparent to those of skill in the art that the point **42** is

merely a reference point discussed herein for the purpose of enabling a full description of the swage collar **14**, and is not a physical element of the swage collar **14**. It will also be apparent to those of skill in the art that the point **42** is not located at any specific point around the circumference of the cylindrical shank **36**, but may be located at any point around the circumference of the cylindrical shank **36** at the axial location described above (i.e., where the shank **36** meets the curved transition area **40**). The point **42** may alternately be referred to as a flange endpoint of the flange **34**.

It will be apparent to those of skill in the art that pin members and corresponding swage collars (e.g., the pin member **12** and the swage collar **14**) may be produced in a variety of sizes appropriate for installation in correspondingly sized aligned holes within a plurality of workpieces in order to secure together such workpieces.

FIG. 2 illustrates a cross-sectional view of the swage collar **14**. The shank **36** has an outside diameter **44**. The through bore **38** defines an inside diameter **46**. A wall **47** having a wall thickness **48** is formed by the through bore **38**. The swage collar **14** has an overall length **50** between the first end **32** and the second end **34**. The swage collar **14** has a nominal size. In an embodiment, the swage collar **14** includes a swage length **54** that is the length from the point **42** to the second end **34**. In an embodiment, the above-noted measurements for various sizes of the swage collar **14** are as shown in the following table:

20

Nominal Size	Overall Length 50	Swage Length 54	Inside Diameter 46	Outside Diameter 44	Wall Thickness 48
12 mm	22.4 mm	19.8 mm	12.2 mm	18.4 mm	3.1 mm
16 mm	29.8 mm	26.4 mm	16.2 mm	24.3 mm	4.1 mm
20 mm	37.3 mm	33.0 mm	20.3 mm	30.4 mm	5.1 mm

In each of the above-noted sizes of the swage collar **14**, the wall thickness **48** is in a range from about 0.1 to 0.4 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.1 to about 0.35 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.1 to about 0.3 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.1 to about 0.26 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.15 to about 0.4 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.15 to about 0.35 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.15 to about 0.3 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.15 to about 0.26 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.2 to about 0.4 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.2 to about 0.35 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.2 to about 0.3 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.2 to about 0.26 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.24 to about 0.4 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.24 to about 0.35 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.24 to about 0.3 times the inside diameter **46**. In an embodiment, the wall thickness **48** is in a range from about 0.24 to about 0.26 times the inside diameter **46**.

In each of the above-noted sizes of the exemplary collar **14**, the wall thickness **48** is in a range from about 0.1 to about 0.2 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.1 to about 0.16 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.1 to about 0.15 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.1 to about 0.14 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.11 to about 0.16 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.11 to about 0.15 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.11 to about 0.14 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.12 to about 0.16 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.12 to about 0.15 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.12 to about 0.14 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.13 to about 0.16 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.13 to about 0.15 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.13 to about 0.14 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.13 to about 0.15 times the overall length **50**. In an embodiment, the wall thickness **48** is in a range from about 0.135 to about 0.14 times the overall length **50**.

In each of the above-noted sizes of the exemplary collar **14**, the swage length **54** is in a range from about 5.0 to 7.5 times the wall thickness **48**. In an embodiment, the swage length **54** is in a range from about 5.0 to 7.0 times the wall thickness **48**. In an

embodiment, the swage length **54** is in a range from about 5.0 to 6.5 times the wall thickness **48**. In an embodiment, the swage length **54** is in a range from about 5.5 to 7.5 times the wall thickness **48**. In an embodiment, the swage length **54** is in a range from about 5.5 to 7.0 times the wall thickness **48**. In an embodiment, the swage length **54** is in a range from about 5.5 to 6.5 times the wall thickness **48**. In an embodiment, the swage length **54** is in a range from about 6.0 to 7.5 times the wall thickness **48**. In an embodiment, the swage length **54** is in a range from about 6.0 to 7.0 times the wall thickness **48**. In an embodiment, the swage length **54** is in a range from about 6.0 to 6.7 times the wall thickness **48**. In an embodiment, the swage length **54** is in a range from about 6.0 to 6.5 times the wall thickness **48**. In an embodiment, the swage length **54** is in a range from about 6.3 to 7.5 times the wall thickness **48**. In an embodiment, the swage length **54** is in a range from about 6.3 to 7.0 times the wall thickness **48**. In an embodiment, the swage length **54** is in a range from about 6.3 to 6.6 times the wall thickness **48**. In an embodiment, the swage length **54** is in a range from about 6.25 to 6.67 times the wall thickness **48**.

In an embodiment, the swage collar **14** is made of low carbon steel. In another embodiment, the swage collar **14** is made from unannealed low carbon steel. In another embodiment, the swage collar **14** is made from annealed low carbon steel. In another embodiment, the swage collar **14** is made from medium carbon steel. In another embodiment, the swage collar **14** is made from medium carbon steel that has been thermally processed. In another embodiment, the swage collar **14** is "as-headed" and does not require thermal processing. As employed herein, the term "as-headed" refers to a collar which is strain hardened, for example, from cold working, rather than

changing hardness using a thermal process (e.g., quench and tempering; stress relieving; etc.). In another embodiment, the swage collar **14** is thermally processed. In an embodiment, the thermal processing of the swage collar **14** includes quench and tempering. In an embodiment, the thermal processing of the swage collar **14** includes stress relieving.

Referring to **FIG. 3**, in an embodiment, the swage collar **14** and the pin member **12** are adapted to secure a plurality of workpieces **56, 58** together. In an embodiment, the shank portion **16** of the pin member **12** is inserted through aligned holes of the workpieces **56, 58**, with the head **18** abutting one side **60** of the workpiece **56** and the shank portion **16** extending outwardly from one side **62** of the workpiece **58**. In an embodiment, the swage collar **14** is fitted on the shank portion **16** of the pin member **12**, whereby the shank portion **16** is inserted within the through bore **38** of the collar **14** (as shown in **FIG. 2**). The swage collar **14** is fitted on the pin member **12** until the flange **36** of the collar **14** abuts the side **62** of the workpiece **58**.

In an embodiment, the pull grooves **28** of the pull portion **28** of the pin member **12** are adapted to be gripped by matching teeth of chuck jaws of a fastener installation tool having a swage anvil (not shown in the Figures). In an embodiment, the fastener installation tool may consist of the tools disclosed and described in U.S. Patent No. 7,293,339 to Mercer et al. In an embodiment, the swage anvil of the tool is adapted to engage the swage collar **14** and apply a relative axial force between the collar **14** and the pin member **12**, and to move over the collar **14** and swage it into the lock grooves **24** of the pin member **12** (not shown in the Figures). **FIG. 3** shows the collar **14** fully installed on the pin member **12**.

FIG. 4 shows a graph showing the relationship of the swage load on the exemplary fastener **10** during installation (as shown along the vertical axis) to the displacement of a swage anvil that is swaging the exemplary fastener **10** (as shown along the horizontal axis). It may be seen that the exemplary fastener **10** swages at a relatively constant load throughout the installation thereof.

FIG. 5 shows a CAT scan image **200** showing the lock grooves **24** of the pin member **12** as filled by the material of the swage collar **14** after swaging. It is shown that spaces within the lock grooves **24** of the pin member **12** are filled to a fill level of between about 75% and about 90%. The clamp strength and tensile strength of a swage fastener increase as the fill level of the lock grooves increases. Consequently, the exemplary fastener **10** can provide high clamp strength to the fastened workpieces **56, 58**. In an embodiment, the exemplary fastener **10** having the pin member **12** that is a class 10.9 strength level bolt can achieve a higher clamp load than that specified by the ASTM International F568M standard for class 10.9 strength level bolts. In an embodiment, the exemplary fastener **10** having the pin member **12** that is a class 10.9 strength level bolt can achieve a clamp load comparable to that specified by the ASTM International F568M standard for class 12.9 strength level bolts. In an embodiment, the exemplary fastener **10** can achieve such a clamp load with the swage collar **14** that is as-headed and not thermally processed. It will be apparent to those of skill in the art that the pin member **12** can have a strength level other than a class 10.9 strength level bolt, and that clamp loads greater than those specified by applicable standards can also be achieved for such bolts as implemented in the exemplary fastener **10** including the swage collar **14**.

It should 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. Accordingly, all such variations and modifications are intended to be included within the scope of the

5 embodiments described herein.

CLAIMS

What is claimed is:

1. A swage collar, comprising:
 - 5 a shank having a first end, a second end opposite the first end, an outside diameter, and an overall length between the first end and the second end;
 - a flange extending from the first end of the shank; and
 - a through bore extending longitudinally through the shank from the first end of the shank to the second end of the shank, the through bore defining an inside diameter,
10 the inside diameter and the outside diameter together defining a wall thickness of the shank,
wherein the wall thickness of the shank is in a range of about 0.1 times the overall length of the shank to about 0.16 times the overall length of the shank.
- 15 2. The swage collar of Claim 1, wherein the wall thickness of the shank is a range of about 0.13 times the overall length of the shank to about 0.14 times the overall length of the shank.
3. The swage collar of Claim 1, wherein the swage collar is made from either low-
20 carbon steel or medium-carbon steel.
4. The swage collar of Claim 3, wherein the swage collar is as-headed.

5. The swage collar of Claim 3, wherein the swage collar is thermally processed.
6. The swage collar of Claim 1, further comprising an internal fit-up tab.
- 5 7. A swage collar, comprising:
- a shank having a first end, a second end opposite the first end, an outside diameter, and an overall length between the first end and the second end of the shank;
- a flange extending from the first end of the shank to a flange endpoint that is located intermediate the first end of the shank and the second end of the shank, the
10 flange endpoint defining a swage length of the shank between the flange endpoint and the second end of the shank; and
- a through bore extending longitudinally through the shank from the first end of the shank to the second end of the shank, the through bore defining an inside diameter, the inside diameter and the outside diameter together defining a wall thickness of the
15 shank,
- wherein the swage length of the shank is in a range of about 5 times the wall thickness of the shank to about 7.5 times the wall thickness of the shank.
8. The swage collar of Claim 7, wherein the swage length of the shank is in a range
20 of about 6.0 times the wall thickness of the shank to about 7.0 times the wall thickness of the shank.

9. The swage collar of Claim 8, wherein the swage length of the shank is a range of from about 6.3 times the wall thickness of the shank to about 6.6 times the wall thickness of the shank.
- 5 10. The swage collar of Claim 7, wherein the swage collar is made from either low-carbon steel or medium-carbon steel.
11. The swage collar of Claim 10, wherein the swage collar is as-headed.
- 10 12. The swage collar of Claim 10, wherein the swage collar is thermally processed.
13. The swage collar of Claim 7, further comprising an internal fit-up tab.
14. A fastener, comprising:
- 15 a pin member having an elongated shank portion having a first end and a second end opposite the first end, a head at the first end, a pull portion at the second end, and a plurality of lock grooves intermediate the first and second ends of the shank portion; and
- a swage collar including
- 20 a shank having a first end, a second end opposite the first end of the shank of the swage collar, an outside diameter, and an overall length between the first end of the shank of the swage collar and the second end of the shank of the swage collar,

a flange extending from the first end of the shank of the swage collar to a flange endpoint intermediate the first and second ends of the shank of the swage collar, the flange endpoint defining a swage length of the shank of the swage collar between the flange endpoint and the second end of the shank of the swage collar,

and a through bore extending longitudinally through the shank of the swage collar from the first end of the shank of the swage collar to the second end of the shank of the swage collar, the through bore defining an inside diameter, the inside diameter and the outside diameter together defining a wall thickness of the shank of the swage collar,

wherein the swage length of the shank of the swage collar is in a range of about 5 times the wall thickness of the shank of the swage collar to about 7.5 times the wall thickness of the shank of the swage collar.

15. The fastener of Claim 14, wherein the swage length of the shank of the swage collar is in a range of about 6.25 times the wall thickness of the shank of the swage collar to about 6.67 times the wall thickness of the shank of the swage collar.

16. The fastener of Claim 14, wherein the shank portion of the pin member includes a threaded portion having a plurality of threads, and wherein the lock grooves are formed by the plurality of threads.

17. The fastener of Claim 14, wherein the pin member is a Class 10.9 strength level bolt.

18. The fastener of Claim 14, wherein the swage collar is made from either low-
5 carbon steel or medium-carbon steel.

19. The fastener of Claim 18, wherein the swage collar is as-headed.

20. The fastener of Claim 18, wherein the swage collar is thermally processed.

10

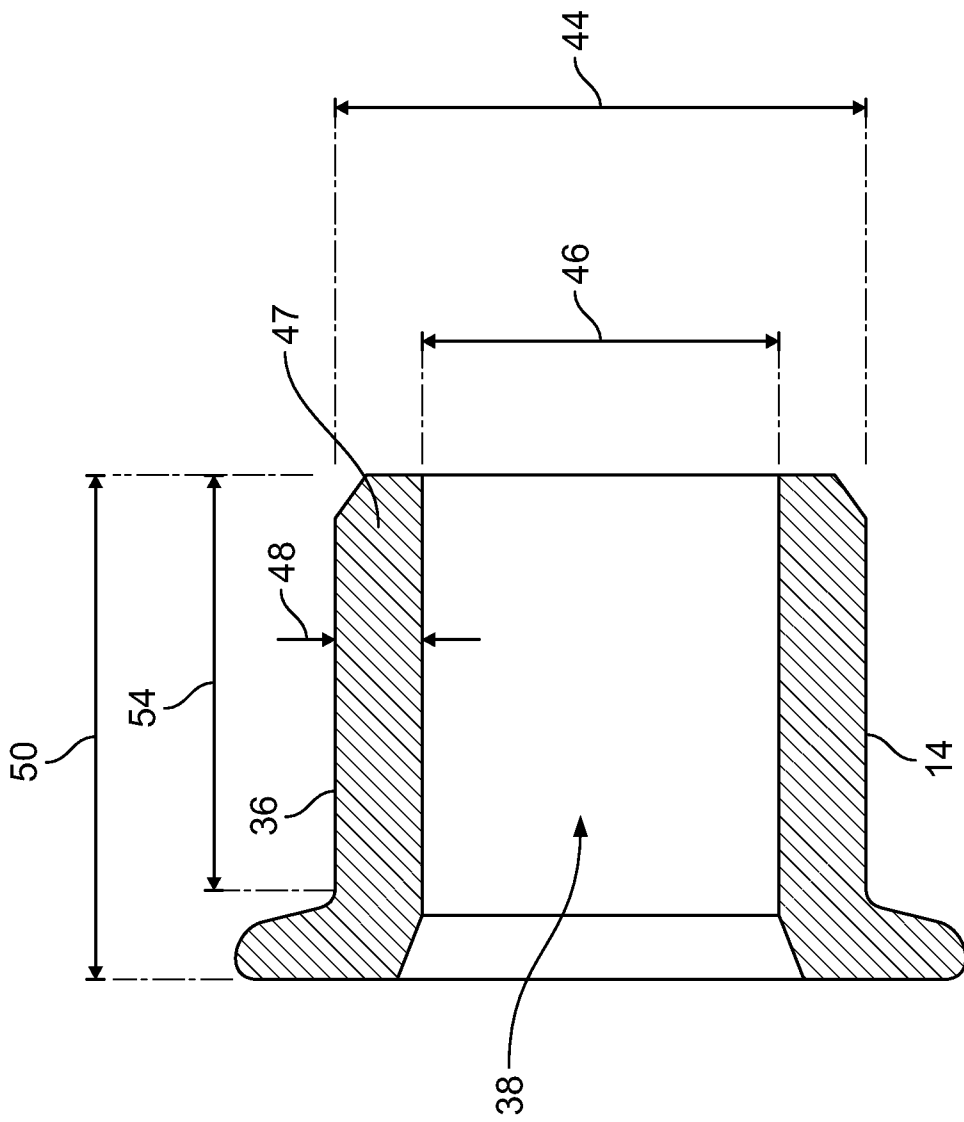


FIG. 2

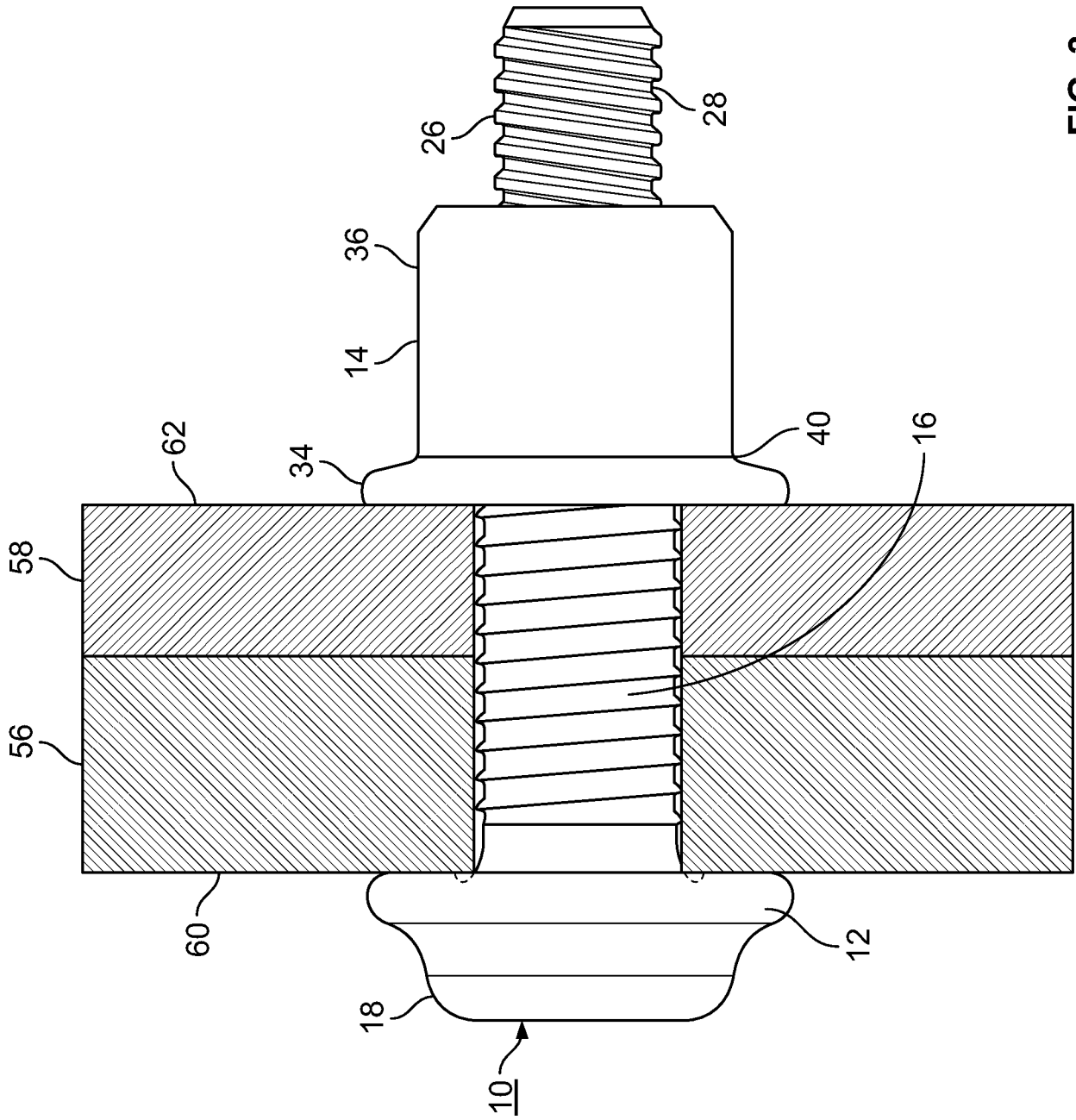


FIG. 3

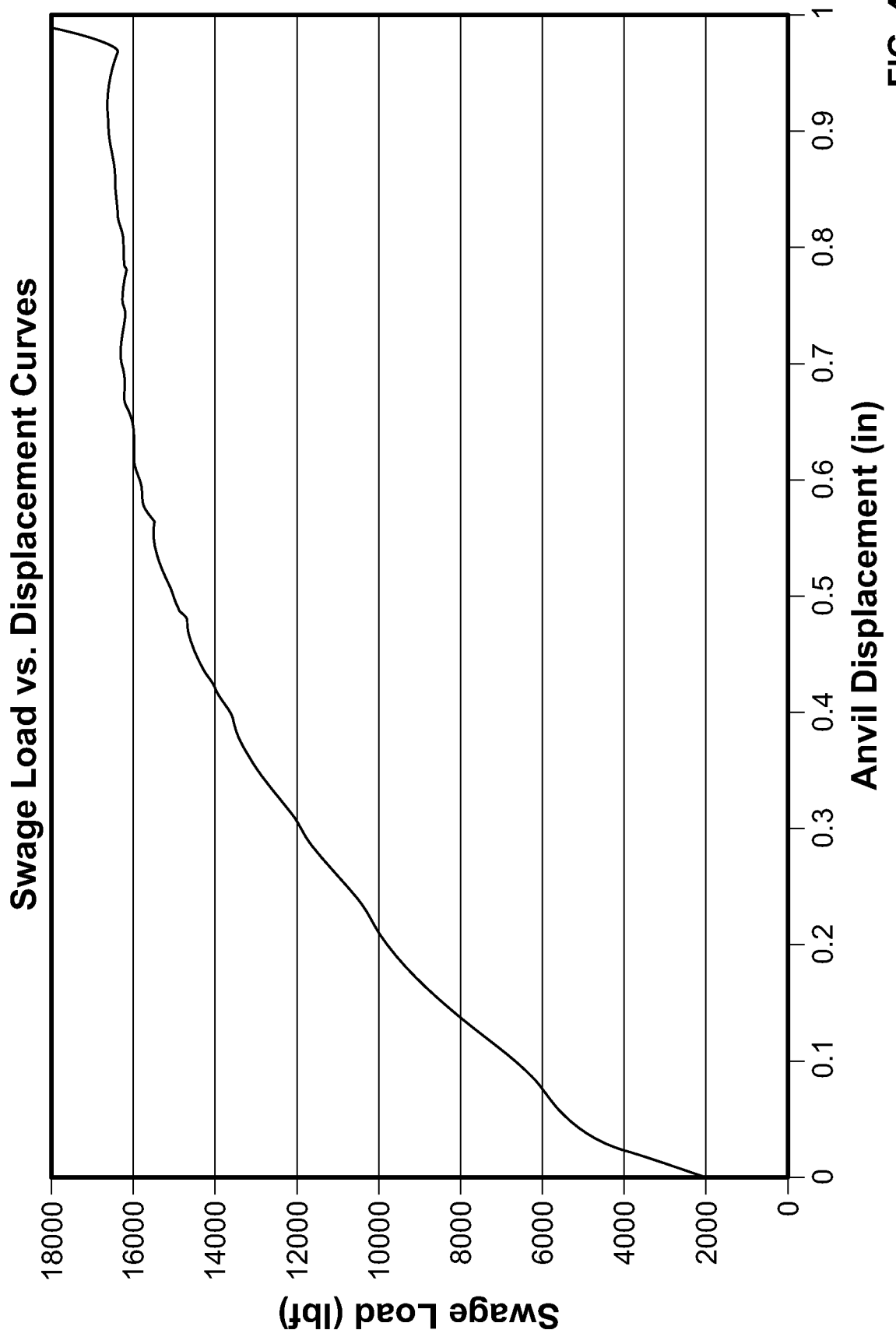


FIG. 4

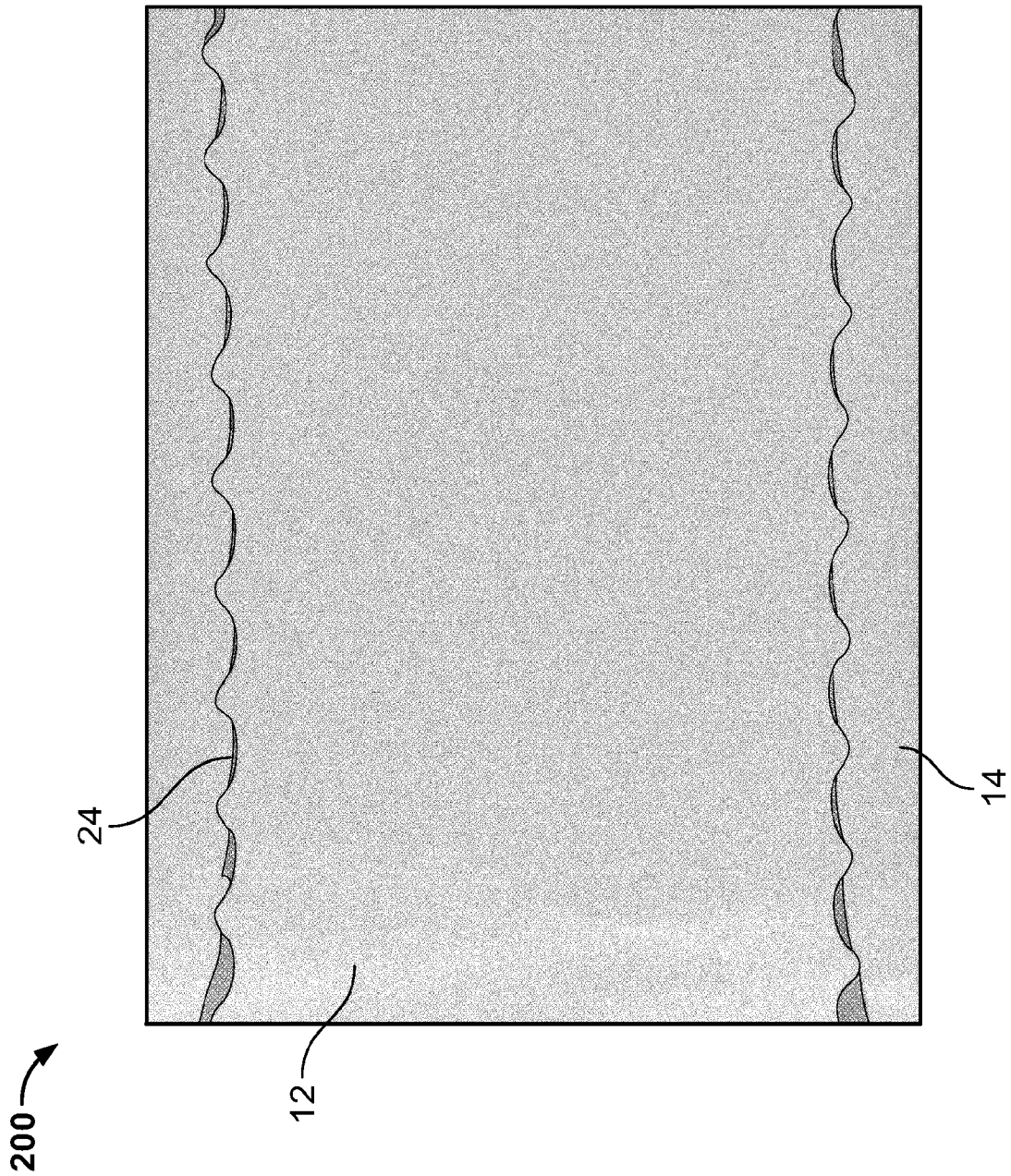


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No PCT/US2017/025927
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A. CLASSIFICATION OF SUBJECT MATTER INV. F16B19/05 B21J15/02 F16B5/04 ADD.				
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) B21J 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 practicable, search terms used) EPO-Internal, WPI Data				
C. DOCUMENTS CONSIDERED TO BE RELEVANT				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
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<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;"><input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C.</td> <td style="width: 50%; border: none;"><input checked="" type="checkbox"/> See patent family annex.</td> </tr> </table>			<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C.	<input checked="" type="checkbox"/> See patent family annex.
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C.	<input checked="" type="checkbox"/> See patent family annex.			
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"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"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 "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family			
Date of the actual completion of the international search	Date of mailing of the international search report			
5 July 2017	17/07/2017			
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Schandel, Yannick			

INTERNATIONAL SEARCH REPORT

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