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(71) Applicant: **PERI AG** [DE/DE]; Rudolf-Diesel-Str. 19,
89264 Weissenhorn (DE).

(72) Inventors: **HUBER, Julian**; Birkenweg 5, 89188 Merklingen
(DE). **READ, Andrew**; Burghaldeweg 1, 89269
Voehringen (DE). **STURM, Florian**; Hoehlgasse 10, 89299
Unterroth (DE).

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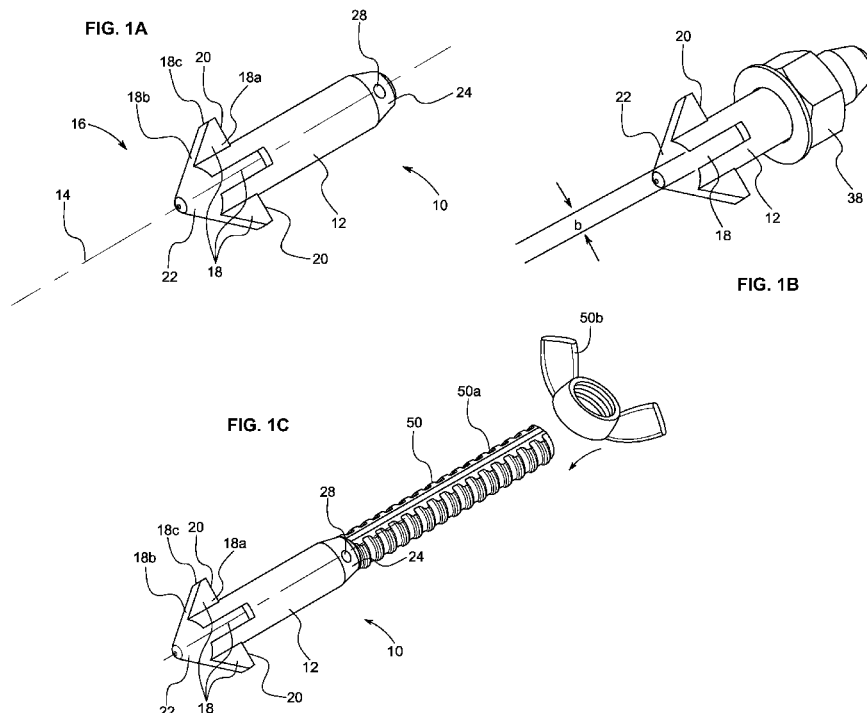
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(54) Title: MULTI-HEAD BOLT AND FASTENER SYSTEM



(57) Abstract: A multi-head bolt (10) having a bolt shaft (12) defining a longitudinal axis (14) of the multi-head bolt and a multi-head (16) disposed at a first end of the bolt shaft, the multi-head having at least three pawls (18), each pawl having a fixed radial orientation relative to the bolt shaft and having a primary plane being aligned with the longitudinal axis of the bolt shaft and having a support surface (20).



MULTI-HEAD BOLT AND FASTENER SYSTEM

5 FIELD OF THE INVENTION

[0001] The present invention relates to a multi-head bolt used as a quick-access-blind-fastener and further to a fastener system including the bolt. In particular, the present invention relates to a fastener system used to connect and align two objects to each other, wherein the fastening action requires access from only one side of the objects. The present invention also provides a method for such aligning and connecting.

BACKGROUND OF THE INVENTION

[0002] Certain fasteners of the prior art generally require access from both sides of the members and the use of two tools – and which is not convenient in certain configurations. In addition, there are known fasteners which, whilst allowing an assembly from one side of the junction only, also draw the members together, being easily removable and re-usable, which can be provided as one assembly and which can be used from either side of the junction. A special configuration of such fastener is also known as a hammer-head bolt, as it shown for example in documents GB 20 2,239,686 A, FR 2,429,885 A1, CN 109518965 A, DE 21 2017 000 250 U1 or US 5,076,748 A. However, the known bolt configuration is inconvenient in view of absorbing shear forces, tensile forces or traction forces that can arise between the panels. In case of the occurrence of lateral shear forces in-between the panels there is always inherently a force component that acts laterally onto the longitudinal axis of the fastener bolt itself what leads to a misalignment of the fastener.

SUMMARY OF THE INVENTION

[0003] The present application provides provide a bolt and a fastener system being improved over the prior art insofar as being able to better divert shearing forces and/or tensile and/or traction forces. At least, the invention shall provide an improved method for an alignment and connection of such objects.

[0004] One aspect of the disclose provides a multi-head bolt, comprising a bolt shaft defining a longitudinal axis of the multi-head bolt; a multi-head disposed at a first end of the bolt shaft, the multi-head comprising at least three pawls, each pawl

having a fixed radial orientation relative to the bolt shaft and having a primary plane being aligned with the longitudinal axis of the bolt shaft and having a support surface.

[0005] In one example, the primary plane for each pawl is parallel to two opposing lateral sides of each respective pawl.

5 [0006] In one example, each pawl has an angled side that intersects the primary plane and wherein a radial distance of the angled side relative to bolt shaft linearly decreases as measured from the support surface to the first end of the bolt.

[0007] In one example, the pawls extend from the bolt shaft in a star-shape configuration symmetrically relative to an outer circumference of the bolt shaft.

10 [0008] In one example, at least one pawl is in the form of a fin.

[0009] In one example, the support surface extends perpendicularly to the longitudinal axis of the bolt shaft, projecting therewith radially from the bolt shaft's outer circumference.

[0010] In one example, at least one pawl is fin-shaped such that the primary
15 plane lies on the longitudinal axis of the bolt shaft and the support surface is perpendicular to the primary plane.

[0011] In one example, a width of at least one pawl is smaller than a diameter of the bolt shaft.

[0012] In one example, the width of the at least one pawl is at least 15% of a
20 diameter of the bolt shaft and at maximum 65% of the diameter of the bolt shaft.

[0013] In one example, the width of the at least one pawl is at least 25% of a diameter of the bolt shaft and at maximum 40% of the diameter of the bolt shaft.

[0014] In one example, the width of the at least one pawl is about 33% of the diameter of the bolt shaft.

25 [0015] In one example, a width defined between the two lateral sides of the at least one pawl is substantially constant along the longitudinal axis.

[0016] In one example, the bolt shaft defines a cone shape at the first end of the bolt shaft.

[0017] In one example, at least a portion of the angled side is coplanar plane
30 to the cone shape of the first end of the bolt shaft.

[0018] In one example, the bolt shaft defines has a cone end at an opposite end relative to the multi-head to facilitate insertion of a nut.

- [0019] In one example, the multi-head bolt further comprises a tension-rod-shank fixed to an end of the bolt shaft opposing the multi-head, on which shank a nut can be screwed.
- [0020] In one example, the at least three pawls comprises four pawls.
- 5 [0021] In one example, the bolt shaft defines a hole extending through the bolt shaft at an opposite end relative to the multi-head a for securing a safety split pin.
- [0022] In one example, the primary plane for each pawl intersects with a support surface of the pawl and an angled edge of the pawl such that the longitudinal axis lies upon the primary plane.
- 10 [0023] In one example, the primary plane for each pawl symmetrically bisects each pawl relative to lateral sides of each pawl.
- [0024] In one example, the lateral sides are oriented at an acute angle relative to the longitudinal axis.
- [0025] In one example, a width between two lateral sides of each pawl
15 decreases as measured from a support surface toward a cone-shaped portion.
- [0026] In one example, the bolt shaft defines a truncated cone shape at the first end of the bolt shaft.
- [0027] In one example, the bolt shaft defines has a hexagonal attachment
20 portion at an opposite end relative to the multi-head to facilitate engagement with a tool.
- [0028] In one example, an opposite end relative to the multi-head defines a plurality of slots defining a + configuration, with each of the plurality of slots aligning with a respective pawl and being configured to provide visual guidance during bolt installation.
- 25 [0029] Another aspect of the disclosure provides a fastener system for connecting and aligning elements together, the system comprising: a multi-head bolt for fastening and aligning the elements, the bolt comprising a bolt shaft defining a longitudinal axis of the multi-head bolt, a multi-head disposed at a first end of the bolt shaft and comprising a plurality of pawls each arranged in a fixed radial orientation
30 relative to the bolt shaft and each having a primary plane being aligned with the longitudinal axis of the bolt shaft and having a support surface; and the plurality of elements each defining an opening extending therethrough, the opening having a shape corresponding to a cross-section profile of the multi-head of the bolt through which opening the multi-head pawls pass.

- [0030] In one example, the fastener system further comprises a fastening element configured to connect the elements in a fixed manner.
- [0031] In one example, the multi-head bolt has an external thread and the fastener element comprises a nut having a female thread fitting onto the external
5 thread of the bolt.
- [0032] In one example, the opening defines cut-outs in a plane direction of the element corresponding to a number and dimension of the plurality of pawls.
- [0033] In one example, at least one pawl is fin-shaped and has a width that is smaller than a diameter of the bolt shaft.
- 10 [0034] In one example, the width of the at least one pawl is at least 15% of a diameter of the bolt shaft and at maximum 65% of the diameter of the bolt shaft.
- [0035] In one example, the width of the at least one pawl is at least 25% of a diameter of the bolt shaft and at maximum 40% of the diameter of the bolt shaft.
- [0036] In one example, the width of the at least one pawl is about 33% of the
15 diameter of the bolt shaft.
- [0037] In one example, a width defined between two lateral sides of the at least one pawl is substantially constant along the longitudinal axis.
- [0038] In one example, the bolt shaft defines a cone shape at the first end of the bolt shaft.
- 20 [0039] In one example, each pawl has an angled side that intersects the primary plane and wherein a radial distance of the angled side relative to bolt shaft linearly decreases as measured from the support surface to the first end of the bolt.
- [0040] In one example, at least a portion of the angled side is coplanar to a cone-shaped portion of the first end of the bolt shaft.
- 25 [0041] In one example, the bolt shaft defines has a cone end at an opposite end relative to the multi-head to facilitate insertion of a nut.
- [0042] In one example, the elements comprise anti-twist-structures in an element surface being adjacent to the openings, in or at which anti-twist-structure a pawl can rest, respectively, after having rotated the bolt around the longitudinal axis
30 and having inserted the bolt through the opening.
- [0043] In one example, the anti-twist structure is a recess in which the pawl can rest, such that when resting in the recess rotational movement of the pawl is prevented when the recess receives the support surface of the pawl.

[0044] In one example, the element comprises at least one twist-stop protruding from a surface of at least one of the elements and preventing rotation of the multi-head bolt around the longitudinal axis after having inserted the bolt through the opening.

5 [0045] In one example, the twist-stop comprises an abutting surface against which a lateral side of the pawl abuts when being inserted and having turned the bolt until abutting the abutting surface.

[0046] In one example, the fastener system comprises a separate plate in which an anti-twist-structure is incorporated and/or at least one twist-stop protruding from the plate is provided, in which plate is to be arranged between the head of the
10 multi-head bolt and an element surface.

[0047] In one example, a number of anti-twist structures and/or a number of twist-stop(s) is less or at least equal to the number of pawls.

[0048] In one example, the pawls are branched off from the bolt shaft in a
15 star-shaped configuration that is essentially symmetrical around an outer circumference of the bolt shaft.

[0049] In one example, the support surface extends essentially perpendicularly to the longitudinal axis of the bolt shaft projecting therewith radially from an outer circumference of the bolt shaft.

20 [0050] In one example, the opening is located in a frame of the element.

[0051] In one example, the elements comprises at least one of a formwork panel or a formwork element.

[0052] Another aspect of the disclosure provides a method of aligning and connecting at least two elements together, comprising: inserting a multi-head bolt
25 through respective openings of a plurality of panels such that a plurality of pawls with a fixed radial orientation relative to the multi-head bolt align with a plurality of cut-outs of the plurality of panels; rotating the multi-head bolt relative to the plurality panels such that the pawls are out of alignment with the plurality of cutouts such that the plurality of panels are secured relative to the multi-head bolt.

30 [0053] In one example, rotating the multi-head bolt comprises rotating the multi-head bolt and retracting the bolt in an opposite direction of an insertion direction until a support surface of the pawls abuts against a surface of one of the elements.

[0054] In one example, the method further comprises fastening the bolt relative to the elements with a fastening element.

BRIEF DESCRIPTION OF THE DRAWINGS

5 [0055] The invention description below refers to the accompanying drawings, of which:

[0056] Fig. 1A is a perspective view of a multi-head bolt according to one or more aspects of the disclosure;

[0057] Fig. 1B is a perspective view of the multi-head bolt of Fig. 1B engaged
10 with a nut according to one or more aspects of the disclosure;

[0058] Fig. 1C is a perspective view of the multi-head bolt of Fig. 1A engaged with an extension shank according to one or more aspects of the disclosure;

[0059] Fig. 2A is a perspective view of a multi-head bolt engaged with a plurality of panels according to one or more aspects of the disclosure;

15 [0060] Fig. 2B is a perspective view of a multi-head bolt engaged with a panel having recesses according to one or more aspects of the disclosure

[0061] Figs. 3A-D depicts various stages of connecting a plurality of panels with a multi-head bolt according to one or more aspects of the disclosure;

[0062] Figs. 4A-E depicts examples of multi-head bolt geometries according
20 to one or more aspects of the disclosure;

[0063] Fig. 5A is a perspective view a multi-head bolt according to one or more aspects of the disclosure;

[0064] Fig. 5B is a side view a multi-head bolt according to one or more aspects of the disclosure; and

25 [0065] Fig. 5C is a rear view a multi-head bolt according to one or more aspects of the disclosure.

DETAILED DESCRIPTION

[0066] Fig. 1A is a perspective view of a multi-head bolt 10 according to one or more aspects of the disclosure and Fig. 1B is a perspective view of the multi-head
30 bolt 10 of Fig. 1A engaged with a nut 38 according to one or more aspects of the disclosure.

[0067] As shown in Fig. 1A, the multi-head bolt 10 (also referred to as bolt 10) has a longitudinal shaft 12 having a multi-head 16 at one end thereof. At least a portion of the longitudinal shaft 12 can be cylindrical or substantially cylindrical and

can define a diameter. The longitudinal shaft 12 can include external threading for engaging with a nut, as described in detail below. In one example, the longitudinal shaft 12 can define a longitudinal axis 14 that is co-axial or substantially co-axial relative to the longitudinal shaft and the longitudinal shaft can define an outer
5 circumference.

[0068] The multi-head 16 has a plurality of pawls 18 that extend radially from the longitudinal axis 14 defined by the longitudinal shaft 12. In the example of Fig. 1A, the multi-head 16 of the bolt 10 includes four pawls 18 that are arranged radially and symmetrically with respect to longitudinal axis 14 and can be arranged in a
10 symmetrical star-shaped configuration around an outer circumference of the shaft 12. In other examples, the bolt 10 can include greater or fewer pawls 18 and can be arranged radially, symmetrically and/or arbitrarily with respect to longitudinal axis 14. For example, the multi-head 16 can include at least or exactly three pawls 18 that can be arranged arbitrarily or radially and symmetrically with respect to longitudinal
15 axis 14. In another example, the multi-head 16 can include at least or exactly five pawls 18 that can be arranged arbitrarily or radially and symmetrically with respect to longitudinal axis 14.

[0069] Each of the pawls 18 can be unitarily and rigidly formed with respect to the longitudinal shaft 12 of the bolt 10 such that each of the pawls 18 has a fixed
20 radial orientation with respect to the longitudinal axis. In this regard, the pawls 18 can be inelastic and immovable relative to the longitudinal shaft 12 of the bolt 10. The pawls 18 can be generally fin-shaped and can be defined by a support surface 20, lateral sides 18a, and angled side 18b. The lateral sides 18a of each respective pawl 18 can be parallel to one another and can be parallel to a plane extending radially with
25 respect to longitudinal axis 14. The lateral sides 18a can extend between the support surface 20, the angled side 18b, and the longitudinal shaft 12. The support surface 20 can be perpendicular to the lateral sides 18a and can extend along a plane that is perpendicular to the longitudinal axis 14.

[0070] The angled side 18b can extend from a cone-shaped portion 22 to the support surface 20. In some examples, the angled side 18b can extend as a continuous
30 surface from the cone-shaped portion 22 to the support surface 20, while in other examples there can be a flat portion 18c between the angled side 18b and support surface 20. The angled side 18b can be coplanar with a cone-shaped portion 22 and can form a continuous, uninterrupted surface with the cone-shaped portion 22 and a

plane coinciding with the angled side 18b can form an angle with the longitudinal axis 14. In one example, the angle can be an acute angle between 5 and 50 degrees and in another example, the angle can be about 45 degrees. While a cone-shaped portion 22 is depicted, it is contemplated that the portion 22 can be a truncated cone shape in other examples.

[0071] The lateral sides 18a can be parallel to each other and can both be parallel with a plane extending radially with respect to the longitudinal axis 14. In this regard, the lateral sides can be perpendicular to the support surface 20. By virtue of the configuration, a radial distance of angled side 18b relative to shaft 12 linearly decreases as measured from support surface 20 toward cone-shaped portion 22.

[0072] At an opposing end of the longitudinal shaft 12 relative to the cone-shaped portion 22 is a cone end 24 that defines a hole 28 therethrough. The hole 28 allows the bolt 10 to be secured by a safety split pin to one or more formwork panels or formwork elements. The cone end 24 facilitates the threading of nut 38 onto the longitudinal shaft.

[0073] As shown in Fig. 1B, the bolt 10 can be engaged with the nut 38 to facilitate engagement with formwork elements (for example one or more beams) and/or formwork panels and/or any pair of elements that can be connected, as will be described in greater detail below. The nut 38 can have a female thread and can have wings to enable hand-tightening.

[0074] A width of the pawls 18, e.g., a distance between opposing lateral sides 18a, is depicted as a width b in Fig. 1B. The width can be measured at any portion of the pawl, and in one example the width can be measured at or near the support surface 20. In one example, the width of pawls 18 is less than a diameter of the shaft 12. In one particular example, the width can be at least 15% of the shaft diameter and at most 65% of the diameter of the shaft. In another example, the width can be in the range of 25% to 40% of the shaft diameter. In yet another example, the width b is approximately 33% of a diameter of the longitudinal shaft 12. In these examples, the diameter of the shaft 12 is measured at a middle portion of the shaft, e.g., a portion that is disposed between the panels 32 when secured thereto. In one example, a width of the pawl can be substantially constant along the longitudinal axis. A width of the pawl influences the load bearing capacity of the bolt in such a way that, the greater the width the greater the load-bearing capacity with respect to higher tensile force. The width also influences load-bearing capacity with respect to transverse force in an

inverse manner, e.g. increasing width reduces load-bearing capacity with respect to transverse force. Above a certain width, almost no additional transverse force can be absorbed.

[0075] In one example, an extension shank 50 is disposed at the end of the shaft opposing the multi-head 16. By way of the extension shank 50, the shaft can be equipped with a tension rod. In another example, the end part of the shaft 12 the multi-head bolt 10 can be equipped with a tension rod. The shank 50 can have an external thread 50a on which a nut 50b can be screwed or the shank 50 can be in the form of an anchor that is to be fixed in the concrete. Such shank 50 is commercially available from DYWIDAG® known under the corresponding trademark DYWIDAG®-extension.

[0076] Each of the pawls 18 can define a primary plane associated therewith, the primary plane being defined as parallel to each of the lateral sides 18a and extending through the pawl 18 such that the longitudinal axis 14 lies on the primary plane. In the example of a four-pawl configuration, the primary plane of a pawl and its opposing pawl are co-planar. In this regard, the primary plane of the pawl 18 can be defined intersecting with the support surface 20 and angled edge 18b such that the longitudinal axis 14 lies upon the primary plane.

[0077] Fig. 2A is a perspective view of a multi-head bolt 10 engaged with a plurality of plates 32 according to one or more aspects of the disclosure and Fig. 2B is a perspective view of plate 32 having recesses according to one or more aspects of the disclosure.

[0078] Each of the plates 32 can engage with formwork panels or formwork elements, or in another example can be integrally formed with the formwork panel or formwork element, for example by welding or the like. Each of the plates 32 (e.g., a frame of the plate 32) define respective an opening 32a for receiving the bolt 10, with the opening 32a corresponding to an outer diameter of the longitudinal shaft 12. The opening 32a of the plates 32 can define cut-outs 34 shaped to receive the pawls 18 and to allow the pawls 18 to pass through the opening 32a. In this regard, the cut-outs 34 are positioned to correspond to radial positions of the pawls 18 and the number of cut-outs 34 corresponds to the number of pawls 18. For example, in the example of three pawls 18, the panel 32 defines three cut-outs 34.

[0079] The plates 32 can also define recesses 36 (e.g., anti-twist structures) that are circumferentially adjacent to the cut-outs 34. In this regard, the recesses 36

do not extend an entire thickness of the plates 32 and have a thickness that is less than the overall thickness of the plate 32. This thickness arrangement creates a space to receive the pawls 18, and in one example, the support surfaces 20, to ensure a locking arrangement, which will be explained in greater detail below. In one example, the
5 recesses 36 can define chamfered edges to provide easier movement and insertion of the pawls 18 relative to the opening 32a and recesses 36. In one example, the recesses 36 can define a stepped design along a thickness direction of the plate 32 corresponding to a shape of the pawls 16. The plates 32 can also include stoppers 30 (e.g., twist-stop(s)) protruding from a surface of the plate 32 and extending above a
10 surface of the plates 32 arranged circumferentially adjacent to the recesses 36 to prevent rotation of the bolt 10 and pawls 18 beyond a locking position and to prevent the respective pawls 18 from aligning with a cut-out 34 different from the cut-out through which it was advanced. In this regard, rotation of the pawls 18 and the multi-head can be prevented or limited when a lateral side 18a (e.g., an abutting surface or any
15 other surface of the pawl) abuts against an abutting surface of the stopper 30. The number of stoppers 30 (e.g., twist-stop(s)) can be less than or at least equal to the number of pawls.

[0080] This provides a stable configuration for diverting a shear force and/or tension force from the bolt 10 to the plate 32. In the example of a star-like
20 arrangement of the at least three pawls around the bolt shaft, any shear force is diverted in the plane of the panel irrespective from which direction it is caused. This provides a positive high clamp load and, in particular by virtue of the at least three pawls a high capability to absorb shear loads and/or tension loads aiding therewith to divert any shear force and/or tension force into those objects as fastened by the
25 system, e.g., onto the panel's surface

[0081] Figs. 3A-D depict various stages of connecting a plurality of plates 32 with a multi-head bolt 10 according to one or more aspects of the disclosure.

[0082] As shown in Fig. 3A, the bolt 10 is inserted into both of the respective openings 32a defined by the plates 32. In this regard, each of the pawls 18 of the
30 multi-head 16 are aligned with the corresponding cut-outs 34 of the plates 32, allowing the pawls 18 and the bolt 10 to pass through the openings 32a.

[0083] By virtue of the relationship between cone-shaped portion 22 and angled edge 18b, the bolt 10 can be easily inserted through the openings 32a of the plates 32. Further, if the plates 32 are slightly out of alignment, the bolt 10 and the

cone-shaped portion 22 and pawls 18 provide a centering function between the plates 32. For example, if the plates 32 are slightly out of alignment, pushing the bolt 10 with truncated cone 22 will automatically orient the plates 32 such that the openings 32a are aligned since the bolt 10 can only pass through the openings 32a and the pawls 18 can only pass through the cut-outs 34 when they are in alignment.

5 [0084] As shown in Fig. 3B, the bolt 10 has been inserted into both plates 32 and will be rotated according to the directional arrow. The pawls 18 having previously been aligned with cut-outs 34 will rotate out of position with cut-outs 34 and the support surfaces 20 of the pawls will engage with a face of the plate 32 (or within 10 recesses 36, for example by retracting the bolt in a direction opposite of the insertion direction and allowing the pawls to rest and engage within the space defined by the recesses and preventing further rotation).

[0085] As shown in Fig. 3C, the bolt has been rotated (e.g., by 45 degrees or a geometric multiple) and the pawls 18 are 45 degrees out of alignment with the cut- 15 outs 34, thereby preventing the bolt 10 from being removed from the plates 32 without additional rotation. In one example, the rotation of the pawls can be ceased or limited by one or more stoppers 30.

[0086] As shown in Fig. 3D, the plates 32 are aligned and engaged with one another by virtue of the bolt 10. A nut 38 (and optional washer) can be threaded onto 20 the bolt 10 to secure the plates 32 relative to one another.

[0087] Figs. 4A-E depict examples of multi-head bolt geometries according to one or more aspects of the disclosure. As shown, the multi-head of the bolt can be a triangle, a three-pawl, four-pawl, or five-pawl arrangement. Various multi-head configurations are their corresponding openings and cut-outs in an exemplary plate 25 are depicted in Fig. 4A.

[0088] Fig. 4B depicts a five-pawl configuration in which five pawls are arranged symmetrically with respect to bolt shaft. In this regard, there is approximately 72 degrees between each of the pawls. With this multi-head, the plate can be configured with an opening that defines five cut-outs, five recesses, and five 30 stoppers.

[0089] Fig. 4C depicts a four-pawl configuration in which four pawls are arranged symmetrically with respect to bolt shaft. In this regard, there is approximately 90 degrees between each of the pawls. With this multi-head, the plate can be configured with an opening that defines four cut-outs, four recesses, and four

stoppers. In this example, each of the pawls can be diametrically opposed to a respective pawl. In this regard, each pawl can have an oppositely oriented pawl disposed 180 degrees therefrom.

[0090] Since the design of pawls as extending from the shaft simultaneously define and dictate the negative profile in an opening of the plate to push the bolt through, meaning the cut-outs for the pawls that extend from the cut-out for the circumference of the shaft, in one example the number of pawls is advantageously four. This allows for a configuration that each pawl namely decreases the support area on the surface of the plate on which the pawl can rest on after fastening the bolt – which is also dependent from the width of a pawl.

[0091] Fig. 4D depicts a three -pawl configuration in which three pawls are arranged symmetrically with respect to bolt shaft. In this regard, there is approximately 120 degrees between each of the pawls. With this multi-head, the plate can be configured with an opening that defines three cut-outs, three recesses, and three stoppers. Such a three-pawl configuration provides a well-balanced force distribution in the horizontal plane on the panel's surface in any direction around 360°.

[0092] Fig. 4E depicts a multi-head having a triangular cross-section, with each corner defining a pawl and thus a three-pawl configuration. With this multi-head, the plate can be configured with an opening that defines three cut-outs, three recesses, and three stoppers.

[0093] Fig. 5A is a perspective view a multi-head bolt 500 according to one or more aspects of the disclosure. Fig. 5B is a side view a multi-head bolt 500 according to one or more aspects of the disclosure. Fig. 5C is a rear view a multi-head bolt 500 according to one or more aspects of the disclosure.

[0094] As shown in Fig. 5A, the multi-head bolt 500 (also referred to as bolt 500) has a longitudinal shaft 512 having a multi-head 516 at one end thereof. At least a portion of the longitudinal shaft 512 can be cylindrical or substantially cylindrical and can define a diameter. The longitudinal shaft 512 can include external threading 526 for engaging with a nut, as described in detail above. In one example, the longitudinal shaft 512 can define a longitudinal axis 514 that is co-axial or substantially co-axial relative to the longitudinal shaft and the longitudinal shaft can define an outer circumference.

[0095] The multi-head 516 has a plurality of pawls 18 that extend radially from the longitudinal axis 514 defined by the longitudinal shaft 512. In the example of Fig. 5A, the multi-head 516 of the bolt 510 includes four pawls 518 that are arranged radially and symmetrically with respect to longitudinal axis 514 and can be arranged in a symmetrical star-shaped configuration around an outer circumference of the shaft 512. In other examples, the bolt 510 can include greater or fewer pawls 518 and can be arranged radially, symmetrically and/or arbitrarily with respect to longitudinal axis 514. For example, the multi-head 516 can include at least or exactly three pawls 518 that can be arranged arbitrarily or radially and symmetrically with respect to longitudinal axis 514. In another example, the multi-head 516 can include at least or exactly five pawls 518 that can be arranged arbitrarily or radially and symmetrically with respect to longitudinal axis 14.

[0096] Each of the pawls 518 can be unitarily and rigidly formed with respect to the longitudinal shaft 512 of the bolt 510 such that each of the pawls 518 has a fixed radial orientation with respect to the longitudinal axis. In this regard, the pawls 518 can be inelastic and immovable relative to the longitudinal shaft 512 of the bolt 510. The pawls 518 can be generally fin-shaped and can be defined by a support surface 520, lateral sides 518a, and angled side 518b. The lateral sides 518a of each respective pawl 518 can be symmetrically opposed to one another and form an acute angle relative to a plane extending radially with respect to longitudinal axis 514. The lateral sides 518a can extend between the support surface 520, the angled side 518b, and the longitudinal shaft 512. A transition between longitudinal shaft 512 and support surface 520 can be a right angle or can be rounded due to manufacturing tolerances. In some examples, the rounded transition can be rounded in such a manner that the rounding can be felt upon handling but may not be visible to the eye. A transition between longitudinal shaft 512 and lateral sides 518a can be angled or can be rounded due to manufacturing tolerances. In some examples, the rounded transition can be rounded in such a manner that the rounding can be felt upon handling but may not be visible to the eye. A transition between support surface 520 and flat portion 518c can be a right angle or can be rounded due to manufacturing tolerances. In some examples, the rounded transition can be rounded in such a manner that the rounding can be felt upon handling but may not be visible to the eye. A transition between flat surface 518c and angled side 518b can be angled or can be rounded due to manufacturing tolerances. In some examples, the rounded transition can be rounded in

such a manner that the rounding can be felt upon handling but may not be visible to the eye. The support surface 520 can extend radially with respect to the longitudinal axis 514 and the longitudinal shaft 512 and can extend along a plane that is perpendicular to the longitudinal axis 514.

5 [0097] The angled side 518b can extend from a cone-shaped portion 522 to the support surface 20. In some examples, the angled side 518b can extend as a continuous surface from the cone-shaped portion 522 to the support surface 520, while in other examples there can be a flat portion 518c between the angled side 518b and support surface 520. The angled side 518b can be coplanar with a cone-shaped
10 portion 522 and can form a continuous, uninterrupted surface with the cone-shaped portion 522 and a plane coinciding with the angled side 518b can form an angle with the longitudinal axis 514. In one example, the angle can be an acute angle between 5 and 50 degrees and in another example, the angle can be about 45 degrees. Cone-shaped portion 522 can include a substantially flat portion 522a, such that cone-
15 shaped portion 522 is a truncated cone shape with the flat portion 522a being perpendicular to the longitudinal axis 514.

[0098] At an opposing end of the longitudinal shaft 512 relative to the cone-shaped portion 522 is a threaded portion 526 that defines a hole 528 therethrough and a hexagonal attachment portion 524 that defines a plurality of slots 524a. The hole
20 528 allows the bolt 510 to be secured by a safety split pin to one or more formwork panels or formwork elements. The cone end 524 facilitates the threading of nut (e.g., nut 38 described above) onto the longitudinal shaft.

[0099] The bolt 500 can be engaged with a nut (e.g. nut 38) to facilitate engagement with formwork elements (for example one or more beams) and/or
25 formwork panels and/or any pair of elements that can be connected, as will be described in greater detail below. The nut can have a female thread and can have wings to enable hand-tightening.

[00100] While the example of Figs. 1A-1C, the lateral sides 18a are parallel, as shown in Fig. 5B, the lateral sides 518a are not parallel with one another and are
30 arranged at an acute angle relative to the longitudinal axis and the primary plane. This is depicted in Fig. 5B and 5C, with lateral sides 518a defining a plane AE that forms an acute angle relative to the primary plane PP, with the longitudinal axis 514 lying on the primary plane PP (with the primary plane PP bisecting the pawl 518 and the lateral sides 518a being symmetric relative to the primary plane PP). As depicted in

Fig. 5B and 5C, the lateral sides 518a extend outwardly from the longitudinal shaft 512 and define two tapers: 1) the lateral sides 518a are tapered or slightly tapered toward each other from the longitudinal shaft 514 toward the angled side 518b relative to the primary plane PP when viewed from the hexagonal attachment portion 524 in Fig. 5C, resulting in an acute angle between PP and AE as viewed from the hexagonal attachment portion 524, and 2), opposing lateral sides 518a taper toward each other from the support surface 520 toward the cone-shaped portion 522 when viewed from the side in Fig. 5B, resulting in a narrowing/decrease in width of the angled side 518b from the support surface 520 toward the cone-shaped portion 522. In this regard, a width of the pawls 518 can decrease as measured from the support surface 520 toward the cone-shaped portion 522. In some examples, the acute angle for each lateral side 518a between AE and PP can be approximately 5 degrees or less. In one example, the acute angle for each lateral side 518a between AE and PP can be approximately 3 degrees. In some examples, the cone-shaped portion 522 is shaped as a truncated cone, with a substantially flat portion 522a.

[00101] As described above, a width of the pawls 518, e.g., a distance between opposing lateral sides 518a, can decrease as measured from the support surface 520 toward the cone-shaped portion 522 by virtue of the acute angle relationship of the lateral sides 518a relative to the longitudinal axis.

[00102] In one example, the width of pawls 518 is less than a diameter of the shaft 512. In one particular example, the width can be at least 15% of the shaft diameter and at most 65% of the diameter of the shaft. In another example, the width can be in the range of 25% to 40% of the shaft diameter. In yet another example, the width b is approximately 33% of a diameter of the longitudinal shaft 512. In these examples, the diameter of the shaft 512 is measured at a middle portion of the shaft, e.g., a portion that is disposed between the panels 32 when secured thereto, and the width of the pawls 518 is measured at a portion near the support surface 520 (e.g., where the width of the pawl 518 is greatest, by virtue of the acute angle orientation of lateral sides 518a).

[00103] As described above, a width of the pawl influences the load bearing capacity of the bolt in such a way that, the greater the width the greater the load-bearing capacity with respect to higher tensile force. The width also influences load-bearing capacity with respect to transverse force in an inverse manner, e.g. increasing

width reduces load-bearing capacity with respect to transverse force. Above a certain width, almost no additional traverse force can be absorbed.

[00104] Each of the pawls 518 can define a primary plane associated therewith, the primary plane being defined as a plane that symmetrically bisects each pawl 518, and intersects both the support surface 520 and angled edge 518b of the pawl such that the longitudinal axis 514 lies on the primary plane. In the example where the lateral sides 518a are not parallel, the lateral sides 518a would be oriented at the same acute angle relative to the primary plane as they are to the longitudinal axis 514.

[00105] As shown in Fig. 5C, a rear end 524 defines a hexagonal attachment portion that is configured to be engaged with a tool, such as an open end wrench, for efficient rotation of the bolt 500. The rear end 524 can also define one or more slots 524a that generally define a "+" (e.g., plus sign) configuration. As shown, the slots of the + configuration align with the pawls 518 such that the primary plane of each pawl 518 would intersect with its respectively aligned slot 524a. During insertion of the bolt 500 through an opening and/or corresponding cutouts (e.g., of plate 32, or any other type of formwork elements (for example one or more beams) and/or formwork panels and/or any pair of elements that can connected), the slots 524a can provide visual alignment to the worker installing the bolt 500 such that, upon rotation of the bolt 500 to engage with the element (as depicted in Figs. 2A-B and 3A-D above), angular rotation of the pawls 518 results in corresponding angular rotation of the slots 524a, providing the worker with visual guidance regarding engagement of the bolt 500 with the element.

[00106] The foregoing has been a detailed description of illustrative embodiments of the invention. Various modifications and additions can be made without departing from the spirit and scope of this invention. Features of each of the various embodiments described above may be combined with features of other described embodiments as appropriate in order to provide a multiplicity of feature combinations in associated new embodiments. Furthermore, while the foregoing describes a number of separate embodiments of the apparatus and method of the present invention, what has been described herein is merely illustrative of the application of the principles of the present invention. Accordingly, this description is meant to be taken only by way of example, and not to otherwise limit the scope of this invention.

[00107] What is claimed is:

CLAIMS

- 1 1. A multi-head bolt, comprising
2 a bolt shaft defining a longitudinal axis of the multi-head bolt;
3 a multi-head disposed at a first end of the bolt shaft, the multi-head comprising
4 at least three pawls, each pawl having a fixed radial orientation relative to the bolt
5 shaft and having a primary plane being aligned with the longitudinal axis of the bolt
6 shaft and having a support surface.
- 1 2. The multi-head bolt of claim 1, wherein the primary plane for each pawl is
2 parallel to two opposing lateral sides of each respective pawl.
- 1 3. The multi-head bolt of claim 1, wherein each pawl has an angled side that
2 intersects the primary plane and wherein a radial distance of the angled side relative to
3 bolt shaft linearly decreases as measured from the support surface to the first end of
4 the bolt.
- 1 4. The multi-head bolt of claim 1, wherein the pawls extend from the bolt shaft
2 in a star-shape configuration symmetrically relative to an outer circumference of the
3 bolt shaft.
- 1 5. The multi-head bolt of claim 1, wherein at least one pawl is in the form of a
2 fin.
- 1 6. The multi-head bolt of claim 1, wherein the support surface extends
2 perpendicularly to the longitudinal axis of the bolt shaft, projecting therewith radially
3 from the bolt shaft's outer circumference.
- 1 7. The multi-head bolt of claim 1, wherein at least one pawl is fin-shaped such
2 that the primary plane lies on the longitudinal axis of the bolt shaft and the support
3 surface is perpendicular to the primary plane.

1 8. The multi-head bolt of claim 7, wherein a width of at least one pawl is smaller
2 than a diameter of the bolt shaft.

1 9. The multi-head bolt of claim 8, wherein the width of the at least one pawl is at
2 least 15% of a diameter of the bolt shaft and at maximum 65% of the diameter of the
3 bolt shaft.

1 10. The multi-head bolt of claim 9, wherein the width of the at least one pawl is at
2 least 25% of a diameter of the bolt shaft and at maximum 40% of the diameter of the
3 bolt shaft.

1 11. The multi-head bolt of claim 9, wherein the width of the at least one pawl is
2 about 33% of the diameter of the bolt shaft.

1 12. The multi-head bolt of claim 2, wherein a width defined between the two
2 lateral sides of the at least one pawl is substantially constant along the longitudinal
3 axis.

1 13. The multi-head bolt of claim 3, wherein the bolt shaft defines at least one of a
2 cone shape or a truncated cone shape at the first end of the bolt shaft.

1 14. The multi-head bolt of claim 13, wherein at least a portion of the angled side is
2 coplanar plane to the cone shape of the first end of the bolt shaft.

1 15. The multi-head bolt claim 1, wherein the bolt shaft defines has a cone end at
2 an opposite end relative to the multi-head to facilitate insertion of a nut.

1 16. The multi-head bolt of claim 1, further comprising a tension-rod-shank fixed
2 to an end of the bolt shaft opposing the multi-head, on which shank a nut can be
3 screwed.

1 17. The multi-head bolt of claim 1, wherein the at least three pawls comprises four
2 pawls.

1 18. The multi-head bolt of claim 1, wherein the bolt shaft defines a hole extending
2 through the bolt shaft at an opposite end relative to the multi-head a for securing a
3 safety split pin.

1 19. The multi-head bolt of claim 1, wherein the primary plane for each pawl
2 intersects with a support surface of the pawl and an angled edge of the pawl such that
3 the longitudinal axis lies upon the primary plane.

1 20. The multi-head bolt of claim 1, wherein the primary plane for each pawl
2 symmetrically bisects each pawl relative to lateral sides of each pawl.

1 21. The multi-head bolt of claim 20, wherein the lateral sides are oriented at an
2 acute angle relative to the longitudinal axis.

1 22. The multi-head bolt of claim 1, wherein a width between two lateral sides of
2 each pawl decreases as measured from a support surface toward a cone-shaped
3 portion.

1 23. The multi-head bolt of claim 1, wherein the bolt shaft defines a truncated cone
2 shape at the first end of the bolt shaft.

1 24. The multi-head bolt claim 1, wherein the bolt shaft defines has a hexagonal
2 attachment portion at an opposite end relative to the multi-head to facilitate
3 engagement with a tool.

1 25. The multi-head bolt claim 1, wherein an opposite end relative to the multi-
2 head defines a plurality of slots defining a + configuration, with each of the plurality
3 of slots aligning with a respective pawl and being configured to provide visual
4 guidance during bolt installation.

5
6 26. A fastener system for connecting and aligning elements together, the system
7 comprising:

8 a multi-head bolt for fastening and aligning the elements, the bolt comprising
9 a bolt shaft defining a longitudinal axis of the multi-head bolt, a multi-head disposed

10 at a first end of the bolt shaft and comprising a plurality of pawls each arranged in a
11 fixed radial orientation relative to the bolt shaft and each having a primary plane
12 being aligned with the longitudinal axis of the bolt shaft and having a support surface;
13 and
14 the plurality of elements each defining an opening extending therethrough, the
15 opening having a shape corresponding to a cross-section profile of the multi-head of
16 the bolt through which opening the multi-head pawls pass.

1 27. The fastener system according to claim 26, further comprising a fastening
2 element configured to connect the elements in a fixed manner.

1 28. The fastener system according to claim 27, wherein the multi-head bolt has an
2 external thread and the fastener element comprises a nut having a female thread fitting
3 onto the external thread of the bolt.

1 29. The fastener system according to claim 26, wherein the opening defines cut-
2 outs in a plane direction of the element corresponding to a number and dimension of
3 the plurality of pawls.

1 30. The fastener system according to claim 26, wherein at least one pawl is fin-
2 shaped and has a width that is smaller than a diameter of the bolt shaft.

1 31. The fastener system of claim 30, wherein the width of the at least one pawl is
2 at least 15% of a diameter of the bolt shaft and at maximum 65% of the diameter of
3 the bolt shaft.

1 32. The fastener system of claim 31, wherein the width of the at least one pawl is
2 at least 25% of a diameter of the bolt shaft and at maximum 40% of the diameter of
3 the bolt shaft.

1 33. The fastener system of claim 32, wherein the width of the at least one pawl is
2 about 33% of the diameter of the bolt shaft.

1 34. The fastener system of claim 26, wherein a width defined between two lateral
2 sides of the at least one pawl is substantially constant along the longitudinal axis.

1 35. The fastener system of claim 26, wherein the bolt shaft defines a cone shape at
2 the first end of the bolt shaft.

1 36. The fastener system according to claim 26, wherein each pawl has an angled
2 side that intersects the primary plane and wherein a radial distance of the angled side
3 relative to bolt shaft linearly decreases as measured from the support surface to the
4 first end of the bolt.

1 37. The fastener system according to claim 36, wherein at least a portion of the
2 angled side is coplanar to a cone-shaped portion of the first end of the bolt shaft.

1 38. The fastener system according to claim 26, wherein the bolt shaft defines has a
2 cone end at an opposite end relative to the multi-head to facilitate insertion of a nut.

1 39. The fastener system of claim 26, wherein the elements comprise anti-twist-
2 structures in an element surface being adjacent to the openings, in or at which anti-
3 twist-structure a pawl can rest, respectively, after having rotated the bolt around the
4 longitudinal axis and having inserted the bolt through the opening.

1 40. The fastener system of claim 39, wherein the anti-twist structure is a recess in
2 which the pawl can rest, such that when resting in the recess rotational movement of
3 the pawl is prevented when the recess receives the support surface of the pawl.

1 41. The fastener system of claim 26, wherein the element comprises at least one
2 twist-stop protruding from a surface of at least one of the elements and preventing
3 rotation of the multi-head bolt around the longitudinal axis after having inserted the
4 bolt through the opening.

1 42. The fastener system of claim 41, wherein the twist-stop comprises an abutting
2 surface against which a lateral side of the pawl abuts when being inserted and having
3 turned the bolt until abutting the abutting surface.

1 43. The fastener system of claim 26, wherein the fastener system comprises a
2 separate plate in which an anti-twist-structure is incorporated and/or at least one twist-
3 stop protruding from the plate is provided, in which plate is to be arranged between
4 the head of the multi-head bolt and an element surface.

1 44. The fastener system of 39, wherein in that a number of anti-twist structures
2 and/or a number of twist-stop(s) is less or at least equal to the number of pawls.

1 45. The fastener system of claim 26, wherein the pawls are branched off from the
2 bolt shaft in a star-shaped configuration that is essentially symmetrical around an
3 outer circumference of the bolt shaft.

1 46. The fastener system of claim 26, wherein the support surface extends
2 essentially perpendicularly to the longitudinal axis of the bolt shaft projecting
3 therewith radially from an outer circumference of the bolt shaft.

1 47. The fastener system of claim 26, wherein the opening is located in a frame of
2 the element.

1 48. The fastener system of claim 26, wherein the elements comprises at least one
2 of a formwork panel or a formwork element.

1 49. A method of aligning and connecting at least two elements together,
2 comprising:
3 inserting a multi-head bolt through respective openings of a plurality of panels
4 such that a plurality of pawls with a fixed radial orientation relative to the multi-head
5 bolt align with a plurality of cut-outs of the plurality of panels;
6 rotating the multi-head bolt relative to the plurality panels such that the pawls
7 are out of alignment with the plurality of cutouts such that the plurality of panels are
8 secured relative to the multi-head bolt.

1 50. The method of claim 49, wherein rotating the multi-head bolt comprises
2 rotating the multi-head bolt and retracting the bolt in an opposite direction of an

3 insertion direction until a support surface of the pawls abuts against a surface of one
4 of the elements.

1 51. The method of claim 49, further comprising fastening the bolt relative to the
2 elements with a fastening element.

1

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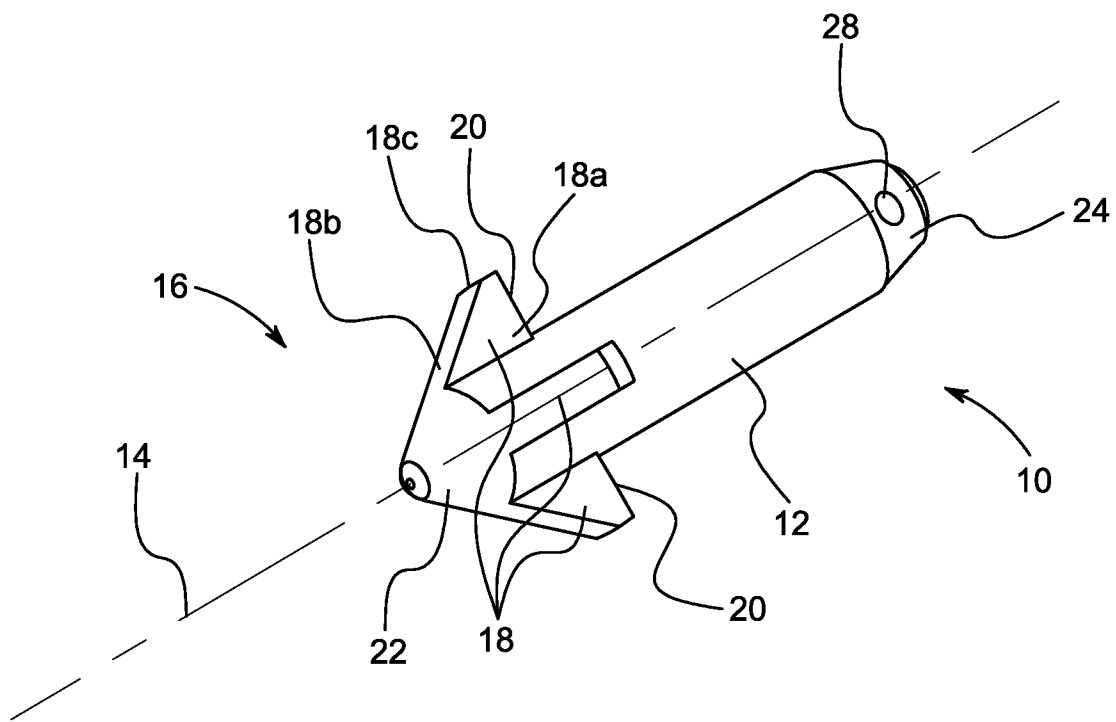


FIG. 1A

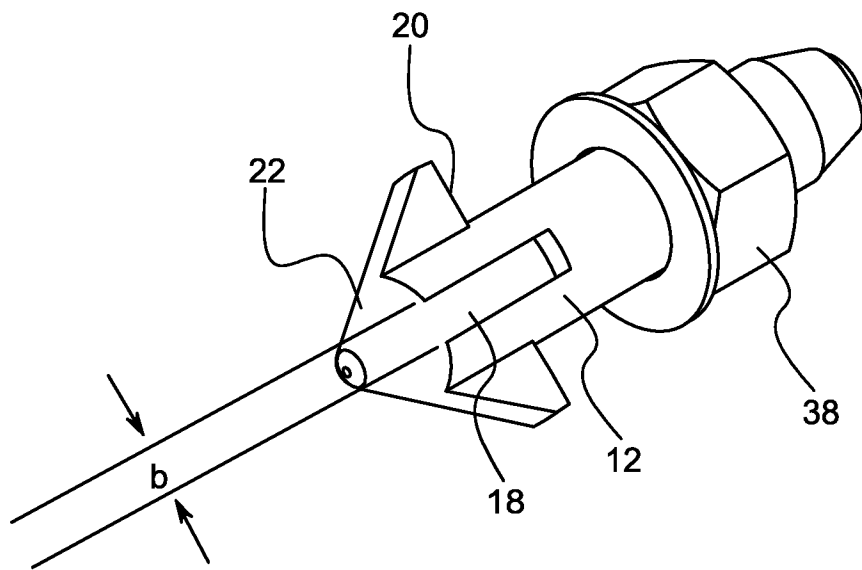


FIG. 1B

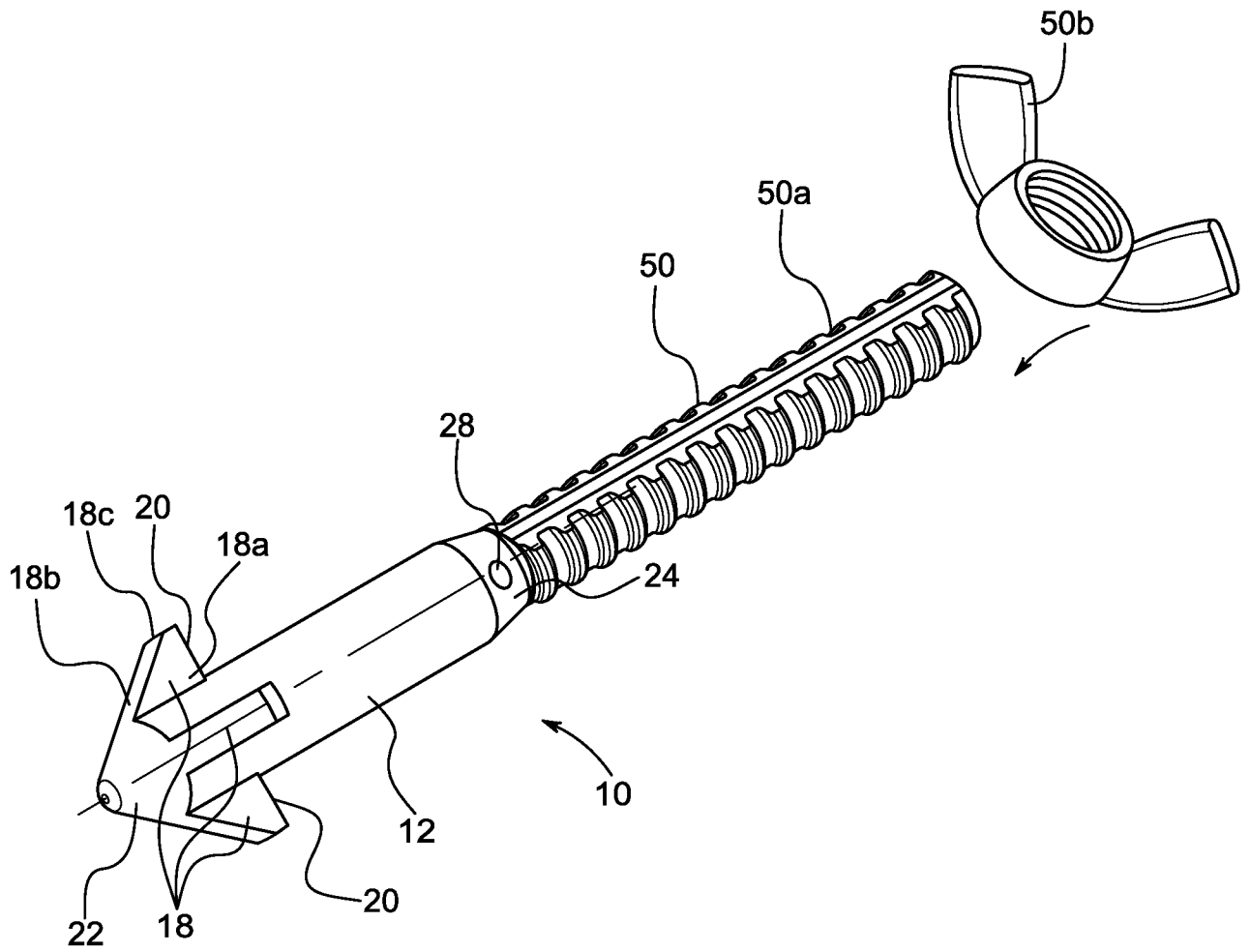


FIG. 1C

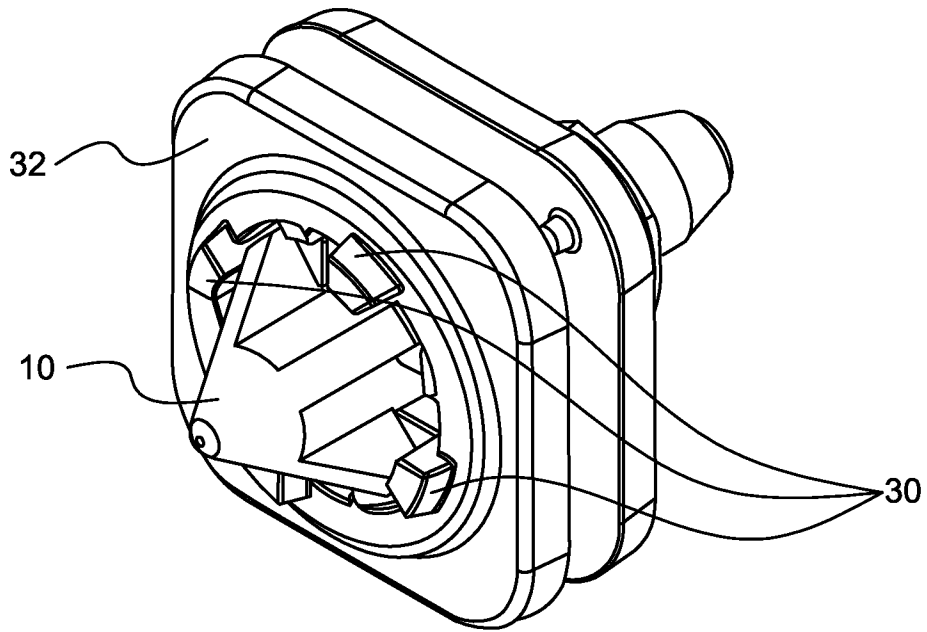


FIG. 2A

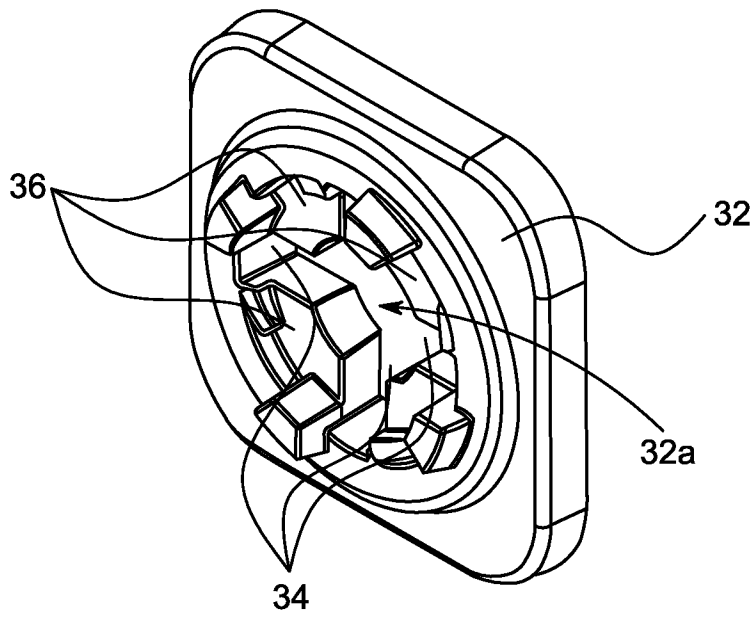


FIG. 2B

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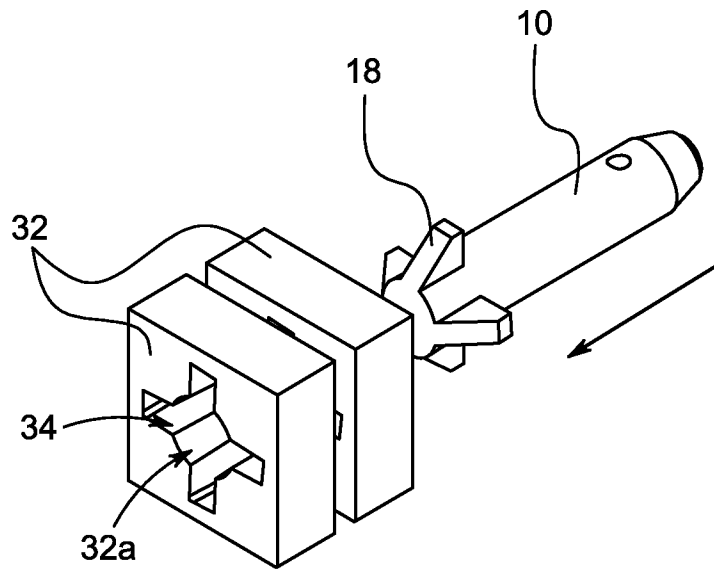


FIG. 3A

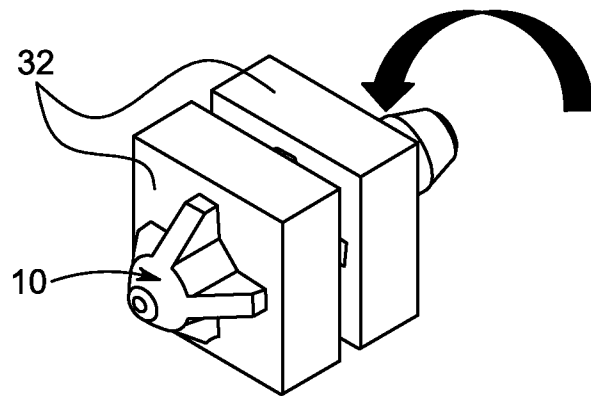


FIG. 3B

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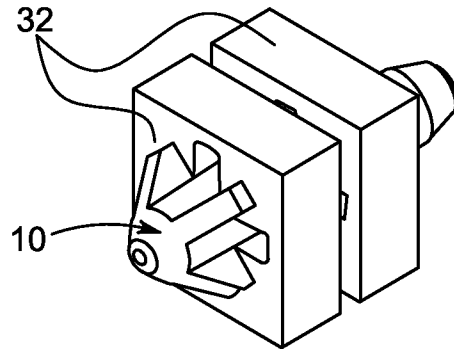


FIG. 3C

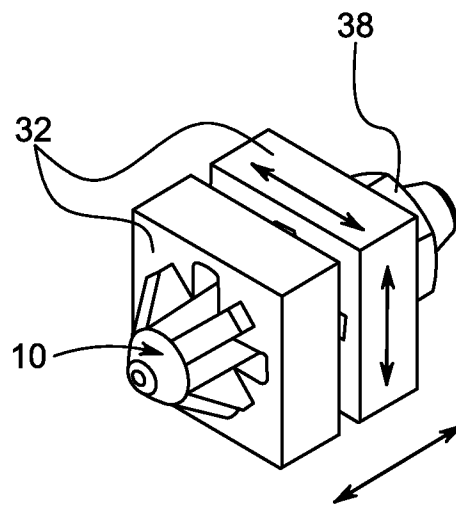


FIG. 3D

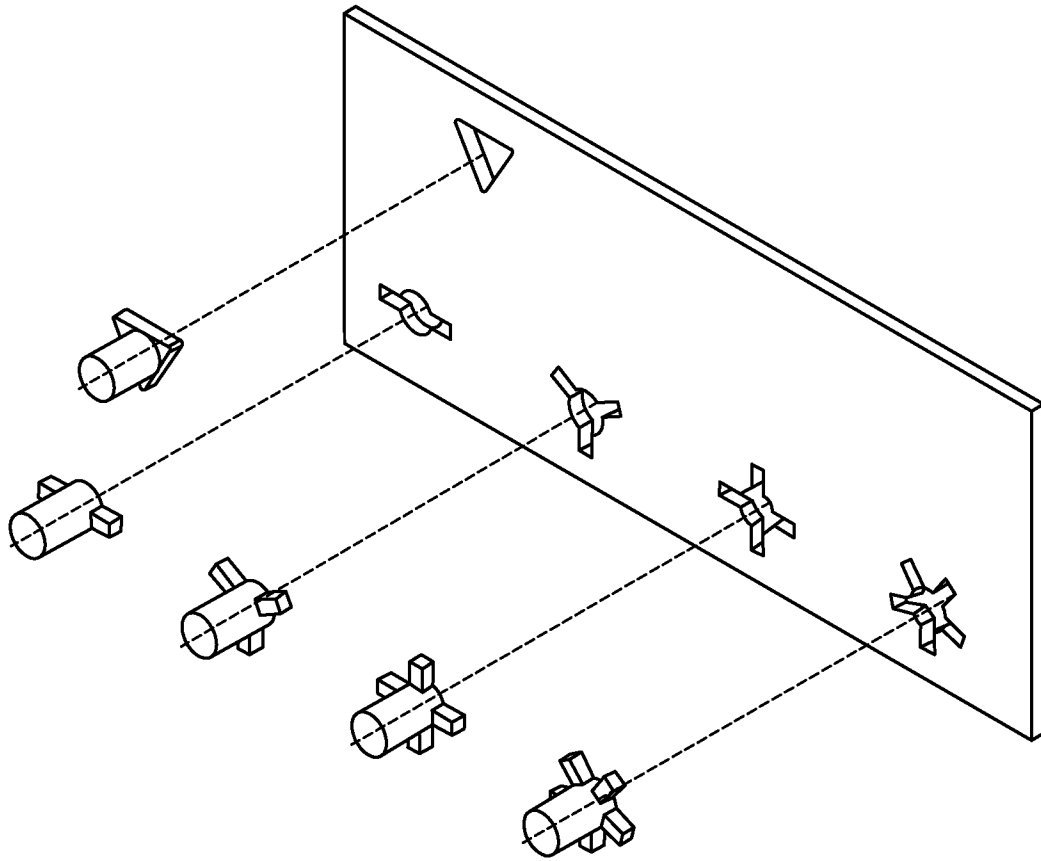


FIG. 4A

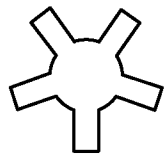


FIG. 4B

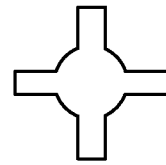


FIG. 4C

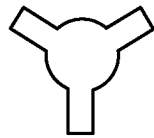


FIG. 4D

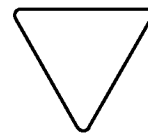


FIG. 4E

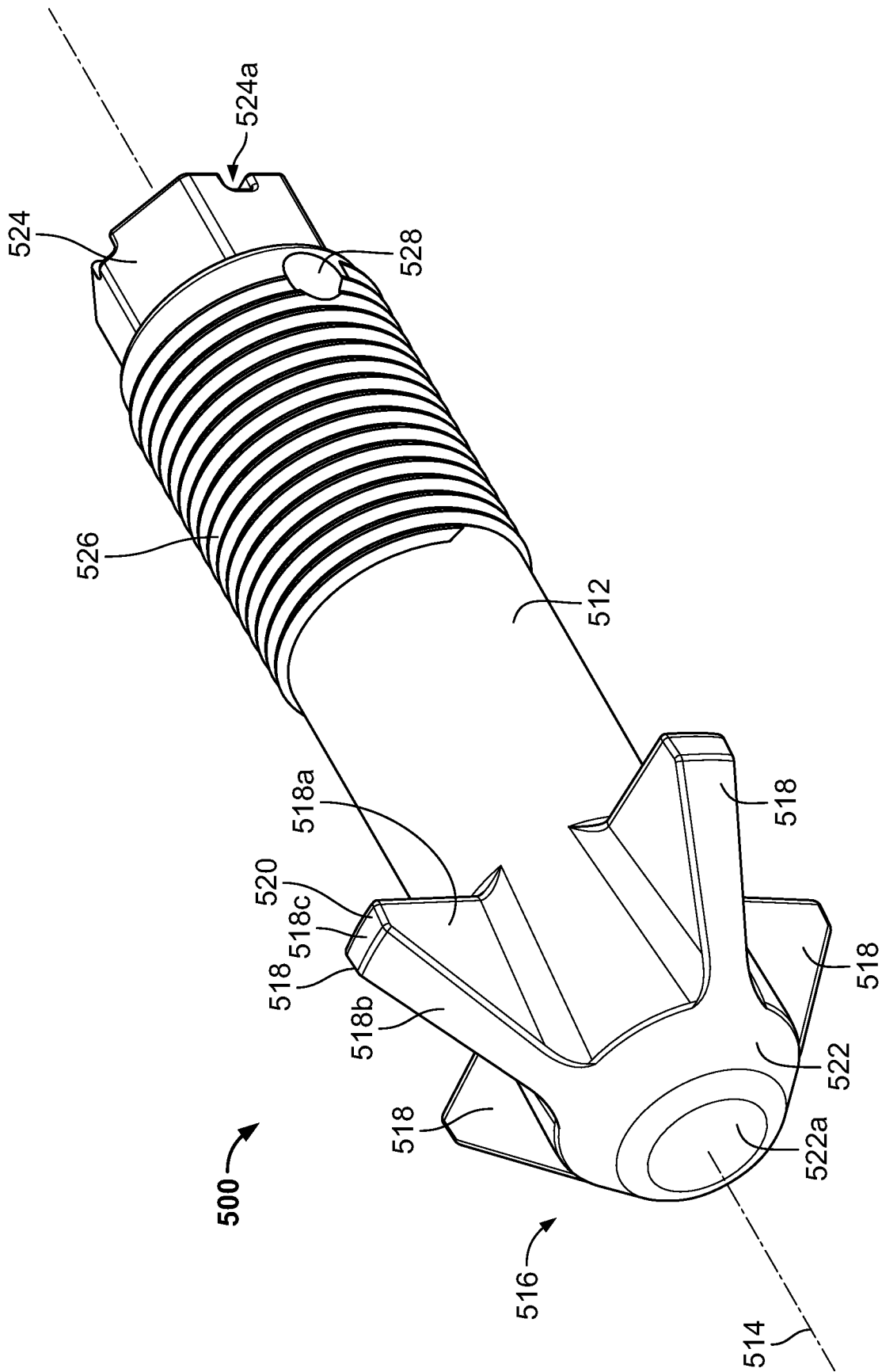


FIG. 5A

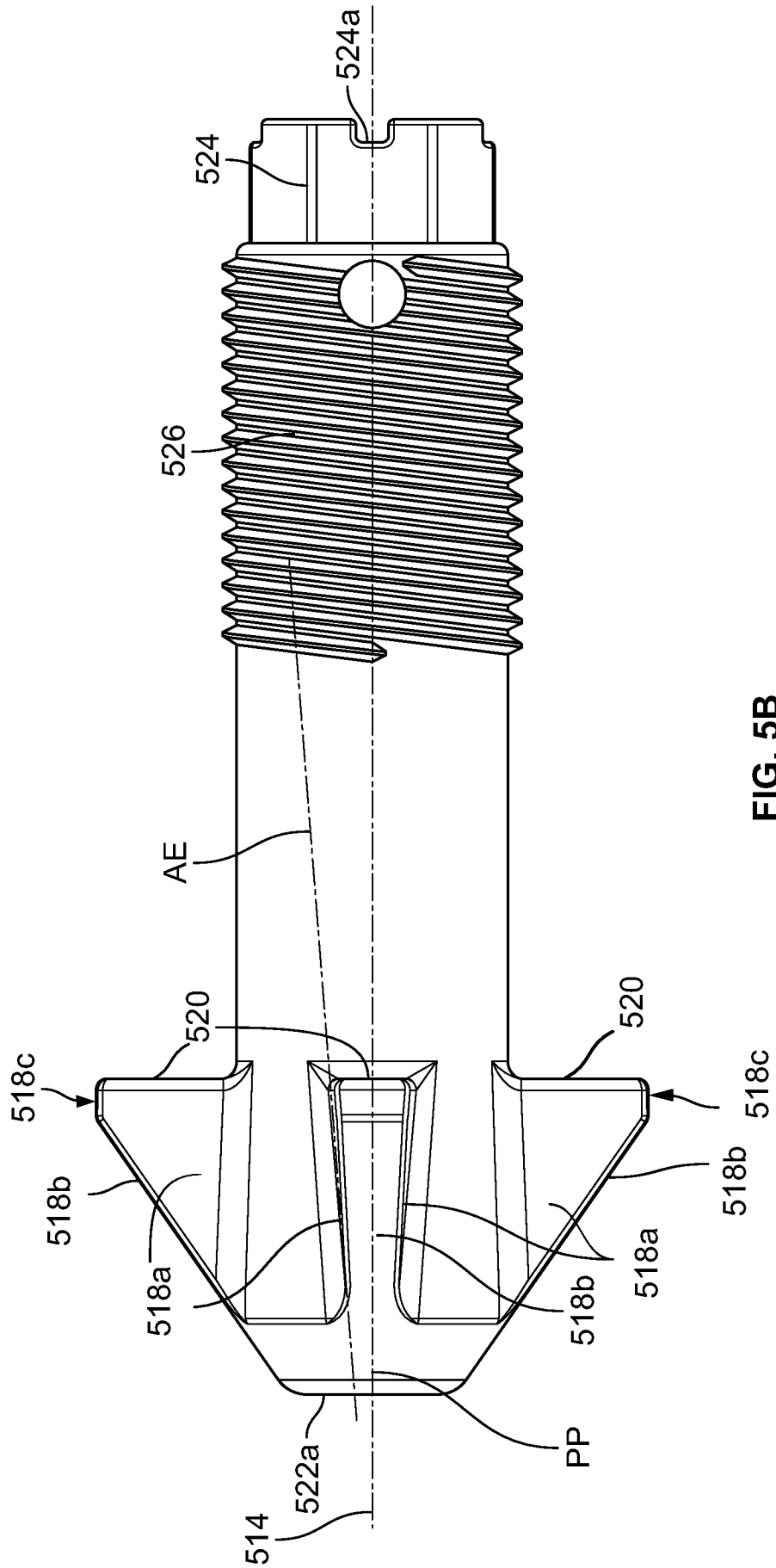


FIG. 5B

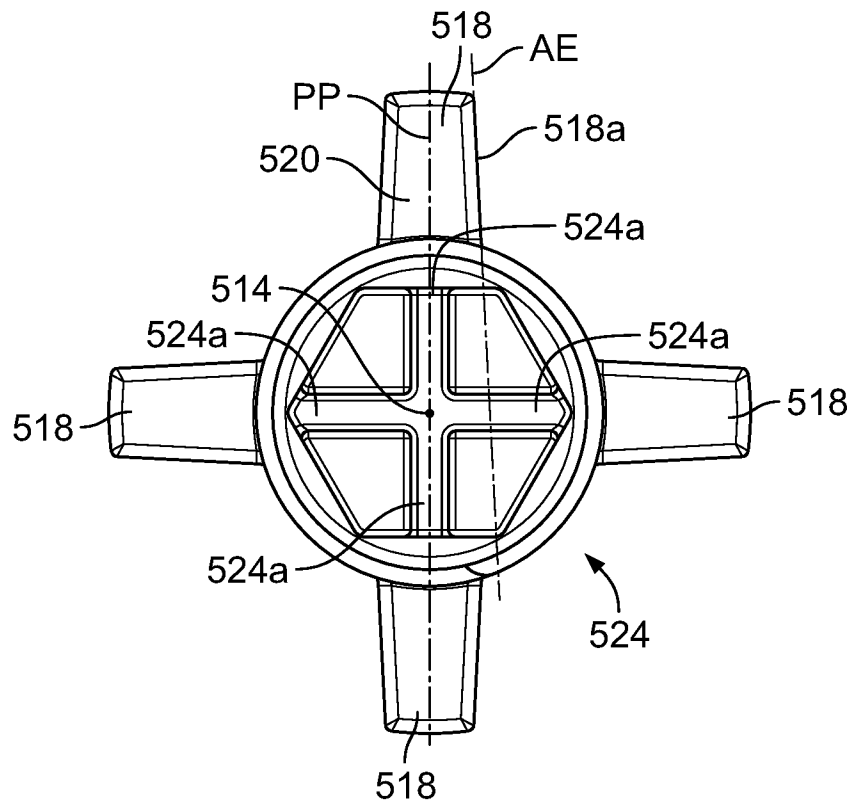


FIG. 5C