



- (51) **International Patent Classification:**
F16H 25/20 (2006.01) *F16B 39/00* (2006.01)
- (21) **International Application Number:**
PCT/US2014/031619
- (22) **International Filing Date:**
24 March 2014 (24.03.2014)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
13/893,627 14 May 2013 (14.05.2013) US
- (71) **Applicant:** THE BOEING COMPANY [US/US]; 100 North Riverside Plaza, Chicago, Illinois 60606-2016 (US).
- (72) **Inventor:** GUNTER, Ian Miles; 7755 East Marginal Way South, Seattle, Washington 98108 (US).
- (74) **Agents:** WOO, Euclid et al.; The Boeing Company, P.O. Box 2515, MC 110-SD54, Seal Beach, California 90740-1515 (US).
- (81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

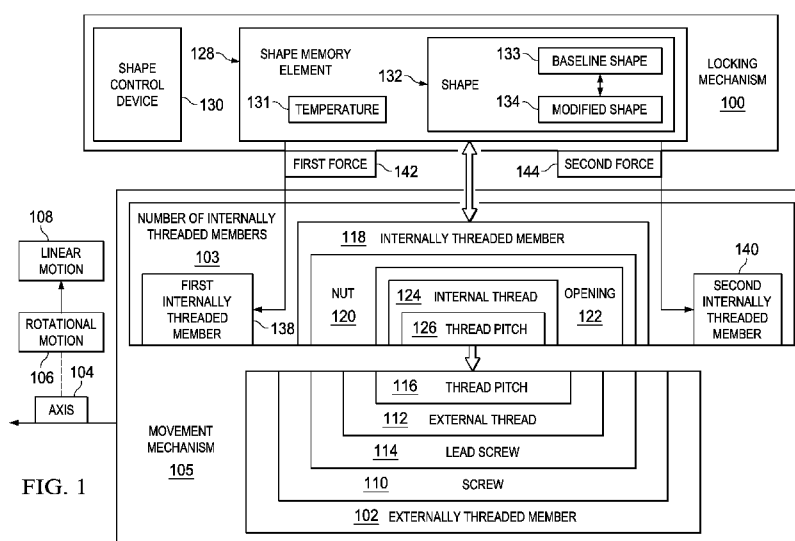
(54) **Title:** LEAD SCREW LOCKING MECHANISM AND METHOD FOR OPERATING THE SAME

FIG. 1

(57) **Abstract:** A method and apparatus for locking an externally threaded member in place. An apparatus comprises a number of internally threaded members and a shape memory element associated with the number of internally threaded members. The number of internally threaded members is configured to engage the externally threaded member. Changing a baseline shape of the shape memory element to a modified shape either prevents or allows movement of the number of internally threaded members relative to the externally threaded member.

LEAD SCREW LOCKING MECHANISM AND METHOD FOR OPERATING THE SAME

BACKGROUND INFORMATION**1. Field:**

The present disclosure relates generally to threaded members and, in particular, to locking mechanisms for threaded members. Still more particularly, the present disclosure relates to an apparatus and method for preventing rotational motion of an externally threaded member relative to one or more internally threaded members using a shape memory element.

2. Background:

In certain systems and assemblies, threaded shafts, such as, for example, lead screws, are used to convert rotational motion into linear motion. For example, rotating a lead screw about a longitudinal axis through the lead screw relative to a nut engaged with the lead screw may cause translation of the nut in a direction along the axis relative to the lead screw. As one specific example, a lead screw in a milling machine may be rotated by a motor, which may drive a nut engaged with the lead screw in a direction along a longitudinal axis through the lead screw.

This type of movement mechanism may allow for precise control of the position of the nut. Further, with this type of movement mechanism, the thread pitch of the external thread of the lead screw and the thread pitch of the internal thread of the nut may be designed such that the nut moves relative to the lead screw according to selected mechanical requirements.

Depending on the implementation, rotation of the lead screw may result in translation of the nut or the lead screw relative to the other. In other examples, rotation of the nut around the lead screw may result in translation of the lead screw or the nut relative to the other.

In some cases, a mechanism that prevents the nut engaged with the lead screw from moving relative to the lead screw in response to vibration, movement of the assembly, and/or other factors may be desirable. For example, when a lead screw is used in a braking system, a mechanism for preventing the nut engaged with the lead screw from back driving may be required. However, a locking mechanism capable of

preventing the relative rotation between a lead screw and a nut within selected tolerances may not be available. Therefore, it would be desirable to have a method and apparatus that take into account at least some of the issues discussed above, as well as other possible issues.

5

SUMMARY

In one illustrative embodiment, an apparatus comprises a number of internally threaded members and a shape memory element associated with the number of internally threaded members. The number of internally threaded members is configured to engage an externally threaded member. Changing a baseline shape of the shape memory element to a modified shape either prevents or allows movement of the number of internally threaded members relative to the externally threaded member.

In another illustrative embodiment, a locking mechanism comprises a shape memory element associated with a number of internally threaded members engaged with an externally threaded. Changing a baseline shape of the shape memory element to a modified shape either prevents or allows movement of the number of internally threaded members relative to the externally threaded member.

In yet another illustrative embodiment, a method for operating an externally threaded member with a number of internally threaded members is provided. The externally threaded member is received within the number of internally threaded members. A baseline shape of a shape memory element associated with the number of internally threaded members is changed to a modified shape to either prevent or allow movement of the number of internally threaded members relative to the externally threaded member.

The features and functions can be achieved independently in various embodiments of the present disclosure or may be combined in yet other embodiments in which further details can be seen with reference to the following description and drawings.

The invention is further described according to the following clauses:

30

Clause 1. An apparatus comprising: a number of internally threaded members configured to engage an externally threaded member; and a shape memory element associated with the number of internally threaded members, wherein changing a

baseline shape of the shape memory element to a modified shape either prevents or allows movement of the number of internally threaded members relative to the externally threaded member.

5 Clause 2. The apparatus of clause 1 further comprising: a shape control device configured to change the baseline shape of the shape memory element to the modified shape.

10 Clause 3. The apparatus of clause 2, wherein the shape memory element and the shape control device form a locking mechanism.

Clause 4. The apparatus of clause 1, wherein the shape memory element is comprised of a shape memory material.

15 Clause 5. The apparatus of clause 4, wherein the shape memory material is a nickel titanium alloy.

Clause 6. The apparatus of clause 1, wherein the externally threaded member is a lead screw.

20 Clause 7. A locking mechanism comprising: a shape memory element associated with a number of internally threaded members engaged with an externally threaded member, wherein changing a baseline shape of the shape memory element to a modified shape either prevents or allows movement of the number of internally threaded members
25 relative to the externally threaded member.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the illustrative embodiments are set forth in the appended claims. The illustrative embodiments, however, as well as a
30 preferred mode of use, further objectives and features thereof, will best be understood by reference to the following detailed description of an illustrative embodiment of the present disclosure when read in conjunction with the accompanying drawings, wherein:

Figure 2 is an illustration of an isometric view of a locking mechanism for use with an externally threaded member in accordance with an illustrative embodiment;

Figure 4 is an illustration of a cross-sectional view of a locking mechanism and a lead screw in accordance with an illustrative embodiment;

Figure 6 is an illustration of a side view of a locking mechanism and a lead screw in accordance with an illustrative embodiment;

Figure 8 is an illustration of a process for locking an externally threaded member and a number of internally threaded members in the form of a flowchart in accordance with an illustrative embodiment;

Figure 10 is an illustration of a process for locking in place two nuts engaged with a lead screw in the form of a flowchart in accordance with an illustrative embodiment.

DETAILED DESCRIPTION

The illustrative embodiments recognize and take into account different considerations. For example, the illustrative embodiments recognize and take into account that it may be desirable to have a locking mechanism that can easily and quickly prevent the relative rotation between a lead screw and one or more nuts engaged with the lead screw in an assembly within selected tolerances. Further, the illustrative embodiments recognize and take into account that it may be desirable to have a locking mechanism that does not increase the weight and/or size of this assembly more than desired.

Thus, the illustrative embodiments provide a locking mechanism for use with an externally threaded member and a number of internally threaded members configured to engage the externally threaded member. In one illustrative embodiment, a locking mechanism comprises a number of internally threaded members, a shape memory element associated with the number of internally threaded members, and a shape control device. The number of internally threaded members is configured to engage an externally threaded member such that rotational motion of the externally threaded member relative to the number of internally threaded members is translated into linear motion of the externally threaded member relative to the number of internally threaded members. The shape memory element has a shape that changes in response to a change in temperature of the shape memory element. Changing the shape of the shape memory element prevents the rotational motion of the externally threaded member relative to the number of internally threaded members. The shape control device is configured to change the temperature of the shape memory element.

Referring now to the figures and, in particular, with reference to **Figure 1**, an illustration of a locking mechanism is depicted in the form of a block diagram in accordance with an illustrative embodiment. In this illustrative example, locking mechanism **100** may be configured to prevent relative rotation between externally threaded member **102** and number of internally threaded members **103**.

As used herein, a “number of” items may be one or more items. In this manner, number of internally threaded members **103** may include one or more internally threaded members.

Externally threaded member **102** and number of internally threaded members **103** may form movement mechanism **105**. As used herein, an externally threaded member, such as externally threaded member **102**, may be implemented in the form of any elongate member having an external thread along at least a portion of the outer surface of the externally threaded member. In this illustrative example, externally threaded member **102** may be rotatable about axis **104** through externally threaded member **102**. Axis **104** may be, for example, a center longitudinal axis through externally threaded member **102**.

Externally threaded member **102** may be configured to convert rotational motion **106** into linear motion **108**. In particular, externally threaded member **102** may convert the rotational motion **106** of one of externally threaded member **102** and number of

internally threaded members **103** about axis **104** relative to the other into linear motion **108** of one of externally threaded member **102** and number of internally threaded members **103** relative to the other.

As used herein, an internally threaded member, such as one of number of internally threaded members **103**, may be implemented in the form of any structure having an opening configured to receive externally threaded member **102**. Further, the opening may have an internal thread configured to engage the external thread on externally threaded member **102**.

In one illustrative example, externally threaded member **102** may take the form of screw **110** having external thread **112**. Screw **110** may be referred to as lead screw **114** in some cases. External thread **112** may have thread pitch **116**. As used herein, the thread pitch of a threaded member, such as thread pitch **116** of screw **110**, may be the distance from one thread groove to the next adjacent groove.

In this illustrative example, internally threaded member **118** may be an example of one of number of internally threaded members **103**. Internally threaded member **118** may take the form of, for example, without limitation, nut **120** having opening **122** lined by internal thread **124**. Internal thread **124** may have thread pitch **126**. Thread pitch **126** of nut **120** may be designed to engage thread pitch **116** of screw **110**. Of course, depending on the implementation, internally threaded member **118** may take the form of any structure or object having opening **122** with internal thread **124**.

Locking mechanism **100** may be used to prevent rotation of internally threaded member **118** relative to externally threaded member **102** about axis **104** to prevent the movement of internally threaded member **118** in a direction along axis **104** relative to externally threaded member **102**. As depicted, locking mechanism **100** may include shape memory element **128** and shape control device **130**.

Shape control device **130** may be used to control temperature **131** of shape memory element **128** to control shape **132** of shape memory element **128**. For example, shape memory element **128** may be comprised of a shape memory material, such as a shape memory alloy. A shape memory material, as used herein, is a material configured to deform when heated or cooled but remember its original shape. The shape memory material may take the form of, for example, without limitation, a nickel titanium alloy.

In one illustrative example, shape control device **130** may heat shape memory element **128** to change shape **132** of shape memory element **128** from baseline shape **133** to modified shape **134**. Baseline shape **133** may be shape **132** of shape memory element **128** when temperature **131** of shape memory element **128** is at a baseline temperature or within a selected range of the baseline temperature. The baseline temperature may be, for example, without limitation, room temperature, ambient temperature, or some reference temperature.

Modified shape **134** may be, for example, any shape that is different from baseline shape **133** beyond selected tolerances. As one illustrative example, modified shape **134** may be a shape that is larger than baseline shape **133** by some selected percentage.

Shape control device **130** may comprise a heating device configured to heat shape memory element **128**. The heating device may be an active heating device or a passive heating device, depending on the implementation.

Shape memory element **128** may be implemented in a number of different ways. In one illustrative example, shape memory element **128** may take the form of at least a portion of internally threaded member **118**. In this manner, all of internally threaded member **118** may form shape memory element **128** in one example. For example, nut **120** may be a shape memory nut.

In another example, the portion of internally threaded member **118** comprising internal thread **124** may be shape memory element **128**. In some cases, internal thread **124** may be considered shape memory element **128**. For example, internal thread **124** may be comprised of a shape memory material such that internal thread **124** forms shape memory element **128**.

When shape memory element **128** takes the form of at least a portion of internally threaded member **118**, shape control device **130** may change temperature **131** of shape memory element **128** to change thread pitch **126** of internally threaded member **118**. In particular, changing temperature **131** changes shape **132** of shape memory element **128**, which may, in turn, change thread pitch **126**. Shape **132** of shape memory element **128** may be, for example, without limitation, contracted, expanded, twisted, and/or changed in some other manner.

Changing thread pitch **126** of internally threaded member **118** prevents internally threaded member **118** from rotating about axis **104** relative to externally threaded

member **102**. In this manner, internally threaded member **118** may be locked in place relative to externally threaded member **102**.

In another illustrative example, number of internally threaded members **103** may include first internally threaded member **138** and second internally threaded member **140** configured to receive externally threaded member **102**. In this example, shape memory element **128** may take the form of a separate component configured to be positioned between first internally threaded member **138** and second internally threaded member **140**.

For example, shape memory element **128** may be associated with both first internally threaded member **138** and second internally threaded member **140**. As used herein, when one component is “associated” with another component, the association is a physical association in the depicted examples. For example, a first component, such as shape memory element **128**, may be considered to be associated with a second component, such as first internally threaded member **138**, by being secured to the second component, bonded to the second component, mounted to the second component, welded to the second component, fastened to the second component, and/or connected to the second component in some other suitable manner. The first component also may be connected to the second component using a third component. Further, the first component may be considered to be associated with the second component by being formed as part of and/or as an extension of the second component.

Shape memory element **128** may have an opening configured to receive externally threaded member **102**. The inner surface of the opening of shape memory element **128** may have improved wear performance than the bearing surfaces of first internally threaded member **138** and second internally threaded member **140**. Shape memory element **128** may function as a shape memory actuator between first internally threaded member **138** and second internally threaded member **140**.

Changing temperature **131** of shape memory element **128** may change shape **132**. For example, temperature **131** of shape memory element **128** may be changed to change shape **132** of shape memory element **128** such that shape memory element **128** exerts first force **142** to first internally threaded member **138** and second force **144** to second internally threaded member **140**. First force **142** and second force **144** may

be pushing forces, pulling forces, and/or other types of forces, depending on the implementation.

In one illustrative example, shape memory element **128** may contract to pull first internally threaded member **138** and second internally threaded member **140** closer together. In another example, shape memory element **128** may expand to push first internally threaded member **138** and second internally threaded member **140** away from each other. In yet another illustrative example, shape memory element **128** may twist to push and/or pull on each of first internally threaded member **138** and second internally threaded member **140**.

First force **142** and second force **144** may prevent first internally threaded member **138** and second internally threaded member **140**, respectively, from rotating about axis **104** relative to externally threaded member **102**. In this manner, first internally threaded member **138** and second internally threaded member **140** may be locked in place relative to externally threaded member **102**.

When number of internally threaded members **103** no longer need to be locked in place relative to externally threaded member **102**, shape control device **130** may change temperature **131** back to the baseline temperature such that modified shape **134** of shape memory element **128** may revert back to baseline shape **133**. When shape memory element **128** has baseline shape **133**, number of internally threaded members **103** may be configured to rotate about axis **104** relative to externally threaded member **102** and thus, move in a direction along axis **104** relative to externally threaded member **102**.

Shape control device **130** is described as controlling temperature **131** of shape memory element **128** to control shape **132** of shape memory element **128**. However, in other illustrative examples, shape control device **130** may use pressure, magnetic forces, and/or other types of forces to control shape **132** of shape memory element **128**.

The illustration of locking mechanism **100** in **Figure 1** is not meant to imply physical or architectural limitations to the manner in which an illustrative embodiment may be implemented. Other components in addition to or in place of the ones illustrated may be used. Some components may be optional. Also, the blocks are presented to illustrate some functional components. One or more of these blocks may be combined, divided, or combined and divided into different blocks when implemented in an illustrative embodiment.

Depending on the implementation, number of internally threaded members **103** may be considered part of locking mechanism **100**. Further, in one illustrative example, shape control device **130** may be separate from shape memory element **128**. However, in other illustrative examples, shape memory element **128** may be comprised of a material configured to function as a passive heating device. In this manner, shape control device **130** may be part of shape memory element **128**.

Further, in other illustrative examples, baseline shape **133** of shape memory element **128** may be configured to prevent movement of number of internally threaded members **103** relative to externally threaded member **102**. In these examples, changing baseline shape **133** to modified shape **134** may then be configured to allow movement of number of internally threaded members **103** relative to externally threaded member **102**. In this manner, depending on the implementation, changing baseline shape **133** to modified shape **134** may either prevent or allow movement of number of internally threaded members **103** relative to externally threaded member **102**.

With reference now to **Figure 2**, an illustration of an isometric view of a locking mechanism for use with an externally threaded member is depicted in accordance with an illustrative embodiment. In this illustrative example, locking mechanism **200** may be an example of one implementation for locking mechanism **100** in **Figure 1**.

Locking mechanism **200** may be used with lead screw **202** to prevent relative rotation between shape memory nut **204** and lead screw **202**. Lead screw **202** is an example of one implementation for lead screw **114** in **Figure 1**. Shape memory nut **204** is an example of one implementation for shape memory element **128** in **Figure 1** in which shape memory element **128** is implemented as part of nut **120** in **Figure 1**.

Lead screw **202** may be rotated in the direction of arrow **206** about axis **208** to cause shape memory nut **204** to move in a direction along axis **208**. For example, lead screw **202** has external thread **210**. Shape memory nut **204** has an internal thread (not shown) configured to engage external thread **210**. Rotation of lead screw **202** about axis **208** relative to shape memory nut **204** may cause movement of shape memory nut **204** in a direction along axis **208** as guided by external thread **210** of lead screw **202** and the internal thread of shape memory nut **204**.

In this illustrative example, locking mechanism **200** is formed by both shape memory nut **204** and heating device **212**. Heating device **212** is an example of one implementation for shape control device **130** in **Figure 1**. Heating device **212** is

attached to shape memory nut **204** and positioned between flange **214** and flange **216** of shape memory nut **204**. Heating device **212** may heat shape memory nut **204** to change a shape of shape memory nut **204** such that movement of shape memory nut **204** along axis **208** is prevented.

5 With reference now to **Figure 3**, an illustration of a side view of locking mechanism **200** and lead screw **202** from **Figure 2** is depicted in accordance with an illustrative embodiment. As depicted, external thread **210** of lead screw **202** has thread pitch **300**.

10 Turning now to **Figure 4**, an illustration of a cross-sectional view of locking mechanism **200** and lead screw **202** from **Figures 2-3** is depicted in accordance with an illustrative embodiment. In particular, in **Figure 4**, a cross-sectional view of locking mechanism **200** and lead screw **202** from **Figures 2-3** is depicted taken with respect to lines **4-4** in **Figure 2**.

15 In this illustrative example, internal thread **400** of shape memory nut **204** may be seen. Internal thread **400** has thread pitch **402**. Thread pitch **402** is selected to engage thread pitch **300** such that shape memory nut **204** may be moved along axis **208** relative to lead screw **202** when shape memory nut **204** is at a baseline temperature within selected tolerances.

20 Heating device **212** may be configured to heat shape memory nut **204** such that thread pitch **402** changes. This change in thread pitch **402** may prevent shape memory nut **204** from being able to rotate relative to lead screw **202**. In this manner, shape memory nut **204** may be prevented from moving linearly along axis **208** relative to lead screw **202**.

25 When the temperature of shape memory nut **204** returns to a baseline temperature or within a selected range of the baseline temperature, the shape of shape memory nut **204** may return to its baseline shape and thread pitch **402** may return to its original size. In this manner, shape memory nut **204** may then be allowed to move linearly along axis **208** relative to lead screw **202**.

30 With reference now to **Figure 5**, an illustration of an isometric view of a different configuration for a locking mechanism is depicted in accordance with an illustrative embodiment. In this illustrative example, locking mechanism **500** may be an example of one implementation for locking mechanism **100** in **Figure 1**.

Locking mechanism **500** may be used with lead screw **502**. Lead screw **502** is an example of one implementation for lead screw **114** in **Figure 1**. As depicted, lead screw **502** has external thread **504**.

Lead screw **502** may be rotated in the direction of arrow **506** about axis **508** to cause first nut **510** and second nut **512** to move in a direction along axis **508**. First nut **510** and second nut **512** may be examples of implementations for first internally threaded member **138** and second internally threaded member **140**, respectively, in **Figure 1**.

In this illustrative example, locking mechanism **500** comprises shape memory element **514** and heating device **516**. Shape memory element **514** is an example of one implementation for shape memory element **128** in **Figure 1**. In this illustrative example, shape memory element **514** may function as a shape memory actuator. Shape memory element **514** may be attached to first nut **510** and second nut **512** in this illustrative example.

Heating device **516** is an example of one implementation for shape control device **130** in **Figure 1**. Heating device **516** is attached to shape memory element **514** and positioned between flange **518** and flange **520** of shape memory element **514** in this example. Heating device **516** may heat shape memory element **514** to change a shape of shape memory element **514** such that movement of first nut **510** and second nut **512** along axis **508** is prevented.

With reference now to **Figure 6**, an illustration of a side view of locking mechanism **500** and lead screw **502** from **Figure 5** is depicted in accordance with an illustrative embodiment. As depicted, external thread **504** of lead screw **502** has thread pitch **600**.

Turning now to **Figure 7**, an illustration of a cross-sectional view of locking mechanism **500** and lead screw **502** from **Figures 5-6** is depicted in accordance with an illustrative embodiment. In particular, in **Figure 7**, a cross-sectional view of locking mechanism **500** and lead screw **502** from **Figures 5-6** is depicted taken with respect to lines **7-7** in **Figure 5**.

In this illustrative example, first internal thread **700** of first nut **510** and second internal thread **702** of second nut **512** are shown. First internal thread **700** and second internal thread **702** are configured to engage external thread **504** of lead screw **502**.

As depicted, shape memory element **514** has bearing surface **704** that does not conform to external thread **504**. In other words, bearing surface **704** may contact external thread **504** but may not engage external thread **504**.

5 Heating device **516** may be configured to heat shape memory element **514** such that shape memory element **514** expands. The expansion of shape memory element **514** applies first force **706** to first nut **510** and second force **708** to second nut **512**. These forces push first nut **510** and second nut **512** away from each other. Further, these forces prevent first nut **510** and second nut **512** from being able to rotate relative to lead screw **502**. In this manner, first nut **510** and second nut **512** may be prevented
10 from moving linearly along axis **508** relative to lead screw **502**.

When the temperature of shape memory element **514** returns to a baseline temperature or within a selected range of the baseline temperature, the shape of shape memory element **514** may return to its baseline shape and first force **706** and second force **708** may be removed. In this manner, first nut **510** and second nut **512** may then
15 be allowed to move linearly along axis **508** relative to lead screw **502**.

The illustrations of locking mechanism **200** in **Figures 2-4** and locking mechanism **500** in **Figures 5-7** are not meant to imply physical or architectural limitations to the manner in which an illustrative embodiment may be implemented. Other components in addition to or in place of the ones illustrated may be used. Some
20 components may be optional.

The different components shown in **Figures 2-7** may be illustrative examples of how components shown in block form in **Figure 1** can be implemented as physical structures. Additionally, some of the components in **Figures 2-7** may be combined with components in **Figure 1**, used with components in **Figure 1**, or a combination of the
25 two.

With reference now to **Figure 8**, an illustration of a process for locking an externally threaded member and a number of internally threaded members is depicted in the form of a flowchart in accordance with an illustrative embodiment. The process illustrated in **Figure 8** may be implemented using a locking mechanism such as, for
30 example, locking mechanism **100** in **Figure 1**, to lock an externally threaded member with a number of internally threaded members. In particular, this process may be used to prevent movement of the number of internally threaded members relative to the externally threaded member.

The process may begin by receiving an externally threaded member within a number of internally threaded members (operation **800**). In operation **800**, rotational motion of the externally threaded member relative to the number of internally threaded members is translated into linear motion of the number of internally threaded members relative to the externally threaded member.

Thereafter, a baseline shape of a shape memory element associated with the number of internally threaded members is changed to a modified shape using a shape control device to either prevent or allow the movement of the number of internally threaded members relative to the externally threaded member (operation **802**), with the process terminating thereafter

Operation **802** may be performed by changing, for example, the temperature of the shape memory element. For example, the shape memory element may be either cooled or heated to change the shape of the shape memory element from a baseline shape to a modified shape. In one illustrative example, when the shape memory element has the baseline shape, the number of internally threaded members may be allowed to move relative to the externally threaded member by rotating relative to the externally threaded member and moving linearly along an axis through the number of internally threaded members. In this example, when the shape memory element has the modified shape, the number of internally threaded members may be prevented from moving relative to the externally threaded element.

With reference now to **Figure 9**, an illustration of a process for locking in place a shape memory nut engaged with a lead screw is depicted in the form of a flowchart in accordance with an illustrative embodiment. The process illustrated in **Figure 9** may be implemented using a locking mechanism such as, for example, locking mechanism **100** in **Figure 1**. In particular, the process may be implemented using a locking mechanism implemented in a manner similar to locking mechanism **200** in **Figure 2**.

The process begins by receiving a lead screw through an opening in a shape memory nut in which the opening is lined by an internal thread configured to engage an outer thread of the lead screw (operation **900**). Next, the shape memory nut is heated such that a thread pitch of the internal thread lining the opening of the shape memory nut is changed to a modified thread pitch (operation **902**). In operation **902**, changing the thread pitch of the internal thread of the shape memory nut changes the manner in which the nut engages the lead screw. Consequently, movement of the shape memory

nut relative to the lead screw is prevented using the shape memory nut having the modified thread pitch (operation **904**), with the process terminating thereafter.

With reference now to **Figure 10**, an illustration of a process for locking in place two nuts engaged with a lead screw is depicted in the form of a flowchart in accordance with an illustrative embodiment. The process illustrated in **Figure 10** may be implemented using a locking mechanism such as, for example, locking mechanism **100** in **Figure 1**. In particular, the process may be implemented using a locking mechanism similar to locking mechanism **500** in **Figure 5**.

The process begins by receiving a lead screw through a first opening in a first nut, through an opening in a shape memory element, and through a second opening in a second nut (operation **1000**). The first nut and the second nut may have internal threads configured to engage the lead screw. The shape memory element may have a substantially smooth bearing surface with no thread.

Next, the shape memory element may be heated to change a shape of the shape memory element from a baseline shape to a modified shape (operation **1002**). In response to the shape memory element having the modified shape, a first force is exerted on the first nut and a second force is exerted on the second nut by the modified shape (operation **1004**). Movement of the first nut and the second nut relative to the lead screw is prevented by the first force and the second force (operation **1006**), with the process terminating thereafter.

The flowcharts and block diagrams in the different depicted embodiments illustrate the architecture, functionality, and operation of some possible implementations of apparatuses and methods in an illustrative embodiment. In this regard, each block in the flowcharts or block diagrams may represent a module, a segment, a function, and/or a portion of an operation or step.

In some alternative implementations of an illustrative embodiment, the function or functions noted in the blocks may occur out of the order noted in the figures. For example, in some cases, two blocks shown in succession may be executed substantially concurrently, or the blocks may sometimes be performed in the reverse order, depending upon the functionality involved. Also, other blocks may be added in addition to the illustrated blocks in a flowchart or block diagram.

The description of the different illustrative embodiments has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited

to the embodiments in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. Further, different illustrative embodiments may provide different features as compared to other desirable embodiments. The embodiment or embodiments selected are chosen and described in order to best

5 explain the principles of the embodiments, the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

CLAIMS:

What is claimed is:

- 5 1. An apparatus comprising:
a number of internally threaded members configured to engage an externally
threaded member; and
a shape memory element associated with the number of internally threaded
members,
10 wherein changing a baseline shape of the shape memory element to a
modified shape either prevents or allows movement of the number of internally
threaded members relative to the externally threaded member.
2. The apparatus of claim 1, wherein the shape memory element is formed by at
15 least a portion of an internally threaded member in the number of internally threaded
members.
3. The apparatus of claim 2, wherein the shape memory element is an internal
thread of the internally threaded member that is configured to engage an external
20 thread of the externally threaded member.
4. The apparatus of claim 3, wherein changing the baseline shape of the shape
memory element to the modified shape changes a thread pitch of the internal thread of
the internally threaded member such that rotational motion of the number of internally
25 threaded members relative to the externally threaded member is prevented.
5. The apparatus of claim 1, wherein the number of internally threaded members
comprises:
a first internally threaded member configured to receive the externally threaded
30 member; and
a second internally threaded member configured to receive the externally
threaded member, wherein the shape memory element is associated with and

positioned between the first internally threaded member and the second internally threaded member.

6. The apparatus of claim 5, wherein changing the baseline shape of the shape memory element to the modified shape exerts a first force on the first internally threaded member and exerts a second force on the second internally threaded member that prevent rotational motion of the number of internally threaded members relative to the externally threaded member.

7. The apparatus of claim 5, wherein the first internally threaded member is a first nut and wherein the second internally threaded member is a second nut.

8. The apparatus of claim 1 further comprising:
a shape control device configured to change the baseline shape of the shape memory element to the modified shape.

9. The apparatus of claim 8, wherein the shape control device is a heating device configured to heat the shape memory element such that the baseline shape of the shape memory element changes to the modified shape.

10. The apparatus of claim 9, wherein a shape of the shape memory element is configured to return to the baseline shape within selected tolerances when a temperature of the shape memory element returns to a baseline temperature within selected tolerances.

11. A method for operating an externally threaded member with a number of internally threaded members, the method comprising:
receiving the externally threaded member within the number of internally threaded members; and
changing a baseline shape of a shape memory element associated with the number of internally threaded members to a modified shape to either prevent or allow movement of the number of internally threaded members relative to the externally threaded member.

12. The method of claim 11, wherein receiving the externally threaded member within the number of internally threaded members comprises:

receiving the externally threaded member through an opening in an internally threaded member in the number of internally threaded members, wherein the shape memory element is an internal thread of the internally threaded member that is configured to engage an external thread of the externally threaded member.

13. The method of claim 12, wherein changing the baseline shape of the shape memory element to the modified shape comprises:

changing a temperature of the shape memory element to change a thread pitch of the internal thread such that rotational motion of the internally threaded member relative to the externally threaded member is prevented.

14. The method of claim 11, wherein receiving the externally threaded member within the number of internally threaded members comprises:

receiving the externally threaded member through a first opening in a first internally threaded member in the number of internally threaded members, through an opening in the shape memory element, and through a second opening in a second internally threaded member in the number of internally threaded members, wherein the shape memory element is associated with and positioned between the first internally threaded member and the second internally threaded member.

15. The method of claim 14, wherein changing the baseline shape of the shape memory element to the modified shape comprises:

changing a temperature of the shape memory element to change the baseline shape of the shape memory element to the modified shape such that a first force is exerted on the first internally threaded member and a second force is exerted on the second internally threaded member to prevent rotational motion of the first internally threaded member and the second internally threaded member relative to the externally threaded member.

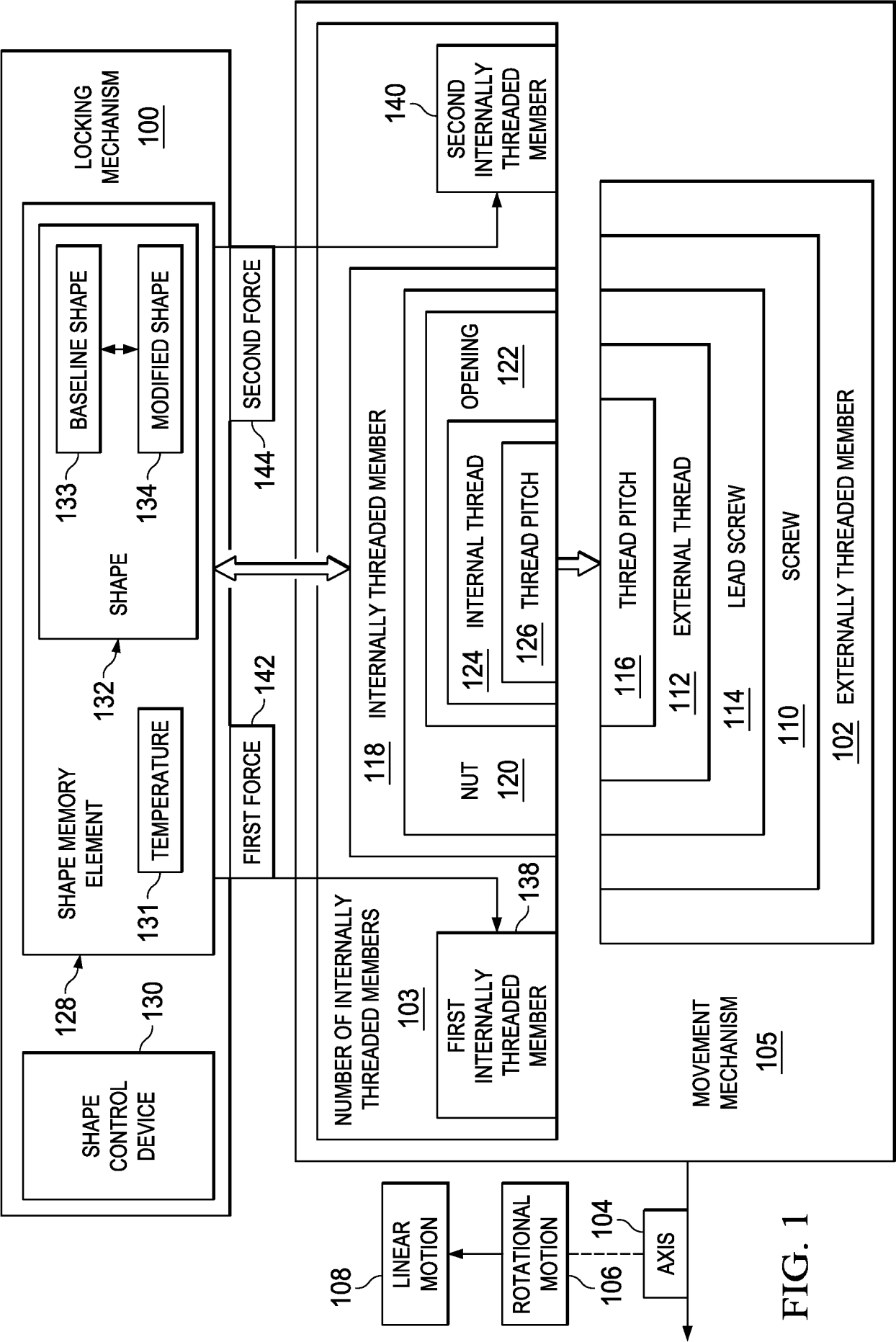
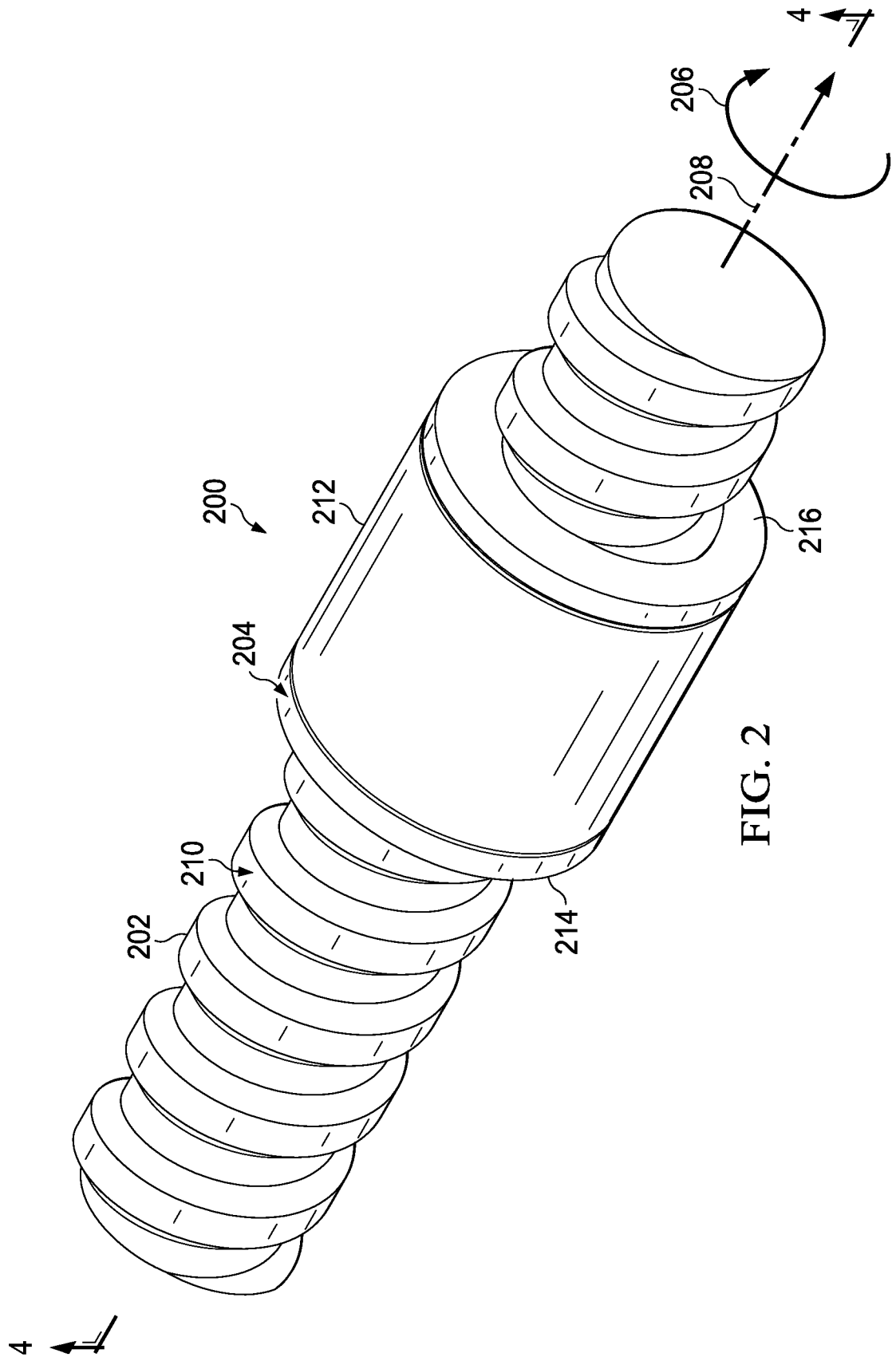


FIG. 1



3/7

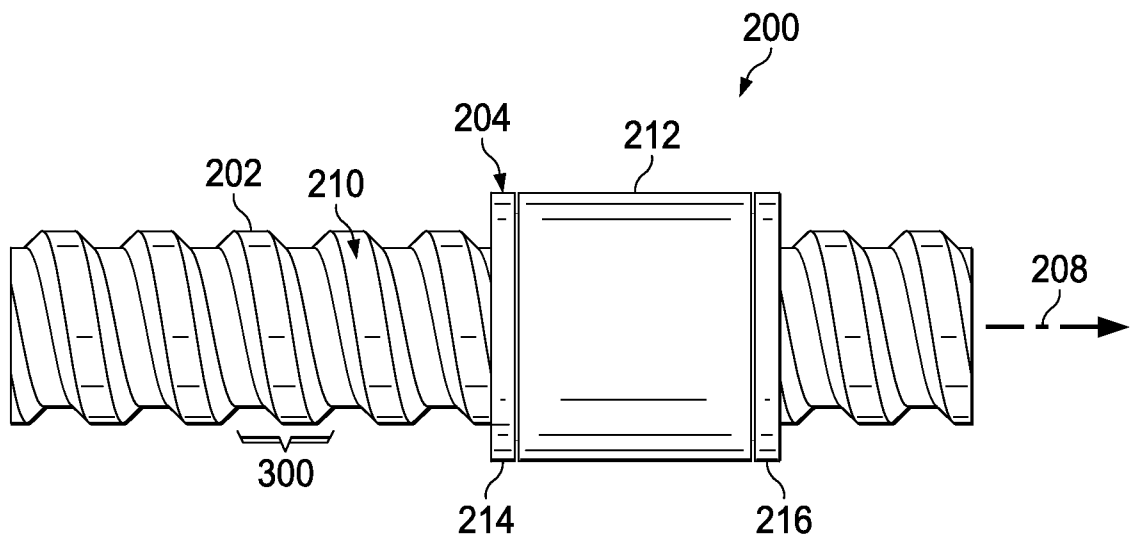


FIG. 3

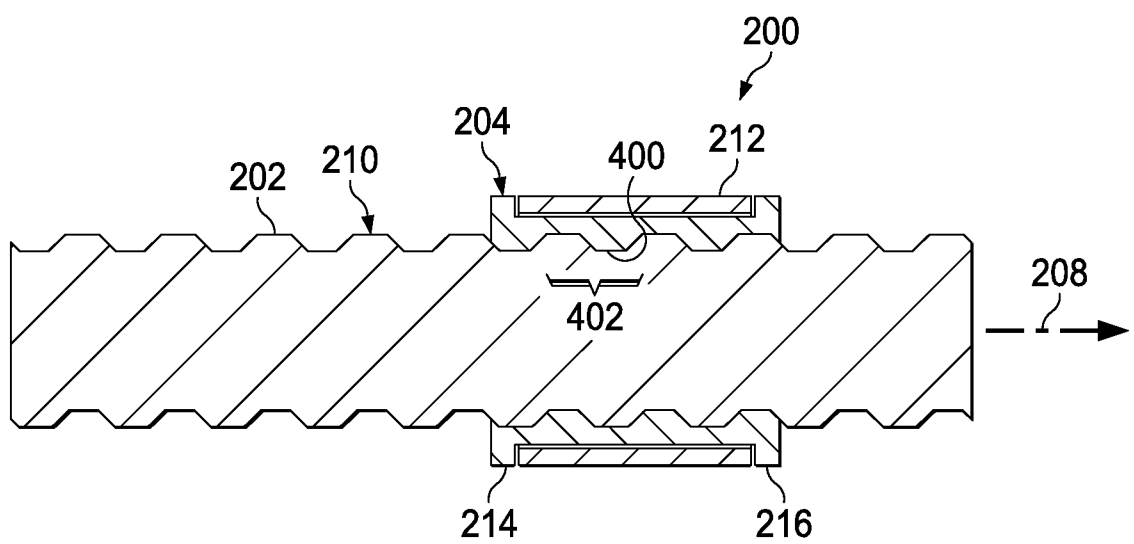
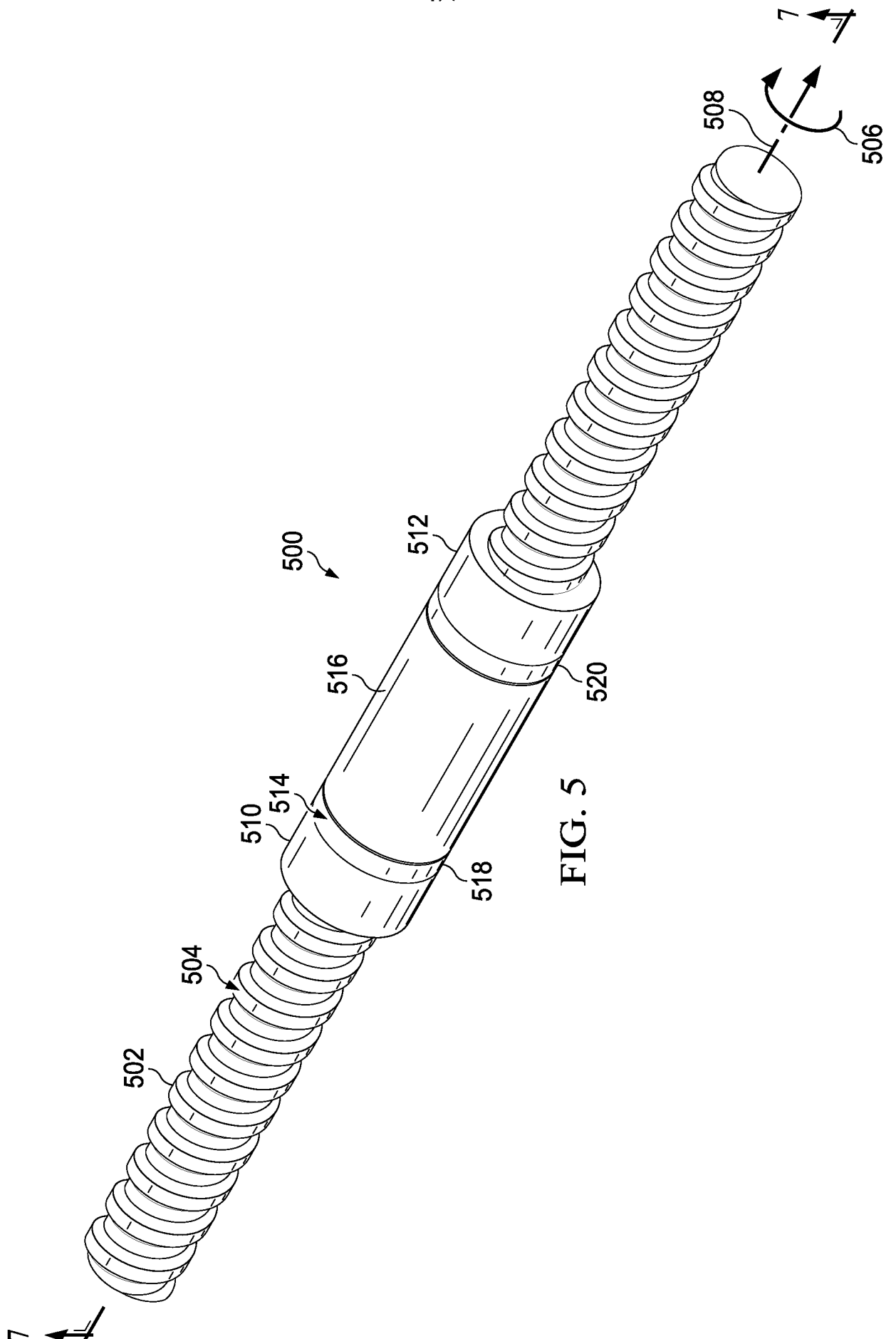
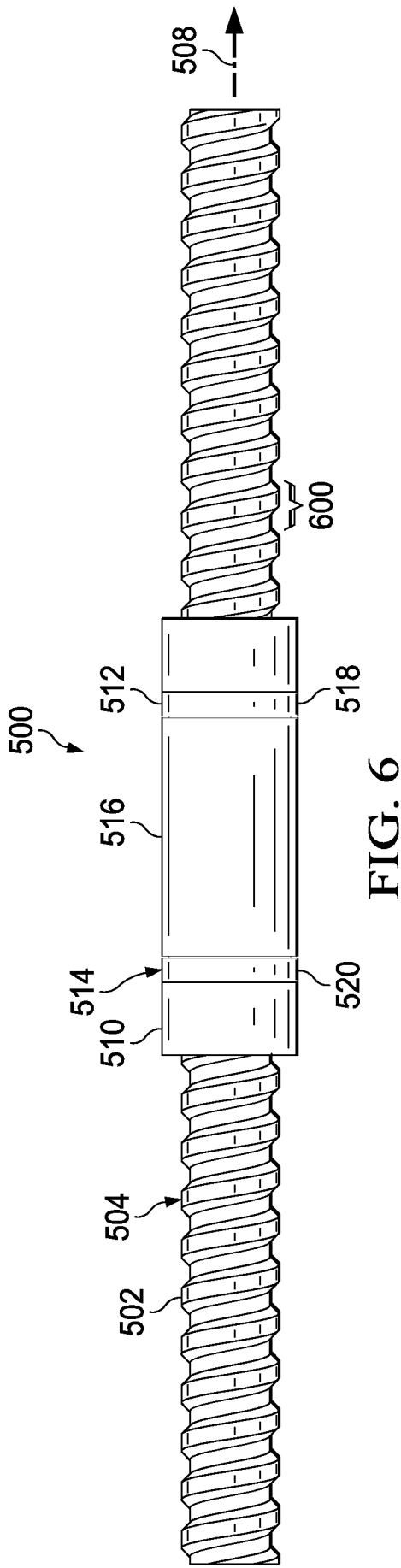
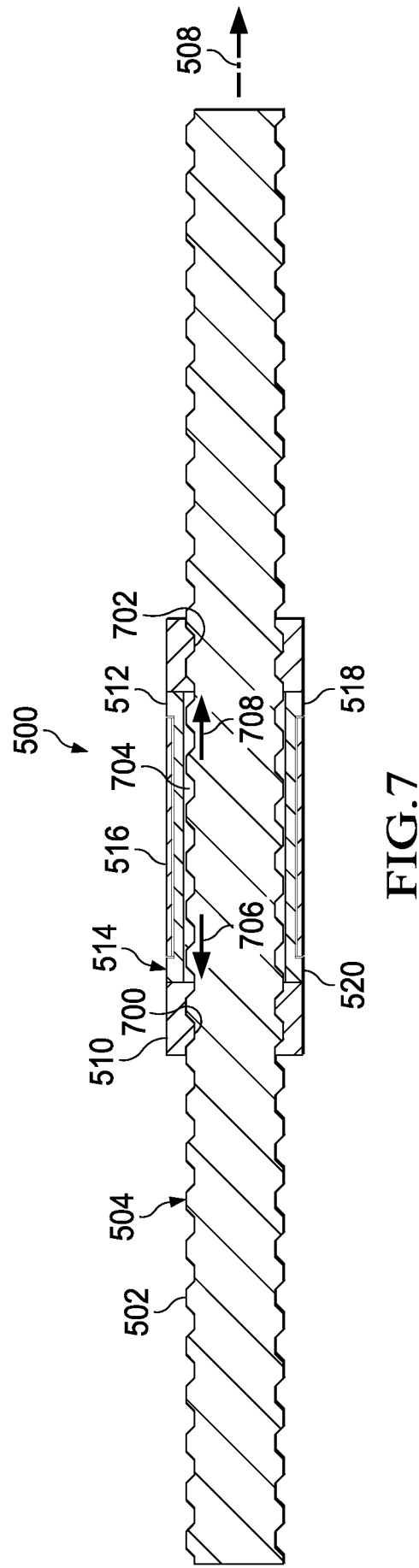


FIG. 4

4/7





6/7

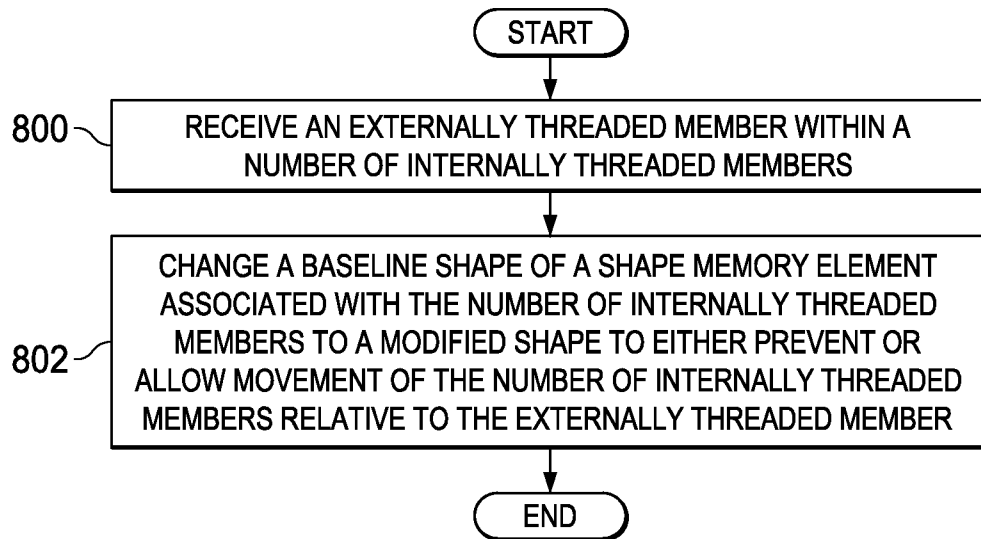


FIG. 8

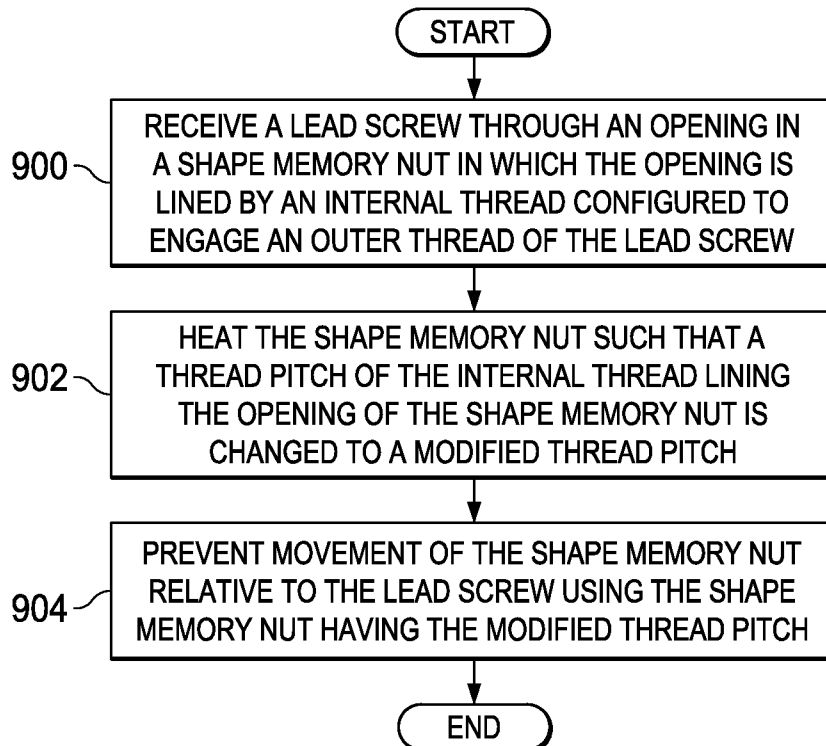


FIG. 9

7/7

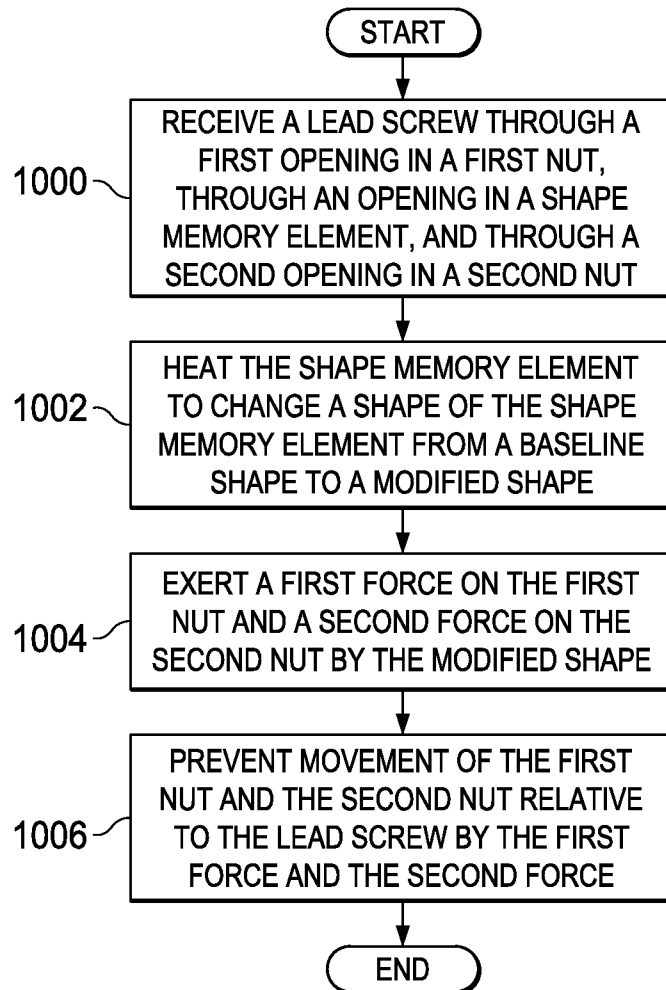


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/031619

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16H25/20 F16B39/00
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)
F16H 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)

EP0-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.
X	FR 2 961 876 A1 (SAGEM DEFENSE SECURITE [FR]) 30 December 2011 (2011-12-30) the whole document -----	1,2, 5-11,14, 15
X	JP 2009 133334 A (MEIRA CORP) 18 June 2009 (2009-06-18) the whole document -----	1-4, 11-13
X	GB 1 569 915 A (DELTA MATERIALS RESEARCH LTD) 25 June 1980 (1980-06-25) the whole document -----	1-4, 11-13

☐

Further documents are listed in the continuation of Box C.

☒

See patent family annex.

* Special categories of cited documents :

"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

11 August 2014

Date of mailing of the international search report

26/08/2014

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

Masset, Candie

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2014/031619

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 2961876	A1	30-12-2011	NONE

JP 2009133334	A	18-06-2009	JP 5145018 B2 13-02-2013
		JP 2009133334 A	18-06-2009

GB 1569915	A	25-06-1980	NONE
