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Winn et al.

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(54) **TUBE STRAIGHTENING TOOL AND METHOD OF STRAIGHTENING A TUBE**

(71) Applicant: **United States of America as represented by the Administrator of the National Aeronautics and Space Administration**, Washington, DC (US)

(72) Inventors: **Ross Winn**, Houston, TX (US); **Anthony Hood**, Houston, TX (US); **Heather Bergman**, Houston, TX (US); **Curtis Newman**, Houston, TX (US); **Eric Breaux**, Houston, TX (US)

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B21D 3/10 (2006.01)

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CPC ***B21D 3/10*** (2013.01)

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USPC 72/31.03
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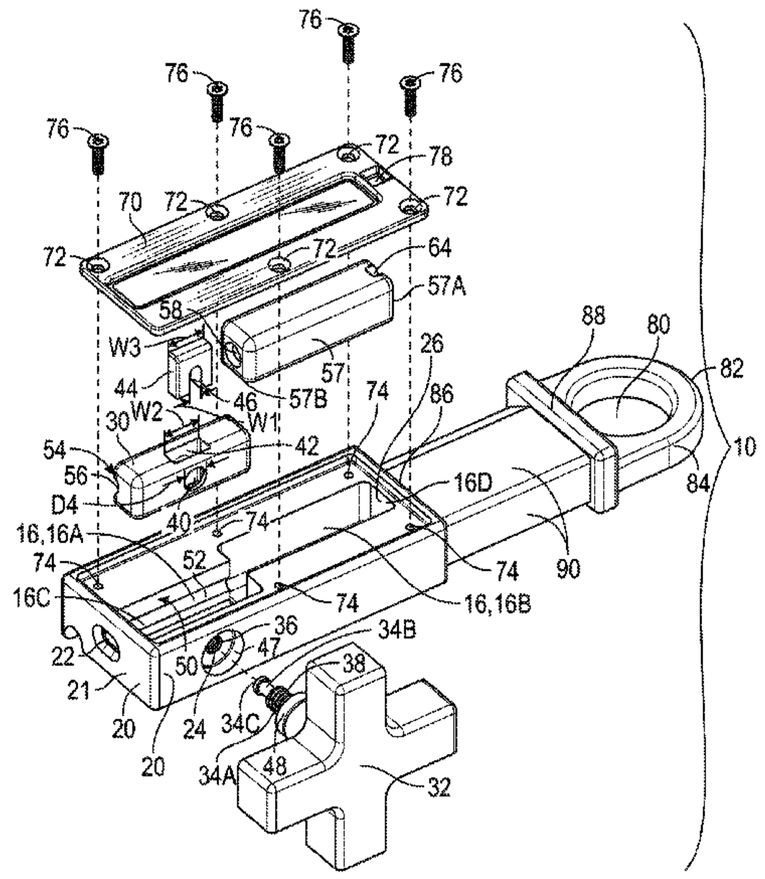
Primary Examiner — Bobby Yeonjin Kim
(74) *Attorney, Agent, or Firm* — Kurt G. Hammerle; Edward K. Kein

(57) **ABSTRACT**

A tube straightening tool includes a tool housing having an exterior defining a tube entrance opening that opens into a first end of an internal cavity, and has an interior end wall at a second end of the internal cavity. The tool housing has an interior side wall extending from the tube entrance opening toward the interior end wall. A press block is in the internal cavity and a knob is external to the tool housing. A threaded shaft extends from the knob through the shaft opening into the internal cavity. The press block is coupled to the threaded shaft. Turning the knob moves the press block toward the interior side wall, and an exterior of a tube resting in the internal cavity is confronted by the press block and moved against the interior side wall. A method of straightening a tube using the tool is disclosed.

20 Claims, 7 Drawing Sheets



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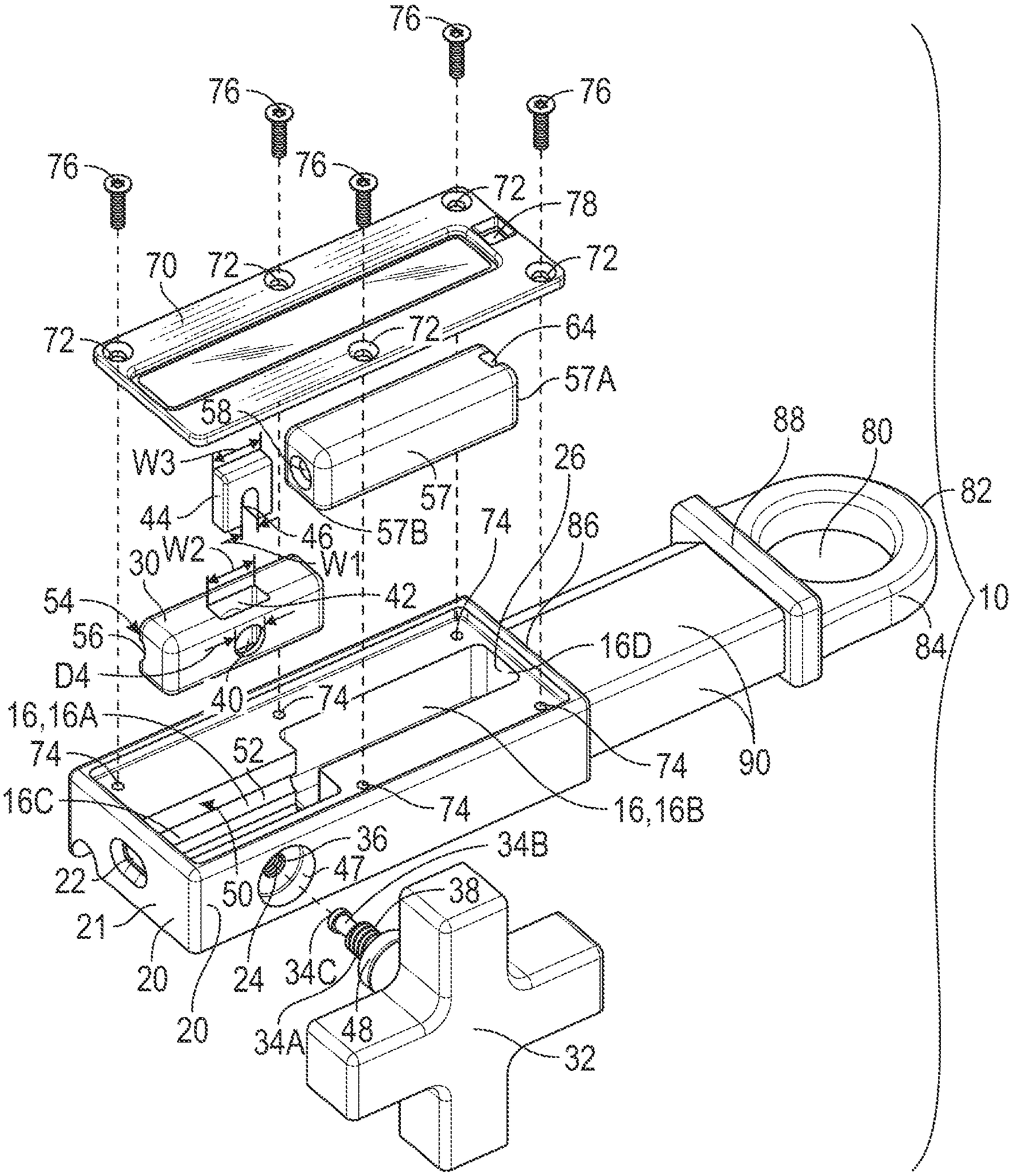
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W3
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74
86
30
W2
W1
42
54
56
D4
16D
40
74
16,16A
52
74
74
90
74
16C
16,16B
36
34B
22
47
50
38
21
20
24
34C
20
34A
48
32
88
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84
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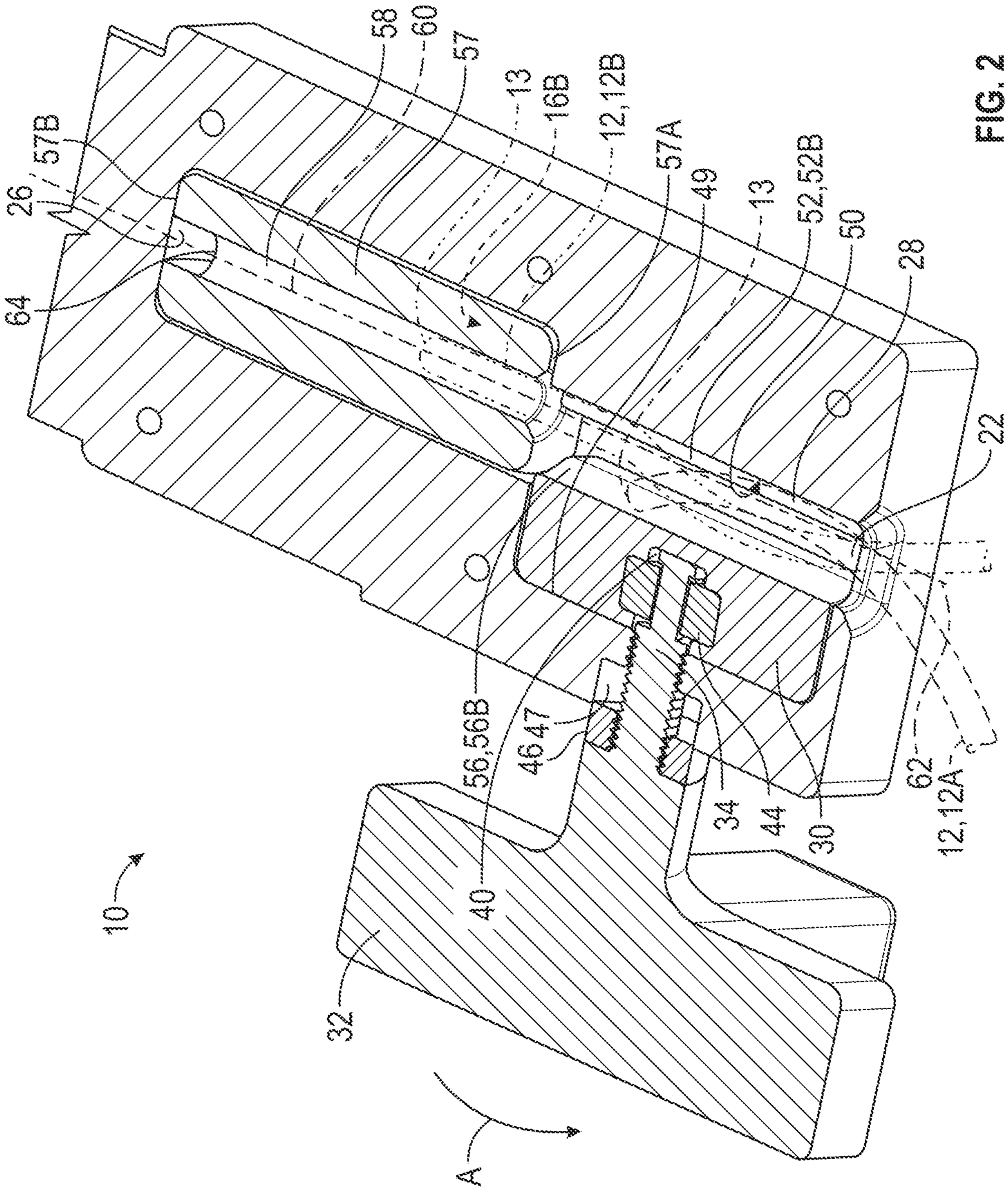
FIG. 1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60
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16B
12,12B
57A
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50
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64
26
57B
56,56B
46,47
40
32
10
A

FIG. 2

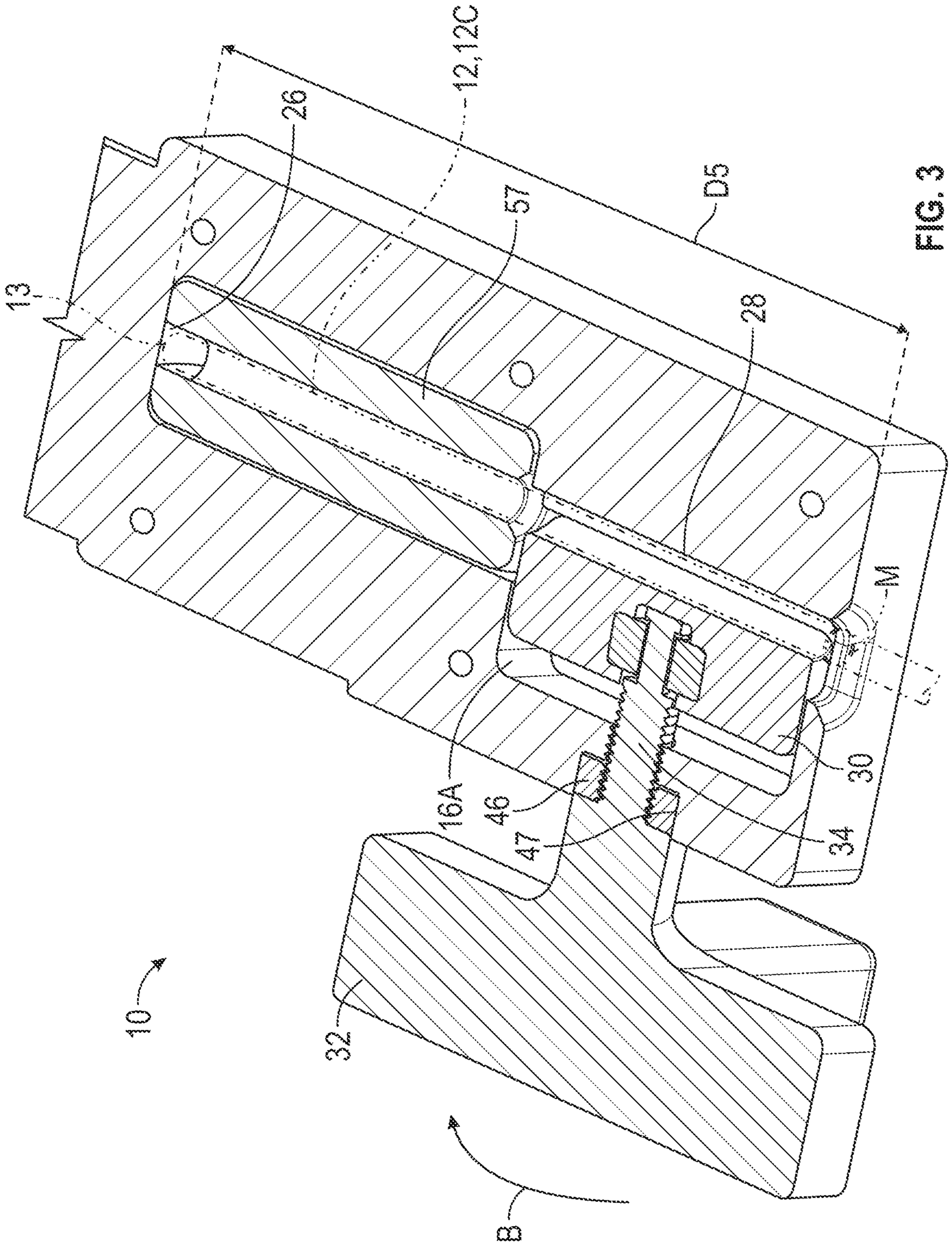
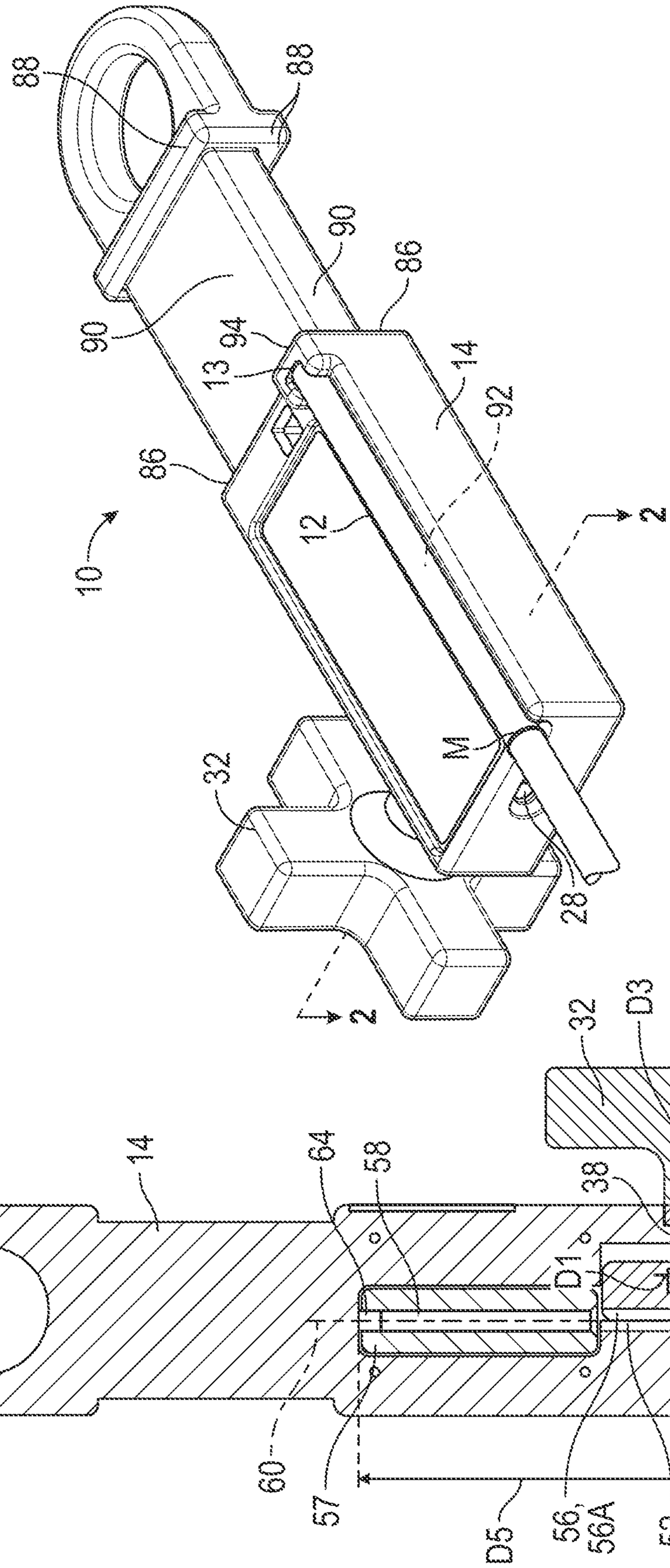


FIG. 3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94
13
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12
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2
M
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28
2
10
32
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14
64
58
38
36
34C
34A
D1
34B
62
60
57
44
D2
D5
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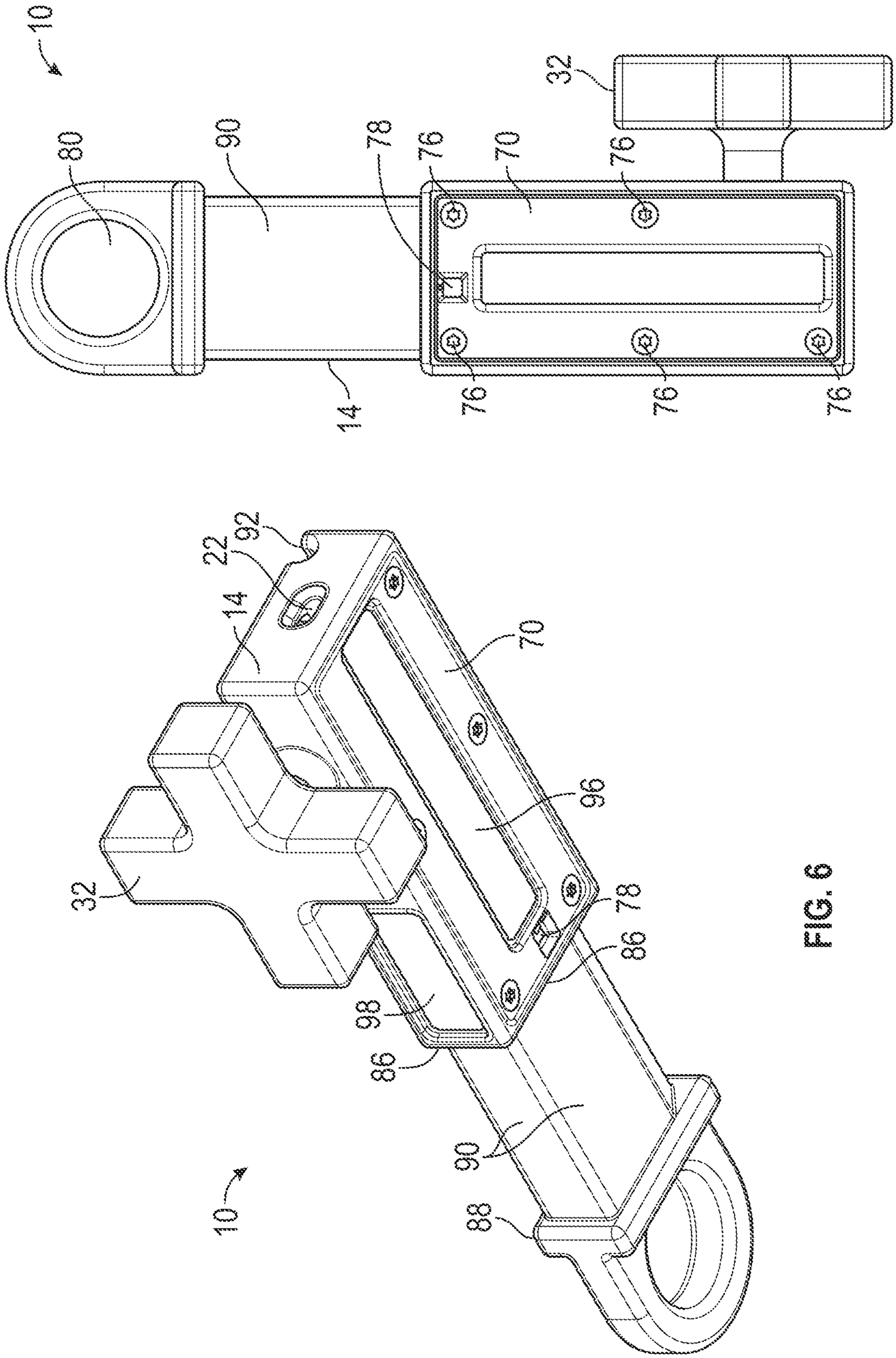
56A
52,
52A

FIG. 5

FIG. 4


10
32
80
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78
76
70
76
14
60
60
60

FIG. 7

22
92
14
70
96
32
78
86
98
86
90
88
10

FIG. 6

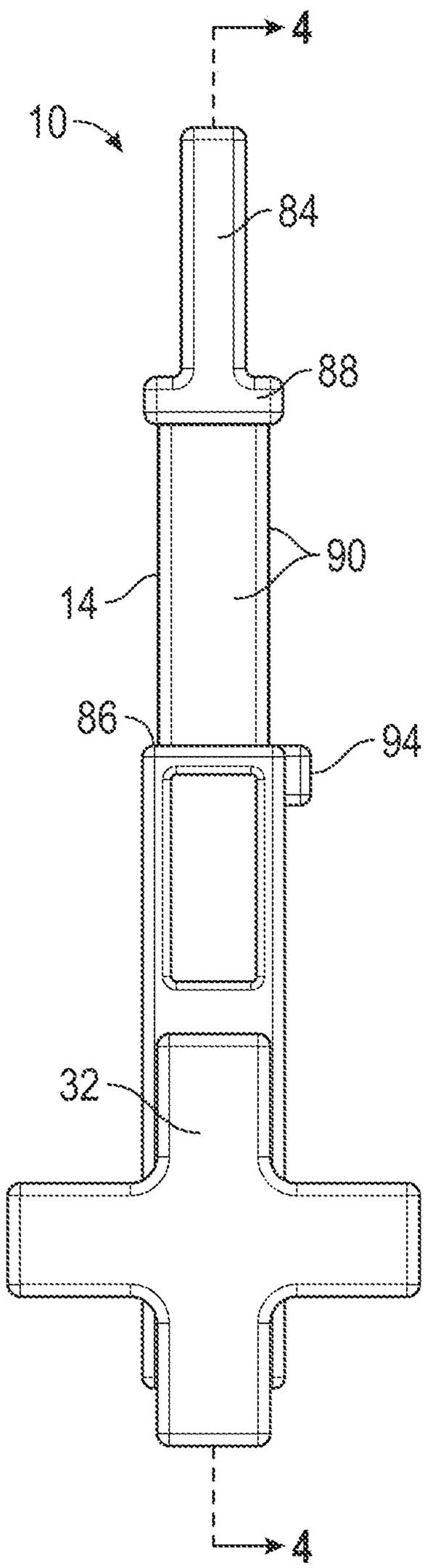

FIG. 8

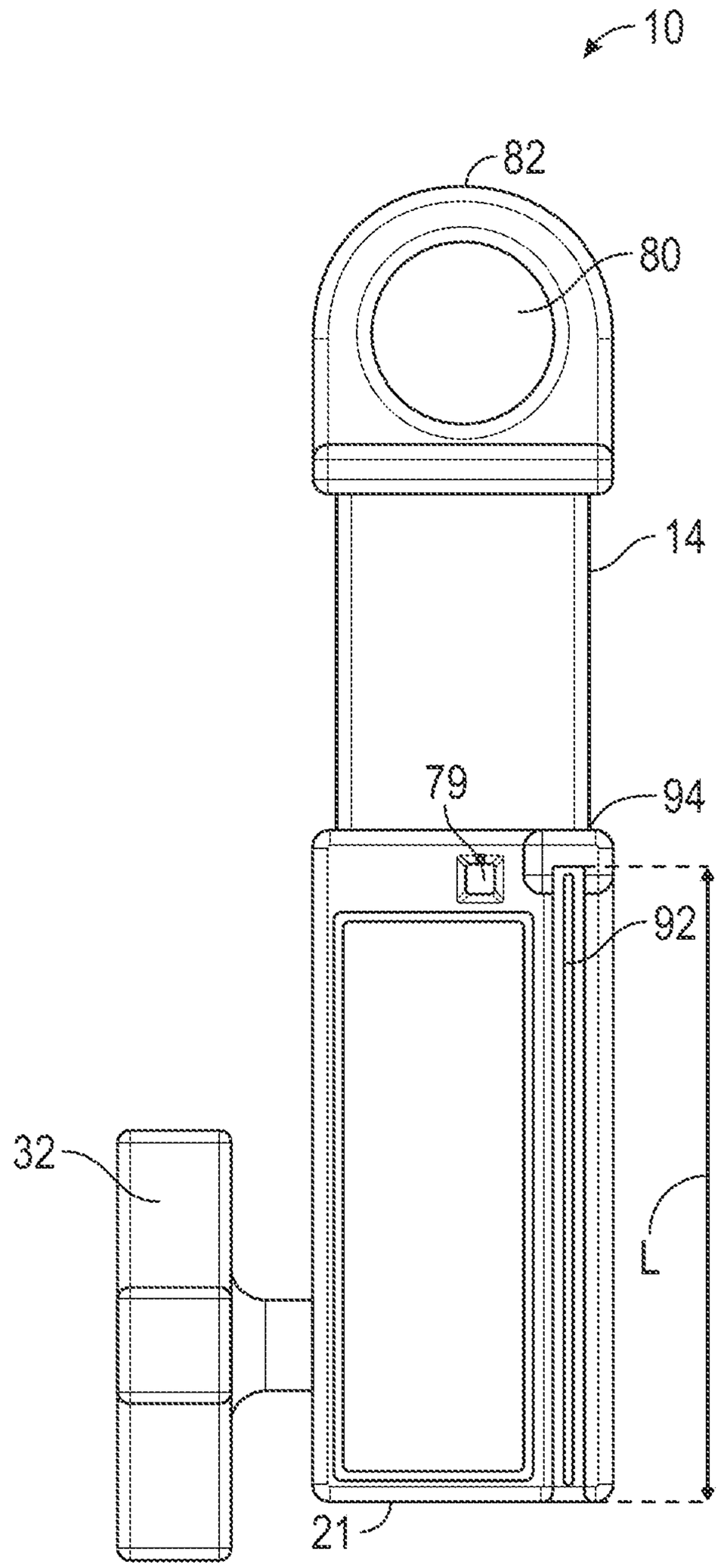

FIG. 9

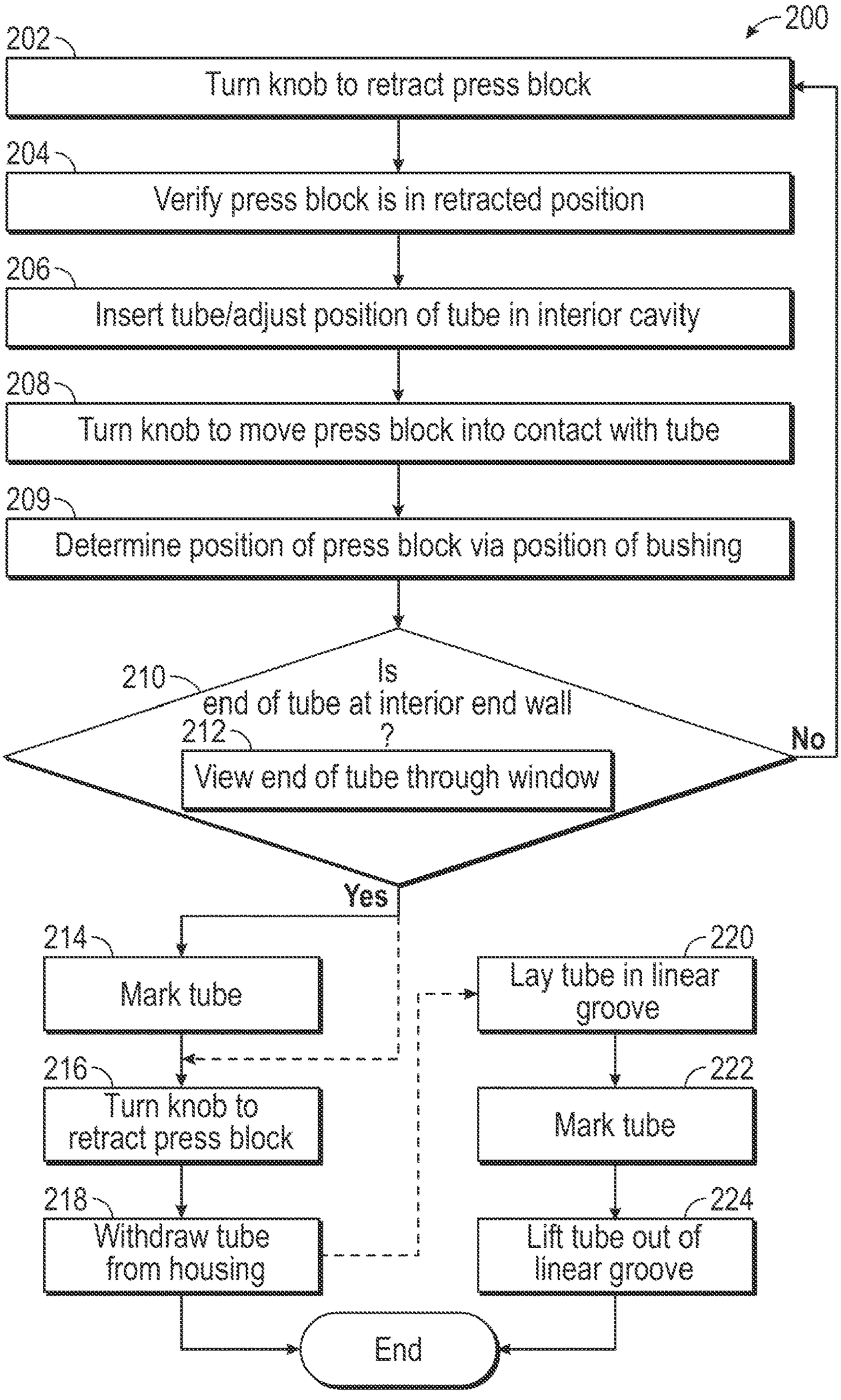
200
202
Turn knob to retract press block
204
Verify press block is in retracted position
206
Insert tube/adjust position of tube in interior cavity
208
Turn knob to move press block into contact with tube
209
Determine position of press block via position of bushing
210
Is end of tube at interior end wall ?
212
View end of tube through window
No
Yes
214
Mark tube
216
Turn knob to retract press block
218
Withdraw tube from housing
220
Lay tube in linear groove
222
Mark tube
224
Lift tube out of linear groove
End

FIG. 10

TUBE STRAIGHTENING TOOL AND METHOD OF STRAIGHTENING A TUBE

STATEMENT OF GOVERNMENT INTEREST

The embodiments described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without payment of any royalties thereon or therefor.

TECHNICAL FIELD

The present disclosure relates to a tube straightening tool and a method of straightening a tube using the same.

BACKGROUND

Tubes may be used as conduits for fluids, such as gasses and liquids. The end of the tube may be connected to another component through which the gas or liquid flows. In some implementations, the end of the tube should be straight in order to ensure a leakproof connection. Some tubes may need to be straightened prior to connecting. For example, tubes of a softer material may bend during handling and need to be straightened prior to connection.

SUMMARY

A leakproof connection is desirable for conduit tubes. This type of connection depends in part on fully inserting a straight and unscratched end of the tube into a fitting. A tube straightening tool and method of straightening a tube are disclosed herein that ensure that a desired length at the end of the tube (e.g., the tip of the tube) is straightened without a risk of introducing linear scratches that could create a leak path at the fitting. Avoiding linear scratches at the end of the tube is desirable, as a scratch on the exterior of the tube that extends at least partially lengthwise (e.g., past the fitting), may create a leak path, especially when high pressure gas flows in the tube. Many available tube straighteners, such as those that require sliding the tube through the straightener under resistance (e.g., during straightening), introduce linear scratches. Many available tube straighteners also do not include a way to measure the length of tube straightened, so the operator must do so with a separate tool. The tube straightening tool and method provided herein accomplish both of these goals via a portable and easy to use tool that functions equally well on earth and in space.

A tube straightening tool for straightening a length of tube includes a tool housing defining an internal cavity and having an exterior defining a tube entrance opening that opens into a first end of the internal cavity. The tool housing also defines a shaft opening orthogonal to the tube entrance opening. The shaft opening also opens into the internal cavity. The tool housing has an interior end wall at a second end of the internal cavity, and has an interior side wall extending from the tube entrance opening toward the interior end wall. A press block is disposed in the internal cavity. A knob is external to the tool housing, and a threaded shaft extends from the knob through the shaft opening and into the internal cavity. The press block is coupled to the threaded shaft. Turning the knob in a first direction moves the press block in the internal cavity toward the interior side wall, and turning the knob in a second direction opposite from the first direction moves the press block away from the interior side wall. With this configuration of the tube straightening tool, an exterior of a tube inserted through the tube entrance opening and resting in the internal cavity will be confronted by the press block and moved against the interior side wall to straighten the tube.

The tube straightening tool is configured to minimize movement of the tube in a direction along its longitudinal axis while under resistance during the straightening process. Longitudinal scratches at the exterior of the tube are thus minimized. For example, the tube entrance opening may be elongated in a direction from the interior side wall toward the press block. This elongation will allow a bent end of a tube to be inserted without resistance. Additionally, the internal cavity is sufficiently wide relative to the size of tube to be straightened that, even for a relatively severely bent tube, the tube is not moved longitudinally against any resistance when being inserted into the internal cavity. If the operator feels resistance when inserting a bent tube into the internal cavity, the operator can stop inserting the tube, and then operate the knob to apply force against the side of the tube with the press block while the tube is resting in the internal cavity. Because the tube is at rest when the press block contacts the side of the tube, and the press block moves orthogonally to the longitudinal axis of the tube (if the tube were straight) rather than along a length of the tube, movement of the tube along its longitudinal axis relative to the press block during straightening is minimal.

In some implementations, the interior side wall may have a stationary tube contact surface configured as a groove facing the press block and extending lengthwise along the internal cavity from the tube entrance opening toward the interior end wall. The press block may have a tube contact surface configured as a groove facing the interior side wall and extending lengthwise parallel with the groove of the stationary tube contact surface. As the tube contact surface of the press block moves closer to the stationary tube contact surface of the interior side wall, bends in the tube are lessened to no more than the distance between these two surfaces. In an embodiment for straightening tubing with a circular cross-section, for example, the groove of the stationary tube contact surface of the interior side wall and the groove of the tube contact surface of the press block are both semi-circular.

In order to ensure that the portion of the tube nearest the end of the tube is protected from scratches and is straight, a tube sleeve may be disposed in a portion of the cavity adjacent the interior end wall (e.g., a second cavity portion). The tube sleeve has a linear passage extending lengthwise through the tube sleeve from a first end of the tube sleeve at a portion of the cavity nearest the tube entrance opening (e.g., a first cavity portion) to a second end of the tube sleeve at the interior end wall. A longitudinal center axis of the linear passage aligns with a longitudinal center axis of the groove of the stationary tube contact surface of the interior side wall. The tube sleeve may be a first material, the tool housing may be a second material, and the first material may be softer than the second material. If the portion of the tube nearest the tube end (also referred to as the tip) is sufficiently straightened by the press block in the first portion of the cavity it can be slid into further into the internal cavity (e.g., into the linear passage) with little or no resistance, and, in any event, any resistance would be lessened by the relatively soft material. The portion of the tube near the tube end remains in the linear passage of the tube sleeve while a portion of the tube slightly further from the tip is now in the first portion of the internal cavity, and may be straightened by the press block.

The tube straightening tool may have features that aid the operator in ensuring that a desired length of the tube has

been straightened (e.g., the length of the tube that is needed for a leakproof connection to the fitting). For example, the tool housing may define a window extending through the tool housing to the internal cavity at the interior end wall. The operator can then view the end of the tube at the interior end wall to ensure that the tube has been fully inserted into the tool housing. The distance from the entrance opening to the interior end wall may be the same or greater than the length to be straightened to ensure a leak free connection at the end of the tube (e.g., is the predefined distance).

Alternatively or in addition, the exterior of the tool housing may define a linear groove having a length equal to the distance from the entrance opening to the interior end wall. The operator may use these features to verify that the end of the tube contacts the interior end wall. For example, the operator may view the end of the tube at the interior end wall through the window. The operator may mark the tube at the predefined distance from the end of the tube by laying the tube in the linear groove in the exterior of the tool housing, or the operator may mark the tube at the entrance opening after inserting the tube until the end of the tube contacts the interior end wall. Marking the tube may be with an ink marker or with tape, for example. With the marked tube, the operator can insert the tube end into a connector fitting to the marking and be assured that the tube end is fully inserted.

The tube straightening tool may also have features that aid the operator in determining how far and in which direction to rotate the knob during the straightening process. For example, the tool housing may have a counterbore at the exterior of the tool housing around the shaft opening. The tube straightening tool may include a bushing fixed to the threaded shaft. The bushing may move at least partially into the counterbore when the knob is turned in the first direction and may move at least partially out of the counterbore when the knob is turned in the second direction. By viewing the position of the bushing relative to the housing at the counterbore, the operator is informed of the position of the press block in the internal cavity (e.g., whether it is relatively close to the interior side wall, or relatively far from the interior side wall) and, accordingly, which way to turn the knob.

The tube straightening tool may have features that couple the press block to the shaft so that the shaft can rotate relative to the press block with the knob, but not move axially relative to the press block. For example, the press block may have a blind hole extending partially through the press block. The threaded shaft may extend into the blind hole, and the press block may have a shaft access opening extending at least partially through the press block orthogonal to and in communication with the blind hole. A retainer clip may be disposed in the shaft access opening with a narrowed portion of the threaded shaft in a notch of the retainer clip to fix the threaded shaft axially relative to the press block.

The tool housing may have internal threads at the shaft opening, and the threaded shaft may have an externally-threaded portion that threads to the internal threads. The threaded shaft may also have a terminal end portion opposite the knob, and the narrowed portion may be between the externally-threaded portion and the terminal end portion. A diameter of the narrowed portion is less than a diameter of the terminal end portion and less than a diameter of the externally-threaded portion. A width of the notch is less than the diameter of the terminal end portion and less than the diameter of the externally-threaded portion. The shaft access opening is wider than the blind hole, and wider than the retainer clip. With this configuration, the retainer clip locks the shaft axially relative to the press block.

In some embodiments, the straightening tool may include a cover plate fastenable to the tool housing to enclose the internal cavity. The cover plate may define a window extending through the cover plate to the internal cavity at the interior end wall when the cover plate is fastened to the tool housing. Like the window in the tool housing, the window in the cover plate can be used to determine whether the tube is fully inserted to the end wall.

Accordingly, during assembly, the press block can be inserted into the internal cavity, the shaft extended into the shaft opening, the retainer clip then placed around the shaft in the shaft access opening. The sleeve may also be placed in the internal cavity. Once the components are in the internal cavity, the cover plate may be fastened to the housing to enclose the components in the internal cavity.

The tube straightening tool may have additional features making it easy for an operator to carry and use, especially in space, where diminished gravitational forces may require retaining the tool to prevent it floating away from the operator. The exterior of the tool housing may have a first ridge, a second ridge spaced from the first ridge, and a tool mount portion recessed between the first ridge and the second ridge. For example, the tool mount portion may be relatively flat, and a supporting apparatus may be mounted to the tube straightening tool at the tool mount portion to support the tool during use and hold it in place, leaving the operator's hands free to manipulate the tube. The ridges help to prevent movement of the tool relative to the supporting apparatus.

Another convenience feature for the operator may include a through hole extending through the tool housing orthogonal to the entrance opening at an end of the tool housing opposite from the entrance opening. For example, the tool housing may form a ring around the through hole, and the tool may be connected to the operator's belt, for example, with a connector extending through the through hole around the ring.

A method of straightening a tube using the tube straightening tool includes inserting an end of a tube at least partially into the internal cavity through the entrance opening so that the tube is in an initial resting position in the internal cavity. The method further includes turning the knob in a first direction to move the press block toward the interior side wall and into contact with an exterior of the tube to force the tube toward the interior side wall. Next, the knob is turned in a second direction to move the press block away from the interior side wall and out of contact with the exterior of the tube.

The position of the tube within the internal cavity can then be adjusted to a subsequent resting position, such as by rotating the tube at least partially about its longitudinal axis so that another orientation of the tube is presented to the press block for straightening, by inserting the tube further into the internal cavity so that the press block can act against a new portion of the tube, or by both rotating the tube about its longitudinal axis and inserting the tube further into the internal cavity.

The knob is then turned in the first direction again to move the press block toward the interior side wall and into contact with the exterior of the tube to force the tube toward the interior side wall. Manipulating the resting position of the tube within the internal cavity by rotating the tube and/or by inserting the tube further into the cavity may thus be accomplished in stages, with each repositioning of the tube occurring without resistance from the press block or the tool

housing, as the press block is first moved out of contact with the tube when the knob is rotated in the second direction prior to each manipulation of the tube. Eventually, the tube may be inserted without resistance until an end of the tube contacts the interior end wall.

The method may include verifying that the end of the tube contacts the interior end wall by viewing the end of the tube at the interior end wall through a window extending through the tool housing at the interior end wall and/or through a window extending through a cover plate at the interior end wall when the cover plate is fastened to the tool housing.

The method may include marking the tube at a predefined distance from the end of the tube by laying the straightened tube in a linear groove in the exterior of the tool housing. The linear groove has a length equal to the predefined distance. Alternatively, the tube may be marked at the entrance opening after inserting the tube until the end of the tube contacts the interior end wall. The tube straightening tool is configured so that a distance from the entrance opening to the interior end wall equal to the predefined distance.

The above summary is not intended to represent every embodiment or aspect of the present disclosure. Rather, the foregoing summary exemplifies certain novel aspects and features as set forth herein. The above noted and other features and advantages of the present disclosure will be readily apparent from the following detailed description of representative embodiments and modes for carrying out the present disclosure when taken in connection with the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings described herein are for illustrative purposes only, are schematic in nature, and are intended to be exemplary rather than to limit the scope of the disclosure.

FIG. **1** is an exploded perspective view of a tube straightening tool.

FIG. **2** is a fragmentary cross-sectional view of the tube straightening tool taken at lines **2-2** in FIG. **5** and showing a press block in a first position relative to an interior side wall of a tool housing, and with a portion of a tube shown in fragmentary phantom view.

FIG. **3** is a fragmentary cross-sectional view of the tube straightening tool showing the press block in a second position relative to the interior side wall of the tool housing with the tube straightened by the press block.

FIG. **4** is a cross-sectional view of the tube straightening tool taken at lines **4-4** in FIG. **8**.

FIG. **5** is a perspective view of a top side of the tube straightening tool.

FIG. **6** is a perspective view of a bottom side of the tube straightening tool.

FIG. **7** is a plan view of the bottom side of the tube straightening tool.

FIG. **8** is a side view of a first side of the tube straightening tool.

FIG. **9** is a plan view of the top side of the tube straightening tool.

FIG. **10** is a flowchart of a method of straightening a tube using the tube straightening tool.

DETAILED DESCRIPTION

With reference to the drawings, wherein like reference numbers refer to the same or similar components throughout the several views, an example tube straightening tool **10** is shown schematically in exploded view in FIG. **1**. The tube straightening tool **10** straightens a length of a tube **12** shown in phantom in FIGS. **2** and **3**. The tube straightening tool **10** includes a tool housing **14** defining an internal cavity **16**. The internal cavity **16** has a first cavity portion **16**A and a second cavity portion **16**B. An exterior **20** of the tool housing **14** defines a tube entrance opening **22** that opens into a first end **16**C of the internal cavity **16**. The end **13** of the tube **12** is inserted into the internal cavity **16** at the entrance opening **22**. The tool housing also defines a shaft opening **24** orthogonal to the tube entrance opening **22**. The shaft opening **24** also opens into the internal cavity **16**. The tool housing **14** has an interior end wall **26** at a second end **16**D of the internal cavity **16**, and has an interior side wall **28** extending from the tube entrance opening **22** toward the interior end wall **26**.

The tube straightening tool **10** includes a press block **30** that is configured to be disposed in the first cavity portion **16**A, as shown in FIGS. **2-4**. Stated differently, the press block **30** is sized and shaped to fit in the first cavity portion **16**A. The tube straightening tool **10** also includes a knob **32** that is external to the tool housing **14** when assembled, as shown in FIGS. **2-9**.

The tube straightening tool **10** includes a threaded shaft **34** that extends from the knob **32** through the shaft opening **24** and into the internal cavity **16** as shown in FIGS. **2-3**. The threaded shaft **34** may be integrally formed as a unitary component with the knob **32** as shown herein. Alternatively, the threaded shaft **34** may be a separate component secured to the knob **32** with a set screw, for example. The tool housing **14** has internal threads **36** at the shaft opening **24**. The threaded shaft **34** has external threads **38** at an externally-threaded portion **34**A. The external threads **38** thread to the internal threads **36**.

The tube straightening tool **10** includes a press block **30** that has a blind hole **40** extending partially through the press block **30**. The press block **30** also has a shaft access opening **42** extending at least partially through the press block **30** orthogonal to and in communication with the blind hole **40**. The threaded shaft **34** extends into the blind hole **40**, as shown in FIGS. **2-4**.

The tube straightening tool **10** includes a retainer clip **44** that may be disposed in the shaft access opening **42**. The retainer clip **44** has a notch **46**. The retainer clip **44** fits to the shaft **34** so that a narrowed portion **34**B of the threaded shaft **34** is in the notch **46** when the retainer clip **44** is disposed in the shaft access opening **42** and the threaded shaft **34** is disposed through the blind hole **40** to fix the threaded shaft **34** axially relative to the press block **30**. As best shown in FIG. **4**, the threaded shaft **34** has a terminal end portion **34**C opposite the knob **32**. The narrowed portion **34**B is between the externally-threaded portion **34**A and the terminal end portion **34**C. The externally-threaded portion **34**A and the terminal end portion **34**C have diameters greater than the width of the notch **46** so that the retainer clip **44** locks the shaft **34** axially relative to the press block **30**. Referring to FIG. **4**, a diameter D**1** of the narrowed portion **34**B is less than a diameter D**2** of the terminal end portion **34**C, and less than a diameter D**3** of the externally-threaded portion **34**A. A width W**1** of the notch **46** (see FIG. **1**) is less than the diameter D**2** of the terminal end portion **34**C and less than the diameter D**2** of the externally-threaded portion **34**A. The shaft access opening **42** has a width W**2** greater than the diameter D**4** of the blind hole **40**, and a width W**3** the retainer clip **44** is less than the width W**2** of the shaft access opening **42**. With this configuration, the retainer clip **44** locks the shaft **34** axially relative to the press block **30**.

In this manner, the press block **30** is coupled to the threaded shaft **34** so that it is moved with the threaded shaft **34** axially toward and away from the interior side wall **28** but does not rotate with the threaded shaft **34**. The threaded shaft **34** can rotate relative to the press block **30** as the knob **32** is turned so that the threaded shaft **34** moves axially relative to the tool housing **14** as the external threads **38** engage the internal threads **36**.

The interior side wall **28** has a stationary tube contact surface **50** configured with a groove **52** facing the press block **30** and extending lengthwise along the internal cavity **16** from the tube entrance opening **22** toward the interior end wall **26**. A first half **52**A of the groove **52** is shown in FIG. **4**, and a second half **52**B of the groove **52** is shown in FIG. **2**. These halves **52**A, **52**B are shown on either side of a cutting plane in FIGS. **2** and **4** that extends along the longitudinal center axis **62**. As is evident from the two halves **52**A, **52**B and from the entire groove **52** shown in FIG. **1**, the groove **52** is semi-circular (e.g., the stationary tube contact surface **50** is a concave semi-circle at a cross-section perpendicular to the longitudinal center axis **62** of the groove **52** of FIG. **2**).

The press block **30** has a tube contact surface **54** configured with a groove **56** facing the interior side wall **28** and extending lengthwise parallel with the groove **52** of the stationary tube contact surface **50**. FIG. **1** shows an end of the groove **56**. A first half **56**A of the groove **56** is shown in FIG. **4**, and a second half **56**B is shown in FIG. **2**. As is evident from the two halves **56**A, **56**B and from FIG. **1**, the groove **56** is semi-circular (e.g., the tube contact surface **54** is a concave semi-circle at a cross-section perpendicular to the longitudinal center axis **62** of FIG. **2**). The stationary tube contact surface **50** and the tube contact surface **54** and their respective grooves **52**, **56** are thus configured to straighten round tubes (tubes having a circular outer perimeter in a cross section perpendicular to the length of the tube). In other embodiments, the stationary tube contact surface **50** and the tube contact surface **54** could have grooves with other cross-sectional shapes configured for straightening tubes with outer perimeters having other cross-sectional shapes (e.g., oval tubes, square tubes, etc.).

Referring to FIG. **1**, the tool housing **14** has a counterbore **47** at the exterior **20** of the tool housing **14** around the shaft opening **24**. The tube straightening tool **10** includes a bushing **48** fixed to the threaded shaft **34** between the knob **32** and the externally-threaded portion **34**A. For example, the bushing **48** may be adhered to the threaded shaft **34**. Although the threads **38** are shown extending under the bushing **48**, the threads **38** may be only between the bushing **48** and the narrowed portion.

The bushing **48** has an axial width equal to the depth of the counterbore **47** so that the bushing **48** fits entirely into the counterbore **47** when the knob **32** is moved in the first direction as far as possible (e.g., until the portion of the tube contact surface **54** above and below the groove **56** confronts the portion of the stationary tube contact surface **50** at the interior side wall **28** above and below the groove **52**, which occurs when the tube **12** is entirely within the adjacent grooves **52**, **56**).

The tube straightening tool **10** includes a tube sleeve **57** that is disposed in the second cavity portion **16**B adjacent to the interior end wall **26** as shown in FIG. **2**. The tube sleeve **57** a has a linear passage **58** extending lengthwise through the tube sleeve **57** from a first end **57**A of the tube sleeve **57** at the first cavity portion **16**A to a second end **57**B of the tube sleeve **57** at the interior end wall **26**, as shown in FIG. **2**. A longitudinal center axis **60** of the linear passage **58** aligns with a longitudinal center axis **62** of the groove **52** of the stationary tube contact surface **50** of the interior side wall **28** as shown in FIG. **2**. The tube sleeve **57** includes a notch **64** extending entirely through the second end **57**B orthogonal to the longitudinal center axis **60** of the linear passage **58**, as is evident from FIGS. **1** and **4**. The linear passage **58** has a cross-sectional shape that is the desired shape and size of the straightened tube **12**, such as a cylindrical shape.

Referring again to FIG. **1**, the tube straightening tool **10** includes a cover plate **70** with multiple spaced fastener openings **72**. The fastener openings **72** align with fastener openings **74** in bottom of the tool housing **14**. Fasteners **76** extend through the fastener openings **72** and thread to the tool housing **14** at the fastener openings **74** to secure the cover plate **70** to the tool housing **14**. The cover plate **70** extends over the internal cavity **16** and thus retains the retainer clip **44** in the first cavity portion **16**A around the shaft **34**, and retains the tube sleeve **57** in the second cavity portion **16**B. The press block **30** is retained in the first cavity portion **16**A due to the shaft **34** extending through the blind hole **40**, and the cover plate **70** additionally retains the press block **30** in the internal cavity **16**.

The cover plate **70** has a window **78** that extends through the cover plate **70**. When the cover plate **70** is secured to the tool housing **14**, the window **78** is disposed over the second cavity portion **16**B of the internal cavity **16** at the interior end wall **26** and is aligned with the notch **64**. The top of the tool housing **14** also has a window **79**, as shown in FIG. **9**, that aligns with the window **78** and the notch **64**. The windows **78**, **79** and the notch **64** enable the operator to verify that the end of the tube **12** is fully inserted to the interior end wall **26** during use.

The cover plate **70** is relatively flat. Referring to FIG. **6**, a label may be adhered to the cover plate **70** at a recessed portion **96**. The tool housing **14** has a similar recessed portion **98**. A label may also be placed at the recessed portion **98**. For example, the label or labels may include a part number or serial number assigned to the tube straightening tool **10** and/or may include instructions for use, etc.

Accordingly, to assemble the tube straightening tool **10**, the press block **30** is inserted into the first cavity portion **16**A of the internal cavity **16**, the knob **32** is positioned so that the shaft **34** extends into the blind hole **40**, and the retainer clip **44** is then placed around the narrowed portion **34**B of the shaft **34** in the shaft access opening **42**. The tube sleeve **57** is placed in the second cavity portion **16**B of the internal cavity **16** either before or after inserting the press block **30**. The cover plate **70** is then fastened to the tool housing **14** to enclose these components in the internal cavity **16**.

The tube straightening tool **10** may have additional features making it easy for an operator to carry and use, especially in space, where the tube straightening tool **10** may need to be retained due to the relatively low gravitational forces. For example, as shown in FIG. **7**, the tool housing **14** has a through hole **80** extending through the tool housing **14** orthogonal to the entrance opening **22** at an end **82** of the tool housing **14** opposite from the entrance opening **22**. In the embodiment shown, the tool housing **14** forms a ring **84** around the through hole **80**. A clip, tie, or other securing mechanism may extend through the through hole **80** around the ring **84** to connect the tube straightening tool **10** to a person or apparatus. The tube straightening tool **10** may be connected to the operator's belt, for example, with a connector ring on the belt extending through the through hole **80** and around the ring **84**.

The exterior **20** of the tool housing **14** has a first ridge **86**, a second ridge **88** spaced from the first ridge **86**, and a tool

mount portion **90** recessed between the first ridge **86** and the second ridge **88**. The tool mount portion **90** is shown as relatively flat and four-sided, as is evident in FIGS. **5** and **6**, for example. The ridges **86**, **88** extend outward at the four sides of the tool housing **14**, and a supporting apparatus may be mounted to the tube straightening tool **10** at the tool mount portion **90** to support the tube straightening tool **10** during use and hold it in place, leaving the operator's hands free to manipulate the tube **12** as described herein. For example, a retaining tool such as a clamp may be mounted at the tool mount portion **90** to hold the tube straightening tool **10**, and the ridges **86**, **88** help to limit movement of the clamp on the tube straightening tool **10**.

Referring to FIGS. **5** and **9**, the exterior **20** of the tool housing **14** also has a linear groove **92** extending from the end **21** of the tool housing **14** in which the entrance opening **22** is defined toward the end **82**. The linear groove **92** has a length L that is equal to the distance D**5** indicated in FIG. **4** from the entrance opening **22** to the interior end wall **26**. The housing **14** has an elevated stop **94** at the end of the linear groove **92** so that the tube **12** can be slid in the linear groove **92** to the stop **94** to accurately determine a length of the tube from the stop **94** to the end **21** (e.g., the length L). The length L and the distance D**5** are predetermined as being equal to a length of the tube **12** that will be inserted into a connector fitting and should be free of linear scratches at its exterior for a secure connection. Stated differently, the tube straightening tool **10** is designed to be used for straightening the tube **12** that will be used with certain types of fittings, such as swage fittings of a certain size or range of sizes, and into which a certain length L of the tube **12** is to be inserted to ensure a secure connection. Additionally, the length of the sleeve **57** may be that portion of the length of tube **12** that is inserted that interfaces most directly with the fitting and, accordingly, is the portion of tube to be straight and without scratches. In one example, tube straightening tool **10** is designed for straightening the last 3.5 inches of 4 millimeter, cylindrical, stainless steel tube **12**, so that the length L and distance D**5** are both 3.5 inches.

A method **200** of straightening a tube **12** using the tube straightening tool **10** is indicated in FIG. **10** and is described with respect to FIGS. **2-4**. The method **200** may begin with step **202**, turning the knob **32** so that the press block **30** is in a retracted position, such as the fully retracted position shown in FIG. **2**. Depending upon the direction of the threads **36**, **38**, this step of turning the knob may be represented by arrow A in FIG. **2** (for example, a traditional right-hand thread will retract by turning the knob counterclockwise when viewed from the direction shown in FIG. **1** and close onto the tube by turning clockwise), which shows the press block **30** in the fully retracted position. Depending upon the severity of the bends in the tube **12**, the operator may decide that only a partially retracted position of the press block **30** is needed to enable insertion of the tube **12**. If the press block **30** is already in the retracted position, the method **200** may skip step **202** and proceed to step **204**.

The method **200** may include step **204**, verifying that the press block **30** is in the retracted position. This step may be done by tactile feel, such as may be determined when the knob **32** will not turn any further as the press block **30** abuts an interior side wall **49** of the tool housing **14** when the press block **30** is in the fully retracted position, as shown in FIG. **2**. Verification may also be by viewing the position of the bushing **48** relative to the tool housing **14** at the counterbore **47**, which informs the operator of the position of the press block in the internal cavity (e.g., whether it is relatively close to the interior side wall, or relatively far from the interior side wall). The bushing **48** moves into the counterbore **47** when the knob **32** is turned in a first direction (represented by arrow B in FIG. **3**) and moves at least partially out of the counterbore **47** when the knob **32** is turned in a second direction (represented by arrow A in FIG. **2**). In the embodiment shown, the bushing **48** moves fully out of the counterbore **47** in the fully retracted position of the press block **30**. In other embodiments, it may only move partway out, and could include a marker that indicates a fully retracted position.

Next, in step **206**, the tube **12** is positioned in the internal cavity **16**. Initially, this is by inserting an end **13** of the tube **12** through the entrance opening **22** so that the tube **12** extends at least partially into the internal cavity **16** and is in an initial resting position in the internal cavity **16**. If steps **202-210** are repeated one or more times as described herein, positioning the tube in step **206** may be by rotating the tube **12** about its longitudinal axis, may be by inserting the tube **12** further into the internal cavity **16**, or both, and may or may not include first withdrawing the tube **12** from the internal cavity **16** before repositioning it in the internal cavity **16** in this manner.

To illustrate the progressive straightening of the tube **12**, the tube **12** is illustrated at **12**A in an initial bent state prior to any straightening. The tube entrance opening **22** is elongated in a direction from the interior side wall **28** toward the press block **30**. The width of the tube entrance opening **22** is the full width of the distance from the groove **56** to the groove **52** when the press block **30** is in the fully retracted state. This elongation will allow a bent end **13** of a tube **12** to be inserted without resistance. Additionally, the internal cavity **16** is sufficiently wide even with the press block **30** in the first cavity portion **16**A relative to the size of tube **12** to be straightened that, even for a relatively severely bent tube, the tube **12** is not moved longitudinally against any resistance when being inserted into the internal cavity **16**. In other words, if the operator feels resistance when inserting the bent tube into the internal cavity **16**, the operator can stop inserting the tube **12**, establishing the initial resting position **12**A of the tube **12**. The tube **12** is then in its initial resting position, shown at **12**A.

Next, the method **200** moves to step **208**, turning the knob **32** in a first direction (indicated by arrow B in FIG. **3**) to move the press block **30** toward the interior side wall **28** and into contact with an exterior of the resting tube at position **12**A to force the bent tube at position **12**A toward the interior side wall **28**. Turning the knob **32** will require more force as the tube **12** is moved from the initial resting position **12**A toward a straight position by the press block **30**. The force of the press block **30** is against the side of the tube **12**, and the tube **12** is not being moved along its length during this step, except for any localized linear movement caused by its unbending. Because the tube **12** is at rest when the press block **30** contacts the side of the tube **12**, and the press block **30** provides forces on the tube orthogonally to the longitudinal axis of the tube **12** (if the tube were straight) rather than along a length of the tube **12**, and movement of the tube **12** along its longitudinal axis relative to the press block **30** during straightening is minimal.

As the tube contact surface **54** of the press block **30** moves closer to the stationary tube contact surface **50** of the interior side wall **28**, the overall bend in the tube **12** is lessened to the distance between these two surfaces. In step **209**, the operator determines the position of the press block **30** by determining how much if any of the bushing **48** is visible. When the press block **30** is fully extended and the knob **32**

is thus fully tightened, the bushing **48** is fully within the counterbore **47** so that a side surface of the bushing **48** is not visible.

When the press block **30** is moved to the fully extended position of FIG. **3**, the semi-circular grooves **52**, **56** are adjacent one another, each confronting half of the exterior surface of the tube **12**, defining a cylindrical space. Depending on the severity of the bend or bends in the tube **12**, the press block **30** may not reach the fully extended state the first time, or even the first several times, that steps **202** to **210** are performed. After one or more repetitions of steps **202-210**, the tube **12** will be sufficiently straightened to allow the press block **30** to the fully extended position with the tube **12** within the adjacent grooves **52**, **56**. When the press block **30** reaches the fully extended position, the longitudinal center axis **62** of the groove **56** will now be coaxial with the longitudinal center axis **60**, and the portion of the tube **12** initially inserted (represented as **12**A) will be straight.

Next, in step **210**, the operator determines whether the tube **12** has been fully inserted into the internal cavity **16** such that the end **13** of the tube **12** is at the interior end wall **26**. Step **210** may include sub step **212**, verifying that the end **13** of the tube **12** contacts the interior end wall **26** by viewing the end **13** of the tube **12** at the interior end wall **26** through the window **79** extending through the tool housing **14** at the interior end wall **26** and/or through the window **78** in the cover plate **70**. The operator may determine from the initial resting position **12**A that the tube **12** is not yet with the end **13** at the interior end wall **26**, based on tactile feel and visually watching only a short length of the tube **12** entering the internal cavity **16**.

If the end **13** of the tube **12** is not verified to be the interior end wall **26**, then the method **200** will return to step **202**, and the knob **32** is turned in the second direction A to move the press block **30** to the retracted position away from the interior side wall **28** and out of contact with the exterior of the tube **12**. Step **204** can then be repeated, and the position of the tube **12** within the internal cavity **16** can then be adjusted in step **206**, either by rotating the tube **12** at least partially about its longitudinal axis so that another orientation of the bent tube is presented to the press block **30** for straightening, or, by inserting the tube **12** further into the internal cavity **16** so that the press block **30** can act against a new portion of the tube **12**. For illustrative purposes, the tube **12** has a bend in another direction than the initial bend existing when inserted to initial resting position **12**A, and is both rotated about its longitudinal axis and further inserted to a subsequent resting position **12**B, with the initially straightened portion of the tube **12** inserted further into the internal cavity **16**, partway into the tube sleeve **57**.

Moreover, in order to ensure that the portion of the tube **12** nearest the end **13** of the tube is protected from scratches and is straight, the tube sleeve **57** may be a first material, such as Aluminum Bronze HR50 per AMS 4640, and the tool housing **14** may be a second material, such as Stainless Steel CRES 15-5 PH per AMS 5659 age hardened to condition H-1025, and the first material may be softer than the second material. For example, the Aluminum Bronze HR50 per AMS 4640 may have a hardness of 94 on the Rockwell Hardness B scale, which is equivalent to a hardness of 15 on the Rockwell Hardness C scale. The Stainless Steel CRES 15-5 PH per AMS 5659 age hardened to condition H-1025 may have a hardness of 39 on the Rockwell Hardness C scale, which is equivalent to a hardness of 111 on the Rockwell Hardness B scale.

Accordingly, after the portion of the tube **12** nearest the end **13** is sufficiently straightened by the press block **30** in the first cavity portion **16**A of the internal cavity **16** it can be slid into the linear passage **58** of the tube sleeve **57** without resistance, and, in any event, any resistance would be lessened by the relatively soft material. It remains in the linear passage **58** while a portion of the tube **12** slightly further from the end **13** is now in the first cavity portion **16**A of the internal cavity **16**, and is straightened by the press block **30**.

Steps **202** to **210** are repeated until the press block **30** has been moved to the fully extended position (as verified in step **209**) with the end of the tube **12** at the interior end wall **26** in the resting position **12**C (as verified in step **210** (and possibly sub-step **212**).

The method **200** then proceeds either to step **214** or step **218**, which are alternative modes of marking the tube **12** at a predefined distance from the end **13** of the tube **12**. In step **214**, the press block **30** is left in the fully extended position (e.g., clamped onto the fully inserted and straightened tube **12**), and the tube **12** is marked at the portion immediately at the entrance opening **22**, as indicated by marking M. This marking may be with ink (e.g., via a pen) or with tape, for example. The tube straightening tool **10** is configured so that a distance D**5** from the entrance opening **22** to the interior end wall **26** (shown in FIG. **4**) is equal to a predefined distance, which is the length of tube **12** that will be inserted into a connector fitting, for example, and which should therefore be the straight, and without linear scratches along the exterior. By marking the predefined distance, the operator is able to ensure that this portion of the tube **12** is subsequently fully inserted into the connector to provide a secure connection.

Following step **214**, the knob **32** is turned in the second direction A in step **216** to withdraw the press block **30**, and the straight tube is withdrawn from the tube straightening tool **10** in step **218**. The straightened tube **12** may then be used for its purpose (e.g., connected to a fitting for use as a conduit, etc.).

As an alternative to marking the tube **12** in step **214**, the method **200** may instead proceed from step **210** to step **216** (skipping step **214**), and, after the tube **12** is withdrawn in step **218**, the method **200** may proceed to step **220**, laying the tube **12** in a linear groove **92** in the exterior **20** of the tool housing **14** until the end **13** of the tube **12** contacts the stop **94**, as shown schematically in FIG. **5**. Then, in step **222**, the tube **12** may be marked with ink or tape at a position along the tube **12** level with the end **21**. This marking M (shown in FIG. **5**) will be at the same location as the marking M applied in the alternative marking action of step **214** (shown in FIG. **4**). In step **224**, the tube **12** is then lifted out of the linear groove **92** and the method **200** ends, as the straightened tube may then be used for its purpose (e.g., connected to a fitting for use as a conduit, etc.).

The following Clauses provide example configurations of a tube straightening tool and a method of straightening a tube disclosed herein.

Clause 1. A tube straightening tool for straightening a length of tube, the tube straightening tool comprising: a tool housing defining an internal cavity and having an exterior defining a tube entrance opening that opens into a first end of the internal cavity, a shaft opening orthogonal to the tube entrance opening and that opens into the internal cavity, the tool housing having an interior end wall at a second end of the internal cavity, and the tool housing having an interior side wall extending from the tube entrance opening toward the interior end wall; a press block disposed in the internal cavity; a knob external to the tool housing; a threaded shaft extending from the knob through the shaft opening and into

the internal cavity; wherein the press block is coupled to the threaded shaft; wherein turning the knob in a first direction moves the press block in the internal cavity toward the interior side wall, and turning the knob in a second direction opposite from the first direction moves the press block away from the interior side wall.

Clause 2. The tube straightening tool of clause 1, wherein: the interior side wall has a stationary tube contact surface configured as a groove facing the press block and extending lengthwise from the tube entrance opening toward the interior end wall; and the press block has a tube contact surface configured as a groove facing the interior side wall and extending lengthwise parallel with the groove of the stationary tube contact surface.

Clause 3. The tube straightening tool of clause 2, wherein: the groove of the stationary tube contact surface of the interior side wall and the groove of the tube contact surface of the press block are both semi-circular.

Clause 4. The tube straightening tool of any of clauses 2-3, wherein the internal cavity has a first cavity portion adjacent the tube entrance opening and a second cavity portion adjacent the interior end wall, and the tube straightening tool further comprising: a tube sleeve disposed in the second cavity portion; wherein the tube sleeve has a linear passage extending lengthwise through the tube sleeve from a first end of the tube sleeve at the first cavity portion to a second end of the tube sleeve at the interior end wall; and wherein a longitudinal center axis of the linear passage aligns with a longitudinal center axis of the groove of the stationary tube contact surface of the interior side wall.

Clause 5. The tube straightening tool of clause 4, wherein the tube sleeve is a first material, the tool housing is a second material, and the first material is softer than the second material.

Clause 6. The tube straightening tool of any of clauses 1-5, wherein the tube entrance opening is elongated in a direction from the interior side wall toward the press block.

Clause 7. The tube straightening tool of any of clauses 1-6, wherein the tool housing has a counterbore at the exterior of the tool housing around the shaft opening, and the tube straightening tool further comprising: a bushing fixed to the threaded shaft; wherein the bushing moves at least partially into the counterbore when the knob is turned in the first direction and moves at least partially out of the counterbore when the knob is turned in the second direction.

Clause 8. The tube straightening tool of any of clauses 1-7, wherein the press block has a blind hole extending partially through the press block; wherein the threaded shaft extends into the blind hole; wherein the press block has a shaft access opening extending at least partially through the press block orthogonal to and in communication with the blind hole; and the tube straightening tool further comprising: a retainer clip having a notch, and disposed in the shaft access opening with a narrowed portion of the threaded shaft in the notch to fix the threaded shaft axially relative to the press block.

Clause 9. The tube straightening tool of clause 8, wherein the tool housing has internal threads at the shaft opening, the threaded shaft has an externally-threaded portion that threads to the internal threads, a terminal end portion opposite the knob, and the narrowed portion between the externally-threaded portion and the terminal end portion; wherein a diameter of the narrowed portion is less than a diameter of the terminal end portion and less than a diameter of the externally-threaded portion; and wherein a width of the notch is less than the diameter of the terminal end portion and less than the diameter of the externally-threaded portion, the shaft access opening is wider than the blind hole, and wider than the retainer clip.

Clause 10. The tube straightening tool of any of clauses 1-9, wherein the tool housing defines a window extending through the tool housing to the internal cavity at the interior end wall.

Clause 11. The tube straightening tool of any of clauses 1-10, wherein the exterior of the tool housing has a first ridge, a second ridge spaced from the first ridge, and a tool mount portion recessed between the first ridge and the second ridge.

Clause 12. The tube straightening tool of any of clauses 1-11, further comprising: a cover plate fastenable to tool housing to enclose the internal cavity.

Clause 13. The tube straightening tool of clause 12, wherein the cover plate defines a window extending through the cover plate to the internal cavity at the interior end wall when the cover plate is fastened to the tool housing.

Clause 14. A method of straightening a tube, the method comprising: inserting an end of a tube at least partially into an internal cavity of a tool housing through an entrance opening at an exterior of the tool housing so that the tube is in an initial resting position in the internal cavity; wherein the entrance opening opens into a first end of the internal cavity; the tool housing having an interior end wall at a second end of the internal cavity, and the tool housing having an interior side wall extending from the entrance opening to the interior end wall; and turning a knob disposed at the exterior of the tool housing in a first direction to move a press block coupled to on a shaft connected to the knob toward the interior side wall and into contact with an exterior of the tube to force the tube toward the interior side wall.

Clause 15. The method of clause 14, further comprising: turning the knob in a second direction to move the press block away from the interior side wall and out of contact with the exterior of the tube; adjusting a position of the tube within the internal cavity to a subsequent resting position; and turning the knob in the first direction to move the press block toward the interior side wall and into contact with the exterior of the tube to force the tube toward interior the side wall.

Clause 16. The method of clause 15, wherein adjusting the position of the tube includes rotating the tube at least partially around a longitudinal axis of the tube.

Clause 17. The method of any of clauses 15-16, wherein adjusting the position of the tube includes inserting the tube until an end of the tube contacts the interior end wall.

Clause 18. The method of any of clauses 14-17, further comprising: verifying that the end of the tube contacts the interior end wall.

Clause 19. The method of clause 18, wherein verifying that the end of the tube contacts the interior end wall comprises viewing the end of the tube at the interior end wall through a window extending through the tool housing at the interior end wall.

Clause 20. The method of any of clauses 14-19, further comprising: marking the tube at a predefined distance from the end of the tube by one of laying the tube in a linear groove in the exterior of the tool housing, the linear groove having a length equal to the predefined distance; or marking the tube at the entrance opening after inserting the tube until the end of the tube contacts the interior end wall, a distance from the entrance opening to the interior end wall equal to the predefined distance.

While several modes for carrying out the many aspects of the present teachings have been described in detail, those

familiar with the art to which these teachings relate will recognize various alternative aspects for practicing the present teachings that are within the scope of the appended claims. It is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and exemplary of the entire range of alternative embodiments that an ordinarily skilled artisan would recognize as implied by, structurally and/or functionally equivalent to, or otherwise rendered obvious based upon the included content, and not as limited solely to those explicitly depicted and/or described embodiments. Moreover, the present concepts expressly include combinations and sub-combinations of the described elements and features. The detailed description and the drawings are supportive and descriptive of the present teachings, with the scope of the present teachings defined solely by the claims.

The invention claimed is:

1. A tube straightening tool for straightening a length of tube, the tube straightening tool comprising: a tool housing defining an internal cavity and having an exterior defining a tube entrance opening that opens into a first end of the internal cavity, a shaft opening orthogonal to the tube entrance opening and that opens into the internal cavity, the internal cavity having an interior end wall at a second end of the internal cavity, and the internal cavity having an interior side wall extending from the tube entrance opening to the interior end wall; a press block disposed in the internal cavity; a knob external to the tool housing; and a threaded shaft extending from the knob through the shaft opening and into the internal cavity; wherein the press block is coupled to the threaded shaft; and wherein turning the knob in a first direction moves the press block in the internal cavity toward the interior side wall, and turning the knob in a second direction opposite from the first direction moves the press block away from the interior side wall.

2. The tube straightening tool of claim **1**, wherein:

the interior side wall has a stationary tube contact surface configured as a groove facing the press block and extending lengthwise from the tube entrance opening toward the interior end wall; and

the press block has a tube contact surface configured as a groove facing the interior side wall and extending lengthwise parallel with the groove of the stationary tube contact surface.

3. The tube straightening tool of claim **2**, wherein:

the groove of the stationary tube contact surface of the interior side wall and the groove of the tube contact surface of the press block are both semi-circular.

4. The tube straightening tool of claim **2**, wherein the internal cavity has a first cavity portion adjacent the tube entrance opening and a second cavity portion adjacent the interior end wall, and the tube straightening tool further comprising:

a tube sleeve disposed in the second cavity portion; wherein the tube sleeve has a linear passage extending lengthwise through the tube sleeve from a first end of the tube sleeve at the first cavity portion to a second end of the tube sleeve at the interior end wall; and

wherein a longitudinal center axis of the linear passage aligns with a longitudinal center axis of the groove of the stationary tube contact surface of the interior side wall.

5. The tube straightening tool of claim **4**, wherein the tube sleeve is a first material, the tool housing is a second material, and the first material is softer than the second material.

6. The tube straightening tool of claim **1**, wherein the tube entrance opening is elongated in a direction from the interior side wall toward the press block.

7. The tube straightening tool of claim **1**, wherein the tool housing has a counterbore at the exterior of the tool housing around the shaft opening, and the tube straightening tool further comprising:

a bushing fixed to the threaded shaft; wherein the bushing moves at least partially into the counterbore when the knob is turned in the first direction and moves at least partially out of the counterbore when the knob is turned in the second direction.

8. The tube straightening tool of claim **1**, wherein the press block has a blind hole extending partially through the press block; wherein the threaded shaft extends into the blind hole; wherein the press block has a shaft access opening extending at least partially through the press block orthogonal to and in communication with the blind hole; and the tube straightening tool further comprising:

a retainer clip having a notch, and disposed in the shaft access opening with a narrowed portion of the threaded shaft in the notch to fix the threaded shaft axially relative to the press block.

9. The tube straightening tool of claim **8**, wherein the tool housing has internal threads at the shaft opening, the threaded shaft has an externally-threaded portion that threads to the internal threads, a terminal end portion opposite the knob, and the narrowed portion between the externally-threaded portion and the terminal end portion;

wherein a diameter of the narrowed portion is less than a diameter of the terminal end portion and less than a diameter of the externally-threaded portion; and

wherein a width of the notch is less than the diameter of the terminal end portion and less than the diameter of the externally-threaded portion, the shaft access opening is wider than the blind hole, and wider than the retainer clip.

10. The tube straightening tool of claim **1**, wherein the tool housing defines a window extending through the tool housing to the internal cavity at the interior end wall.

11. The tube straightening tool of claim **1**, wherein the exterior of the tool housing has a first ridge, a second ridge spaced from the first ridge, and a tool mount portion recessed between the first ridge and the second ridge.

12. The tube straightening tool of claim **1**, further comprising:

a cover plate fastenable to tool housing to enclose the internal cavity.

13. The tube straightening tool of claim **12**, wherein the cover plate defines a window extending through the cover plate to the internal cavity at the interior end wall when the cover plate is fastened to the tool housing.

14. A method of straightening a tube, the method comprising: inserting an end of a tube at least partially into an internal cavity of a tool housing through an entrance opening at an exterior of the tool housing so that the tube is in an initial resting position in the internal cavity; wherein the entrance opening opens into a first end of the internal cavity; the internal cavity having an interior end wall at a second end of the internal cavity, and the internal cavity having an interior side wall extending from the entrance opening to the interior end wall; and turning a knob disposed at the exterior of the tool housing in a first direction to move a press block coupled to on a shaft connected to the knob toward the interior side wall and into contact with an exterior of the tube to force the tube toward the interior side wall.

15. The method of claim 14, further comprising:

turning the knob in a second direction to move the press block away from the interior side wall and out of contact with the exterior of the tube;

adjusting a position of the tube within the internal cavity to a subsequent resting position; and

turning the knob in the first direction to move the press block toward the interior side wall and into contact with the exterior of the tube to force the tube toward interior the side wall.

16. The method of claim 15, wherein adjusting the position of the tube includes rotating the tube at least partially around a longitudinal axis of the tube.

17. The method of claim 15, wherein adjusting the position of the tube includes inserting the tube until an end of the tube contacts the interior end wall.

18. The method of claim 17, further comprising:

verifying that the end of the tube contacts the interior end wall.

19. The method of claim 18, wherein verifying that the end of the tube contacts the interior end wall comprises viewing the end of the tube at the interior end wall through a window extending through the tool housing at the interior end wall.

20. The method of claim 14, further comprising:

marking the tube at a predefined distance from the end of the tube by one of:

laying the tube in a linear groove in the exterior of the tool housing, the linear groove having a length equal to the predefined distance; or

marking the tube at the entrance opening after inserting the tube until the end of the tube contacts the interior end wall, a distance from the entrance opening to the interior end wall equal to the predefined distance.

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