US012392208B1

(12) **United States Patent**
Burkett

(10) **Patent No.: US 12,392,208 B1**
(45) **Date of Patent: Aug. 19, 2025**

(54) **WELL TUBING ANCHOR AND CATCHER TOOL ASSEMBLY**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **18/621,305**

(22) Filed: **Mar. 29, 2024**

(51) **Int. Cl.**
E21B 23/01 (2006.01)

(52) **U.S. Cl.**
CPC ***E21B 23/01*** (2013.01)

(58) **Field of Classification Search**
CPC E21B 23/01
See application file for complete search history.

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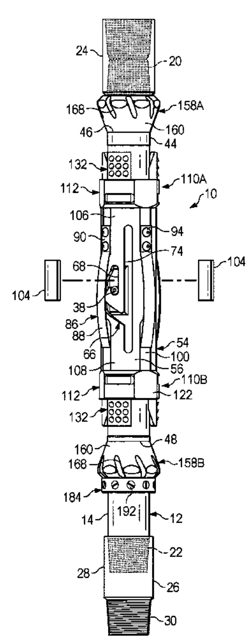
(57) **ABSTRACT**

A tool assembly for anchoring and/or catching well equipment within a well casing utilizes a mandrel that carries a pair of cones and a control body that surrounds the mandrel and carries a pair of slip assemblies configured to engage the well casing. The control body has a set of interconnected slots that are configured to receive a control pin of the mandrel. The control pin travels within the set of interconnected slots that comprise a run slot that limits the distance the control pin and mandrel travel so that the tool assembly is maintained in a released condition wherein the slip assemblies are disengaged from the cones. The interconnected slots further comprising a set slot that is spaced circumferentially apart from the run slot and has a length that allows the control pin of the mandrel to travel further so that the cones can engage the slip assemblies to thereby anchor or catch the tool assembly within the well casing. The run slot and set slot being joined together by a slot passage that allows the control pin to move between the run slot and the set slot when the mandrel is rotated about a central longitudinal axis.

20 Claims, 17 Drawing Sheets



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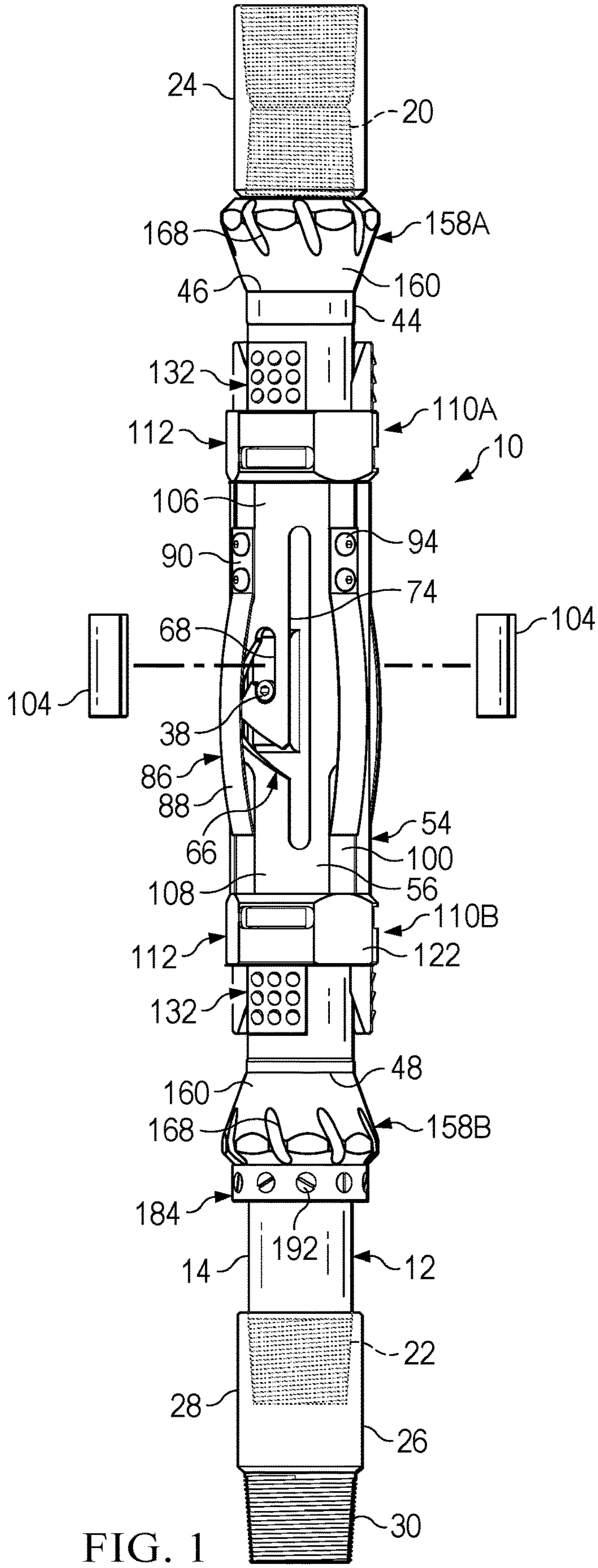
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FIG. 1

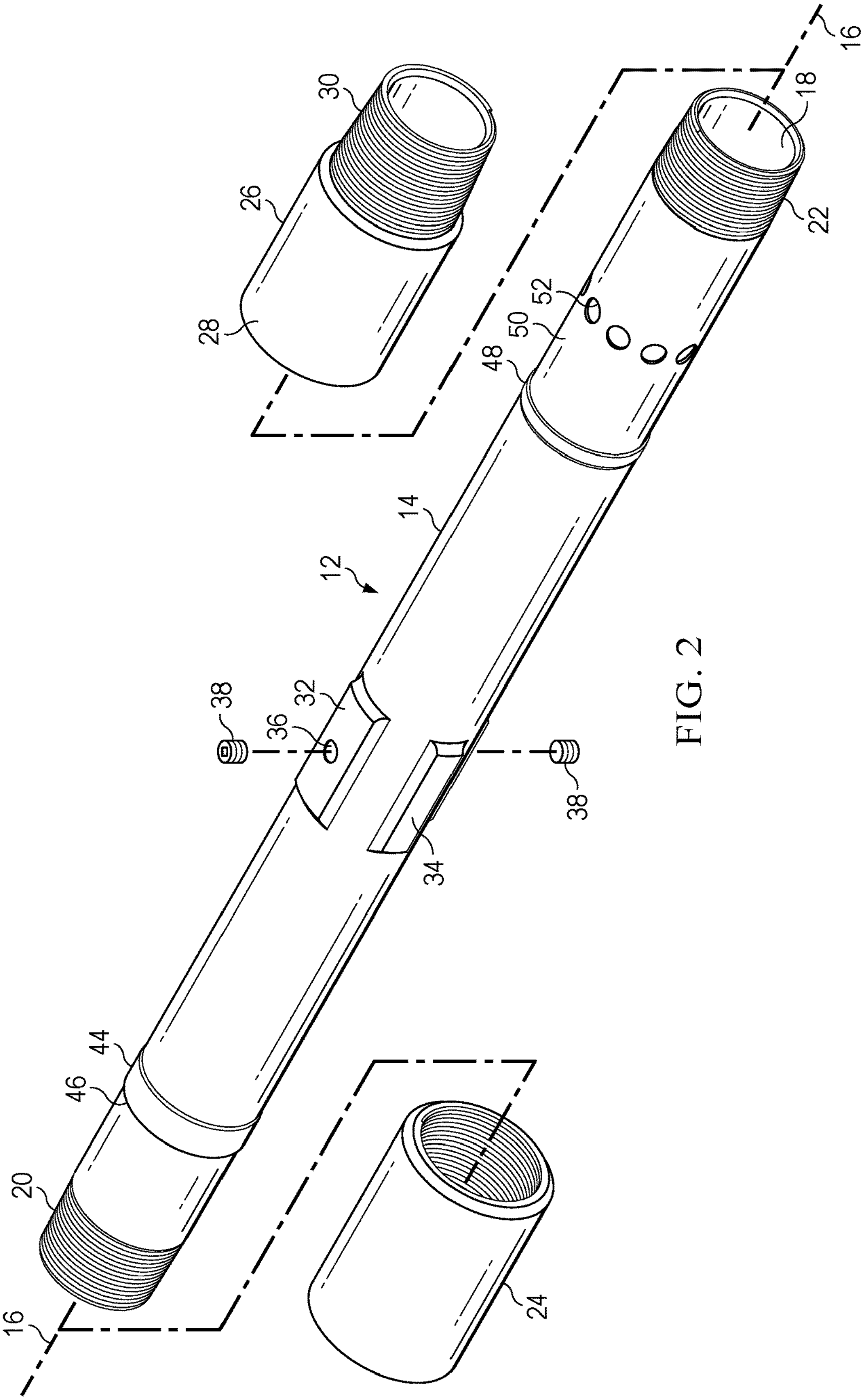

FIG. 2

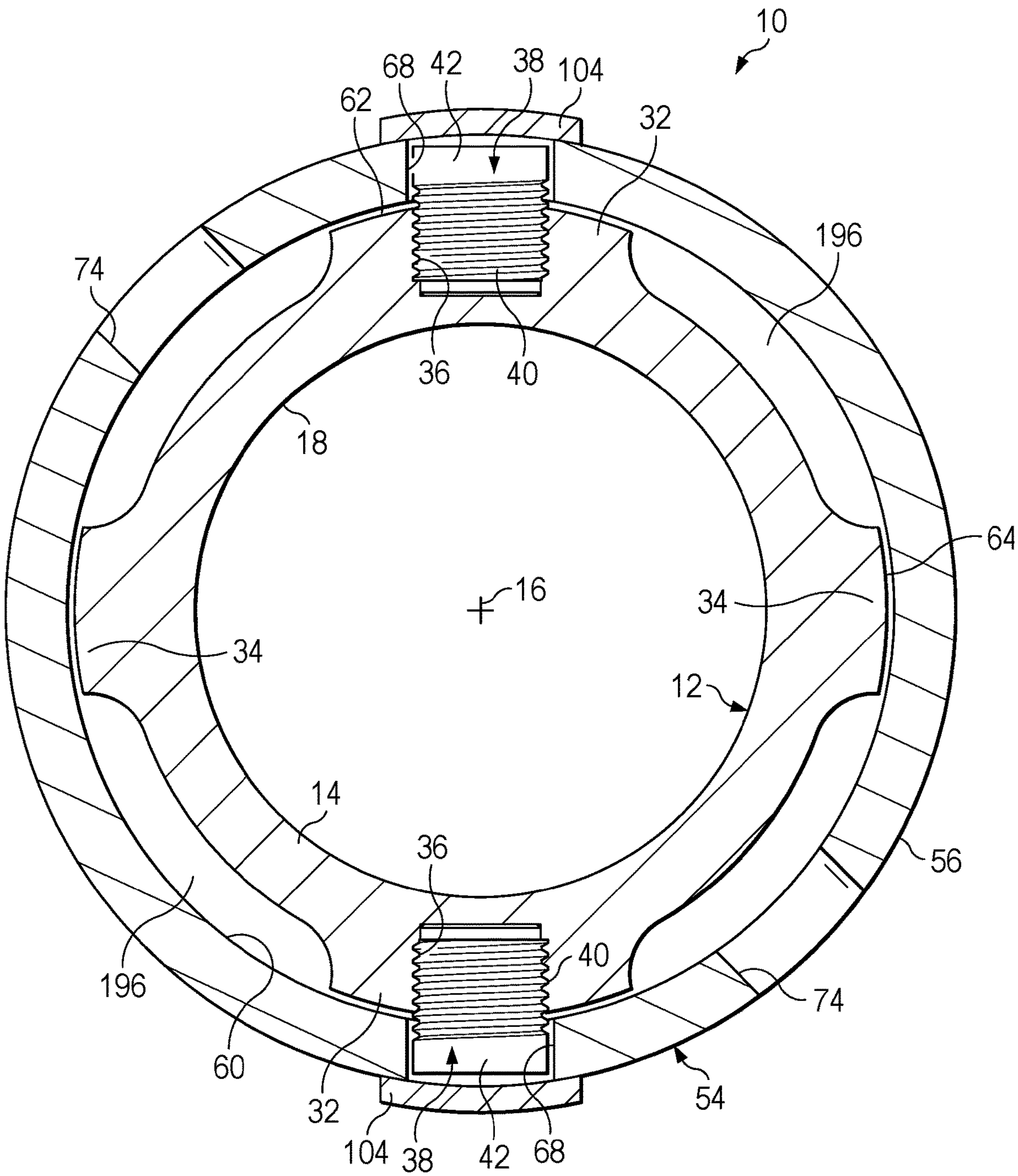
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FIG. 3

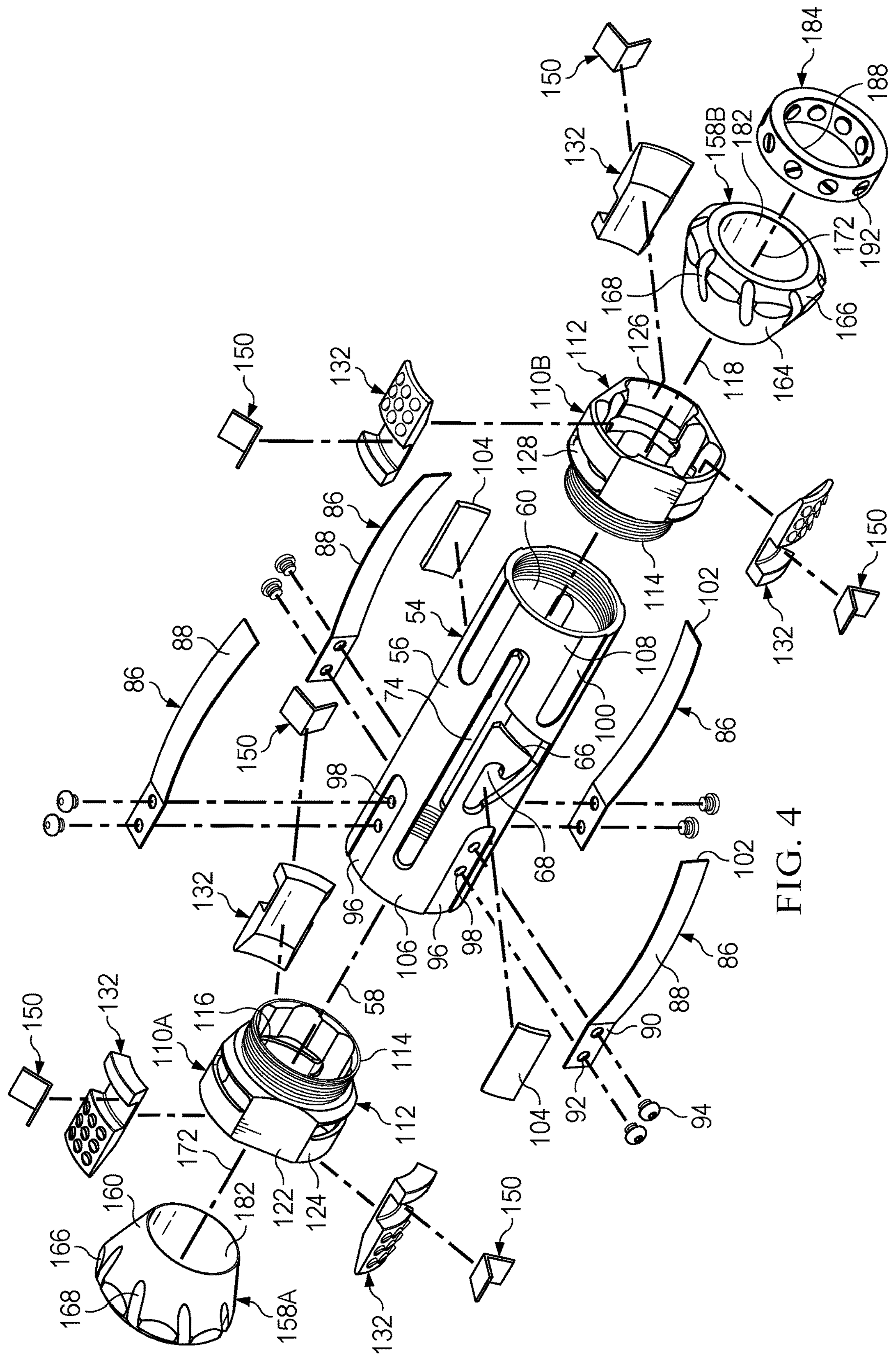
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FIG. 4

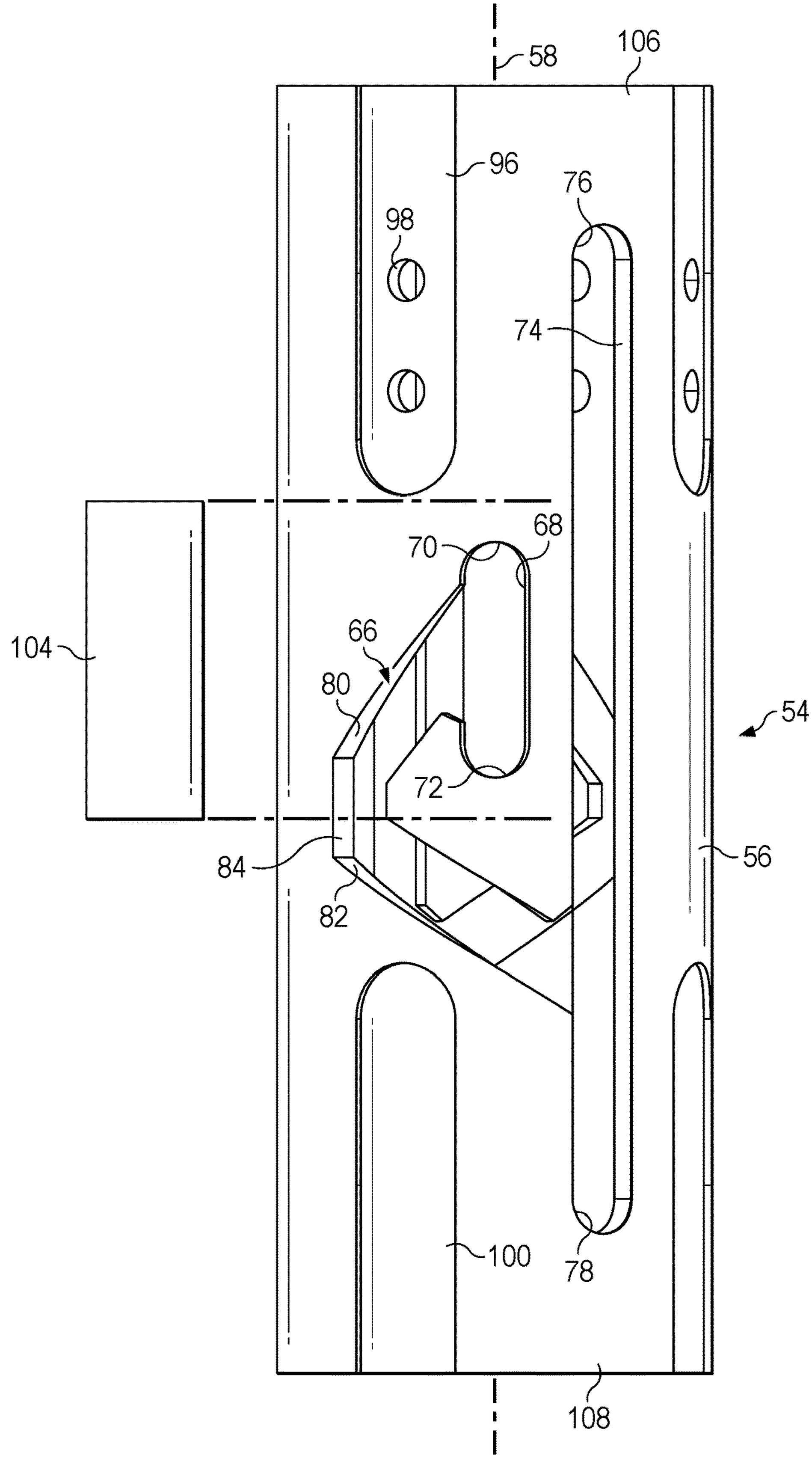

FIG. 5

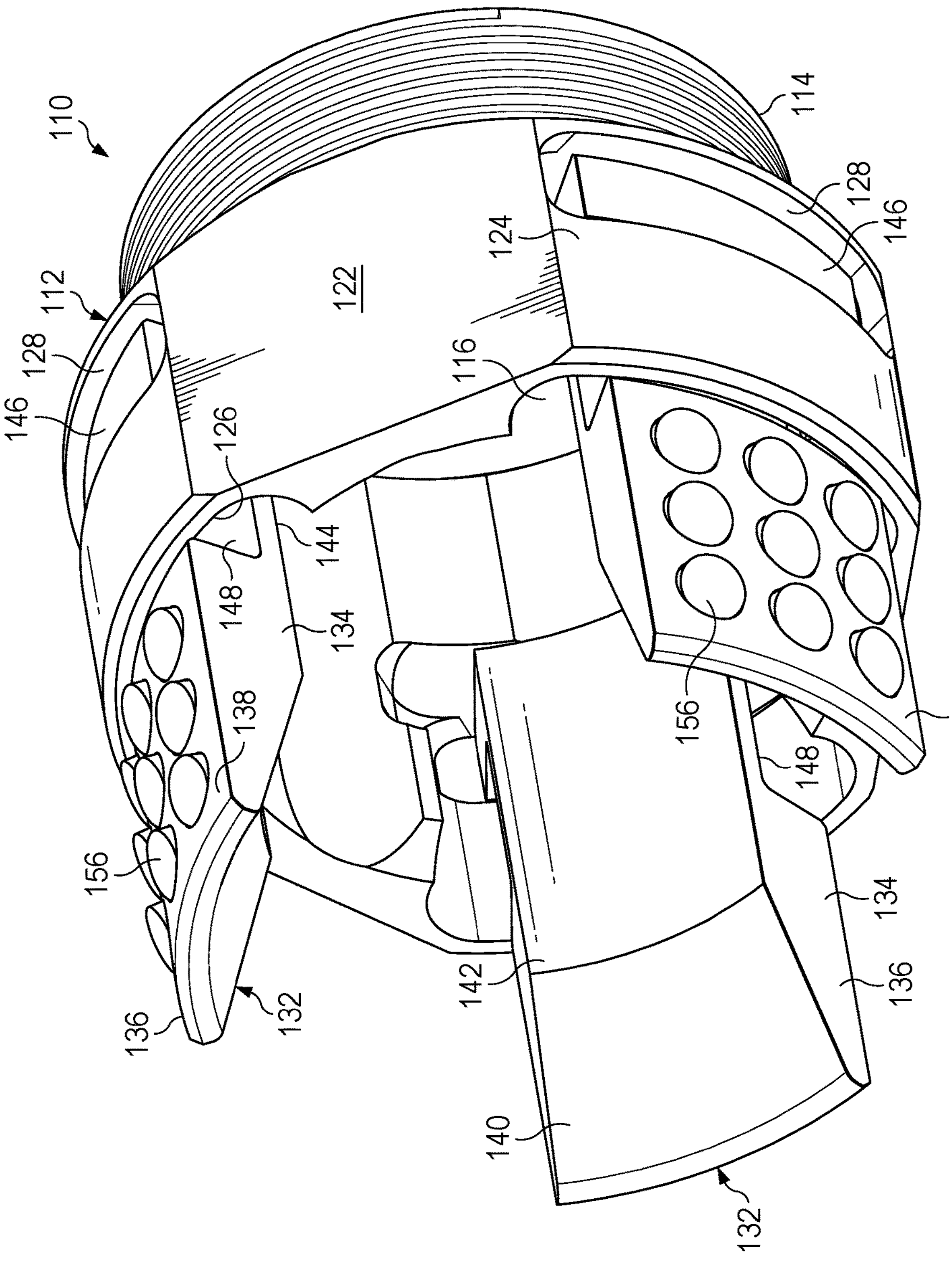
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FIG. 6

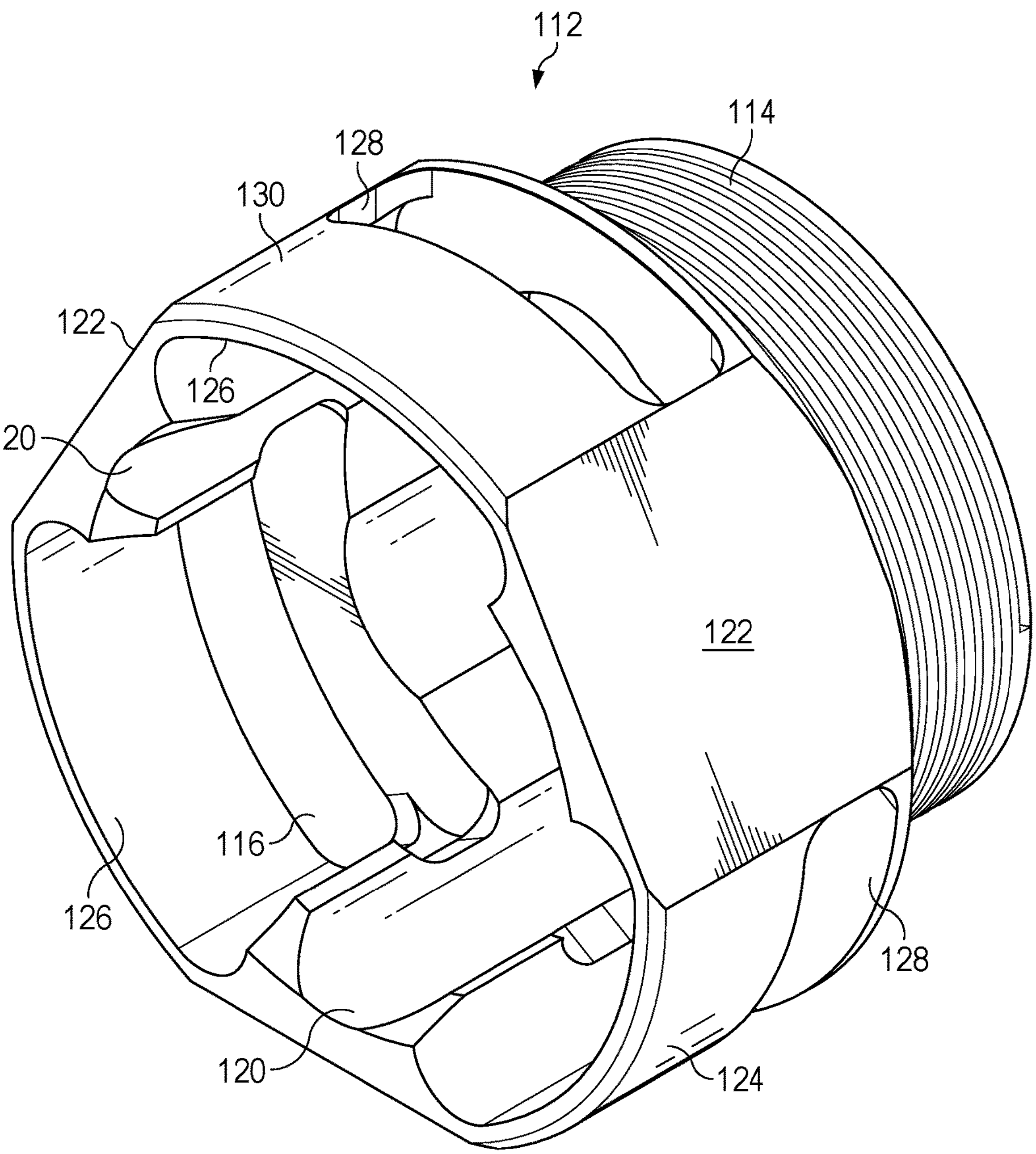

FIG. 7

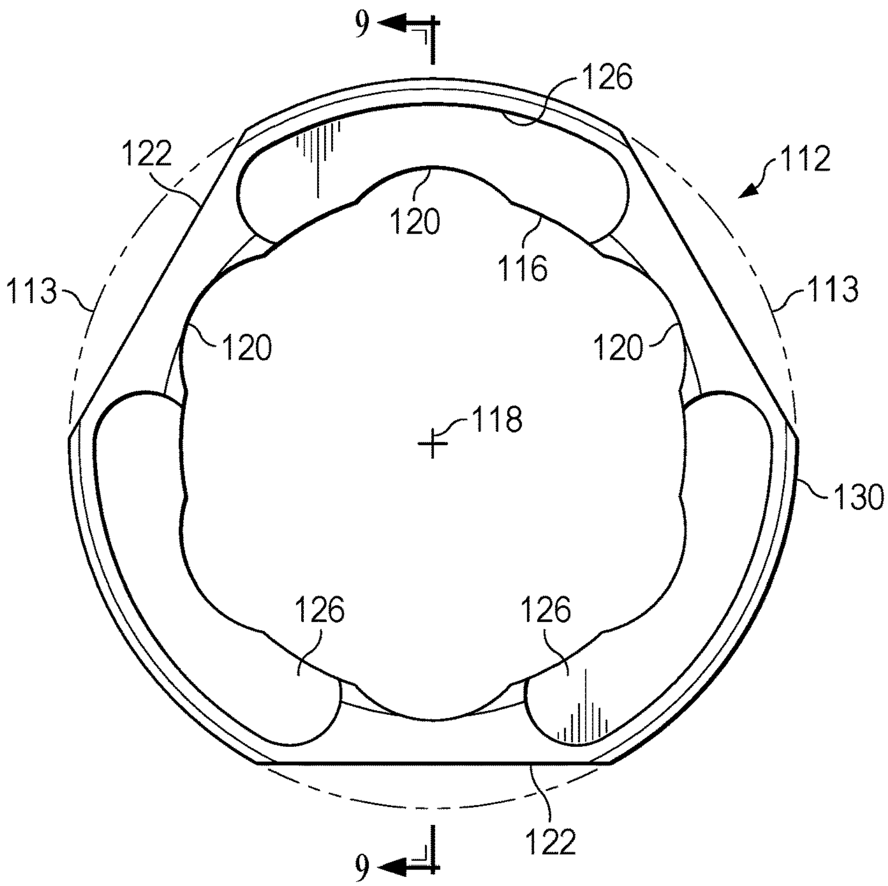
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FIG. 8

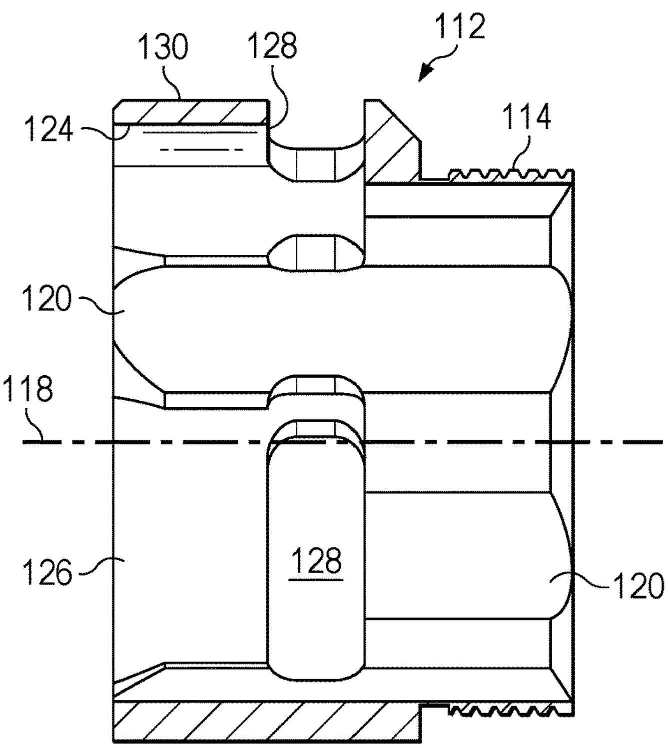
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FIG. 9

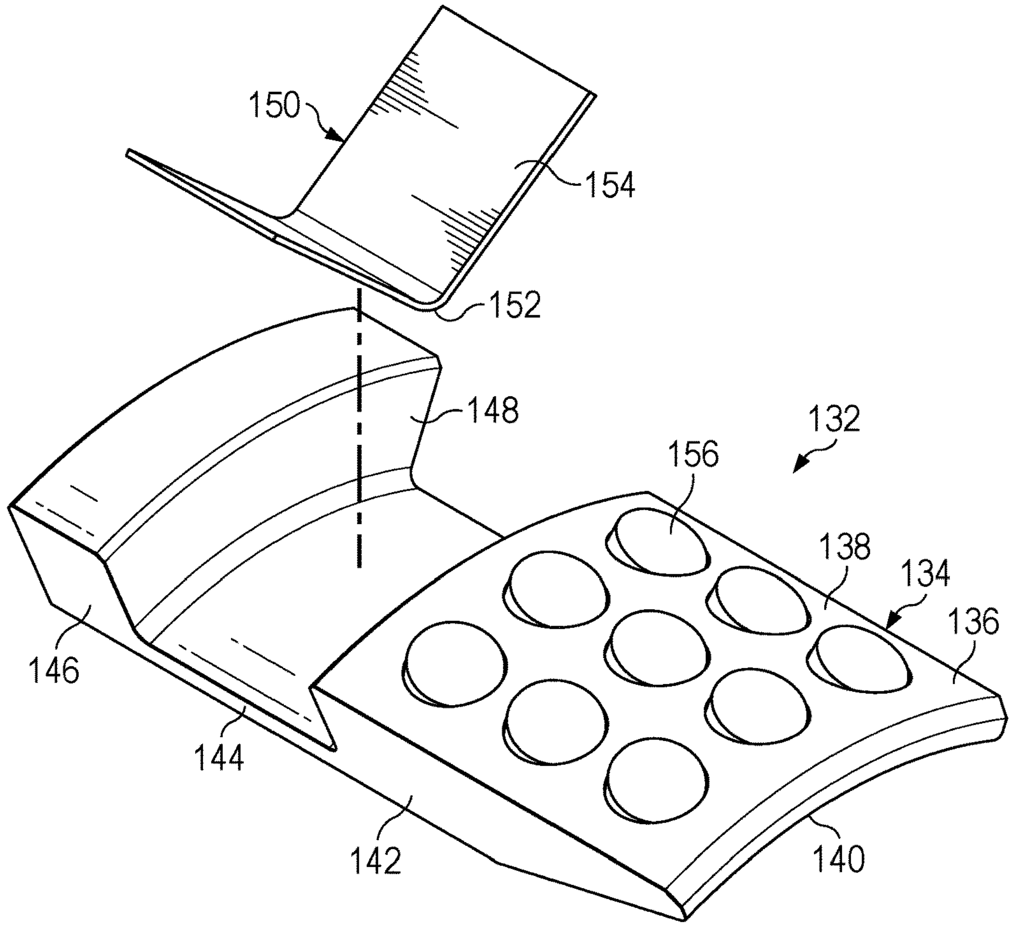
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FIG. 10

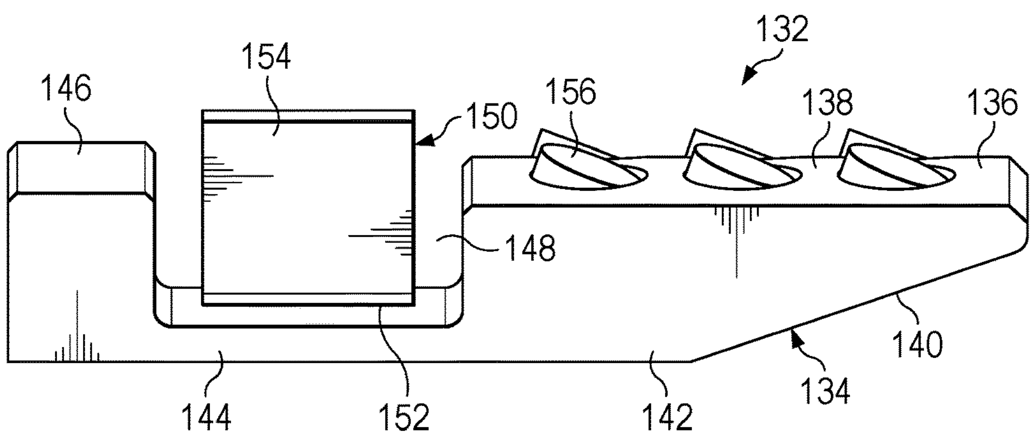
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FIG. 11

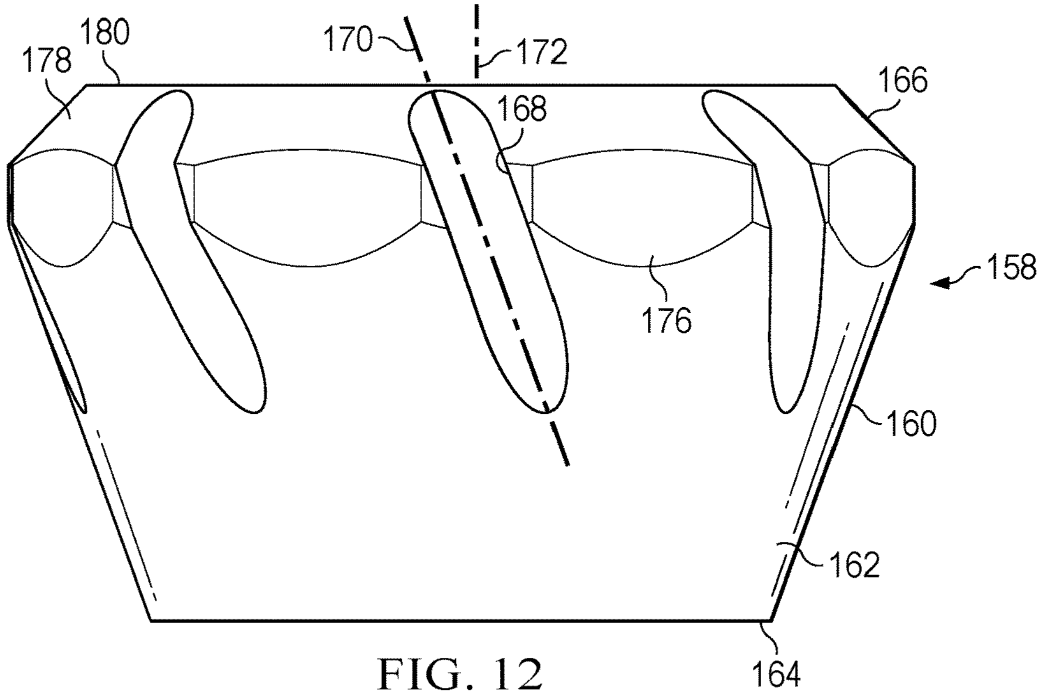
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FIG. 12

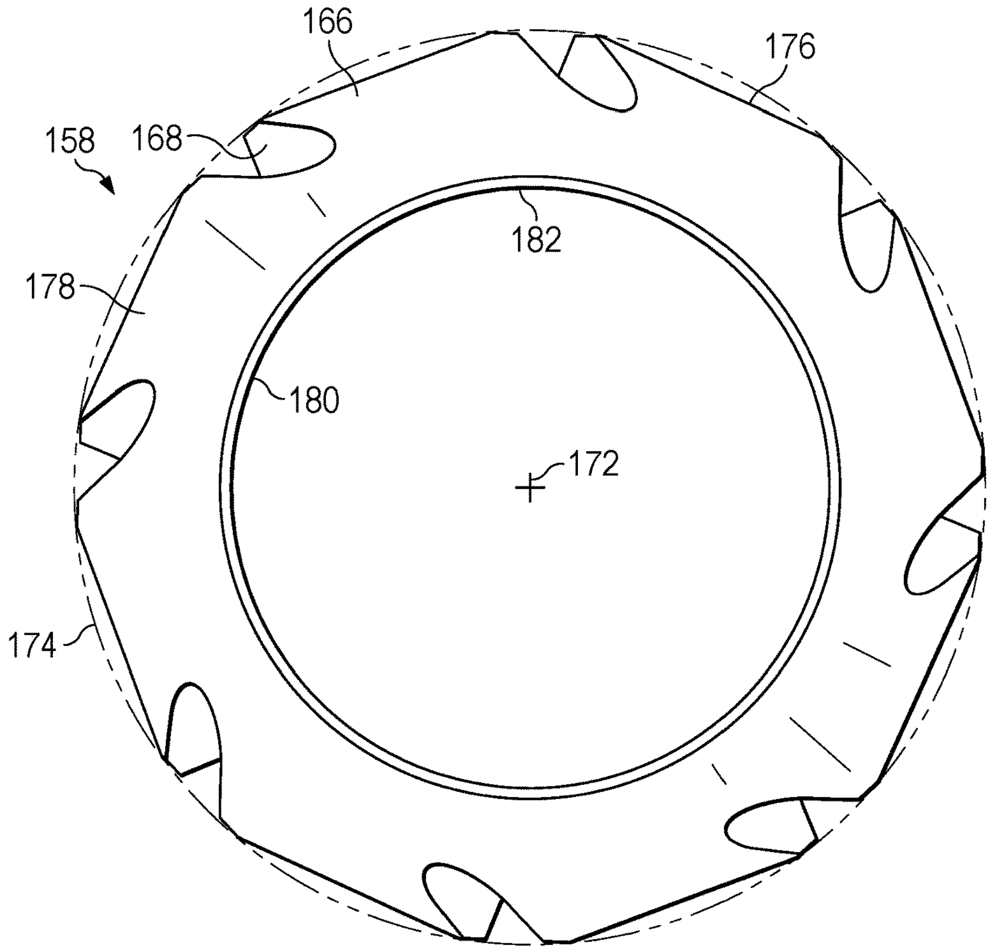
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FIG. 13

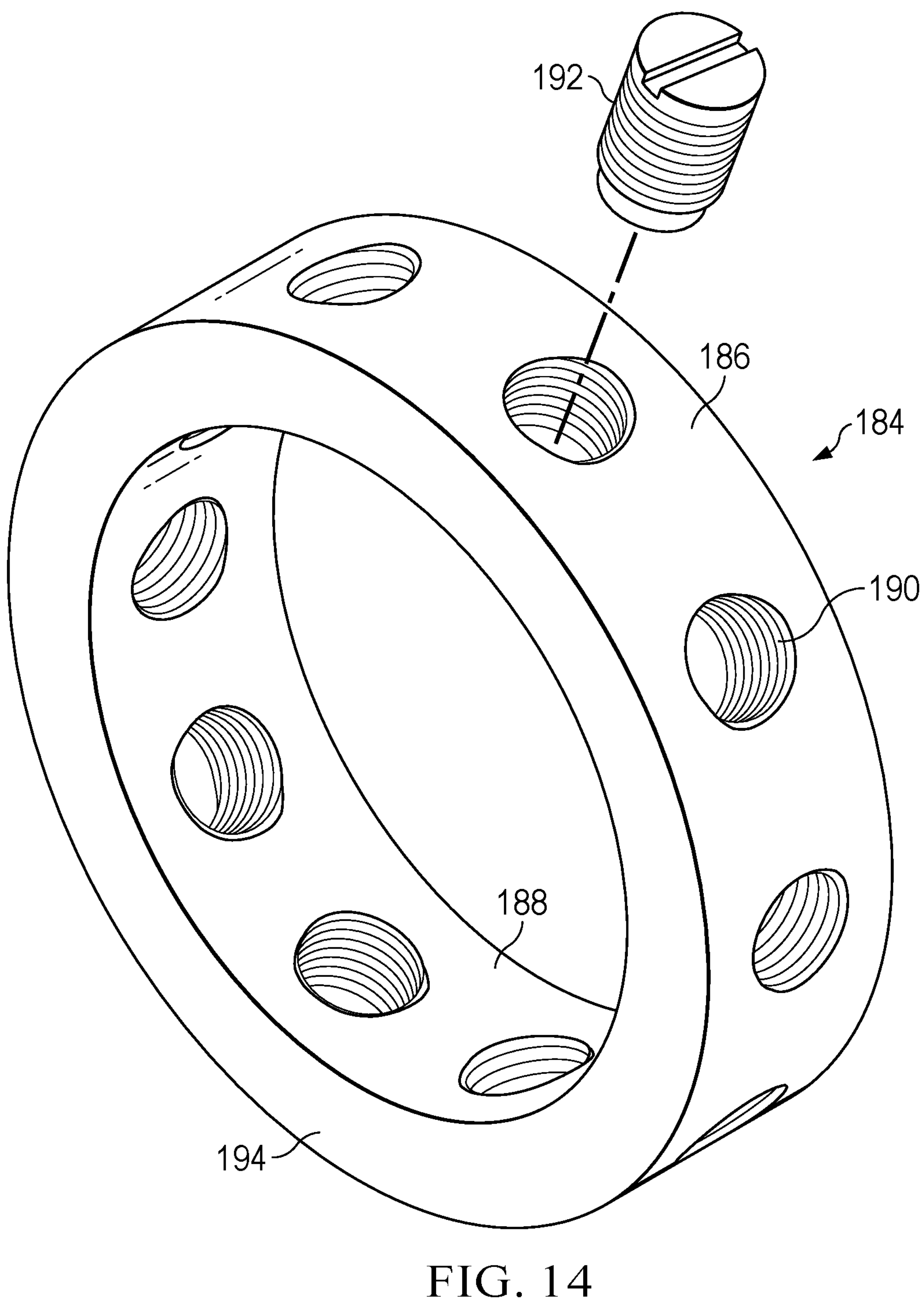

FIG. 14

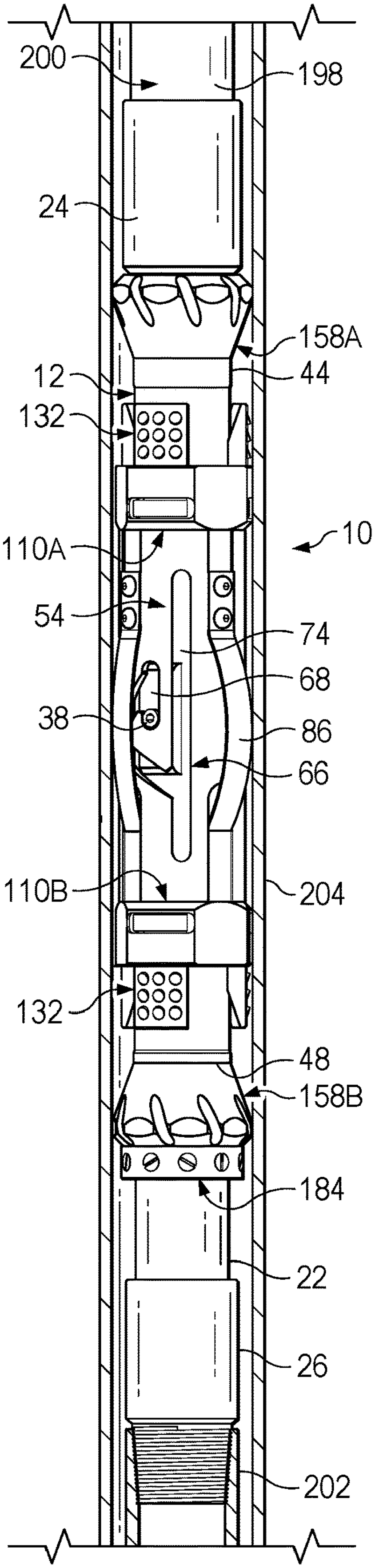
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FIG. 15

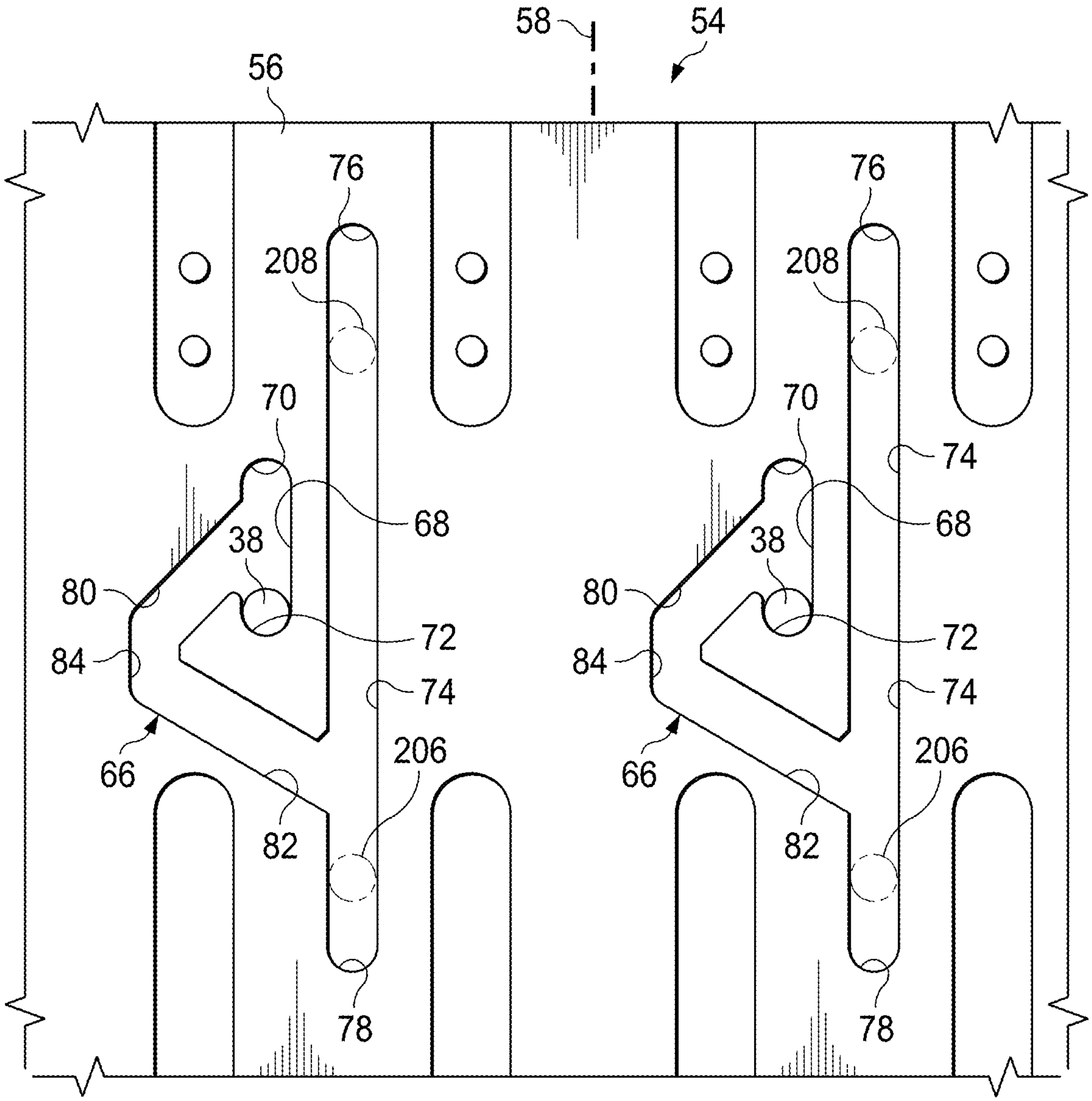

FIG. 16

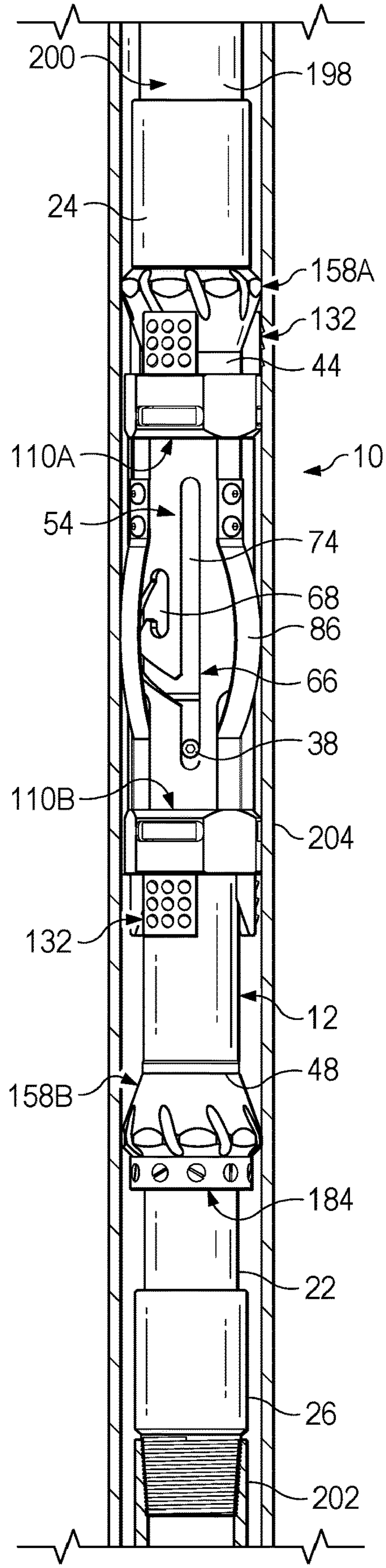
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FIG. 17

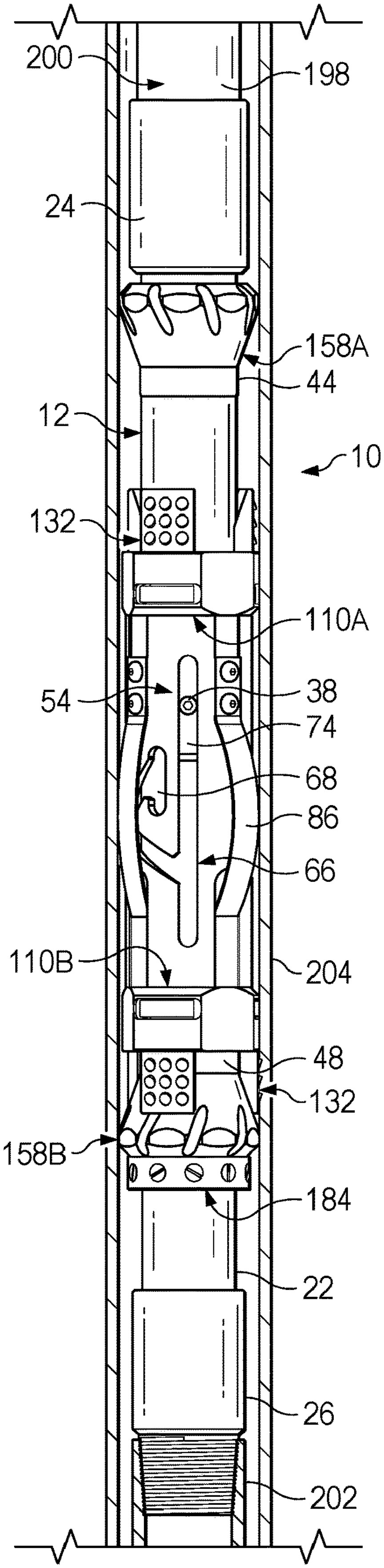
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FIG. 18

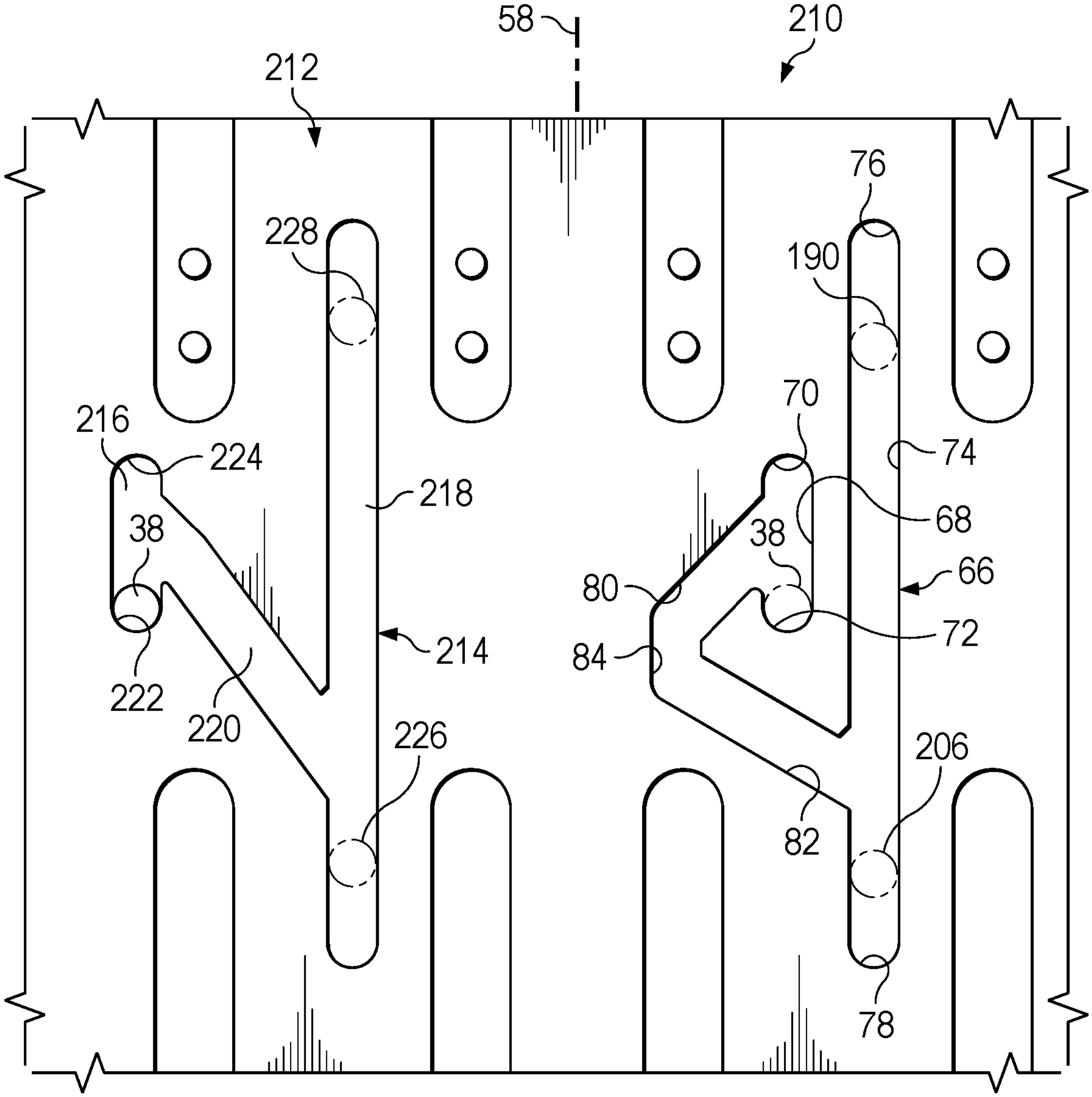
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FIG. 19

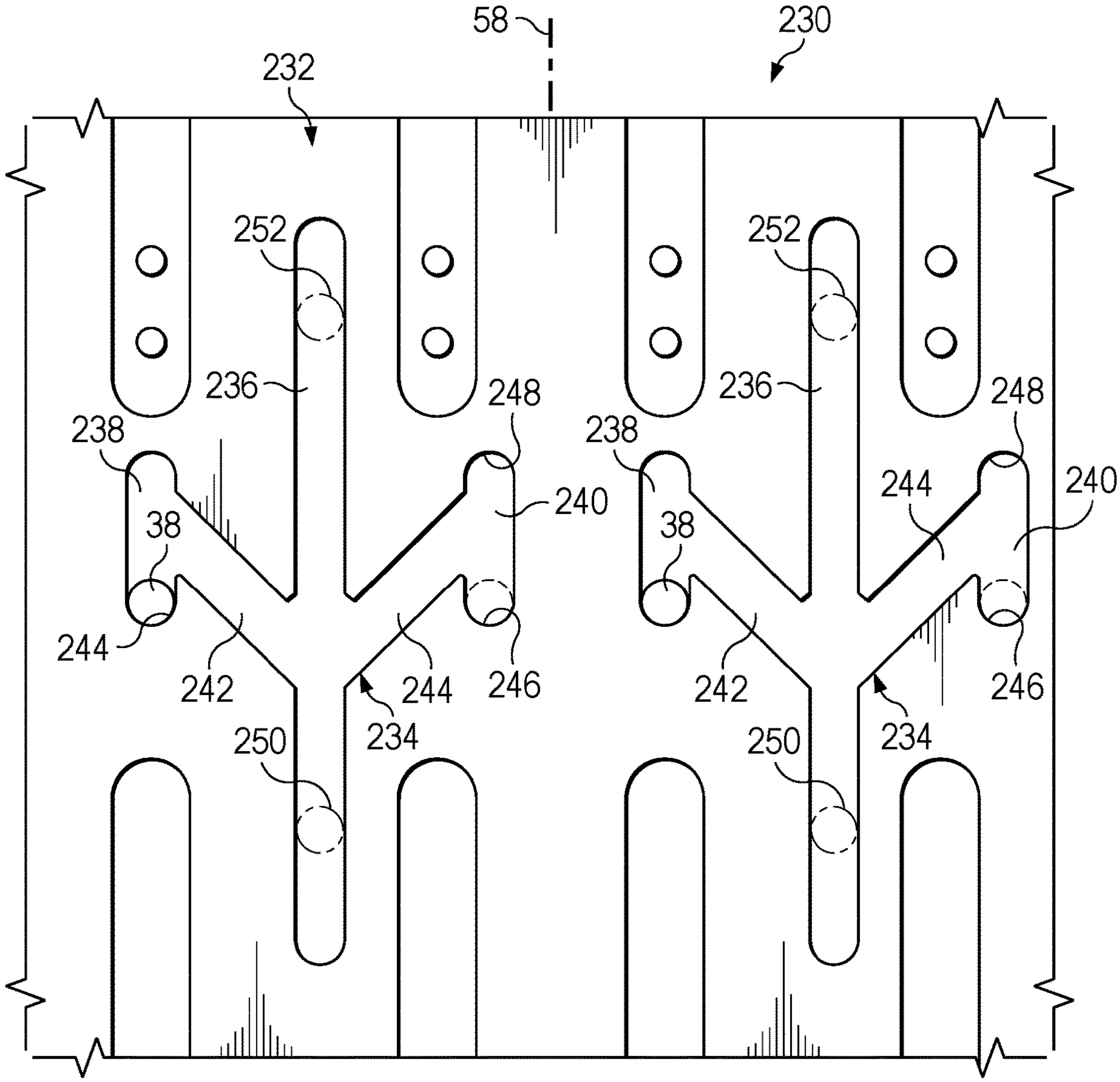
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FIG. 20

WELL TUBING ANCHOR AND CATCHER TOOL ASSEMBLY

TECHNICAL FIELD

The invention relates to those tools used for anchoring and/or catching well equipment, such as tubing strings, within a well casing.

BACKGROUND

Tubing anchor and catcher tools have been widely used in the oil and gas industry to secure tubing strings and well equipment within well casings. The designs of these tools have not changed significantly over many years. An example of a conventional tubing anchor/catcher is that described in U.S. Pat. No. 3,077,933. These tools utilize helical threaded portions on the tool and are actuated by rotational movement to anchor or release the tool and tubing within the casing. Typically, rotation of the tool to the left or counterclockwise causes the tool to be set, while rotation of the tool to the right or clockwise causes the tool to be released. Multiple rotations of the tubing string and tool may be required before the tool is set or released.

Problems with these types of tools, however, are often encountered. The threaded portions of the tool are prone to damage, such as through corrosion or other physical damage to the threads. Seizing of the threaded portions is not uncommon so that the full number of rotations cannot be achieved, preventing the tool from being either set or released. Additionally, applying excessive rotational force to the tool to achieve the required number of turns can result in the tool, the connection between the tubing and tool, or even the tubing itself to break.

Accordingly, there is a need for improved tubing and anchor tools that overcome these and other problems and improve operational efficiency of the tool.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the embodiments described herein, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying figures, in which:

FIG. **1** is a front elevational view of a tool assembly for anchoring and catching well equipment within a well casing, and constructed in accordance with a particular embodiment;

FIG. **2** is a perspective view of a mandrel of the tool assembly of FIG. **1**, shown with upper and lower tubing couplings exploded away from the mandrel;

FIG. **3** is a transverse cross-sectional view of the mandrel of FIG. **2**, shown with a control body surrounding the mandrel and control pins positioned within run slots of the control body;

FIG. **4** is a perspective view of the control body, slip assemblies, cones and other various components of the tool assembly of FIG. **1**, shown exploded away;

FIG. **5** is an enlarged front elevational view of the control body of the tool assembly of FIG. **1**;

FIG. **6** is a perspective view of a slip assembly of the tool assembly of FIG. **1**;

FIG. **7** is a perspective view of a slip housing of the slip assembly of FIG. **6**;

FIG. **8** is a top plan view of the slip housing of FIG. **7**;

FIG. **9** is a cross-sectional view of the slip housing of FIG. **8** taken along the lines **9-9**;

FIG. **10** is a perspective view of a slip of the slip assembly of FIG. **6**;

FIG. **11** is a side elevational view of the slip of FIG. **10**;

FIG. **12** is a front elevational view of a cone of the tool assembly of FIG. **1**;

FIG. **13** is a top plan view of the cone of FIG. **12**;

FIG. **14** is a perspective view of a shear ring of the tool assembly of FIG. **1**;

FIG. **15** is a front elevational view of the tool assembly of FIG. **1**, positioned within a well casing and shown in a neutral or released condition;

FIG. **16** is a schematic representation of the control body of FIG. **4**, shown flattened out to illustrate a set of interconnected slots of the control body configured to provide right-hand (RH)/RH release operation of the tool assembly;

FIG. **17** is a front elevational view of the tool assembly of FIG. **15**, positioned within a well casing and shown in a caught condition;

FIG. **18** is a front elevational view of the tool assembly of FIG. **15**, positioned within a well casing and shown in an anchored condition;

FIG. **19** is a schematic representation of another embodiment of a control body for use with the tool assembly of FIG. **1**, shown flattened out to illustrate a set of interconnected slots of the control body configured to selectively provide RH set/left-hand (LH) release or RH set/RH release operation of the tool assembly; and

FIG. **20** is a schematic representation of still another embodiment of a control body for use with the tool assembly of FIG. **1**, shown flattened out to illustrate a set of interconnected slots of the control body configured to selectively provide any one of RH set/RH release, RH set/LH release, LH set/RH release, or LH set/LH release operation of the tool assembly.

DETAILED DESCRIPTION

Referring to FIG. **1**, a tool assembly **10** for anchoring and/or catching tubing and other well equipment within a well casing is shown. The materials of the tool assembly **10** and its various components may be formed from various strong, durable metal materials, such as high-strength steel or steel alloys. In many instances, all or portions of the surfaces of these materials used for the various components of the tool assembly **10** may be treated or coated, such as with a zinc-phosphate coating, to reduce or prevent wear resistance and corrosion in those fluids (e.g., salt water, brine, etc.) and harsh conditions that are often encountered in oil and gas wells.

The tool assembly **10** comprises a mandrel **12**, as shown in FIG. **2**. The mandrel **12** is configured as an elongated, cylindrical body formed by a cylindrical mandrel wall **14** that surrounds a central longitudinal axis **16**. The mandrel wall **14** defines a hollow interior or central flow passage **18** of the mandrel **12**. The central passage **18** may have a uniform diameter along all or a portion of the length of the mandrel **12**.

In many embodiments, the flow passage **18** may have a uniform diameter along its entire length that matches or is within certain tolerances of the inner diameter of the well tubing with which it is used. For example, commonly used well tubing has an inner diameter of 2.30 inches. Thus, the inner diameter of the central flow passage **18** mandrel **12** may be configured to have an inner diameter of 2.30 inches, as well. The inner diameter of the central flow passage **18** may be within ±0.50% or less of that of the inner diameter of the tubing with which the mandrel **12** is used. In certain embodiments, the inner diameter of the central flow passage **18** may be within a tolerance of from at least, equal to, and/or between any two of ±0.01%, ±0.05%, ±0.10%, ±0.15%, ±0.20%, ±0.25%, ±0.30%, ±0.35%, ±0.40%, ±0.45%, and ±0.50% of that of the inner diameter of the tubing string with which the mandrel **12** is used.

It should be noted in the description, if a numerical value or range is presented, each numerical value should be read once as modified by the term "about" (unless already expressly so modified), and then read again as not so modified unless otherwise indicated in context. Also, in the description, it should be understood that an amount range listed or described as being useful, suitable, or the like, is intended that any and every value within the range, including the end points, is to be considered as having been stated. For example, "a range of from 1 to 10" is to be read as indicating each and every possible number along the continuum between about 1 and about 10. Thus, even if specific points within the range, or even no point within the range, are explicitly identified or referred to, it is to be understood that the inventors appreciate and understand that any and all points within the range are to be considered to have been specified, and that inventors possess the entire range and all points within the range.

Upper and lower ends **20**, **22** of the mandrel **12** are externally threaded for coupling to top and bottom couplings **24**, **26**, respectively. As used herein, unless stated otherwise or is apparent from its context, the expressions "upper," "top", "up," "upward," "above," "bottom," "lower," "down," "downward," "below" and similar expressions are used for convenience and refer to the orientation of the tool assembly **10**, as shown in FIG. **1** and as it would be positioned within a well casing, with "upper," "top", "up," "upward", "above," etc., referring to that position or direction within the well casing that is closer to or in a direction through the well casing towards the wellhead or surface, while "bottom," "lower," "down," "downward," "below," etc., refer to that position or direction through the well casing that is further from or in a direction away from the wellhead.

The top coupling **24** may be internally threaded at both ends for coupling at one end to the externally threaded upper end **20** of the mandrel **12** and at the other end to externally threaded tubing or other well equipment that extends from the wellhead. The bottom coupling **26** may be internally threaded at an upper end **28** for coupling to the externally threaded lower end **22** of the mandrel **12**. The lower end **30** of the bottom coupling **26** may be externally threaded and configured to couple to internal threads of tubing or other well equipment. In other embodiments, the ends **20**, **22** of the mandrel **12** and/or the couplings **24**, **26** may be configured differently to facilitate coupling to other tubing, well equipment or other couplings. The upper end **28** of bottom coupling **26** is shown configured as a female end and is internally threaded for receiving the threaded lower end **22** of the mandrel **12**.

Provided on the exterior of the mandrel wall **14** at or near the center of the mandrel **12** are raised or projecting areas **32**, **34** that project from the mandrel wall **14**. The raised areas **32**, **34** may have an overall rectangular perimeter, with the length of the areas **32**, **34** being parallel with the longitudinal axis **16**. Each of the raised areas **32**, **34** has a transverse arcuate convex exterior surface, as shown in FIG. **3**. The arcuate convex exterior surfaces of the raised areas **32**, **34** may have a constant radius of curvature along their lengths, with the radius of curvature being a line that extends perpendicularly from the longitudinal axis **16** to the exterior surfaces of the raised areas **32**, **34**. The raised areas **32**, **34** are circumferentially spaced approximately 900 apart from one another on the mandrel wall **14**. One or more or all of the raised areas **32**, **34** may be provided with an internally helically threaded control pin port **36**. In the embodiment shown, only the two raised areas **32** that are spaced at or approximately 180° apart on the mandrel wall **14** are provided with the control pin port **36**, while the raised areas **34** that are located between the raised areas **32** and are also spaced 180° do not have any such ports.

The control pin ports **36** of raised areas **32** are each configured to receive a control pin **38**. Each control pin **38** has a threaded inner end portion **40** that is received and threads into one of the threaded ports **36**. The outer end **42** of the control pin **38** projects radially outward from the ports **36** and raised areas **32**, as shown in FIG. **3**. The outer end **42** of the control pin **38** may be free of threads and have short cylindrical configuration with a generally uniform circular transverse cross section along all or a portion of its height.

An annular band or collar **44** near the upper end **20** of the mandrel **12** projects radially outward from the mandrel wall **14** and is spaced longitudinally on the mandrel wall **14** above the raised portions **32**, **34** to form an upper annular shoulder **46** on the mandrel **12**. A lower annular shoulder **48** is provided near the lower end **22** of the mandrel **12** and is located longitudinally below the raised portions **32**, **34**. The lower annular shoulder **48** may be formed by a stepped-down portion **46** of the mandrel wall **14** having a smaller outer diameter than that above the shoulder **48**. The stepped-down portion **46** may have a generally uniform diameter along its length extending towards the lower end **22** of the mandrel **12**.

As shown in FIG. **2**, a series of circumferentially-spaced apart apertures or ports **52** are formed in the stepped-down portion **46** of the mandrel wall **14**. The apertures or ports **52** may be equally spaced apart about the circumference of the mandrel wall **14** and are non-threaded for receiving the ends of shear screws of a shear ring, as discussed later.

Referring to FIG. **4**, various components of the tool assembly **10** that are configured to be mounted over the mandrel **12** are shown. A control body **54** of the tool assembly **10** comprises a cylindrical control body wall **56** that surrounds a central longitudinal axis **58** of the control body **54**. The control body wall **56** is configured as a sleeve that defines an interior central cylindrical passage **60** that surrounds the axis **58** and extends the length of the control body **54**. The control body **54** is mounted over the mandrel **12**, with the mandrel **12** being received within the central opening **60** of the control body **54**. When the control body **54** is mounted on the mandrel **12**, the axis **58** of the control body **54** is concentric with the central axis **16** of the mandrel **12**. The mandrel **12** is movable relative to the control body **54** both longitudinally and rotationally about the central axes **16**, **58** relative to the control body **12**. As shown in FIG. **3**, the raised areas **32**, **34** of mandrel **12** facilitate centering of the control body **54** on the mandrel.

The central opening **60** of the control body **54** is sized and configured to accommodate the raised areas **32**, **34** so that they are also spaced from the interior of the control body wall **56** to provide small clearances **62**, **64**, respectively. The raised areas **32**, **34** facilitate centering the control body on the mandrel **12**, with the clearances **62**, **64**, allowing the mandrel **12** and control body **54** to rotate relative to one another around their concentric axes **16**, **58**.

The control body **54** comprises a right-hand (RH) set/right-hand (RH) release control body so that the tool assembly **10** employing the control body **54** functions as a RH set/RH release tool assembly. As will be described later, differently configured control bodies can alter the direction of setting and releasing of the tool assembly **10**.

Formed in the control body wall **56** are a set of interconnected slots **66** that extend through all or a portion of the thickness of the control body wall **56** from the interior surface of the wall **56**. In the embodiment shown, all or some of the interconnected set of slots **66** extend through the entire thickness of the wall **56** so that the slots **66** form open areas in the control body wall **56**. In other embodiments, however, all or some of the slots may extend only partially through the entire thickness of the control body wall **56** from the interior of the control body wall **56**. When the control body **54** is mounted over the mandrel **12**, the interconnected slots **66** receive the outer end **42** of the control pin **38** that projects from the raised areas **32** of the mandrel wall **14**. The slots **66** are sized and configured to allow the control pin **38** to travel within the slots **66** as the mandrel **12** is moved relative to the control body **54**.

In the embodiment shown, there are two sets of interconnected slots **66** that each have the same configuration but are each positioned 180° apart on opposite sides of the control body wall **56**. As can be seen more readily in the embodiment of FIG. **3**, when the control pin **38** is received within the slots **66**, the outer end **42** of the control pin **38** remains at or is flush with the edges of the slots **66** or is otherwise recessed or spaced radially inward from the exterior edges of the slots **66** so that the control pin **38** does not project beyond the exterior surface of the control body wall **56**. In other embodiments, the control pin **38** may project radially outward a distance from the exterior surface of the control body wall **56** through the interconnected slots **66**.

Each set of interconnected slots **66** comprises a run slot **68** provided at a first circumferential position on the control body wall **56**. The run slot **68** has a generally linear configuration and extends longitudinally along the wall **56**. The opposite upper and lower ends **70**, **72**, respectively, of the slot **68** may be concavely curved or arcuate to accommodate and receive the circular outer end **42** of the control pin **38** when it abuts against the ends of the slot **68**. The center of the run slot **68** may be positioned at or near the center or midpoint of the control body **54** and has a width that accommodates the diameter of the control pin **38** so that the control pin **38** can freely move along the length of the slot **68**. The run slot **68** is positioned on the control body wall **56** and has a longitudinal length that limits the distance the control pin **38** and mandrel **12** can travel longitudinally relative to the control body **54**. This ensures that the tool assembly **10** is maintained in a released condition when the control pin **38** is located within the run slot **68**.

While not to be limited necessarily to any particular dimensions, in certain embodiments, the run slot **68** may have an overall longitudinal length of from 1 inch to 5 inches. In certain embodiments the run slot **68** may have an overall longitudinal length of from at least, equal to, and/or between any two of 1 inch, 1.1 inches, 1.2 inches, 1.3 inches, 1.4 inches, 1.5 inches, 1.6 inches, 1.7 inches, 1.8 inches, 1.9 inches, 2.0 inches, 2.1 inches, 2.2 inches, 2.3 inches, 2.4 inches, 2.5 inches, 2.6 inches, 2.7 inches, 2.8 inches, 2.9 inches, 3.0 inches, 3.1 inches, 3.2 inches, 3.3 inches, 3.4 inches, 3.5 inches, 3.6 inches, 3.7 inches, 3.8 inches, 3.9 inches, and 4.0 inches, 4.1 inches, 4.2 inches, 4.3 inches, 4.4 inches, 4.5 inches, 4.6 inches, 4.7 inches, 4.8 inches, 4.9 inches, and 5.0 inches.

Each set of interconnected slots **66** further comprises a set slot **74** provided on the control body wall **56** that is circumferentially spaced apart from the run slot **68**. The set slot **74** has a generally linear configuration and extends longitudinally along the wall **56** and is parallel with the run slot **68**. The opposite upper and lower ends **76**, **78**, respectively, of the set slot **74** may also be concavely curved or arcuate. In most instances the set slot **74** has a sufficient length so that during use of the tool assembly **10** the control pin **38** will not travel the full length or engage the ends **76**, **78** of the set slot **74**. The set slot **74** may also be positioned with its center at or near the center or midpoint of the control body **54** so that the centers of each of the run slot **68** and set slot **74** may be at or near the same longitudinal position on the control body wall **56**.

As can be seen in FIG. **5**, the set slot **74** has a longitudinal length that is longer than that of the run slot **68**, with the upper and lower halves of the set slot **74** extending longitudinally beyond the ends **70**, **72** of the run slot **68** on the control body wall **56**. The set slot **74** may have a width that accommodates the diameter of the control pin **38** to allow it to freely move longitudinally within the slot **74** while limiting lateral or circumferential movement of the control pin **38** within the slot **74** as it is moved towards the ends **76**, **78** of the slot **74**. The set slot **74** is positioned on the control body wall **56** and has a longitudinal length that allows the control pin **38** and mandrel **12** to travel longitudinally relative to the control body **54** so that the tool assembly **10** can be moved to a set condition where the tool assembly **10** is in an anchored or caught condition within the well casing with which it is used.

While not to be necessarily limited to any particular dimensions, in certain embodiments, the set slot **74** may have an overall longitudinal length of from 5 inches to 12 inches or more. In certain embodiments the run slot **68** may have an overall longitudinal length of from at least, equal to, and/or between any two of 5.0 inches, 5.1 inches, 5.2 inches, 5.3 inches, 5.4 inches, 5.5 inches, 5.6 inches, 5.7 inches, 5.8 inches, 5.9 inches, 6.0 inches, 6.1 inches, 6.2 inches, 6.3 inches, 6.4 inches, 6.5 inches, 6.6 inches, 6.7 inches, 6.8 inches, 6.9 inches, 7.0 inches, 7.1 inches, 7.2 inches, 7.3 inches, 7.4 inches, 7.5 inches, 7.6 inches, 7.7 inches, 7.8 inches, 7.9 inches, 8.0 inches, 8.1 inches, 8.2 inches, 8.3 inches, 8.4 inches, 8.5 inches, 8.6 inches, 8.7 inches, 8.8 inches, 8.9 inches, 9.0 inches, 9.1 inches, 9.2 inches, 9.3 inches, 9.4 inches, 9.5 inches, 9.6 inches, 9.7 inches, 9.8 inches, 9.9 inches, 10.0 inches, 10.1 inches, 10.2 inches, 10.3 inches, 10.4 inches, 10.5 inches, 10.6 inches, 10.7 inches, 10.8 inches, 10.9 inches, 11.0 inches, 11.1 inches, 11.2 inches, 11.3 inches, 11.4 inches, 11.5 inches, 11.6 inches, 11.7 inches, 11.8 inches, 11.9 inches, and 12.0 inches.

The run slot **68** and set slot **74** of each set of interconnected slots **66** are circumferentially spaced apart from 900 or less on the control body wall **56**, as measured from a center line of each slot **68**, **74**. In certain embodiments, the run slot **68** and set slot **74** of each set of interconnected slots **66** are circumferentially spaced apart less than 90°, 85°, 80°, 75°, 70°, 65°, 60°, 55°, 50°, 45°, 40°, 35°, 30°, 25°, 20°, 15°, 100 or less, as measured from a center line of each slot. In certain embodiments run slot **68** and set slot **74** of each set of interconnected slots **66** are circumferentially spaced apart from one another from at least, equal to, and/or between any two of 10°, 11°, 12°, 13°, 14°, 15°, 16°, 17°, 18°, 19°, 20°, 21°, 22°, 23°, 24°, 25°, 26°, 27°, 28°, 29°, 30°, 31°, 32°, 33°, 34°, 35°, 36°, 37°, 38°, 39°, 40°, 41°, 42°, 43°, 44°, 45°, 46°, 47°, 48°, 49°, 50°, 51°, 52°, 53°, 54°, 55°, 56°, 57°, 58°, 59°, 60°, 61°, 62°, 63°, 64°, 65°, 66°, 67°, 68°, 69°, 70°, 71°, 72°, 73°, 74°, 75°, 76°, 77°, 78°, 79°, 80°, 81°, 82°, 83°, 84°, 85°, 86°, 87°, 88°, 89°, and 90°, as measured from the center line of each slot **68**, **74**.

The run slot **68** and set slot **74** are interconnected by upper and lower passage slots **80**, **82** of the set of interconnected slots **66**. As viewed in FIG. **5**, the upper passage slot **80** opens into and extends from the left side of run slot **68**. The upper passage slot **80** is angled downward from the run slot **68** towards the left, or the direction away from both the run slot **68** and set slot **74**, where it is joined at its lower end to an upper end of a short longitudinally oriented transition slot **84**. In certain embodiments, the upper passage slot **80** may be oriented downward to the left from the run slot **68** at an angle of from 30° to 60°, more particularly from 40° to 50°, relative to the longitudinal axis **58** of the control body **54**. In particular embodiments, the upper passage slot **80** may be oriented at an angle of from at least, equal to, and/or between any two of 30°, 31°, 32°, 33°, 34°, 35°, 36°, 37°, 38°, 39°, 40°, 41°, 42°, 43°, 44°, 45°, 46°, 47°, 48°, 49°, 50°, 51°, 52°, 53°, 54°, 55°, 56°, 57°, 58°, 59°, and 70°, relative to the longitudinal axis **58** of the control body **54**.

The lower passage slot **82** is joined at its upper end to the lower end of the transition slot **84**, extending downward at an angle to the right, as viewed in FIG. **5**, towards the set slot **74**. The lower end of the lower passage slot **80** opens into the left side of the set slot **74** at a longitudinal position below the lower end **72** of the run slot **68**, as is shown. The lower passage slot **82** is oriented downward to the right from the transition slot **84** or lower end of the upper passage slot **80**. In certain embodiments, the lower passage slot **82** may be oriented downward to the right at an angle of from 30° to 60°, more particularly from 40° to 50°, relative to the longitudinal axis **58** of the control body **54**. In particular embodiments, the upper passage slot **80** may be oriented at an angle of from at least, equal to, and/or between any two of 30°, 31°, 32°, 33°, 34°, 35°, 36°, 37°, 38°, 39°, 40°, 41°, 42°, 43°, 44°, 45°, 46°, 47°, 48°, 49°, 50°, 51°, 52°, 53°, 54°, 55°, 56°, 57°, 58°, 59°, and 70°, relative to the longitudinal axis **58** of the control body **54**.

As can be seen in FIG. **5**, the transition slot **84** is situated at the greatest circumferential distance from the set slot **74**. The transition slot **84** forms a corner where the upper passage slot **80** and lower passage slot **82** come together or meet. In some embodiments, the transition slot **84** may merely be the junction or corner where the lower end of the upper passage slot **80** and the upper end of the lower passage slot **82** are joined directly together. In such instances, the corner formed where the two passage slots **80**, **82** are joined should be configured to provide sufficient room or clearance for the control pin **38** to transition and pass between the upper passage slot **80** and the lower passage slot **82**.

In certain embodiments, the transition slot **84** of each set of interconnected slots **66** is circumferentially spaced apart from the run slot **68** and/or set slot **74** no further than 90°, 85°, 80°, 75°, 70°, 65°, 60°, 55°, 50°, 45°, 40°, 35°, 30°, 25°, 20°, 15°, 100 or less, as measured from the center of each slot. In this configuration, the run slot **68** is positioned circumferentially closer to the transition slot **84** than the set slot **74**. In certain embodiments, the transition slot **84** and run slot **68** and/or set slot **74** of each set of interconnected slots **66** are circumferentially spaced apart from one another from at least, equal to, and/or between any two of 10°, 11°, 12°, 13°, 14°, 15°, 16°, 17°, 18°, 19°, 20°, 21°, 22°, 23°, 24°, 25°, 26°, 27°, 28°, 29°, 30°, 31°, 32°, 33°, 34°, 35°, 36°, 37°, 38°, 39°, 40°, 41°, 42°, 43°, 44°, 45°, 46°, 47°, 48°, 49°, 50°, 51°, 52°, 53°, 54°, 55°, 56°, 57°, 58°, 59°, 60°, 61°, 62°, 63°, 64°, 65°, 66°, 67°, 68°, 69°, 70°, 71°, 72°, 73°, 74°, 75°, 76°, 77°, 78°, 79°, 80°, 81°, 82°, 83°, 84°, 85°, 86°, 87°, 88°, 89°, and 90°, as measured from the center of each slot **84** and **68** and/or **74**. In the embodiment shown, the transition slot **84** is circumferentially spaced approximately 350 from the run slot **68** and approximately 650 from the set slot **74**. And the run slot **68** is circumferentially spaced from the set slot **74** approximately 30°. Thus, in the embodiment shown, the total amount of rotation of the tubing string and mandrel **12** relative to the control body **54** encountered in moving the control pin **38** from the run slot **68** to the transition slot is only 35°. And the rotation in moving the control pin **38** from the transition slot **84** to the set slot **74** is only 65°.

The longitudinal position of the lower end of the lower passage slot **82** where it opens into and meets the set slot **74** should be at a location on the set slot **74** where the control pin **38** and mandrel **12** are still at a position where the tool assembly **10** is maintained in a released condition or at a position where tool assembly **10** just enters into a set condition.

Referring to FIG. **4**, two or more control springs **86** are provided with the control body **54**. In the embodiment shown, there are four control springs **86** circumferentially spaced apart an equal distance on the exterior of the control body **54**. The control springs **86** may each comprise an elongated leaf spring body **88** that bows radially outward and an attachment flange or extension **90** that is joined to the leaf spring body **88** at one end. The attachment flange or extension **90** is formed as a rectangular body having a pair of apertures **92** for receiving threaded screws or fasteners **94**. A surface groove or channel **96** may be formed in the exterior surface of the control body **54** at its upper end and be sized and configured to receive the flange or extension **90** of the control spring **86**. A pair of threaded apertures **98** of the groove **96** that align with the apertures **92** of the flange or extension **90** extend from the groove **96** into the control body wall **56** to receive the ends of the screws or fasteners **94** to secure the control springs **86** to the control body **54**.

A longitudinal surface groove or channel **100** is formed in the exterior surface of the control body wall **56** below the attachment groove or channel **96**. In the embodiment shown, when control spring **86** is mounted to the control body **54** through the attachment flange or extension **90**, the leaf spring body **88** extends longitudinally downward along the side of the control body **54**, with a lower end **102** of the leaf spring body **88** being received within the groove or channel **100**. The groove or channel **100** is sized and configured to allow the spring **86** to flex, with the lower end **102** of the leaf spring body **88** being able to slide longitudinally within the groove or channel **100** relative to the control body **54** during radial compression or expansion of the bowed leaf spring body **88**, while restricting circumferential or lateral movement of the lower end **102** of the leaf spring body **88**.

In some embodiments, one or more reinforcement plates **104** is provided with the control body **54**. In the embodiment shown, the reinforcement plate **104** is secured over the run slot **68** to reinforce the edges and ends **76**, **78** of the slot **68** where large forces may be encountered when contacted by the control pin **38** on the ends **76**, **78** of the slot **68** during run and retrieval of the tool assembly **10**. As can be seen in FIG. **3**, the reinforcement plate **104** may have a curved transverse cross section along all or a portion of its length to accommodate the curvature of the control body wall **56**. The reinforcement plate **104** may be welded to the exterior of the control body wall **56**. In other instances, thickened areas of the control body wall **56** surrounding the run slot **68**, such as may be formed during the machining of the control body

54, may provide reinforcement. If necessary, other areas of the interconnected slots 66 may be similarly reinforced.

As shown in FIG. 4, the central opening 60 at both upper and lower ends 106, 108, respectively, of the control body 54 has threads formed on the interior of the control body wall 56 for coupling to a pair of slip assemblies 110A, 110B. For ease of description, the slip assemblies 110A, 110B, are collectively referred to with the reference numeral 110, but are individually referred to with the reference numerals 110A, 110B. As viewed in FIG. 1, the slip assembly 110A constitutes an upper or catcher slip assembly and the slip assembly 110B constitutes a lower or anchor slip assembly.

A more detailed view of the slip assembly 110 is shown in FIG. 6. Each slip assembly 110 comprises a slip housing 112, shown in detail in FIGS. 7-9. As shown, the slip housing 112 has an externally threaded end portion 114 that is configured to screw into the internally threaded ends 106, 108 of the control body 54 to couple the housing 112 to the control body 54.

An interior central bore 116 of the housing 112 surrounds a central longitudinal axis 118 that extends along the length of the housing 112. The central bore 116 is configured to position over and receive the mandrel 12 when the housing 112 is coupled to the control body 54. When coupled, the central axis 118 of the housing 112 may be concentric with the central longitudinal axes 16, 58 of the mandrel 12 and control body 54, respectively.

As can be seen in FIG. 8, the interior bore 116 is provided with circumferentially spaced-apart bypass flow passages 120 that extend along the length of the housing 112. The flow passages 120 increase the open transverse cross-sectional area of the interior bore 116. The bypass flow passages 120 increase the transverse cross-sectional area of the interior bore 116 along its length to allow increased fluid to flow through the interior of the slip housing 112, minimizing the obstruction to fluid flow within the well casing caused by the tool assembly 10. In the embodiment shown, the bypass flow passages 120 are configured as six longitudinally extending concave interior surface grooves that are circumferentially spaced approximately 60° apart. The bypass flow passages 120 may have other configurations, with fewer or more of these bypass passages being used in the slip housing 112 in other embodiments.

The exterior wall of the slip housing 112 is generally cylindrical. This can be seen by the circumferential dashed lines 113, shown in FIG. 8. In certain embodiments, the exterior of the slip housing 112 may be provided with circumferentially spaced apart cutout areas 122 that extend along the length of the housing 112. The cutout areas 122 are shown as longitudinally extending flats that each lie in a plane that is parallel to the axis 118. The cutout areas 122 reduce the exterior transverse cross-sectional area of the slip housing 112 along its length to reduce the area taken up by the slip housing 112. This reduction in area is equivalent to the area between the circumferential dashed line 113 and the cutout areas 122. This increases the area of fluid flow within the well casing around the slip housing 112. In the embodiment shown, the cutouts 122 are configured as three longitudinally extending flats formed on the exterior of the slip housing 112 that are circumferentially spaced approximately 120° apart. The cutouts 122 may have other configurations, such as concave arcuate surface instead of being flat, with fewer or more of these cutout areas 122 being used in the slip housing in other embodiments.

The non-threaded end 124 of the slip housing 112 opposite the threaded end 114 is provided with a set of circumferentially spaced apart internal recessed areas 126 for receiving slips of the slip assembly 110. In the embodiment shown, there are three recessed areas 126 spaced 1200 apart. The recessed areas 126 are formed in the interior bore 116 of the slip housing 112 and extend from the end 124 of the slip housing 112 to a slot or open area 128 that is formed in a circumferential wall 130 of the slip housing 112 located between the cutout areas 122.

In the embodiment shown, a set of three slips 132 is provided with each slip assembly 110 that are each configured the same. As shown in FIGS. 10 and 11, each slip 132 is comprised of a slip body 134 that has a tapered end portion 136 that is configured generally in a wedge shape. The slip body 134 has an outer face 138 and an opposite inner face 140 that tapers or is sloped inward from the tip of the end portion 136 so that the distance between the outer and inner faces increases along the length of the tapered end portion 136. The inner face 140 then extends generally parallel to the outer face 138 to form a non-tapered portion 142 of the slip body 134 of generally uniform thickness along its length that extends from the tapered end portion 136.

As can be seen in FIG. 10, the outer and inner faces 138, 140 are arcuate surfaces. The outer face 138 may have a convex curvature, with a generally uniform radius of curvature along its length around an axis aligned with the length of the slip body 134. The inner face 140, conversely, may feature a concave curvature.

Extending longitudinally from the inner side of the non-tapered portion 142 of the slip body 134 opposite the tapered portion 136 is a leg 144 of the slip 132. A projecting foot or projecting end portion 146 projects outward from the end of the leg 144 to define a slot or recess 148 between the foot 146 and the non-tapered portion 142 of the slip body 134. The slot or recess 148 is configured to receive a slip spring 150.

In the embodiment shown, the slip spring 150 is shown as a V-shaped biasing member that may be formed from a single piece of thin resilient sheet metal, such as steel, which is bent in the middle across its width to form the V-shape. The V-shaped biasing member 150 is positioned in the slot 148 of the slip 132 with the length of the apex 152 of the V-shaped member 150 resting against the center of the bottom of the slot or recess 148 and being oriented longitudinally with the slip 132. When so positioned, the flat legs 154 of the V-shaped biasing member 150 extend outward and laterally to either side, as shown in FIG. 10.

A set of teeth or projections 156 may be provided in the outer face 138 of the slip body 134. The teeth 156 may be inclined outward from the direction of longitudinal force the slip 132 is configured to encounter during use to help the teeth 156 dig or cut into the walls of the well casing with which the tool assembly 10 is used. The teeth 156 may be formed from a different, harder material (e.g., tungsten carbide) than the material of the well casing to facilitate this digging or cutting action. In certain embodiments, the teeth 156 may be formed as individual inserts that are mounted in apertures formed the outer face 138 of the slip body 134.

Referring to FIG. 6, the slips 132 are mounted in the slip housing 112 by extending the leg 144 and foot 146 of each slip 132 into the interior 116 of the slip housing 112 so that it overlays one of the recessed areas 126, with the foot 146 being received in the slot 128 and the recess 148 overlaying the circumferential wall 130 of the slip housing 112, which is located between the cutout areas 122. When mounted, the legs 154 of the V-shaped spring 150 will abut against the interior of the wall 130 and provide a biasing force against the slip 132 so that the outer face 138 of the slip body 134 is biased or forced inwardly. This causes the slips 132 to be in an inwardly retracted position when the tool assembly **10** is in a released condition, as will be described more fully later. When the slips **132** are mounted and carried by the slip housing **112**, the tapered portion **136** and non-tapered portion **142** of the slip body **134** will extend longitudinally from the non-threaded end portion **124** of the slip housing **112**, as is shown.

The tool assembly **10** also comprises a pair of cones **158**, which are each configured similarly. For ease of description, the cones **158** are collectively referred to with the reference numeral **158** but are individually referred to with the reference numerals **158**A, **158**B. As viewed in FIG. **1**, the cone **158**A constitutes an upper or catcher cone and the cone **158**B constitutes a lower or anchor cone. As shown in FIGS. **12-13**, each cone **158** is formed as a unitary body with a frustoconical tapered lower portion **160** having a tapered exterior surface **162** that tapers radially inward along its length to a narrow end **164**. The inner face **140** of the tapered end portion **136** of the slip body **134** may be configured to have a concave curvature that corresponds to the tapered exterior surface **162** of the lower portion **160** of the cone **158**.

An upper portion **166** of the cone **158** has a series of circumferentially spaced apart grooves or channels **168** formed in its exterior surface. The bottom of each groove or channel **168** may be a concave curve of a constant or variable radius that extends along the length of the groove or channel **168**. These grooves or channels **168** constitute flow passages to allow fluid flow past the cone **158** where the cone **158** is at its widest dimension to facilitate increased fluid flow around the cone **158**. In the embodiment shown, the grooves or channels **168** are slanted along a line **170** set at a non-parallel angle relative to a central longitudinal axis **172** of the cone **158**. The grooves or channels **168** are configured to impart a swirling or helical fluid flow pattern, which may create turbulent fluid flow within the well casing around the tool assembly **10**. Such swirling turbulent flow may prevent minerals and particles from settling out and depositing on the surfaces of the tool assembly **10**. In other embodiments, the grooves or channels **168** may be oriented along a line that is parallel to the longitudinal axis **172** and configured to impart no such swirling or helical flow pattern.

The outer perimeter of the upper portion **166** of the cone **158** where the cone **158** is widest is generally configured as a cylinder. This can be seen by the circumferential dashed lines **174**, shown in FIG. **13**. The upper portion of the cone **166** may be provided with circumferentially spaced cutouts or flats **176** located between the grooves or channels **168**. The cutouts or flats **176** may be flat areas that are oriented in planes that are parallel to the longitudinal axis **172**. These cutouts or flats **176** reduce the cross-sectional area of the cone **158** to facilitate increased fluid flow within the well casing around the cone **158**. This reduction in area is equivalent to the area between the circumferential dashed line **174** and the cutout areas **176**, as shown in FIG. **13**.

As shown in FIG. **12**, the upper portion **166** has circumferential beveled or chamfered area that forms frustoconical end portion **178** of the cone **158** that tapers radially inward along the longitudinal axis **170** towards an upper end **180** of the cone **158**. The grooves or channels **168** may extend through this frustoconical end portion **178** and into the tapered lower portion **160** of the cone **158**.

Referring to FIG. **13**, a cylindrical central bore **182** is provided in the cone **158**. The central bore **182** has a smooth inner surface and is concentric with and surrounds the central longitudinal axis **172** and has a uniform diameter along its length. The bore **182** is sized and configured to receive the mandrel **12**.

The tool assembly **10** further comprises a shear ring **184**. The shear ring **184** is formed as a short cylindrical wall **186** of uniform thickness having a central cylindrical opening **188** that has a smooth inner surface and is sized and configured to receive the mandrel **12**. A set of circumferentially spaced apart, threaded apertures **190** extend radially through the thickness of the wall **186** for receiving externally threaded shear screws **192**. The number, spacing and configuration of the apertures **190** is such that they correspond to and align with the shear ports **52** formed in the mandrel wall **12**. When the shear ring **184** is mounted over the mandrel **12**, the shear screws **192** are threaded into the apertures **190** so that the inner ends of the shear screws **192** project into the shear ports **52** of the mandrel **12** to hold the shear ring **184** in place. An upper end **194** of the shear ring **184** provides an annular shoulder when mounted to the mandrel **12**.

The shear screws **192** are made of a softer material (e.g., brass) than the shear ring **184** and mandrel **12** and may be selected with a particular shear rating so that the screws **192** shear under a given amount of force (e.g., 5,000 lbs/screw). Thus, for example, if there are ten apertures **190** in the shear ring **184**, each aperture **190** having a shear screw **192** that has a shear strength of 5,000 lbs/screw, the shear ring **184** should be held in place when subjected to a force from 50,000 lbs or less before the shear ring **184** fails and is freed from the mandrel **12**. By increasing or decreasing the number of shear screws **192** of known shear strength used with the shear ring **184**, a user can select the desired degree of force required to shear apart and disengage the shear ring **184** from the mandrel **12**.

In assembly of the tool assembly **10**, the upper cone **158**A (FIG. **4**) is mounted over the mandrel **12** by passing the upper end **20** of the mandrel **12** through the central bore **182** of the cone **158**A so that the narrow end **164** of cone **158**A abuts and rests against the upward facing annular shoulder **46** of the mandrel **12**. The upper coupling **24**, having a greater diameter than the mandrel **12** so that it creates a lower facing shoulder, may then be threaded onto upper end **20** to secure the cone **158**A in place on the upper end **20** of the mandrel **12**, as shown in FIG. **1**.

The threaded end **114** of upper slip assembly **110**A is threaded into and coupled to the upper end **106** of the control body **54** and the lower slip assembly **110**B is threaded into and coupled to the lower end **108** of the control body **54**. The control body **54** with the slip assemblies **110** is passed over the lower end **22** of the mandrel **12**, with the mandrel **12** being received within the central opening **60** of the control body **54** and interior bores **116** of the slip housings **112**. When the control body **54** is mounted over the mandrel **12**, as shown in FIG. **3**, the exterior of the mandrel wall **14** is spaced radially inward from the interior of the control body wall **56** to define annular spaces **196**. These annular spaces **196** create flow passages that allow fluid to flow within the annular spaces **196** between the mandrel **12** and control body **54**.

With the control body **54** mounted over the mandrel **12**, the control pins **38** can be positioned within the set of slots **66** and screwed into the threaded ports **36** through the open areas of the slots **66**. As shown in FIG. **3**, outer end **42** of the control pin **38** will not project out of the slots **66** but will be flush or slightly recessed within the slots **66**. This provides a clearance so that the control pin **38** does not contact the reinforcement plate **104** that is mounted over the run slot **68**.

The lower cone **158**B (FIG. **4**) is then mounted over the mandrel **12** by passing the cone **158**B over the lower end **22** of the mandrel **12** through the central bore **182** of the cone **158**B so that the narrow end **164** of cone **158**B abuts and rests against the lower annular shoulder **48** (FIG. **2**). The shear ring **184** is then mounted over the mandrel **12** with the threaded apertures **190** aligning with the shear ports **52** formed in the mandrel wall **14**. The desired number of shear screws **192** are then threaded into the apertures **190** so that the inner end **171** of the shear screws project into the shear ports **52** of the mandrel **12**. With the shear ring **184** is mounted, the end **180** of lower cone **158**B will abut and rest against the upper end **194** of shear ring **184** so that the lower cone **158**B is secured in place on the mandrel **12** between the lower annular shoulder **48** and shear ring **184**.

The lower coupling **26** may then be threaded onto the lower end **22** of the mandrel. As can be seen in FIG. **1**, the upper end **28** of bottom coupling **26** is longitudinally spaced below the shear ring **184** on the mandrel **12**. When the shear ring **184** parts due to excessive force and shearing, the shear ring **184** and lower cone **158**B will drop away on the mandrel **12** so that the shear ring **184** and cone **158**B rest on the upper end **28** of the bottom coupling **26**.

When so assembled, the central axes **58**, **118**, **172** of the control body **54**, slip housing **112** of the slip assemblies **110**A, **110**B and cones **158**A, **158**B, respectively, may be aligned, parallel, and/or concentric with central longitudinal axis **16** of the mandrel **12**.

In operation, as shown in FIG. **15**, the tool assembly **10** is coupled at the top coupling **24** to the lower end of tubing **198** of a tubing string **200** used in a well, such as an oil and/or gas well. The bottom coupling **26** likewise is coupled at the lower end **30** to lower tubing **202** of the tubing string **200** or other well equipment (not shown) that may be coupled to the bottom coupling **26**. When the tool assembly **10** is coupled to the tubing string **200**, the tool assembly **10** is lowered or run into a well casing **204** of the well. Initially, during the lowering or running of the tubing string and tool assembly **10** into the well casing **204**, the control pin **38** of the tool assembly will be positioned and maintained within the run slot **68**.

FIG. **16** shows a more detailed view of the control pins **38** and two interconnected slot sets **66** formed in the control body wall **56**. For ease of understanding, the cylindrical control body wall **14** shown in FIG. **16** is shown schematically in a flattened condition to better illustrate the movement of the control pins **38** within the two slot sets **66**. As discussed previously, there may be two identical slot sets **66** that are positioned on opposite sides of the control body **54** circumferentially spaced 180° apart, each slot set receiving a single control pin **38**. Because the slot sets **66** are configured the same, the movement of the control pins **38** with the slots will be the same. The configuration of the slot sets **66** of the control body **54** of FIG. **16** provides the RH set/RH release actuation for the tool assembly **10**.

As the tool assembly **10** is run into the well casing, the control pin **38** will abut and push against the bottom end **72** of the shorter run slot **68**, as shown in FIGS. **15** and **16**. When the tool assembly **10** is located within the well casing **204**, the control springs **86** on the outside of the control body **18** contact and engage the interior of the well casing **204**. The control springs **86** each constituting a drag body that provides a degree of resistance to movement of the control body **54** relative to the well casing **204** and/or mandrel **12**. The slip springs **86** thus facilitate maintaining the control body **54** and the slip assemblies **110**A, **110**B coupled thereto stationary within the well casing **204** and prevent movement of the control body **54** slip assemblies **110**A, **110**B relative to the mandrel **12** to perform the operations described herein. The shorter run slot **68** prevents the mandrel **12** from further downward movement through the control body **54** as the tool assembly **10** is lowered through the casing **204**. Because of the position of the run slot **68** at or near the center of the control body **54** and its shorter length, the upper cone **158**A carried by the mandrel **12** is prevented from being lowered further and engaging the upper slip assembly **110**A so the individual slips **132**, which are inwardly biased by the slip springs **150**, are each retracted away from the interior walls of the well casing **204** in a retracted condition. This facilitates maintaining the tool assembly **10** in a released condition where neither of the slip assemblies **110**A, **110**B are in engagement or in contact with the well casing **204**.

When the tubing string **200** and tool assembly **10** are run into and positioned in the well casing **204** at the depth where it is to be set and it is desired to anchor the tubing string, slight upward tension is placed on the tubing string **200**. This acts on the mandrel **12** and causes the control pin **38** to ride upward in the run slot **68** to its upper end **70**. Once at this position, the tubing string **200** is rotated to the right or clockwise (as viewed from above) and the upward tension on the tubing string **200** is released. This causes the tubing string **200** and mandrel **12** to drop, with the control pin **38** traveling through the upper and lower passage slots **80**, **82** and transition slot **84** and downward to the left into set slot **74**. In the embodiment shown, very little rotation of the tubing string **200** is required to position the control pin **38** in the set slot **74** as the circumferential distance from the run slot **68** to the transition slot **84** is only about 350 and the total amount of rotation encountered as the control pin **38** passes from the furthermost transition slot **84** to the set slot **74** is only about 65°, or substantially less than a quarter (90°) turn.

Once the control pin **38** is in the set slot **74**, the control pin **38** and mandrel **12** will drop further into the lower portion of the longer set slot **74** to a longitudinal position that is below the run slot **68**, as shown at **206**. The upper cone **158**A carried by the mandrel **12** will also drop so that the tapered portion **160** of the upper cone **158**A contacts and slides along the tapered inner face **140** of the slips **132** of upper slip assembly **110**A. This forces the slips **132** of upper slip assembly **110**A radially outward so that the outer faces **138** of the slips **132** are forced towards the interior wall of the well casing **204**, as shown in FIG. **17**, so that the teeth **156** of the outer face **138** will bite or grip into the wall of the casing **204**. Sufficient force is exerted against the slips **132** of the upper slip assembly **110**A so that the tool assembly **10** and tubing string **200** are held in a stationary, caught position and the tubing string **200** and tool assembly **10** are prevented from further downward movement. The teeth **156** of the outer face **138** bite or grip into the wall of the casing **204** with sufficient force to facilitate holding the tool assembly **10** and tubing string **200** in this position. It should be noted that when the slips **132** of upper slip assembly **110**A engage and contact the well casing **204**, further downward movement of the control pin **38** from the lower position **206** within the set slot **74** is prevented. Thus, the control pin **38** does not contact the lower end **78** of the set slot **74**. This ensures that no force is exerted on the control pin **38** while it is in the set slot **74** at the lower position **206** when the tool assembly **10** is in this caught condition.

By lifting the tubing string **200** and placing the tubing string **200** in upward tension, the mandrel **12** is lifted so that the upper cone **158**A is lifted and disengaged from the upper slip assembly **110**A. This causes the slips **132** of the upper slip assembly **110**A to return to the inward retracted position and away from the wall of the well casing **204** so that the tool assembly **10** is in a released condition.

Continued upward movement of the tubing string **200** and mandrel **12** will move the control pin **38** upward within the set slot **74** to an upper position, as shown at **208**, which is located above the upper end **70** of the run slot **68**. This movement lifts the lower cone **158**B upward and into engagement with the lower slip assembly **110**B. As the lower cone **158**B engages the lower slip assembly **110**B, the tapered portion **160** of the lower cone **158**B contacts and slides along the tapered end inner face **140** of the slips **132** of lower slip assembly **110**B. This forces the slips **132** of lower slip assembly **110**B radially outward so that the outer faces **138** of the slips **132** with the teeth **156** are forced into contact with the interior wall of the well casing **204**, as shown in FIG. **18**. While upward tension of the tubing string is maintained, sufficient force is exerted against the slips **132** of the lower slip assembly **110**B so that the tool assembly **10** and tubing string **200** are held in a stationary, anchored condition and the tubing string **200** and tool assembly **10** are prevented from further upward movement. The teeth **156** of the outer face **138** will also bite or grip into the wall of the casing **204** to facilitate holding the tool assembly **10** and tubing string **200** in this anchored condition.

It should be noted, as well, that when the slips **132** of lower slip assembly **110**B engage and contact the well casing **204**, further upward movement of the control pin **38** within the set slot **74** is prevented and the control pin **38** does not contact the upper end **76** of the set slot **74**. Thus, no force is exerted on the control pin **38** while it is in the set slot **74** at the upper position **208** when the tool assembly **10** is in under upward tension or in the anchored condition. When anchored, the tubing string **200** can be used in a normal fashion, such as for pumping well fluids, etc.

If the event that the tubing string **200** happens to part or fail above the tool assembly **10** while the control pin **38** is located in the set slot **74**, the mandrel **12** will drop causing the control pin **38** to drop to the lower position **206**. This causes the upper cone **158**A to engage the upper slip assembly **110**A so that the slips **132** contact and engage the well casing **204**. This prevents the tubing **200** from falling or hitting the bottom of the well, which could otherwise damage the tubing, well casing and/or other well equipment of the well.

To release the anchor assembly **10**, a right-hand (RH) release is used wherein the tubing string **200** is rotated to the right (i.e., clockwise), as viewed from above. This is achieved by releasing upward tension on the tubing string **200** when it is the anchored condition so that the mandrel **12** and control pin **38** drop. This disengages the lower slip assembly **110**B from the lower cone **158**B so that the slips **132** are retracted and disengaged from the well casing **204**. The tubing string is then rotated to the right so that the mandrel **12** is rotated and the control pin **38** enters the lower passage slot **82**. The control pin **38** follows the lower passage slot **82** and upper passage slot **80** to the run slot where the tool assembly **10** is in a neutral condition where neither of the upper and lower slip assemblies **110**A, **110**B are engaged with the well casing **204** and the tubing string **200** and tool assembly **10** can be withdrawn or repositioned.

The shear ring **186** of the tool assembly **10** also prevents the tool assembly **10** from being caught or stuck in an anchored condition. If the tool assembly **10** happens to be stuck in the anchored condition, with the lower cone **158**B remaining engaged with the lower slip assembly **110**B, so that the tubing string **200** cannot be moved or repositioned, the shear ring **186** can be sheared away to release the tool assembly **10**. This is achieved by increasing the upward tension on the tubing string **200** so that the force exerted by the lower cone **158** against the shear ring **184** by this upward tension exceeds the shear strength of the shear screws **192** and causes the shear screws **192** to shear and fail. Once the screws **192** are sheared, the shear ring **184** and lower cone **158**B will drop away from the lower slip assembly **110**B, resting on lower coupling **26**. The slip assembly **110**B will then disengage from the well casing **204** and the tubing string **200** and tool assembly **10** can be withdrawn.

FIG. **19** shows an alternate embodiment of a control body **210** for use with the tool assembly **10**. The various components of the tool assembly **10** for use with the control body **210** in all respects is the same for that used with the control body **54**, with similar components labeled with the same reference numerals. The control body **210** has a control body wall **212**, which is similar to the control body wall **56** of control body **54**. For ease of understanding, the cylindrical control body wall **212** is shown schematically in a flattened condition to better illustrate its configuration and functioning. The control body wall **212** is provided with a single set of interconnected slots **66** configured the same as those of control body **54** for RH set/RH release, as was described previously.

The control body **210** differs from the control body **54** in that it also includes a different single set of interconnected slots **214** that constitutes a lefthand (LH) set/righthand (RH) release set of slots. In this embodiment, the two different sets of slots **66**, **214** may also be circumferentially spaced on opposite sides or approximately 1800 apart on the control body wall **212**. In the embodiment of FIG. **19**, however, only a single control pin **38** is used with the control body **210**, which is selectively positioned in only one of the two sets of interconnected slots **66**, **214** for either RH set/RH release or LH set/RH release, but not both.

For RH set/RH release the control pin **38** is positioned in the set of slots **66**, with no control pin residing in the set of interconnected slots **214**. With the control pin **38** positioned within the interconnected slots **66** the operation is the same as that for the tool assembly **10** employing the RH set/RH release control body **54**, as previously described.

For LH set/RH release, the control pin **38** is positioned in the interconnected set of slots **214**, while no control pin is used in the set of slots **66** for RH set/RH release. The set of slots **214** include a longitudinal run slot **216** and a longitudinal set slot **218**, which may each be similar in size, longitudinal position and configuration to the run slot **68** and set slot **74**, respectively, as previously described for control body **54**.

The run slot **216** of slot set **214** is circumferentially spaced apart on the control body wall **212** from the set slot **218** no further than 90°, 85°, 80°, 75°, 70°, 65°, 60°, 55°, 50°, 45°, 40°, 35°, 30°, 25°, 20°, 15°, 10° or less, as measured from the center line of each slot. In certain embodiments run slot **216** and set slot **218** of the set of interconnected slots **214** are circumferentially spaced apart from one another on the control body wall **212** from at least, equal to, and/or between any two of 10°, 11°, 12°, 13°, 14°, 15°, 16°, 17°, 18°, 19°, 20°, 21°, 22°, 23°, 24°, 25°, 26°, 27°, 28°, 29°, 30°, 31°, 32°, 33°, 34°, 35°, 36°, 37°, 38°, 39°, 40°, 41°, 42°, 43°, 44°, 45°, 46°, 47°, 48°, 49°, 50°, 51°, 52°, 53°, 54°, 55°, 56°, 57°, 58°, 59°, 60°, 61°, 62°, 63°, 64°, 65°, 66°, 67°, 68°, 69°, 70°, 71°, 72°, 73°, 74°, 75°, 76°, 77°, 78°, 79°, 80°, 81°, 82°, 83°, 84°, 85°, 86°, 87°, 88°, 89°, and 90°, as measured from the center line of each slot **216**, **218**. In the embodiment shown, the run slot **216** is circumferentially spaced from the set slot **218** approximately 75°.

As viewed in FIG. **19**, a single passage slot **220** opens into and extends from the right side of run slot **216**. The passage slot **220** is sloped or angled downward from the run slot **216** towards the right towards the set slot **218**. The lower end of the lower passage slot **220** opens into the left side of the set slot **218** at a longitudinal position below the lower end **222** of the run slot **216**, as is shown. The passage slot **220** may be oriented downward to the right from the run slot **216** at an angle of from 30° to 60°, more particularly from 40° to 50°, relative to the longitudinal axis **58** of the control body **210**. In particular embodiments, the passage slot **220** may be oriented at an angle of from at least, equal to, and/or between any two of 30°, 31°, 32°, 33°, 34°, 35°, 36°, 37°, 38°, 39°, 40°, 41°, 42°, 43°, 44°, 45°, 46°, 47°, 48°, 49°, 50°, 51°, 52°, 53°, 54°, 55°, 56°, 57°, 58°, 59°, and 70°, relative to the longitudinal axis **58** of the control body **210**.

The longitudinal position of the lower end of the passage slot **220** where it opens into and meets the set slot **218** should be at a location on the set slot **218** where the control pin **38** and mandrel **12** are still at a position where the tool assembly **10** is maintained in a released condition or at a position where tool assembly **10** just enters into the set condition.

In use of the tool assembly **10** employing the control body **210** of FIG. **19**, when the control pin **38** is selectively positioned within the interconnected slots **66** for RH set/RH release, the operation is the same as that previously described for the control body **54**.

If the control pin **38** is positioned within the interconnected slots **214** for LH set/RH release the operation is as follows. As the tool assembly **10** is run into the well casing, the control pin **38** will abut and push against the bottom end **222** of the shortened run slot **216**, as shown in FIG. **19**. In this position, the tool assembly **10** is in a neutral condition where the slip assemblies **110**A, **110**B are out of engagement with the well casing **204**.

With the control pin **38** abutting the bottom end **222** of the run slot **216**, when the tubing string and tool assembly **10** employing control body **210** are run into and positioned in the well casing **204** at the depth where it is to be set and it is desired to anchor the tubing string, slight upward tension is placed on the tubing string **200**. This acts on the mandrel **12** and causes the control pin **38** to ride upward in the run slot **216** to its upper end **224**. Once at this position, the tubing string **200** is rotated to the left or counterclockwise (as viewed from above) and the upward tension on the tubing string **200** is released. This causes the tubing string **200** and mandrel **12** to drop, with the control pin **38** traveling through the passage slot **220** and into set slot **218**. In the embodiment shown, the total amount of rotation by the tubing string **200** and mandrel **12** as the control pin **38** passes from the run slot **216** to the set slot **218** and vice versa is 75°, or less than a quarter (i.e., 90°) turn.

Once the control pin **38** is in the set slot **218**, the control pin **38** and mandrel **12** will drop further into the lower portion of the longer set slot **218** to a longitudinal position **226** that is below the lower end **222** of the run slot **216**. This causes the upper cone **158**A to drop and engage the slip assembly **110**A, causing the upper slip assembly **110**A to engage the well casing **204** so that the tool assembly **10** is maintained in a stationary, caught condition. The teeth **156** of the outer face **138** will bite or grip into the wall of the casing **204** to facilitate holding the tool assembly **10** and tubing string **200** in this position. It should be noted that when the slips **132** of upper slip assembly **110**A engage and contact the well casing **204**, further downward movement of the control pin **38** from the lower position **226** within the set slot **218** is prevented. Thus, no force is exerted on the control pin **38** while it is in the set slot **218** at the lower position **226** when the tool assembly **10** is in this caught condition.

By lifting the tubing string and placing the tubing string in upward tension, the mandrel **12** of the tool assembly **10** employing the control body **212** is lifted so that upper cone **158**A is lifted out of engagement with the slip assembly **110**A and the slip assembly **110**A is disengaged from the well casing **204**.

Continued upward movement of the tubing string **200** and mandrel **12** will move the control pin **38** upward within the set slot **218** to an upper position **228**, which is located above the upper end **224** of the run slot **68**. This movement lifts the lower cone **158**B upward and into engagement with the lower slip assembly **110**B so that the lower slip assembly **110**B engages the walls of the well casing **204**. While upward tension of the tubing string is maintained, the lower slip assembly **110**B is held in engagement with the well casing **204** to facilitate holding the tool assembly **10** employing the control body **210** and tubing string **200** in an anchored condition to prevent further upward movement.

To release the tool assembly **10** employing the control body **210**, with the control pin **38** in the set slot **218**, a right-hand (RH) release is used wherein the tubing string **200** is rotated to the right (i.e., clockwise), as viewed from above. This is achieved by releasing upward tension on the tubing string **200** so that the mandrel **12** and the control pin **38** drops to a lower position within the set slot **218**. This disengages the lower cone **158**B from the lower slip assembly **110**B so that the slips **132** are retracted and the lower slip assembly **110**B is disengaged from the well casing **204**. The tubing string **200** is then rotated to the right so that the mandrel **12** is rotated and the control pin **38** enters the passage slot **220**. The control pin **38** follows the passage slot **220** to the run slot **216** where the tool assembly **10** is in a neutral condition where neither of the upper and lower slip assemblies **110**A, **110**B are engaged with the well casing **204** and the tubing string **200** and tool assembly **10** can be withdrawn or repositioned.

The control body **210** employing the two different slot configurations **66**, **214** allows the operator to select whether they want to use the tool assembly **10** in an RH set/RH release operation or a LH set/RH release operation. Operators may select this LH set/RH release option as it is the typical operation for conventional anchor tools and may be more familiar to well operators when setting and releasing conventional anchor/catcher assemblies.

FIG. **20** shows a further embodiment of a control body **230** having a control body wall **232** that may be employed with the tool assembly **10**. The various components of the tool assembly **10** for use with the control body **230** in all respects is the same for that used with the control body **54**, with similar components labeled with the same reference numerals. For ease of understanding, the cylindrical control body wall **232** is shown schematically in a flattened condition to better illustrate its configuration and functioning.

The control body **230** is similar to the control bodies **54**, **210**, previously described. The control body wall **232** differs, however, in that it employs two sets of interconnected slots **234** configured so that tool assembly **10** can be either RH set/RH release, LH set/LH release, RH set/LH release, or LH set/RH release. The two sets of interconnected slots **234** are configured the same and are circumferentially spaced 1800 apart on the control body wall **232**. A control pin **38** may be simultaneously used in each set of slots **234**.

Each set of slots **234** includes a single, longitudinal set slot **236** that is similar in size, longitudinal position on the control body **230** and configuration to the set slots **74**, **218** of control bodies **54**, **210**, as previously described.

As viewed in FIG. **20**, circumferentially spaced apart from the set slot **236** of each slot set **234** to the left is a LH set/RH release run slot **238**. Circumferentially spaced apart from the set slot **236** to the right on the opposite side is a RH set/LH release run slot **240**, with the set slot **236** being equally spaced between each of the run slots **238**, **240**. Each run slot **238**, **240** is a longitudinal slot that is similar in size, longitudinal position on the control body **230** and configuration to the run slots **68**, **216**, as previously described.

Each run slot **238**, **240** is circumferentially spaced apart on the control body wall **232** from the set slot **236** no further than 90°, 85°, 80°, 75°, 70°, 65°, 60°, 55°, 50°, 45°, 40°, 35°, 30°, 25°, 20°, 15°, 100 or less, as measured from a center line of each slot. In certain embodiments, each of the run slots **238**, **240** of the set of interconnected slots **234** is circumferentially spaced apart from the set slot **236** on the control body wall **232** from at least, equal to, and/or between any two of 10°, 11°, 12°, 13°, 14°, 15°, 16°, 17°, 18°, 19°, 20°, 21°, 22°, 23°, 24°, 25°, 26°, 27°, 28°, 29°, 30°, 31°, 32°, 33°, 34°, 35°, 36°, 37°, 38°, 39°, 40°, 41°, 42°, 43°, 44°, 45°, 46°, 47°, 48°, 49°, 50°, 51°, 52°, 53°, 54°, 55°, 56°, 57°, 58°, 59°, 60°, 61°, 62°, 63°, 64°, 65°, 66°, 67°, 68°, 69°, 70°, 71°, 72°, 73°, 74°, 75°, 76°, 77°, 78°, 79°, 80°, 81°, 82°, 83°, 84°, 85°, 86°, 87°, 88°, 89°, and 90°, as measured from the center line of each run slot **238**, **240** and set slot **236**. In the embodiment shown in FIG. **20**, each of the run slots **238**, **240** is circumferentially spaced from the set slot **236** approximately 75°.

The LH set/RH release run slot **238** in combination with the set slot **236** is configured similarly to the slot set **214** of the control body **210** of FIG. **19**. Like the set slot **214** of FIG. **19**, a single passage slot **242** opens into and extends from the right side of run slot **238**. The passage slot **242** is angled downward from the run slot **238** towards the right towards the set slot **236**. The lower end of the passage slot **242** opens into the left side of the set slot **236** at a longitudinal position below the lower end of the run slot **238**, as is shown. The passage slot **242** may be oriented downward to the right from the run slot **238** at an angle of from 30° to 60°, more particularly from 40° to 50°, relative to the longitudinal axis **58** of the control body **230**. In particular embodiments, the passage slot **242** may be oriented at an angle of from at least, equal to, and/or between any two of 30°, 31°, 32°, 33°, 34°, 35°, 36°, 37°, 38°, 39°, 40° 41°, 42°, 43°, 44°, 45° 46°, 47°, 48°, 49° 50°, 51°, 52°, 53°, 54°, 55°, 56°, 57°, 58°, 59°, and 70°, relative to the longitudinal axis **58** of the control body **230**.

In a similar manner the RH set/LH release run slot **240** has a single passage slot **244** that opens into and extends from the left side of run slot **240**. The passage slot **244** is angled downward from the run slot **240** towards the left towards the set slot **236**. The lower end of the passage slot **244** opens into the right side of the set slot **236** at a longitudinal position below the lower end of the run slot **240**, as is shown. The passage slot **244** may be oriented downward to the left of the run slot **240** at an angle of from 30° to 60°, more particularly from 40° to 50°, relative to the longitudinal axis **58** of the control body **230**. In particular embodiments, the passage slot **244** may be oriented at an angle of from at least, equal to, and/or between any two of 30°, 31°, 32°, 33°, 34°, 35°, 36°, 37°, 38°, 39°, 40°, 41°, 42°, 43°, 44°, 45°, 46°, 47°, 48°, 49°, 50°, 51°, 52°, 53°, 54°, 55°, 56°, 57°, 58°, 59°, and 70°, relative to the longitudinal axis **58** of the control body **230**.

In use, when the control pin **38** is initially in the LH set/RH release run slot **238**, the operation of the tool assembly **10** employing the control body **230** is generally the same for a LH set/RH release operation as that described for the control body **210** of FIG. **19**, when the control pin **38** is located in the set of interconnected slots **214** for LH set/RH release. In FIG. **20**, with control pin **38** in the set slot **236** of control body **230**, however, a LH release operation may be performed to release the tool assembly **10** to a released condition. Thus, after tension is released from the tubing string **200** while the control pin **38** is in the set slot **236**, an operator can rotate the tubing string **200** to the left or counterclockwise, as viewed from above. This causes the control pin **38** to travel through passage slot **244** to the RH set/LH release run slot **240**, where the tool assembly **10** is held in a neutral or released condition.

In operations when the control pin **38** is initially in the RH set/LH release run slot **240**, as the tool assembly **10** is run into the well casing, the control pin **38** will abut and push against the bottom end **246** of the shorter RH set/LH release run slot **240**, as shown in FIG. **20**. In this position, the tool assembly **10** is in a neutral condition where the slip assemblies **110**A, **110**B are out of engagement with the well casing **204**.

With the control pin **38** at the bottom end **246** of run slot **240**, when the tubing string and tool assembly **10** employing control body **230** are run into and positioned in the well casing **204** at the depth where it is to be set and it is desired to anchor the tubing string, slight upward tension is placed on the tubing string **200**. This acts on the mandrel **12** and causes the control pin **38** to ride upward in the run slot **240** to its upper end **248**. Once at this position, the tubing string **200** is rotated to the right or clockwise (as viewed from above) and the upward tension on the tubing string **200** is released. This causes the tubing string **200** and mandrel **12** to drop, with the control pin **38** traveling through the passage slot **244** and into set slot **236** where the control pin **38** drops to a lower position **250** within set slot **236** below the run slots **238**, **240** where the tool assembly **10** is moved to and maintained in a stationary, caught condition.

Once the control pin **38** is in the set slot **236**, the tubing string **200** can be lifted so that the control pin **38** is moved to an upper position **252**, which is located above the run slots **238**, **240**. This movement causes the tubing string **200** and anchor tool **10** to be moved to and maintained in stationary, anchored condition.

To release the tool assembly **10** employing the control body **230** with the control pin **38** in the set slot **236**, a right-hand (RH) or left-hand (LH) release may be used wherein the tubing string **200** is rotated to the right (i.e., clockwise) or left (counterclockwise), as viewed from above. This is achieved by releasing upward tension on the tubing string **200** so that the mandrel **12** and the control pin **38** drops to a lower position within the set slot **236**. This disengages the tool assembly **10** so that it is in a neutral or released condition. If the tubing string **200** is rotated to the right (clockwise), the control pin **38** will travel from set slot **236** through passage slot **242** and into run slot **238** where tool assembly **10** is maintained in the neutral or released condition to withdraw or reposition the tubing string and tool assembly **10**.

Alternatively, if the tubing string is rotated to the left or counterclockwise, the control pin **38** will travel from set slot **236** through passage slot **244** and into run slot **240** where tool assembly **10** is also maintained in the neutral or released condition to withdraw or reposition the tubing string **200** and tool assembly **10**.

Thus, in the embodiment of the tool assembly **10** employing the control body **230**, the interconnected slots allow for

RH set/RH release, LH set/LH release, RH set/LH release, or LH set/RH release. In the embodiment shown, the total amount of rotation of the tubing string **200** and mandrel **12** encounter to move the control pin **38** from one of the run slots **238**, **240** to the set slot **236** or vice versa is 750 or less than a quarter (90°) turn.

The various embodiments of the tool assembly described herein have several advantages over those anchoring systems used in the prior art. Unlike conventional anchoring systems that require multiple turns of the tubing string to set and release the anchoring system, the present tool assembly requires very little rotation of the tubing string. Indeed, in all cases, the tubing string will undergo less than 90° or less than a quarter turn of rotation to go from the released to set conditions and vice versa. When going from the released to set condition, the amount of rotation required at the surface is very little, as the tubing string and mandrel will rotate on their own as they drop and the control pin is guided and travels downward from the run slot to the set slot through the interconnected slots.

The tool assembly can be readily used with well casings of different sizes without modification of the tool assembly. Well casings may come in different sizes, such as 14 lbs/ft, 15.5 lbs/ft, 17 lbs/ft, 20 lbs/ft, 23 lbs/ft and 26 lbs/ft. The greater the weight, the thicker the wall of the well casing and the smaller the interior diameter. Thus, with well casings with thicker walls (i.e., smaller inner diameters), the control pin **38** will slide a shorter distance within the set slot of the control bodies when the slip assemblies **110**A, **110**B fully engage the casing wall. With thinner wall casings (i.e., casings with larger inner diameters), the control pin **38** will locate closer to the ends of the set slot, while still avoiding contact with the ends of the slot. The cones, slip assemblies and set slots of the control bodies of the tool assembly **10** can be configured to facilitate engaging the different size well casings and the length of the set slots can be selected to prevent contact of the control pin **38** with the upper and lower ends of the set slot even when used for different size well casings.

The tool assembly also provides increased fluid flow through both the tubing string and in the annular space between the tool assembly and the interior of the well casing. Conventional tubing anchors, such as those that require multiple turns to set and release the anchoring system typically have an outer diameter of 4.50 inches with no fluid flow bypass passages. In other tubing anchor systems that reduce the outer diameter of the anchoring system, this is typically achieved by reducing the inner diameters of the interior flow passage of the tubing anchors so that the inner diameter of the anchoring system is less than the inner diameter of the tubing string, thus causing a constriction at the anchor tool that limits the flow through the tubing string. Tubing strings typically have an inner diameter of 2.30 inches. In one such system that has reduced exterior dimensions of the anchoring system that is less than 4.50 inches, the decreased outer diameter is provided by decreasing the inner diameter of the anchoring system to approximately 1.9 inches, which is much less than the inner diameter of the tubing itself.

The various embodiments of the tool assembly described herein do not decrease the flow through either the annular space between the tubing string and well casing or through the tubing string itself. This is because the exterior of the tool itself can have a reduced outer diameter without requiring the inner diameter of the interior flow passage to be reduced. In particular embodiments, the outer diameter of the tool assembly can be reduced with a maximum outer diameter of 4.40 inches and the inner diameter central passage **18** of the mandrel **12** of the tubing anchor assembly can be the same or closely match that of the tubing itself, e.g., 2.30 inches. Thus, no decrease in the flow through the tubing string results from the use of the tool assembly.

Additionally, longitudinal interior passages **120** formed as recesses on the interior wall of the slip housing **112** and cutout areas **122** on the exterior of the slip housing **112**, as well as grooves or channels **168** and cutouts or flats **176** on the exterior of the cones **158** also facilitate increased fluid flow around the exterior of the tool assembly **10**. These features also may produce turbulent fluid flow around the exterior and surfaces of the tool assembly so that minerals and other particles are prevented from being deposited on the surfaces of the tool.

Additionally, in many anchoring systems, the tool itself is configured to latch or lock when it is in a caught or anchored condition. This can present a problem if the latching or locking mechanism becomes stuck so that it is difficult to free. In the embodiments of the present tool assembly, there is no latching or locking when the tool assembly is in the caught or anchored condition. Thus, there is no risk of such latching or locking becoming stuck.

While the invention has been shown in some of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to various changes and modifications without departing from the scope of the invention. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

I claim:

1. A tool assembly for anchoring and/or catching well equipment within a well casing, the tool assembly comprising:

an elongated mandrel having a central longitudinal axis and being configured to couple at one end to the well equipment, the mandrel having a cylindrical mandrel wall having at least one non-circumferential raised or projecting area that projects from the mandrel wall;

a control pin stationarily coupled to and projecting radially outward from the exterior of the mandrel;

a control body comprising a control body wall with a central opening that is mounted over the mandrel, the mandrel being movable within the central opening to allow longitudinal and rotational movement of the mandrel relative to the control body, the control body having at least one drag body configured to engage the well casing to provide a degree of resistance to movement of the control body relative to the well casing and/or mandrel;

wherein the mandrel wall is spaced radially inward from the interior of the control body wall along the length of the control body to define an annular space that creates a flow passage adjacent to the at least one raised or projecting area, the at least one raised or projecting area configured to facilitate centering the control body on the mandrel;

at least one cone having a tapered exterior surface that tapers radially inwardly along the length of the cone to a narrow end, the at least one cone being coupled to the mandrel with the narrower end of the cone facing the control body;

a slip assembly associated with the at least one cone comprising a slip housing coupled to one end of the control body that faces the at least one cone and at least one slip body that is carried by the slip housing, the at least one slip body being configured to contact and slide along the tapered exterior surface of the cone so that the at least one slip body is forced radially outward by the cone to facilitate engagement of the slip body with the well casing during anchoring and/or catching of the tool assembly within the well casing when the tool assembly is changed to a set condition, and wherein the slip body is moved away from the at least one cone and retracts radially inward so that the at least one slip body is disengaged from the well casing when the tool assembly is changed to a released condition; and

a set of interconnected slots formed in the control body wall of the control body that are configured to receive the control pin, with the control pin traveling within the set of interconnected slots, the interconnected slots comprising a run slot at a first circumferential position of the control body wall, the run slot having a longitudinal length that limits the distance the control pin and mandrel travel longitudinally relative to the control body so that the tool assembly is maintained in the released condition while the control pin resides within the run slot, the interconnected slots further comprising a set slot that is spaced circumferentially apart from the run slot on the control body wall, the run slot and set slot being joined together by a slot passage that allows the control pin to move between the run slot and the set slot when the mandrel is rotated about the central longitudinal axis, and wherein the set slot has a longitudinal length that allows the control pin and mandrel to travel longitudinally relative to the control body to allow the tool assembly to be moved to the set condition.

2. The tool assembly of claim **1**, wherein:

there are two spaced apart cones comprising a catcher cone coupled to the mandrel at an upper position and an anchor cone coupled to the mandrel at a lower position, with the control body being positioned on the mandrel between the catcher and anchor cones, the narrow end of each cone facing the control body; and wherein

there are two slip assemblies comprising an upper slip assembly and a lower slip assembly, each slip assembly coupled to opposite ends of the control body, the upper slip assembly being associated with the catcher cone and the lower slip assembly being associated with the anchor cone, wherein the at least one slip body of the upper slip assembly is forced radially outward by the catcher cone to facilitate engagement of the at least one slip body with the well casing when the control pin is positioned in the set slot and the mandrel is moved downward in the well casing and so that the tool assembly is set in a caught set condition; and wherein

the at least one slip body of the lower slip assembly is forced radially outward by the anchor cone to facilitate engagement of the at least one slip body with the well casing when the control pin is positioned in the set slot and the mandrel is moved upward in the well casing so that the tool assembly is set in an anchored set condition.

3. The tool assembly of claim **2**, wherein:

the anchor cone is slidingly coupled to the mandrel through a shear ring assembly against which the anchor cone abuts, the shear ring assembly comprising a shear ring having multiple apertures for receiving shear fasteners and one or more shear fasteners of selected shear ratings, the shear ring being fastened to the mandrel through the one or more shear fasteners, the shear ring assembly being configured to provide a selected degree of shear resistance before shearing by increasing or decreasing the number of shear fasteners, and wherein shearing of the shear ring assembly occurs when the shear resistance of the shear ring assembly is exceeded by sufficient upward force being applied to the mandrel and causing the anchor cone to drop away from the control body.

4. The tool assembly of claim **1**, wherein:

the run slot and the set slot are circumferentially spaced apart on the control body wall from 90 degrees or less.

5. The tool assembly of claim **1**, wherein:

the run slot and the set slot are circumferentially spaced apart on the control body wall from 75 degrees or less.

6. The tool assembly of claim **1**, wherein:

the set of interconnected slots are configured to cause the control pin to travel from the run slot to the set slot by rotating the mandrel in a first rotational direction, and wherein the interconnected slots are configured to cause the control pin to travel from the set slot to the run slot by further rotation of the mandrel in the first rotational direction.

7. The tool assembly of claim **1**, wherein:

the set of interconnected slots are configured to cause the control pin to travel from the run slot to the set slot by rotating the mandrel in a first rotational direction, and wherein the interconnected slots are configured to cause the control pin to travel from the set slot to the run slot by rotation of the mandrel in an opposite second rotational direction.

8. The tool assembly of claim **1**, wherein:

the set of interconnected slots are configured to cause the control pin to travel from the run slot to the set slot and vice versa by rotating the mandrel in any rotational direction.

9. The tool assembly of claim **1**, wherein:

there are two sets of interconnected slots on opposite sides of the control body.

10. The tool assembly of claim **9**, wherein:

one of the two sets of interconnected slots are configured to cause the control pin to travel from the run slot to the set slot by rotating the mandrel in a first rotational direction, and wherein the interconnected slots of said one of the two sets of interconnected slots are configured to cause the control pin to travel from the set slot to the run slot by continued rotation of the mandrel in the first rotational direction; and

the other of the two sets of interconnected slots is configured to cause the control pin to travel from the run slot to the set slot by rotating the mandrel in a first rotational direction, and wherein the interconnected slots of said other of the two sets of interconnected slots are configured to cause the control pin to travel from the set slot to the run slot by rotation of the mandrel in an opposite second rotational direction.

11. The tool assembly of claim **1**, wherein:

the slip housing of the slip assembly has an interior that is provided with interior fluid bypass passages configured to facilitate increased fluid flow through an interior of the slip housing.

12. The tool assembly of claim **1**, wherein:

the slip housing of the slip assembly has an exterior that is provided with cutouts configured to increase fluid flow through the well casing around the exterior of the slip housing.

13. The tool assembly of claim **1**, wherein:

the at least one cone has one or more grooves formed in an exterior of the cone configured to increase fluid flow through the well casing around the at least one cone.

14. The tool assembly of claim **13**, wherein:

at least one of the one or more grooves is set at an angle of from greater than 0° and less than 90° relative to the longitudinal axis of the mandrel.

15. The tool assembly of claim **1**, wherein:

the well equipment is a tubing string having a cylindrical, central flow passage with an inner diameter; and wherein

the mandrel has a cylindrical, central flow passage having an inner diameter that is not less than the inner diameter of the tubing string.

16. A tool assembly for anchoring and/or catching a tubing string within a well casing, the tool assembly comprising:

an elongated mandrel having a central longitudinal axis and being configured to couple at an upper end to the tubing string, the mandrel having a cylindrical mandrel wall having at least one non-circumferential raised or projecting area that projects from the mandrel wall;

a control pin stationarily coupled to and projecting radially outward from the exterior of the mandrel;

a control body comprising a control body wall with a central opening that is mounted over the mandrel, the mandrel being movable within the central opening to allow longitudinal and rotational movement of the mandrel relative to the control body, the control body have at least one drag body configured to engage the well casing to provide a degree of resistance to movement of the control body relative to the well casing and/or mandrel;

wherein the mandrel wall is spaced radially inward from the interior of the control body wall along the length of the control body to define an annular space that creates a flow passage adjacent to the at least one raised or projecting area, the at least one raised or projecting area configured to facilitate centering the control body on the mandrel;

a pair of spaced apart cones comprising a catcher cone coupled to the mandrel at an upper position and an anchor cone coupled to the mandrel at an opposite lower position, with the control body being positioned on the mandrel between the catcher and anchor cones, each cone having a tapered exterior surface that tapers radially inwardly along the length of the cone to a narrow end, with the narrower end of each cone facing the control body, each cone having one or more grooves formed in an exterior of the cone configured to increase fluid flow through the well casing around the at least one cone;

a pair of slip assemblies comprising an upper slip assembly and a lower slip assembly, each slip assembly coupled to opposite ends of the control body, the upper slip assembly being associated with the catcher cone and the lower slip assembly being associated with the anchor cone, each slip assembly comprising a slip housing coupled to one end of the control body and two or more circumferentially spaced apart slip bodies that are carried by the slip housing, the slip bodies being configured to contact and slide along the tapered exterior surface of one of the cones so that the slip bodies are forced radially outward by the cone to facilitate engagement of the slip bodies with the well casing during anchoring and/or catching of the tool assembly within the well casing when the tool assembly is changed to a set condition, and wherein the slip bodies are moved away from the cone and retract radially inward so that the slip bodies are disengaged from the well casing when the tool assembly is changed to a released condition;

wherein the slip housing of each slip assembly further comprises at least one of: 1) an interior with fluid bypass passages configured to facilitate increased fluid flow through an interior of the slip housing; and 2) an exterior with cutouts configured to increase fluid flow through the well casing around the exterior of the slip housing;

a set of interconnected slots formed in the control body wall of the control body that are configured to receive the control pin, with the control pin traveling within the set of interconnected slots, the interconnected slots comprising a run slot at a first circumferential position of the control body wall, the run slot having a longitudinal length that limits the distance the control pin and mandrel travel longitudinally relative the control body so that the tool assembly is maintained in the released condition while the control pin resides within the run slot, the interconnected slots further comprising a set slot that is spaced circumferentially apart from the run slot on the control body wall from 90° or less, the run slot and set slot being joined together by a slot passage that allows the control pin to move between the run slot and the set slot when the mandrel is rotated about the central longitudinal axis, and wherein the set slot has a longitudinal length that allows the control pin and mandrel to travel longitudinally relative the control body to allow the tool assembly to be moved to the set condition; and wherein

the slip bodies of the upper slip assembly are forced radially outward by the catcher cone to facilitate engagement of the slip bodies of the upper slip assembly with the well casing when the control pin is positioned in the set slot and the mandrel is moved downward in the well casing and so that the tool assembly is set in a caught set condition; and wherein

the slip bodies of the lower slip assembly are forced radially outward by the anchor cone to facilitate engagement of the slip bodies with the well casing when the control pin is positioned in the set slot and the mandrel is moved upward in the well casing so that the tool assembly is set in an anchored set condition.

17. The tool assembly of claim **16**, wherein:

the set of interconnected slots are configured to cause the control pin to travel from the run slot to the set slot by rotating the mandrel in a first rotational direction, and wherein the interconnected slots are configured to cause the control pin to travel from the set slot to the run slot by further rotation of the mandrel in the first rotational direction.

18. The tool assembly of claim **16**, wherein:

the set of interconnected slots are configured to cause the control pin to travel from the run slot to the set slot by rotating the mandrel in a first rotational direction, and wherein the interconnected slots are configured to cause the control pin to travel from the set slot to the run slot by rotation of the mandrel in an opposite second rotational direction.

19. The tool assembly of claim **16**, wherein:

the set of interconnected slots are configured to cause the control pin to travel from the run slot to the set slot and vice versa by rotating the mandrel in any rotational direction.

20. The tool assembly of claim **16**, wherein:

there are two sets of interconnected slots on opposite sides of the control body; and

one of the two sets of interconnected slots are configured to cause the control pin to travel from the run slot to the set slot by rotating the mandrel in a first rotational direction, and wherein the interconnected slots of said one of the two sets of interconnected slots are configured to cause the control pin to travel from the set slot to the run slot by continued rotation of the mandrel in the first rotational direction; and

the other of the two sets of interconnected slots is configured to cause the control pin to travel from the run slot to the set slot by rotating the mandrel in a first rotational direction, and wherein the interconnected slots of said other of the two sets of interconnected slots are configured to cause the control pin to travel from the set slot to the run slot by rotation of the mandrel in an opposite second rotational direction.

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