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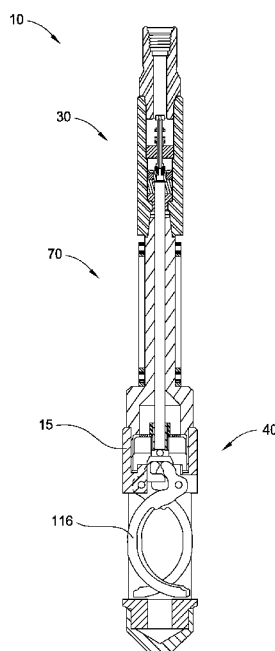


FIG. 2A

(57) Abstract: A tool for cutting a tubular includes a housing, a first blade having a first cutting surface, and a second blade having a second cutting surface. The first blade and the second blade are configured to move between an extended position and a retracted position. The first blade and the second blade are disposed in the housing in the retracted position. The first cutting surface and the second cutting surface overlap in the retracted position.



APPARATUS AND METHOD FOR CUTTING CASINGS

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present disclosure generally relates to apparatus and method for cutting casing in a wellbore.

Description of the Related Art

[0002] A wellbore is formed to access hydrocarbon bearing formations, for example crude oil and/or natural gas, by the use of drilling. Drilling is accomplished by utilizing a drill bit that is mounted on the end of a tubular string, such as a drill string. To drill within the wellbore to a predetermined depth, the drill string is often rotated by a top drive or rotary table on a surface platform or rig, and/or by a downhole motor mounted towards the lower end of the drill string. After drilling to a predetermined depth, the drill string and drill bit are removed and a section of casing is lowered into the wellbore. An annulus is thus formed between the string of casing and the formation. The casing string is temporarily hung from the surface of the well. The casing string is cemented into the wellbore by circulating cement into the annulus defined between the outer wall of the casing and the borehole. The combination of cement and casing strengthens the wellbore and facilitates the isolation of certain areas of the formation behind the casing for the production of hydrocarbons.

[0003] It is common to employ more than one string of casing in a wellbore. In this respect, the well is drilled to a first designated depth with the drill string. The drill string is removed. A first string of casing is then run into the wellbore and set in the drilled-out portion of the wellbore, and cement is circulated into the annulus behind the casing string. Next, the well is drilled to a second designated depth, and a second string of casing or liner, is run into the drilled-out portion of the wellbore. If the second string is a liner string, the liner is set at a depth such that the upper portion of the second string of casing overlaps the lower portion of the first string of casing. The liner string may then be fixed, or “hung” off of the existing casing by the use of slips which utilize slip members and cones to frictionally affix

the new string of liner in the wellbore. If the second string is a casing string, the casing string may be hung off of a wellhead. This process is typically repeated with additional casing/liner strings until the well has been drilled to total depth. In this manner, wells are typically formed with two or more strings of casing/liner of an ever-decreasing diameter.

[0004] From time to time, for example once the hydrocarbon-bearing formations have been depleted, the wellbore must be plugged and abandoned (P&A) using cement plugs. This P&A procedure seals the wellbore from the environment, thereby preventing wellbore fluid, such as hydrocarbons and/or salt water, from polluting the surface environment. This procedure also seals sensitive formations, such as aquifers, traversed by the wellbore from contamination by the hydrocarbon-bearing formations. Setting of a cement plug when there are two adjacent casing strings lining the wellbore is presently done by cutting a window in each of the adjacent casing strings and squeezing cement into the windows to provide a satisfactory seal.

[0005] After the wellbore has been plugged, the sub-sea wellhead may be retrieved. A tool is lowered down and secured to the wellhead. A casing cutter of the tool is used to make a cut through the casing strings attached to the wellhead. The wellhead and the portion of the casing strings attached to the wellhead above the cut are then retrieved to the surface with the tool.

[0006] A casing cutter is used to make a cut above the placement of the cement plug and separate the casing into a first or upper portion and a second or lower portion. Conventional casing cutters have straight blades extending diagonally outwards towards the casing string(s), such as the casing cutter 5 shown in Figure 1. The straight blades are pivotally mounted to the body of the cutting tool and disposed symmetrically about the cutting tool. The blades are actuated and pivot outward, cutting the casing in the process. The straight blades cut on a diagonal cutting surface through the casing string(s) and cement. As the straight blades extend outward to cut outer casing string(s), the straight blade continues to cut previous inner casing string(s), as shown in Figure 1. The straight blades cut out a hemisphere of material around the casing cutter. The large

amount of material required to be cut by using conventional straight blades increases time and cost of abandonment operations and often damages conventional blades, thereby decreasing reliability. In addition, the adjacent casing strings may not be concentric, requiring larger straight blades to ensure the outermost casing string is cut fully. There is a need, therefore, for apparatus and method for cutting casings which reduces the amount of material cut, lowers costs, and lowers time for cutting operations.

SUMMARY OF THE INVENTION

[0007] A tool for cutting a tubular in a wellbore includes a housing, a first blade having a first cutting surface, and a second blade having a second cutting surface. The first blade and the second blade are configured to move between an extended position and a retracted position. The first blade and the second blade are disposed in the housing in the retracted position. The first cutting surface and the second cutting surface overlap in the retracted position.

[0008] A tool for cutting a tubular in a wellbore includes a housing and a blade configured to move between an extended position and a retracted position. The blade includes a curved portion having a cutting surface disposed on at least a part of the curved portion. The radius of curvature of the curved portion is substantially similar to an outer diameter of the housing.

[0009] A tool for cutting a tubular in a wellbore includes a housing having a first window and a second window formed through a wall of the housing, a pin disposed adjacent the first window, and a blade configured to rotate about the pin between an extended position and a retracted position, the blade having a curved portion disposed adjacent the second window in the retracted position.

[0010] A method for cutting a tubular includes positioning a rotatable cutting tool in the tubular, the cutting tool having a housing and a blade with a cutting surface disposed thereon. The method includes rotating the blade about a pin through a window formed in the housing.

[0011] A method of cutting a tubular includes positioning a rotatable cutting tool in the tubular, the cutting tool having a housing and a blade with a cutting surface disposed thereon. The method includes moving the blade between a retracted position, wherein at least a portion of the cutting surface is disposed on a first side of a longitudinal axis of the housing, and an extended position wherein at least a portion of the cutting surface is disposed on a second side of the longitudinal axis. The method further includes rotating the cutting tool relative to the tubular and cutting the tubular using the cutting surface.

[0012] In another embodiment, a tool for cutting a tubular in a wellbore, includes a housing having a longitudinal axis; a pin connected to the housing and disposed on a first side of the longitudinal axis; and a blade configured to move between an extended position and a retracted position about the pin, wherein the blade includes a cutting surface disposed thereon, the cutting surface disposed at least in part on a second side of the longitudinal axis in the retracted position.

[0013] In another embodiment, a method of cutting a tubular includes positioning a rotatable cutting tool in the tubular, the cutting tool having a housing and a blade, the blade including a cutting surface disposed thereon; moving the blade between a retracted position, wherein at least a portion of the cutting surface is disposed on a first side of a longitudinal axis of the housing, and an extended position, wherein the portion of the cutting surface is disposed on a second side of the longitudinal axis; rotating the cutting tool relative to the tubular; and cutting the tubular using the blade.

[0014] In yet another embodiment, a method of cutting a tubular includes positioning a rotatable cutting tool in the tubular, the cutting tool having a housing and a blade, the blade including a cutting surface; moving a portion of the cutting surface of the blade between a first side of a longitudinal axis of the housing and a second side of the longitudinal axis; rotating the cutting tool relative to the tubular; and cutting the tubular using the blade.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0016] Figure 1 illustrates the cutting path of a conventional casing cutter.

[0017] Figure 2A illustrates a cross-sectional view of an embodiment of a tool for cutting a tubular, in a first or retracted position.

[0018] Figure 2B illustrates a cross-sectional view of the tool, in a second or extended position.

[0019] Figure 3A illustrates a cross-sectional view of an actuation assembly of the tool.

[0020] Figure 3B illustrates a cross-sectional view of a stabilizer assembly of the tool.

[0021] Figure 3C illustrates a cross-sectional view of a blade assembly of the tool, in the first or retracted position.

[0022] Figure 4A illustrates an exemplary embodiment of a blade of the tool.

[0023] Figure 4B illustrates an isometric view of the blade of Figure 4A.

[0024] Figure 5A illustrates a cross-sectional view of the blade assembly of the tool, in an extended position.

[0025] Figure 5B illustrates a cross-sectional view of the blade assembly of the tool, in a further extended position.

[0026] Figure 5C illustrates a cross-sectional view of the actuation assembly of the tool.

DETAILED DESCRIPTION

[0027] In the description of the representative embodiments of the invention, directional terms, such as “above”, “below”, “upper”, “lower”, etc., are used for convenience in referring to the accompanying drawings. In general, “above”, “upper”, “upward” and similar terms refer to a direction toward the earth’s surface along a longitudinal axis of a wellbore, and “below”, “lower”, “downward” and similar terms refer to a direction away from the earth’s surface along the longitudinal axis of the wellbore.

[0028] Figure 2A illustrates a rotatable cutting tool 10 for cutting a tubular in a wellbore 20. The tubular may be an inner tubular 50 at least partially disposed in an outer tubular 60, as shown in Figure 2A. However, tool 10 may be equally well used in tubulars that are not surrounded by any other tubulars. Exemplary tubulars include casing, liner, drill pipe, drill collars, coiled tubing, production tubing, pipeline, riser, and other suitable wellbore tubulars. The tool includes an actuation assembly 30 and a blade assembly 40 both shown in Figure 2A positioned in a housing 15. The housing 15 may be tubular having a bore therethrough. The housing 15 may include one or more sections 15a-d, as shown in Figures 3A-C. The housing sections 15a-d may be connected at longitudinal ends thereof. The housing section 15a may be connected at an upper longitudinal end to a workstring. The tool 10 may be lowered into the wellbore 20 on the workstring. The tool 10 is configured to be disposed within a tubular such that the longitudinal axis of the tool is essentially parallel (within +/- 10 degrees) with the longitudinal axis of the tubular. The tool 10 is configured to rotate about its longitudinal axis.

[0029] The actuation assembly 30 acts to extend blades 116a,b of the blade assembly 40. The actuation assembly may be at least partially disposed in the bores of the housing sections 15b-d. In one embodiment, actuation assembly 30 includes a retaining member 102 having at least one aperture 106 and a bore

therethrough, as seen in Figure 3A. The bore of the retaining member 102 is configured to receive a movable member 104. The movable member 104 includes a bore therethrough. In one embodiment, the movable member 104 is biased upward, for example by a spring 108. The movable member 104 includes a thick bottom portion that prevents disengagement from the retaining member 102. In one embodiment, a bottom surface of the movable member 104 is initially sealingly engaged with a bushing 31 which is threadedly engaged with an actuator piston 112, each having a bore therethrough. The bore of the bushing 31 and the actuator piston 112 have a larger diameter than the bore of the movable member 104. The actuator piston 112 includes a packing seal 114 for preventing fluid flow around the actuator piston 112. In one embodiment, the actuator piston 112 is biased upward against the bottom surface of the movable member 104, for example by a spring. A mandrel 124 may be threadedly connected to the actuator piston 112 at an upper longitudinal end. The mandrel 124 may be tubular and threadedly connected to a blade piston 126 at a lower longitudinal end, opposite the actuator piston 112. In one embodiment, the blade piston 126 is biased upward against the lower longitudinal end of the mandrel 124, for example by a spring. The blade piston 126 may include a shoulder 126a. The shoulder 126a may be configured to receive the blades 116a,b in a corresponding inner recessed region. The shoulder 126a may have a lower lip and an upper lip. In one embodiment, the shoulder 126a of the blade piston 126 may include an equal number of inner recessed regions, lower lips, and upper lips for each blade 116a,b. A sleeve 128 may be disposed about an upper portion of the blade piston 126. The sleeve 128 may be disposed in the housing section 15d. The sleeve 128 may be threadedly connected to an outer surface of the blade piston 126. The sleeve 128 may be longitudinally movable with the blade piston 126 between a first or upper position, shown in Figure 3B, and a second or lower position, shown in Figure 5B. The sleeve 128 may be configured to prevent hydraulic lock of the actuator assembly. For example, the sleeve 128 may have apertures formed therethrough. The apertures of the sleeve 128 may permit fluid communication through the sleeve and prevent excess fluid pressure acting on the sleeve.

[0030] The blade assembly 40 includes at least one blade 116 in a respective recess 118 of the housing section 15d, as shown in Figure 3C. The recess 118 may be formed in a bore of the housing section 15d. The blades 116a,b may be disposed in the bore of the housing section 15d. Any appropriate number of blades 116 may be used in the blade assembly 40. In some embodiments, the number of blades 116 ranges from 1 to 4. Each blade 116a,b is rotatable with respect to the tool 10, about a pin 120, between a retracted position (Figure 2A and 3C) and a series of extended positions (Figures 2B and 5A-B). The pin 120 may be disposed in the housing section 15d. The housing section 15d may have a window formed through a wall thereof. The housing section 15d may have a window for each corresponding blade 116a,b. The blades 116a,b may be configured to at least partially exit the recess 118 through the windows when moving to the extended position. The pin 120 may be disposed adjacent the blade piston 126. The pin 120 may be disposed adjacent the corresponding window through which the blade 116a exits the recess 118. The pin 120 may be disposed on a first side of a longitudinal axis B of the housing section 15d, as shown in Figures 3C, 5B. The pin 120 may be connected to the housing 15 and disposed on the first side of the longitudinal axis B opposite the corresponding cutting surface of the blade. The pin 120 may be at least partially disposed through a shoulder of the housing section 15d. The pin 120 may be disposed adjacent the shoulder 126a of the blade piston 126. In the retracted position, the blade 116 is disposed in the recess 118. In the retracted position, the blade 116 is disposed in the bore of the housing section 15d. In the extended positions, the blade 116 is at least partially extended outward from the recess 118. In some embodiments, the blade 116 extends radially outward from the longitudinal axis of the cutting tool 10. In one embodiment, the blades 116a,b are biased towards the retracted position, for example by the spring acting on the blade piston 126. The weight of blade 116a may cause the blade 116a to rotate about the pin 120 towards the retracted position. A person of ordinary skill in the art with the benefit of this disclosure would appreciate that other configurations of blade assemblies 40 and actuator assemblies 30 could serve to provide one or more blades that move from a retracted position to an extended position within the spirit of this disclosure.

[0031] The tool 10 may optionally include a stabilizer assembly 70, as shown in Figure 3B. The stabilizer assembly 70 may be disposed between the blade assembly 40 and the actuation assembly 30. Alternatively, the stabilizer assembly may be disposed about the blade assembly 40 and the actuation assembly 30. The stabilizer assembly 70 may include a stabilizer configured to stabilize the tool 10 inside the innermost tubular during a cutting operation. An exemplary stabilizer assembly is disclosed in U.S. Patent Application No. 14/569,414, which is hereby fully incorporated by reference. The mandrel 124 may extend through a bore of the stabilizer assembly 70. In another embodiment, the tool 10 may not include the stabilizer assembly 70. In this example, the mandrel 124 and blade piston 126 may not be included in the tool 10. Instead, the actuator piston 112 may include a shoulder similar to the shoulder 126a of the blade piston 126. The shoulder of the actuator piston 112 may be configured to receive the blades 116a,b in a corresponding inner recessed region. The shoulder of the actuator piston 112 may include an inner recessed region, a lower lip, and an upper lip. The shoulder of the actuator piston 112 may include an equal number of inner recessed regions, lower lips, and upper lips for each blade.

[0032] An exemplary embodiment of the blade 116 is shown in Figures 4A and 4B. The blade 116 includes a blade body 200 with an aperture 201 for receiving a pivot pin at pin 120. The blade body 200 may include a wall. The aperture 201 may be formed through the wall of the blade body 200. The blade body 200 may include a shoulder 202 and a curved portion 204. The aperture 201 may be located at an end of the curved portion 204. The curved portion 204 may have an outer, convex surface and an inner, concave surface. The convex surface of the curved portion 204 may face laterally outwardly from the housing in the retracted position. The concave surface of the curved portion 204 may face laterally inwardly of the housing in the retracted position. The curved portion 204 may be an arcuate segment. In one embodiment, the curved portion 204 may include a plurality of straight segments. Each subsequent straight segment may be angled relative to a previous straight segment. The curved portion 204 may be substantially semi-circular (within +/- ninety degrees of a semi-circle). The curved portion 204 may include a cutting surface 206. The cutting surface 206 may be

disposed on the blade 116. The cutting surface 206 may be disposed on the inner, concave surface of the curved portion 204. The cutting surface 206 may face radially inwardly in the retracted position. The cutting surface 206 may extend to an end of the curved portion 204 opposite the aperture 201. The cutting surface 206 may be disposed on a corner 210 of the blade 116. The cutting surface 206 may include any material suitable for cutting a tubular. For any given tubular, the cutting surface 206 may include any suitable material that is at least as hard as the material of the inner surface of that tubular. The cutting surface 206 may include one or more cutting elements 208a-c. The one or more cutting elements 208a-c may be tiered cutting elements. The cutting element 208c may extend further from the blade body 200 than the cutting elements 208a and 208b. The cutting element 208b may extend further from the blade body 200 than the cutting element 208a. An exemplary tiered cutting element is disclosed in UK Patent Application No. GB1705993.2, which is hereby fully incorporated by reference. The cutting surface 206 may include a radius of curvature 206r on an innermost surface of the cutting surface 206. In one embodiment, the radius of curvature 206r may vary along the cutting surface 206. The radius of curvature 206r may be substantially (within +/- thirty percent) uniform. The curved portion 204 may include a radius of curvature 204r. In one embodiment, the radius of curvature 204r may vary along the curved portion 204. The radius of curvature 204r may be substantially (within +/- thirty percent) uniform. The radius of curvature 204r of the curved portion 204 may be greater than the radius of curvature 206r of the cutting surface 206.

[0033] The cutting surface 206 may be configured to cut a tubular, such as the inner tubular 50. In some embodiments, the cutting surface 206 is configured to cut through a tubular, thereby making a full-thickness cut. In some embodiments, the blade 116 includes a pivot pin in aperture 201 along axis A. In some embodiments, as the blade 116 extends radially outward from the longitudinal axis of cutting tool 10, the cutting surface 206 moves upward within the nested tubulars. Consequently, the amount of extension of the blade 116 from the cutting tool 10 may be expressed as a measurement of rotation angle about axis A. The cutting surface 206 cuts the inner tubular 50 when the blade 116 is in an extended

position. An edge 212 of the cutting surface 206 may engage the inner tubular 50. The edge 212 may be disposed at an end of the corner 210 opposite the curved portion 204. The sweep of the tool 10 is the diameter of a circle formed by the edge 212 as the tool 10 rotates about its longitudinal axis. The edge 212 may include an initial engagement point configured to engage a surrounding tubular. The edge 212 of the cutting surface 206 may make initial contact with a surrounding tubular.

[0034] In cutting to the fully extended position, the blades 116a,b may remove material substantially equivalent to a hemisphere having a radius equivalent to the radius of curvature 204r minus the volume of the borehole of the wellbore and minus half the volume of a toroid having a minor radius equivalent to the radius of curvature 206r and a major radius equivalent to the sum of the distance from the longitudinal axis of the tool 10 to the pin 120 and the radius of curvature 206r.

[0035] During operation, the tool 10 may be lowered into the inner tubular 50 with the blades 116a,b in the retracted position. In one embodiment, the blades 116a,b may be completely disposed in the housing 15 in the retracted position. An outer diameter of the housing section 15d may be substantially similar (within +/- thirty percent) to the radius of curvature 204r of the blade 116, such that the blades 116a,b are at least partially disposed in the housing section 15d in the retracted position. The blades 116a,b may laterally overlap in the retracted position, as shown in Figure 2A and 3C. The cutting surfaces 204 of the blades 116a,b may face inwards of the housing 15 in the retracted position. The cutting surface 206 of one of the blades 116a,b may face towards a cutting surface 206 of another of the blades 116a in the retracted position. The curved portion 204 of the blade 116a may be disposed at least in part on a second side of the longitudinal axis B of the housing 15 opposite the corresponding pin 120. In one embodiment, the tubular 50 is tubing disposed in casing. In another embodiment, the inner tubular 50 is casing/liner disposed in the wellbore 20. In yet another embodiment, the inner tubular 50 is an inner casing/liner disposed in an outer casing/liner, such as outer tubular 60, as shown in Figure 2A. Cement may or may not be disposed on an outer surface of any one or more of the nested tubulars. In one

embodiment, the inner tubular 50 and the outer tubular 60 are concentrically aligned in the wellbore 20. In another embodiment, the inner tubular 50 and the outer tubular 60 are not concentrically aligned, as shown in Figure 2A. The tool 10 may be positioned at a desired depth. As shown in Figure 2A, the inner and outer tubulars 50, 60 may overlap at the desired depth. Thereafter, the blades 116a,b may be extended outwardly relative to the longitudinal axis of the cutting tool 10, as shown in Figures 2B, 5A, and 5B.

[0036] Actuation assembly 30 may act to extend blades 116a,b of the blade assembly 40. In some embodiments, actuation assembly 30 is hydraulic. To actuate the blades 116a,b into an extended position, fluid is injected through the tool 10. A first portion of the injected fluid enters the bore of the movable member 104 before entering the larger bore of the actuator piston 112. Thereafter, the first portion of fluid passes through the mandrel 124, through a bore of the blade piston 126, and exits the tool 10 through the recess 18 of the housing 15. A second portion of the injected fluid passes through the apertures 106 of the retaining member 102 and may act on the packing seal 114 of the actuator piston 112. Fluid pressure in the housing 15 is increased, thereby moving the movable member 104 downward and compressing the spring 108 against the retaining member 102. In turn, the movable member 104 urges the actuator piston 112 downward. In turn, the actuator piston 112 urges the mandrel 124 and blade piston 126 downward, thereby compressing the spring acting on the blade piston 126. The blade piston 126 acts on the blades 116a,b, thereby actuating the blades 116a,b into an extended position. Figure 5A shows the blades 116a,b extending toward the inner tubular 50. In this example, the upper lips of the shoulder 126a act on a corresponding shoulder of each blade 116a,b, thereby causing each blade 116a,b to rotate about its respective pin 120. In turn, each blade 116a,b is at least partially extended through the corresponding window formed in the housing section 15d. As each blade 116a,b extends towards the inner tubular 50, the center of gravity of the blade 116a may move laterally from a first side of the corresponding pin 120 to an alternate side of the pin 120. Likewise, at least a portion 206a of the cutting surface 206 may move laterally from a first side of the corresponding pin 120 to an alternate side of the pin 120.

For example, at least a portion 206a of the cutting surface 206 may move laterally towards the pin 120 as the blade 116a begins extending outward. In turn, the portion of the cutting surface 206 may move laterally past the pin 120. Next, the portion 206a of the cutting surface 206 may move laterally outward away from the pin 120, as the blade 116a continues extending. The portion 206a of the cutting surface 206 may be disposed laterally between the longitudinal axis B and a parallel axis through the pin 120. In turn, the portion 206a of the cutting surface 206 may move through and/or past the parallel axis through the pin 120, as the blade 116a continues extending outward. As would be apparent to one of ordinary skill in the art with the benefit of this disclosure, actuation assembly 30 can be other than hydraulic while still being capable of selectively extending blades 116a,b of the blade assembly 40. For example, actuation assembly 30 could be an electromagnetic device.

[0037] In one embodiment, the tool 10 provides an indication at the surface of the wellbore 20 that the blades 116a,b have cut through the inner tubular 50. For example, the actuation assembly 30 is configured such that the movable member 104 and the actuator piston 112 disengage when the blades 116a,b cut through the wall of the inner tubular 50. Upon cutting through the inner tubular 50, the movable member 104 reaches a stop and the fluid acting on the piston surface of the actuator piston 112 causes the actuator piston 112 to move downward relative to the movable member 104. As a result, the actuator piston 112 disengages from the bottom surface of the movable member, as shown in Figure 5C. In turn, the second portion of the injected fluid enters the bore of the actuator piston 112 and causes the fluid pressure in the housing 15 to decrease. In one embodiment, the pressure drop corresponds to the blades having extended to a predetermined cutting radius which corresponds to having cut through the inner tubular 50. In another embodiment, the tool 10 provides an indication at the surface of the wellbore 20 that the blades 116a,b have extended to a predetermined cutting radius which corresponds to having cut through the inner tubular 50 and the outer tubular 60, as shown in Figure 5B. In another embodiment, the pressure drop corresponds to the blades 116a,b having cut through both the inner tubular 50 and the outer tubular 60. In another embodiment, the tool 10 provides an

indication at the surface of the wellbore 20 that the blades 116a,b have cut through three or more nested tubulars. In another embodiment, the pressure drop corresponds to the blades 116a,b having cut through three or more nested tubulars. In another embodiment, the pressure drop corresponds to the blades 116a,b being perpendicularly positioned relative to the inner tubular 50. In another embodiment, the pressure drop corresponds to the blades 116a,b having reached a fully extended position, as shown in Figure 5B. As would be apparent to one of ordinary skill in the art with the benefit of this disclosure, actuation assembly 30 can be other than hydraulic while still being capable of providing an indication at the surface of the wellbore 20 that the blades 116a,b have cut through the inner tubular 50 and responding appropriately. For example, the actuation assembly 30 may be at least partially disposed below the blade assembly 40. The actuation assembly 30 may be configured to push upwards against an outer surface of the blade body 200, urging the blades 116a,b to the extended position. An exemplary actuation assembly is disclosed in U.S. Patent No. 5,201,817, which is hereby fully incorporated by reference.

[0038] Upon indication that the blades 116a,b have completed the cutting operation, the blades 116a,b are returned to the retracted position. In some embodiments, to return the blades 116a,b to the retracted position, fluid pressure in the housing 15 may be decreased. As a result, the spring acting on the blade piston 126 may overcome the fluid force acting on the packing seal 114. The blade piston 126 is urged upwards, thereby engaging the blades 116a,b with the lower lips of the shoulder 126a. In turn, the actuator piston 112 is urged upwards into engagement with the bottom surface of the movable member 104. By moving upwards, the blade piston 126 urges the blades 116a,b into the retracted position. The blades 116a,b pivot about the pin 120 to the retracted position, as shown in Figure 3C. The blades 116a,b may scissor together and overlap in the retracted position. In one embodiment, the curved portion 204 of a first blade may face laterally in a first direction. The curved portion 204 of a second blade may face laterally in a second direction. The second direction may be opposite of the first direction. For example, the blades 116a,b may be disposed adjacent and/or side-by-side in the housing section 15d in the retracted position. In one embodiment, a

first blade may be disposed laterally in a first direction from the longitudinal axis B of the housing section 15d. A second blade may be disposed laterally in a second direction from the longitudinal axis B of the housing section 15d. The second direction may be opposite of the first direction. The portion 206a of the cutting surface 206 of the first blade may be disposed on a second side of the longitudinal axis B of the housing 15 in the retracted position, as shown in Figure 3C. The portion 206a of the cutting surface 206 of the first blade may be disposed on the first side of the longitudinal axis B of the housing 15 in the extended position, as shown in Figure 5B. The cutting surface 206 may be disposed at least in part on the second side of the longitudinal axis B of the housing 15 in the retracted position, as shown in Figure 3C. The corresponding pin 120 of the blade may be laterally disposed on the second side of the longitudinal axis B of the housing 15. In one embodiment, the corresponding curved portions 204 of the blades 116a,b may overlap in the retracted position. For example, the curved portion 204 of a first blade may extend past the curved portion 204 of a second blade in the retracted position.

[0039] In another embodiment, the stabilizer assembly 70, the mandrel 124, the blade piston 126, and the spring acting on the blade piston 126 may be omitted. The actuator piston 112 may include a shoulder substantially similar to shoulder 126a of the blade piston 126. The actuator piston 112 may be biased upwards against the bottom surface of the movable member 104 by a spring. The actuator piston 112 may be configured to move the blades 116a,b between the extended position and the retracted position. The actuator piston 112 acts on the blades 116a,b, thereby actuating the blades 116a,b into the extended position. The upper lips of the shoulder of the actuator piston 112 act on a corresponding shoulder of the blades 116a,b, thereby causing each blade 116a,b to rotate about its respective pin 120. In some embodiments, to return the blades 116a,b to the retracted position, fluid pressure in the housing 15 may be decreased. As a result, the spring of the actuator piston 112 may overcome the fluid force acting on the packing seal 114. The actuator piston 112 is urged upwards into engagement with the bottom surface of the movable member 104. In turn, the actuator piston 112 urges the blades 116a,b into the retracted position. The blade 116a may pivot

about the pin 120 to the retracted position. The blades 116a,b may scissor together and overlap in the retracted position. In one embodiment, the first blade may move laterally towards the second blade while moving from the extended position to the retracted position. The first blade may move laterally past at least a portion of the second blade when moving from the extended position to the retracted position. The cutting surface of the first blade may move laterally past at least a portion of the cutting surface of the second blade when the blades move from the extended position to the retracted position.

[0040] In one embodiment, the tool 10 is rotated relative to the inner tubular 50 while the blades 116a,b are extending toward the inner tubular 50. In one embodiment, a mud motor rotates the tool 10.

[0041] In one embodiment, the actuation assembly 30 provides an evenly distributed cut by actuating the blades 116a,b into an extended position, as shown in Figure 5A. For example, the blade piston 126 of the actuation assembly 30 may provide a substantially equal (within +/- 10 percent) force on the shoulder of each blade 116a,b such that each blade 116a,b engages the inner tubular 50 with a substantially equal radial force. The radial forces from the blades 116a,b may cause the tool 10 to move laterally, thereby causing each blade 116a,b to engage the inner tubular 50. For example, in the event that tool 10 is not centralized in inner tubular 50, the radial forces from the blades 116a,b engaging with inner tubular 50 may cause the tool 10 to move laterally, thereby repositioning the tool 10 to be more centralized in inner tubular 50.

[0042] In one embodiment, the blades 116a,b may be mechanically retracted from the extended position. In some instances, the blades 116a,b may become stuck or pinched during a cutting operation. For example, one of the nested tubulars may fall and pinch or land on the blades 116a,b, causing a lockup and preventing further cutting. In certain instances, the spring acting on the blade piston 126 may not be able to overcome the frictional force on the blades 116a,b to move the blades 116a,b from the extended position to the retracted position. In one embodiment, a longitudinal force may be applied to the tool 10 in order to retract the blades 116a,b. For example, the tool 10 may be lifted or pulled

upwards from the surface to free the blades 116a,b from the stuck or pinched condition and move the blades from the extended position to the retracted position. In turn, the uncut material (e.g., tubulars, cement) adjacent the blades 116a,b will urge the blades 116a,b towards the retracted position. The spring acting on the blade piston 126 may assist the longitudinal force on the tool 10 in retracting the blades 116a,b.

[0043] In one embodiment, the blades 116 may be retracted and the cutting operation described herein may be repeated any number of times. For example, the tool 10 may be moved axially upward in the wellbore 20 and the nested tubulars may be cut at the new position.

[0044] In one or more of the embodiments described herein, a tool for cutting a tubular in a wellbore includes a housing, a first blade having a first cutting surface, and a second blade having a second cutting surface.

[0045] In one or more of the embodiments described herein, the first blade and the second blade are configured to move between an extended position and a retracted position.

[0046] In one or more of the embodiments described herein, the first blade and the second blade are disposed in the housing in the retracted position.

[0047] In one or more of the embodiments described herein, the first cutting surface and the second cutting surface overlap in the retracted position.

[0048] In one or more of the embodiments described herein, the first blade includes a first curved portion, the first cutting surface disposed on at least a part of the first curved portion.

[0049] In one or more of the embodiments described herein, the second blade includes a second curved portion, the second cutting surface disposed on at least a part of the second curved portion.

[0050] In one or more of the embodiments described herein, the first curved portion and the second curved portion are substantially semi-circular.

[0051] In one or more of the embodiments described herein, the first curved portion extends laterally past the second curved portion in the retracted position.

[0052] In one or more of the embodiments described herein, the first curved portion is an arcuate segment.

[0053] In one or more of the embodiments described herein, the second curved portion is an arcuate segment.

[0054] In one or more of the embodiments described herein, the first blade is configured to rotate about a first pin.

[0055] In one or more of the embodiments described herein, the second blade is configured to rotate about a second pin.

[0056] In one or more of the embodiments described herein, the tool further includes a window formed through a wall of the housing, the first blade configured to extend at least partially through the first window in the extended position.

[0057] In one or more of the embodiments described herein, the first cutting surface and the second cutting surface overlap laterally in the retracted position.

[0058] In one or more of the embodiments described herein, a tool for cutting a tubular in a wellbore includes a housing and a blade configured to move between an extended position and a retracted position.

[0059] In one or more of the embodiments described herein, the blade includes a curved portion having a cutting surface disposed on at least a part of the curved portion.

[0060] In one or more of the embodiments described herein, the radius of curvature of the curved portion is substantially similar to an outer diameter of the housing.

[0061] In one or more of the embodiments described herein, the radius of curvature is substantially uniform.

[0062] In one or more of the embodiments described herein, the cutting surface includes a radius of curvature, the radius of curvature of the curved portion greater than the radius of curvature of the cutting surface.

[0063] In one or more of the embodiments described herein, the blade further includes an initial engagement point configured to engage the tubular.

[0064] In one or more of the embodiments described herein, the cutting surface faces laterally inward of the housing in the retracted position.

[0065] In one or more of the embodiments described herein, the radius of curvature varies along the curved portion.

[0066] In one or more of the embodiments described herein, the blade is substantially semi-circular.

[0067] In one or more of the embodiments described herein, the radius of curvature of the cutting surface varies along the cutting surface.

[0068] In one or more of the embodiments described herein, a tool for cutting a tubular in a wellbore includes a housing, a first blade having a first cutting surface and configured to move between an extended position and a retracted position, and a second blade having a second cutting surface and configured to move between an extended position and a retracted position, wherein the first cutting surface faces inward of the housing towards the second cutting surface in the retracted position.

[0069] In one or more of the embodiments described herein, the first blade and the second blade are disposed adjacent in the housing in the retracted position.

[0070] In one or more of the embodiments described herein, a tool for cutting a tubular in a wellbore includes a housing having a first window and a second window formed through a wall of the housing, a pin disposed adjacent the first window, and a blade configured to rotate about the pin between an extended position and a retracted position, the blade having a curved portion disposed adjacent the second window in the retracted position.

[0071] In one or more of the embodiments described herein, a method of cutting a tubular includes positioning a rotatable cutting tool in the tubular, the cutting tool having a housing and a blade with a cutting surface disposed thereon, rotating the blade about a pin through a window formed in the housing, rotating the cutting tool relative to the tubular, and cutting the tubular using the cutting surface.

[0072] In one or more of the embodiments described herein, a method of cutting a tubular includes positioning a rotatable cutting tool in the tubular, the rotatable cutting tool having a housing and a blade with a cutting surface disposed thereon.

[0073] In one or more of the embodiments described herein, the method further includes moving the blade between a retracted position, wherein at least a portion of the cutting surface is disposed on a first side of a longitudinal axis of the housing, and an extended position, wherein the portion of the cutting surface is disposed on a second side of the longitudinal axis.

[0074] In one or more of the embodiments described herein, the method further includes rotating the cutting tool relative to the tubular.

[0075] In one or more of the embodiments described herein, the method further includes cutting the tubular using the cutting surface.

[0076] In one or more of the embodiments described herein, the method further includes stabilizing the cutting tool by engaging the tubular with a stabilizer.

[0077] In one or more of the embodiments described herein, the method further includes cutting a second tubular surrounding the tubular.

[0078] In one or more of the embodiments described herein, moving the blade further includes rotating the blade about a pin.

[0079] In one or more of the embodiments described herein, the pin is disposed in the housing on the second side of the longitudinal axis.

[0080] In one or more of the embodiments described herein, the housing has a longitudinal axis.

[0081] In one or more of the embodiments described herein, a pin is connected to the housing and disposed on a first side of the longitudinal axis.

[0082] In one or more of the embodiments described herein, a blade is configured to move between an extended position and a retracted position about the pin.

[0083] In one or more of the embodiments described herein, the blade includes a cutting surface disposed thereon, wherein the cutting surface is disposed at least in part on a second side of the longitudinal axis in the retracted position.

[0084] In one or more of the embodiments described herein, a method of cutting a tubular includes positioning a rotatable cutting tool in the tubular, the cutting tool having a housing and a blade, the blade including a cutting surface disposed thereon.

[0085] In one or more of the embodiments described herein, the method further includes moving the blade between a retracted position, wherein at least a portion of the cutting surface is disposed on a first side of a longitudinal axis of the housing, and an extended position, wherein the portion of the cutting surface is disposed on a second side of the longitudinal axis.

[0086] In one or more of the embodiments described herein, the method further includes rotating the cutting tool relative to the tubular.

[0087] In one or more of the embodiments described herein, the method further includes cutting the tubular using the blade.

[0088] In one or more of the embodiments described herein, a method of cutting a tubular includes positioning a rotatable cutting tool in the tubular, the cutting tool having a housing and a blade, the blade including a cutting surface disposed thereon; moving a portion of the cutting surface of the blade between a first side of a longitudinal axis of the housing and a second side of the longitudinal

axis; rotating the cutting tool relative to the tubular; and cutting the tubular using the blade.

[0089] As will be understood by those skilled in the art, a number of variations and combinations may be made in relation to the disclosed embodiments all without departing from the scope of the invention. While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims:

1. A tool for cutting a tubular in a wellbore, comprising:
a housing;
a first blade having a first cutting surface; and
a second blade having a second cutting surface, wherein:
the first blade and the second blade are configured to move between
an extended position and a retracted position; and
the first cutting surface and the second cutting surface overlap in the
retracted position.
2. The tool of claim 1, further comprising:
the first blade having a first curved portion, the first cutting surface
disposed on at least a part of the first curved portion; and
the second blade having a second curved portion, the second cutting
surface disposed on at least a part of the second curved portion.
3. The tool of claim 2, wherein the first curved portion and the second curved
portion are substantially semi-circular.
4. The tool of claim 2, wherein the first curved portion extends laterally past
the second curved portion in the retracted position.
5. The tool of claim 2, wherein:
the first curved portion is an arcuate segment; and
the second curved portion is an arcuate segment.
6. The tool of claim 1, wherein:
the first blade is configured to rotate about a first pin; and
the second blade is configured to rotate about a second pin.

7. The tool of claim 6, further comprising a window formed through a wall of the housing, the first blade configured to extend at least partially through the window in the extended position.
8. The tool of claim 1, wherein the first cutting surface and the second cutting surface overlap laterally in the retracted position.
9. A tool for cutting a tubular in a wellbore, comprising:
 - a housing having a longitudinal axis;
 - a pin connected to the housing and disposed on a first side of the longitudinal axis; and
 - a blade including a cutting surface, the blade configured to move between an extended position and a retracted position about the pin, wherein a portion of the cutting surface is disposed on a second side of the longitudinal axis in the retracted position.
10. The tool of claim 9, wherein:
 - the blade includes a curved portion; and
 - the cutting surface is disposed on the curved portion.
11. The tool of claim 10, wherein the cutting surface of the blade includes a radius of curvature, wherein a radius of curvature of the curved portion is greater than the radius of curvature of the cutting surface.
12. The tool of claim 9, the blade further including an initial engagement point configured to engage the tubular.
13. The tool of claim 9, wherein the cutting surface faces laterally inward of the housing in the retracted position.
14. The tool of claim 10, wherein the curved portion is substantially semi-circular.

15. The tool of claim 11, wherein the radius of curvature of the cutting surface varies along the cutting surface.
16. A method of cutting a tubular, comprising:
positioning a rotatable cutting tool in the tubular, the cutting tool having a housing and a blade, the blade including a cutting surface;
moving a portion of the cutting surface of the blade between a first side of a longitudinal axis of the housing and a second side of the longitudinal axis;
rotating the cutting tool relative to the tubular; and
cutting the tubular using the blade.
17. The method of claim 16, further comprising stabilizing the cutting tool by engaging the tubular with a stabilizer.
18. The method of claim 16, further comprising cutting a second tubular surrounding the tubular.
19. The method of claim 16, moving the blade further comprising rotating the blade about a pin.
20. The method of claim 19, wherein the pin is disposed in the housing on the second side of the longitudinal axis.

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Claims:

1. A tool for cutting a tubular in a wellbore, comprising:
a housing;
a first blade having a first cutting surface; and
a second blade having a second cutting surface, wherein:
the first blade and the second blade are configured to move between
an extended position and a retracted position; and
in the retracted position, the first and second blades overlap,
extending past one another at an upper and lower ends.
2. The tool of claim 1, further comprising:
the first blade having a first curved portion, the first cutting surface
disposed on at least a part of the first curved portion; and
the second blade having a second curved portion, the second cutting
surface disposed on at least a part of the second curved portion.
3. The tool of claim 2, wherein the first curved portion and the second curved
portion are substantially semi-circular.
4. The tool of claim 2, wherein the first curved portion extends laterally past
the second curved portion in the retracted position.
5. The tool of claim 2, wherein:
the first curved portion is an arcuate segment; and
the second curved portion is an arcuate segment.
6. The tool of claim 1, wherein:
the first blade is configured to rotate about a first pin; and
the second blade is configured to rotate about a second pin.

7. The tool of claim 6, further comprising a window formed through a wall of the housing, the first blade configured to extend at least partially through the window in the extended position.

16. A method of cutting a tubular, comprising:
positioning a rotatable cutting tool in the tubular, the cutting tool having a housing;
a first blade having a first cutting surface;
a second blade having a second cutting surface, wherein in a retracted position, the first and second blades overlap, extending past one another at an upper and lower ends;
shifting the tool from the retracted to an extended position whereby the blades are in contact with an inner wall of the tubular;
rotating the cutting tool relative to the tubular; and
cutting the tubular using the blade.

17. The method of claim 16, further comprising stabilizing the cutting tool by engaging the tubular with a stabilizer.

18. The method of claim 16, further comprising cutting a second tubular surrounding the tubular.

19. The method of claim 16, extending the blades further comprising rotating the first and second blades about a first and second pin.

21. A tool for cutting a tubular in a wellbore, comprising:
a housing;
a first blade pivotally mounted at a first location in the housing and having a first cutting surface; and
a second blade pivotally mounted adjacent the first blade in the housing and having a second cutting surface, wherein:

the first blade and the second blade are configured to move between an extended position and a retracted position;

the first cutting surface and the second cutting surface overlap in the retracted position; and

when moving between the positions, the housing upon which the blades are mounted does not move axially within the tool.

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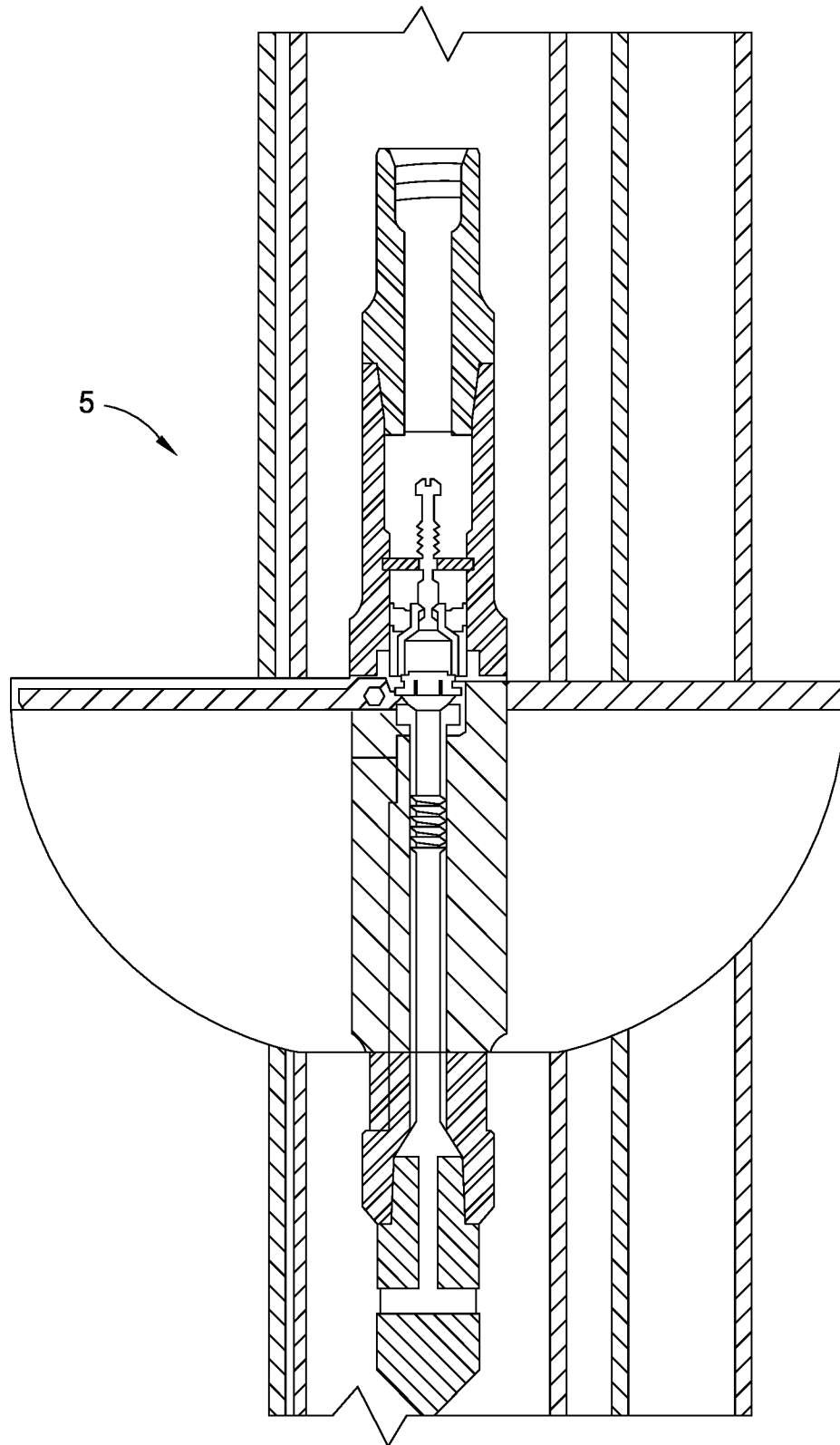


FIG. 1
(PRIOR ART)

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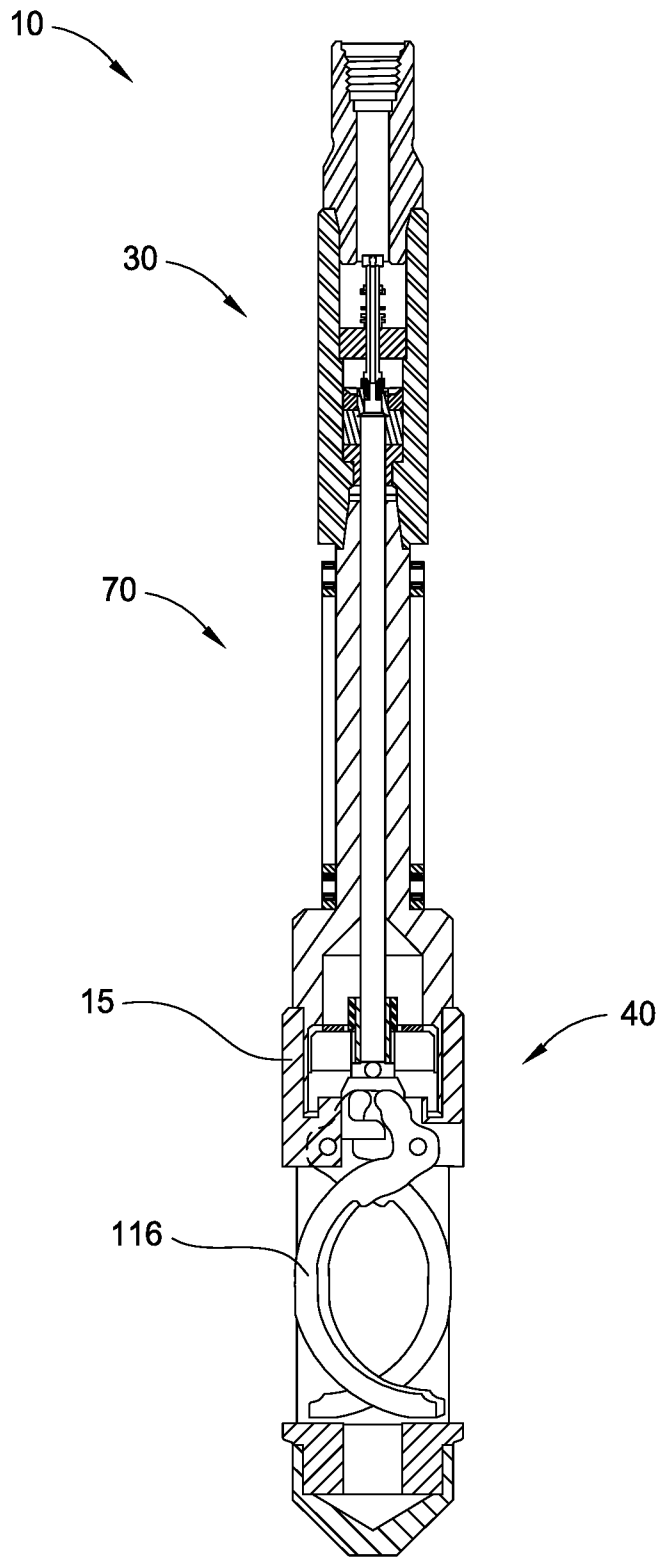


FIG. 2A

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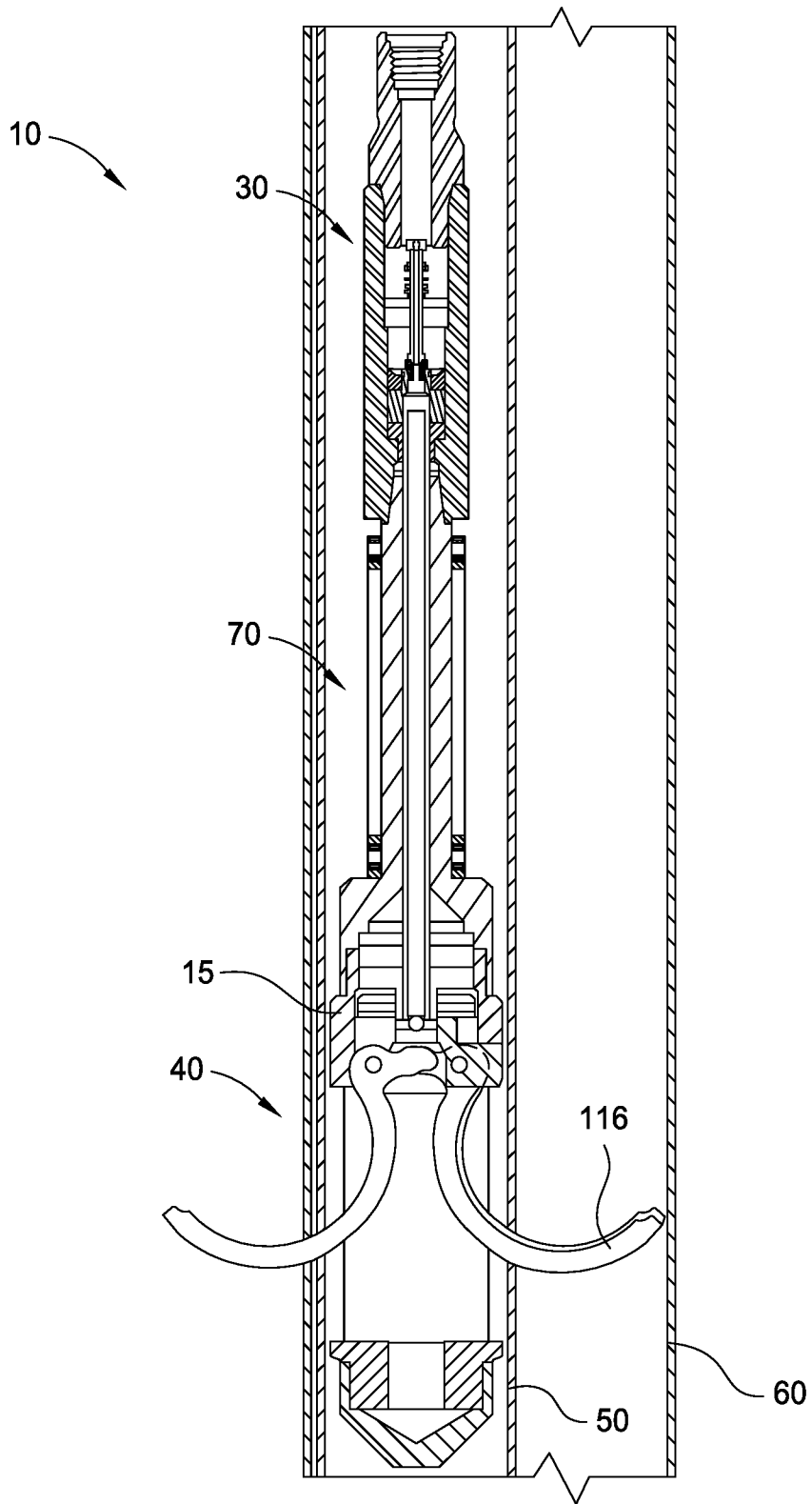


FIG. 2B

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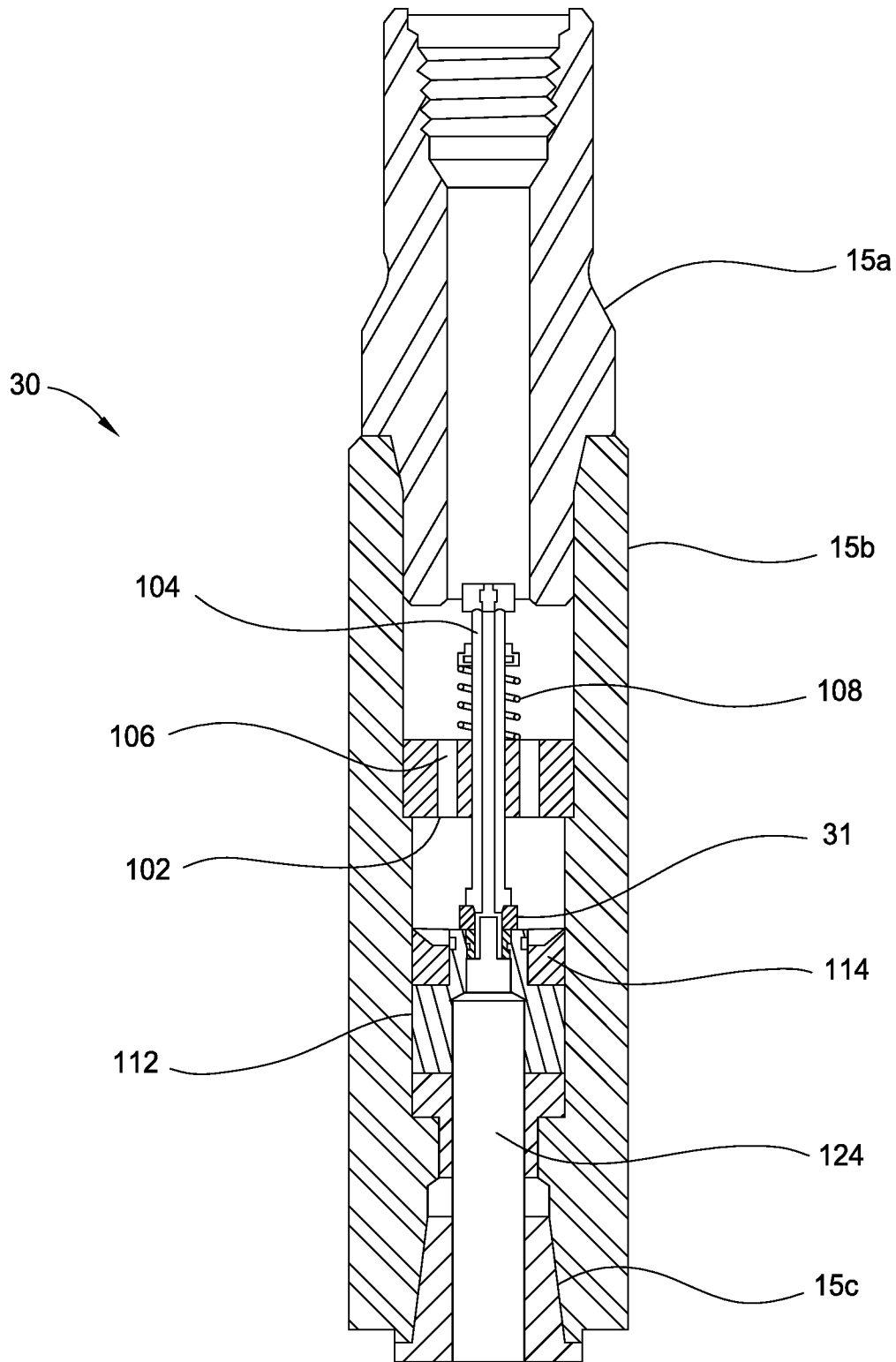


FIG. 3A

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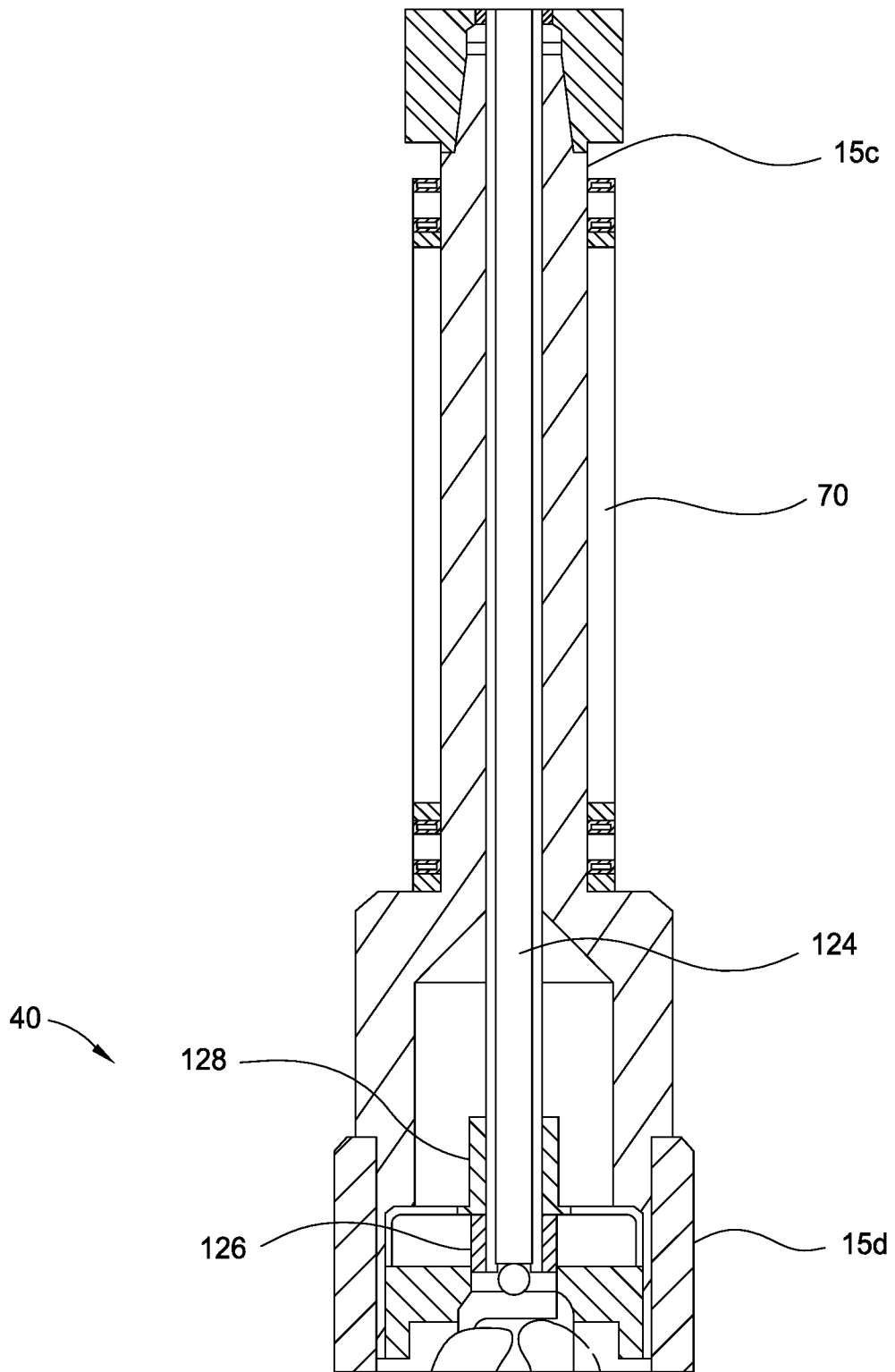


FIG. 3B

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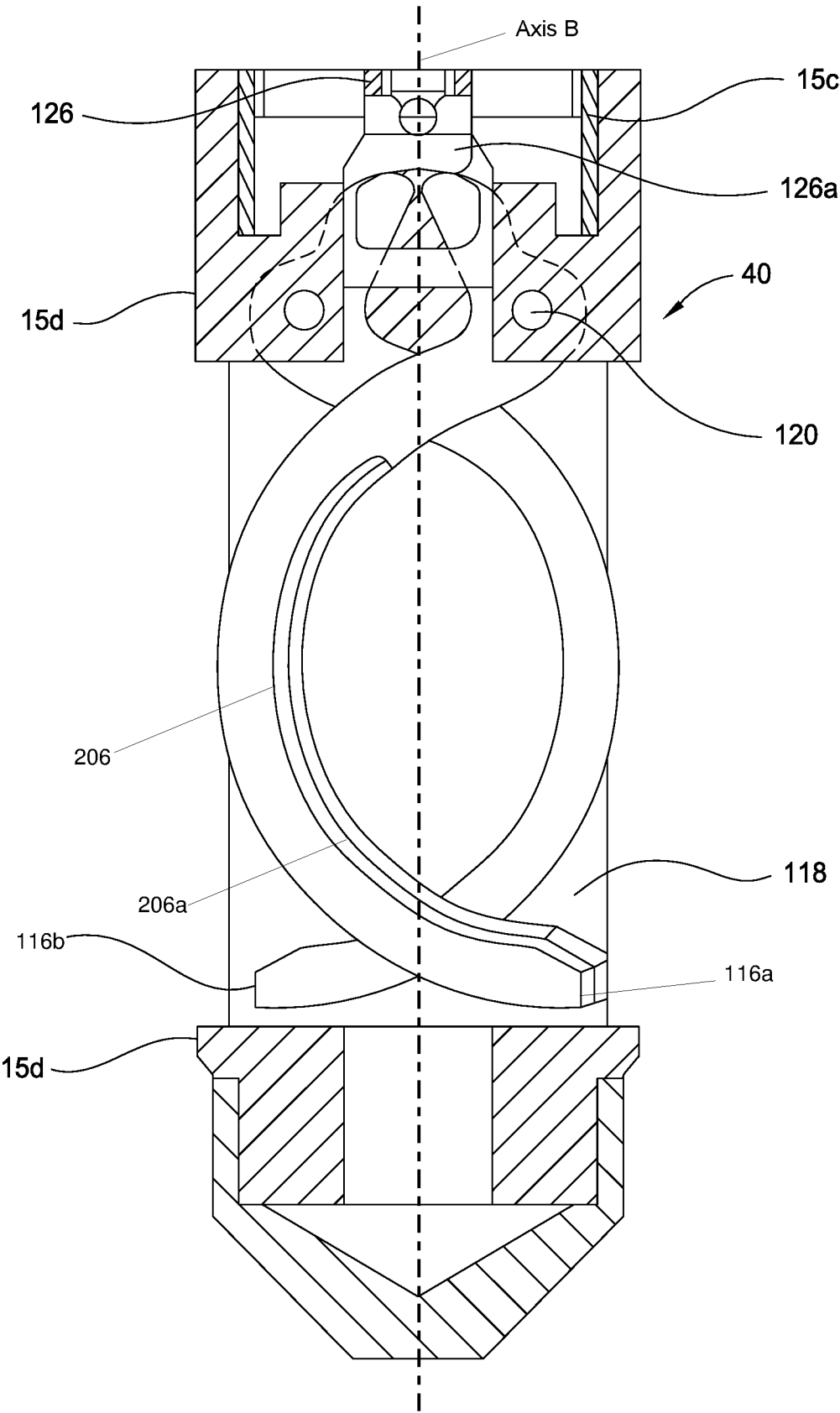


FIG. 3C

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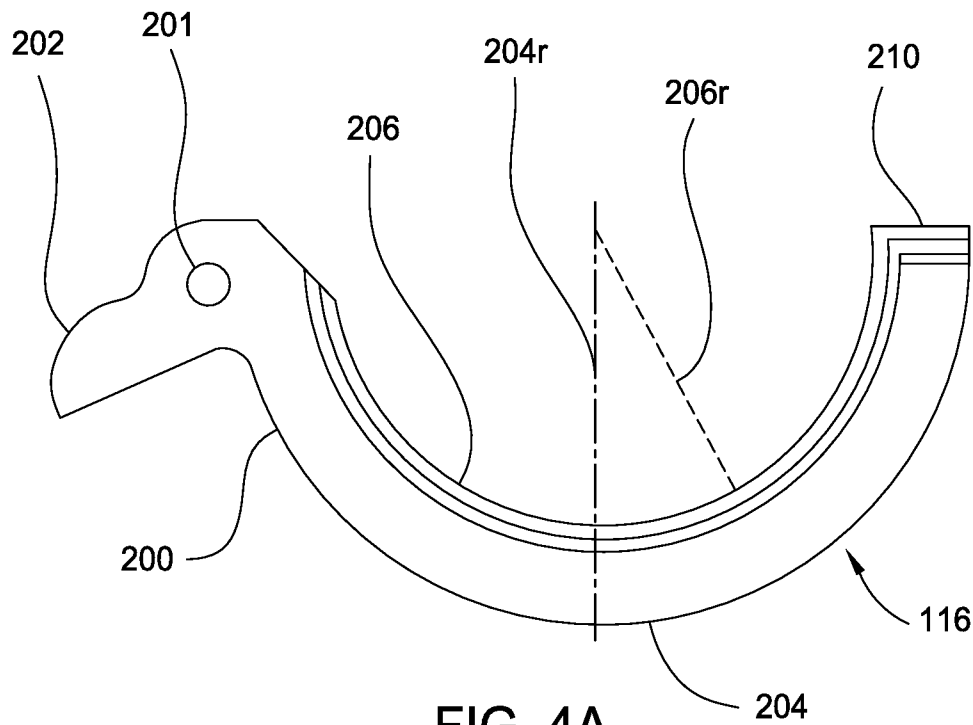


FIG. 4A

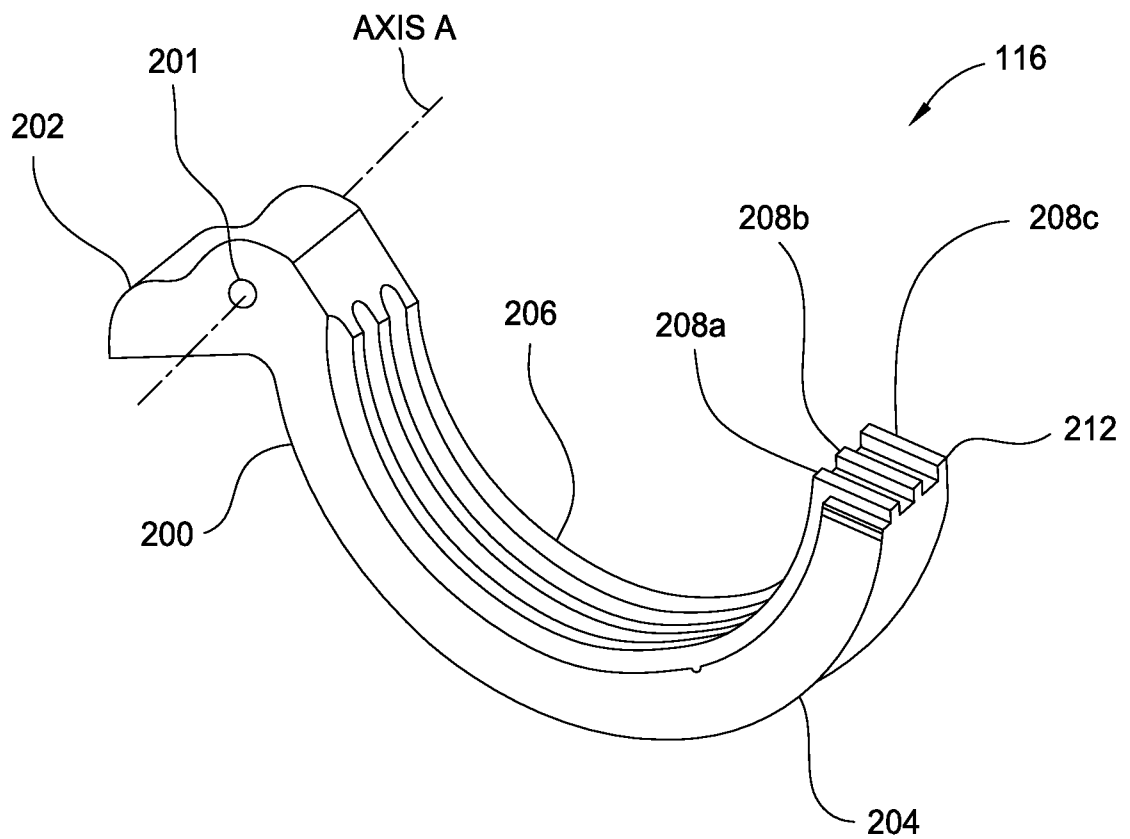


FIG. 4B

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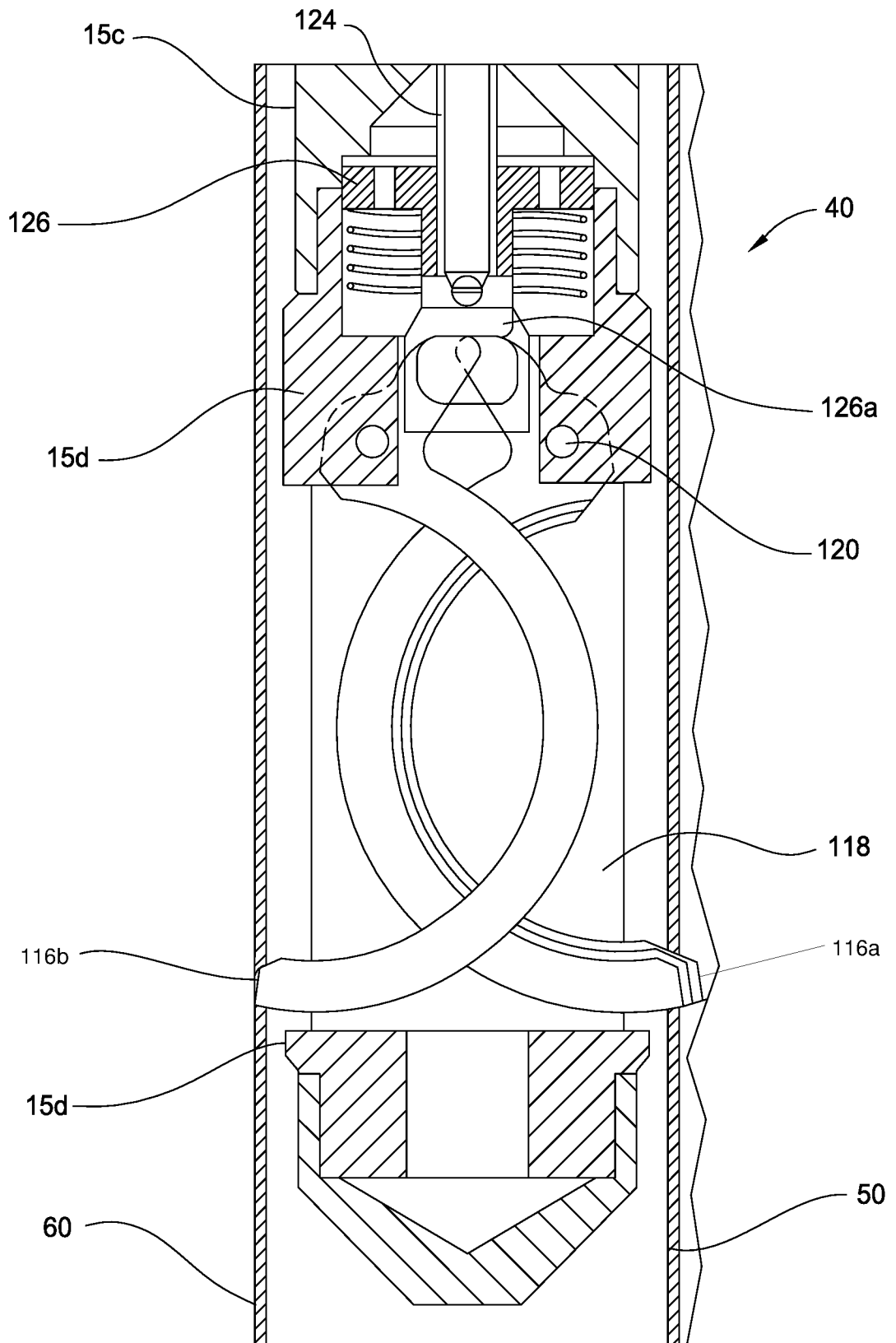


FIG. 5A

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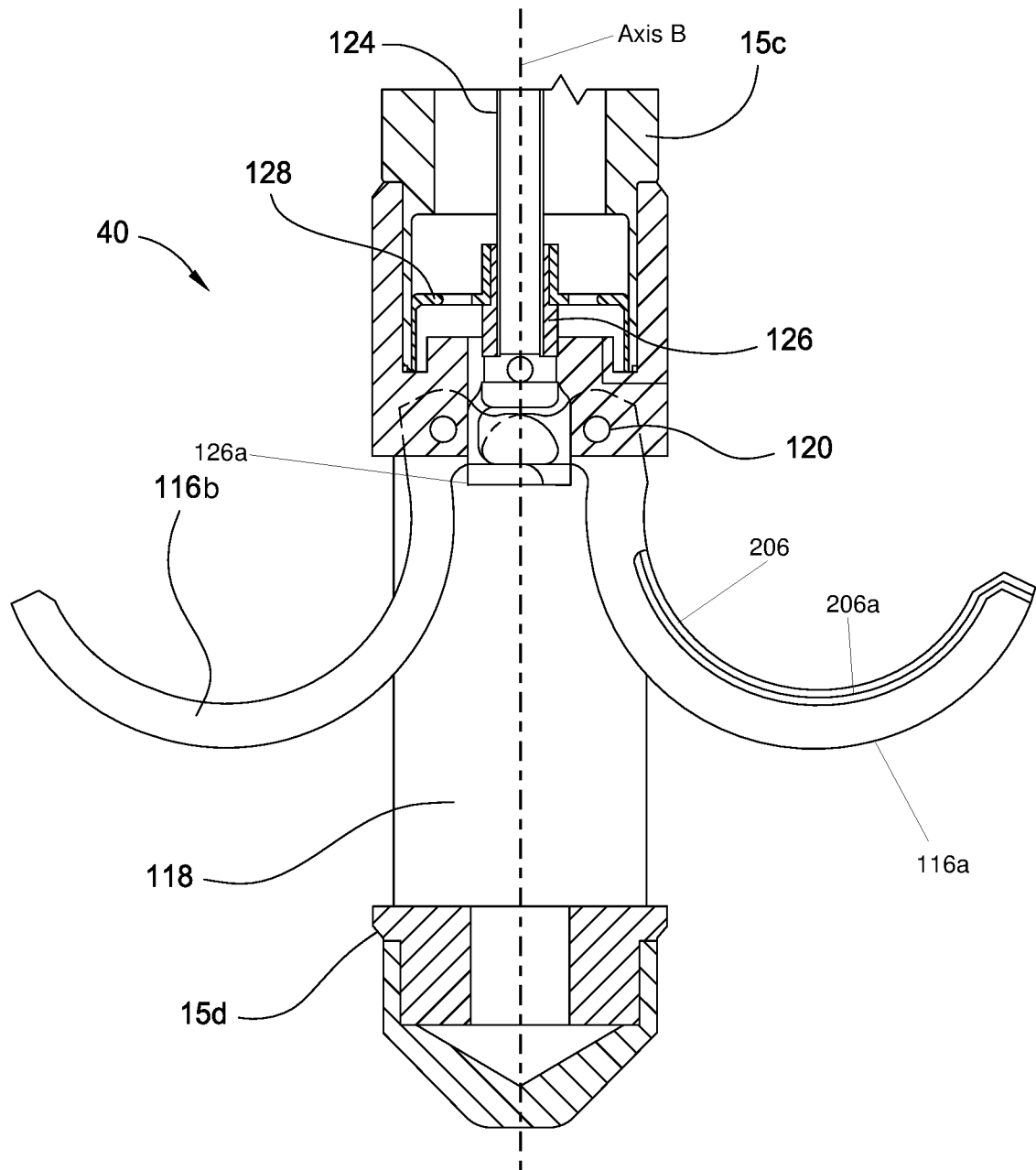


FIG. 5B

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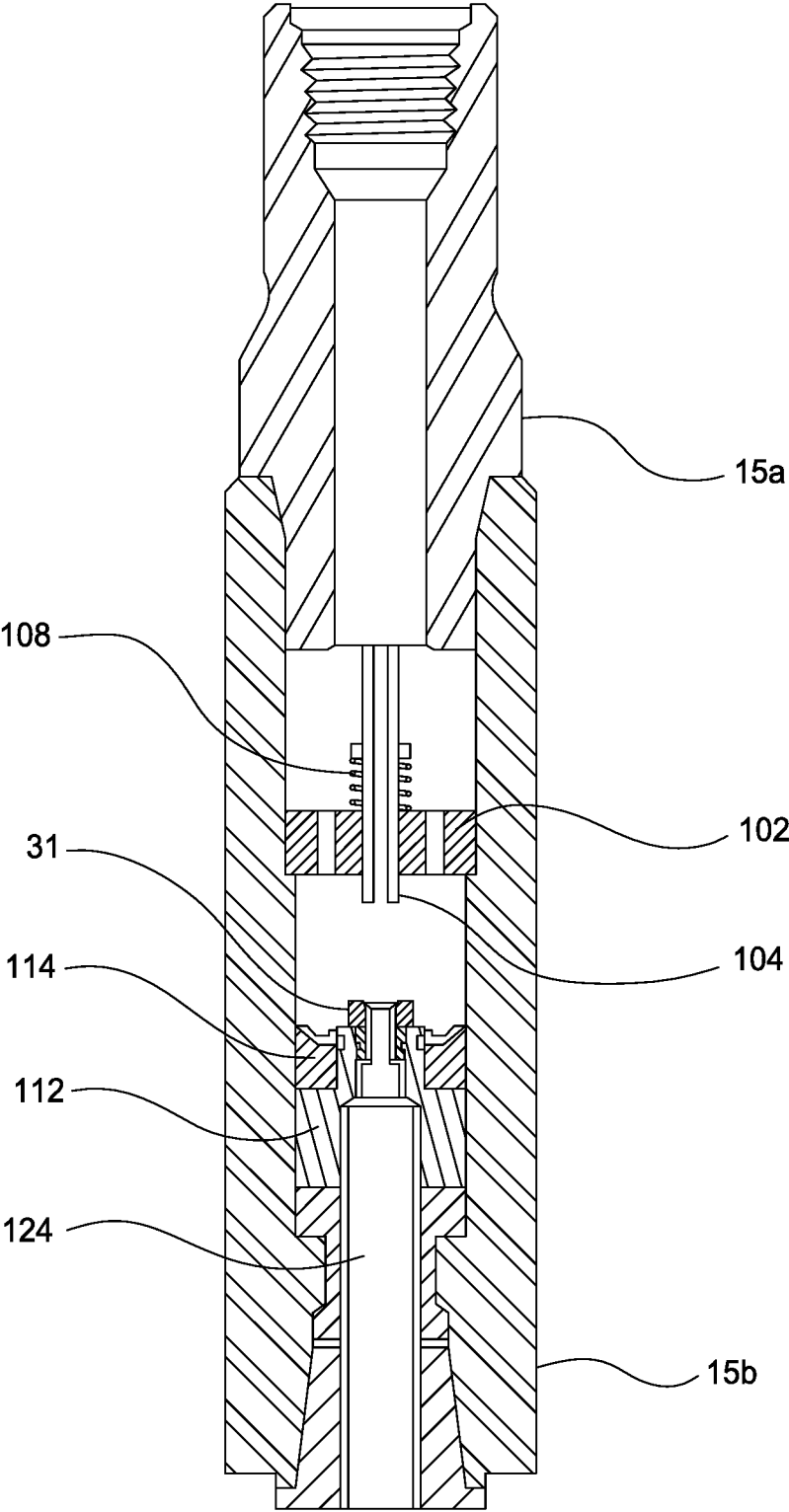


FIG. 5C

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2018/061320

A. CLASSIFICATION OF SUBJECT MATTER
 INV. E21B29/00
 ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 1 777 713 A (BRADEN SAMUEL O) 7 October 1930 (1930-10-07) the whole document	1-20
X	US 1 868 757 A (MYRACLE HOBART M) 26 July 1932 (1932-07-26) the whole document	1-20
X	US 3 050 122 A (HUITT JIMMIE L ET AL) 21 August 1962 (1962-08-21) the whole document	1-5,8
X	US 1 814 048 A (LINCOLN ROBERT A) 14 July 1931 (1931-07-14) the whole document	1-5,8
	----- -/-	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

31 January 2019

Date of mailing of the international search report

11/02/2019

Name and mailing address of the ISA/

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Authorized officer

Strømmen, Henrik

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2018/061320

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	EP 2 530 238 A1 (WELLTEC AS [DK]) 5 December 2012 (2012-12-05) paragraph [0035]; figures 2-4 -----	1-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2018/061320

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