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(54) CONTAINER, AND SELECTIVELY FORMED SHELL, AND TOOLING AND ASSOCIATED METHOD FOR PROVIDING SAME

BEHÄLTER UND SELEKTIV GEFORMTE HÜLLE SOWIE WERKZEUG UND VERFAHREN ZUR BEREITSTELLUNG DAVON

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(73) Proprietor: **Stolle Machinery Company, LLC**
Centennial, Colorado 80112 (US)

(72) Inventors:
- **CARSTENS, Aaron E.**
Centerville, Ohio 45458 (US)
- **MCCLUNG, James A.**
Canton, Ohio 44721 (US)
- **RIPPLE, Paul L.**
Canton, Ohio 44714 (US)
- **BUTCHER, Gregory H.**
Columbus, Ohio 43215 (US)
- **MCCARTY, Patrick K.**
Dayton, Ohio 45420 (US)

(74) Representative: **Mewburn Ellis LLP**
Aurora Building
Counterslip
Bristol BS1 6BX (GB)

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Description

BACKGROUND

Field

[0001] The disclosed concept relates generally to tooling for forming containers and, more particularly, to tooling for forming can ends or shells for metal containers such as, for example, beer or beverage cans, as well as food cans. The disclosed concept also relates to tooling for selectively forming a can end or shell to reduce the amount of material used therein.

Background Information

[0002] Metallic containers (e.g., cans) for holding products such as, for example, food and beverages, are typically provided with an easy open can end on which a pull tab is attached (e.g., without limitation, riveted) to a tear strip or severable panel. The severable panel is defined by a scoreline in the exterior surface (e.g., public side) of the can end. The pull tab is structured to be lifted and/or pulled to sever the scoreline and deflect and/or remove the severable panel, thereby creating an opening for dispensing the contents of the can.

[0003] When the can end is made, it originates as a can end shell, which is formed from a blank cut (e.g., blanked) from a sheet metal product (e.g., without limitation, sheet aluminum; sheet steel). The shell is then conveyed to a conversion press, which has a number of successive tool stations. As the shell advances from one tool station to the next, conversion operations such as, for example and without limitation, rivet forming, paneling, scoring, embossing, tab securing and tab staking, are performed until the shell is fully converted into the desired can end and is discharged from the press.

[0004] In the can making industry, large volumes of metal are required in order to manufacture a considerable number of cans. Thus, an ongoing objective in the industry is to reduce the amount of metal that is consumed. Efforts are constantly being made, therefore, to reduce the thickness or gauge (sometimes referred to as "down-gauging") of the stock material from which can ends and can bodies are made. However, as less material (e.g., thinner gauge) is used, problems arise that require the development of unique solutions. There is, therefore, a continuing desire in the industry to reduce the gauge and thereby reduce the amount of material used to form such containers. However, among other disadvantages associated with the formation of can ends from relatively thin gauge material, is the tendency of the can end to wrinkle, for example, during forming of the shell.

[0005] Prior proposals for reducing the volume of metal used reduce the blank size for the can end, but sacrifice the area of the end panel. This undesirably limits the available space, for example, for the scoreline, the severable panel and/or the pull tab.

[0006] There is, therefore, room for improvement in containers such as beer/beverage cans and food cans, as well as in selectively formed can ends or shells and tooling and methods for providing such can ends or shells.

[0007] WO-A-2013/173398 discloses a container, and selectively formed shell, and tooling and associated method for providing same.

SUMMARY

[0008] These needs and others are met by the present invention, which is directed to a tooling as set forth in claim 1.

[0009] For an understanding of the disclosed concept, a shell is structured to be affixed to a container. The shell comprises: a center panel; a circumferential chuck wall; an annular countersink between the center panel and the circumferential chuck wall; and a curl extending radially outwardly from the chuck wall. The material of at least one predetermined portion of the shell is selectively stretched relative to at least one other portion of the shell, thereby providing a corresponding thinned portion.

[0010] The shell may be formed from a blank of material, wherein the blank of material has a base gauge prior to being formed, and wherein, after being formed, the material of the shell at or about the thinned portion has a thickness. The thickness of the material at or about the thinned portion is less than the base gauge. The thinned portion may include the chuck wall.

[0011] Also for an understanding of the disclosed concept, the shell is formed by a method. The method comprises: introducing material between tooling, forming the material to include a center panel, a circumferential chuck wall, an annular countersink between the center panel and the circumferential chuck wall, and a curl extending radially outwardly from the chuck wall, and selectively stretching at least one predetermined portion of the shell relative to at least one other portion of the shell to provide a corresponding thinned portion of the shell.

[0012] The method may comprise the step of converting the shell into a finished can end. The method may further comprise the step of seaming the finished can end onto a container body.

[0013] According to the disclosed concept, tooling is provided for forming a shell. The tooling comprises: an upper tool assembly; and a lower tool assembly cooperating with the upper tool assembly to form material disposed therebetween to include a center panel, a circumferential chuck wall, an annular countersink between the center panel and the circumferential chuck wall, and a curl extending radially outwardly from the chuck wall. The upper tool assembly and the lower tool assembly cooperate to selectively stretch the material of at least one predetermined portion of the shell relative to at least one other portion of the shell, thereby providing a corresponding thinned portion.

[0014] Selectively thinning a predetermined portion of the shell relative to at least one other portion of the shell to provide a corresponding thinned portion of the shell has been determined to create certain complications such as an overloading condition on the tooling and/or press. Further, the selective thinning may result in excessively uneven thinning. That is, while some unevenness in the thinning is acceptable, excessive uneven thinning is not desirable. It is desirable that the selective thinning be accomplished with existing presses. There is, therefore, room for improvement in the tooling.

[0015] These needs and others are met by the disclosed concept, which is directed to a tooling including a force and/or pressure concentrating forming surface and/or a hybrid bias generating assembly. In an exemplary embodiment, the hybrid bias generating assembly is one of an active hybrid bias generating assembly or a selectable hybrid bias generating assembly, as defined below. It is understood that, in the known art, to increase the pressure acting on a shell, manufacturers simply increased the pressure acting on the tooling. This increase in pressure created a counter load that was applied to the press. As disclosed herein, concentrating the force/pressure on a forming surface allows for reduced counter loads to be applied to the press. An increase in the pressure surface area of the upper surface of the upper tool assembly and a reduction in the forming surface area that clamps the blanks solves the stated problem. In an exemplary embodiment, the concentrating forming surface allows for a ratio of the total bias pressure to the clamping pressure of between about 1:10 to 1:50, or between about 1:20 and 1:40, or about 1:30. That is, a total bias pressure is applied to a pressure surface and the resulting pressure at the clamping surface is between about 10 to 50, or between about 20 and 40, or about 30 times greater. Such ratios of total bias pressure to the clamping pressure allows for a reduction in the loading condition on the tooling and/or press and therefore solves the stated problem. Further, the use of a hybrid bias generating assembly prevents an excessive amount of uneven thinning and therefore solves the stated problem.

[0016] In an exemplary embodiment, an upper tool assembly piston includes a piston that is coupled to an upper pressure sleeve. The piston includes an upper side that is exposed to a pressure. The upper pressure sleeve includes a lower forming surface. The area ratio of the upper tool assembly piston upper side to the upper pressure sleeve lower forming surface is between about 10:1 to 50:1, 20:1 and 40:1, or about 30:1. A tool assembly with this area ratio solves the problems stated above. That is, as shown in Figure 12A and 12B, in the known art, the ratio of the area of the upper tool assembly piston upper side to the upper pressure sleeve lower forming surface is about 4:1. This ratio, compared to the disclosed concept, includes a smaller upper tool assembly piston upper side and a large upper pressure sleeve lower forming surface. It is noted that, in this configuration, the metal is not thinned, as discussed above. As shown in in Figure 13A and 13B, and in an exemplary embodiment, the ratio of the area of the upper tool assembly piston upper side to the upper pressure sleeve lower forming surface is about 30:1. An upper tool assembly having the configuration of the disclosed concept is a force concentrating, and/or pressure concentrating, forming surface that solves the stated problems.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] A full understanding of the disclosed concept can be gained from the following description of the preferred embodiments when read in conjunction with the accompanying drawings in which:

Figure 1 is a side elevation section view of a shell for a beverage can end, also showing a portion of a beverage can in simplified form in phantom line drawing;

Figure 2 is a side elevation section view of the shell of Figure 1, showing various thinning locations;

Figure 3 is a side elevation section view of tooling in accordance with an embodiment of the invention;

Figure 4 is a side elevation section view of a portion of the tooling of Figure 3;

Figure 5 is a side elevation section view of the portion of the tooling of Figure 4, modified to show the tooling in a different position, in accordance with a non-limiting example forming method of the disclosed concept;

Figures 6A-6E are side elevation views of consecutive forming stages for forming a shell;

Figure 7 is a side elevation section view of tooling in accordance with an alternate embodiment of the invention;

Figure 8 is a detail side elevation section view of pressure concentrating forming surface showing a prior art forming surface in ghost;

Figure 9 is a detail side elevation section view of pressure concentrating forming surface with three landings;

Figure 10 is a detail side elevation section view of pressure concentrating forming surface with five landings;

Figure 11 is a flow chart of a disclosed method;

Figure 12A is a schematic representation of the force, pressure, and selected component areas associated with the prior art wherein there is a 1:4 ratio of pressure on the upper piston to lower clamp surface pressure on material, Figure 12B is a partial cross-sectional side view of a prior art tooling capable of the 1:4 pressure ratio; and

Figure 13A is a schematic representation of the force, pressure, and selected component areas associated with the disclosed concept wherein there is a 1:30 ratio of pressure on the upper piston to lower clamp surface pressure on material, and Figure 13B is a partial cross-sectional side view of the tooling shown in Figure 3 and capable of the 1:30 pressure ratio.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] For purposes of illustration, embodiments of the disclosed concept will be described as applied to shells for a can end known in the industry as a "B64" end, although it will become apparent that they could also be employed to suitably selectively stretch and thin predetermined portions or areas of any known or suitable alternative type (e.g., without limitation, beverage/beer can ends; food can ends) and/or configuration other than B64 ends.

[0019] It will be appreciated that the specific elements illustrated in the figures herein and described in the following specification are simply exemplary embodiments of the disclosed concept, which are provided as non-limiting examples solely for the purpose of illustration.

[0020] Directional phrases used herein, such as, for example, clockwise, counterclockwise, left, right, top, bottom, upwards, downwards and derivatives thereof, relate to the orientation of the elements shown in the drawings and are not limiting upon the claims unless expressly recited therein.

[0021] As used herein, the singular form of "a," "an," and "the" include plural references unless the context clearly dictates otherwise.

[0022] As used herein, the statement that two or more parts or components are "coupled" shall mean that the parts are joined or operate together either directly or indirectly, *i.e.,* through one or more intermediate parts or components, so long as a link occurs. As used herein, "directly coupled" means that two elements are directly in contact with each other. It is noted that moving parts, such as but not limited to circuit breaker contacts, are "directly coupled" when in one position, e.g., the closed, second position, but are not "directly coupled" when in the open, first position. As used herein, "fixedly coupled" or "fixed" means that two components are coupled so as to move as one while maintaining a constant orientation relative to each other. Accordingly, when two elements are coupled, all portions of those elements are coupled. A description, however, of a specific portion of a first element being coupled to a second element, *e.g.,* an axle first end being coupled to a first wheel, means that the specific portion of the first element is disposed closer to the second element than the other portions thereof.

[0023] As used herein, the phrase "removably coupled" means that one component is coupled with another component in an essentially temporary manner. That is, the two components are coupled in such a way that the joining or separation of the components is easy and would not damage the components. For example, two components secured to each other with a limited number of readily accessible fasteners are "removably coupled" whereas two components that are welded together or joined by difficult to access fasteners are not "removably coupled." A "difficult to access fastener" is one that requires the removal of one or more other components prior to accessing the fastener wherein the "other component" is not an access device such as, but not limited to, a door.

[0024] As used herein, "operatively coupled" means that a number of elements or assemblies, each of which is movable between a first position and a second position, or a first configuration and a second configuration, are coupled so that as the first element moves from one position/configuration to the other, the second element moves between positions/configurations as well. It is noted that a first element may be "operatively coupled" to another without the opposite being true.

[0025] As used herein, a "coupling assembly" includes two or more couplings or coupling components. The components of a coupling or coupling assembly are generally not part of the same element or other component. As such, the components of a "coupling assembly" may not be described at the same time in the following description.

[0026] As used herein, a "coupling" or "coupling component(s)" is one or more component(s) of a coupling assembly. That is, a coupling assembly includes at least two components that are structured to be coupled together. It is understood that the components of a coupling assembly are compatible with each other. For example, in a coupling assembly, if one coupling component is a snap socket, the other coupling component is a snap plug, or, if one coupling component is a bolt, then the other coupling component is a nut.

[0027] As used herein, "correspond" indicates that two structural components are sized and shaped to be similar to each other and may be coupled with a minimum amount of friction. Thus, an opening which "corresponds" to a member is sized slightly larger than the member so that the member may pass through the opening with a minimum amount of friction. This definition is modified if the two components are to fit "snugly" together. In that situation, the difference between the size of the components is even smaller whereby the amount of friction increases. If the element defining the opening and/or the component inserted into the opening are made from a deformable or compressible material, the opening may even be slightly smaller than the component being inserted into the opening. With regard to surfaces, shapes, and lines, two, or more, "corresponding" surfaces, shapes, or lines have generally the same size, shape, and contours.

[0028] As used herein, and in the phrase "[x] moves between a first position and a second position corresponding to [y] first and second positions," wherein "[x]" and "[y]" are elements or assemblies, the word "correspond" means that when element [x] is in the first position, element [y] is in the first position, and, when element [x] is in the second position, element [y] is in the second position. It is noted that "correspond" relates to the final positions and does not mean the elements must move at the same rate or simultaneously. That is, for example, a hubcap and the wheel to which it is attached rotate in a corresponding manner. Conversely, a spring biased latched member and a latch release move at different rates. Thus, as stated above, "corresponding" positions mean that the elements are in the identified first positions at the same time, and, in the identified second positions at the same time.

[0029] As used herein, the statement that two or more parts or components "engage" one another shall mean that the elements exert a force or bias against one another either directly or through one or more intermediate elements or components. Further, as used herein with regard to moving parts, a moving part may "engage" another element during the motion from one position to another and/or may "engage" another element once in the described position. Thus, it is understood that the statements, "when element A moves to element A first position, element A engages element B," and "when element A is in element A first position, element A engages element B" are equivalent statements and mean that element A either engages element B while moving to element A first position and/or element A either engages element B while in element A first position.

[0030] As used herein, "operatively engage" means "engage and move." That is, "operatively engage" when used in relation to a first component that is structured to move a movable or rotatable second component means that the first component applies a force sufficient to cause the second component to move. For example, a screwdriver may be placed into contact with a screw. When no force is applied to the screwdriver, the screwdriver is merely "coupled" to the screw. If an axial force is applied to the screwdriver, the screwdriver is pressed against the screw and "engages" the screw. However, when a rotational force is applied to the screwdriver, the screwdriver "operatively engages" the screw and causes the screw to rotate.

[0031] As used herein, the word "unitary" means a component that is created as a single piece or unit. That is, a component that includes pieces that are created separately and then coupled together as a unit is not a "unitary" component or body.

[0032] As used herein, "structured to [verb]" means that the identified element or assembly has a structure that is shaped, sized, disposed, coupled and/or configured to perform the identified verb. For example, a member that is "structured to move" is movably coupled to another element and includes elements that cause the member to move or the member is otherwise configured to move in response to other elements or assemblies. As such, as used herein, "structured to [verb]" recites structure and not function. Further, as used herein, "structured to [verb]" means that the identified element or assembly is intended to, and is designed to, perform the identified verb. Thus, an element that is merely capable of performing the identified verb but which is not intended to, and is not designed to, perform the identified verb is not "structured to [verb]." As used herein, "associated" means that the elements are part of the same assembly and/or operate together, or, act upon/with each other in some manner. For example, an automobile has four tires and four hub caps. While all the elements are coupled as part of the automobile, it is understood that each hubcap is "associated" with a specific tire.

[0033] As used herein, in the phrase "[x] moves between its first position and second position," or, "[y] is structured to move [x] between its first position and second position," "[x]" is the name of an element or assembly. Further, when [x] is an element or assembly that moves between a number of positions, the pronoun "its" means "[x]," *i.e.* the named element or assembly that precedes the pronoun "its."

[0034] As employed herein, the terms "can" and "container" are used substantially interchangeably to refer to any known or suitable container, which is structured to contain a substance (e.g., without limitation, liquid; food; any other suitable substance), and expressly includes, but is not limited to, beverage cans, such as beer and soda cans, as well as food cans.

[0035] As employed herein, the term "can end" refers to the lid or closure that is structured to be coupled to a can, in order to seal the can.

[0036] As employed herein, the term "can end shell" is used substantially interchangeably with the term "can end." The "can end shell" or simply the "shell" is the member that is acted upon and is converted by the disclosed tooling to provide the desired can end.

[0037] As employed herein, the terms "tooling," "tooling assembly" and "tool assembly" are used substantially interchangeably to refer to any known or suitable tool(s) or component(s) used to form (e.g., without limitation, stretch) shells in accordance with the disclosed concept.

[0038] As employed herein, the term "fastener" refers to any suitable connecting or tightening mechanism expressly including, but not limited to, screws, bolts and the combinations of bolts and nuts (e.g., without limitation, lock nuts) and bolts, washers and nuts.

[0039] As employed herein, the term "number" shall mean one or an integer greater than one (i.e., a plurality).

[0040] Figures 1 and 2 show a can end shell 4 that is selectively formed. Specifically, as described in detail herein below, the material in certain predetermined areas of the shell 4, has been stretched, thereby thinning it, whereas other areas of the shell 4 preferably maintain the base metal thickness. Although the example shown and described herein refers to a shell (see, for example and without limitation, shell 4 of Figures 1-3, 5 and 6E) for a beverage can body 100 (partially shown in simplified form in phantom line drawing in Figure 1), it will be appreciated that the disclosed concept could be employed to stretch and thin any known or suitable can end shell type and/or configuration for any known or suitable alternative type of container (e.g., without limitation, food can (not shown)), which is subsequently further formed (e.g., converted) into a finished can end for such a container.

[0041] The shell 4 in the non-limiting example shown and described herein includes a circular center panel 6, which is connected by a substantially cylindrical panel wall 8 to an annular countersink 10. The example annular countersink 10 has a generally U-shaped cross-sectional profile. A tapered chuck wall 12 connects the countersink 10 to a crown 14, and a peripheral curl or outer lip 16 extends radially outwardly from the crown 14, as shown in Figures 1, 2 and 6E.

[0042] In the non-limiting example of Figure 2, the shell 4 has a base metal thickness of about 0.2083mm (.0082 inch). This base metal thickness is preferably substantially maintained in areas such as the center panel 6 and outer lip or curl 16. Keeping the center panel 6 in the base metal thickness helps with rivet, score and tab functions in the converted end (not explicitly shown). For example and without limitation, undesirable issues such as wrinkling and/or undesired scoreline and/or rivet or tab failures that can be attributed to reduced strength associated with thinned metal, are substantially eliminated by substantially maintaining the base thickness in the panel 6. Similarly, substantially maintaining the outer lip 16 at base gauge helps with the seaming ability, for seaming the lid or can end 4 to the can body 100 (partially shown in simplified form in phantom line drawing in Figure 1). This area where preferably minimal to no thinning occurs, is indicated generally in Figure 2 by reference 18.

[0043] Accordingly, the majority of the thinning (e.g., without limitation, between 5-20%, or about 10%, thinning) preferably occurs in the chuck wall 12. More specifically, thinning preferably occurs in the area between the crown 14 and the countersink 10, which is generally indicated as area 20 in Figure 2. Thus, by way of illustration, in the non-limiting example of Figure 2, the thickness of the material in the chuck wall 12 may be reduced to about 0.1880mm (.0074 inch). It will be appreciated that this is a substantial reduction, which results in significant weight reduction and cost savings over conventional can ends.

[0044] It will further be appreciated that the particular shell type and/or configuration and/or dimensions shown in Figure 2 (and all of the figures provided herein) are provided solely for purposes of illustration and are not limiting on the scope of the disclosed concept. That is, any known or suitable alternative thinning of the base gauge could be implemented in additional and/or alternative areas of the shell (e.g., without limitation, 4) for any known or suitable shell, or end type and/or configuration, without departing from the scope of the disclosed concept.

[0045] Moreover, the disclosed concept achieves material thinning and an associated reduction in the overall amount and weight of material, without incurring increased material processing charges associated with the stock material that is supplied to form the end product. For example and without limitation, increased processing (e.g., rolling) of the stock material to reduce the base gauge (i.e., thickness) of the material can undesirably result in a relatively substantial increase in initial cost of the material. The disclosed concept achieves desired thinning and reduction, yet uses stock material having a more conventional and, therefore, less expensive base gauge.

[0046] Figures 3-5 show various tooling assemblies 200 (or "tooling 200") for stretching and thinning the shell material, in accordance with one non-limiting example embodiment of the disclosed concept. Specifically, the selective forming (e.g., stretching and thinning) is accomplished by way of precise tooling geometry, placement and interaction. In accordance with one non-limiting embodiment, the process begins by introducing a blank of material (see, for example and without limitation, blank 2 of Figure 6A) having a base metal thickness or gauge, between components of a tooling assembly 200.

[0047] Figure 3 illustrates a single station 300, also known as a "pocket" 300, of a multiple station tooling assembly 200 coupled to a press 400. For example and without limitation, typically one shell 4 is produced at each station 300 during each stroke of a conventional high-speed single-action or double-action mechanical press 400 to which the multiple station tooling assembly 200 of the disclosed concept is coupled. The tooling assembly 200 includes opposing upper and lower tool assemblies 202, 204 that cooperate to form (e.g., without limitation, stretch; thin; bend) metal (see, for example and without limitation, metal blank 2 of Figure 6A) to achieve the desired shell (see, for example, and without limitation, shell 4 of Figures 1-3, 5 and 6E), in accordance with the disclosed concept.

[0048] More specifically, the upper and lower tool assemblies 202, 204 are coupled to upper and lower die shoes 206, 208, which are respectively supported by the press bed and/or bolster plates and the ram within the press 400 in a generally well known manner. An annular blank and draw die 210 includes an upper flange portion 212, which is coupled to a retainer or riser body 214 by a number of fasteners 216. The blank and draw die 210 surrounds an upper pressure sleeve 218. That is, the blank and draw die 210 is proximate to the upper pressure sleeve 218 and is located radially outward from the upper pressure sleeve 218. An inner die member or die center 220 is supported within the upper pressure sleeve 218 by a die center riser 222. The blank and draw die 210 includes an inner curved forming surface 224 (Figures 4 and 5). The lower end 227 of the upper pressure sleeve 218 includes a contoured annular forming surface 226 (Figures 4 and 5).

[0049] Continuing to refer to Figure 3, an annular die retainer 230 is coupled to the lower die shoe 208 within a counterbore 232. An annular cut edge die 234 is coupled to the die retainer 230 by suitable fasteners 236. An annular lower pressure sleeve 240 includes a lower piston portion 242 for movement within the die retainer 230. The lower pressure sleeve 240 further includes an upper end 244 having a substantially flat surface which opposes the lower end of the aforementioned blank and draw die 210. The cut edge die 234 is located proximate to the lower pressure sleeve 240 and radially outward from the upper end 244 of the lower pressure sleeve 240, as shown. A die core ring 250 is disposed within the lower pressure sleeve 240, and includes an upper end 252 that opposes the lower end or forming surface 226 of the upper pressure sleeve 218, as best shown in Figures 4 and 5. The upper end 252 includes a tapered surface 254, a rounded, or curvilinear, inner surface 256 and a rounded outer surface 258 (all shown in Figures 4 and 5). A circular panel punch 260 is disposed within the die core ring 250 opposite the aforementioned die center 220. The panel punch 260 includes a circular, substantially flat upper surface 262 having a peripheral rounded surface 264. A peripheral recessed portion 266 extends downwardly from the rounded surface 264, as best shown in Figures 4 and 5.

[0050] Accordingly, the foregoing tools of the upper tool assembly 202 and lower tool assembly 204 cooperate to form and, in particular, stretch and thin predetermined selected areas of, the shell 4, as will now be described in greater detail with respect to Figures 6A-6E, which illustrate the method and associated forming stages for forming the stretched and thinned shell 4.

[0051] Figure 6A shows a first forming step wherein a blank 2 is provided using the aforementioned tooling assembly 200 (Figures 3-5). More specifically, respective cut edges of the blank and draw die 210 and annular cut edge die 234 cooperate to cut (e.g., blank) the blank 2, for example, from a web or sheet of material. In a second step, shown in Figure 6B, the tooling 200 cooperates to make a first bend, namely bending the peripheral edges of the blank 2 downward, as shown. Next, in the forming step shown in Figure 6C, the outer portions of the blank 2 are further formed, as shown. This is achieved by the inner curved surface 224 of the blank and draw die 210 cooperating with the upper end 252 of the die core ring 250, and by the forming surface 226 of the upper pressure sleeve 218 cooperating with the upper end 252 of the die core ring 250.

[0052] Stretching and thinning in accordance with the aforementioned concept will be further described and understood with reference to the fourth forming step, illustrated in Figures 4 and 6D. Specifically, Figure 4 shows the tooling assembly 200 after a down stroke, wherein all of the tools shown have moved downward in the direction of arrows 410 to the positions shown. That is, the blank and draw die 210 and lower pressure sleeve 240 have moved downward in the direction of arrows 410 to further form the outer lip or curl 16. The upper pressure sleeve 218 has also moved downward in the direction of arrow 410, such that the forming surface 226 of the upper pressure sleeve 218 cooperates with the upper end 252 of the die core ring 250 to further form the crown 14, as shown. The die center 220, which also moves downward in the direction of arrow 410, stretches the metal of the blank 2 in the area of the chuck wall 12 as the substantially flat surface of the lower end of the die center 220 clamps the material between the die center 220 and the substantially flat upper surface 262 of the panel punch 260. The die center 220 and panel punch 260 both move downward in the direction of arrows 410 to stretch and thin the metal in the area of the chuck wall 12 as it cooperates with the tapered surface 254 of the die core ring 250. Thus, in the fourth forming step, the material of the blank 2 is stretched and thinned in the area that will become the chuck wall 12, but little to no stretching or thinning occurs in the outer lip or curl area 16, or in the area that will be later formed into the panel 6 (Figures 5 and 6E) or in the lower area that will be later formed into the annular countersink 10 (Figures 5 and 6E). These areas remain substantially at base gauge metal thickness, as previously discussed hereinabove.

[0053] In the fifth and final shell forming step, formation of the shell 4 is completed. Specifically, as shown in Figure 5, which illustrates the same tooling assembly 200 shown and described hereinabove with respect to the downward stroke of Figure 4, some of the tooling assembly 200 has moved upward in Figure 5 in the direction of arrows 420 to form the panel 6 of the shell 4. Specifically, the blank and draw die 210, die center 220, lower pressure sleeve 240, and panel punch 260 all move upward in the direction of arrow 420, whereas the upper pressure sleeve 218 has stopped moving downward in the direction of arrow 410 at this point and is holding pressure on the shell 4. This results in the further formation of the outer lip or curl 16 over the rounded outer surface 258 of the die core ring 250, as well as the further formation of the crown 14 between the forming surface 226 of the upper pressure sleeve 218 and the upper end 252 of the die core ring 250. The desired final form of the chuck wall 12 is provided by interaction of the upper pressure sleeve 218 and surfaces 254 and 256 of the die core ring 250. The panel 6 is formed by interaction of the substantially flat upper surface 262 of the panel punch 260 with the die center 220 as both of these components move upward in the direction of arrows 420 with the metal of the blank 2 that becomes the panel 6 disposed (e.g., clamped) therebetween. This movement also facilitates the formation of the cylindrical panel wall 8 and countersink 10. Specifically, as the panel punch 260 moves upward and the upper pressure sleeve 218 moves downward, the annular countersink 10 is formed within the peripheral recessed portion 266 of the panel punch 260. The cylindrical panel wall 8 is, therefore, formed as the metal cooperates with the peripheral rounded surface 264 of the panel punch 260.

[0054] Accordingly, it will be appreciated that the disclosed concept differs substantially from conventional shell forming methods and tooling, wherein the material of the blank 2 or shell 4 is not specifically stretched or thinned. That is, while the panel 6, countersink 10 and outer lip or curl 16 portions of the example shell 4 (Figures 1-3, 5 and 6E) are not stretched or are nominally stretched, the area 20 (Figure 2) between the countersink

10 and crown 14 is stretched and thinned during the forming process and, in particular in the fourth forming step shown in Figures 5 and 6D.

[0055] It will be appreciated that while five forming stages are shown in Figures 6A-6E, that any known or suitable alternative number and/or order of forming stages could be performed to suitably selectively stretch and thin material in accordance with the disclosed concept. It will further be appreciated that any known or suitable mechanism for sufficiently securing certain areas of the material to resist movement (e.g., sliding) or flow or thinning of the material while other predetermined areas of the material are stretched and thinned could be employed, without departing from the scope of the disclosed concept. Moreover, alternative, or additional, areas of the shell 4 (e.g., without limitation, 4) other than those which are shown and described herein could be suitably stretched and thinned, and the disclosed concept could be applied to stretch shells that are of a different type and/or configuration altogether (not shown).

[0056] Accordingly, it will be appreciated that the disclosed concept provides tooling assembly 200 (Figures 3-5) and methods for selectively stretching and thinning predetermined areas (see, for example and without limitation, area 20 of Figure 2) of a shell 4 (Figures 1-3, 5 and 6E), thereby providing relatively substantially material and cost savings.

[0057] Another embodiment is shown in Figure 7. Other than the elements discussed below, the tooling 200A is substantially similar to the tooling assembly 200 discussed above and like elements will use like reference numbers. As discussed above, and in an exemplary embodiment, the die core ring upper end 252 opposes the lower end or forming surface 226 of the upper pressure sleeve 218. As further described above, the outer portions of the blank 2 are formed by the forming surface 226 of the upper pressure sleeve 218 cooperating with the upper end 252 of the die core ring 250. That is, both the die core ring upper end 252 and the upper pressure sleeve forming surface 226 engage the blank 2. As used herein, simultaneous engagement by elements disposed in opposition to each other is identified as "clamping."

[0058] As noted above, the die core ring upper end 252 includes a tapered surface 254, a rounded inner surface 256 and a rounded outer surface 258. In an exemplary embodiment, the die core ring upper end 252 further includes a generally horizontal surface 257. As used herein, the "generally horizontal surface" 257 is that portion of the die core ring upper end that extends in a plane that is generally perpendicular to the axis of motion of the upper and lower tool assemblies 202, 204. As used herein, "generally perpendicular" means perpendicular +/- about 10 degrees.

[0059] In this exemplary embodiment, the upper tool assembly 202 and the lower tool 204 assembly move between a separated, first position, wherein the upper tool assembly 202 is spaced from the lower tool assembly 204, and a forming position, wherein the upper tool assembly 202 is immediately adjacent the lower tool assembly 204 to selectively stretch the material of at least one predetermined portion of the shell 4 relative to at least one other portion of the shell, thereby providing a corresponding thinned portion. When the upper tool assembly 202 and the lower tool 204 are in the forming position, the upper pressure sleeve 218 and the die core ring 250 clamp the shell 4, as described above. The force acting on the blank 2 is, as used herein, the "clamping force."

[0060] In this exemplary embodiment, the upper tool assembly 202 also includes a hybrid bias generating assembly 500 and the upper pressure sleeve forming surface 226 is a force concentrating forming surface 600. As used herein, a "hybrid bias generating assembly" is an assembly that generates a bias in at least two different manners, and, the bias is applied to the same component. That is, as used herein, a "hybrid bias generating assembly" includes at least two bias generating assemblies that apply bias to the same component as well as a number of hybrid components. Thus, an assembly, such as, but not limited to the hybrid bias generating assembly 500 described herein, which generates a bias via a compressed fluid (pressure bias) and via a spring (mechanical bias) satisfies the first requirement of being an active hybrid bias generating assembly. Conversely, a device with a high pressure compressor and a low pressure compressor (both producing pressure bias) is not a "hybrid bias generating assembly" because the manner of producing bias is the same. Further, an assembly wherein one type of bias is applied to one component and another type of bias is applied to a different component is also not an "hybrid bias generating assembly" because the bias is not applied to the same component.

[0061] Further, as used herein, an "active hybrid bias generating assembly" is an assembly that includes at least two bias generating assemblies that apply bias to the same component at the same time. Further, as used herein, a "selectable hybrid bias generating assembly" is an assembly that includes at least two bias generating assemblies, and, the bias is selectively applied to the same component. That is, in a "selectable hybrid bias generating assembly" has the capability of applying bias in at least two different manners and the user determines which bias generating assembly, or both, apply bias to a component. Thus, when a user selects two manners of applying bias, the "selectable hybrid bias generating assembly" operates as an "active hybrid bias generating assembly." Stated alternately, an "active hybrid bias generating assembly" is a type of "selectable hybrid bias generating assembly" but the opposite is not always true. That is, not all "selectable hybrid bias generating assemblies" are "active hybrid bias generating assemblies." A "selectable hybrid bias generating assembly" that applies bias in only one of several available manners is a "selectable hybrid bias generating assembly" but not an "active hybrid bias generating assembly." In an exemplary embodiment, the hybrid bias generating assembly 500 is one of an active hybrid bias generating assembly 502 or a selectable hybrid bias generating assembly 504.

[0062] The hybrid bias generating assembly 500 includes a pressure generating assembly 510, a mechanical bias assembly 550, and a number of hybrid components 570. As used herein, "hybrid components" 570 are components that are structured to be utilized by both bias generating assemblies, in the exemplary embodiment, the pressure generating assembly 510 and the mechanical bias assembly 550. The pressure generating assembly 510 includes a pressure generating device 512 (shown schematically), a pressure communication assembly 514 (shown schematically), a pressure chamber 516, and a piston assembly 518. The pressure generating device 512 is any known device structured to compress a fluid, or store compressed fluid, at an increased pressure, such as, but not limited to a fluid pump or compressor. The pressure communication assembly 514 includes any number of hoses, conduits, passages or any other construct capable of communicating a pressurized fluid. It is understood the pressure communication assembly 514 also includes seals, valves or any other construct required to control the communication of a pressurized fluid.

[0063] In an exemplary embodiment, the riser body 214 is sealingly coupled, directly coupled, or fixed to the upper die shoe 206. In this configuration, the riser body 214 defines the pressure chamber 516. It is understood that the pressure chamber 516 includes a number of seals, not identified, required to prevent fluid from escaping. The piston assembly 518 includes a torus-shaped body 520 and, in an exemplary embodiment, a spring seat 554, as discussed below. In another embodiment, not shown, the piston body and the spring seat are a unitary body. It is understood that the description of the piston body 520 applicable to the spring seat 554 is an embodiment that includes a spring seat 554. For example, the piston body 520 corresponds to the pressure chamber 516 and the die center riser 222; it is understood that in an embodiment with a spring seat 554 the spring seat 554 corresponds to the pressure chamber 516 and the die center riser 222. Thus, the outer radial surface of the piston body 520, or the spring seat 554, is sealingly coupled to the inner surface of the pressure chamber 516, and, the inner radial surface of the piston body 520 is sealingly coupled to the outer surface of the die center riser 222. It is understood that the piston assembly 518 includes a number of seals, not identified, required to prevent fluid from escaping the pressure chamber 516. The piston assembly 518 is movably disposed in the pressure chamber 516.

[0064] The pressure generating device 512 is in fluid communication, via the pressure communication assembly 514, with the pressure chamber 516. The fluid, and therefore the pressure associated therewith, is communicated to the upper side of the piston body 520, hereinafter the "pressure surface" 521. It is understood that, in an embodiment with a spring seat 554, the pressure surface 521 may be the upper surface of the spring seat 554. In an exemplary embodiment, the total bias force is applied to the pressure surface 521 which has an area of between about 22.32cm^2 (3.46 in^2) to 111.61cm^2 (17.3 in^2), or about 66.97cm^2 (10.38 in^2). Thus, the pressure generating device 512 is structured to control the position of the piston assembly 518 in the pressure chamber 516, and is structured to move the piston assembly 518 in the pressure chamber 516. The piston assembly 518 is coupled to the upper pressure sleeve 218. That is, the upper pressure sleeve 218 includes an upper end 225 opposite the forming surface 226. The piston assembly 518 is coupled to the upper pressure sleeve upper end 225. Thus, as the piston assembly 518 moves within the pressure chamber 516, the upper pressure sleeve 218 moves between an extended, first position, wherein the upper pressure sleeve lower end 227 is more spaced from the upper die shoe 206, and a retracted, second position, wherein the upper pressure sleeve lower end 227 is less spaced from the upper die shoe 206.

[0065] **In** this configuration, the piston assembly 518 and the piston body 520 are "hybrid components" 570 as defined herein. That is, the piston assembly 518 and the piston body 520 are structured to be utilized by both the pressure generating assembly 510 and the mechanical bias assembly 550. It is noted that a piston associated exclusively with a pressure generating assembly 510 or exclusively with a mechanical bias assembly 550 cannot be a "hybrid component" as defined herein. That is, by definition, a piston assembly 518 associated exclusively with a pressure generating assembly 510 cannot be "structured to" be utilized by both bias generating assemblies. Similarly, by definition, a piston assembly 518 associated exclusively with a mechanical bias assembly 550 cannot be "structured to" be utilized by both bias generating assemblies. Accordingly, a piston associated exclusively with a pressure generating assembly 510 or exclusively with a mechanical bias assembly 550 is not a "hybrid component" as used herein.

[0066] In an exemplary embodiment, the mechanical bias assembly 550 includes a number of spring assemblies 552 and a number of spring seats 554. A spring assembly 552 includes a number of springs 560 associated with each spring seat 554. In one embodiment, each spring assembly 552 includes a single, linear spring rate compression spring 560. In this embodiment, the mechanical bias assembly 550 is structured to, and does, apply a bias at a generally linear rate during the compression of the spring assemblies 552.

[0067] In another exemplary embodiment, each spring assembly 552 includes a number of springs 560 that have a variable spring rate. (It is understood that reference number 560 represents a "spring" rather than a specific type of spring.) The variable spring rate may be any of a progressive spring rate, a degressive spring rate, or a dual rate (sometime identified as "progressive with knee") spring rate. As used herein, a "progressive spring rate" is a spring rate that increases in compression in a non-linear manner. As used herein, a "degressive spring rate" is a spring rate that decreases in compression in a non-linear manner. As used herein, a "dual rate" spring rate is a spring rate that increases at a first linear, or generally linear, spring rate until a selected compression is achieved and thereafter the spring rate increases at a different second linear, or generally linear, spring rate. That is, the first and second spring rates are substantially different from each other. Variable rate springs include, but are not limited to, cylindrical springs with a variable pitch rate, conical springs, and mini block springs.

[0068] In one exemplary embodiment, all spring assemblies 552 include substantially the same type of spring 560. that is, for example, each spring assembly 552 includes a number of substantially similar linear spring rate compression springs 560, or, a number of substantially similar dual rate compression springs 560. In another exemplary embodiment, the spring assemblies 552 include different types of springs. For example, within the mechanical bias assembly 550, one set of spring assemblies 552 include a number of substantially similar linear spring rate compression springs 560, and, a second set includes a number of substantially similar dual rate compression springs 560. In another exemplary embodiment, the variable rate spring assemblies 552 may include any of a number of dual rate springs, a plurality of springs with different compression rates, a number of progressive springs, a number of degressive springs, or a combination of any of these .

[0069] In an exemplary embodiment, compression springs 560 are disposed in the pressure chamber 516. In this embodiment, at least a lower spring seat 554' is a torus-shaped body 562 that corresponds to the pressure chamber 516 and the die center riser 222. The lower spring seat 554' is coupled, directly coupled, fixed, or unitary with, the upper side of the piston body 520. The compression springs 560 are sized to be in compression when disposed in the pressure chamber 516. In this configuration, the mechanical bias assembly 550 biases, *i.e.* operatively engages, the piston assembly 518 and therefore the upper pressure sleeve 218. That is, the upper pressure sleeve 218 is biased to its first position.

[0070] In one exemplary embodiment, wherein the pressure concentrating forming surface 600, described below, has an area of about 2.23 cm^2 (0.346 in^2), the total bias pressure is a force of between about 31 kN (7,000 lbfs) and 40kN (9,000 lbfs), or about 35kN (8,000 lbfs) acting on the pressure surface 521, which has an area of between about 22.32cm^2 (3.46 in^2) to 111.61cm^2 (17.3 in^2), between about 44.65cm^2 (6.92 in^2) to 89.29cm^2 (13.84 in^2), or about 66.97cm^2 (10.38 in^2). Alternatively; in an embodiment wherein the pressure surface 521 has an area of about 66.97cm^2 (10.38 in^2), the pressure concentrating forming surface 600, described below, has an area of between about 6.70cm^2 (1.038 in^2) to 1.34cm^2 (0.208 in^2), between about 3.35cm^2 (0.519 in^2) to 1.674cm^2 (0.2595 in^2), or about 2.23cm^2 (0.346 in^2).. That is, the force/pressure is concentrated by a ratio of between about 1:10 to 1:50, or between about 1:20 and 1:40, or about 1:30.

[0071] In an exemplary embodiment, a multiple station tooling assembly 200 is coupled to a press 400, *i.e.* a one hundred ton press, as noted above. The multiple station tooling assembly 200 includes twenty-four stations or pockets 300. In an embodiment wherein about 35kN (8,000 lbfs) acts on each pressure surface 521, *i.e.* on twenty-four pressure surfaces 521, the total load is about 35.4kN (8,000 lbfs) * 24 (pockets) = 850kN (192,000 lbfs). About 850kN (192,000 lbfs) is about 85Tonnes (96 tons (192,000 lbfs/2000)). Thus, the upper tool assembly 202 with a hybrid bias generating assembly 500 in the configuration described herein solves the stated problem of being usable with existing presses and includes a force concentrating forming surface 600 that is structured to operate with existing 90Tonne (one hundred ton presses).

[0072] The total bias/force generated by the hybrid bias generating assembly 500 can also be expressed as a "total bias pressure." As used herein, the "total bias pressure" means the total bias/pressure generated by the hybrid bias generating assembly 500, and therefore the upper tool assembly 202. Further, the mechanical bias assembly 550 creates a force which, as used herein, is considered to be evenly distributed over the pressure surface 521. That is, the mechanical force may be treated as a pressure for purposes of calculating the forces and pressure acting on the components. In an exemplary embodiment, the mechanical bias assembly 550 generates between about 70%-80%, or about 75%, of the total bias pressure. Conversely, the pressure generating assembly 510 generates between about 20%-30%, or about 25%, of the total bias pressure. The force/pressure generated by the pressure generating device 512 acts upon the pressure surface 521. In an exemplary embodiment, wherein the pressure surface 521 has an area of about 10.38 in^2, the hybrid bias generating assembly 500 generates a pressure of between about 4650 kPa (674.4 psi) and about 5978 kPa (867.1 psi), or about 5314kPa (770.7 psi). Further, in an exemplary embodiment wherein the mechanical bias assembly 550 generates about 75%, of the total bias pressure and the pressure generating assembly 510 generates about 25%, of the total bias pressure, the mechanical bias assembly 550 generates a pressure between about 3487kPa (505.8 psi) and about 4484kPa (650.3 psi), or about 3985 kPa (578.0 psi), and, the pressure generating assembly 510 generates a pressure between about 1162kPa (168.6 psi) and about 1495kPa (216.8 psi), or about 1329kPa (192.7 psi). Further, the pressure generating assembly 510 is structured to pressurize the pressure chamber 516 at a generally constant pressure.

[0073] In an alternate exemplary embodiment, the hybrid bias generating assembly 500 is structured to have substantially all, or all, of the total bias pressure generated by the mechanical bias assembly 550 with the pressure generating assembly 510 generating a generally constant, but generally minimal pressure. That is, in this embodiment, the mechanical bias assembly 550 generates between about 90%-99%, or about 95%, of the total bias pressure. Conversely, the pressure generating assembly 510 generates between about 1%-10%, or about 5%, of the total bias pressure. Further, the pressure generating assembly 510 is structured to pressurize the pressure chamber 516 at a generally constant pressure. In this embodiment, the hybrid bias generating assembly 500 is an active hybrid bias generating assembly 502.

[0074] Further, in this embodiment, the hybrid bias generating assembly 500 is structured to alter the ratio of force generated by the mechanical bias assembly 550 and the pressure generating assembly 510. That is, for example, during an initial clamping operation, the total bias pressure is substantially generated by the mechanical bias assembly 550, *i.e.* the mechanical bias assembly 550 generates between about 90%-100%, or about 99%, of the total bias pressure, and, the pressure generating assembly 510 generates between about 0%-10%, or about 5%, of the total bias pressure. After the initial clamping operation, *i.e.* during a secondary clamping operation, the total bias pressure generated by the mechanical bias assembly 550 is reduced to be greater than, or equal to, 75% of the total bias pressure while the pressure generating assembly 510 generates up to 25%, of the total bias pressure.

[0075] In an alternative embodiment, the hybrid bias generating assembly 500 is a selectable hybrid bias generating assembly 504 wherein the user selects the source that generates the pressure, *i.e.* either the mechanical bias assembly 550 or the pressure generating assembly 510. In this embodiment, the mechanical bias assembly 550 generates between about 99%-100%, or substantially all of the total bias pressure. Conversely, the pressure generating assembly 510 generates between about 0%-1%, or a negligible percentage of the total bias pressure. That is, for example, the pressure generating assembly 510 generates a negligible percentage of the total bias pressure while generating enough pressure to bias elements of the upper tool assembly 202 downwardly during the upstroke. As before, the pressure generating assembly 510 is, in an exemplary embodiment, structured to pressurize the pressure chamber 516 at a generally constant pressure.

[0076] In another embodiment, the hybrid bias generating assembly 500 is again a selectable hybrid bias generating assembly 504 wherein the user selects the source that generates the pressure, *i.e.* either the mechanical bias assembly 550 or the pressure generating assembly 510. In this embodiment, however, the pressure generating assembly 510 generates between about 99%-100%, or substantially all of the total bias pressure. Conversely, the mechanical bias assembly 550 generates between about 0%-1%, or a negligible percentage of the total bias pressure. That is, for example, the mechanical bias assembly 550 generates a negligible percentage of the total bias pressure while generating enough pressure to bias elements of the upper tool assembly 202 downwardly during the upstroke. As before, the pressure generating assembly 510 is, in an exemplary embodiment, structured to pressurize the pressure chamber 516 at a generally constant pressure.

[0077] In this embodiment, the pressure generating assembly 510 is structured to apply a variable pressure. That is, the pressure generating assembly 510 includes a pressure control assembly 530 (shown schematically) that is structured to vary the pressure within the pressure chamber 516. The pressure control assembly 530 in an exemplary embodiment, includes a number of pressure sensors (not shown) in the pressure chamber 516 as well as a position sensor (not shown) structured to determine the position of the piston assembly 518. The pressure control assembly 530 is structured to alter the pressure within the pressure chamber 516 according to a pressure profile. That is, the pressure control assembly 530 is structured to increase or decrease the pressure within the pressure chamber 516 depending upon the position of the piston assembly 518. In an exemplary embodiment, the pressure control assembly 530 includes a programmable logic circuit (PLC)(not shown) and a number of electronic pressure regulators. The sensors and electronic pressure regulators are coupled to, and in electronic communication with, the PLC. The PLC further includes instructions for operating the electronic pressure regulators as well as data representing the pressure profile.

[0078] In an exemplary embodiment, the hybrid bias generating assembly 500 is structured to be switchable between an active hybrid bias generating assembly 502 or a selectable hybrid bias generating assembly 504, or switchable between different configurations of either an active hybrid bias generating assembly 502 or a selectable hybrid bias generating assembly 504, by virtue of removable springs 552. That is, the springs 552 are removably coupled to the spring seats 554 within the pressure chamber 516.

[0079] It is noted that, in another embodiment, the upper tool assembly 202 does not include a hybrid bias generating assembly 500, but rather one of a mechanical bias assembly 550 or a pressure generating assembly 510 wherein the selected assembly provides 100% of the total bias pressure. The mechanical bias assembly 550 or the pressure generating assembly 510 is coupled to a "pressure concentrating forming surface" 600 as discussed below. That is, the mechanical bias assembly 550 or the pressure generating assembly 510 is coupled to the other elements described herein.

[0080] As noted above, the upper pressure sleeve forming surface 226 is a pressure concentrating forming surface 600. As used herein, a "pressure concentrating forming surface" 600 is a forming surface that engages a reduced area of the blank 2 relative to prior art forming surfaces. That is, prior art forming surfaces clamped the blank 2 disposed over the die core ring upper end's 252 rounded inner surface 256, generally horizontal surface 257 and, in some configurations, the rounded outer surface 258. As used herein, a "pressure concentrating forming surface" 600 is a forming surface that engages a limited portion of the surfaces of die core ring upper end 252, or a limited portion of a crown 14 disposed between the pressure concentrating forming surface 600 and the die core ring upper end 252. That is, a surface that does not "clamp" the blank cannot be part of the "pressure concentrating forming surface" 600. The limited area, in one exemplary embodiment wherein the blank is generally circular, is a radially contiguous annular reduced clamp area. As used herein, a "reduced clamp area" is a radially contiguous annular area extending over a portion of the die core ring upper end's 252 generally horizontal surface 257, but does not extend over the die core ring upper end's 252 rounded inner surface 256. Further, as used herein, a "diminished clamp area" is a radially contiguous annular area extending over about 25-75% of the die core ring upper end's 252 generally horizontal surface 257, but does not extend over the die core ring upper end's 252 rounded inner surface 256. That is, in the known art, the forming surface was generally planar and the entire surface, *i.e*. 100%, engaged the die core ring upper end 252 and acted as a clamp area, whereas the presently disclosed force concentrating forming surface 600 includes a reduced clamp area.

[0081] In another exemplary embodiment, shown in Figures 9 and 10, the pressure concentrating forming surface 600 includes a plurality of "landings" 610. As used herein, a "landing" is a limited area of the upper pressure sleeve forming surface 226. In an exemplary embodiment, the pressure concentrating forming surface plurality of landings 610 includes between two and five substantially concentric landings 610A, 610B, 610C, 610D, 610E. That is, in an exemplary embodiment, the lower end of the upper pressure sleeve 218 includes an annular, *i.e.* generally circular, forming surface 226. The plurality of landings 610 are concentric portions of the annular forming surface 226 which clamp the blank 2. That is, only the landings 610 engage the blank 2. The areas between the landings 610 are upwardly offset relative to the landings 610 so that these areas do not engage the blank 2. Stated alternately, in an exemplary embodiment, there are concentric grooves 612 between the landings 610.

[0082] As shown in Figure 7, the upper pressure sleeve forming surface 226 has a cross-sectional area that is much smaller than the cross-sectional area of the piston assembly 518 and/or the lower spring seat 554'. In this configuration, the pressure/area applied to the blank 2 by the upper pressure sleeve forming surface 226 is greater than the pressure/area acting on the piston assembly 518 and/or the lower spring seat 554'. That is, while the bias/force remains constant, the area upon which the bias/force acts is greater at the piston assembly 518 and/or the lower spring seat 554' compared to the area at the upper pressure sleeve forming surface 226. Thus, as the area at the upper pressure sleeve forming surface 226 is smaller, the pressure per unit of area is greater.

[0083] The increase in pressure per a unit of area is greater for a pressure concentrating forming surface 600. That is, the area of a pressure concentrating forming surface 600, as defined herein, is even smaller than the area upper pressure sleeve forming surface 226. In an exemplary embodiment, using a pressure concentrating forming surface 600, the ratio of the total bias pressure to the clamping pressure is between about 1:10 to 1:50 or between about 1:20 and 1:40, or about 1:30.

[0084] In this configuration, the clamping pressure is, in an exemplary embodiment, about at the elastic limit of the material being deformed. Moreover, in an exemplary embodiment, the material being deformed has a "thinning limit." That is, as used herein, a "thinning limit" is the elastic limit of the material while under compression. That is, a material under compression may be placed under tension that exceeds the elastic limit of the material without tearing the material. Thus, as used herein, the "thinning limit" is pressure that allows the material to thin by about 10% without tearing. The exemplary measurements above, *e.g.* the area of pressure surface 521, are for a tooling assembly 200 working on aluminum that is initially about 0.2083mm (0.0082 inch thick). The pressure concentrating forming surface 600 is structured to generate a clamping pressure that is about at the thinning limit of aluminum and to thin the aluminum so that the thickness of the material in the chuck wall 12 may be reduced to a thickness of about 0.1880mm (.0074 inch).

[0085] Accordingly, as shown in Figure 11, use of the tooling assembly 200A described above includes introducing 1000 material between tooling assembly 200A, generating 1002 a total bias force within the tooling assembly 200A, clamping 1004 the material between an upper tool assembly 202 and a lower tool assembly 204, forming 1006 the material to include a center panel, a circumferential chuck wall, an annular countersink between the center panel and the circumferential chuck wall, and a curl extending radially outwardly from the chuck wall, and selectively stretching 1008 at least one predetermined portion of the shell relative to at least one other portion of the shell to provide a corresponding thinned portion of the shell.

[0086] It is noted that the method and assemblies for thinning a shell disclosed herein may also be used to thin the metal thickness on a can body, a can end and/or dome as well as on a cup, *i.e.* a precursor construct for a can body.

[0087] While specific embodiments of the disclosed concept have been described in detail, it will be appreciated by those skilled in the art that various modifications and alternatives to those details could be developed in light of the overall teachings of the disclosure without departing from the scope of the appended claims.

Claims

1. Tooling (200A) for forming a shell (4), the tooling (200A) comprising:

   an upper tool assembly (202) including an upper pressure sleeve (218);
   the upper pressure sleeve (218) including a lower end (227);
   a lower tool assembly (204) including a die core ring (250);
   the die core ring (250) including an upper end (252), the die core ring upper end (252) disposed in opposition to the upper pressure sleeve lower end (227), and the die core ring upper end (252) including an inner, tapered surface (254), a rounded inner surface (256), a generally horizontal surface (257) and a rounded outer surface (258);
   the lower tool assembly (204) cooperating with the upper tool assembly (202) to form material disposed therebetween to include a center panel (6), a circumferential chuck wall (12), an annular countersink (10) between the center panel (6) and the circumferential chuck wall (12), and a curl (16) extending radially outwardly from the chuck wall (12); and
   wherein the upper tool assembly (202) and the lower tool assembly (204) move between a separated, first position, wherein the upper tool assembly (202) is spaced from the lower tool assembly (204), and a forming position, wherein the upper tool assembly (202) is immediately adjacent the lower tool assembly (204) to selectively stretch the material of at least one predetermined portion of the shell (4) relative to at least one other portion of the shell (4), thereby providing a corresponding thinned portion,
   charaterised in that
   the lower end (227) defines a pressure concentrating forming surface (600) that engages said material when the upper tool assembly (202) and the lower tool assembly (204) are in the forming position, the pressure concentrating forming surface (600) is disposed in opposition to a portion of the die core ring generally horizontal surface (257) but does not extend over the die core ring upper end's (252) rounded inner surface (256).

2. The tooling (200A) of claim 2 wherein the pressure concentrating forming surface (600) includes a diminished clamp area, wherein the diminished clamp area is a radially contiguous annular area extending over about 25-75% of the die core ring upper end's 252 generally horizontal surface 257.

3. The tooling (200A) of claim 2 wherein the pressure concentrating forming surface (600) includes a plurality of landings (610), wherein each landing is a limited area of the upper pressure sleeve forming surface (226).

4. The tooling (200A) of claim 3 wherein the pressure concentrating forming surface plurality of landings (610) includes between two and five substantially concentric landings (610A-610E).

5. The tooling (200A) of claim 1 wherein:

   the upper tool assembly (202) includes an upper die shoe (206), a riser body (214), and a hybrid bias generating assembly (500);
   the riser body (214) coupled to the die shoe (206), the riser body (214) defining a pressure chamber (516);
   the upper pressure sleeve (218) movably disposed in the riser body pressure chamber (516);
   the upper pressure sleeve (218) movable between an extended, first position, wherein the upper pressure sleeve lower end (227) is more spaced from the upper die shoe (206), and a retracted, second position, wherein the upper pressure sleeve lower end (227) is less spaced from the upper die shoe (206);
   the hybrid bias generating assembly (500) operatively coupled to the upper pressure sleeve (218); and
   wherein the hybrid bias generating assembly (500) controls the movement of the upper pressure sleeve (218) as the upper tool assembly (202) and the lower tool assembly (204) move between the first and forming positions.

6. The tooling (200A) of claim 5 wherein the hybrid bias generating assembly (500) includes a pressure generating assembly (510) a mechanical bias assembly (550), and a number of hybrid components (570).

7. The tooling (200A) of claim 5 wherein the hybrid bias generating assembly (500) is an active hybrid bias generating assembly (502).

8. The tooling (200A) of claim 6 wherein:

   the pressure generating assembly (510) is structured to pressurize the pressure chamber (516); and
   the mechanical bias assembly (550) includes a number of springs (552).

9. The tooling (200A) of claim 8 wherein the number of springs (552) are disposed within the pressure chamber (516).

10. The tooling (200A) of claim 8 wherein:

the hybrid bias generating assembly (500) generates a total bias force as the upper tool assembly (202) and the lower tool assembly (204) move between the first and second positions; wherein the pressure generating assembly (510) generates between about 20%-30% of the total bias force; and wherein the mechanical bias assembly (550) generates between about 70%-80% of the total bias force, wherein:

the pressure generating assembly (510) generates about 25% of the total bias force; and the mechanical bias assembly (550) generates about 75% of the total bias force.

11. The tooling (200A) of claim 8 wherein:

the hybrid bias generating assembly (500) generates a total bias force as the upper tool assembly (202) and the lower tool assembly (204) move between the first and forming, positions; wherein the total bias force is communicated through the upper pressure sleeve (218) to the pressure concentrating forming surface (600); wherein the pressure concentrating forming surface (600) is structured to apply a clamping force to a work piece; and wherein the ratio of the total bias force to the clamping force is between about 20:1 and 40:1.

12. The tooling (200A) of claim 1 wherein;

the upper tool assembly (202) generates a total bias force as the upper tool assembly (202) and the lower tool assembly (204) move between the first and forming positions; wherein the total bias force is communicated through the upper pressure sleeve (218) to the pressure concentrating forming surface (600); wherein the pressure concentrating forming surface (600) is structured to apply a clamping force to a work piece; and wherein the ratio of the total bias force to the clamping force is between about 20:1 and 40:1.

Patentansprüche

1. Werkzeug (200A) zum Ausbilden einer Hülle (4), wobei das Werkzeug (200A) Folgendes umfasst:

eine obere Werkzeuganordnung (202), die eine obere Druckhülse (218) beinhaltet; wobei die obere Druckhülse (218) ein unteres Ende (227) beinhaltet;
eine untere Werkzeuganordnung (204), die einen Formwerkzeugkernring (250) beinhaltet;
wobei der Formwerkzeugkernring (250) ein oberes Ende (252) beinhaltet, wobei das obere Ende (252) des Formwerkzeugkernrings gegenüberliegend zum unteren Ende (227) der oberen Druckhülse angeordnet ist und das obere Ende (252) des Formwerkzeugkernrings eine innere, verjüngte Fläche (254), eine gerundete Innenfläche (256), eine im Wesentlichen horizontale Fläche (257) und eine gerundete Außenfläche (258) umfasst;
wobei die untere Werkzeuganordnung (204) mit der oberen Werkzeuganordnung (202) zusammenwirkt, um dazwischen angeordnetes Material zu formen, um eine Mittelwand (6), eine Umfangsspannwand (12) eine ringförmige Versenkung (10) zwischen der Mittelwand (6) und der Umfangsspannwand (12) und eine Umbiegung (16), die sich radial von der Umfangsspannwand (12) nach außen erstreckt, zu beinhalten; und
wobei die obere Werkzeuganordnung (202) und die untere Werkzeuganordnung (204) sich zwischen einer getrennten, ersten Position, in der die obere Werkzeuganordnung (202) von der unteren Werkzeuganordnung (204) beabstandet ist, und einer Formungsposition, in der die obere Werkzeuganordnung (202) unmittelbar benachbart zur unteren Werkzeuganordnung (204) ist, bewegen, um das Material von zumindest einem vorbestimmten Abschnitt der Hülle (4) relativ zu zumindest einem anderen Abschnitt der Hülle (4) zu strecken, wodurch ein entsprechender verdünnter Abschnitt bereitgestellt wird,
dadurch gekennzeichnet, dass
das untere Ende (227) eine druckkonzentrierende Formungsoberfläche (600) definiert, welche mit dem Material in Eingriff gelangt, wenn die obere Werkzeuganordnung (202) und die untere Werkzeuganordnung (204) sich in der Formungsposition befinden, wobei die druckkonzentrierende Formungsoberfläche (600) zu einem Abschnitt der im Wesentlichen horizontalen Fläche (257) des Formwerkzeugkernrings gegenüberliegend angeordnet ist, sich aber nicht über die gerundete Innenfläche (256) des oberen Endes (252) des Formwerkzeugkernrings erstreckt.

2. Werkzeug (200A) nach Anspruch 2, wobei die druckkonzentrierende Formungsoberfläche (600) einen verkleinerten Klemmbereich aufweist, wobei der verkleinerte Klemmbereich ein radial zusammenhängender ringförmiger Bereich ist, der sich über etwa 25-75 % der im Allgemeinen horizontalen Fläche (257) des oberen Endes (252) der Formwerkzeugkernrings erstreckt.

3. Werkzeug (200A) nach Anspruch 2, wobei die druckkonzentrierende Formungsoberfläche (600) eine Vielzahl von Anlagebereichen (610) umfasst, wobei jeder Anlagebereich ein begrenzter Bereich der Formungsoberfläche (226) der oberen Druckhülse ist.

4. Werkzeug (200A) nach Anspruch 3, wobei die Vielzahl von Anlagebereichen (610) der druckkonzentrierenden Formungsoberfläche zwischen zwei und fünf im Wesentlichen konzentrische Anlagebereiche (610A-610E) umfasst.

5. Werkzeug (200A) nach Anspruch 1, wobei:

die obere Werkzeuganordnung (202) eine obere Kopfplatte (206), einen Stufenkörper (214) und eine hybride Vorspannungserzeugungsanordnung (500) umfasst;
der Stufenkörper (214) mit der Kopfplatte (206) gekoppelt ist, wobei der Stufenkörper (214) eine Druckkammer (516) definiert;
die obere Druckhülse (218) beweglich in der Druckkammer (516) des Stufenkörpers angeordnet ist;
die obere Druckhülse (218) zwischen einer ausgefahrenen, ersten Position, in der das untere Ende (227) der oberen Druckhülse weiter von der oberen Kopfplatte (206) beabstandet ist, und einer eingefahrenen, zweiten Position, in der das untere Ende (227) der oberen Druckhülse weniger von der oberen Kopfplatte (206) beabstandet ist, bewegbar ist;
die hybride Vorspannungserzeugungsanordnung (500) mit der oberen Druckhülse (218) wirkgekoppelt ist; und
wobei die hybride Vorspannungserzeugungsanordnung (500) die Bewegung der oberen Druckhülse (218) steuert, während die obere Werkzeuganordnung (202) und die untere Werkzeuganordnung (204) sich zwischen der ersten und der Formungsposition bewegen.

6. Werkzeug (200A) nach Anspruch 5, wobei die hybride Vorspannungserzeugungsanordnung (500) eine Druckerzeugungsanordnung (510), eine mechanische Vorspannungsanordnung (550) und eine Anzahl von hybriden Komponenten (570) umfasst

7. Werkzeug (200A) nach Anspruch 5, wobei die hybride Vorspannungserzeugungsanordnung (500) eine aktive hybride Vorspannungserzeugungsanordnung (502) ist.

8. Werkzeug (200A) nach Anspruch 6, wobei:

die Druckerzeugungsanordnung (510) strukturiert ist, um die Druckkammer (516) mit Druck zu beaufschlagen; und
die mechanische Vorspannungsanordnung (550) eine Anzahl von Federn (552) umfasst.

9. Werkzeug (200A) nach Anspruch 8, wobei die Anzahl von Federn (552) innerhalb der Druckkammer (516) angeordnet ist.

10. Werkzeug (200A) nach Anspruch 8, wobei:

die hybride Vorspannungserzeugungsanordnung (500) eine Gesamtvorspannkraft erzeugt, während sich die obere Werkzeuganordnung (202) und die untere Werkzeuganordnung (204) zwischen der ersten und der zweiten Position bewegen;
wobei die Druckerzeugungsanordnung (510) zwischen etwa 20 % und 30 % der Gesamtvorspannkraft erzeugt; und
wobei die mechanische Vorspannungsanordnung (550) zwischen etwa 70 % und 80 % der Gesamtvorspannkraft erzeugt,
wobei:

die Druckerzeugungsanordnung (510) etwa 25 % der Gesamtvorspannkraft erzeugt; und
die mechanische Vorspannungsanordnung (550) etwa 75 % der Gesamtvorspannkraft erzeugt.

11. Werkzeug (200A) nach Anspruch 8, wobei:

die hybride Vorspannungserzeugungsanordnung (500) eine Gesamtvorspannkraft erzeugt, während sich die obere Werkzeuganordnung (202) und die untere Werkzeuganordnung (204) zwischen der ersten und der Formungsposition bewegen;
wobei die Gesamtvorspannkraft über die obere Druckhülse (218) an die druckkonzentrierende Formungsoberfläche (600) kommuniziert wird;
wobei die druckkonzentrierende Formungsoberfläche (600) strukturiert ist, um eine Klemmkraft auf ein Werkstück zu beaufschlagen; und
wobei das Verhältnis der Gesamtvorspannkraft zur Klemmkraft zwischen etwa 20:1 und 40:1 beträgt.

12. Werkzeug (200A) nach Anspruch 1, wobei:

die obere Werkzeuganordnung (202) eine Gesamtvorspannkraft erzeugt, während sich die obere Werkzeuganordnung (202) und die untere Werkzeuganordnung (204) zwischen der ersten und der Formungsposition bewegen;

wobei die Gesamtvorspannkraft über die obere Druckhülse (218) an die druckkonzentrierende Formungsoberfläche (600) kommuniziert wird; wobei die druckkonzentrierende Formungsoberfläche (600) strukturiert ist, um eine Klemmkraft auf ein Werkstück zu beaufschlagen; und wobei das Verhältnis der Gesamtvorspannkraft zur Klemmkraft zwischen etwa 20:1 und 40:1 beträgt.

Revendications

1. Outillage (200A) pour former une coque (4), l'outillage (200A) comprenant :

un ensemble d'outil supérieur (202) incluant un manchon de pression supérieur (218) ;
le manchon de pression supérieur (218) comprenant une extrémité inférieure (227) ;
un ensemble d'outil inférieur (204) incluant un anneau de noyau de matrice (250) ;
l'anneau de noyau de matrice (250) incluant une extrémité supérieure (252), l'extrémité supérieure d'anneau de noyau de matrice (252) disposée en opposition à l'extrémité inférieure de manchon de pression supérieur (227), et l'extrémité supérieure d'anneau de noyau de matrice (252) incluant une surface interne effilée (254), une surface interne arrondie (256), une surface généralement horizontale (257) et une surface externe arrondie (258) ;
l'ensemble d'outil inférieur (204) coopérant avec l'ensemble d'outil supérieur (202) pour former un matériau disposé entre ceux-ci pour inclure un panneau central (6), une paroi de mandrin circonférentielle (12), une fraisure annulaire (10) entre le panneau central (6) et la paroi de mandrin circonférentielle (12), et un bord roulé (16) s'étendant radialement vers l'extérieur à partir de la paroi de mandrin (12) ; et
dans lequel l'ensemble d'outil supérieur (202) et l'ensemble d'outil inférieur (204) se déplacent entre une première position séparée, dans laquelle l'ensemble d'outil supérieur (202) est espacé de l'ensemble d'outil inférieur (204), et une position de formage, dans laquelle l'ensemble d'outil supérieur (202) est immédiatement adjacent à l'ensemble d'outil inférieur (204) pour étirer sélectivement le matériau d'au moins une partie prédéterminée de la coque (4) par rapport à au moins une autre partie de la coque (4), en fournissant ainsi une partie amincie correspondante,
caractérisé en ce
l'extrémité inférieure (227) définit une surface de formage à concentration de pression (600) qui vient en prise avec ledit matériau lorsque l'ensemble d'outil supérieur (202) et l'ensemble d'outil inférieur (204) sont dans la position de formage, la surface de formage à concentration de pression (600) est disposée en opposition à une partie de la surface généralement horizontale de l'anneau de noyau de matrice (257) mais ne s'étend pas au-dessus de la surface interne arrondie (256) de l'extrémité supérieure d'anneau de noyau de matrice (252).

2. Outillage (200A) selon la revendication 2, dans lequel la surface de formage à concentration de pression (600) inclut une zone de serrage réduite, dans lequel la zone de serrage réduite est une zone annulaire radialement contiguë s'étendant sur environ 25 à 75 % de la surface généralement horizontale 257 de l'extrémité supérieure d'anneau de noyau de matrice 252.

3. Outillage (200A) selon la revendication 2, dans lequel la surface de formage à concentration de pression (600) inclut une pluralité de paliers (610), dans lequel chaque palier est une zone limitée de la surface de formage de manchon de pression supérieure (226).

4. Outillage (200A) selon la revendication 3, dans lequel la pluralité de paliers (610) formant une surface à concentration de pression inclut entre deux et cinq paliers sensiblement concentriques (610A-610E).

5. Outillage (200A) selon la revendication 1, dans lequel :

l'ensemble d'outil supérieur (202) inclut une semelle de matrice supérieure (206), un corps de colonne montante (214), et un ensemble de génération de sollicitation hybride (500).
le corps de colonne montante (214) étant couplé à la semelle de matrice (206), le corps de colonne montante (214) définissant une chambre de pression (516) ;
le manchon de pression supérieur (218) étant disposé de manière mobile dans la chambre de pression de corps de colonne montante (516) ;
le manchon de pression supérieur (218) est mobile entre une première position étendue, dans laquelle l'extrémité inférieure du manchon de pression supérieur (227) est plus espacée de la semelle de matrice supérieure (206), et une seconde position rétractée, dans laquelle l'extrémité inférieure de manchon de pression supérieur (227) est moins espacée de la semelle de matrice supérieure (206) ;
l'ensemble de génération de sollicitation hybride (500) étant couplé de manière opérationnelle au manchon de pression supérieur (218) ; et
dans lequel l'ensemble de génération de solli-

citation hybride (500) commande le déplacement du manchon de pression supérieur (218) lorsque l'ensemble d'outil supérieur (202) et l'ensemble d'outil inférieur (204) se déplacent entre la première position et la position de formage.

6. Outillage (200A) selon la revendication 5, dans lequel l'ensemble de génération de sollicitation hybride (500) inclut un ensemble de génération de pression (510), un ensemble de sollicitation mécanique (550) et un certain nombre de composants hybrides (570).

7. Outillage (200A) selon la revendication 5, dans lequel l'ensemble de génération de sollicitation hybride (500) est un ensemble de génération de sollicitation hybride actif (502).

8. Outillage (200A) selon la revendication 6, dans lequel :

l'ensemble de génération de pression (510) est structuré pour pressuriser la chambre de pression (516) ; et
l'ensemble de sollicitation mécanique (550) inclut un certain nombre de ressorts (552).

9. Outillage (200A) selon la revendication 8, dans lequel le certain nombre de ressorts (552) est disposé à l'intérieur de la chambre de pression (516).

10. Outillage (200A) selon la revendication 8, dans lequel :

l'ensemble de génération de sollicitation hybride (500) génère une force de sollicitation totale lorsque l'ensemble d'outil supérieur (202) et l'ensemble d'outil inférieur (204) se déplacent entre les première et seconde positions ;
dans lequel l'ensemble de génération de pression (510) génère entre environ 20 % et 30 % de la force de sollicitation totale ; et
dans lequel l'ensemble de sollicitation mécanique (550) génère entre environ 70 % et 80 % de la force de sollicitation totale,
dans lequel :

l'ensemble de génération de pression (510) génère environ 25 % de la force de sollicitation totale ; et
l'ensemble de sollicitation mécanique (550) génère environ 75 % de la force de sollicitation totale.

11. Outillage (200A) selon la revendication 8, dans lequel :

l'ensemble de génération de sollicitation hybride (500) génère une force de sollicitation totale lorsque l'ensemble d'outil supérieur (202) et l'ensemble d'outil inférieur (204) se déplacent entre la première position et la position de formage ;
dans lequel la force de sollicitation totale est communiquée via le manchon de pression supérieur (218) à la surface de formage de concentration de pression (600) ;
dans lequel la surface de formage de concentration de pression (600) est structurée pour appliquer une force de serrage à une pièce à usiner ; et
dans lequel le rapport de la force de sollicitation totale par rapport à la force de serrage est compris entre environ 20:1 et 40:1.

12. Outillage (200A) selon la revendication 1, dans lequel :

l'ensemble d'outil supérieur (202) génère une force de sollicitation totale lorsque l'ensemble d'outil supérieur (202) et l'ensemble d'outil inférieur (204) se déplacent entre la première position et la position de formage ;
dans lequel la force de sollicitation totale est communiquée via le manchon de pression supérieur (218) à la surface de formage de concentration de pression (600) ;
dans lequel la surface de formage de concentration de pression (600) est structurée pour appliquer une force de serrage à une pièce à usiner ; et
dans lequel le rapport de la force de sollicitation totale par rapport à la force de serrage est compris entre environ 20:1 et 40:1.

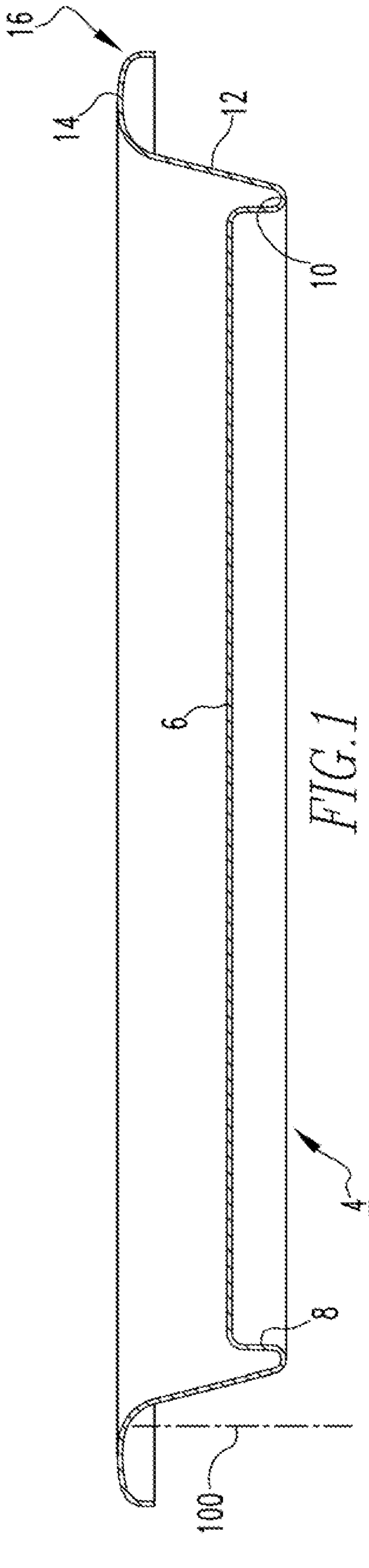

FIG.1

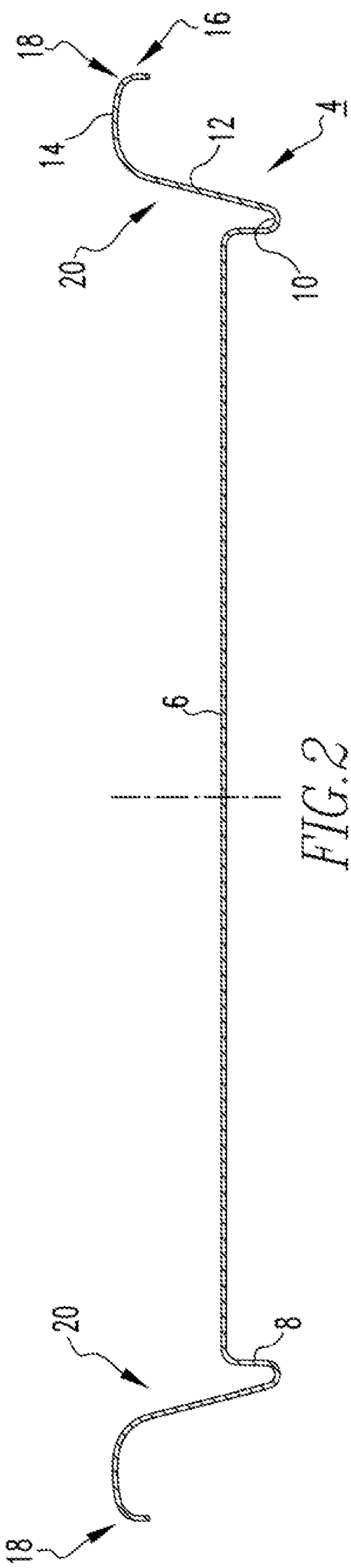

FIG.2

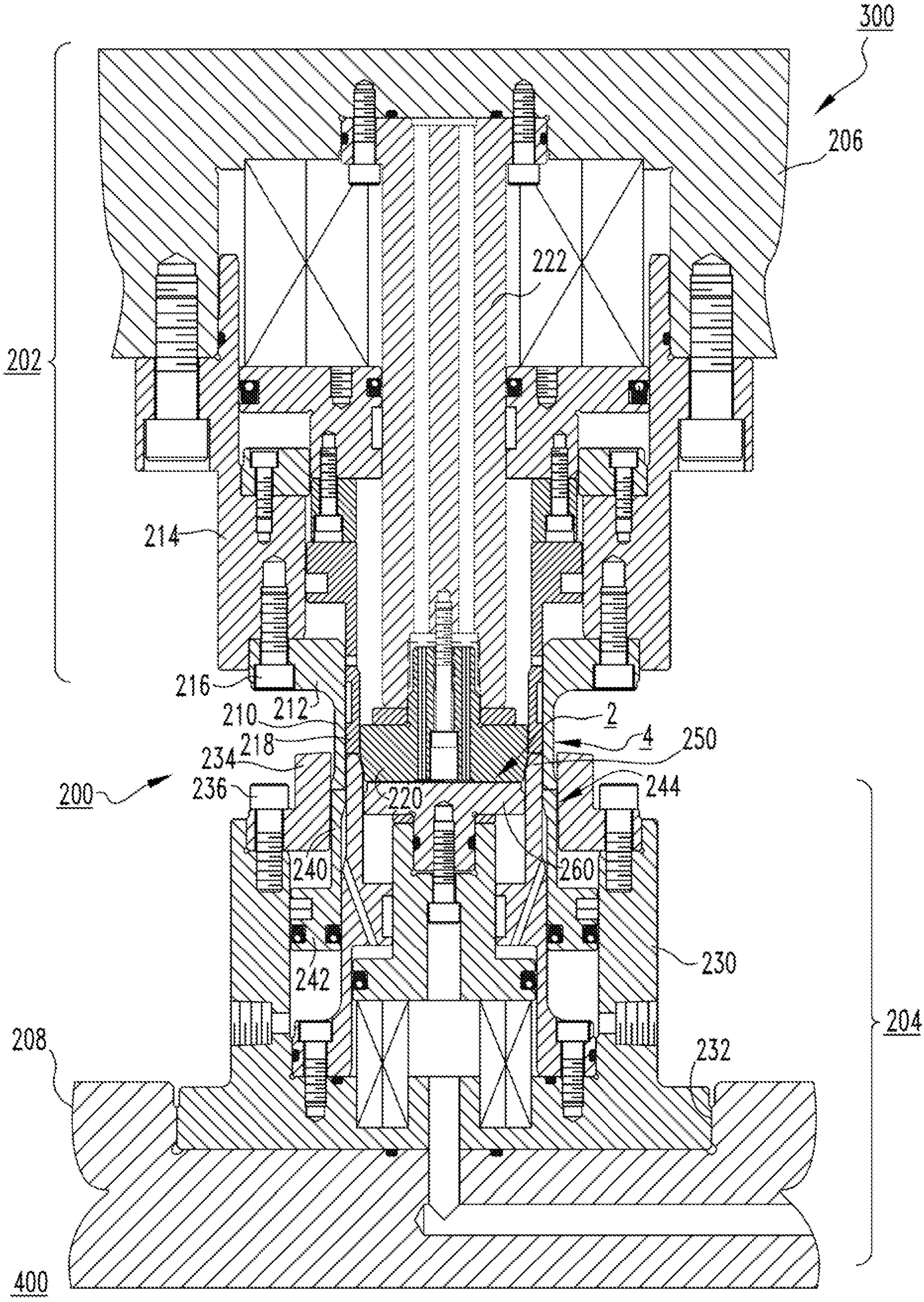
300
206
222
202
214
216
212
210
218
234
236
200
2
4
250
220
244
240
260
242
230
204
208
232
400

FIG.3

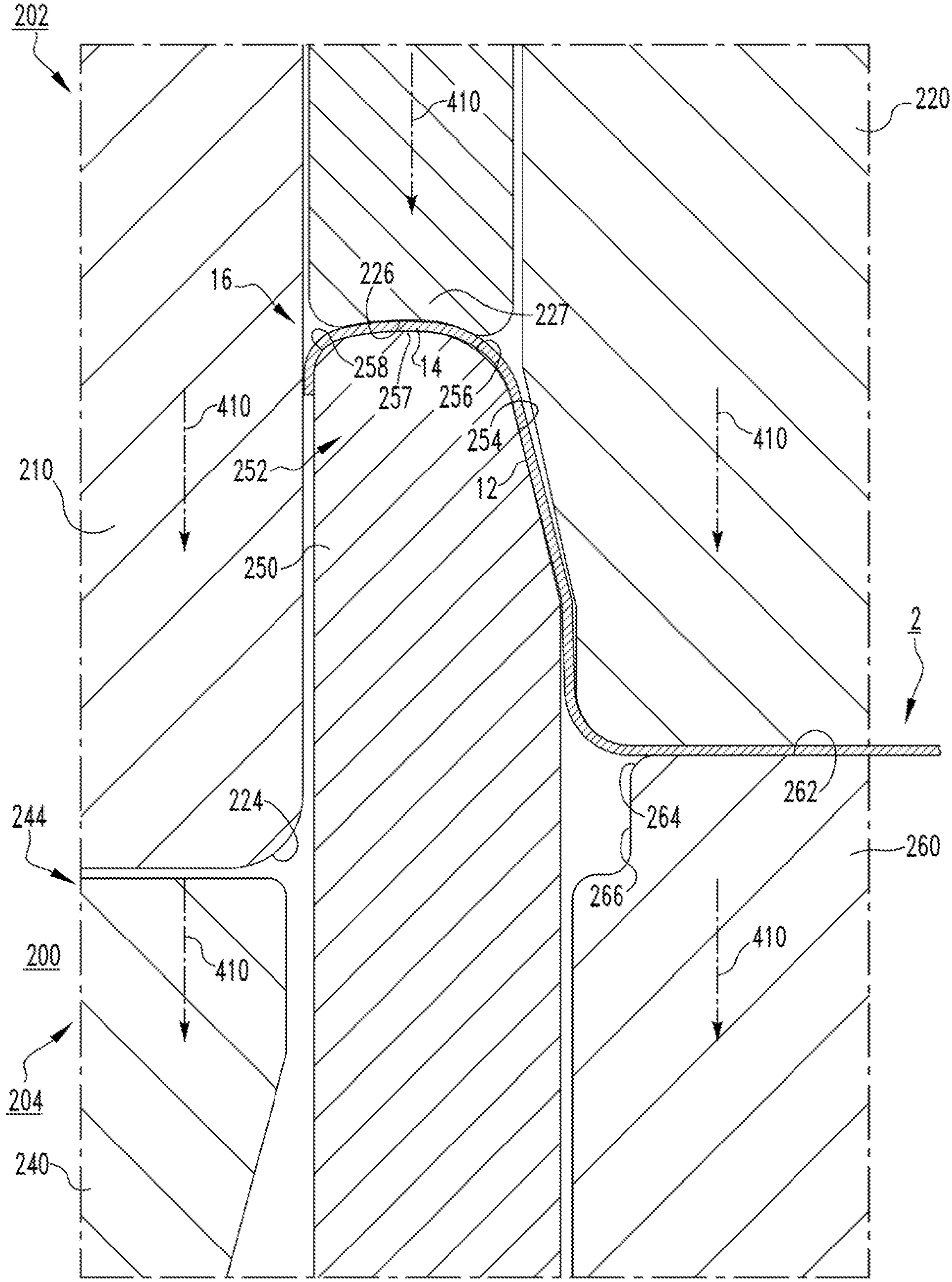
202
410
220
16
226
227
258
14
257
256
410
410
254
210
252
12
250
2
224
262
244
264
260
266
200
410
410
204
240

FIG.4

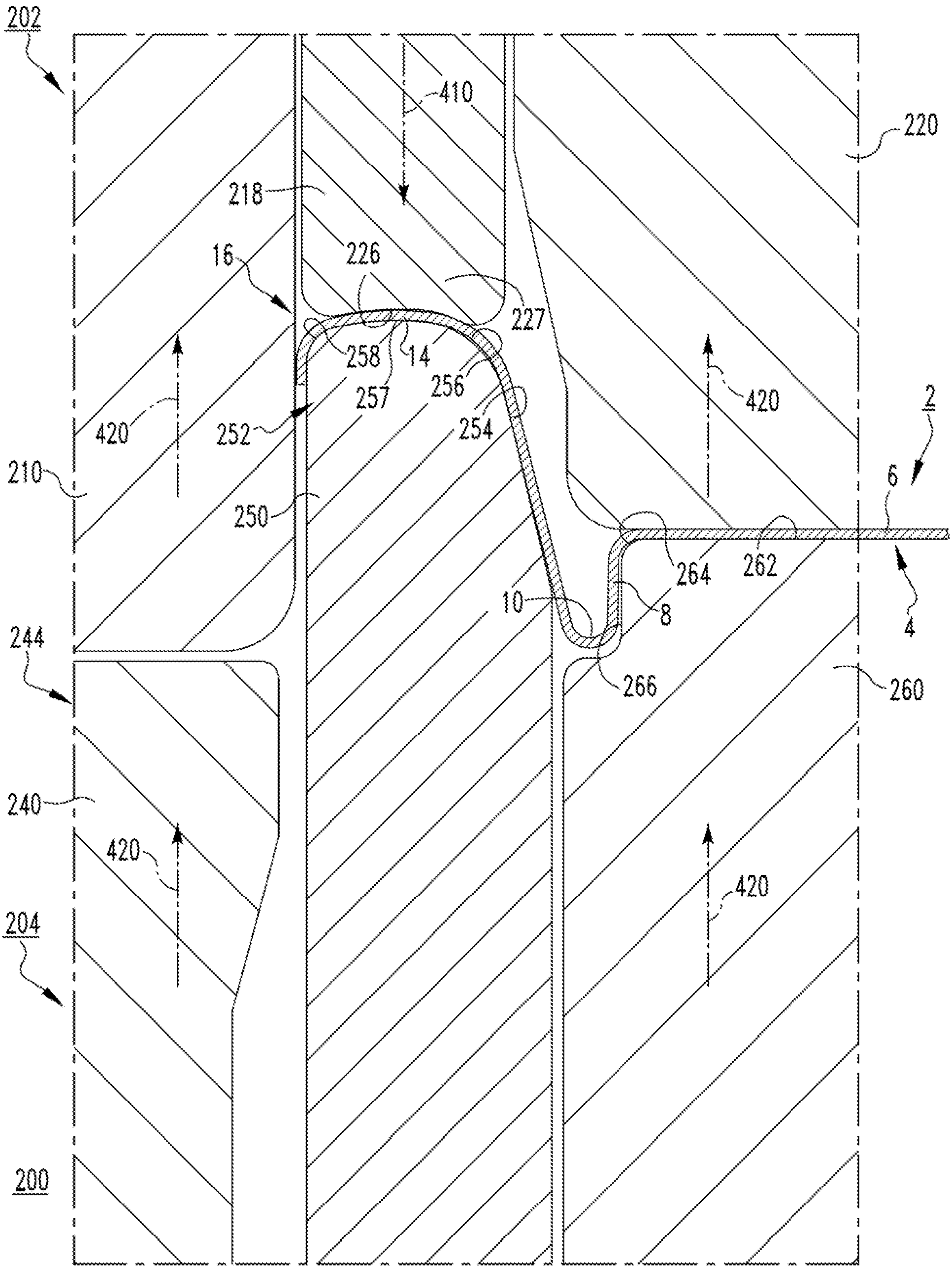
202
410
220
218
16
226
227
258
14
256
257
420
420
252
254
2
6
210
250
264
262
10
8
4
244
266
260
240
420
420
204
200

FIG.5

FIG.6A

FIG.6B

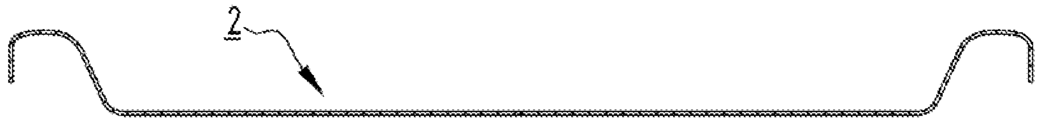

FIG.6C

FIG.6D

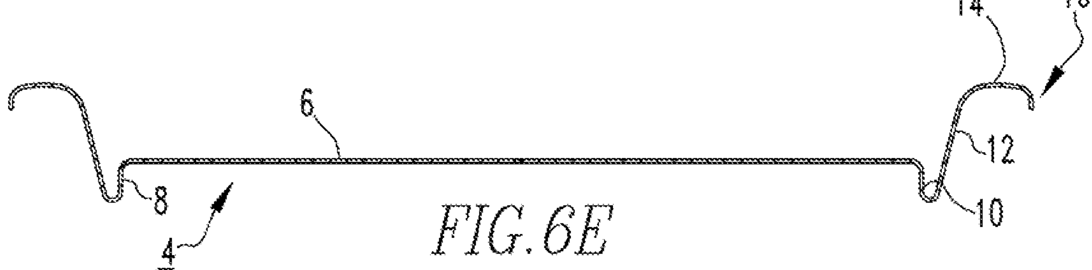

FIG.6E

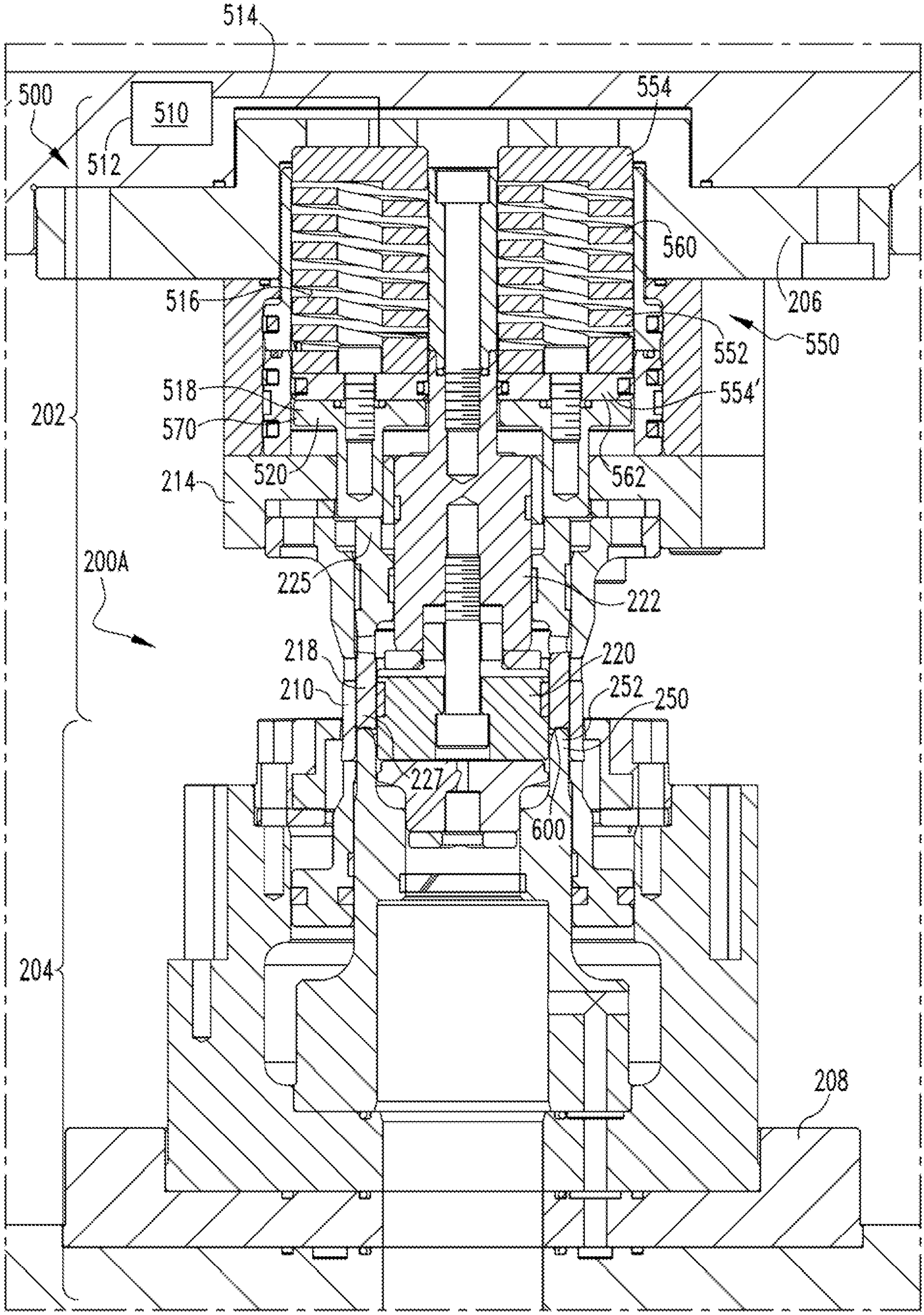
514
500
510
512
554
560
206
516
552
550
518
554'
202
570
520
562
214
200A
225
222
218
220
210
252
250
227
600
204
208

FIG. 7

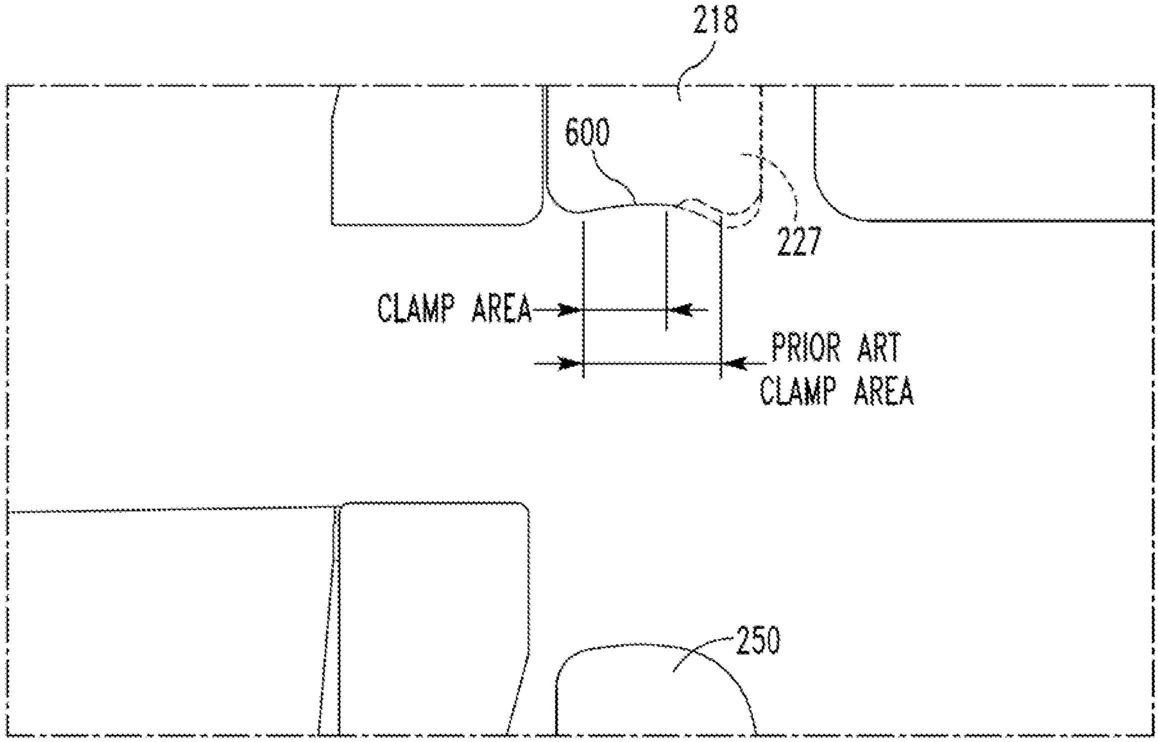

FIG.8

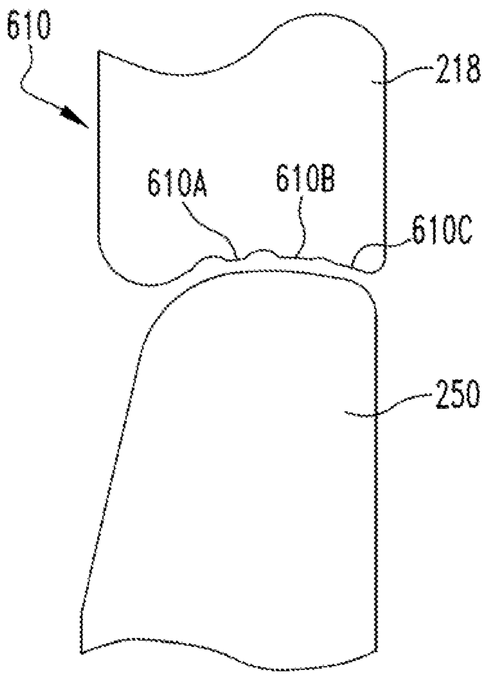

FIG.9

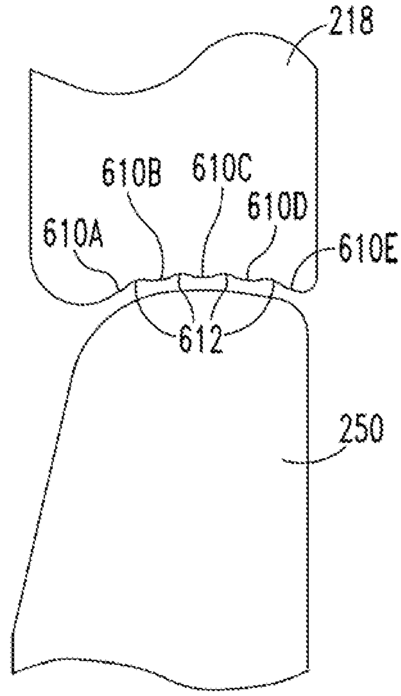

FIG.10

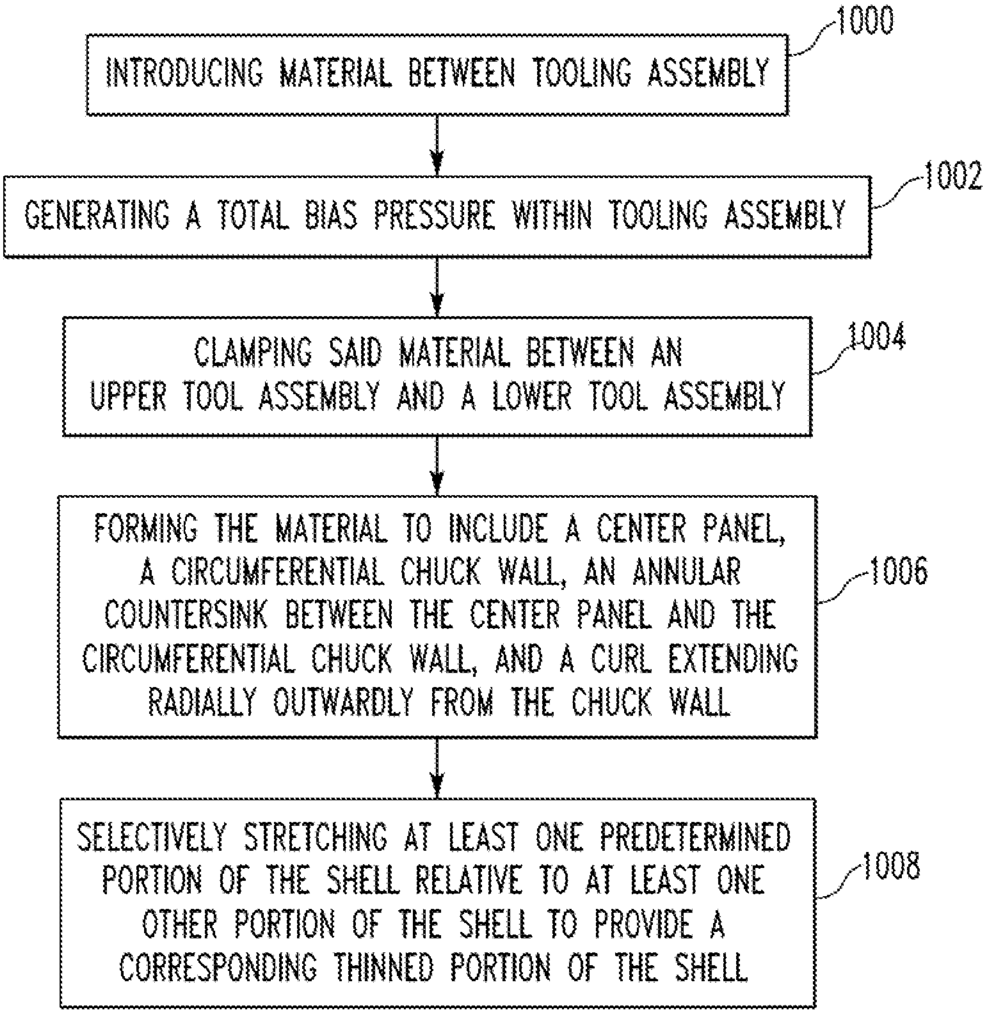
1000
INTRODUCING MATERIAL BETWEEN TOOLING ASSEMBLY
1002
GENERATING A TOTAL BIAS PRESSURE WITHIN TOOLING ASSEMBLY
1004
CLAMPING SAID MATERIAL BETWEEN AN UPPER TOOL ASSEMBLY AND A LOWER TOOL ASSEMBLY
1006
FORMING THE MATERIAL TO INCLUDE A CENTER PANEL, A CIRCUMFERENTIAL CHUCK WALL, AN ANNULAR COUNTERSINK BETWEEN THE CENTER PANEL AND THE CIRCUMFERENTIAL CHUCK WALL, AND A CURL EXTENDING RADIALLY OUTWARDLY FROM THE CHUCK WALL
1008
SELECTIVELY STRETCHING AT LEAST ONE PREDETERMINED PORTION OF THE SHELL RELATIVE TO AT LEAST ONE OTHER PORTION OF THE SHELL TO PROVIDE A CORRESPONDING THINNED PORTION OF THE SHELL

FIG11

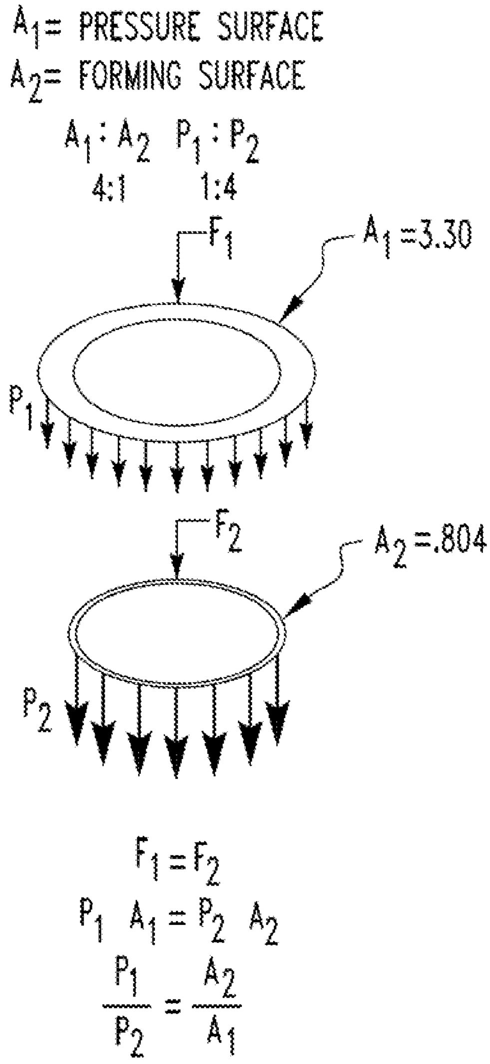

FIG.12A
(PRIOR ART)

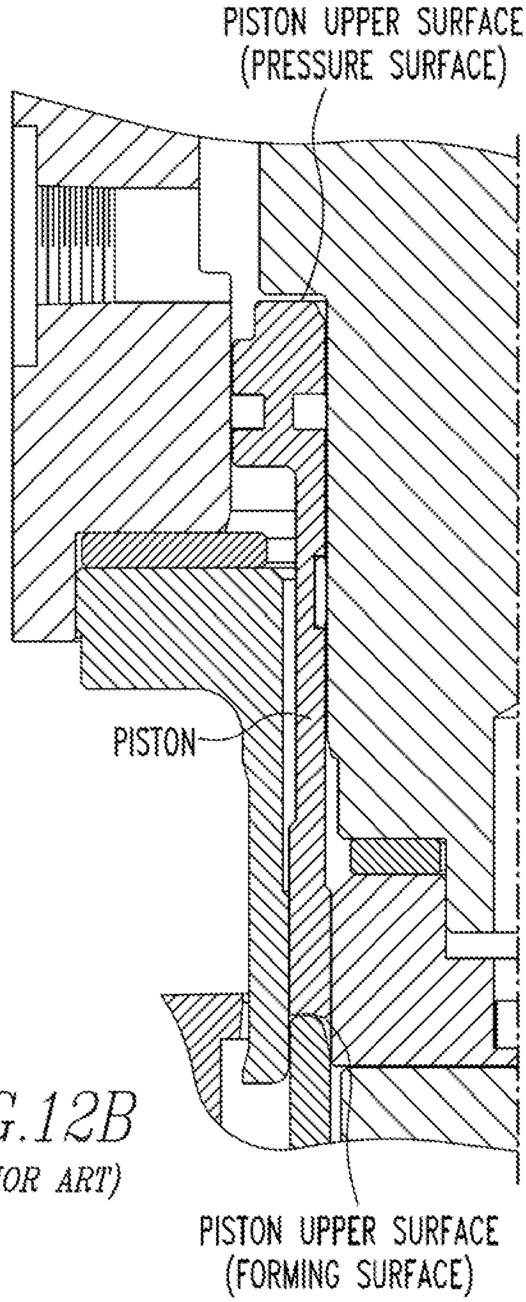

FIG.12B
(PRIOR ART)

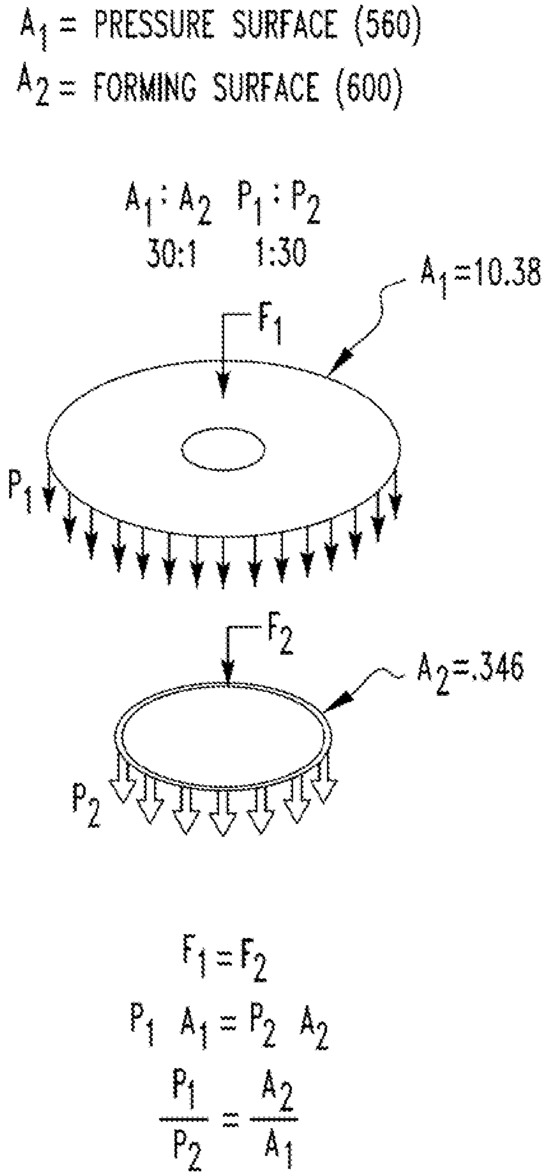

FIG.13A

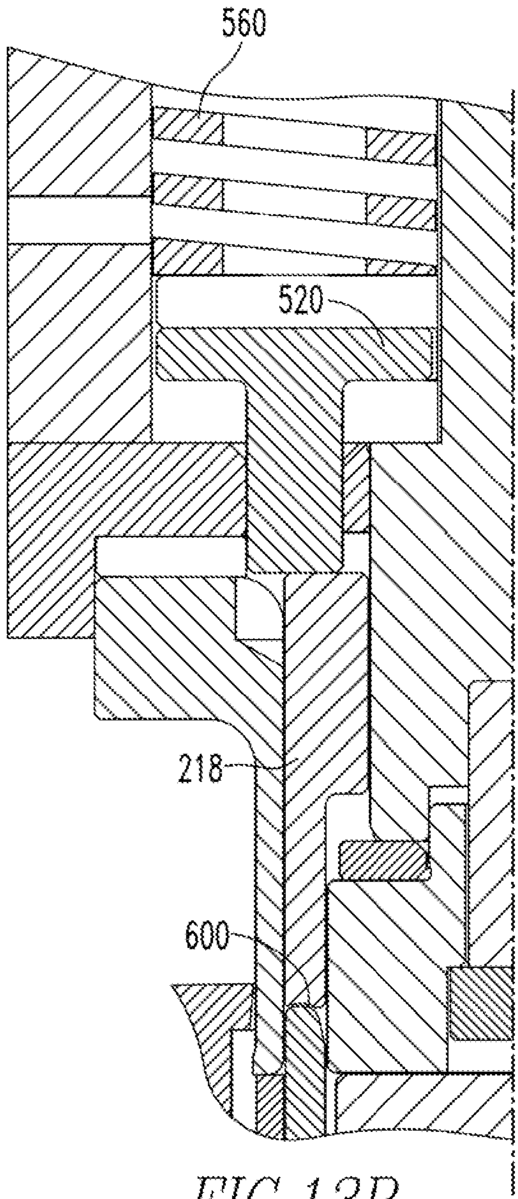

FIG.13B

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2013173398 A **[0007]**