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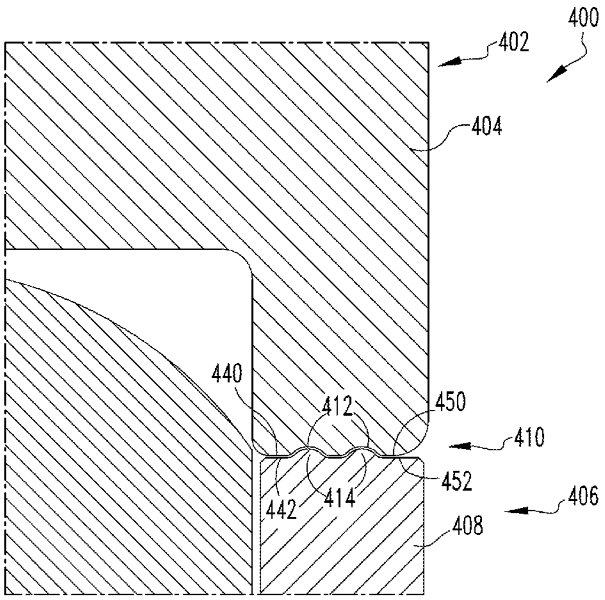

FIG.15

(57) Abstract: A container, such as a beverage or food can is provided, which includes a first sidewall, a second sidewall and a bottom portion extending between the first and second sidewalls. The material of the bottom portion is stretched relative to the first sidewall and the second sidewall to form a thinned preselected profile, such as a dome. The material of the container at or about the dome has a substantially uniform thickness. The container is formed from a blank of material, which has a base gauge prior to being formed. After being formed, the blank of material of the container at or about the dome has a thickness less than the base gauge. Tooling having a clamp bead, or a progressive clamp bead, for selectively forming a blank of material into a container, as well as an associated method are also disclosed.

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CONTAINER, AND SELECTIVELY FORMED CUP, TOOLING AND ASSOCIATED METHOD FOR PROVIDING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Patent Application Serial No. 15/286,954 filed October 6, 2016, which is incorporated by reference herein, which application is a continuation-in-part application of U.S. Patent Application Serial No. 13/856,694, filed April 4, 2013, entitled "CONTAINER, AND SELECTIVELY FORMED CUP, TOOLING AND ASSOCIATED METHOD FOR PROVIDING SAME," which application is a divisional application of U.S. Patent Application Serial No. 12/902,202, filed October 12, 2010, (U.S. Patent No. 8,439,222, issued May 14, 2013) entitled "CONTAINER, AND SELECTIVELY FORMED CUP, TOOLING AND ASSOCIATED METHOD FOR PROVIDING SAME," which application claims the benefit of U.S. Provisional Application Serial No. 61/253,633, filed on October 21, 2009, entitled "CONTAINER, AND SELECTIVELY FORMED CUP, TOOLING AND ASSOCIATED METHOD FOR PROVIDING SAME."

BACKGROUND

Field

The disclosed concept relates generally to containers and, more particularly, to metal containers such as, for example, beer or beverage cans, as well as food cans. The disclosed concept also relates to cups and blanks for forming cups and containers. The disclosed concept further relates to methods and tooling for selectively forming a cup or bottom portion of a container to reduce the amount of material in the cup or bottom portion and to reduce the force required to form the material as well as the counter forced acting on the tooling.

Background Information

It is generally well known to draw and iron a sheet metal blank to make a thin walled container or can body for packaging beverages (*e.g.*, carbonated beverages; non-carbonated beverages), food or other substances. Typically, one of the initial steps in forming such containers is to form a cup. The cup is generally shorter and wider than the finished container. Accordingly, the cups are typically subjected to a variety of additional processes that further form the cup into the finished container. As shown, for example, in Figure 1, a conventional can body 2 has thinned first and second sidewalls 4, 6 and a bottom profile 8, which includes an outwardly protruding annular ridge 10. It is understood that in the cross-sectional view the opposing first and second sidewalls 4, 6 are portions of a contiguous sidewall (which hereinafter may be identified by a single reference number, *e.g.*, reference “4”). The bottom profile 8 slopes inwardly from the annular ridge 10 to form an inwardly projecting dome portion 12. The can body 2 is formed from a blank of material 14 (*e.g.*, without limitation, sheet metal).

There is a constant desire in the industry to reduce the gauge, and thus the amount of material used to form such containers. However, among other disadvantages associated with the formation of containers from relatively thin gauge material, is the tendency of the container to wrinkle, particularly during redrawing and doming. Prior proposals have, in large part, focused on forming bottom profiles of various shapes that were intended to be strong and, therefore, capable of resisting buckling while enabling metal having a thinner base gauge to be used to make the can body. Thus, the conventional desire has been to maintain the material thickness in the dome and bottom profile to maintain or increase strength in this area of the can body and thereby avoid wrinkling.

Tooling for forming domed cups or can bodies has conventionally included a curved, convex punch core and a concave die core, such that a domed can body is formed from material (*e.g.*, without limitation, a sheet metal blank) conveyed between the punch core and the die core. Typically, the punch core extends downwardly into the die core, forming the domed cup or can body. In order to maintain the thickness of the domed portion, the material is relatively lightly clamped on either side of the portion to be domed. That is, the material can move (*e.g.*, slide) or flow toward the dome as it is formed in order to maintain the desired thickness in the bottom profile. Doming methods and apparatus are disclosed, for example and without limitation, in U.S. Patent Nos. 4,685,322; 4,723,433; 5,024,077; 5,154,075; 5,394,727; 5,881,593; 6,070,447; and 7,124,613, which are hereby incorporated herein by reference.

There is, therefore, room for improvement in containers such as beer/beverage cans and food cans, as well as in selectively formed cups and tooling and methods for providing such cups and containers.

SUMMARY

These needs and others are met by embodiments of the disclosed concept which provide metal containers, such as beverage and food cans, cups and blanks for forming cups and containers, and methods and tooling for selectively forming a cup or bottom portion of a container to reduce the amount of material in the cup or bottom portion.

As one aspect of the disclosed concept, a container comprises: a first sidewall, a second sidewall, and a bottom portion extending between the first sidewall and the second sidewall. The material of the bottom portion is stretched relative to the first sidewall and the second sidewall to form a thinned preselected profile.

The thinned preselected profile may be a dome. The material of the container at or about the dome may have a substantially uniform thickness. The container may be formed from a blank of material, wherein the blank of material has a base gauge prior to being formed. After being formed, the material of the container at or about the dome may have a thickness less than the base gauge. The thickness of the material at or about the dome may be about 0.0003 inch to about 0.003 inch thinner than the base gauge. That is, there is about 10% maximum thinning of aluminum material, or 25% maximum thinning for steel, at the dome.

The container may be formed from a blank of material, wherein the blank of material has a preformed dome portion.

As another aspect of the disclosed concept, tooling is provided for selectively forming a blank of material into a container. The container includes a first sidewall, a second sidewall, and a bottom portion extending between the first sidewall and the second sidewall. The tooling comprises: an upper tooling assembly and a lower tooling assembly. The blank of material is clamped between the upper tooling assembly and the lower tooling assembly, proximate to the first sidewall and proximate to the second sidewall. The bottom portion is stretched relative to the first sidewall and the second sidewall to form a thinned preselected profile.

As a further aspect of the disclosed concept, a method for selectively forming a container is provided. The method comprises: introducing a blank of material to tooling; forming the blank of material to include a first sidewall, a second sidewall and a bottom portion extending between the first sidewall and the second sidewall; clamping the material between the tooling proximate to the first sidewall and proximate to the second

sidewall to resist movement of the material; and stretching the bottom portion to form a thinned preselected profile.

As a further aspect of the disclosed concept, tooling, including a clamp bead, is provided for selectively forming a blank of material into a container. Generally, a “bead” is a resulting formation on the can body 2. In one exemplary embodiment, the clamping of the material between the tooling proximate to the first sidewall and proximate to the second sidewall to resist movement of the material utilizes a contoured step bead. As employed herein, a “step bead” in relation to tooling, means elements of the tooling are structured to form a “step bead.” As employed herein, a “step bead” in relation to a can body, means a bead, *i.e.*, an elongated projection, extending about, *i.e.*, encircling, an inner area, wherein one perimeter of the bead is at one elevation and the opposing perimeter of the bead is at another elevation, where the “elevation” is relative to the inner area about which the “step bead” extends. It is noted that the step bead facilitates holding the material substantially stationary, for example, by crimping it and locking the material just inboard of the cup sidewall, as described below. Similarly, as employed herein, a “non-step bead” is a bead extending about an inner area, wherein both perimeters of the bead are at one elevation which is generally aligned with the inner area about which the “non-step bead” extends.

Further as employed herein, the term(s) “clamp bead” when used in relation to tooling, means elements of the tooling are structured to form a “clamp bead.” It is understood that a tooling “clamp bead” includes a protrusion on one tooling assembly and a recess on an opposed tooling assembly. As employed herein, a “clamp bead” means a non-step bead wherein the upper tool assembly and the lower tool assembly clamp (see definition below) the material being formed. That is, material does not substantially move (*e.g.*, slide) or flow in at least one direction past or through the “clamp bead,” as discussed below. Further, as employed herein, in reference to material or a container, a “clamp bead” remains a “clamp bead” after the forming process is complete. That is, as used herein, the bead on a container that was formed as a “clamp bead” remains a “clamp bead” after the forming process is complete. Further, it is understood that containers, and therefore the tooling that made those containers, included common “beads.” Tooling for such beads allowed material to flow through the bead. Such beads, and the tooling used to form such beads, are not a “clamp beads” as used herein. That is, unless a bead is specifically described as, and/or is shown to be, a “clamp bead,” as defined above, then a bead is just a bead. Similarly, unless the tooling that created such beads are specifically described as, and/or are shown to be, structured to form a "clamp bead," then, as used herein, such tooling only forms a common bead.

Similarly as employed herein, the term(s) "progressive clamp bead" when used in relation to tooling, means elements of the tooling are structured to form a "progressive clamp bead" on a material being formed. As employed herein, a "progressive clamp bead" when used in relation to a material being formed means a non-step bead formed by an upper tool assembly and a lower tool assembly that progressively clamp (see definition below) the material being formed. That is, material is maintained in a substantially fixed position while initially allowing material to move (*e.g.*, slide) or flow in at least one direction through the "progressively clamped" area. As the force of the engagement increases, the amount of material that moves/flows through the "progressively clamped" area decreases until the amount is negligible.

Further, as employed herein, in reference to a container, a "progressive clamp bead" remains a "progressive clamp bead" after the forming process is complete. Further, it is understood that containers, and therefore the tooling that made those containers, included beads. Tooling for such beads allowed material to consistently flow through the bead. Such beads are not a "progressive clamp bead." That is, unless a bead is specifically described as, and/or is shown to be, a "progressive clamp bead," as defined above, then a bead is just a bead. Similarly, unless the tooling that created such beads are specifically described as, and/or are shown to be, structured to form a "progressive clamp bead," then, as used herein, such tooling only forms a common bead.

Selectively thinning a predetermined portion of the shell or cup relative to at least one other portion of the shell or cup 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.

These needs and others are met by the disclosed concept, which is directed to a tooling including a reduced force 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 cup (or 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. Further, use of a clamp bead or a progressive clamp bead also allows for reduced forces and counter loads to be applied to the press and solves the problems stated above. Further, reduced forces and counter loads, as stated below, allows for the use of existing presses and solves the problems stated above. Further, the use of a hybrid bias generating assembly prevents an excessive amount of uneven thinning and therefore solves the stated problem.

It is further noted that the reduction in the load required to form a shell or cup allows for additional pockets on a tooling thereby increasing the efficiency of the associated press and solves the problems stated above.

BRIEF DESCRIPTION OF THE DRAWINGS

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 view of a beverage can and a blank of material used to form the beverage can;

Figure 2 is a side elevation view of one non-limiting example of a container and a blank from which the container is formed in accordance with an embodiment of the disclosed concept, also showing, in phantom line drawing, a pre-formed blank of material in accordance with another aspect of the disclosed concept;

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

Figure 4 is a side elevation section view of tooling in accordance with another embodiment of the disclosed concept;

Figure 5 is a top plan view of a portion of the tooling of Figure 4;

Figure 6 is a section view taken along line 6-6 of Figure 5;

Figure 7 is a section view taken along line 7-7 of Figure 5;

Figure 8 is an enlarged view of segment 8 of Figure 6;

Figures 9A-9D are side elevation views of consecutive forming stages of a cup, in accordance with a non-limiting example embodiment of the disclosed concept;

Figures 10A-10C are side elevation views of consecutive forming stages of a cup, in accordance with another non-limiting example embodiment of the disclosed concept;

Figures 11A-11D are side elevation views showing the metal thickness of the cup thinned in accordance with a non-limiting example embodiment of the disclosed concept, respectively showing the substantial uniform thickness of the dome in a direction with the grain of the material, in a direction against the grain, in a direction at 45 degrees with respect to the grain, and in a direction 135 degrees with respect to the grain;

Figure 12 is a graph plotting the metal thickness of the dome at various locations of the dome, in accordance with a non-limiting example embodiment of the disclosed concept;

Figure 13 is a graph plotting the metal thickness of the base metal and of the dome at the various locations of the dome of Figure 12, for each of the directions of Figures 11A-11D, as well as in the cross grain direction;

Figure 14 is an enlarged view of an alternate embodiment of a forming surface including a single clamp bead;

Figure 15 is an enlarged view of an alternate embodiment of a forming surface including two clamp beads;

Figures 16A-16D are side elevation views of consecutive forming stages of a cup, in accordance with a non-limiting example embodiment of the disclosed concept;

Figure 17 is a side elevation section view of tooling in accordance with another embodiment of the disclosed concept including a hybrid bias generating assembly;

Figure 17A is a detailed side view of a progressive clamp bead;

Figure 18 is a flowchart showing a disclosed method;

Figure 19A is a chart showing exemplary reduced forces when forming a steel cup relative to an example of the prior art, Figure 19A is a chart showing exemplary reduced forces when forming an aluminum cup relative to an example of the prior art;

Figure 20 is a chart showing outer slide and punch positions relative to position of stroke as well as associated prior art loads and reduced forces; and

Figure 21 is a flowchart showing another disclosed method.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

For purposes of illustration, embodiments of the disclosed concept will be described as applied to cups, although it will become apparent that they could also be employed to suitably stretch the end panel or bottom portion of any known or suitable can body or container (*e.g.*, without limitation, beverage/beer cans; food cans).

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. Therefore, specific dimensions, orientations, assembly, number of components used, embodiment configurations and other physical characteristics related to the embodiments disclosed herein are not to be considered limiting on the scope of the disclosed concept.

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.

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

As employed 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 employed 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 employed 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.

As employed 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.

As employed 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.

As employed 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.

As employed 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.

As employed 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.

As employed 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.

As employed 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 employed 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.

As employed 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.

As employed 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.

As employed 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 employed herein, "structured to [verb]" recites structure and not function. Further, as employed 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 employed 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.

As employed 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."

As employed herein, simultaneous engagement by elements disposed generally in opposition to each other is identified as "clamping." That is, as employed herein, to "clamp" means to secure a material in a substantially fixed position so as not to permit the material to move (*e.g.*, slide) or flow in at least one direction. Thus, as employed herein, a material that is "clamped" is secured in a substantially fixed position so as not to permit the material to move (*e.g.*, slide) or flow in at least one direction, for example, the clamped material cannot move/flow to the bottom portion of a cup.

As employed herein, "stretch" means to increase in length or area without any additional material substantially moving/flowing into the material being formed. Thus, as employed herein, "stretching" is not "ironing" or "drawing" the material because, as used herein, those processes allow additional material to move/flow into the material being formed. Thus, a material that is "stretched," as employed herein, has one dimension (*e.g.*, length/area) of the material being increased and another dimension of the material (*e.g.*, thickness) being decreased.

As employed herein, simultaneous engagement by elements disposed generally in opposition to each other wherein the force of the engagement increases is identified as "progressive clamping." That is, as employed herein, to "progressively clamp" means to secure a material in a substantially fixed position while initially allowing material to move (*e.g.*, slide) or flow in at least one direction through the "progressively clamped" area. As the force of the engagement increases, the amount of material that moves/flows through the "progressively clamped" area decreases until the amount is negligible. Thus, as employed herein, a material that is "progressively clamped" is secured in a substantially fixed position while allowing some material flow after initially being "progressively clamped" and wherein the force of the engagement increases so as to permit only a negligible amount of material to move/flow through the "progressively clamped" area.

As employed herein, "progressively stretch" means to increase in length or area with an initial flow of material into the material being formed and wherein the initial flow of material into the material being formed is reduced to a negligible amount of material so that, at the end of the "progressively stretching" process, almost no additional material is moving/flowing into the material being formed. Thus, as employed herein, "progressively stretching" is not "ironing" or "drawing" the material because, as used herein, those processes allow additional material to move/flow into the material being formed. Thus, a material at the end of a "progressively stretching" process as employed herein, has one dimension (length/area) of the material being increased and another dimension of the material (thickness) being decreased.

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.

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.

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.

As employed herein, the term “number” shall mean one or an integer greater than one (*i.e.*, a plurality).

As employed herein, the term “bead” when used in reference to the formed material means a protrusion relative to at least one surface of the material. Further, as employed herein, the term “bead” when used in reference to the tooling means the elements of the tooling that form the bead in the material. The elements of the tooling that form the bead, *i.e.*, the tooling “bead” elements, are in one or both of the upper tooling and/or lower tooling.

Figure 2 shows a blank of material 20 and a beverage can 22, *i.e.*, a “can body,” having a selectively formed bottom profile 24 in accordance with one non-limiting example in accordance with the disclosed concept. Specifically, as described in detail hereinbelow, the material in the can bottom profile 24 and, in particular the domed portion 26 thereof, has been stretched, thereby thinning it. Although the example of Figure 2 shows a beverage can, it will be appreciated that the disclosed concept can be employed to stretch and thin the bottom portion of any known or suitable alternative type of container (*e.g.*, without limitation, food can (not shown)), or cup (see, for example, cup 122 of Figures 9A-9D and 11A-11D, and cup 222 of Figures 10A-10C), which is subsequently further formed into such a container.

It will also be appreciated that the particular 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 alternative thinning of the base gauge could be implemented for any known or suitable container, end panel, or cup, without departing from the scope of the disclosed concept. In the non-limiting example of Figure 2, the can body 22 has a wall thickness of 0.0040 inch and a substantially uniform thickness in the can bottom profile 24 and domed portion 26 of 0.0098 inch. Thus, the material in the can bottom profile 24 has been thinned by about 0.0010 inch from the base gauge of the blank of material 20 of 0.0108 inch. It will be appreciated that this is a substantial reduction, which results in significant weight reduction and cost savings over conventional cans (see, for example, the can body 2 of Figure 1 having a can bottom profile 8 thickness of 0.0108 inch). Additionally, among other advantages, this enables a smaller blank of material to be used to form the same can body. For example and without limitation, the blank of material 20 in the non-limiting example of Figure 2 has a diameter of about 5.325 inches, whereas the blank of material 14 of Figure 1 has a diameter of about 5.400 inches. This, in turn, enables a shorter coil width (not shown) of material to be employed (*i.e.*, supplied to the tooling), resulting in less shipping cost.

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.

Continuing to refer to Figure 2, it will be appreciated that the disclosed concept could employ, or be implemented to be employed with, preformed blanks of material 20′. For example and without limitation, a preformed blank of material 20′ having a preformed dome portion 26′ is shown in phantom line drawing in Figure 2. Such a preformed blank 20′ could be fed to the tooling 300 (Figure 3), 300′ (Figures 4-8) and subsequently further formed into the desired cup 122 (Figures 9A-9D and 11A-11D), 222 (Figures 10A-10C) or container 22 (Figure 1). One advantage of such a preformed blank of material 20′, is the ability of a plurality of such blanks 20′ to nest, one within another, for purposes of transporting and shipping the blanks 20′. The preformed dome portion 26′ also provides a mechanism to grab and orient the blank 20′ within the tooling 300 (Figure 3), 300′ (Figures 4-8), as desired. Furthermore, it also enables the width of the blank 20′ to be still further reduced. For example and without limitation, in the non-limiting example of Figure 2, the preformed blank 20′ has a reduced diameter of 5.300 inches.

Figures 3-8 show various tooling 300 (Figure 3), 300′ (Figures 4-8) for stretching and thinning the container material (*e.g.*, without limitation, blank; cup; can body), in accordance with the disclosed concept. Specifically, the selective forming (*e.g.*, stretching) is accomplished by way of precise tooling geometry and placement. In accordance with one non-limiting embodiment, the process begins by introducing a blank of material (*e.g.*, without limitation, blank 20) between components of a tooling assembly 300 (Figure 3), 300′ (Figures 4-8), and forming a standard flat bottom cup 122 (see, for example, Figures 9A and 10A) with base metal thickness or gauge.

As shown in Figures 3 and 4, the tooling 300 preferably includes an upper tool assembly 302, 302’ (Figure 4) with a forming punch 304 (Figure 3), 304′ (Figure 4), and, a lower tool assembly 306 (Figure 3), 306′ (Figure 4). As is known, the upper tool assembly 302, 302’ moves between a first position, wherein the upper tool assembly 302, 302’ is spaced from the lower tool assembly 306, 306’, and a second position, wherein the upper tool assembly 302, 302’ is immediately adjacent and minimally spaced from the lower tool assembly 306, 306’. That is, as the upper tool assembly 302, 302’ moves from the first position to the second position, the forming punch 304, 304’ engages and deforms the can 22 or cup 122, 222.

After the cup 122, 222 is formed, the forming punch 304, 304’ continues moving downward, pushing the cup 122, 222 lower until the cup 122, 222 contacts a lower pad 308, 308′. In the non-limiting embodiment shown and described herein, the forming punch 304, 304’ and lower pad 308, 308’ have a contoured step bead 310 (best shown in the enlarged view of Figure 8 as step bead 310′ in lower pad 308′), although it will be appreciated that such a step bead is not required. That is, as shown in Figures 8 and 14, the lower end of the forming punch 304, 304’ and the upper end of the lower pad 308, 308’ have a generally planar inner portion 140, 142, respectively. The forming punch shown in Figures 3 and 4, forming punch 304, 304’, further includes a curvilinear outer portion 150. The lower pad 308, 308’ has a generally planar outer portion 152. The contoured step bead 310, 310′ facilitates holding the material substantially stationary, for example, by crimping it and locking the material just inboard of the cup sidewall 124 described below, as shown in Figure 8. That is, the forming punch inner portion 140 and the lower pad inner portion 142 are structured to clamp the cup sidewall 124. In this manner, the material in the sidewall 124 is held securely, preventing it from sliding or flowing into the bottom portion 128 of the cup 122.

Accordingly, it will be appreciated that the disclosed concept differs substantially from conventional container bottom forming (*e.g.*, without limitation, doming) methods and apparatus. That is, while the side portions of the cup or container in a traditional forming process might be clamped, relatively little pressure is applied so that movement (*e.g.*, sliding; flowing) of the material into the bottom portion of the cup or container is promoted. In other words, traditionally clamping and stretching the material in the bottom portion of the container was expressly avoided, so as to maintain the thickness of the material in the bottom portion.

It will be appreciated that the aforementioned step bead 310, 310′ is not a required aspect of the disclosed concept. For example, Figures 9A-9D illustrate the consecutive steps or stages of forming a non-limiting example cup 122 in accordance with an embodiment of the disclosed concept wherein the tooling 300, 300′ includes the step bead 310, 310′, whereas Figures 10A-10C illustrate the consecutive forming stages of a cup 222 in accordance with another embodiment of the disclosed concept wherein the tooling does not include any step bead. That is, in this embodiment, the forming punch 304, 304’ and lower pad 308, 308’ have a generally planar inner portion 140, 142, respectively. The forming punch 304, 304’ further includes a curvilinear outer portion 150. The lower pad 308, 308’ has a generally planar outer portion 152. Thus, in this embodiment, there is no angled portion 144, 146 on either the forming punch 304, 304’, 304A or lower pad 308, 308’.

It will be appreciated that while four forming stages are shown in Figures 9A-9D and three forming stages are shown in the example of Figures 10A-10C, that any known or suitable alternative number and/or order of forming stages could be performed to suitably stretch and thin material in accordance with the disclosed concept. It will further be appreciated that any known or suitable mechanism for sufficiently securing the material to resist movement (*e.g.*, sliding) or flow of the material into the bottom portion 128 (*e.g.*, a contoured shape or dome 130) could be employed, without departing from the scope of the disclosed concept. For example and without limitation, pressure to secure the sidewalls 124, 126 of the cup 122 or container body 22 (Figure 2), or locations proximate thereto, can be provided pneumatically, as generally shown in Figure 3, or by a predetermined number of biasing elements (*e.g.*, without limitation, springs 312, 314), as shown in Figures 4-7, or by any other known or suitable holding means (*e.g.*, without limitation, hydraulic force) or mechanism (not shown).

In accordance with one non-limiting embodiment of the disclosed concept, it will be appreciated that although the material is clamped (*e.g.*, secured in a substantially fixed position) so as not to permit it to move (*e.g.*, slide) or flow, and to instead be stretched in a subsequent forming step, the amount of force (*e.g.*, pressure) that is necessary to apply such a clamping effect, is preferably minimized. In this manner, it is possible to provide the necessary clamping force to facilitate the disclosed stretching and thinning, without requiring a different press (*e.g.*, without limitation, a press having greater capacity) (not shown). Accordingly, the disclosed concept can advantageously be readily employed with existing equipment in use in the field, by relatively quickly and easily retooling the existing press.

Table 1 quantifies the clamping force and deflection resulting from employing different numbers (*e.g.*, 5; 10; 20) of springs (*e.g.*, without limitation, springs 312, 314) to apply the clamping force in accordance with several non-limiting example embodiments of the disclosed concept.

Table 1

deflection (mm)		load (kg)	deflection (in)	load (lbs)	x 5 springs	x 10 springs	x 20 springs
4	6.2%	60	0.16	132.2	661.2	1,322.4	2,644.8
10.4	16.0%	156	0.41	343.8	1,719.1	3,438.2	6,876.5
11	16.9%	176	0.43	387.9	1,939.5	3,879.0	7,758.1
13	20.0%	195	0.51	429.8	2,148.9	4,297.8	8,595.6

In another exemplary embodiment, Table 2 quantifies the clamping force and deflection for a system forming aluminum, or steel, shells on a dual action press and forming shells on a dual action press. It is noted that the spring deflection associated with forming aluminum is 0.410 inch and the spring deflection associated with forming steel is 0.810 inch. Further, in this example, there are fifteen tooling stations associated with forming aluminum and nine tooling stations associated with forming steel. Further, in this example, the press is a one-hundred and fifty ton press with a 75 ton (150,000 lbf) capacity for each of the inner slide (also identified as the punch 404A, below) and the outer slide.

				x8 springs	x8 springs	x10 springs	x10 springs
Cup Material	Max. % Thinning	% of Free Length	Force Limit Per Tooling Pocket (lb/station)	Spring Load Limit/ Spring (lbs)	Spring Stiffness Limit/ Spring (lb/in)	Spring Load Limit/ Spring (Lbs)	Spring Stiffness Limit/ Spring (lb/in)
Aluminum	10.0%	8.2%	10000	1250	3049	1000	2439
Steel	25.0%	16.2 %	16667	2083	2572	1667	2058

It is noted that spring deflection generally corresponds to the maximum dome thinning. That is, for a one-hundred and fifty ton press the inner and outer slides can support 75 ton (150,000 lbf). Therefore, in relation to a single spring forming aluminum in a 15-out configuration, there is 150,000 lbf per each of the 15 “pockets”, resulting in an about 10,000 lbf force limit per tooling pocket. Further, in this example, each pocket has eight springs. Thus, 10,000 lbf/eight spring means that there is 1,250 lbf acting on each spring. When each spring has a stiffness of 3049 lb/in and has 1,250 lbf acting on it, it will be deflected 0.410 inch. This corresponds to the maximum thinning of an aluminum dome, *i.e.*, about 10%. Thus, it is understood that the variables, *e.g.*, the number of springs, stiffness, etc. are related to the maximum limits of the press and the desired spring deflection (which corresponds to the thinning of the dome). Structuring the tooling 300 so that the total load is less than the limit of the press, as discussed below, solves the problems stated above.

Once the peripheral material is suitably clamped (*e.g.*, secured in a substantially fixed in position, as shown for example and without limitation in Figure 8), the punch 304′ continues to move downward, forcing the material in the cup bottom portion 128 to be forced into the contour 316 (Figures 6-8) of the tools 300′ causing the material to stretch into the contoured shape 130 (also identified as a “dome” and is shown in Figures 9D, 10C, 11A-11D, 12 and 13), thereby thinning the material. A non-limiting example of a cup 122 which has been formed in accordance with this process is shown in Figures 9A-9D (tooling 300′ includes step bead 310′). Another example cup 222 is shown in Figures 10A-10C (tooling does not include step bead). It will be appreciated, for example with reference to Figure 9D, that the material in the contoured shape or dome 130 (Figures 9D and 11D), 230 (Figure 10C) can be stretched and, therefore, thinned by up to about 0.001 inch, or more. It will also be appreciated that while the contoured shape in the example shown and described herein is a dome 130, 230, that any other known or suitable alternative shapes could be formed without departing from the scope of the disclosed concept.

Referring to Figures 9C, 9D, 11A-11D, 12 and 13, it will be appreciated that the stretched material of the dome 130 is also advantageously substantially uniform in thickness. More specifically, the material is uniform in thickness not only for various locations (see, for example, measurement locations A-I of Figures 12 and 13) along the width or diameter of the dome 130, as shown in Figures 9C (partially formed cup dome 130′) and 9D (completely formed cup dome 130), but also in various directions, such as with the grain as shown in Figures 11A and 13, against the grain as shown in Figures 11B and 13, at 45 degrees with respect to the grain as shown in Figures 11C and 13, and at 135 degrees with respect to the grain, as shown in Figures 11D and 13. The graphs of Figures 12 and 13 further confirm these findings. Figure 13 shows, in one graph, a plot of the metal thicknesses at locations A-I for each of the foregoing directions with respect to the grain, as well as in the cross grain direction.

Accordingly, it will be appreciated that the disclosed concept provides tooling 300 (Figure 3), 300′ (Figures 4-8) and methods for selectively stretching and thinning the bottom profile 24 (Figure 2), bottom portion 128 (Figures 9A-9D and 11A-11D), and bottom profile 228 (Figures 10A-10C) of a container 22 (Figure 2) or cup 122 (Figures 9A-9D and 11A-11D), 222 (Figures 10A-10C), such as a domed portion 26 (Figure 2), dome 130 (Figures 9D and 11A-11D), and dome 230 (Figure 10C), thereby providing relatively substantially material and cost savings.

In another exemplary embodiment, the disclosed concept provides tooling 400 and methods for selectively stretching and thinning the bottom profile 24 of a container 22 or cup 122, including a domed portion 330 by utilizing a (tooling) clamp bead 410 (discussed below). As noted above, in reference to tooling 400, utilizing a clamp bead means that the tooling 400, *i.e.*, the upper tool assembly 402 and the lower tool assembly 406, include construct(s) structured to form "clamp beads." That is, and as used herein, the "upper tool assembly and the lower tool assembly include a number of clamp beads" means that the tooling 400, *i.e.*, the upper tool assembly 402 and the lower tool assembly 406, include construct(s) structured to form "clamp beads," as defined above. In this exemplary embodiment, and as shown in Figures 16A-16B, the material forms a cup 422 including sidewalls 424, 426 and a bottom portion 428.

In this embodiment, shown in Figures 14-18, the tooling 400 preferably includes an upper tool assembly 402 with a forming punch 404, and, a lower tool assembly 406. It is understood that the tooling 400 identified by reference number "400" also include the other elements of the tooling identified by reference numbers "300, 300'" with the differences noted below. As described above, the upper tool assembly 402 also moves between a first position, wherein the upper tool assembly 402 is spaced from the lower tool assembly 406, and a second position, wherein the upper tool assembly 402 is immediately adjacent and minimally spaced from the lower tool assembly 406. That is, as the upper tool assembly 402 moves from the first position to the second position, the forming punch 404 engages and deforms the can 22 or cup 122.

In an embodiment that forms a cup 122 and after the cup 122 is formed, the forming punch 404 continues moving downward, pushing the cup 122 lower until the cup 122 contacts a lower pad 408. In the non-limiting embodiment shown and described herein, the forming punch 404 and lower pad 408 have elements that form a "clamp bead" 410. That is, as used herein, the cooperative elements of the tooling 400 that form the clamp bead in the material are collectively identified by reference number 410. As shown in Figures 14 and 15, the lower end of the forming punch 404 and the upper end of the lower pad 408 have a generally planar inner portion 440, 442, respectively, and a generally planar outer portion 450, 452. The forming punch 404 outermost portion is, in an exemplary embodiment, curvilinear. Further, the clamp bead 410 includes a number of recesses 412 (hereinafter "clamp bead recess" 412) on the lower end of the forming punch 404, *i.e.*, on the upper tool assembly 402, and, a number of upwardly extending projections 414 (hereinafter "clamp bead projection" 414) on the upper end of the lower pad 408, *i.e.*, on the lower tool assembly 406. Each clamp bead recess 412 has a shape, size and contour that substantially corresponds to the shape, size and contour of an associated clamp bead projection 414. That is, each clamp bead recess 412 is disposed between the forming punch inner portion 440 and forming punch outer portion 450. Similarly, each clamp bead projection 414 is disposed between the lower pad inner portion 442 and lower pad outer portion 452. Further, each clamp bead recess 412 is aligned with an associated clamp bead projection 414 so that when the upper tool assembly 402 is in the second position, each clamp bead projection 414 is disposed substantially within the associated clamp bead recess 412. In one exemplary embodiment, there is a single clamp bead 410, as shown in Figure 14. In another exemplary embodiment, there are two clamp beads 410, as shown in Figure 15. These examples are non-limiting and there may be any number of clamp beads 410. The clamp bead 410 facilitates holding the material substantially stationary, for example, by crimping it and locking the material just inboard of the cup sidewall 124, as discussed above.

Accordingly, it will be appreciated that the disclosed concept differs substantially from conventional container bottom forming (*e.g.*, without limitation, doming) methods and apparatus. That is, while the side portions of the cup or container in a traditional forming process might be clamped, relatively little pressure is applied so that movement (*e.g.*, sliding; flowing) of the material into the bottom portion of the cup or container is promoted. In other words, traditionally clamping and stretching the material in the bottom portion of the container was expressly avoided, so as to maintain the thickness of the material in the bottom portion.

Once the peripheral material is suitably clamped (*e.g.*, secured in a substantially fixed position), the forming punch 404 continues to move downward, forcing the material in the cup bottom portion 128 to be forced into the contour 316 (in a manner similar to that shown in Figures 6-7) of the tooling 400 causing the material to form a clamp bead 420 (the reference number 420 identifies the "clamp bead" in the material or cup) and to stretch the material into a contoured shape 430, hereinafter the "dome" 430, thereby thinning the material. That is, a non-limiting example of a cup 422 which has been formed in accordance with the process including a clamp bead 420 is shown in Figures 16A-16D. It will be appreciated, for example with reference to Figure 16D, that the material in the dome 430 can be stretched and, therefore, thinned by up to about 0.001 inch, or more. It will also be appreciated that while the contoured shape in the example shown and described herein is a dome 430, that any other known or suitable alternative shapes could be formed without departing from the scope of the disclosed concept. As before, the stretched material of the dome 430 is also advantageously substantially uniform in thickness at various locations and in various directions relative to the grain, as described above.

As noted above, the material is clamped (*e.g.*, secured in a substantially fixed position) so as not to permit the material to move (*e.g.*, slide) or flow, and to instead be stretched in a subsequent forming step; the amount of force (*e.g.*, pressure) that is necessary to apply such a clamping effect, is preferably minimized, and, pressure to secure the sidewalls 124, 126 of the cup 122 or container body 22 (Figure 2), or locations proximate thereto, can be provided pneumatically, as generally shown in Figure 3, or by a predetermined number of biasing elements (*e.g.*, without limitation, springs 312, 314), as shown in Figures 4-7, or by any other known or suitable holding means (*e.g.*, without limitation, hydraulic force) or mechanism (not shown). As shown in Figures 17 and 17A, in another exemplary embodiment, the tooling 400A includes features, constructs and assemblies that are structured to progressively clamp the sidewalls 124, 126 (424, 426) of the cup 122 (422) or container body 22 via a hybrid bias generating assembly 500, shown in Figure 17, and a progressive clamp bead 600, shown in Figure 17A.

That is, in another embodiment, wherein the elements are substantially similar to the tooling 400 described above, the tooling 400 is structured to progressively clamp the material while progressively stretching the material in the contoured shape 430. In this embodiment, the tooling 400A creates a progressive clamp bead 620, as defined above, in the material. In an exemplary embodiment, the tooling 400A structured to progressively clamp the material utilizes a hybrid bias generating assembly 500. That is, in this embodiment, pressure to secure the sidewalls 124, 126 (424, 426) of the cup 122 (422) or container body 22 (Figure 2), or locations proximate thereto, are provided by the hybrid bias generating assembly 500. In one embodiment, the pneumatic elements and springs 312, 314, shown in Figures 3 and 4, are incorporated into the hybrid bias generating assembly 500. As employed 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 employed herein, a “hybrid bias generating assembly” includes at least two bias generating assemblies that apply bias to the same component. A “hybrid bias generating assembly” also includes 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 a "hybrid bias generating assembly" because the bias is not applied to the same component.

Further, as employed 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 employed 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, 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. As shown schematically, while including the elements of the active hybrid bias generating assembly 502, the selectable hybrid bias generating assembly 504 is associated with additional controls for the pressure generating assembly 510 (discussed below).

The hybrid bias generating assembly 500 includes a pressure generating assembly 510 (shown schematically), a mechanical bias assembly 550, and a number of hybrid components 570. As employed 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, which is part of the lower tool assembly 406A, includes a pressure generating device 512 (shown schematically), a pressure communication assembly 514 (shown schematically), a pressure chamber 516, and a riser assembly 515. 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.

In an exemplary embodiment, the lower tool assembly 406 includes a pressure chamber 516 and a riser assembly 515. That is, the lower tool assembly 406 defines the pressure chamber 516. The riser assembly 515 is movably and sealingly disposed in the pressure chamber 516. The riser assembly 515 is further sealed against, and coupled, and/or operatively coupled, to the lower pad 408 and/or a dome support assembly 517 (including a domed member 519) that defines tool contour 316. In this configuration, lower pad 408 and riser assembly 515 move between an upper, first position, and a lower, second position. Further, lower pad 308, 308' is maintained in the first position, at least in part, by the pressurized fluid in pressure chamber 516. That is, when pressure chamber 516 is pressurized, lower pad 408 and riser assembly 515 move to the upper, first position. To move toward the second position, the punch 304 must overcome the bias created by the pressurized fluid in pressure chamber 516.

That is, in an exemplary embodiment, the riser assembly 515 is sealingly and movably coupled, directly coupled to the inner surface of the pressure chamber 516 defined by the lower tool assembly 306. It is understood that the pressure chamber 516 includes a number of seals, not identified, required to prevent fluid from escaping.

The riser assembly 515 includes a torus-shaped body 520 and, in an exemplary embodiment, a spring seat 554, as discussed below. In another embodiment, the riser assembly 515 and the spring seat 554 are a unitary body. If the riser assembly 515 is disposed in the pressure chamber 516, it is understood that the spring seat 554 is also the pressure surface 521 (described below). Thus, the outer radial surface of the riser assembly 515, and the spring seat 554 if included, are sealingly coupled to the inner surface of the pressure chamber 516.

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 lower side of the riser assembly 515 (as shown), which is hereinafter identified as the “pressure surface” 521. It is understood that, in an embodiment with a spring seat 554, the pressure surface 521 may be the lower surface of the spring seat 554. Further, it is understood that any area of the pressure surface 521 in contact with a spring 560 (discussed below) does not have pressure acting thereon. Thus, the pressure generating device 512 is structured to control the position of the riser assembly 515 in the pressure chamber 516, and is structured to move the riser assembly 515 in the pressure chamber 516.

In this configuration, the lower pad 408 is a “hybrid component” 570 as defined herein. That is, the lower pad 408 is structured to be utilized by both the pressure generating assembly 510 and the mechanical bias assembly 550. It is noted that a lower pad 408 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 lower pad 408 associated exclusively with a pressure generating assembly 510 cannot be “structured to” be utilized by both bias generating assemblies. Similarly, by definition, a lower pad 408 associated exclusively with a mechanical bias assembly 550 cannot be “structured to” be utilized by both bias generating assemblies. Accordingly, a lower pad 408 associated exclusively with a pressure generating assembly 510 or exclusively with a mechanical bias assembly 550 is not a “hybrid component” as employed herein.

In an exemplary embodiment, the mechanical bias assembly 550 includes a number of spring assemblies 552 (which include springs 312, 314) 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.

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 employed herein, a “progressive spring rate” is a spring rate that increases in compression in a non-linear manner. As employed herein, a “degressive spring rate” is a spring rate that decreases in compression in a non-linear manner. As employed 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.

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.

In an exemplary embodiment, compression springs 560 are disposed in the pressure chamber 516. In this embodiment, at least an upper spring seat 554 is a torus-shaped body 562 that corresponds to the pressure chamber 516 and the dome support assembly 517. The upper spring seat 554 is coupled, directly coupled, fixed, or unitary with, the upper side of the riser assembly 515. 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 lower pad 308, 308’. That is, the lower pad 308, 308’ is biased to its first position by the mechanical bias assembly 550.

The total bias/force generated by the hybrid bias generating assembly 500 can also be expressed as a “total bias pressure.” As employed herein, the “total bias pressure” means the total bias/pressure generated by the hybrid bias generating assembly 500.

Further, the mechanical bias assembly 550 creates a force which, as employed 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. Further, in an exemplary embodiment, the pressure generating assembly 510 is structured to pressurize the pressure chamber 516 at a generally constant pressure. In another 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.

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.

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.

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. For example, in a selectable hybrid bias generating assembly 504, a pressure control assembly 530 (discussed below), is structured to provide a selectable pressure so as to meet the ratio of mechanical bias to pressure bias, as discussed below. 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 lower tool assembly 306 upwardly 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.

In another embodiment, not shown, the pressure generating assembly 510 includes a number of stacked pistons (similar to what is shown in Figure 3) as well as a selectable pressure control assembly. The selectable pressure control assembly is structured to generate a selected pressure profile. The selected pressure profile is, in an exemplary embodiment, a profile wherein the pressure increases in a manner that is similar to a progressive spring rate, described above.

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 lower tool assembly 306 upwardly 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.

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 riser assembly 515. 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 riser assembly 515. 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.

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 spring assemblies 552. That is, the spring assemblies 552 are removably coupled to the spring seats 554 within the pressure chamber 516.

It is noted that, in another embodiment, the upper tool assembly 302 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 “progressive clamp bead” 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.

That is, the tooling 400 as described above, when combined with a hybrid bias generating assembly 500, is structured to create a progressive clamp bead 620 in the material or cup 122, 422. Thus, as used herein, the elements of the tooling 400 that define a clamp bead 410 when combined with a hybrid bias generating assembly 500 become elements of a "progressive clamp bead" 600 in the tooling 400A. Other than the elements discussed below, the tooling 400A is substantially similar to the tooling 400 discussed above and like elements will use like reference numbers followed by the letter "A". That is, the following description relates to an embodiment including a number of beads, which, as discussed below, are "progressive clamp beads" 600 in the tooling 400A and which are structured to form "progressive clamp beads" 620 in the material or cup 122, 422. That is, reference number 620 identifies a progressive clamp bead in the material. It is understood that the hybrid bias generating assembly 500 and the progressive clamp bead 600 may also be used in an embodiment including a step bead 310 or the hybrid bias generating assembly may be used in an embodiment without a bead at all. As discussed above, and in an exemplary embodiment, a punch 404A (or "forming punch" 404A) opposes a lower pad 408A. Thus, when the upper tooling assembly 402A moves to the second position, the punch 404A is disposed immediately adjacent the lower pad 408A. In this configuration, the forming punch 404A and the lower pad 408A engage, *i.e.*, progressively clamp, the cup 122.

In an exemplary configuration of any of these embodiments, either the upper tooling 402A and/or the lower tool assembly 406A defines the progressive clamp bead 600. That is, similar to the embodiment above, the progressive clamp bead 600 includes a progressive clamp bead recess 612 in the punch 404A and a progressive clamp bead projection 614 in the lower pad 408A. These elements create a progressive clamp bead in the material by applying a progressive force to the progressive clamp bead 600.

That is, in an exemplary embodiment, the hybrid bias generating assembly 500, and more specifically the mechanical bias assembly 550, initially applies a spring preload force to the blank of material 14. The initial spring preload force is not sufficient to substantially prevent the flow of material through the progressive clamp bead 600. However, as the dome 430 has not yet begun to form, there is, essentially, no material flowing through the progressive clamp bead 600. That is, there is no force that would cause material 14 to flow through the progressive clamp bead 600. In fact, the initial spring preload force is not sufficient to form the progressive clamp bead 620 in the material 14.

Following the application of the initial spring preload force, the hybrid bias generating assembly 500, and more specifically the pressure generating assembly 510, increases the force on the material 14 and sets, *i.e.*, forms, the progressive clamp bead 600 in the material 14. Because the force has increased, the amount of material 14 that can flow through the progressive clamp bead 600 is reduced relative to the amount that flows during the initial spring preload force. As before, however, the dome 430 has not yet begun to form and there is, essentially, no material flowing through the progressive clamp bead 600.

When the punch 404 continues to move downward, the material in the cup bottom portion 128 is forced into the contour 316 of the tools 400A causing the material 14 to stretch into the contoured shape 430. At this time in the forming process, the force on the material continues to progressively increase due to forces generated by the mechanical bias assembly 550. That is, in an exemplary embodiment, the springs 560 have a variable spring rate which is a progressive spring rate. As the force on the material continues to progressively increase, the amount of material that flows through the progressive clamp bead 600 is reduced to a negligible amount.

It is noted that without the use of a clamp bead 410 or a progressive clamp bead 600, and to form a cup with a dome as discussed in relation to Figure 12, a traditional press would need to apply a pressure of about 23,000 lbf. to 25,000 lbf. per pocket. Thus, the number of pockets would be limited to about 6, or, if more pockets were used there would be excessive counter forces acting on the press. Further, experimentation has shown that a cup dome made with such tooling is unacceptably uneven. The use of a clamp bead 410 or a progressive clamp bead 600 allows the tooling 400, 400A to operate with a “reduced force.” That is, as employed herein, a “reduced force” acting on a tooling 400A means that the force acting on a tooling 400A required to form the material by stretching or progressively stretching is reduced between about 10% to 50%, when compared to the force required to form material into a cup (or a cup with a bead using tooling with a common bead). Further, in an exemplary embodiment, the “reduced force” is about 46% for a steel cup, or about 53% for aluminum, when compared to the force required to form material into a cup (or a cup with a bead using tooling with a common bead). Further, to operate with a “reduced force,” as used herein, the tooling must include a clamp bead 410 or a progressive clamp bead 600, as defined herein. Further, as used herein, to operate with a “reduced force” the tooling must be specifically described as, and/or shown to be, operating with a force between about 10% to 50%, or about 30%, of the force required to form material into a cup (or a cup with a bead using tooling with a common bead). Thus, tooling with a common bead that is, ostensibly, “capable” of operating with a force between about 10% to 50%, or about 30%, of the force required to form material into a similar shape does not operate with a “reduced force” as defined herein. Further, the term “reduced force” may be modified by the term “moderately” which means the force acting on a tooling 400A required to form the material by stretching or progressively stretching is reduced between about 1% to 65%, when compared to the force required to form material into a cup (or a cup with a bead using tooling with a common bead).

That is, the load required to form a shell or cup limits the number of constructs formed at one time. As is known, the tooling 400, 400A is coupled to, and driven by, a press (not shown). The following example demonstrates the use of a clamp bead 410 or a progressive clamp bead 600 that allows the tooling 400, 400A to operate with a “reduced force” or a “moderately reduced force.” That is, the forces associated with traditional tooling compared to tooling 400, 400A including a clamp bead 410 or a progressive clamp bead 600 are shown in Figures 19A and 19B; that is, in Figure 19A, which discloses the loads and tooling position with respect to position of stroke (defined below) and in relation to forming steel. Line 700 represents loads associated with a prior art tooling, line 702 represents reduced forces associated with tooling 400A (and a progressive clamp bead), line 704 represents the position of the outer slide, reduced force and line 706 represents the position of the punch 404A. The position of the outer slide and punch 404A is measured relative to an arbitrary position on the tooling 400, 400A and, in this example, the lowest position is identified as zero inches. Figure 19B relates to the forming of aluminum and includes similar lines 710 (prior art load), 712 (reduced force), 714 (outer slide position) and 716 (punch 404A position).

Figure 20 also shows the position of the outer slide and punch 404A, lines 724, 726, respectively, relative to an arbitrary position on the tooling 400, 400A and, in this example, the lowest position is identified as -3.5 inches. Further, in an exemplary embodiment, the loads and reduced forces relative to position of stroke are shown in the table below.

	145	150	155	160	165	170	175	180	185	190	195	200	205	210
Upper piston @ 60 psi	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500
Upper piston @ 30 psi	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250
Blanking	6152													
Forming											4920	4920	4920	4920
Lower springs														
Total (Current loads) lbs	10,652	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	9,420	9,420	9,420	9,420
Total (Reduced forces) lbs	8,402	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250	7,170	7,170	7,170	7,170

Outer Load (current)	10,652	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500
Outer Load (reduced)	8,402	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250
Inner Load (current)	0	0	0	0	0	0	0	0	0	0	4,920	4,920	4,920	4,920
Inner Load (reduced)	0	0	0	0	0	0	0	0	0	0	4,920	4,920	4,920	4,920

	245	250	255	260	265	270	275	280	285	290	295	300	305	310
Upper piston @ 60 psi														
Upper piston @ 30 psi														
Lower piston @ 400 psi	11,246	11,246	11,246	11,246	11,246	11,246	11,246	11,246	11,246	11,246	11,246	11,246	11,246	
Blanking														
Forming														
Lower springs	213.6	881	1437	1877	2195	2387	2451	2387	2195	1877	1437	881	214	
Total (Current loads) lbs	11,460	12,127	12,683	13,123	13,441	13,633	13,697	13,633	13,441	13,123	12,683	12,127	11,460	
Total (Reduced forces) lbs	214	881	1,437	1,877	2,195	2,387	2,451	2,387	2,195	1,877	1,437	881	214	

Outer Load (current)	0	0	0	0	0	0	0	0	0	0	0	0	0
Outer Load (reduced)	0	0	0	0	0	0	0	0	0	0	0	0	0
Inner Load (current)	11,460	12,127	12,683	13,123	13,441	13,633	13,697	13,633	13,441	13,123	12,683	12,127	11,460
Inner Load (reduced)	214	881	1,437	1,877	2,195	2,387	2,451	2,387	2,195	1,877	1,437	881	214

It is understood that, in this exemplary embodiment, the press is assumed to be a one-hundred and fifty ton dual-action press with a 75 ton (150,000 lbf) capacity for each of the upper and lower tooling and with 15 pockets forming steel. That is, the loads shown are the loads for each pocket. It is further understood that between position of stroke 215° and 240° (between the drawing of the cup and dome formation) the inner and outer loads are 0.0 lbf.

Further, the prior art press is forming steel cups and, due to the higher forces (15,940 lbf), is limited to eight cups at a time. That is, each formed product is formed within a "pocket," as used herein, on the press assembly. That is, each such forming construct is identified as a "pocket" on the press. Thus, for example, if the maximum force required to form a shell, as described above, was eighteen thousand lbf, then a one hundred fifty ton press could include eight pockets. As is known, a press structured to form steel shells typically includes 8-9 pockets, depending upon characteristics of the shell; that is some shells require less than the exemplary eighteen thousand lbf for formation. Further, in an embodiment discussed below, a one hundred fifty ton press structured to form aluminum shells typically includes 14-15 pockets. Thus, the existing tooling(s) are limited to the number of constructs formed by the existing presses. This is a disadvantage as the presses and associated tooling(s) have a limited efficiency in that a limited number of shells/cups are formed at one time.

Further, it is understood that the following discussion relates to forming the dome 430. Figures 19A and 19B also show reduced forces (and moderately reduced forces) are related to the movement of the outer slide and associated with a pressure concentrating forming surface, as disclosed in U.S. Patent Application Serial No. 14/722,187, filed May 27, 2015, Pub. No. 2015/025137 (Sept. 10, 2015) entitled, CONTAINER, AND SELECTIVELY FORMED SHELL, AND TOOLING AND, ASSOCIATED METHOD FOR PROVIDING SAME. The reduced force related to the outer slide are shown to the left of 180° "position of stroke." The reduced force related to the formation of a shell/cup are not, but are not discussed in detail herein.

Before discussing the exemplary embodiment, the following equations and assumptions are noted. Initially, it is noted that forces generated in the press are not typically linear as the press is subject to vibrations and other physical effects; the lines representing the change in forces are shown on Figures 19 and 20 as substantially straight or as smooth curves as this is common in the art. Further, the calculated forces and resulting Figures are based on equations known and accepted in the art and include coefficients and other factors determined by experimentation. For example, the near instantaneous force associated with the blanking of the material, at about position of stroke 145°, includes an "Impact Draw Force" that is determined via experimentation and is about 5,250 lbs. for steel and about 3,750 for aluminum, in the present examples. Further, the Blank Force is determined by the equation:

$$Blank\_Force = K*(UTS)*t*L + (\mathrm{Im}pact\_Draw\_Pad)$$
$$Blank\_Force = 0.7*(UTS)*t*\pi*D + (\mathrm{Im}pact\_Draw\_Pad)$$

wherein

L	PI*D (Blanking Perimeter)
t	gage of blank
K	Blanking coefficient (used as % of UTS when shear strength not avail.)
UTS	Ultimate Tensile Strength

sheet metal and the total area being sheared along the periphery.

- The maximum punch force, F, can be estimated from the equation

$$F = 0.7TL(UTS) \qquad (16.1)$$

That is, the Blank Force is the Punch Force and the Impact Draw Force combined.

Further, the drawing force is determined by the equation

$$Drawing\ Force = \pi * d * t * Ys * \left(\frac{D}{d} - C\right)$$

wherein

d	Cup Diameter
D	Blank Diameter
t	gage of blank
Ys	Yield Strength
C	Friction Constant for Bending

For steel and aluminum, the constant for friction and bending is 0.6 to 0.7. The drawing coefficient (D/d - C) is determined by experimentation.

As noted above, however, the forces that occur before the doming process are not relevant to the present claims. The forces associated with the doming process are determined by the following equations:

$$Dome\_Force = Spring\_Force + Air\_Force$$

$$Dome\_Force = (K * \Delta X * \#Spring) + (Piston\_Area * Piston\_Pressure)$$

$$Dome\_Force = (K * (Press\_Stroke - Preload) * \#Spring) + ((Piston\_Area - Spring\_Area * 8) * Piston\_Pressure$$

$$Dome\_Force = (1360 * (Press\_Stroke - Preload) * 8) + \left(\left(\left(\frac{\pi * 6.75^2}{4}\right) - \left(\frac{\pi * 3.125^2}{4}\right)\right) - \left(\left(\frac{\pi * 1.50^2}{4}\right) - \left(\frac{\pi * 0.75^2}{4}\right)\right) * 8\right) * Piston\_Pressure$$

That is, the riser assembly torus-shaped body 520 acts as the upper spring seat 554 and corresponds to the pressure chamber 516. The area of the torus-shaped body 520 is determined by subtracting the inner area, determined at diameter "A" in Figure 17 from the outer area, determined at "B" in Figure 17. Further, the pressure acts upon the area of the riser assembly torus-shaped body 520 that is not engaged by the eight springs 560. The springs 560, however, also provide a mechanical force as discussed above. In this example, the spring constant is about 1360 and ΔX is the compression of the springs 560 at each position of stroke.

In one exemplary embodiment, the maximum forces associated with forming a 422 steel cup as shown in Figures 16A-16D, and with a dome 430 described above is about 15,940 lbf. whereas the "reduced force" when using a clamp bead 410 and/or progressive clamp bead 600 is about 9,034 lbf. The data supporting the forces shown on Figure 19A are set forth in Appendix 1. On Figure 19A, the maximum forces are shown at about 280° position of stroke. For this example it is assumed that the exemplary hybrid bias generating assembly 500 has a pressure surface 521 with a total area of about 28.11 in^2 (*i.e.*, a torus with an inner diameter of about 3.125 in. and an outer diameter of about 6.75 in.) and eight springs 560. The springs 560 generate a maximum combined force of about 6,735 lbs. Further, the spring seat 554 is also the pressure surface 521, as described above. Thus, the area of the pressure surface 521 upon which pressure acts (*i.e.*, the surface area not in contact with a spring 560) is about 17.5 in^2. In this configuration, and with a traditional tooling without a clamp bead 410 or a progressive clamp bead 600, to form a cup 422, as is known, a pressure generating device must provide a pressure of about 400 psi which generates a force of about 9,205 lbs. As noted above, the mechanical bias assembly 550, *i.e.*, springs 560, generates a force of about 6,735 lbs. Thus, the maximum total force acting on the material 14 is about 15,940 lbs. This force creates a reaction force that acts upon the tooling, this non-reduced force is a disadvantage.

In another exemplary embodiment, a tooling 400A that includes a progressive clamp bead 600 allows for the 422 cup with the profile described above to be formed while predominantly utilizing the mechanical bias assembly 550, *i.e.*, springs 560. That is, in an exemplary embodiment, the pressure generating device 512 provides a pressure of about 100 psi which generates a force of about 2,299 lbs. As before, the mechanical bias assembly 550, *i.e.*, springs 560, generates a force of about 6,735 lbs. Thus, the pressure generating device 512 provides about 25% of the total force and the mechanical bias assembly 550 provides about 75% of the total force. Moreover, the maximum total force is about 9,034 lbs. of force, which is about 56% of the 15,940 lbs. of force required relative to the prior art embodiment above. Accordingly, the tooling 400A that includes a progressive clamp bead 600 operates at a “reduced force” relative to the embodiment above.

It is understood that the pressure provided by the pressure generating assembly 510 may be changed. The following table provides a comparison of pressure bias and mechanical bias at selected pressures. For this example, and for purposes of comparison, the prior art system operated at a pressure of about 432 psi which brings the total load to a maximum allowable load per pocket of 16,667 lbf. It is noted that especially desirable results have been observed when the air pressure is one of 290 psi, 195 psi, and 100 psi.

				Pressure Bias		Mechanical Bias
Force Reduction (%)	Total Force (Air+Spring)	Air Pressure (PSI)	Air Force (Lbs)	Air % of Total Force	Spring Force (Lbs)	Spring % of Total Force
4%	15944	400	9209	58%	6735	42%
10%	15023	360	8288	55%	6735	45%
11%	14792	350	8058	54%	6735	46%
15%	14217	325	7482	53%	6735	47%
20%	13411	290	6676	50%	6735	50%
22%	13066	275	6331	48%	6735	52%
25%	12490	250	5755	46%	6735	54%
29%	11915	225	5180	43%	6735	57%
32%	11339	200	4604	41%	6735	59%
33%	11224	195	4489	40%	6735	60%
35%	10764	175	4029	37%	6735	63%
39%	10188	150	3453	34%	6735	66%
42%	9612	125	2878	30%	6735	70%
46%	9037	100	2302	25%	6735	75%
49%	8461	75	1727	20%	6735	80%
53%	7886	50	1151	15%	6735	85%
56%	7310	25	576	8%	6735	92%
58%	6965	10	230	3%	6735	97%
59%	6781	2	46	1%	6735	99%
60%	6735	0	0	0%	6735	100%

Figure 19B discloses a similar reduction in force when forming aluminum. That is, when forming aluminum with the prior art tooling and with a pressure of about 365 psi, the maximum load when forming the dome was about 9,916 lbf per pocket (at position of stroke 280°) as shown on Figure 19B and as detailed in Appendix 1. In this configuration, a one-hundred and fifty ton dual-action press with a 75 ton (150,000 lbf) capacity for each of the upper and lower tooling had fifteen pockets. Using the tooling 400A described above, and with a pressure of about 70 psi, the maximum load is reduced to about 4,750 lbf. In this embodiment, it is again assumed that the exemplary hybrid bias generating assembly 500 has a pressure surface 521 with a total area of about 28.11 in^2 (*i.e.*, a torus with an inner diameter of about 3.125 in. and an outer diameter of about 6.75 in.) and eight springs 560. In this example, the springs 560 generate a maximum combined force of about 3,526 lbs. Thus, in this example, the pressure generating assembly 510 generates a force of about 1,224 lbf. and the mechanical bias assembly 550 generates a force of about 3,526 lbf.

As before, the pressure generated by the pressure generating assembly 510 may be changed. The following table provides a comparison of pressure bias and mechanical bias at selected pressures. For this example, and for purposes of comparison, the total load, which is the maximum allowable load per pocket, was determined to be 10,000 lbf. per pocket. It is noted that especially desirable results have been observed when the air pressure is one of 200 psi, 135 psi, and 68 psi.

				Pressure Bias		Mechanical Bias
Force Reduction (%)	Total Force (Air+Spring)	Air Pressure (PSI)	Air Force (Lbs)	Air % of Total Force	Spring Force (Lbs)	Spring % of Total Force
	10000					
1%	9918	365	6392	64%	3526	36%
2%	9830	360	6304	64%	3526	36%
3%	9655	350	6129	63%	3526	37%
8%	9217	325	5691	62%	3526	38%
12%	8779	300	5254	60%	3526	40%
17%	8342	275	4816	58%	3526	42%
21%	7904	250	4378	55%	3526	45%
25%	7466	225	3940	53%	3526	47%
30%	7028	200	3502	50%	3526	50%
34%	6590	175	3065	47%	3526	53%
38%	6153	150	2627	43%	3526	57%
41%	5890	135	2364	40%	3526	60%
43%	5715	125	2189	38%	3526	62%
47%	5277	100	1751	33%	3526	67%
52%	4839	75	1313	27%	3526	73%
53%	4717	68	1191	25%	3526	75%
56%	4401	50	876	20%	3526	80%
60%	3964	25	438	11%	3526	89%
63%	3701	10	175	5%	3526	95%
64%	3613	5	88	2%	3526	98%
65%	3526	0	0	0%	3526	100%

Further, and as above, in one embodiment, the pressure generating assembly 510 is not used and the mechanical bias assembly 550 generates a total force of about 3,526 lbf.

Accordingly, as shown in Figure 18, use of the tooling 400, 400A described above includes introducing 1000 material, *i.e.*, a can body 2 or cup 22, 122, 422 between tooling 400, 400A, generating 1002 a total bias force within the tooling 400, 400A, clamping 1004 the material between an upper tool assembly 402, 402A and a lower tool assembly 406, 406A, forming 1006 the material to include sidewalls 4, 6 and a bottom profile 8, and, wherein, in an exemplary embodiment, the bottom profile 8 includes a dome portion 12 and an annular ridge 10, and selectively stretching 1008 at least one predetermined portion of the can body 2 or cup 22, 122, 422 relative to at least one other portion of the can body 2 or cup 22, 122, 422 to provide a corresponding thinned portion of the shell. Further, clamping 1004 the material between an upper tool assembly 402, 402A and a lower tool assembly 406, 406A includes clamping 1020 the material at a clamp bead 410, and/or, clamping 1022 the material at a progressive clamp bead 600.

Returning to Figure 19A, in an exemplary embodiment, a tooling 400A that includes a progressive clamp bead 600 allows for reduced forces as shown. This further resulted in reduced counter loads and solves the problems stated above. In an exemplary embodiment, forming a cup with a dome 430, and in this example a standard 0211 x 413 cup (3.5 inch - 3.625 inch diameter cup for a standard 12.0 oz. beverage can), made from steel, without a clamp bead 600 requires a force of about 15,940 lbs. (per cup) which includes 9,205 lbs. of force generated by air pressure and 6,735 lbs. of spring force. In an exemplary embodiment, wherein the tooling 400A that includes a progressive clamp bead 600, forming a cup with a stretched dome 430 made from steel requires a force of about 9,034 lbs. (per cup) which includes 2,299, lbs. of force generated by air pressure and 6,735 lbs. of spring force. In another exemplary embodiment, forming a cup made from steel requires a force of about 6,735 lbs. (per cup) which includes 0 lbs. of air pressure and 6,735 lbs of spring force.

Returning to Figure 19B, in an exemplary embodiment, a tooling 400A that includes a progressive clamp bead 600 allows for reduced forces as shown. This further resulted in reduced counter loads and solves the problems stated above. In an exemplary embodiment, forming a cup with a dome 430, and in this example a standard 0211 x 413 cup (3.5 inch -

3.625 inch diameter cup for a standard 12.0 oz. beverage can), made from aluminum, without a clamp bead 600 requires a force of about 9,916 lbs. (per cup) which includes 6,390 lbs. of force generated by air pressure and 3,526 lbs. of spring force. In an exemplary embodiment, wherein the tooling 400A that includes a progressive clamp bead 600, forming a cup with a stretched dome 430 made from aluminum requires a force of about 4,750 lbs. (per cup) which includes 1,224, lbs. of force generated by air pressure and 3,526 lbs. of spring force. In another exemplary embodiment, forming a cup made from aluminum requires a force of about 3,526 lbs. (per cup) which includes 0 lbs. of air pressure and 3,526 lbs of spring force.

Thus, a method of forming a 2011 steel cup 422 includes providing 1100 a tooling 400A that includes a progressive clamp bead 600, applying a total pressure that is between about 4% to 60%, less than the pressure required by a tooling that does not include a progressive clamp bead 600. Further, a method of forming a 2011 aluminum cup 422 includes providing 1100 a tooling 400A that includes a progressive clamp bead 600, applying a total pressure that is between about 1% to 65%, less than the pressure required by a tooling that does not include a progressive clamp bead 600. It is again noted that the reduction in forming pressure solves the problems stated above.

Stated alternately, a method of forming a cup 422 including a clamp bead 420 or a progressive clamp bead 600 includes the following. Initially, it is noted that the tooling 400, 400A is driven by a drive assembly having a reciprocating arm or ram, or similar construct, coupled to a rotating crank, none shown. The rotating crank moves 360 degrees during a cycle. Thus, the application of loads and the movement of the elements of the tooling 400, 400A are related to the angular position of the crank. For the purpose of this disclosure, it is understood that, as described below, the identified angles represent the ram, or similar construct, angle relative to the crank during its rotation; this angle is, as employed herein, the "position of stroke." Further, this position is associated with the position of the outer slide. That is, as employed herein, the "position of stroke" is the radial position of the crank and is measured herein by degrees wherein zero degrees represents the bottom dead center for the punch 404A on a dual action press. It is further understood that the angles are relative. That is, for example, by altering the configuration of the drive assembly and/or the tooling 400, 400A, the identified steps could occur at similar relative angles, *e.g.*, the initiation, change, duration, and reduction of loads could occur 10 degrees sooner than the angles identified below. The relevant disclosure is that of the value, change, and duration of the identified load(s) as opposed to a specific angle at which the value, change, and duration of the identified load(s) occurs. Further, via the use of cams, or similar constructs (not shown), the punch 404A moves at a different time than the outer slide. The "position of stroke" is identified in relation to the outer slide.

As noted above, Figures 19A and 19B show the forces associated with the formation of a cup wherein the tooling does not include a progressive clamp bead 600. Line 700 represents the load over crank angle of a prior art tooling without a clamp bead 410 and/or progressive clamp bead 600. Line 702 represents the load over time of tooling 400A with a progressive clamp bead 600, as well as an outer slide with a pressure concentrating forming surface (not shown), as disclosed in U.S. Patent Application Serial No. 14/722,187. The horizontal axis shows the crank angle as discussed above. The right vertical axis represents the load for each "pocket" as defined above. The specific loads are exemplary and represent the formation of DAC-150 cups in an eight-out (eight cups formed at one time) press. These specific loads are exemplary; it is understood that different model cups would have different specific loads. The relative, *i.e.*, percentage, reduction in loads solves the problems stated above.

Initially, there is a bottom of inner stroke phase (wherein the material is blanked) for the outer slide when the position of stroke is between about 145° and about 150°. For a steel cup, and as shown on Figure 19A, with prior art tooling, the force during blanking peaks at above 12,000 lbf, or about 12,367 lbf. (see Appendix 1) compared to the tooling 400A, such as an outer slide with a pressure concentrating forming surface (not shown), which has an peak blanking force of about 10,000 lbf. or about 9,589 lbf. By the end of the bottom of inner stroke phase, the prior art tooling allowed the force to be lessened to between 5,000 lbf and 6,000 lbf. and, in an exemplary embodiment, to about 5,250 lbf. Thus, when utilizing the tooling 400A with an outer slide with a pressure concentrating forming surface, the force is reduced; that is, the force is lessened to between 2,000 lbf and 3,000 lbf. or about 2,625 lbf. As used herein, "applying a reduced impact force" means that tooling including an outer slide with a pressure concentrating forming surface applies a reduced force, or a moderately reduced force, relative to the prior art tooling during the impact phase. Further, “applying a reduced impact force” includes “applying a reduced clamp bead impact force” which, as used herein, is the reduced force associated with a tooling 400 including a clamp bead 410. Further, “applying a reduced impact force” includes “applying a reduced progressive clamp bead impact force” which, as used herein, is the reduced force associated with a tooling 400 including a progressive clamp bead 600. Further, “applying a reduced impact force,” “applying a reduced clamp bead impact force,” or “applying a reduced progressive clamp bead impact force” solves the problems stated above.

After the bottom of inner stroke phase, the draw pad bias phase occurs when the position of stroke is between about 150° and about 180°. During the draw pad bias phase, the outer elements of the upper tool assembly 402A engage the material. During the draw pad bias phase, the force (hereinafter the “draw pad bias force”) remains substantially constant. With prior art tooling, the draw pad bias force was about 5,250 lbf. compared to the tooling 400A with a an outer slide with a pressure concentrating forming surface which has a draw pad bias force of about 2,625 lbf. As used herein, “applying a reduced draw pad bias force” means that tooling, including an outer slide with a pressure concentrating forming surface, applies a reduced force, or a moderately reduced force, relative to the prior art tooling during the draw pad bias phase. Further, “applying a reduced draw pad bias force” includes “applying a reduced clamp bead draw pad bias force” which, as used herein, is the reduced force associated with a tooling 400 including a clamp bead 410. Further, “applying a reduced draw pad bias force” includes “applying a reduced progressive clamp bead draw pad bias force” which, as used herein, is the reduced force associated with a tooling 400 including a progressive clamp bead 600. Further, “applying a reduced draw pad bias force,” “applying a reduced clamp bead draw pad bias force,” or “applying a reduced progressive clamp bead draw pad bias force” solves the problems stated above.

After the draw pad bias phase, the draw phase occurs when the position of stroke is between about 180° and about 200°. During the draw phase, the inner elements of the upper tool assembly 402A engage the material and form the cup, as described above. Further, during the draw phase, the force (hereinafter the “draw force”) initially increases then remains substantially constant. With prior art tooling, the draw force increased from about

5,250 lbf to about 6252 lbf. It is noted that for tooling 400A with a clamp bead 410 and/or progressive clamp bead 600, the draw forces are substantially similar, *i.e.*, about 6252 lbf. As used herein, "applying a draw force" means that tooling, including a clamp bead 410 and/or progressive clamp bead 600, applies a similar force relative to the prior art tooling during the draw phase.

After the draw phase, the motion phase occurs when the position of stroke is between about 200° and about 245°. During the motion phase, the partially formed cup is moved toward the contour 316. During the motion phase, the forces on the prior art tooling and the tooling 400, 400A with a clamp bead 410 and/or progressive clamp bead 600 are substantially similar and are, essentially, reduced to zero as the cup moves.

After the motion phase, the pre-doming phase occurs when the position of stroke is between about 245° and about 250°. During the pre-doming phase, the force (hereinafter the "pre-doming force") increases quickly. That is, the pre-doming phase is a second impact wherein the cup engages the contour 316. With prior art tooling, the pre-doming force increased from about 0 (zero) to about 10,242 lbf. compared to the tooling 400A with a clamp bead 410 and/or progressive clamp bead 600 wherein the pre-doming force increases from about 0 (zero) to about 3,336 lbf. As used herein, "applying a reduced pre-doming force" means that tooling, including a clamp bead 410 and/or progressive clamp bead 600, applies a reduced force, or a moderately reduced force, relative to the prior art tooling during the pre-doming phase. Further, "applying a reduced pre-doming force" includes "applying a reduced clamp bead pre-doming force," or "applying a moderately reduced clamp bead pre-doming force" which, as used herein, is the reduced force, or a moderately reduced force, associated with a tooling 400 including a clamp bead 410. Further, "applying a reduced pre-doming force," or "applying a moderately reduced pre-doming force" includes "applying a reduced progressive clamp bead pre-doming force" which, as used herein, is the reduced force, or a moderately reduced force, associated with a tooling 400 including a progressive clamp bead 600. Further, "applying a reduced pre-doming force," or "applying a reduced clamp bead pre-doming force" or "applying a reduced progressive clamp bead pre-doming force" solves the problems stated above.

After the pre-doming phase, the doming phase occurs when the position of stroke is between about 250° and about 280°. During the doming phase, the dome is formed, as described above. Further, during the doming phase, the force (hereinafter the "doming force") increases while the rate of increase in the doming force decreases. When the position of stroke is about 280°, the rate of increasing force levels off and the force begins to decrease in the release phase, discussed below. It is noted that when the position of stroke is between about 245° and about 265°, when the force is between about 667 lbf. and 7,572 lbf. the material is "progressively clamped" as defined above. That is, in the identified range of the position of stroke and the identified range of forces, and when the tooling 400 includes a progressive clamp bead 600, the material initially flows through the "progressively clamped" area. At about position of stroke 266 and at about a force of 7,760 lbf. the amount of material that moves/flows through the progressively clamped area decreases until the amount is negligible.

With prior art tooling, the doming force increased from about 8,194 lbf. to about 15,940 lbf. (as discussed above). The tooling 400, 400A with a clamp bead 410 and/or progressive clamp bead 600 forms the dome 430 using a reduced force wherein the doming force increased from of about 2,669 lbf. to about 9,034 lbf. (as discussed above). As used herein, "applying a reduced doming force" means that tooling, including a clamp bead 410 and/or progressive clamp bead 600, applies a reduced force relative to the prior art tooling during the doming phase. Further, "applying a reduced doming force" includes "applying a reduced clamp bead doming force" which, as used herein, is the reduced force associated with a tooling 400 including a clamp bead 410. Further, "applying a reduced doming force" includes "applying a reduced progressive clamp bead doming force" which, as used herein, is the reduced force associated with a tooling 400 including a progressive clamp bead 600. Further, "applying a reduced doming force," or "applying a reduced clamp bead doming force" or "applying a reduced progressive clamp bead doming force" solves the problems stated above.

Further, as used herein, "applying a moderately reduced doming force" means that tooling, including a clamp bead 410 and/or progressive clamp bead 600, applies a moderately reduced force relative to the prior art tooling during the doming phase. Further, "applying a moderately reduced doming force" includes "applying a moderately reduced clamp bead doming force" which, as used herein, is the moderately reduced force associated with a tooling 400 including a clamp bead 410. Further, "applying a moderately reduced doming force" includes "applying a moderately reduced progressive clamp bead doming force" which, as used herein, is the moderately reduced force associated with a tooling 400 including a progressive clamp bead 600. Further, "applying a moderately reduced doming force," or "applying a moderately reduced clamp bead doming force" or "applying a moderately reduced progressive clamp bead doming force" solves the problems stated above.

After the doming phase, a release phase occurs when the position of stroke is between about 280° and about 310°. During the release the forces decrease in a manner that is substantially the opposite of the rate that the forces increased during the doming phase and the pre-doming phase. That is, the forces decrease while increasing the rate of the decrease. When the upper tool assembly 402, 402A and the lower tool assembly 406, 406A separate, the force is rapidly reduced to zero.

Thus, the method includes, introducing material between tooling 1000, as detailed above, applying a reduced impact force 2002, applying a reduced draw pad bias force 2004, applying a draw force 2006, reducing the force during a motion phase 2007, applying a reduced pre-doming force 2008, and applying a reduced doming force 2010. Further, as noted above, applying a reduced impact force 2002 includes one of applying a reduced clamp bead impact force 2022, or, applying a reduced progressive clamp bead impact force 2032. Similarly, applying a reduced draw pad bias force 2004 includes one of applying a reduced clamp bead draw pad bias force 2024 or applying a reduced progressive clamp bead draw pad bias force 2034. Similarly, applying a reduced pre-doming force 2008 includes one of applying a reduced clamp bead pre-doming force 2028 or applying a reduced progressive clamp bead pre-doming force 2038. Similarly, applying a reduced doming force 2010 includes one of applying a reduced clamp bead doming force 2040 or applying a reduced progressive clamp bead doming force 2050. Further, the disclosed method includes applying a moderately reduced doming force 2011. Applying a moderately reduced doming force 2011 includes one of applying a moderately reduced clamp bead doming force 2041 or applying a moderately reduced progressive clamp bead doming force 2051.

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. Accordingly, the particular arrangements disclosed are meant to be illustrative only and not limiting as to the scope of the disclosed concept which is to be given the full breadth of the claims appended and any and all equivalents thereof.

General Info		**Variable 2 Green/Gold Springs**
Date&Time:	4/22/2015 15:28	**200 PSI**
Job Name:	New Job	**0.145" Dome spacer**
SPM:	158	**Plover locating ring**
Look Window Start Ai	50	**R0.09 dome punch spacer and OD rework**
Look Window End An	229	
Stroke Count:	23734	

	CH1	Ch2	CH3	CH4
Peak:	1.6	1.6	1.7	2
Capacity:	90	90	90	90
Target:	0	0	0	0
Sample:	7	7.7	7.3	7.2
+Tol:	15%	15%	15%	15%
-Tol:	15%	15%	15%	15%
EFactor:	1	1	1	1
Tracking On:	0	0	0	0
PCurve On:	0	0	0	0

Signatures

Angle		CH1	Ch2	CH3	CH4	Σ CH1-CH4 (ton)	Σ CH1-CH4 (lbs)	
50	150	0	0	0	0	0	0	
50.8	150.8	0	0.1	0.1	0.1	0.3	600	
51.6	151.6	0.1	0.1	0.1	0	0.3	600	
52.4	152.4	0.2	0.2	0.2	0.1	0.7	1400	
53.2	153.2	0.2	0.2	0.4	0.2	1	2000	
54	154	0.3	0.2	0.5	0.3	1.3	2600	
54.8	154.8	0.2	0	0.4	0.2	0.8	1600	
55.6	155.6	0.1	0	0.3	0.1	0.5	1000	
56.4	156.4	0.1	0.2	0.3	0.2	0.8	1600	
57.2	157.2	0.1	0.3	0.3	0.4	1.1	2200	
58	158	0.1	0.5	0.3	0.5	1.4	2800	
58.8	158.8	0.3	0.6	0.4	0.6	1.9	3800	
59.6	159.6	0.4	0.6	0.5	0.7	2.2	4400	
60.4	160.4	0.4	0.3	0.6	0.5	1.8	3600	
61.2	161.2	0.4	0.2	0.7	0.4	1.7	3400	
62	162	0.4	0.3	0.7	0.4	1.8	3600	
62.8	162.8	0.3	0.3	0.6	0.5	1.7	3400	
63.6	163.6	0.2	0.3	0.4	0.5	1.4	2800	
64.4	164.4	0.2	0.4	0.4	0.6	1.6	3200	
65.2	165.2	0.3	0.5	0.5	0.6	1.9	3800	
66	166	0.3	0.5	0.5	0.6	1.9	3800	
66.8	166.8	0.4	0.5	0.5	0.6	2	4000	
67.6	167.6	0.4	0.5	0.5	0.6	2	4000	
68.4	168.4	0.5	0.5	0.5	0.6	2.1	4200	
69.2	169.2	0.4	0.4	0.5	0.4	1.7	3400	
70	170	0.4	0.3	0.7	0.4	1.8	3600	
70.8	170.8	0.4	0.3	0.6	0.4	1.7	3400	
71.6	171.6	0.4	0.4	0.6	0.5	1.9	3800	
72.4	172.4	0.3	0.4	0.5	0.6	1.8	3600	
73.2	173.2	0.3	0.5	0.5	0.6	1.9	3800	15589.79
74	174	0.4	0.6	0.4	0.5	1.9	3800	
74.8	174.8	0.4	0.6	0.5	0.5	2	4000	
75.6	175.6	0.4	0.5	0.6	0.5	2	4000	
76.4	176.4	0.5	0.5	0.5	0.4	1.9	3800	
77.2	177.2	0.5	0.4	0.5	0.4	1.8	3600	
78	178	0.5	0.4	0.6	0.4	1.9	3800	
78.8	178.8	0.4	0.4	0.6	0.4	1.8	3600	
79.6	179.6	0.5	0.4	0.5	0.4	1.8	3600	
80.4	180.4	0.5	0.5	0.5	0.5	2	4000	
81.2	181.2	0.4	0.5	0.5	0.5	1.9	3800	

APPENDIX A

82	182	0.4	0.5	0.4	0.5	1.8	3600	
82.8	182.8	0.4	0.5	0.4	0.5	1.8	3600	
83.6	183.6	0.4	0.5	0.5	0.4	1.8	3600	
84.4	184.4	0.4	0.5	0.5	0.4	1.8	3600	
85.2	185.2	0.4	0.4	0.6	0.4	1.8	3600	
86	186	0.4	0.4	0.5	0.4	1.7	3400	
86.8	186.8	0.4	0.4	0.5	0.3	1.6	3200	
87.6	187.6	0.4	0.4	0.4	0.4	1.6	3200	
88.4	188.4	0.4	0.4	0.4	0.4	1.6	3200	
89.2	189.2	0.3	0.5	0.3	0.4	1.5	3000	
90	190	0.3	0.5	0.4	0.4	1.6	3200	
90.8	190.8	0.4	0.5	0.4	0.4	1.7	3400	
91.6	191.6	0.7	0.8	0.6	0.7	2.8	5600	
92.4	192.4	0.9	1	0.9	0.9	3.7	7400	
93.2	193.2	0.9	1.1	1	1	4	8000	
94	194	0.9	1.1	1.1	1.1	4.2	8400	
94.8	194.8	0.9	1.1	1.2	1.2	4.4	8800	
95.5	195.5	0.9	1.1	1.2	1.2	4.4	8800	
96.3	196.3	0.9	1.1	1.1	1.2	4.3	8600	
97.1	197.1	0.9	1.2	1	1.1	4.2	8400	
97.9	197.9	0.9	1.2	0.8	1.1	4	8000	
98.7	198.7	0.8	1.2	0.7	0.9	3.6	7200	
99.5	199.5	0.7	1.1	0.6	0.8	3.2	6400	
100.3	200.3	0.7	1	0.7	0.8	3.2	6400	
101.1	201.1	0.7	1	0.8	0.9	3.4	6800	
101.9	201.9	0.7	0.9	0.8	0.9	3.3	6600	
102.7	202.7	0.6	0.8	0.8	1	3.2	6400	
103.5	203.5	0.6	0.8	0.8	1	3.2	6400	
104.3	204.3	0.6	0.8	0.8	1.1	3.3	6600	
105.1	205.1	0.5	0.8	0.7	1.1	3.1	6200	5250
105.9	205.9	0.5	0.8	0.7	1	3	6000	5250
106.7	206.7	0.5	0.8	0.5	0.9	2.7	5400	5250
107.5	207.5	0.4	0.8	0.5	0.9	2.6	5200	5250
108.3	208.3	0.5	0.7	0.4	0.8	2.4	4800	5250
109.1	209.1	0.5	0.7	0.4	0.6	2.2	4400	5250
109.9	209.9	0.5	0.7	0.4	0.6	2.2	4400	5250
110.7	210.7	0.4	0.6	0.4	0.5	1.9	3800	5250
111.5	211.5	0.2	0.5	0.3	0.5	1.5	3000	5250
112.3	212.3	0	0.3	0.2	0.4	0.9	1800	5250
113.1	213.1	0	0.3	0.3	0.4	1	2000	5250
113.9	213.9	-0.1	0.2	0.2	0.4	0.7	1400	5250
114.7	214.7	-0.1	0.2	0.2	0.3	0.6	1200	5250
115.5	215.5	-0.1	0.1	0.1	0.3	0.4	800	5250
116.3	216.3	-0.2	-0.1	-0.1	0.1	-0.3	-600	5250
117.1	217.1	-0.3	-0.2	-0.2	0	-0.7	-1400	5250
117.9	217.9	-0.4	-0.3	-0.3	-0.2	-1.2	-2400	0
118.7	218.7	-0.5	-0.5	-0.4	-0.4	-1.8	-3600	0
119.5	219.5	-0.5	-0.6	-0.5	-0.5	-2.1	-4200	0
120.3	220.3	-0.6	-0.6	-0.7	-0.7	-2.6	-5200	0
121.1	221.1	-0.7	-0.7	-0.8	-0.7	-2.9	-5800	0
121.9	221.9	-0.7	-0.6	-0.7	-0.7	-2.7	-5400	0
122.7	222.7	-0.7	-0.6	-0.6	-0.7	-2.6	-5200	0
123.5	223.5	-0.6	-0.5	-0.4	-0.5	-2	-4000	0
124.3	224.3	-0.6	-0.6	-0.3	-0.6	-2.1	-4200	0
125.1	225.1	-0.5	-0.6	-0.3	-0.6	-2	-4000	0
125.9	225.9	-0.5	-0.6	-0.4	-0.7	-2.2	-4400	0
126.7	226.7	-0.5	-0.6	-0.5	-0.7	-2.3	-4600	0
127.5	227.5	-0.6	-0.7	-0.6	-0.7	-2.6	-5200	0
128.3	228.3	-0.7	-0.7	-0.6	-0.7	-2.7	-5400	0
129.1	229.1	-0.7	-0.7	-0.6	-0.7	-2.7	-5400	0
129.9	229.9	-0.7	-0.7	-0.5	-0.6	-2.5	-5000	0
130.7	230.7	-0.6	-0.6	-0.5	-0.6	-2.3	-4600	0

131.5	231.5	-0.5	-0.6	-0.5	-0.6	-2.2	-4400	0
132.3	232.3	-0.5	-0.5	-0.5	-0.6	-2.1	-4200	0
133.1	233.1	-0.5	-0.6	-0.5	-0.7	-2.3	-4600	0
133.9	233.9	-0.5	-0.6	-0.5	-0.8	-2.4	-4800	0
134.7	234.7	-0.5	-0.6	-0.6	-0.8	-2.5	-5000	0
135.5	235.5	-0.6	-0.6	-0.6	-0.8	-2.6	-5200	0
136.3	236.3	-0.6	-0.6	-0.6	-0.8	-2.6	-5200	0
137.1	237.1	-0.6	-0.7	-0.5	-0.7	-2.5	-5000	0
137.9	237.9	-0.6	-0.7	-0.4	-0.6	-2.3	-4600	0
138.7	238.7	-0.6	-0.7	-0.4	-0.6	-2.3	-4600	0
139.5	239.5	-0.5	-0.6	-0.3	-0.5	-1.9	-3800	0
140.3	240.3	-0.5	-0.6	-0.4	-0.5	-2	-4000	0
141.1	241.1	-0.5	-0.5	-0.4	-0.6	-2	-4000	0
141.9	241.9	-0.6	-0.6	-0.5	-0.6	-2.3	-4600	0
142.7	242.7	-0.6	-0.6	-0.6	-0.7	-2.5	-5000	0
143.5	243.5	-0.7	-0.6	-0.6	-0.7	-2.6	-5200	0
144.3	244.3	-0.6	-0.6	-0.7	-0.7	-2.6	-5200	0
145.1	245.1	-0.6	-0.5	-0.7	-0.7	-2.5	-5000	0
145.9	245.9	-0.6	-0.5	-0.7	-0.7	-2.5	-5000	0
146.7	246.7	-0.6	-0.6	-0.6	-0.6	-2.4	-4800	0
147.5	247.5	-0.6	-0.6	-0.6	-0.6	-2.4	-4800	0
148.3	248.3	-0.6	-0.7	-0.6	-0.6	-2.5	-5000	0
149.1	249.1	-0.6	-0.7	-0.6	-0.6	-2.5	-5000	0
149.9	249.9	-0.6	-0.6	-0.6	-0.5	-2.3	-4600	0
150.7	250.7	-0.5	-0.4	-0.4	-0.3	-1.6	-3200	0
151.5	251.5	0.1	0.4	0.3	0.4	1.2	2400	0
152.3	252.3	0.6	1	0.8	0.9	3.3	6600	0
153.1	253.1	0.5	0.9	0.8	0.9	3.1	6200	11654
153.9	253.9	0.2	0.5	0.5	0.6	1.8	3600	
154.7	254.7	0.2	0.4	0.4	0.6	1.6	3200	
155.5	255.5	0.4	0.7	0.6	0.8	2.5	5000	
156.3	256.3	0.6	0.9	0.8	0.9	3.2	6400	
157.1	257.1	0.5	0.8	0.5	0.8	2.6	5200	12928.44
157.9	257.9	0.1	0.6	0.1	0.5	1.3	2600	
158.7	258.7	0.2	0.7	0.2	0.6	1.7	3400	
159.5	259.5	0.6	1	0.6	1	3.2	6400	
160.3	260.3	1.1	1.4	1.2	1.5	5.2	10400	
161.1	261.1	1.2	1.5	1.4	1.7	5.8	11600	13991.48
161.9	261.9	1	1.3	1.3	1.7	5.3	10600	
162.7	262.7	0.8	1.1	1.3	1.6	4.8	9600	
163.5	263.5	0.7	1.1	1.2	1.6	4.6	9200	
164.3	264.3	0.9	1.4	1.2	1.7	5.2	10400	
165.1	265.1	1.1	1.5	1.2	1.6	5.4	10800	14831.12
165.9	265.9	1.1	1.5	1.1	1.5	5.2	10400	
166.7	266.7	0.9	1.3	0.9	1.3	4.4	8800	
167.5	267.5	1	1.4	0.9	1.3	4.6	9200	
168.3	268.3	1.2	1.6	1.1	1.5	5.4	10800	
169.1	269.1	1.5	1.8	1.5	1.7	6.5	13000	15437.82
169.9	269.9	1.4	1.8	1.7	1.8	6.7	13400	
170.7	270.7	1.3	1.6	1.6	1.8	6.3	12600	
171.5	271.5	1.2	1.5	1.7	1.9	6.3	12600	
172.3	272.3	1.4	1.6	1.9	2.1	7	14000	
173.1	273.1	1.5	1.8	2.1	2.1	7.5	15000	15804.63
173.9	273.9	1.7	1.9	2.1	2.2	7.9	15800	
174.7	274.7	1.6	1.9	1.9	2	7.4	14800	
175.5	275.5	1.6	1.8	1.8	1.9	7.1	14200	
176.3	276.3	1.6	1.8	1.7	1.9	7	14000	
177.1	277.1	1.7	1.8	1.7	1.8	7	14000	15927.38
177.9	277.9	1.8	1.9	1.8	1.9	7.4	14800	
178.7	278.7	1.8	1.8	1.8	1.9	7.3	14600	
179.5	279.5	1.7	1.7	1.9	1.9	7.2	14400	
180.3	280.3	1.6	1.7	2	1.9	7.2	14400	

181.1	281.1	1.8	1.8	2.1	2.1	7.8	15600	15804.63
181.9	281.9	2	1.9	2.5	2.3	8.7	17400	
182.7	282.7	2.1	2	2.7	2.4	9.2	18400	
183.5	283.5	2	2	2.7	2.3	9	18000	
184.2	284.2	1.9	1.9	2.6	2.2	8.6	17200	
185	285	1.9	1.9	2.5	2.2	8.5	17000	15437.82
185.8	285.8	1.9	1.9	2.4	2.1	8.3	16600	
186.6	286.6	1.9	1.9	2.2	2	8	16000	
187.4	287.4	1.8	1.7	2.1	1.9	7.5	15000	
188.2	288.2	1.5	1.4	1.8	1.6	6.3	12600	
189	289	1.3	1.2	1.6	1.4	5.5	11000	14831.12
189.8	289.8	1.3	1.1	1.6	1.3	5.3	10600	
190.6	290.6	1.3	1.1	1.6	1.4	5.4	10800	
191.4	291.4	1.3	1.2	1.7	1.5	5.7	11400	

192.2	292.2	1.3	1.2	1.8	1.5	5.8	11600	
193	293	1.4	1.2	1.8	1.5	5.9	11800	13991.48
193.8	293.8	1.3	1.3	1.8	1.5	5.9	11800	
194.6	294.6	1.3	1.2	1.8	1.5	5.8	11600	
195.4	295.4	1.3	1.3	1.8	1.5	5.9	11800	
196.2	296.2	1.3	1.3	1.7	1.5	5.8	11600	
197	297	1.2	1.2	1.6	1.4	5.4	10800	12928.44
197.8	297.8	1.1	1.1	1.5	1.3	5	10000	
198.6	298.6	1	1	1.3	1.2	4.5	9000	
199.4	299.4	1	1	1.3	1.1	4.4	8800	
200.2	300.2	1.1	1	1.3	1.1	4.5	9000	
201	301	1.1	1.1	1.3	1.2	4.7	9400	11654
201.8	301.8	1	1.1	1.3	1.2	4.6	9200	
202.6	302.6	1	1.1	1.4	1.3	4.8	9600	
203.4	303.4	1	1.1	1.5	1.3	4.9	9800	
204.2	304.2	1	1.1	1.5	1.4	5	10000	
205	305	1	1.1	1.5	1.4	5	10000	
205.8	305.8	1	1.1	1.4	1.3	4.8	9600	
206.6	306.6	0.9	1	1.3	1.2	4.4	8800	
207.4	307.4	0.9	1	1.2	1.2	4.3	8600	
208.2	308.2	0.8	1	1.1	1.1	4	8000	
209	309	0.8	0.9	0.9	1	3.6	7200	
209.8	309.8	0.8	0.9	0.8	1	3.5	7000	
210.6	310.6	0.8	0.8	0.8	1	3.4	6800	
211.4	311.4	0.8	0.8	0.8	0.9	3.3	6600	
212.2	312.2	0.7	0.8	0.8	0.9	3.2	6400	
213	313	0.7	0.8	0.9	0.9	3.3	6600	
213.8	313.8	0.7	0.8	1	1	3.5	7000	
214.6	314.6	0.7	0.8	1	0.9	3.4	6800	
215.4	315.4	0.6	0.8	1	0.9	3.3	6600	
216.2	316.2	0.5	0.8	0.9	0.8	3	6000	
217	317	0.5	0.7	0.8	0.8	2.8	5600	
217.8	317.8	0.5	0.7	0.7	0.7	2.6	5200	
218.6	318.6	0.5	0.6	0.6	0.6	2.3	4600	
219.4	319.4	0.4	0.5	0.5	0.5	1.9	3800	
220.2	320.2	0.3	0.3	0.3	0.4	1.3	2600	
221	321	0.1	0.1	0.1	0.2	0.5	1000	
221.8	321.8	-0.5	-0.4	-0.4	-0.2	-1.5	-3000	
222.6	322.6	-0.6	-0.6	-0.5	-0.3	-2	-4000	
223.4	323.4	-0.4	-0.3	-0.3	-0.2	-1.2	-2400	
224.2	324.2	0	0.1	-0.1	0	0	0	
225	325	0	0.1	0	0	0.1	200	
225.8	325.8	-0.2	-0.3	-0.2	-0.3	-1	-2000	
226.6	326.6	-0.5	-0.5	-0.4	-0.5	-1.9	-3800	
227.4	327.4	-0.5	-0.4	-0.3	-0.4	-1.6	-3200	
228.2	328.2	-0.2	-0.1	0	-0.1	-0.4	-800	

General Info		**Variable 2 Green/Gold Springs**
Date&Time:	4/22/2015 15:11	**0 PSI**
Job Name:	New Job	**0.145" Dome spacer**
SPM:	31	**Plover locating ring**
Look Window Start Ar	50	**R0.09 dome punch spacer and OD rework**
Look Window End An	229	
Stroke Count:	23694	

	CH1	Ch2	CH3	CH4
Peak:	1.6	1.6	1.7	2
Capacity:	90	90	90	90
Target:	0	0	0	0
Sample:	7	7.7	7.3	7.2
+Tol:	15%	15%	15%	15%
-Tol:	15%	15%	15%	15%
EFactor:	1	1	1	1
Tracking On:	0	0	0	0
PCurve On:	0	0	0	0

Signatures

Angle		CH1	Ch2	CH3	CH4	Σ CH1-CH	Σ CH1-CH4 (lbs)	
50	150	0	0	0.1	0	0.1	200	
50.8	150.8	0.2	0.2	0.2	0.1	0.7	1400	
51.6	151.6	0.2	0.1	0.1	0	0.4	800	
52.4	152.4	0.1	0	0.1	0	0.2	400	
53.2	153.2	0.1	0	0.1	0.1	0.3	600	
54	154	0.1	-0.1	0.1	0	0.1	200	
54.8	154.8	0.1	-0.1	0	0	0	0	
55.6	155.6	0.1	0	0	0	0.1	200	
56.4	156.4	0.1	0	0	0	0.1	200	
57.2	157.2	0.3	0.2	0.1	0.2	0.8	1600	
58	158	0.4	0.4	0.2	0.4	1.4	2800	
58.8	158.8	0.6	0.5	0.4	0.5	2	4000	
59.6	159.6	0.6	0.4	0.6	0.4	2	4000	
60.4	160.4	0.6	0.3	0.8	0.3	2	4000	
61.2	161.2	0.5	0.3	0.8	0.4	2	4000	
62	162	0.3	0.3	0.7	0.4	1.7	3400	
62.8	162.8	0.2	0.3	0.5	0.4	1.4	2800	
63.6	163.6	0.2	0.4	0.4	0.4	1.4	2800	
64.4	164.4	0.3	0.5	0.4	0.5	1.7	3400	
65.2	165.2	0.3	0.5	0.4	0.5	1.7	3400	
66	166	0.3	0.5	0.4	0.6	1.8	3600	
66.8	166.8	0.3	0.5	0.3	0.7	1.8	3600	
67.6	167.6	0.4	0.5	0.3	0.7	1.9	3800	
68.4	168.4	0.4	0.4	0.3	0.6	1.7	3400	
69.2	169.2	0.3	0.4	0.4	0.5	1.6	3200	
70	170	0.3	0.4	0.3	0.6	1.6	3200	
70.8	170.8	0.1	0.4	0.2	0.7	1.4	2800	
71.6	171.6	0	0.5	0.2	0.8	1.5	3000	
72.4	172.4	0	0.5	0.2	0.8	1.5	3000	
73.2	173.2	0.1	0.6	0.2	0.7	1.6	3200	15589.79
74	174	0.1	0.6	0.3	0.7	1.7	3400	
74.8	174.8	0.2	0.6	0.2	0.6	1.6	3200	
75.6	175.6	0.2	0.5	0.2	0.6	1.5	3000	
76.4	176.4	0.1	0.4	0.2	0.6	1.3	2600	
77.2	177.2	0.1	0.4	0.2	0.7	1.4	2800	
78	178	0.1	0.4	0.2	0.7	1.4	2800	
78.8	178.8	0.1	0.4	0.2	0.7	1.4	2800	
79.6	179.6	0.1	0.5	0.1	0.7	1.4	2800	
80.4	180.4	0.1	0.5	0.1	0.7	1.4	2800	
81.2	181.2	0.1	0.5	0.1	0.7	1.4	2800	

APPENDIX B

82	182	0.1	0.4	0.2	0.6	1.3	2600	
82.8	182.8	0.2	0.4	0.2	0.5	1.3	2600	
83.6	183.6	0.2	0.4	0.2	0.5	1.3	2600	
84.4	184.4	0.2	0.3	0.2	0.5	1.2	2400	
85.2	185.2	0.2	0.4	0.1	0.6	1.3	2600	
86	186	0.2	0.4	0.2	0.6	1.4	2800	
86.8	186.8	0.2	0.3	0.2	0.6	1.3	2600	
87.6	187.6	0.2	0.3	0.1	0.5	1.1	2200	
88.4	188.4	0.2	0.3	0.2	0.5	1.2	2400	
89.2	189.2	0.2	0.3	0.2	0.4	1.1	2200	
90	190	0.3	0.3	0.2	0.4	1.2	2400	
90.8	190.8	0.4	0.5	0.4	0.6	1.9	3800	
91.6	191.6	0.5	0.8	0.6	0.9	2.8	5600	
92.4	192.4	0.6	0.8	0.7	1	3.1	6200	
93.2	193.2	0.8	0.9	0.9	1.1	3.7	7400	
94	194	0.9	1	0.9	1.2	4	8000	
94.8	194.8	0.8	0.9	0.7	1.1	3.5	7000	
95.5	195.5	0.8	1	0.7	1.2	3.7	7400	
96.3	196.3	0.7	1	0.7	1.3	3.7	7400	
97.1	197.1	0.6	1	0.7	1.4	3.7	7400	
97.9	197.9	0.7	1	0.7	1.3	3.7	7400	
98.7	198.7	0.6	1.1	0.5	1.3	3.5	7000	
99.5	199.5	0.5	1.2	0.6	1.5	3.8	7600	
100.3	200.3	0.6	1.2	0.5	1.4	3.7	7400	
101.1	201.1	1.3	1.5	1.3	1.5	5.6	11200	
101.9	201.9	1.3	1.5	1.2	1.5	5.5	11000	
102.7	202.7	1.3	1.5	1.3	1.4	5.5	11000	
103.5	203.5	1.2	1.4	1.2	1.4	5.2	10400	
104.3	204.3	1.2	1.4	1.2	1.3	5.1	10200	
105.1	205.1	1.2	1.3	1.1	1.2	4.8	9600	5250
105.9	205.9	1.2	1.3	1.1	1.2	4.8	9600	5250
106.7	206.7	1.1	1.2	1.1	1.1	4.5	9000	5250
107.5	207.5	1.1	1.2	1	1.1	4.4	8800	5250
108.3	208.3	1.1	1.2	1	1	4.3	8600	5250
109.1	209.1	1.1	1.1	1	1	4.2	8400	5250
109.9	209.9	1	1.1	0.9	0.9	3.9	7800	5250
110.7	210.7	1	1	0.9	0.8	3.7	7400	5250
111.5	211.5	0.8	0.8	0.8	0.7	3.1	6200	5250
112.3	212.3	0.7	0.6	0.6	0.5	2.4	4800	5250
113.1	213.1	0.7	0.6	0.6	0.5	2.4	4800	5250
113.9	213.9	0.7	0.7	0.6	0.5	2.5	5000	5250
114.7	214.7	0.6	0.6	0.5	0.4	2.1	4200	5250
115.5	215.5	0.5	0.4	0.4	0.2	1.5	3000	5250
116.3	216.3	0.3	0.2	0.3	0.1	0.9	1800	5250
117.1	217.1	0.3	0.1	0.2	0.1	0.7	1400	5250
117.9	217.9	0.1	-0.1	0	-0.1	-0.1	-200	0
118.7	218.7	-0.1	-0.2	-0.2	-0.3	-0.8	-1600	0
119.5	219.5	-0.2	-0.4	-0.3	-0.5	-1.4	-2800	0
120.3	220.3	-0.2	-0.4	-0.3	-0.5	-1.4	-2800	0
121.1	221.1	-0.2	-0.5	-0.3	-0.6	-1.6	-3200	0
121.9	221.9	-0.1	-0.5	-0.3	-0.6	-1.5	-3000	0
122.7	222.7	-0.1	-0.5	-0.1	-0.5	-1.2	-2400	0
123.5	223.5	-0.3	-0.6	0.1	-0.3	-1.1	-2200	0
124.3	224.3	-0.3	-0.6	0.1	-0.3	-1.1	-2200	0
125.1	225.1	-0.3	-0.5	0.1	-0.3	-1	-2000	0
125.9	225.9	-0.4	-0.6	0.1	-0.3	-1.2	-2400	0
126.7	226.7	-0.4	-0.6	0	-0.4	-1.4	-2800	0
127.5	227.5	-0.3	-0.5	-0.2	-0.6	-1.6	-3200	0
128.3	228.3	-0.3	-0.4	-0.3	-0.7	-1.7	-3400	0
129.1	229.1	-0.3	-0.4	-0.4	-0.7	-1.8	-3600	0
129.9	229.9	-0.2	-0.4	-0.5	-0.8	-1.9	-3800	0
130.7	230.7	-0.1	-0.4	-0.5	-0.8	-1.8	-3600	0

131.5	231.5	-0.2	-0.6	-0.3	-0.7	-1.8	-3600	0
132.3	232.3	-0.3	-0.7	-0.2	-0.5	-1.7	-3400	0
133.1	233.1	-0.3	-0.7	-0.1	-0.5	-1.6	-3200	0
133.9	233.9	-0.2	-0.6	0.1	-0.4	-1.1	-2200	0
134.7	234.7	-0.3	-0.6	0.2	-0.3	-1	-2000	0
135.5	235.5	-0.2	-0.5	0.2	-0.2	-0.7	-1400	0
136.3	236.3	-0.2	-0.4	0.1	-0.2	-0.7	-1400	0
137.1	237.1	-0.2	-0.3	0.1	-0.2	-0.6	-1200	0
137.9	237.9	-0.2	-0.2	-0.1	-0.3	-0.8	-1600	0
138.7	238.7	-0.1	-0.2	-0.3	-0.4	-1	-2000	0
139.5	239.5	-0.2	-0.2	-0.4	-0.6	-1.4	-2800	0
140.3	240.3	-0.2	-0.3	-0.5	-0.6	-1.6	-3200	0
141.1	241.1	-0.2	-0.4	-0.5	-0.6	-1.7	-3400	0
141.9	241.9	-0.2	-0.4	-0.4	-0.6	-1.6	-3200	0
142.7	242.7	-0.2	-0.4	-0.3	-0.5	-1.4	-2800	0
143.5	243.5	-0.2	-0.4	-0.2	-0.4	-1.2	-2400	0
144.3	244.3	-0.3	-0.4	-0.1	-0.2	-1	-2000	0
145.1	245.1	-0.3	-0.4	0	-0.1	-0.8	-1600	0
145.9	245.9	-0.3	-0.3	0	0	-0.6	-1200	0
146.7	246.7	-0.3	-0.3	0	0	-0.6	-1200	0
147.5	247.5	-0.3	-0.3	-0.1	-0.2	-0.9	-1800	0
148.3	248.3	-0.3	-0.3	-0.2	-0.2	-1	-2000	0
149.1	249.1	-0.4	-0.3	-0.4	-0.3	-1.4	-2800	0
149.9	249.9	-0.5	-0.3	-0.6	-0.4	-1.8	-3600	0
150.7	250.7	-0.4	-0.1	-0.6	-0.4	-1.5	-3000	0
151.5	251.5	-0.1	0.1	-0.3	-0.2	-0.5	-1000	0
152.3	252.3	0	0.2	-0.2	0	0	0	0
153.1	253.1	-0.1	0.1	-0.1	0.1	0	0	11654
153.9	253.9	-0.1	0	0	0.2	0.1	200	
154.7	254.7	0	0.1	0.4	0.5	1	2000	
155.5	255.5	0.2	0.2	0.6	0.7	1.7	3400	
156.3	256.3	0.2	0.3	0.5	0.6	1.6	3200	
157.1	257.1	0.1	0.3	0.4	0.5	1.3	2600	12928.44
157.9	257.9	0.2	0.3	0.3	0.5	1.3	2600	
158.7	258.7	0.3	0.5	0.3	0.5	1.6	3200	
159.5	259.5	0.4	0.7	0.3	0.5	1.9	3800	
160.3	260.3	0.3	0.6	0.3	0.5	1.7	3400	
161.1	261.1	0.3	0.6	0.2	0.4	1.5	3000	13991.48
161.9	261.9	0.3	0.6	0.3	0.5	1.7	3400	
162.7	262.7	0.4	0.6	0.5	0.6	2.1	4200	
163.5	263.5	0.6	0.7	0.7	0.8	2.8	5600	
164.3	264.3	0.6	0.7	0.8	0.9	3	6000	
165.1	265.1	0.6	0.7	0.9	0.9	3.1	6200	14831.12
165.9	265.9	0.7	0.7	1	1	3.4	6800	
166.7	266.7	0.9	0.8	1.1	1.1	3.9	7800	
167.5	267.5	1	0.9	1.2	1.1	4.2	8400	
168.3	268.3	0.9	0.9	1.1	1	3.9	7800	
169.1	269.1	0.9	0.9	1	0.9	3.7	7400	15437.82
169.9	269.9	0.9	0.9	0.9	0.8	3.5	7000	
170.7	270.7	0.9	1	1	0.8	3.7	7400	
171.5	271.5	1	1	1.1	0.9	4	8000	
172.3	272.3	1	1	1.1	0.9	4	8000	
173.1	273.1	1	0.9	1.3	1	4.2	8400	15804.63
173.9	273.9	1.1	1	1.4	1.1	4.6	9200	
174.7	274.7	1.3	1	1.6	1.3	5.2	10400	
175.5	275.5	1.3	1.1	1.7	1.4	5.5	11000	
176.3	276.3	1.4	1.1	1.7	1.4	5.6	11200	
177.1	277.1	1.4	1.1	1.7	1.4	5.6	11200	15927.38
177.9	277.9	1.4	1.1	1.6	1.3	5.4	10800	
178.7	278.7	1.4	1.2	1.6	1.3	5.5	11000	
179.5	279.5	1.4	1.2	1.6	1.2	5.4	10800	
180.3	280.3	1.4	1.1	1.5	1.2	5.2	10400	

181.1	281.1	1.4	1.2	1.5	1.1	5.2	10400	15804.63
181.9	281.9	1.4	1.2	1.5	1.1	5.2	10400	
182.7	282.7	1.4	1.2	1.6	1.2	5.4	10800	
183.5	283.5	1.5	1.3	1.8	1.4	6	12000	
184.2	284.2	1.5	1.3	1.8	1.4	6	12000	
185	285	1.5	1.2	1.9	1.5	6.1	12200	15437.82
185.8	285.8	1.5	1.3	2	1.5	6.3	12600	
186.6	286.6	1.5	1.2	1.9	1.5	6.1	12200	
187.4	287.4	1.4	1.1	1.7	1.3	5.5	11000	
188.2	288.2	1.2	0.9	1.4	1.1	4.6	9200	
189	289	1	0.8	1.1	0.9	3.8	7600	14831.12
189.8	289.8	0.9	0.7	0.9	0.7	3.2	6400	
190.6	290.6	0.8	0.7	0.8	0.7	3	6000	
191.4	291.4	0.7	0.7	0.8	0.7	2.9	5800	

192.2	292.2	0.8	0.7	0.8	0.7	3	6000	
193	293	0.8	0.7	1	0.8	3.3	6600	13991.48
193.8	293.8	0.7	0.7	1	0.9	3.3	6600	
194.6	294.6	0.8	0.7	1.1	0.9	3.5	7000	
195.4	295.4	0.7	0.8	1.1	0.9	3.5	7000	
196.2	296.2	0.7	0.8	1	0.9	3.4	6800	
197	297	0.6	0.8	0.9	0.8	3.1	6200	12928.44
197.8	297.8	0.6	0.7	0.8	0.8	2.9	5800	
198.6	298.6	0.5	0.7	0.7	0.8	2.7	5400	
199.4	299.4	0.5	0.7	0.7	0.8	2.7	5400	
200.2	300.2	0.5	0.8	0.7	0.8	2.8	5600	
201	301	0.5	0.8	0.7	0.8	2.8	5600	11654
201.8	301.8	0.5	0.7	0.7	0.9	2.8	5600	
202.6	302.6	0.5	0.7	0.6	0.8	2.6	5200	
203.4	303.4	0.5	0.7	0.6	0.8	2.6	5200	
204.2	304.2	0.5	0.7	0.5	0.8	2.5	5000	
205	305	0.5	0.7	0.5	0.8	2.5	5000	
205.8	305.8	0.4	0.7	0.4	0.7	2.2	4400	
206.6	306.6	0.4	0.7	0.4	0.7	2.2	4400	
207.4	307.4	0.4	0.7	0.5	0.7	2.3	4600	
208.2	308.2	0.4	0.7	0.5	0.7	2.3	4600	
209	309	0.4	0.6	0.5	0.7	2.2	4400	
209.8	309.8	0.4	0.6	0.5	0.7	2.2	4400	
210.6	310.6	0.3	0.6	0.5	0.7	2.1	4200	
211.4	311.4	0.3	0.5	0.5	0.6	1.9	3800	
212.2	312.2	0.3	0.5	0.4	0.6	1.8	3600	
213	313	0.3	0.5	0.3	0.5	1.6	3200	
213.8	313.8	0.3	0.5	0.3	0.4	1.5	3000	
214.6	314.6	0.3	0.4	0.2	0.4	1.3	2600	
215.4	315.4	0.3	0.4	0.3	0.3	1.3	2600	
216.2	316.2	0.3	0.3	0.3	0.3	1.2	2400	
217	317	0.2	0.3	0.3	0.3	1.1	2200	
217.8	317.8	0.2	0.2	0.3	0.2	0.9	1800	
218.6	318.6	0.2	0.2	0.2	0.2	0.8	1600	
219.4	319.4	0.2	0.1	0.2	0.1	0.6	1200	
220.2	320.2	0.1	0	0.1	0	0.2	400	
221	321	0	-0.1	0	-0.1	-0.2	-400	
221.8	321.8	0	-0.1	0	-0.1	-0.2	-400	
222.6	322.6	0.1	0	0.1	-0.1	0.1	200	
223.4	323.4	0.2	0	0.1	-0.1	0.2	400	
224.2	324.2	0.2	-0.1	0.2	-0.1	0.2	400	
225	325	0.2	-0.1	0.2	-0.1	0.2	400	
225.8	325.8	0.2	-0.1	0.3	-0.1	0.3	600	
226.6	326.6	0.2	-0.1	0.3	0	0.4	800	
227.4	327.4	0.3	0	0.3	0	0.6	1200	
228.2	328.2	0.3	0	0.2	-0.1	0.4	800	

General Info		**Variable 2 Green/Gold Springs**
Date&Time:	4/22/2015 18:01	**0 PSI**
Job Name:	New Job	**0.145" Dome spacer**
SPM:	158	**Without Plover locating ring**
Look Window Start Ar	50	**R0.09 dome punch spacer and OD rework**
Look Window End An	229	
Stroke Count:	24089	

	CH1	Ch2	CH3	CH4
Peak:	1.6	1.6	1.7	2
Capacity:	90	90	90	90
Target:	0	0	0	0
Sample:	7	7.7	7.3	7.2
+Tol:	15%	15%	15%	15%
-Tol:	15%	15%	15%	15%
EFactor:	1	1	1	1
Tracking On:	0	0	0	0
PCurve On:	0	0	0	0

Signatures

Angle		CH1	Ch2	CH3	CH4	Σ CH1-CH	Σ CH1-CH4 (lbs)
50	150	-0.1	0	0	0	-0.1	-200
50.8	150.8	0.1	0.1	0.1	0.1	0.4	800
51.6	151.6	0.2	0.2	0.2	0.1	0.7	1400
52.4	152.4	0.2	0.2	0.3	0.2	0.9	1800
53.2	153.2	0.2	0.2	0.4	0.2	1	2000
54	154	0.2	0.2	0.5	0.3	1.2	2400
54.8	154.8	0.1	0	0.4	0.2	0.7	1400
55.6	155.6	0.1	0	0.3	0.1	0.5	1000
56.4	156.4	0.1	0.1	0.4	0.1	0.7	1400
57.2	157.2	0.1	0.2	0.3	0.2	0.8	1600
58	158	0.2	0.4	0.3	0.4	1.3	2600
58.8	158.8	0.3	0.5	0.4	0.6	1.8	3600
59.6	159.6	0.3	0.5	0.4	0.6	1.8	3600
60.4	160.4	0.3	0.3	0.5	0.5	1.6	3200
61.2	161.2	0.3	0.2	0.7	0.4	1.6	3200
62	162	0.3	0.3	0.6	0.4	1.6	3200
62.8	162.8	0.3	0.3	0.5	0.5	1.6	3200
63.6	163.6	0.2	0.3	0.4	0.5	1.4	2800
64.4	164.4	0.3	0.4	0.4	0.5	1.6	3200
65.2	165.2	0.3	0.4	0.5	0.5	1.7	3400
66	166	0.3	0.5	0.5	0.5	1.8	3600
66.8	166.8	0.4	0.5	0.5	0.5	1.9	3800
67.6	167.6	0.4	0.5	0.5	0.5	1.9	3800
68.4	168.4	0.5	0.5	0.5	0.5	2	4000
69.2	169.2	0.4	0.4	0.5	0.5	1.8	3600
70	170	0.4	0.3	0.6	0.4	1.7	3400
70.8	170.8	0.3	0.3	0.6	0.4	1.6	3200
71.6	171.6	0.3	0.4	0.5	0.4	1.6	3200
72.4	172.4	0.3	0.4	0.5	0.5	1.7	3400
73.2	173.2	0.3	0.4	0.4	0.6	1.7	3400
74	174	0.4	0.5	0.4	0.5	1.8	3600
74.8	174.8	0.4	0.5	0.5	0.5	1.9	3800
75.6	175.6	0.4	0.4	0.5	0.4	1.7	3400
76.4	176.4	0.4	0.4	0.5	0.4	1.7	3400
77.2	177.2	0.4	0.4	0.5	0.4	1.7	3400
78	178	0.4	0.3	0.5	0.4	1.6	3200
78.8	178.8	0.4	0.3	0.5	0.4	1.6	3200
79.6	179.6	0.4	0.4	0.5	0.4	1.7	3400
80.4	180.4	0.4	0.4	0.5	0.4	1.7	3400
81.2	181.2	0.4	0.4	0.5	0.5	1.8	3600

APPENDIX C

82	182	0.4	0.4	0.4	0.4	1.6	3200
82.8	182.8	0.4	0.4	0.4	0.4	1.6	3200
83.6	183.6	0.4	0.4	0.5	0.4	1.7	3400
84.4	184.4	0.4	0.4	0.5	0.4	1.7	3400
85.2	185.2	0.4	0.3	0.5	0.4	1.6	3200
86	186	0.4	0.3	0.5	0.3	1.5	3000
86.8	186.8	0.4	0.3	0.5	0.4	1.6	3200
87.6	187.6	0.4	0.3	0.4	0.3	1.4	2800
88.4	188.4	0.3	0.4	0.4	0.4	1.5	3000
89.2	189.2	0.3	0.4	0.3	0.4	1.4	2800
90	190	0.3	0.4	0.4	0.4	1.5	3000
90.8	190.8	0.4	0.5	0.4	0.4	1.7	3400
91.6	191.6	0.7	0.8	0.7	0.6	2.8	5600
92.4	192.4	0.8	1	0.8	0.8	3.4	6800
93.2	193.2	0.9	1.1	1	1	4	8000
94	194	0.9	1.1	1	1.1	4.1	8200
94.8	194.8	0.9	1	1.1	1.1	4.1	8200
95.5	195.5	0.9	1	1.2	1.2	4.3	8600
96.3	196.3	0.9	1	1.1	1.2	4.2	8400
97.1	197.1	0.9	1.1	1	1.2	4.2	8400
97.9	197.9	0.9	1.1	0.8	1.1	3.9	7800
98.7	198.7	0.8	1.1	0.7	1	3.6	7200
99.5	199.5	0.7	1	0.6	0.9	3.2	6400
100.3	200.3	0.7	1	0.7	0.9	3.3	6600
101.1	201.1	0.7	0.9	0.7	0.9	3.2	6400
101.9	201.9	0.6	0.8	0.8	1	3.2	6400
102.7	202.7	0.6	0.8	0.8	1	3.2	6400
103.5	203.5	0.5	0.8	0.8	1	3.1	6200
104.3	204.3	0.5	0.8	0.8	1	3.1	6200
105.1	205.1	0.5	0.8	0.8	1	3.1	6200
105.9	205.9	0.5	0.8	0.7	1	3	6000
106.7	206.7	0.5	0.8	0.6	0.9	2.8	5600
107.5	207.5	0.4	0.7	0.5	0.9	2.5	5000
108.3	208.3	0.4	0.7	0.5	0.8	2.4	4800
109.1	209.1	0.5	0.7	0.5	0.7	2.4	4800
109.9	209.9	0.4	0.6	0.5	0.6	2.1	4200
110.7	210.7	0.3	0.5	0.4	0.5	1.7	3400
111.5	211.5	0.2	0.5	0.3	0.5	1.5	3000
112.3	212.3	0	0.3	0.2	0.4	0.9	1800
113.1	213.1	-0.1	0.3	0.3	0.4	0.9	1800
113.9	213.9	-0.1	0.2	0.3	0.3	0.7	1400
114.7	214.7	-0.1	0.2	0.2	0.3	0.6	1200
115.5	215.5	-0.1	0.1	0.1	0.3	0.4	800
116.3	216.3	-0.2	-0.1	-0.1	0.1	-0.3	-600
117.1	217.1	-0.3	-0.2	-0.2	0	-0.7	-1400
117.9	217.9	-0.4	-0.4	-0.3	-0.2	-1.3	-2600
118.7	218.7	-0.4	-0.5	-0.3	-0.3	-1.5	-3000
119.5	219.5	-0.5	-0.6	-0.5	-0.4	-2	-4000
120.3	220.3	-0.6	-0.7	-0.6	-0.6	-2.5	-5000
121.1	221.1	-0.7	-0.7	-0.7	-0.6	-2.7	-5400
121.9	221.9	-0.7	-0.6	-0.7	-0.6	-2.6	-5200
122.7	222.7	-0.7	-0.6	-0.5	-0.6	-2.4	-4800
123.5	223.5	-0.6	-0.5	-0.4	-0.6	-2.1	-4200
124.3	224.3	-0.6	-0.6	-0.3	-0.6	-2.1	-4200
125.1	225.1	-0.5	-0.6	-0.3	-0.6	-2	-4000
125.9	225.9	-0.5	-0.6	-0.4	-0.7	-2.2	-4400
126.7	226.7	-0.6	-0.6	-0.5	-0.8	-2.5	-5000
127.5	227.5	-0.6	-0.7	-0.6	-0.8	-2.7	-5400
128.3	228.3	-0.6	-0.7	-0.6	-0.8	-2.7	-5400
129.1	229.1	-0.6	-0.7	-0.6	-0.7	-2.6	-5200
129.9	229.9	-0.6	-0.7	-0.6	-0.6	-2.5	-5000
130.7	230.7	-0.5	-0.6	-0.6	-0.6	-2.3	-4600

131.5	231.5	-0.4	-0.6	-0.5	-0.6	-2.1	-4200
132.3	232.3	-0.4	-0.6	-0.5	-0.6	-2.1	-4200
133.1	233.1	-0.4	-0.6	-0.5	-0.7	-2.2	-4400
133.9	233.9	-0.5	-0.6	-0.5	-0.8	-2.4	-4800
134.7	234.7	-0.5	-0.6	-0.6	-0.8	-2.5	-5000
135.5	235.5	-0.5	-0.6	-0.6	-0.8	-2.5	-5000
136.3	236.3	-0.6	-0.6	-0.6	-0.8	-2.6	-5200
137.1	237.1	-0.6	-0.6	-0.5	-0.7	-2.4	-4800
137.9	237.9	-0.6	-0.6	-0.4	-0.7	-2.3	-4600
138.7	238.7	-0.6	-0.6	-0.4	-0.7	-2.3	-4600
139.5	239.5	-0.6	-0.6	-0.4	-0.6	-2.2	-4400
140.3	240.3	-0.6	-0.5	-0.4	-0.6	-2.1	-4200
141.1	241.1	-0.6	-0.5	-0.5	-0.6	-2.2	-4400
141.9	241.9	-0.6	-0.5	-0.5	-0.6	-2.2	-4400
142.7	242.7	-0.6	-0.6	-0.6	-0.7	-2.5	-5000
143.5	243.5	-0.6	-0.6	-0.7	-0.7	-2.6	-5200
144.3	244.3	-0.6	-0.6	-0.7	-0.7	-2.6	-5200
145.1	245.1	-0.6	-0.6	-0.7	-0.6	-2.5	-5000
145.9	245.9	-0.6	-0.6	-0.7	-0.6	-2.5	-5000
146.7	246.7	-0.6	-0.6	-0.6	-0.6	-2.4	-4800
147.5	247.5	-0.6	-0.7	-0.6	-0.5	-2.4	-4800
148.3	248.3	-0.7	-0.7	-0.5	-0.5	-2.4	-4800
149.1	249.1	-0.7	-0.7	-0.5	-0.6	-2.5	-5000
149.9	249.9	-0.7	-0.6	-0.6	-0.6	-2.5	-5000
150.7	250.7	-0.6	-0.4	-0.4	-0.4	-1.8	-3600
151.5	251.5	-0.4	-0.2	-0.3	-0.3	-1.2	-2400
152.3	252.3	-0.3	0	-0.2	-0.1	-0.6	-1200
153.1	253.1	-0.3	-0.1	-0.2	-0.1	-0.7	-1400
153.9	253.9	-0.4	-0.1	-0.3	-0.2	-1	-2000
154.7	254.7	-0.4	-0.1	-0.2	-0.1	-0.8	-1600
155.5	255.5	-0.2	0	-0.2	0	-0.4	-800
156.3	256.3	-0.1	0.1	-0.1	0.1	0	0
157.1	257.1	-0.2	0	-0.2	0	-0.4	-800
157.9	257.9	-0.3	0	-0.2	0	-0.5	-1000
158.7	258.7	-0.1	0	-0.1	0.1	-0.1	-200
159.5	259.5	0	0.2	0.1	0.3	0.6	1200
160.3	260.3	0.2	0.3	0.3	0.5	1.3	2600
161.1	261.1	0.2	0.4	0.4	0.6	1.6	3200
161.9	261.9	0.2	0.3	0.4	0.6	1.5	3000
162.7	262.7	0.2	0.4	0.3	0.5	1.4	2800
163.5	263.5	0.2	0.5	0.3	0.5	1.5	3000
164.3	264.3	0.3	0.6	0.3	0.5	1.7	3400
165.1	265.1	0.3	0.6	0.3	0.5	1.7	3400
165.9	265.9	0.3	0.6	0.3	0.5	1.7	3400
166.7	266.7	0.3	0.6	0.3	0.5	1.7	3400
167.5	267.5	0.4	0.6	0.4	0.5	1.9	3800
168.3	268.3	0.5	0.7	0.6	0.6	2.4	4800
169.1	269.1	0.6	0.7	0.7	0.8	2.8	5600
169.9	269.9	0.6	0.8	0.8	0.8	3	6000
170.7	270.7	0.6	0.8	0.8	0.9	3.1	6200
171.5	271.5	0.6	0.8	0.8	0.9	3.1	6200
172.3	272.3	0.7	0.8	0.9	1	3.4	6800
173.1	273.1	0.8	0.9	1	1	3.7	7400
173.9	273.9	0.8	0.9	1	1	3.7	7400
174.7	274.7	0.8	0.9	0.9	1	3.6	7200
175.5	275.5	0.8	0.9	0.9	1	3.6	7200
176.3	276.3	0.9	0.9	0.9	1	3.7	7400
177.1	277.1	0.9	0.9	1	1	3.8	7600
177.9	277.9	1	1	1	1	4	8000
178.7	278.7	1	1	1.1	1	4.1	8200
179.5	279.5	1	1	1.1	1.1	4.2	8400
180.3	280.3	1	1	1.3	1.1	4.4	8800

181.1	281.1	1	1	1.4	1.2	4.6	9200
181.9	281.9	1.1	1.1	1.5	1.3	5	10000
182.7	282.7	1.1	1.1	1.6	1.3	5.1	10200
183.5	283.5	1.1	1.1	1.6	1.3	5.1	10200
184.2	284.2	1.1	1.1	1.5	1.3	5	10000
185	285	1.1	1.1	1.5	1.2	4.9	9800
185.8	285.8	1.1	1.1	1.4	1.2	4.8	9600
186.6	286.6	1.1	1	1.3	1.1	4.5	9000
187.4	287.4	0.9	0.8	1.1	1	3.8	7600
188.2	288.2	0.8	0.7	1	0.9	3.4	6800
189	289	0.6	0.5	0.9	0.7	2.7	5400
189.8	289.8	0.5	0.4	0.8	0.6	2.3	4600
190.6	290.6	0.5	0.4	0.8	0.6	2.3	4600
191.4	291.4	0.5	0.4	0.8	0.6	2.3	4600

192.2	292.2	0.5	0.5	0.9	0.7	2.6	5200
193	293	0.5	0.5	0.9	0.7	2.6	5200
193.8	293.8	0.5	0.5	0.8	0.6	2.4	4800
194.6	294.6	0.5	0.5	0.8	0.6	2.4	4800
195.4	295.4	0.4	0.5	0.8	0.5	2.2	4400
196.2	296.2	0.4	0.5	0.7	0.6	2.2	4400
197	297	0.4	0.5	0.7	0.5	2.1	4200
197.8	297.8	0.3	0.4	0.6	0.5	1.8	3600
198.6	298.6	0.3	0.3	0.5	0.4	1.5	3000
199.4	299.4	0.3	0.3	0.5	0.5	1.6	3200
200.2	300.2	0.3	0.4	0.5	0.5	1.7	3400
201	301	0.3	0.4	0.6	0.6	1.9	3800
201.8	301.8	0.3	0.4	0.5	0.6	1.8	3600
202.6	302.6	0.3	0.4	0.5	0.6	1.8	3600
203.4	303.4	0.3	0.4	0.5	0.5	1.7	3400
204.2	304.2	0.2	0.4	0.5	0.5	1.6	3200
205	305	0.2	0.4	0.4	0.5	1.5	3000
205.8	305.8	0.2	0.4	0.4	0.4	1.4	2800
206.6	306.6	0.2	0.4	0.4	0.4	1.4	2800
207.4	307.4	0.1	0.4	0.3	0.4	1.2	2400
208.2	308.2	0.1	0.3	0.3	0.4	1.1	2200
209	309	0.1	0.3	0.3	0.4	1.1	2200
209.8	309.8	0.1	0.3	0.3	0.4	1.1	2200
210.6	310.6	0.1	0.3	0.2	0.4	1	2000
211.4	311.4	0.1	0.3	0.2	0.4	1	2000
212.2	312.2	0.1	0.3	0.2	0.4	1	2000
213	313	0.1	0.2	0.2	0.3	0.8	1600
213.8	313.8	0.1	0.3	0.2	0.3	0.9	1800
214.6	314.6	0	0.2	0.2	0.2	0.6	1200
215.4	315.4	0	0.2	0.1	0.1	0.4	800
216.2	316.2	-0.1	0.2	0	0.1	0.2	400
217	317	-0.1	0.2	0	0	0.1	200
217.8	317.8	-0.1	0.1	0	0	0	0
218.6	318.6	-0.2	0	-0.1	-0.1	-0.4	-800
219.4	319.4	-0.2	0	-0.1	-0.1	-0.4	-800
220.2	320.2	-0.3	-0.1	-0.2	-0.1	-0.7	-1400
221	321	-0.3	-0.2	-0.2	-0.2	-0.9	-1800
221.8	321.8	-0.4	-0.3	-0.3	-0.3	-1.3	-2600
222.6	322.6	-0.3	-0.2	-0.3	-0.2	-1	-2000
223.4	323.4	-0.2	-0.2	-0.2	-0.2	-0.8	-1600
224.2	324.2	-0.2	-0.2	-0.2	-0.2	-0.8	-1600
225	325	-0.2	-0.2	-0.2	-0.3	-0.9	-1800
225.8	325.8	-0.3	-0.2	-0.2	-0.3	-1	-2000
226.6	326.6	-0.3	-0.2	-0.2	-0.3	-1	-2000
227.4	327.4	-0.3	-0.2	-0.1	-0.2	-0.8	-1600
228.2	328.2	-0.2	-0.1	-0.1	-0.2	-0.6	-1200

General Info			**Variable 6 Green/Gold Springs**
Date&Time:		4/22/2015 16:44	**200 PSI**
Job Name:	New Job		**0.145" Dome spacer**
SPM:		0	**Plover locating ring**
Look Window Start Ar		50	**R0.09 dome punch spacer and OD rework**
Look Window End An		229	
Stroke Count:		23794	

	CH1	Ch2	CH3	CH4
Peak:	1.6	1.6	1.7	2
Capacity:	90	90	90	90
Target:	0	0	0	0
Sample:	7	7.7	7.3	7.2
+Tol:	15%	15%	15%	15%
-Tol:	15%	15%	15%	15%
EFactor:	1	1	1	1
Tracking On:	0	0	0	0
PCurve On:	0	0	0	0

Signatures

Angle	CH1	Ch2	CH3	CH4	Σ CH1-CH	Σ CH1-CH4 (lbs)
50	150				0	0
50.8	150.8				0	0
51.6	151.6				0	0
52.4	152.4				0	0
53.2	153.2				0	0
54	154				0	0
54.8	154.8				0	0
55.6	155.6				0	0
56.4	156.4				0	0
57.2	157.2				0	0
58	158				0	0
58.8	158.8				0	0
59.6	159.6				0	0
60.4	160.4				0	0
61.2	161.2				0	0
62	162				0	0
62.8	162.8				0	0
63.6	163.6				0	0
64.4	164.4				0	0
65.2	165.2				0	0
66	166				0	0
66.8	166.8				0	0
67.6	167.6				0	0
68.4	168.4				0	0
69.2	169.2				0	0
70	170				0	0
70.8	170.8				0	0
71.6	171.6				0	0
72.4	172.4				0	0
73.2	173.2				0	0
74	174				0	0
74.8	174.8				0	0
75.6	175.6				0	0
76.4	176.4				0	0
77.2	177.2				0	0
78	178				0	0
78.8	178.8				0	0
79.6	179.6				0	0
80.4	180.4				0	0
81.2	181.2				0	0

APPENDIX D

82	182	0	0
82.8	182.8	0	0
83.6	183.6	0	0
84.4	184.4	0	0
85.2	185.2	0	0
86	186	0	0
86.8	186.8	0	0
87.6	187.6	0	0
88.4	188.4	0	0
89.2	189.2	0	0
90	190	0	0
90.8	190.8	0	0
91.6	191.6	0	0
92.4	192.4	0	0
93.2	193.2	0	0
94	194	0	0
94.8	194.8	0	0
95.5	195.5	0	0
96.3	196.3	0	0
97.1	197.1	0	0
97.9	197.9	0	0
98.7	198.7	0	0
99.5	199.5	0	0
100.3	200.3	0	0
101.1	201.1	0	0
101.9	201.9	0	0
102.7	202.7	0	0
103.5	203.5	0	0
104.3	204.3	0	0
105.1	205.1	0	0
105.9	205.9	0	0
106.7	206.7	0	0
107.5	207.5	0	0
108.3	208.3	0	0
109.1	209.1	0	0
109.9	209.9	0	0
110.7	210.7	0	0
111.5	211.5	0	0
112.3	212.3	0	0
113.1	213.1	0	0
113.9	213.9	0	0
114.7	214.7	0	0
115.5	215.5	0	0
116.3	216.3	0	0
117.1	217.1	0	0
117.9	217.9	0	0
118.7	218.7	0	0
119.5	219.5	0	0
120.3	220.3	0	0
121.1	221.1	0	0
121.9	221.9	0	0
122.7	222.7	0	0
123.5	223.5	0	0
124.3	224.3	0	0
125.1	225.1	0	0
125.9	225.9	0	0
126.7	226.7	0	0
127.5	227.5	0	0
128.3	228.3	0	0
129.1	229.1	0	0
129.9	229.9	0	0
130.7	230.7	0	0

131.5	231.5	0	0
132.3	232.3	0	0
133.1	233.1	0	0
133.9	233.9	0	0
134.7	234.7	0	0
135.5	235.5	0	0
136.3	236.3	0	0
137.1	237.1	0	0
137.9	237.9	0	0
138.7	238.7	0	0
139.5	239.5	0	0
140.3	240.3	0	0
141.1	241.1	0	0
141.9	241.9	0	0
142.7	242.7	0	0
143.5	243.5	0	0
144.3	244.3	0	0
145.1	245.1	0	0
145.9	245.9	0	0
146.7	246.7	0	0
147.5	247.5	0	0
148.3	248.3	0	0
149.1	249.1	0	0
149.9	249.9	0	0
150.7	250.7	0	0
151.5	251.5	0	0
152.3	252.3	0	0
153.1	253.1	0	0
153.9	253.9	0	0
154.7	254.7	0	0
155.5	255.5	0	0
156.3	256.3	0	0
157.1	257.1	0	0
157.9	257.9	0	0
158.7	258.7	0	0
159.5	259.5	0	0
160.3	260.3	0	0
161.1	261.1	0	0
161.9	261.9	0	0
162.7	262.7	0	0
163.5	263.5	0	0
164.3	264.3	0	0
165.1	265.1	0	0
165.9	265.9	0	0
166.7	266.7	0	0
167.5	267.5	0	0
168.3	268.3	0	0
169.1	269.1	0	0
169.9	269.9	0	0
170.7	270.7	0	0
171.5	271.5	0	0
172.3	272.3	0	0
173.1	273.1	0	0
173.9	273.9	0	0
174.7	274.7	0	0
175.5	275.5	0	0
176.3	276.3	0	0
177.1	277.1	0	0
177.9	277.9	0	0
178.7	278.7	0	0
179.5	279.5	0	0
180.3	280.3	0	0

181.1	281.1	0	0
181.9	281.9	0	0
182.7	282.7	0	0
183.5	283.5	0	0
184.2	284.2	0	0
185	285	0	0
185.8	285.8	0	0
186.6	286.6	0	0
187.4	287.4	0	0
188.2	288.2	0	0
189	289	0	0
189.8	289.8	0	0
190.6	290.6	0	0
191.4	291.4	0	0

192.2	292.2	0	0
193	293	0	0
193.8	293.8	0	0
194.6	294.6	0	0
195.4	295.4	0	0
196.2	296.2	0	0
197	297	0	0
197.8	297.8	0	0
198.6	298.6	0	0
199.4	299.4	0	0
200.2	300.2	0	0
201	301	0	0
201.8	301.8	0	0
202.6	302.6	0	0
203.4	303.4	0	0
204.2	304.2	0	0
205	305	0	0
205.8	305.8	0	0
206.6	306.6	0	0
207.4	307.4	0	0
208.2	308.2	0	0
209	309	0	0
209.8	309.8	0	0
210.6	310.6	0	0
211.4	311.4	0	0
212.2	312.2	0	0
213	313	0	0
213.8	313.8	0	0
214.6	314.6	0	0
215.4	315.4	0	0
216.2	316.2	0	0
217	317	0	0
217.8	317.8	0	0
218.6	318.6	0	0
219.4	319.4	0	0
220.2	320.2	0	0
221	321	0	0
221.8	321.8	0	0
222.6	322.6	0	0
223.4	323.4	0	0
224.2	324.2	0	0
225	325	0	0
225.8	325.8	0	0
226.6	326.6	0	0
227.4	327.4	0	0
228.2	328.2	0	0

General Info		**Variable 6 Green/Gold Springs**
Date&Time:	4/22/2015 16:50	**0 PSI**
Job Name:	New Job	**0.145" Dome spacer**
SPM:	158	**Plover locating ring**
Look Window Start Ar	50	**R0.09 dome punch spacer and OD rework**
Look Window End An	229	
Stroke Count:	23844	

	CH1	Ch2	CH3	CH4
Peak:	1.6	1.6	1.7	2
Capacity:	90	90	90	90
Target:	0	0	0	0
Sample:	7	7.7	7.3	7.2
+Tol:	15%	15%	15%	15%
-Tol:	15%	15%	15%	15%
EFactor:	1	1	1	1
Tracking On:	0	0	0	0
PCurve On:	0	0	0	0

Signatures

Angle		CH1	Ch2	CH3	CH4	Σ CH1-CH	Σ CH1-CH4 (lbs)
50	150	0	0	0	0	0	0
50.8	150.8	0.1	0.1	0.1	0.1	0.4	800
51.6	151.6	0.1	0.1	0.1	0.1	0.4	800
52.4	152.4	0.1	0.1	0.2	0.1	0.5	1000
53.2	153.2	0.1	0.2	0.3	0.1	0.7	1400
54	154	0.2	0.1	0.4	0.3	1	2000
54.8	154.8	0.1	0	0.4	0.2	0.7	1400
55.6	155.6	0.1	0	0.3	0.1	0.5	1000
56.4	156.4	0.1	0.1	0.3	0.1	0.6	1200
57.2	157.2	0.1	0.3	0.3	0.3	1	2000
58	158	0.1	0.4	0.2	0.4	1.1	2200
58.8	158.8	0.3	0.5	0.3	0.5	1.6	3200
59.6	159.6	0.4	0.5	0.4	0.6	1.9	3800
60.4	160.4	0.3	0.2	0.6	0.4	1.5	3000
61.2	161.2	0.3	0.2	0.7	0.3	1.5	3000
62	162	0.3	0.3	0.6	0.4	1.6	3200
62.8	162.8	0.2	0.2	0.5	0.4	1.3	2600
63.6	163.6	0.2	0.2	0.4	0.4	1.2	2400
64.4	164.4	0.2	0.3	0.4	0.5	1.4	2800
65.2	165.2	0.3	0.5	0.4	0.5	1.7	3400
66	166	0.3	0.5	0.5	0.4	1.7	3400
66.8	166.8	0.3	0.5	0.4	0.5	1.7	3400
67.6	167.6	0.4	0.5	0.4	0.5	1.8	3600
68.4	168.4	0.4	0.4	0.4	0.4	1.6	3200
69.2	169.2	0.4	0.3	0.5	0.3	1.5	3000
70	170	0.4	0.3	0.5	0.3	1.5	3000
70.8	170.8	0.3	0.3	0.5	0.3	1.4	2800
71.6	171.6	0.3	0.3	0.5	0.3	1.4	2800
72.4	172.4	0.3	0.3	0.4	0.5	1.5	3000
73.2	173.2	0.3	0.4	0.4	0.5	1.6	3200
74	174	0.3	0.4	0.4	0.5	1.6	3200
74.8	174.8	0.4	0.4	0.5	0.4	1.7	3400
75.6	175.6	0.4	0.4	0.5	0.4	1.7	3400
76.4	176.4	0.4	0.4	0.5	0.4	1.7	3400
77.2	177.2	0.4	0.4	0.5	0.3	1.6	3200
78	178	0.4	0.3	0.5	0.4	1.6	3200
78.8	178.8	0.4	0.3	0.5	0.4	1.6	3200
79.6	179.6	0.3	0.3	0.5	0.3	1.4	2800
80.4	180.4	0.4	0.4	0.5	0.4	1.7	3400
81.2	181.2	0.3	0.4	0.4	0.4	1.5	3000

APPENDIX E

82	182	0.3	0.4	0.4	0.4	1.5	3000
82.8	182.8	0.4	0.4	0.4	0.4	1.6	3200
83.6	183.6	0.3	0.4	0.5	0.4	1.6	3200
84.4	184.4	0.3	0.3	0.5	0.4	1.5	3000
85.2	185.2	0.4	0.3	0.5	0.3	1.5	3000
86	186	0.4	0.3	0.5	0.3	1.5	3000
86.8	186.8	0.4	0.3	0.5	0.3	1.5	3000
87.6	187.6	0.3	0.3	0.4	0.3	1.3	2600
88.4	188.4	0.3	0.3	0.3	0.3	1.2	2400
89.2	189.2	0.3	0.3	0.3	0.3	1.2	2400
90	190	0.3	0.3	0.4	0.3	1.3	2600
90.8	190.8	0.4	0.4	0.4	0.4	1.6	3200
91.6	191.6	0.6	0.7	0.6	0.6	2.5	5000
92.4	192.4	0.8	0.9	0.8	0.8	3.3	6600
93.2	193.2	0.8	1	0.9	1	3.7	7400
94	194	0.8	1	1	1	3.8	7600
94.8	194.8	0.9	1	1.1	1.1	4.1	8200
95.5	195.5	0.8	1	1.2	1.1	4.1	8200
96.3	196.3	0.9	1	1.1	1.1	4.1	8200
97.1	197.1	0.8	1.1	1	1.1	4	8000
97.9	197.9	0.8	1.1	0.8	1	3.7	7400
98.7	198.7	0.7	1	0.7	0.9	3.3	6600
99.5	199.5	0.7	0.9	0.6	0.8	3	6000
100.3	200.3	0.7	0.9	0.7	0.8	3.1	6200
101.1	201.1	0.7	0.8	0.8	0.9	3.2	6400
101.9	201.9	0.6	0.8	0.8	0.9	3.1	6200
102.7	202.7	0.5	0.7	0.8	1	3	6000
103.5	203.5	0.5	0.8	0.8	1	3.1	6200
104.3	204.3	0.5	0.8	0.8	1	3.1	6200
105.1	205.1	0.5	0.8	0.8	1	3.1	6200
105.9	205.9	0.5	0.8	0.6	1	2.9	5800
106.7	206.7	0.4	0.8	0.6	0.9	2.7	5400
107.5	207.5	0.4	0.7	0.5	0.8	2.4	4800
108.3	208.3	0.4	0.7	0.5	0.7	2.3	4600
109.1	209.1	0.4	0.7	0.4	0.6	2.1	4200
109.9	209.9	0.4	0.6	0.4	0.6	2	4000
110.7	210.7	0.3	0.5	0.3	0.5	1.6	3200
111.5	211.5	0.2	0.4	0.3	0.5	1.4	2800
112.3	212.3	0	0.2	0.1	0.4	0.7	1400
113.1	213.1	0	0.2	0.1	0.3	0.6	1200
113.9	213.9	0	0.1	0.2	0.3	0.6	1200
114.7	214.7	-0.1	0.1	0.2	0.3	0.5	1000
115.5	215.5	-0.2	0.1	0.1	0.2	0.2	400
116.3	216.3	-0.2	-0.1	0	0	-0.3	-600
117.1	217.1	-0.3	-0.2	-0.1	-0.1	-0.7	-1400
117.9	217.9	-0.4	-0.3	-0.2	-0.2	-1.1	-2200
118.7	218.7	-0.5	-0.4	-0.3	-0.3	-1.5	-3000
119.5	219.5	-0.6	-0.6	-0.5	-0.5	-2.2	-4400
120.3	220.3	-0.6	-0.6	-0.6	-0.6	-2.4	-4800
121.1	221.1	-0.7	-0.7	-0.8	-0.7	-2.9	-5800
121.9	221.9	-0.6	-0.7	-0.7	-0.6	-2.6	-5200
122.7	222.7	-0.6	-0.6	-0.6	-0.6	-2.4	-4800
123.5	223.5	-0.5	-0.6	-0.5	-0.6	-2.2	-4400
124.3	224.3	-0.5	-0.7	-0.4	-0.6	-2.2	-4400
125.1	225.1	-0.5	-0.6	-0.4	-0.6	-2.1	-4200
125.9	225.9	-0.5	-0.6	-0.4	-0.7	-2.2	-4400
126.7	226.7	-0.5	-0.6	-0.4	-0.7	-2.2	-4400
127.5	227.5	-0.7	-0.7	-0.5	-0.7	-2.6	-5200
128.3	228.3	-0.7	-0.7	-0.5	-0.7	-2.6	-5200
129.1	229.1	-0.8	-0.7	-0.4	-0.7	-2.6	-5200
129.9	229.9	-0.7	-0.6	-0.4	-0.6	-2.3	-4600
130.7	230.7	-0.6	-0.6	-0.4	-0.6	-2.2	-4400

131.5	231.5	-0.4	-0.6	-0.4	-0.6	-2	-4000
132.3	232.3	-0.4	-0.6	-0.5	-0.7	-2.2	-4400
133.1	233.1	-0.4	-0.7	-0.6	-0.8	-2.5	-5000
133.9	233.9	-0.4	-0.7	-0.6	-0.8	-2.5	-5000
134.7	234.7	-0.4	-0.7	-0.7	-0.9	-2.7	-5400
135.5	235.5	-0.5	-0.7	-0.7	-0.8	-2.7	-5400
136.3	236.3	-0.5	-0.6	-0.6	-0.7	-2.4	-4800
137.1	237.1	-0.6	-0.6	-0.5	-0.6	-2.3	-4600
137.9	237.9	-0.6	-0.6	-0.4	-0.6	-2.2	-4400
138.7	238.7	-0.6	-0.6	-0.3	-0.5	-2	-4000
139.5	239.5	-0.6	-0.5	-0.3	-0.5	-1.9	-3800
140.3	240.3	-0.5	-0.5	-0.4	-0.5	-1.9	-3800
141.1	241.1	-0.5	-0.5	-0.4	-0.6	-2	-4000
141.9	241.9	-0.6	-0.6	-0.5	-0.7	-2.4	-4800
142.7	242.7	-0.6	-0.6	-0.6	-0.7	-2.5	-5000
143.5	243.5	-0.6	-0.6	-0.7	-0.8	-2.7	-5400
144.3	244.3	-0.6	-0.6	-0.8	-0.8	-2.8	-5600
145.1	245.1	-0.6	-0.5	-0.8	-0.8	-2.7	-5400
145.9	245.9	-0.6	-0.6	-0.7	-0.7	-2.6	-5200
146.7	246.7	-0.6	-0.6	-0.6	-0.6	-2.4	-4800
147.5	247.5	-0.6	-0.6	-0.6	-0.6	-2.4	-4800
148.3	248.3	-0.6	-0.6	-0.5	-0.5	-2.2	-4400
149.1	249.1	-0.7	-0.6	-0.5	-0.5	-2.3	-4600
149.9	249.9	-0.7	-0.6	-0.5	-0.5	-2.3	-4600
150.7	250.7	-0.6	-0.5	-0.4	-0.4	-1.9	-3800
151.5	251.5	-0.3	-0.2	-0.2	-0.1	-0.8	-1600
152.3	252.3	-0.2	-0.1	-0.1	0	-0.4	-800
153.1	253.1	-0.3	-0.1	-0.2	-0.1	-0.7	-1400
153.9	253.9	-0.3	-0.2	-0.3	-0.2	-1	-2000
154.7	254.7	-0.2	-0.1	-0.3	-0.1	-0.7	-1400
155.5	255.5	-0.1	0	-0.2	-0.1	-0.4	-800
156.3	256.3	-0.1	0.1	-0.2	0	-0.2	-400
157.1	257.1	-0.2	0.1	-0.2	-0.1	-0.4	-800
157.9	257.9	-0.2	0	-0.2	-0.1	-0.5	-1000
158.7	258.7	-0.2	0	-0.1	0	-0.3	-600
159.5	259.5	0	0.2	0.2	0.3	0.7	1400
160.3	260.3	0.1	0.3	0.4	0.5	1.3	2600
161.1	261.1	0.1	0.4	0.4	0.6	1.5	3000
161.9	261.9	0.1	0.4	0.4	0.5	1.4	2800
162.7	262.7	0.2	0.4	0.4	0.5	1.5	3000
163.5	263.5	0.2	0.4	0.3	0.5	1.4	2800
164.3	264.3	0.3	0.5	0.3	0.5	1.6	3200
165.1	265.1	0.4	0.6	0.3	0.5	1.8	3600
165.9	265.9	0.3	0.5	0.2	0.4	1.4	2800
166.7	266.7	0.3	0.5	0.2	0.4	1.4	2800
167.5	267.5	0.3	0.6	0.3	0.5	1.7	3400
168.3	268.3	0.5	0.7	0.5	0.6	2.3	4600
169.1	269.1	0.5	0.7	0.6	0.7	2.5	5000
169.9	269.9	0.6	0.8	0.7	0.8	2.9	5800
170.7	270.7	0.6	0.8	0.8	0.8	3	6000
171.5	271.5	0.6	0.8	0.8	0.9	3.1	6200
172.3	272.3	0.7	0.8	0.9	0.9	3.3	6600
173.1	273.1	0.8	0.9	1	1	3.7	7400
173.9	273.9	0.8	0.9	1	1	3.7	7400
174.7	274.7	0.8	0.9	0.9	0.9	3.5	7000
175.5	275.5	0.8	0.9	0.9	0.9	3.5	7000
176.3	276.3	0.8	0.9	0.8	0.9	3.4	6800
177.1	277.1	0.9	1	0.9	0.9	3.7	7400
177.9	277.9	0.9	1	0.9	0.9	3.7	7400
178.7	278.7	1	1	1	1	4	8000
179.5	279.5	0.9	1	1	1	3.9	7800
180.3	280.3	1	1	1.1	1	4.1	8200

181.1	281.1	1	1	1.3	1.2	4.5	9000
181.9	281.9	1.1	1	1.4	1.3	4.8	9600
182.7	282.7	1.1	1	1.5	1.3	4.9	9800
183.5	283.5	1.1	1	1.4	1.3	4.8	9600
184.2	284.2	1.1	1	1.4	1.2	4.7	9400
185	285	1.1	1	1.3	1.2	4.6	9200
185.8	285.8	1.1	1	1.3	1.1	4.5	9000
186.6	286.6	1	1	1.2	1	4.2	8400
187.4	287.4	0.9	0.8	1	0.9	3.6	7200
188.2	288.2	0.8	0.7	0.9	0.7	3.1	6200
189	289	0.6	0.5	0.8	0.6	2.5	5000
189.8	289.8	0.5	0.5	0.8	0.6	2.4	4800
190.6	290.6	0.5	0.5	0.8	0.6	2.4	4800
191.4	291.4	0.5	0.5	0.8	0.6	2.4	4800

192.2	292.2	0.5	0.5	0.8	0.7	2.5	5000
193	293	0.5	0.5	0.8	0.7	2.5	5000
193.8	293.8	0.5	0.5	0.8	0.7	2.5	5000
194.6	294.6	0.5	0.5	0.8	0.6	2.4	4800
195.4	295.4	0.5	0.4	0.7	0.6	2.2	4400
196.2	296.2	0.4	0.4	0.6	0.5	1.9	3800
197	297	0.4	0.4	0.6	0.5	1.9	3800
197.8	297.8	0.3	0.4	0.5	0.4	1.6	3200
198.6	298.6	0.3	0.4	0.5	0.4	1.6	3200
199.4	299.4	0.3	0.4	0.5	0.4	1.6	3200
200.2	300.2	0.3	0.4	0.5	0.5	1.7	3400
201	301	0.3	0.5	0.5	0.5	1.8	3600
201.8	301.8	0.3	0.5	0.6	0.6	2	4000
202.6	302.6	0.3	0.5	0.6	0.6	2	4000
203.4	303.4	0.3	0.4	0.6	0.6	1.9	3800
204.2	304.2	0.3	0.4	0.5	0.6	1.8	3600
205	305	0.3	0.4	0.4	0.5	1.6	3200
205.8	305.8	0.3	0.4	0.4	0.5	1.6	3200
206.6	306.6	0.2	0.4	0.3	0.5	1.4	2800
207.4	307.4	0.2	0.4	0.2	0.4	1.2	2400
208.2	308.2	0.2	0.4	0.2	0.4	1.2	2400
209	309	0.1	0.4	0.2	0.4	1.1	2200
209.8	309.8	0.2	0.4	0.2	0.3	1.1	2200
210.6	310.6	0.1	0.4	0.2	0.3	1	2000
211.4	311.4	0.1	0.3	0.2	0.3	0.9	1800
212.2	312.2	0.1	0.3	0.2	0.3	0.9	1800
213	313	0.1	0.3	0.2	0.3	0.9	1800
213.8	313.8	0.1	0.3	0.2	0.3	0.9	1800
214.6	314.6	0.1	0.3	0.1	0.2	0.7	1400
215.4	315.4	0	0.2	0.1	0.2	0.5	1000
216.2	316.2	0	0.2	0	0.1	0.3	600
217	317	0	0.2	0	0.1	0.3	600
217.8	317.8	-0.1	0.1	-0.1	0	-0.1	-200
218.6	318.6	-0.1	0	-0.2	-0.1	-0.4	-800
219.4	319.4	-0.2	0	-0.2	-0.1	-0.5	-1000
220.2	320.2	-0.2	-0.1	-0.3	-0.2	-0.8	-1600
221	321	-0.3	-0.2	-0.4	-0.3	-1.2	-2400
221.8	321.8	-0.4	-0.2	-0.4	-0.3	-1.3	-2600
222.6	322.6	-0.3	-0.2	-0.3	-0.3	-1.1	-2200
223.4	323.4	-0.2	-0.1	-0.3	-0.3	-0.9	-1800
224.2	324.2	-0.2	-0.1	-0.2	-0.3	-0.8	-1600
225	325	-0.2	-0.2	-0.2	-0.3	-0.9	-1800
225.8	325.8	-0.3	-0.3	-0.2	-0.3	-1.1	-2200
226.6	326.6	-0.3	-0.3	-0.1	-0.2	-0.9	-1800
227.4	327.4	-0.2	-0.2	-0.1	-0.2	-0.7	-1400
228.2	328.2	-0.2	-0.1	-0.1	-0.2	-0.6	-1200

What is claimed is:

1. Tooling (300) for selectively forming a blank of material (20) into a container (22), the container (22) including a first sidewall (124), a second sidewall (126), and a bottom portion (128) extending between the first sidewall (124) and the second sidewall (126), the tooling (300) comprising:

an upper tool assembly (302);

a lower tool assembly (306);

the upper tool assembly (302) and the lower tool assembly (306) include a number of clamp beads (410);

wherein the blank of material (20) is clamped between the upper tool assembly (302) and the lower tool assembly (306) at each clamp bead (410); and

wherein the upper tool assembly (302) and the lower tool assembly (306) are structured to stretch the bottom portion (128) which is thereby thinned relative to the first sidewall (124) and the second sidewall (126) to form a thinned preselected profile.

2. The tooling (300) of claim 1 wherein:

the upper tool assembly (302) includes a forming punch (304);

said forming punch (304) includes a number of clamp bead recesses (412);

wherein the lower tool assembly (306) includes a pad (308);

said pad (308) includes a number of clamp bead projections (414); and

wherein the forming punch (304) moves the blank of material (20) into contact with the pad (308).

3. The tooling (300) of claim 2 wherein said number of clamp bead recesses (412) and said number of clamp bead projections (414) are structured to clamp the blank of material (20) between the upper tool assembly (302) and the lower tool assembly (306).

4. The tooling (300) of claim 1 wherein said lower tooling assembly (306) includes a selectable hybrid bias generating assembly (500).

5. The tooling (300) of claim 4 wherein the selectable hybrid bias generating assembly (500) includes a pressure generating assembly (510) and a mechanical bias assembly (550).

6. The tooling (300) of claim 5 wherein the number of clamp beads (410) are a number of progressive clamp beads (600).

7. The tooling (300) of claim 6 wherein:

the upper tool assembly (302) includes a forming punch (304);

said forming punch (304) includes a number of clamp bead recesses (412);

wherein the lower tool assembly (306) includes a pad (308) and a riser assembly (515);

said riser assembly (515) having a pressure surface (521);

said pad (308) includes a number of clamp bead projections (414); and

said riser assembly (515) operatively coupled to said lower pad (308).

8. The tooling (300) of claim 7 wherein:

said lower tool assembly (306) includes a hybrid bias generating assembly (500); and

the hybrid bias generating assembly (500) operatively coupled to said riser (515).

9. The tooling (300) of claim 8 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).

10, The tooling (300) of claim 8 wherein the hybrid bias generating assembly (500) is an active hybrid bias generating assembly (502).

11. The tooling (300) of claim 8 wherein:

the lower tool assembly (306) includes a pressure chamber (516);

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).

12. The tooling (300) of claim 1 wherein the number of clamp beads (410) are a number of progressive clamp beads (600).

13. The tooling (300) of claim 12 wherein:

the upper tool assembly (302) includes a forming punch (304);

said forming punch (304) includes a number of clamp bead recesses (412);

wherein the lower tool assembly (306) includes a pad (308) and a riser assembly (515);

said riser assembly (515) having a pressure surface (521);

said pad (308) includes a number of clamp bead projections (414); and

said riser assembly (515) operatively coupled to said lower pad (308).

14. The tooling (300) of claim 1 wherein:

the lower tool assembly (306) further includes a contour (316); and

wherein the contour (316) engages and stretches the bottom portion (128) to form the thinned preselected profile.

15. The tooling (300) of claim 14 wherein said contour (316) is a dome (130).

16. The tooling (300) of claim 10 wherein the upper tool assembly (302) and the lower tool assembly (306) are structured to stretch the blank of material (20) of the container (22) at or about the dome (130) so as to have a substantially uniform thickness.

17. A method for selectively forming a container (22), the method comprising:

introducing (1000) material between tooling (300);

generating (1002) a total bias force within the tooling (300);

progressively clamping (1004) the material between an upper tool assembly (302) and a lower tool assembly (306); and

selectively stretching (1008) at least one predetermined portion of the material relative to at least one other portion of the material to provide a corresponding thinned portion of the material .

18. The method of claim 17, wherein the tooling (300) includes a clamp bead (410) and wherein the clamping the material between an upper tool assembly (302) and a lower tool assembly (306) includes clamping the material at a clamp bead (410).

19. The method of claim 17, wherein the tooling (300) includes a progressive clamp bead (600) and wherein the clamping the material between an upper tool assembly (302) and a lower tool assembly (306) includes progressively clamping the material at a progressive clamp bead (600).

20. The method of claim 17, further comprising forming the blank of material (20) of the container (22) at or about the dome (130) to have a substantially uniform thickness.

21. A method for selectively forming a container (22), the method comprising:

introducing (1000) material between tooling;

applying (2002) a reduced impact force;

applying a reduced draw pad motion force;

applying (2004, 2006) a reduced draw force;

applying (2008) a reduced pre-doming force; and

applying (2010) a reduced doming force.

22. The method of Claim 21 wherein applying (2010) a reduced doming force includes applying (2050) a reduced progressive clamp bead doming force.

23. The method of Claim 21 wherein applying a reduced impact force (2002) and applying a reduced draw pad motion force include:

applying (2022) a reduced progressive clamp bead impact force; and

applying (2034) a reduced progressive clamp bead draw pad motion force.

given the full breadth of the claims appended and any and all equivalents thereof.

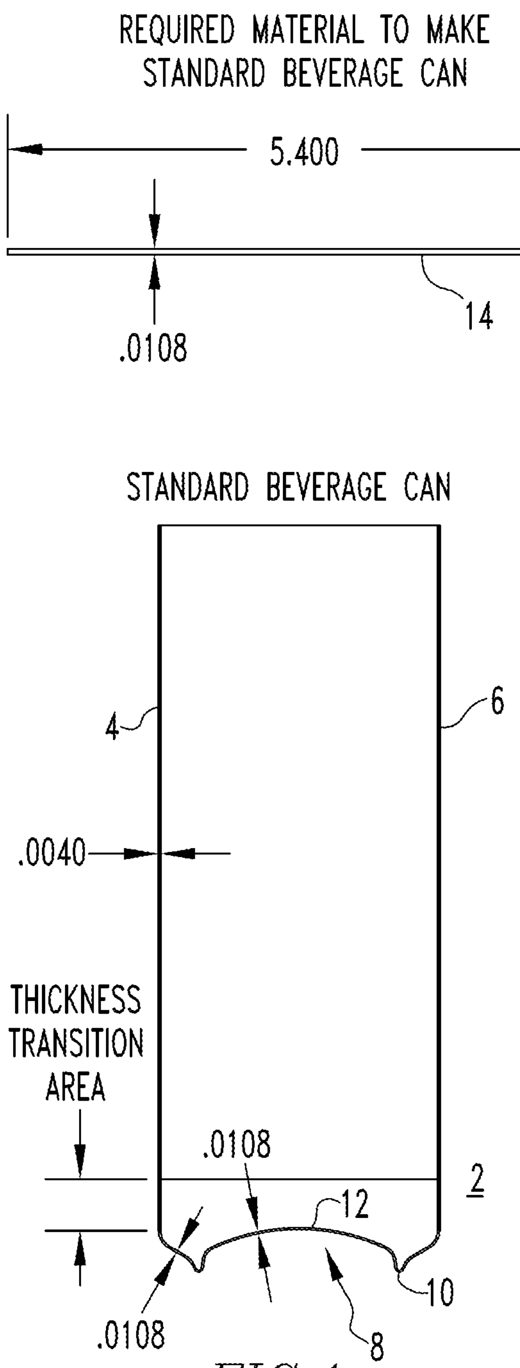


FIG.1
PRIOR ART

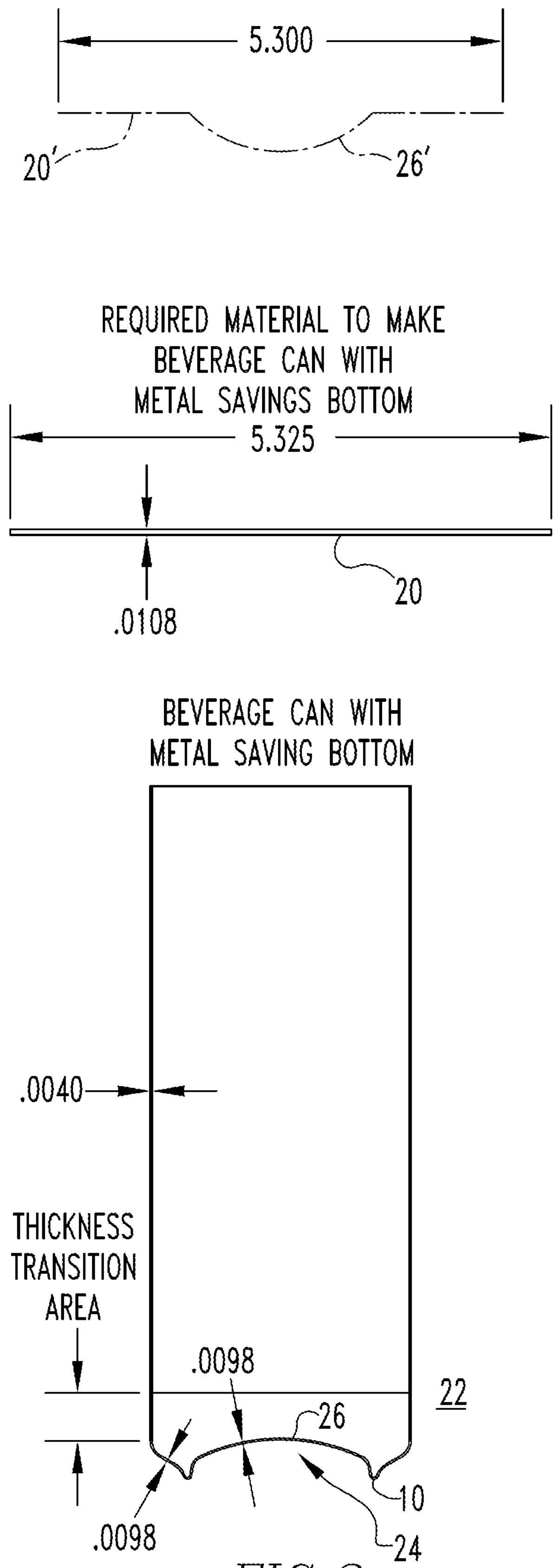


FIG.2

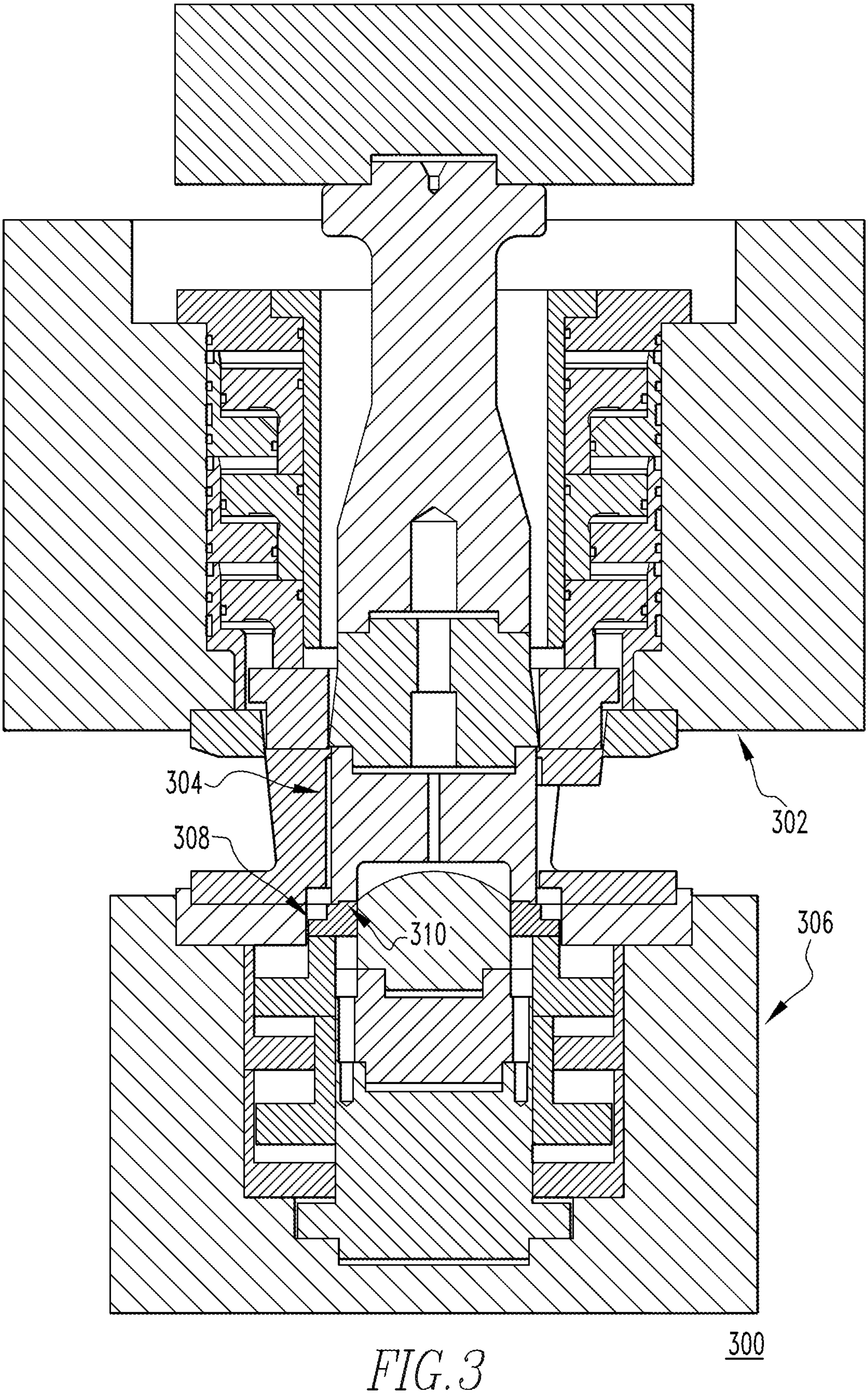


FIG.3

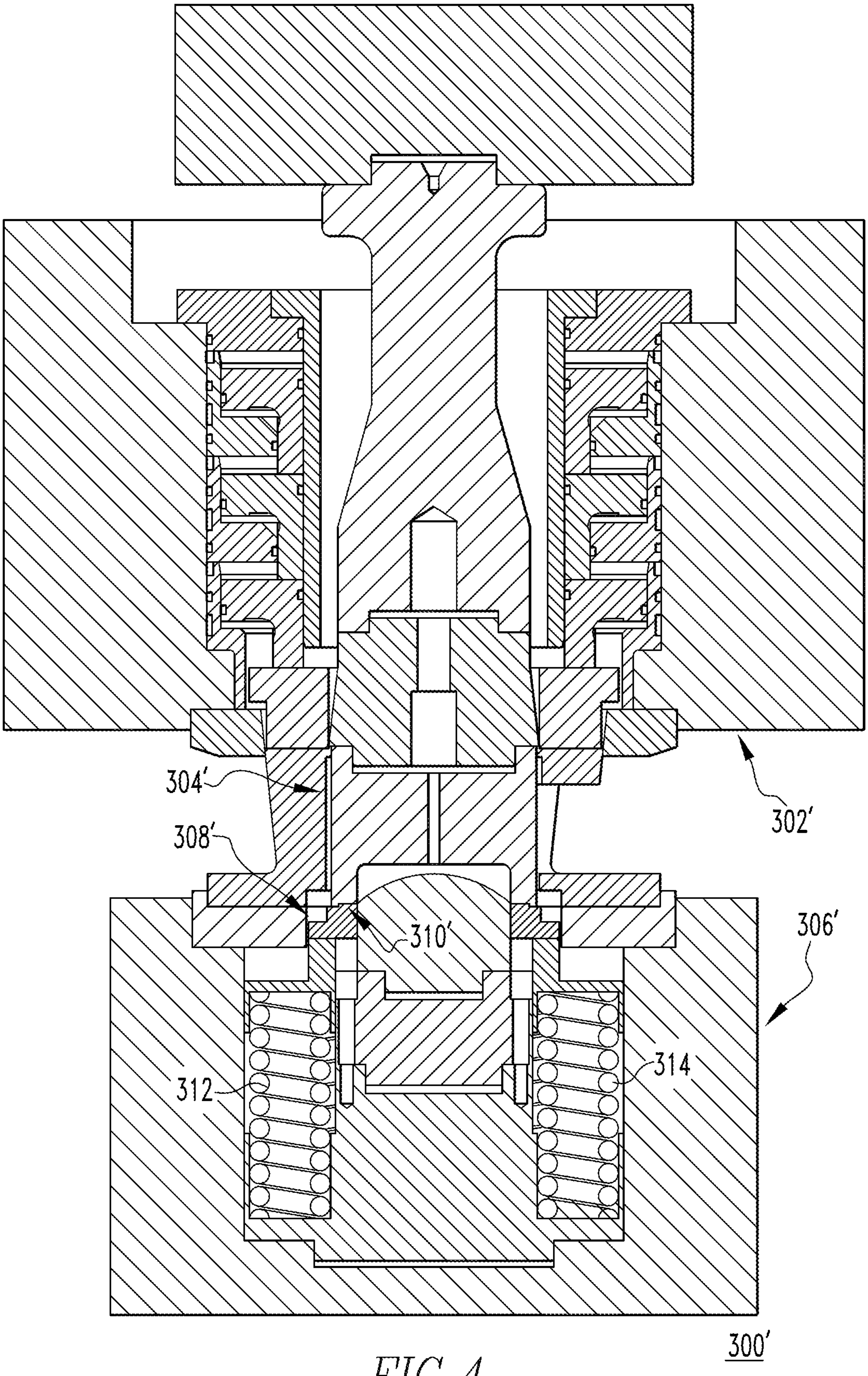


FIG.4

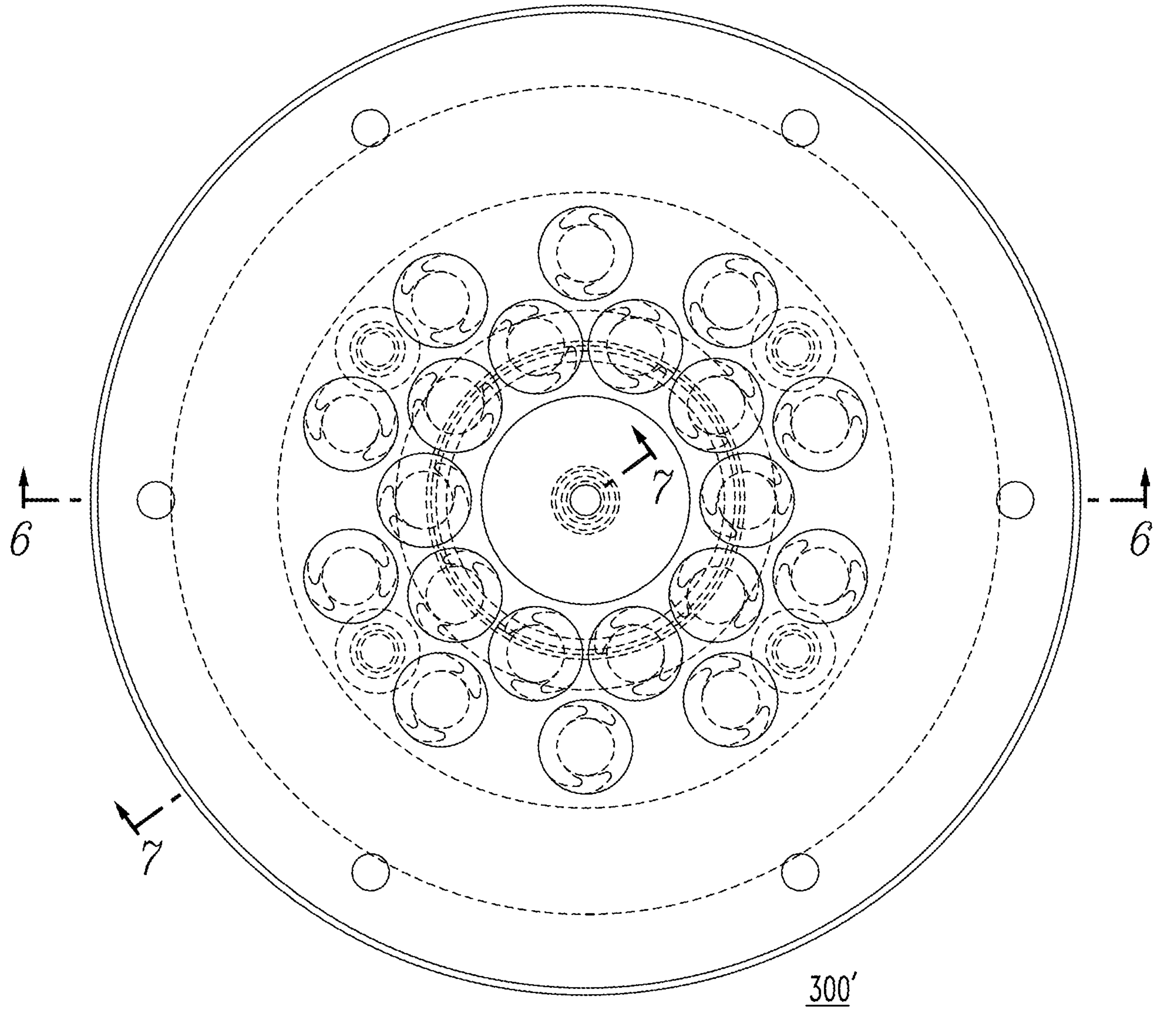


FIG.5

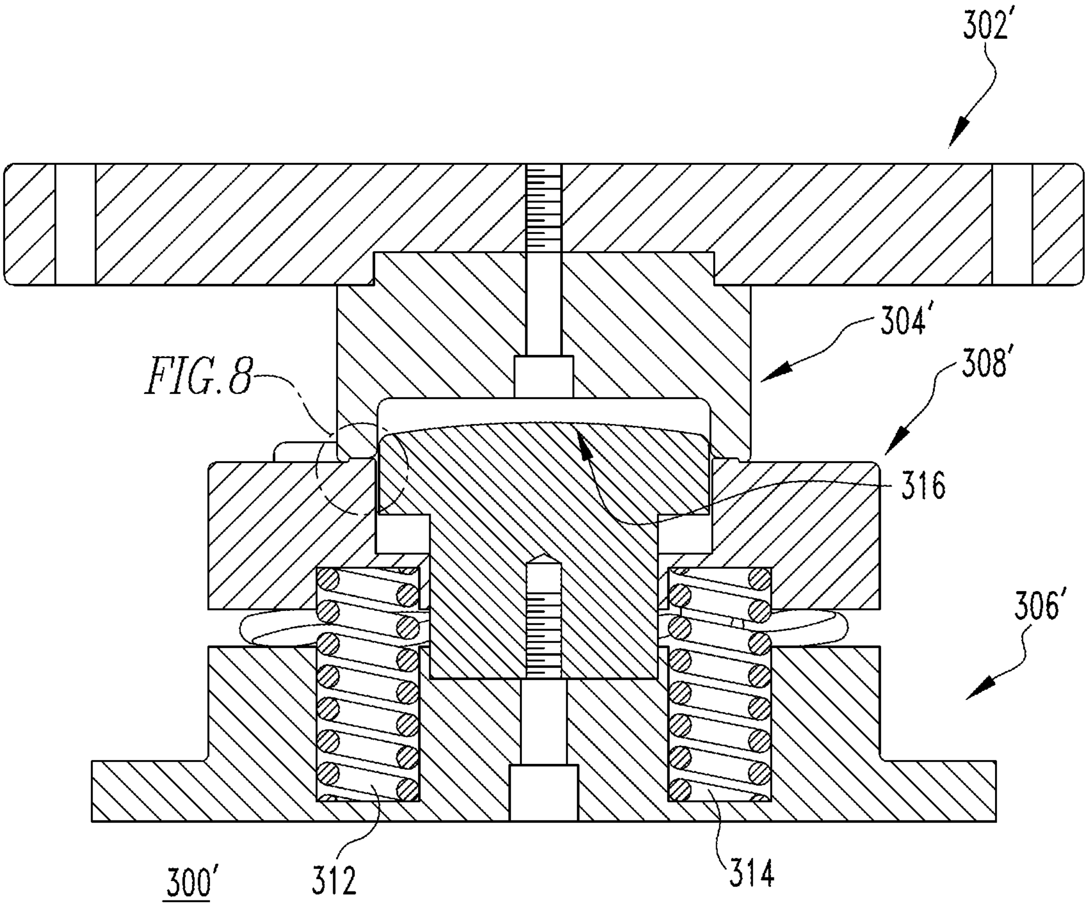


FIG.6

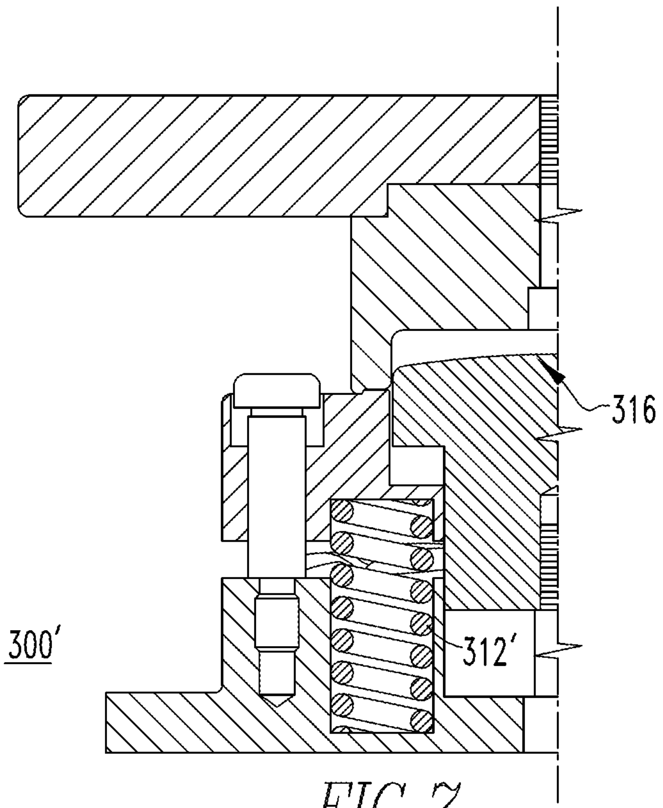

316
312′
300′

FIG.7

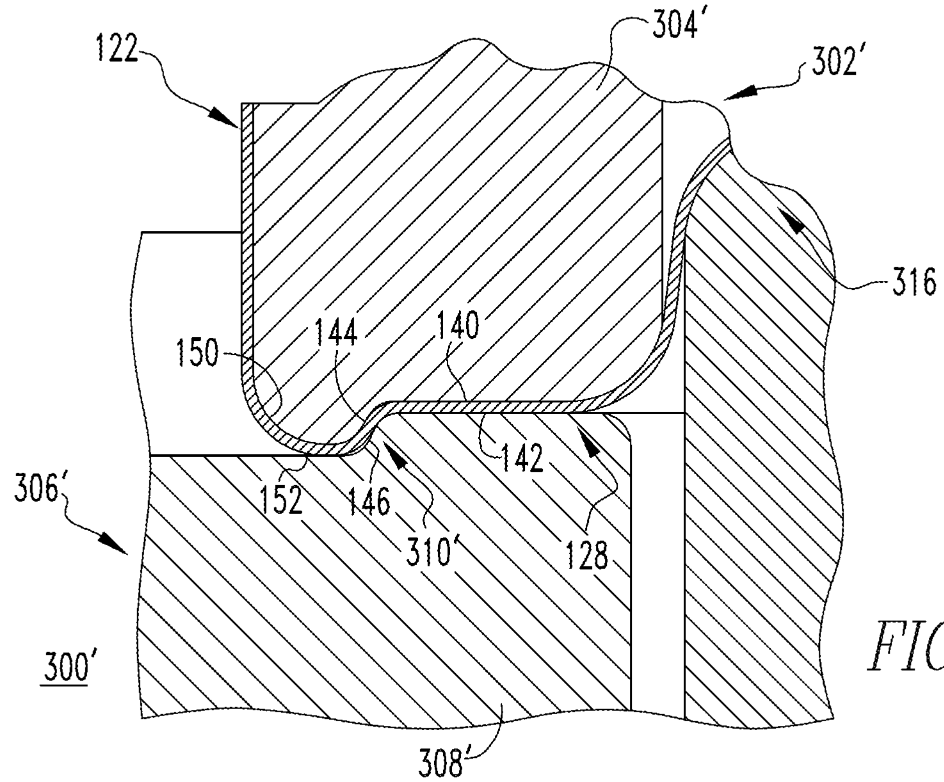

122
304′
302′
316
150
144
140
142
152
146
310′
128
306′
300′
308′

FIG.8

FORMING STAGES (WITH STEP BEAD)

FIG. 9A

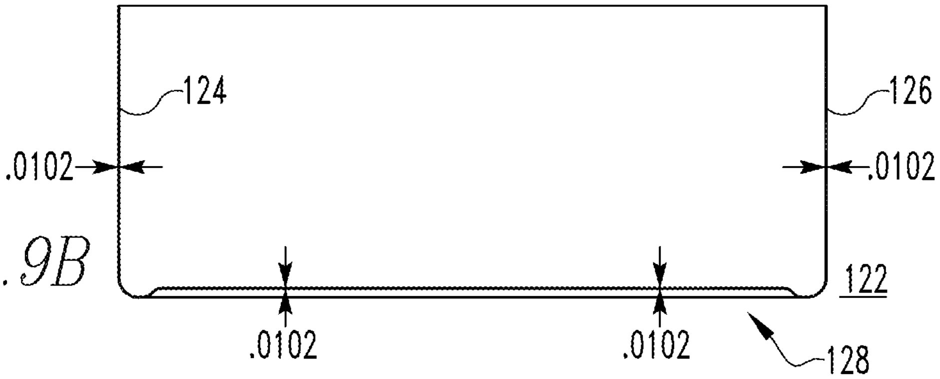


FIG. 9B

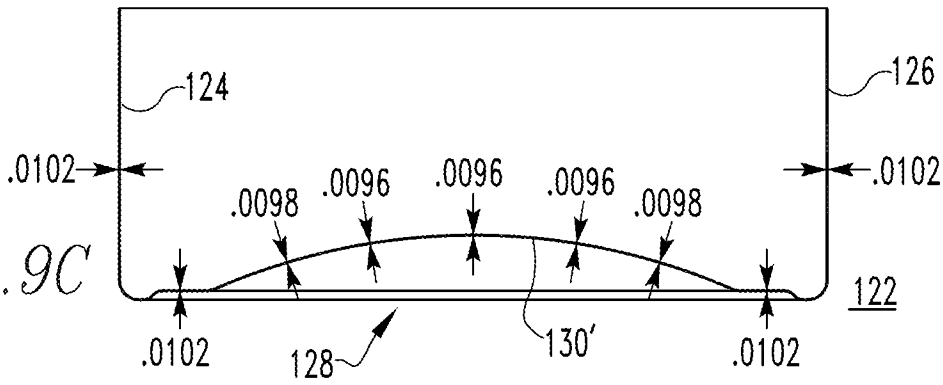


FIG. 9C

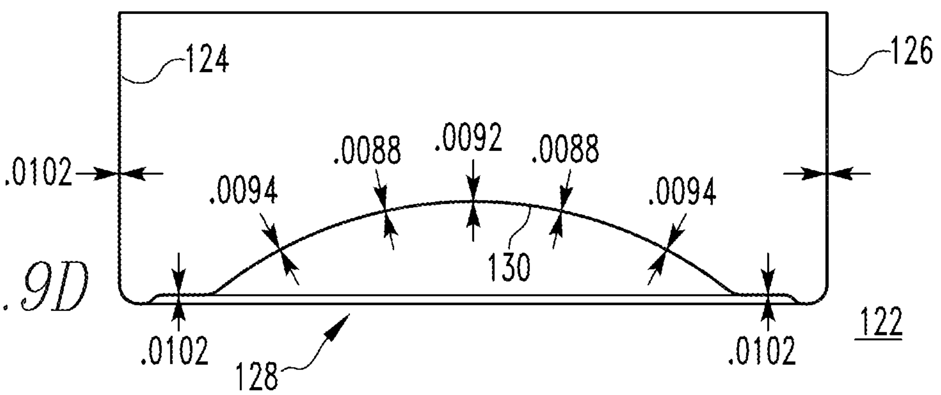


FIG. 9D

FORMING STAGES
(WITHOUT STEPS BEAD)

FIG.10A

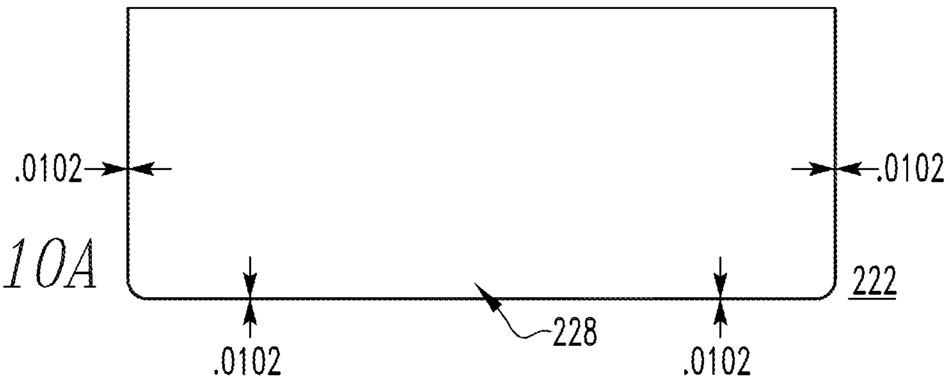


FIG.10B

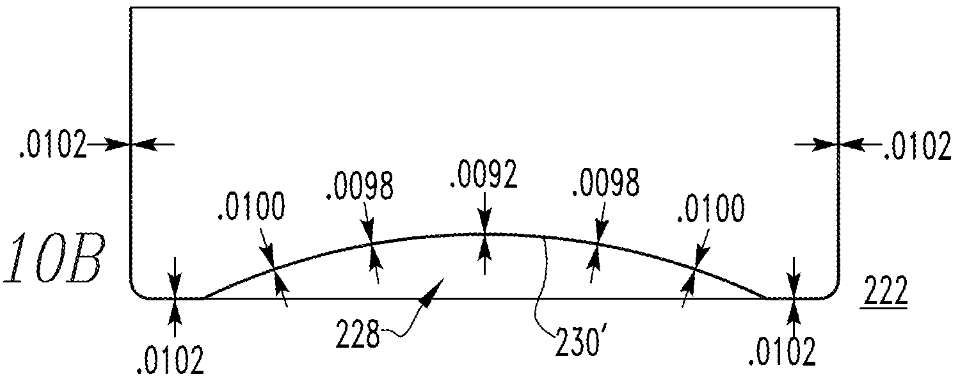


FIG.10C

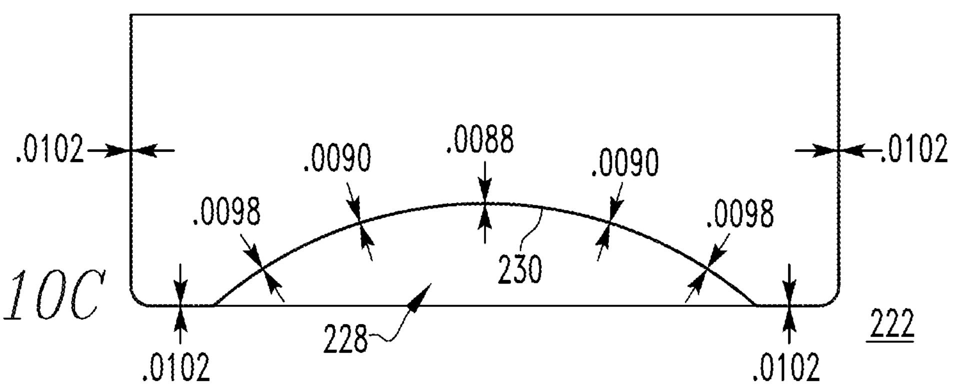


FIG.11A

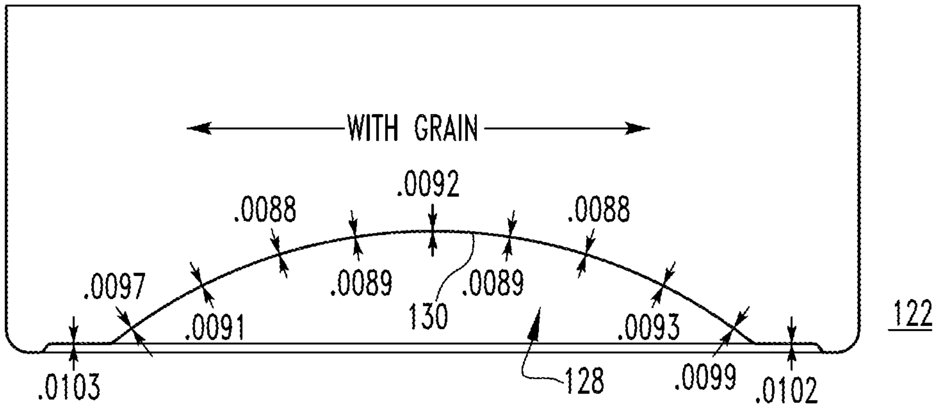


FIG.11B

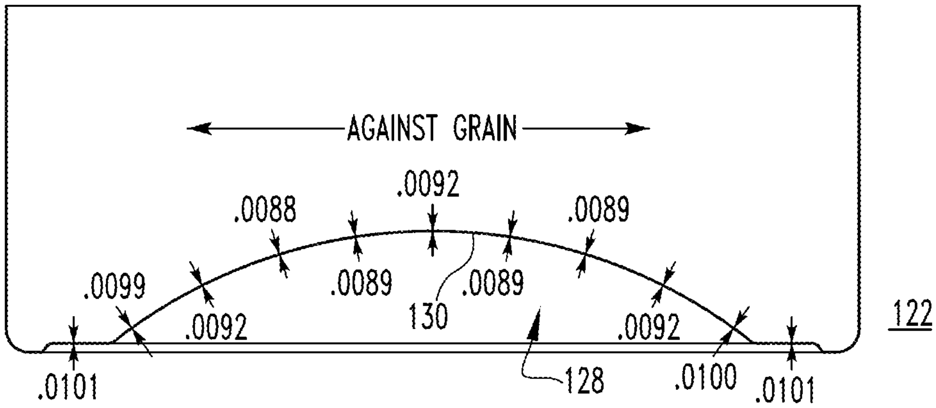


FIG.11C

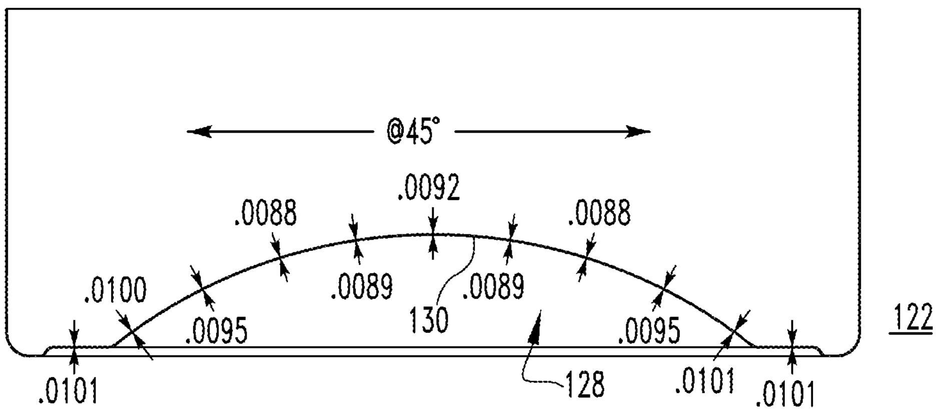
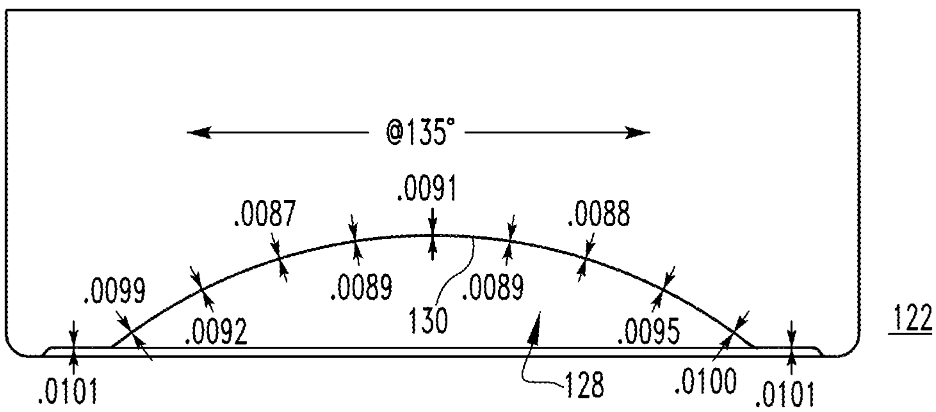


FIG.11D



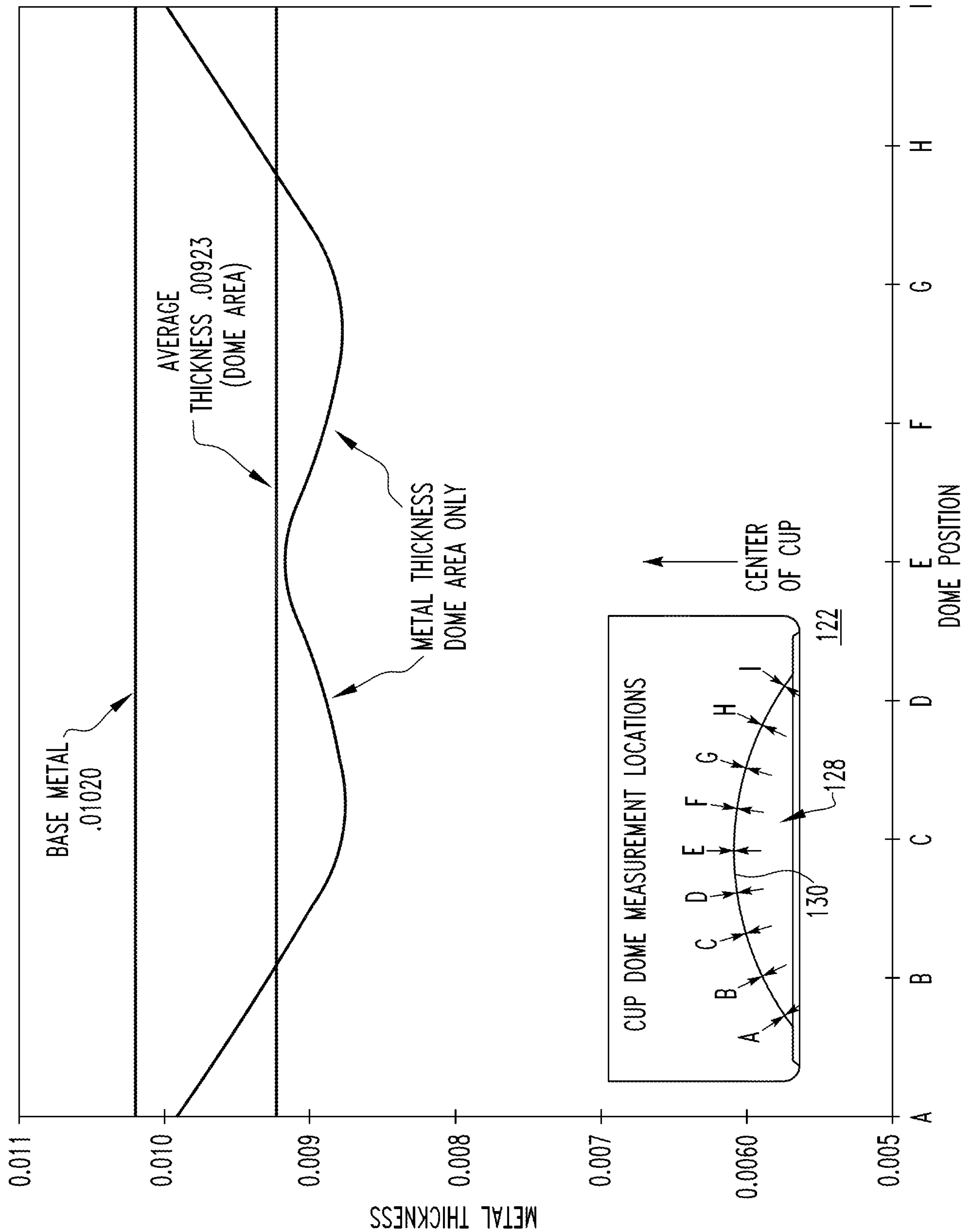

METAL THICKNESS
0.011
0.010
0.009
0.008
0.007
0.0060
0.005
DOME POSITION
A
B
C
D
E
F
G
H
I
BASE METAL
.01020
AVERAGE
THICKNESS .00923
(DOME AREA)
METAL THICKNESS
DOME AREA ONLY
CENTER
OF CUP
CUP DOME MEASUREMENT LOCATIONS
122
128
130

FIG.12

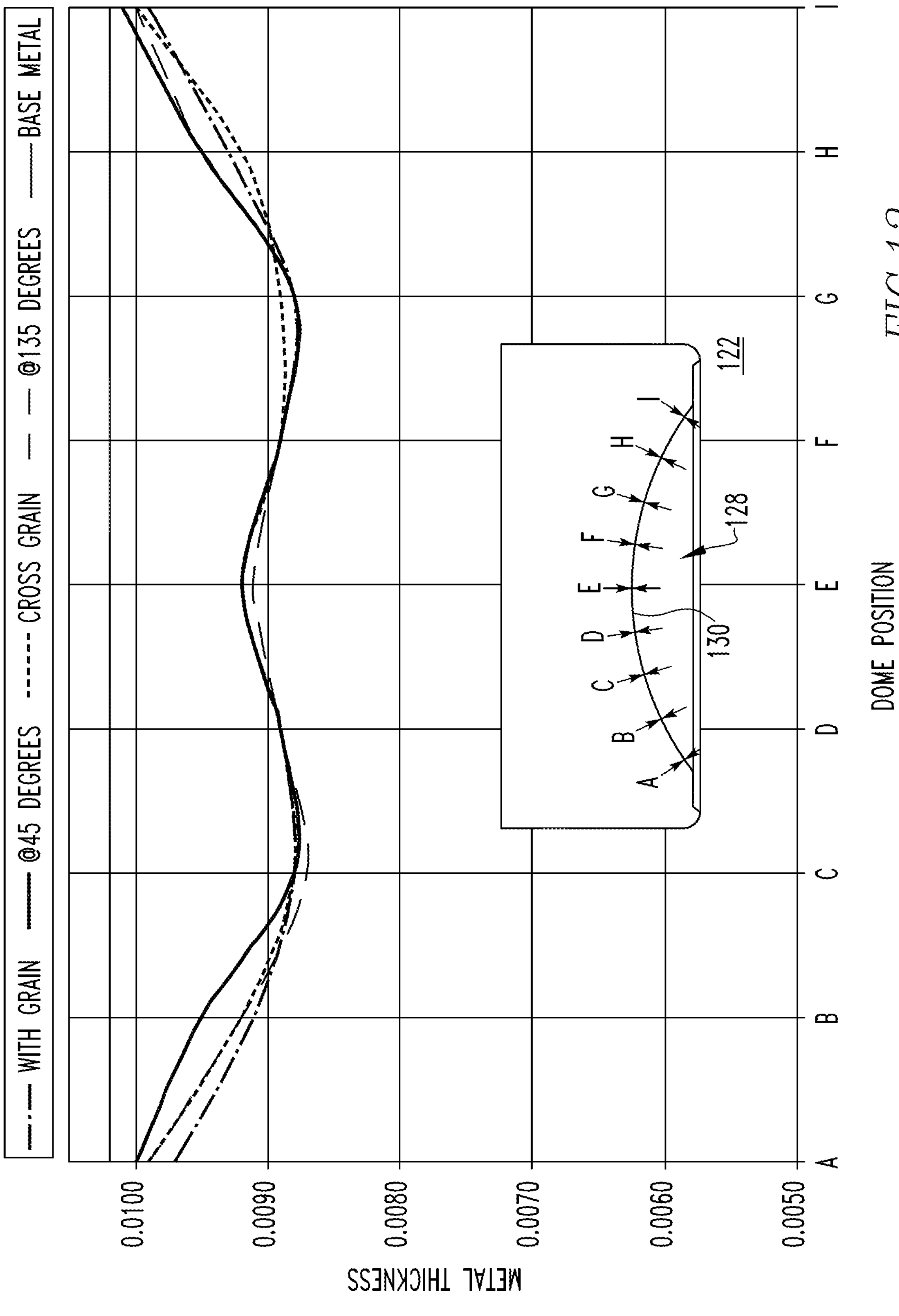

WITH GRAIN
@45 DEGREES
CROSS GRAIN
@135 DEGREES
BASE METAL
METAL THICKNESS
0.0100
0.0090
0.0080
0.0070
0.0060
0.0050
DOME POSITION
A
B
C
D
E
F
G
H
I
122
128
130

FIG.13

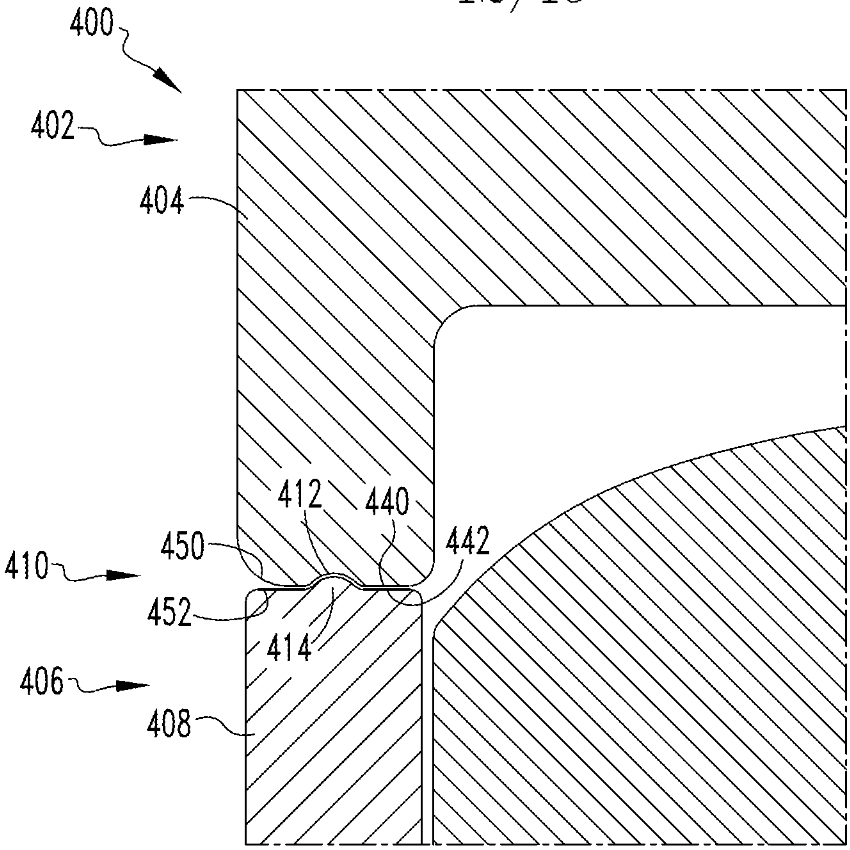

400
402
404
412
440
442
450
410
452
414
406
408

FIG.14

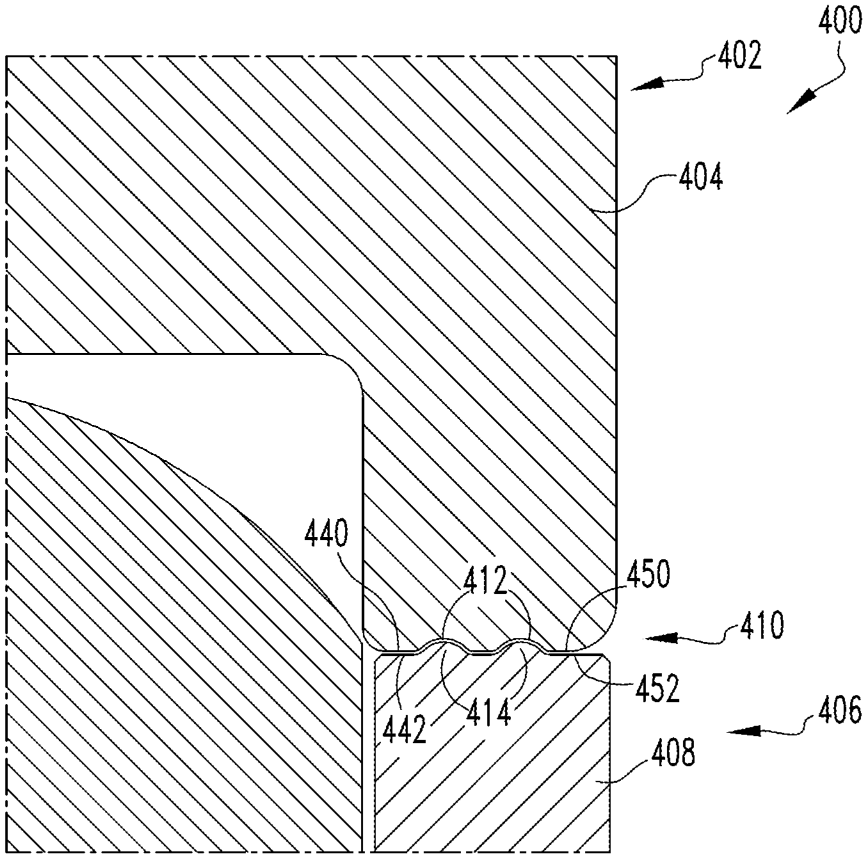

402
400
404
440
412
450
410
452
442
414
406
408

FIG.15

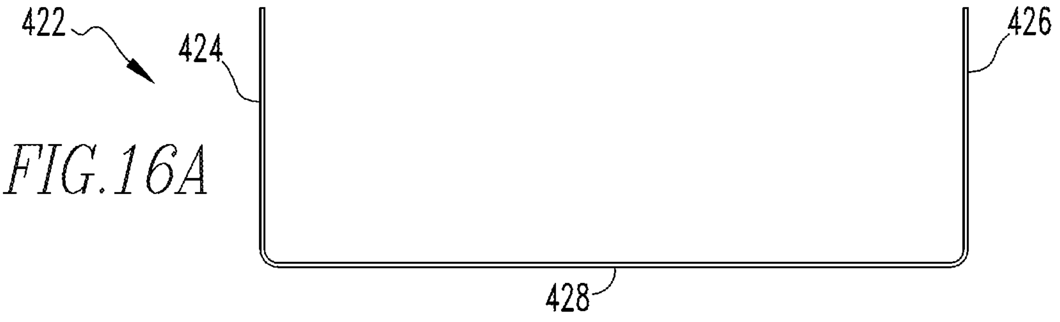


FIG.16A

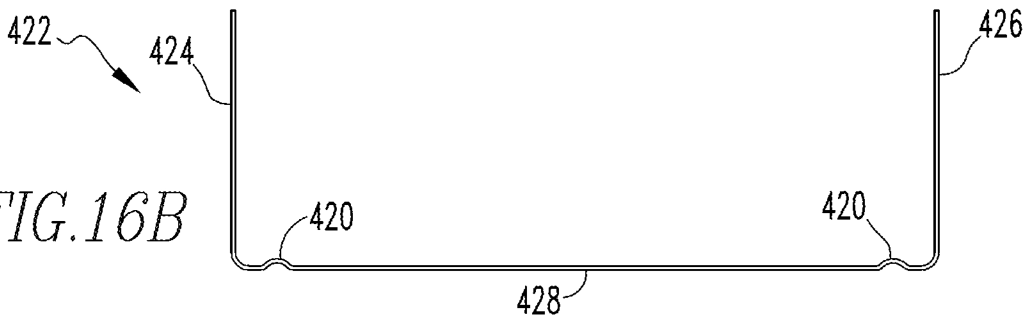


FIG.16B

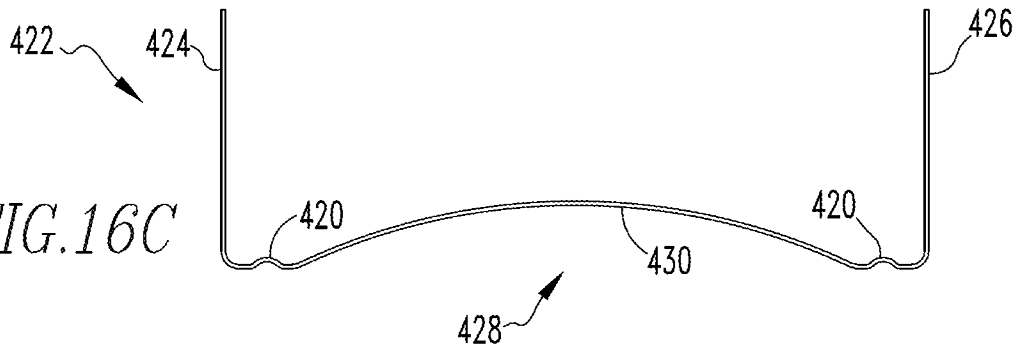


FIG.16C

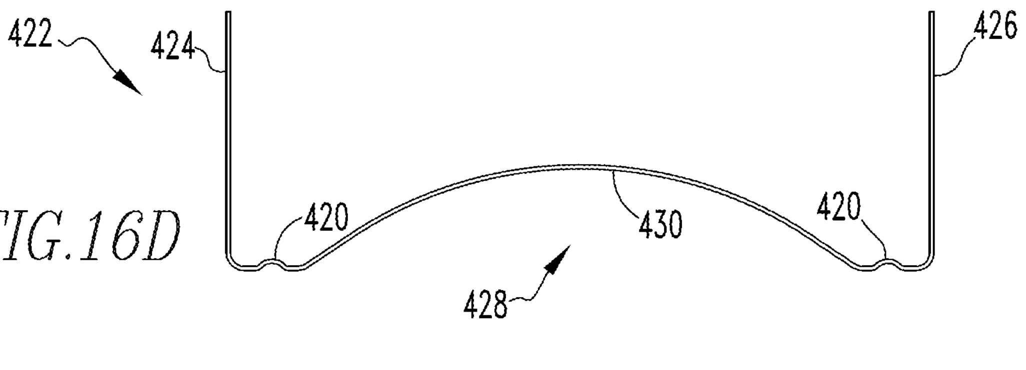


FIG.16D

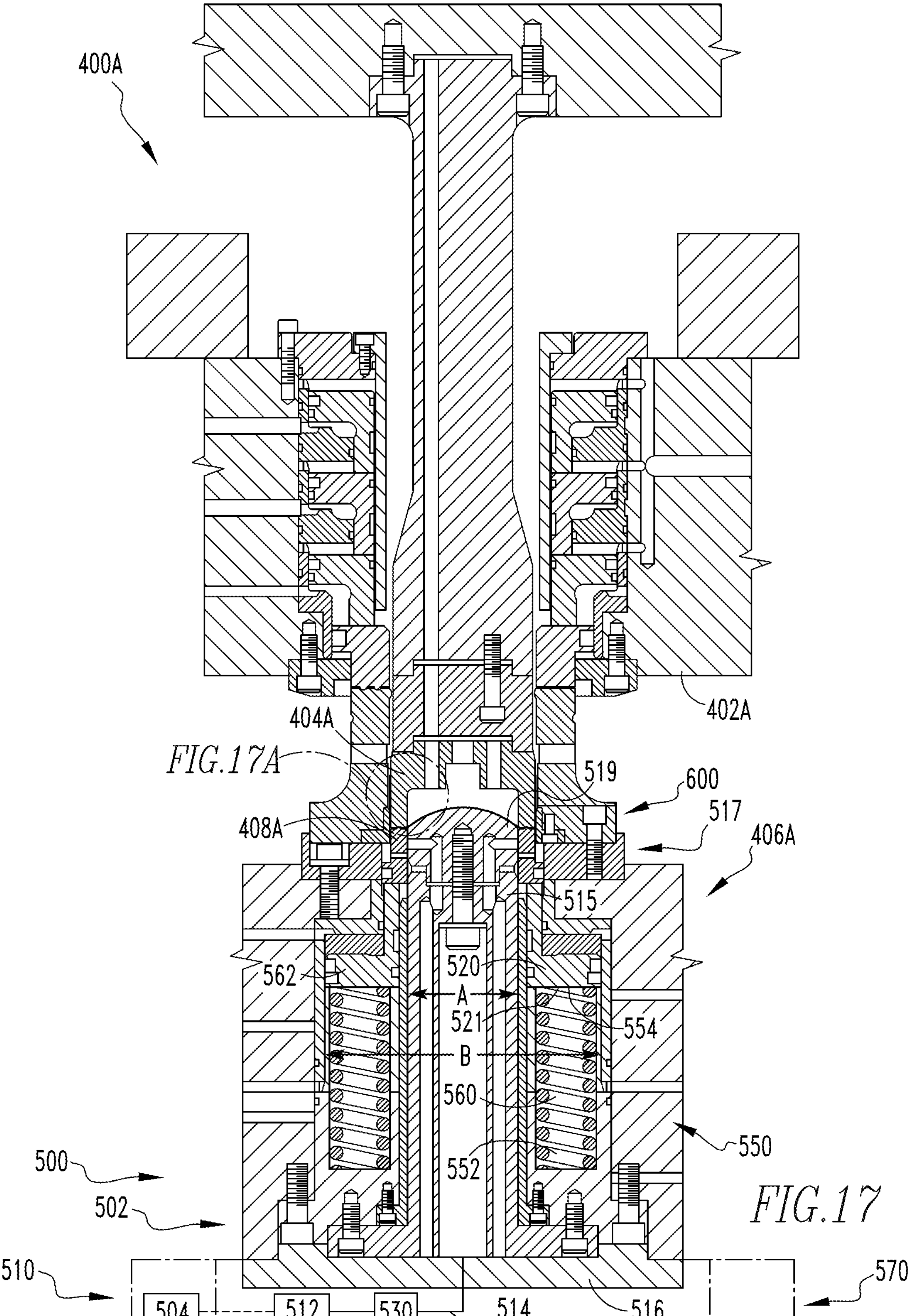

400A
402A
404A
FIG.17A
519
600
517
408A
406A
515
562
520
A
521
554
B
560
550
500
552
502
510
570
504
512
530
514
516

FIG.17

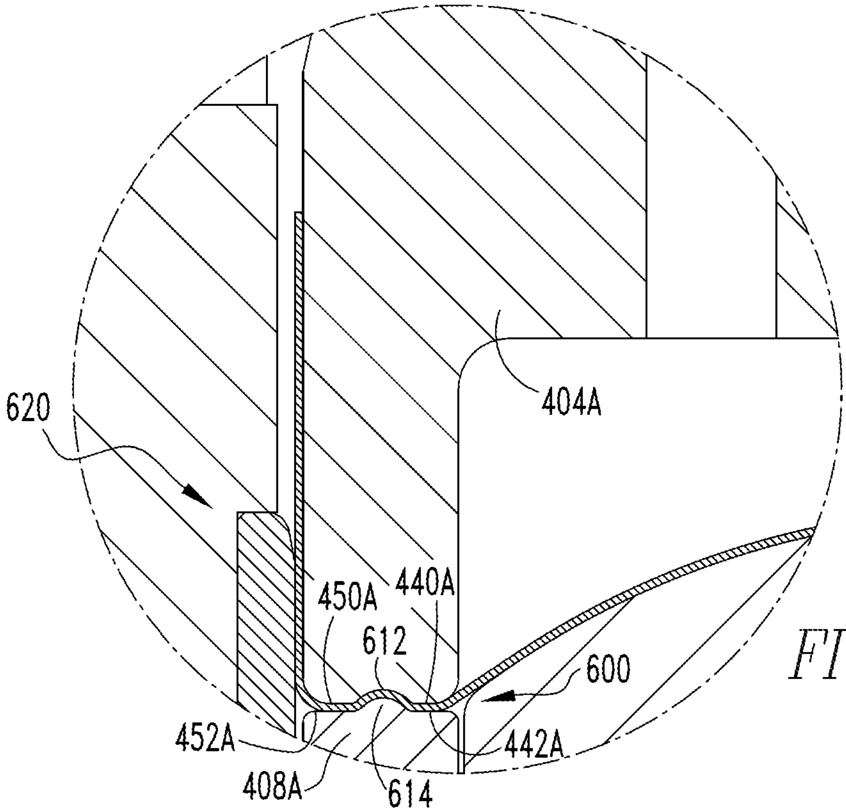


FIG.17A

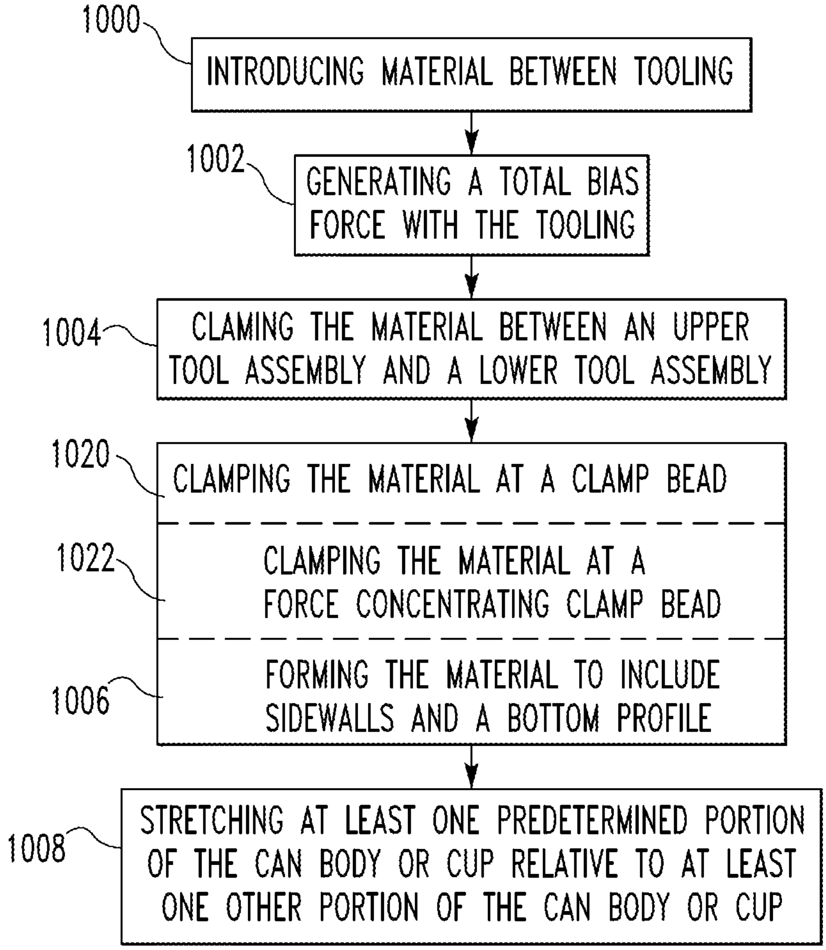


FIG.18

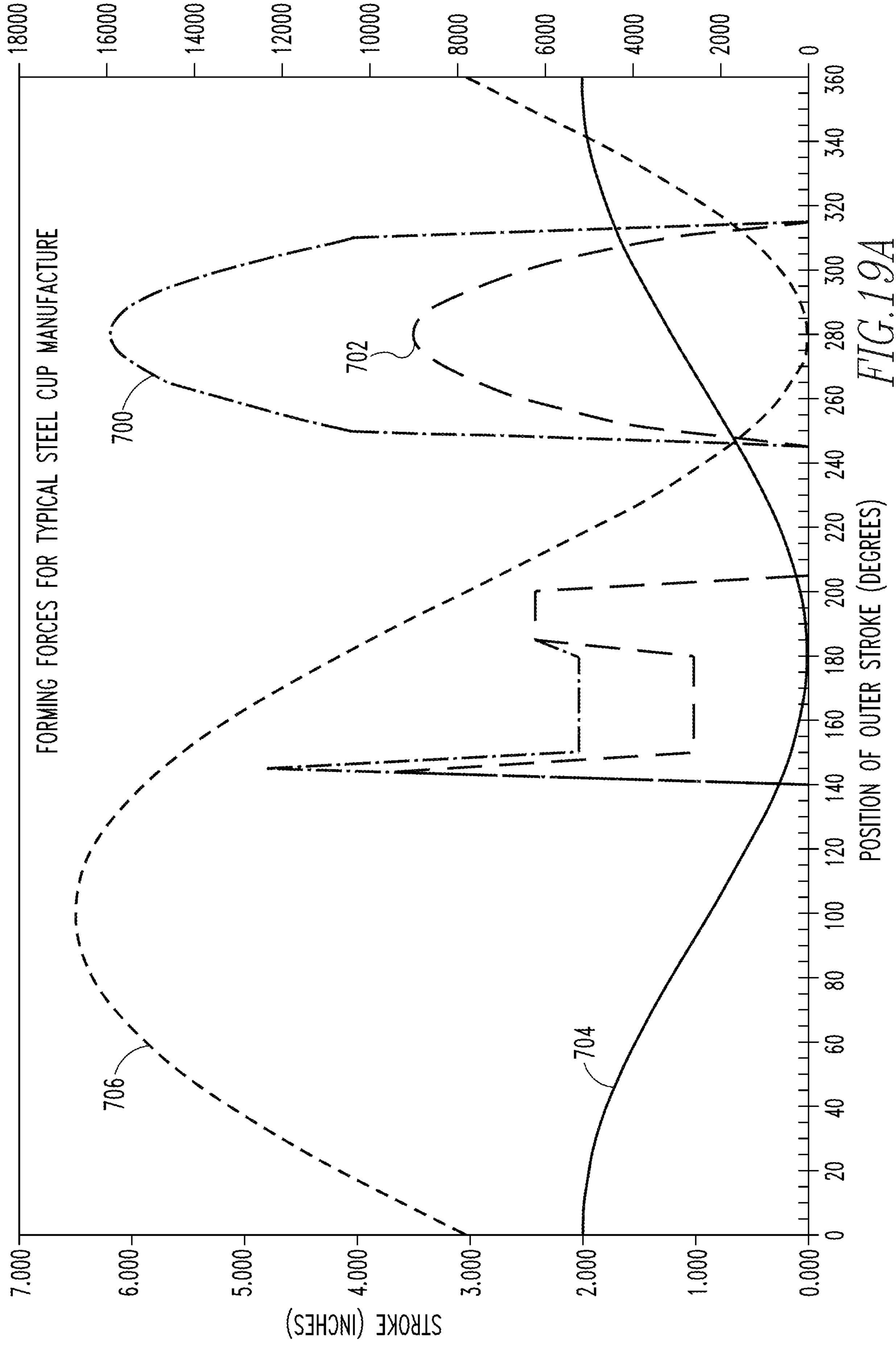

FORMING FORCES FOR TYPICAL STEEL CUP MANUFACTURE
LOAD (LBS)
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
STROKE (INCHES)
0.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
POSITION OF OUTER STROKE (DEGREES)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
700
702
704
706

FIG.19A

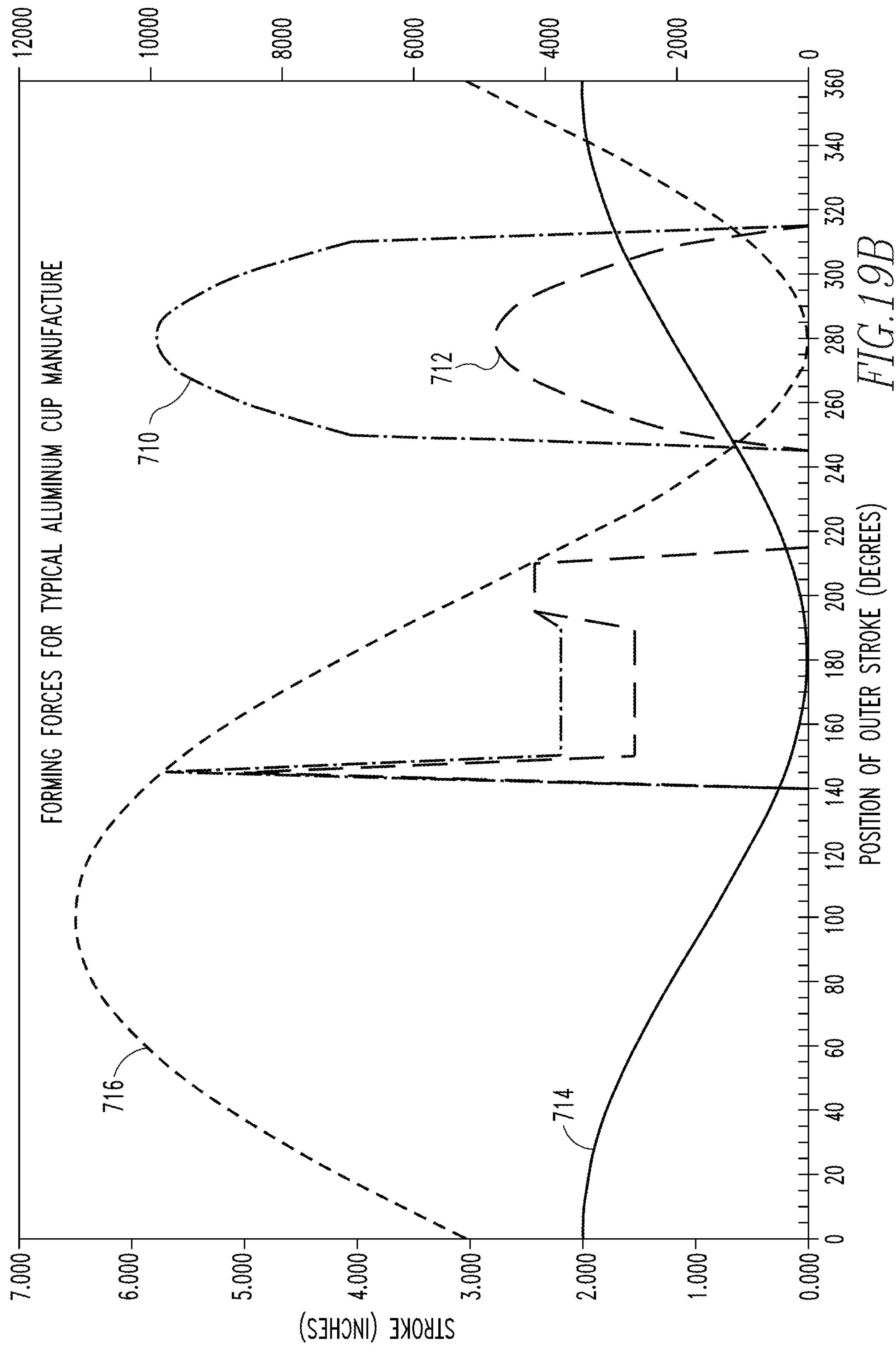

FORMING FORCES FOR TYPICAL ALUMINUM CUP MANUFACTURE
LOAD (LBS)
12000
10000
8000
6000
4000
2000
0
STROKE (INCHES)
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
POSITION OF OUTER STROKE (DEGREES)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
710
712
714
716

FIG.19B

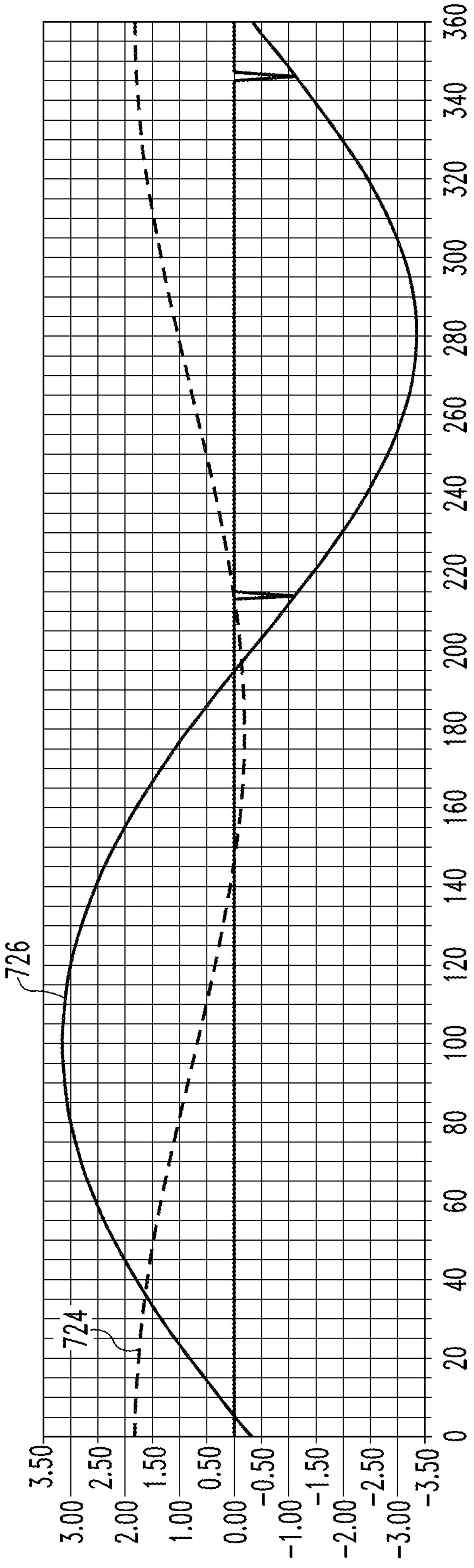

726
724
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360

FIG.20

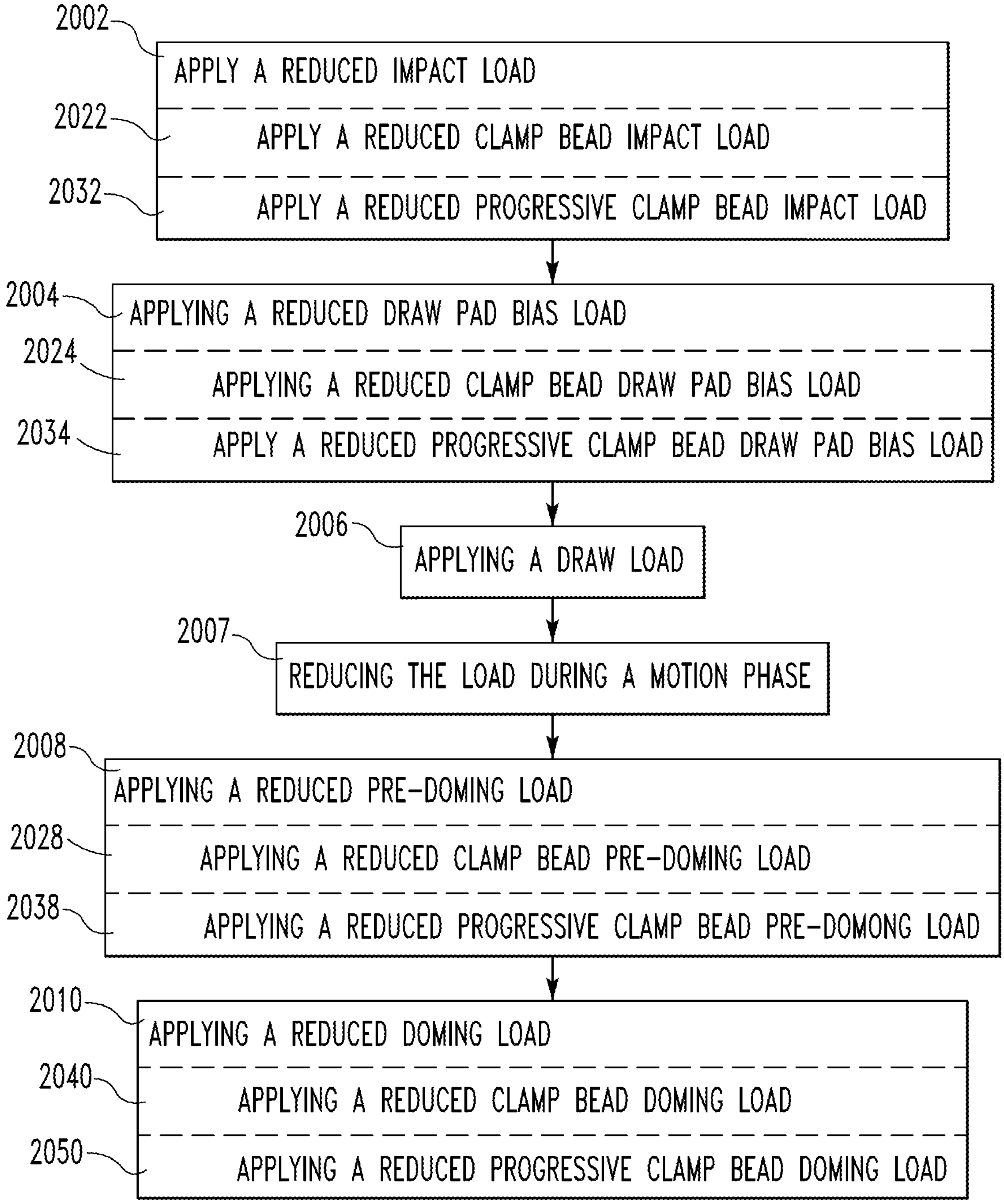

2002
APPLY A REDUCED IMPACT LOAD
2022
APPLY A REDUCED CLAMP BEAD IMPACT LOAD
2032
APPLY A REDUCED PROGRESSIVE CLAMP BEAD IMPACT LOAD
2004
APPLYING A REDUCED DRAW PAD BIAS LOAD
2024
APPLYING A REDUCED CLAMP BEAD DRAW PAD BIAS LOAD
2034
APPLY A REDUCED PROGRESSIVE CLAMP BEAD DRAW PAD BIAS LOAD
2006
APPLYING A DRAW LOAD
2007
REDUCING THE LOAD DURING A MOTION PHASE
2008
APPLYING A REDUCED PRE-DOMING LOAD
2028
APPLYING A REDUCED CLAMP BEAD PRE-DOMING LOAD
2038
APPLYING A REDUCED PROGRESSIVE CLAMP BEAD PRE-DOMONG LOAD
2010
APPLYING A REDUCED DOMING LOAD
2040
APPLYING A REDUCED CLAMP BEAD DOMING LOAD
2050
APPLYING A REDUCED PROGRESSIVE CLAMP BEAD DOMING LOAD

FIG.21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US17/49320

A. CLASSIFICATION OF SUBJECT MATTER
IPC - B21D 22/20, 22/28, 22/30, 51/26 (2017.01)
CPC - B21D 22/20, 22/28, 22/30, 51/26

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2006/0191310 A1 (TURNBULL, RD et al) 31 August 2006; figures 1-3, 5, paragraphs [0007], [0033], [0034], [0036], [0038], [0047]	1-7, 14-15
Y	US 2013/0037555 A1 (MONRO, S) 14 February 2013; figure 4, paragraphs [0023]-[0025], [0028], [0046]	1-10, 12-16
Y	US 4,503,702 A (BULSO, JD et al) 12 March 1985; figures 4, 6, 8, column 3, lines 50-60, column 4, lines 65-68, column 5, lines 1-5, 20-25	1, 8-10, 12-13, 16
Y	US 5,081,859 A (DE SMET, G) 21 January 1992; figure 1, column 3, lines 20-25, lines 45-50, column 4, lines 1-5, column 7, lines 10-15	4-10, 16
A	US 2,075,847 A (HOTHERSALL, JM) 06 April 1937; entire document	1-16
A	US 2013/0239644 A1 (Stolle Machinery Company) 19 September 2013; entire document	1-16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 December 2017 (08.12.2017)	04 JAN 2018

Name and mailing address of the ISA/	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US17/49320

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
-***-Please See Within the Next Supplemental Box-***-

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
Group I: Claims 1-16

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

-***-Continued from Box No. III Observations where unity of invention is lacking-***-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-16 are directed toward a tooling for selectively forming a blank of material into a container comprising: an upper tool assembly and a lower tool assembly include a number of clamp beads.

Group II: Claims 17-20 are directed toward a method for selectively forming a container comprising: generating a total bias force within the tooling.

Group III: Claims 21-23 are directed toward a method for selectively forming a container comprising: applying a reduced impact force.

The inventions listed as Groups I-III do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons.

The special technical feature of Group I includes a container including a first sidewall, a second sidewall, and a bottom portion extending between the first sidewall and the second sidewall, the tooling comprising: an upper tool assembly and a lower tool assembly include a number of clamp beads; wherein the blank of material is clamped between the upper tool assembly and the lower tool assembly at each clamp bead, which are not presented in Group II or Group III.

The special technical feature of Group II includes generating a total bias force within the tooling; progressively clamping the material; and selectively stretching the material, which are not presented in Group I or Group III.

The special technical feature of Group III includes applying a reduced impact force; applying a reduced draw pad motion force; applying a reduced draw force; applying a reduced pre-doming force; and applying a reduced doming force, which are not presented in Group I or Group II.

The common technical features of Groups I, II and III are introducing material between tooling; an upper tool assembly; a lower tool assembly; and wherein the upper tool assembly and the lower tool assembly are structured to stretch the bottom portion which is thereby thinned relative to the first sidewall and the second sidewall to form a thinned preselected profile.

These common technical features are disclosed by US 2013/0239644 A1 to Stolle Machinery Company, LLC ("Stolle").

Stolle discloses introducing material between tooling (introducing blank material between tooling; paragraph [0038]); an upper tool assembly (upper tooling assembly; paragraph [0013]); a lower tool assembly (lower tooling assembly; paragraph [0013]); and wherein the upper tool assembly and the lower tool assembly are structured to stretch the bottom portion which is thereby thinned relative to the first sidewall and the second sidewall to form a thinned preselected profile (blank of material is clamped between upper tooling assembly and lower tooling assembly for stretching bottom portion of container relative to first and second sidewalls to form a thinned preselected profile; paragraph [0013]).

Because the common technical features are disclosed by Stolle, the inventions are not so linked as to form a single general inventive concept. Therefore, Groups I-III lack unity.