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(54) **Can manufacture**

(57) A method and apparatus are disclosed which are suitable for use in the manufacture of two-piece metal containers. In particular, the method and apparatus disclose a way of making cups from metal sheet using a

combination of stretching and (re-)drawing operations. The resulting cups have the advantage of reducing the thickness of the base of the cup relative to the ingoing gauge of material.

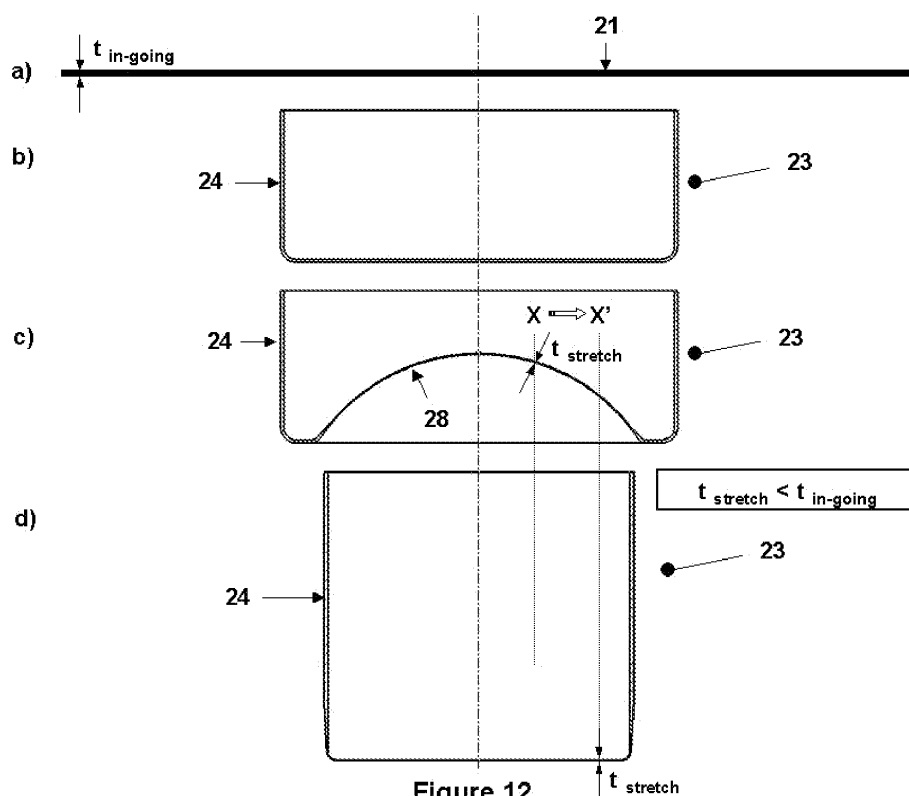


Figure 12

Description

Technical Field

[0001] This invention relates to the production of metal cups and in particular (but without limitation) to metal cups suitable for the production of "two-piece" metal containers.

Background Art

[0002] US 4095544 (NATIONAL STEEL CORPORATION) 20/06/1978 details conventional DWI and DRD processes for manufacturing cup-sections for use in making two-piece metal containers. [Note that in the United States of America, DWI is instead commonly referred to as D&I]. The term "two-piece" refers to i) the cup-section and ii) the closure that would be subsequently fastened to the open end of the cup-section to form the container.

[0003] In a DWI (D&I) process (as illustrated in figures 6 to 10 of US 4,095,544), a flat (typically) circular blank stamped out from a roll of metal sheet is drawn through a drawing die, under the action of a punch, to form a shallow first stage cup. This initial drawing stage does not result in any intentional thinning of the blank. Thereafter, the cup is pushed through one or more annular wall-ironing dies under the action of the punch for the purpose of effecting a reduction in thickness of the sidewall of the cup, thereby resulting in an elongation in the sidewall of the cup. By itself, the ironing process will not result in any change in the nominal diameter of the first stage cup.

[0004] Figure 1 shows the distribution of metal in a container body resulting from a conventional DWI (D&I) process. Figure 1 is illustrative only, and is not intended to be precisely to scale. Three regions are indicated in figure 1:

- Region 1 represents the un-ironed material of the base. This remains approximately the same thickness as the ingoing gauge of the blank, i.e. it is not affected by the separate manufacturing operations of a conventional DWI process.
- Region 2 represents the ironed mid-section of the sidewall. Its thickness (and thereby the amount of ironing required) is determined by the performance required for the container body.
- Region 3 represents the ironed top-section of the sidewall. Typically in can making, this ironed top-section is around 50-75% of the thickness of the ingoing gauge.

[0005] In a DRD process (as illustrated in figures 1 to 5 of US 4,095,544), the same drawing technique is used to form the first stage cup. However, rather than employing an ironing process, the first stage cup is then subjected to one or more re-drawing operations which act to progressively reduce the diameter of the cup and thereby

elongate the sidewall of the cup. By themselves, the re-drawing operations are not intended to result in any change in thickness of the cup material. However, taking the example of container bodies manufactured from a typical DRD process, in practice there is typically some thickening at the top of the finished container body (of the order of 10% or more). This thickening is a natural effect of the re-drawing process and is explained by the compressive effect on the material when re-drawing from a cup of large diameter to one of smaller diameter.

[0006] Note that there are alternative known DRD processes which achieve a thickness reduction in the sidewall of the cup through use of small or compound radii draw dies to thin the sidewall by stretching in the draw and re-draw stages.

[0007] Alternatively, a combination of ironing and re-drawing may be used on the first stage cup, which thereby reduce both the cup's diameter and sidewall thickness. For example, in the field of the manufacture of two-piece metal containers (cans), the container body is typically made by drawing a blank into a first stage cup and subjecting the cup to a number of re-drawing operations until arriving at a container body of the desired nominal diameter, then followed by ironing the sidewall to provide the desired sidewall thickness and height.

[0008] However, all known DWI (D&I) and DRD processes have a serious limitation in that they do not act to reduce the thickness (and therefore weight) of material in the base of the cup. In particular, drawing does not result in reduction in thickness of the object being drawn, and ironing only acts on the sidewalls of the cup. Essentially, for known DWI (D&I) and DRD processes for the manufacture of cups for two-piece containers, the thickness of the base remains unchanged from that of the ingoing gauge of the blank. This can result in the base being far thicker than required for performance purposes.

[0009] The metal packaging industry is fiercely competitive, with weight reduction being a primary objective because it reduces transportation and raw material costs. By way of example, around 65% of the costs of manufacturing a typical two-piece metal food container derive from raw material costs.

[0010] There is therefore a need for improved lightweighting of metal cup-sections in a cost-effective manner. Note that in this document, the terms "cup-section" and "cup" are used interchangeably.

Disclosure of Invention

[0011] Accordingly, in a first aspect of the invention there is provided a method for manufacture of a metal cup, the method comprising the following operations:

- a stretching operation comprising taking a cup having a sidewall and an integral base, the cup formed of metal sheet, clamping an annular region of either or both the sidewall and the base to define an enclosed portion which includes all or part of the base,

and deforming and stretching at least some of that part of the base which lies within the enclosed portion to thereby increase the surface area and reduce the thickness of the base, the annular clamping adapted to restrict or prevent metal flow from the clamped region into the enclosed portion during this stretching operation;

ii. a drawing operation comprising drawing the cup to pull and transfer material from the stretched and thinned base into the sidewall to provide a cup having a base thickness less than that of the metal sheet prior to the stretching operation.

[0012] For the purpose of this document, the "drawing operation" referred to above is occasionally referred to as the "post-stretch drawing operation" to signify it taking place after the stretching operation.

[0013] The method of the invention has the advantage over known processes of thinning the base of the resulting cup relative to the ingoing gauge of the metal sheet prior to the stretching operation, without requiring loss or waste of metal. When applied to the manufacture of two-piece containers, the invention enables cost savings to be made of the order of several dollars per 1,000 containers relative to existing manufacturing techniques.

[0014] The stretching operation is essential to achieve thinning of the base of the cup. The increased surface area in the base resulting from the stretching operation provides "excess material". This "excess material" is pulled and transferred from the base into the sidewall during the subsequent drawing operation. To ensure that the base material is stretched and thinned during the stretching operation, it is essential that the cup be clamped sufficiently to restrict or prevent metal flow from the clamped region into the enclosed portion during the stretching operation. If the clamping loads were insufficient, material from the clamped region (or from outside of the clamped region) would merely be drawn into the enclosed portion (which includes all or part of the base), rather than the enclosed portion (and therefore the base) undergoing any thinning. The subsequent transfer of material from base to sidewall during the post-stretch drawing operation is better illustrated in the embodiments of the invention shown in the attached drawings (see especially figure 10c).

[0015] The method of the invention is particularly suitable for use in the manufacture of metal containers, with the final resulting cup being used as the container body. The drawing operation performed on the stretched cup may comprise two or more drawing stages to effect a staged reduction in cup diameter and increase in sidewall height. Further, the cup may also be subjected to an ironing operation to both thin and increase the height of the sidewall, and thereby maximise the enclosed volume of the final resulting cup. The final resulting cup may be formed into a closed container by the fastening of a closure to the open end of the cup. For example, a metal can end may be seamed to the open end of the final

resulting cup (see figure 13).

[0016] The method of the invention is suitable for use on cups that are both round and non-round in plan. However, it works best on round cups.

[0017] As stated in the description of the Background Art, the sidewall thickness is critical in affecting the performance characteristics of a cup used for a container (can) body. The invention has the advantage of transferring material into the performance critical part of the cup (i.e. the sidewall), whilst also minimising the thickness and weight of the cup's base.

[0018] One way of minimising the amount of material in the base of cup-sections produced using conventional DWI and DRD processes would be to use thinner gauge starting stock. However, tinplate cost per tonne increases as the gauge decreases. This increase is explained by additional costs of rolling, cleaning and tinning the thinner steel. When also taking account of material usage during manufacture of a two-piece container, the variation in net overall cost to manufacture the container versus ingoing gauge of material looks like the graph shown in figure 2. This graph demonstrates that from a cost perspective, going for the thinnest gauge material does not necessarily reduce costs. In essence, there is a cheapest gauge of material for any container of a given sidewall thickness. The graph also shows the effect of reducing the thickness of the top and mid-wall sections of the container in driving down the cost curve. Figure 3 shows the same curve based upon actual data for UK-supplied tinplate of the type commonly used in can-making. For the material illustrated in figure 3, 0.285 mm represents the optimum thickness on cost grounds, with the use of thinner gauge material increasing net overall costs for can production. The graph of figure 3 shows the percentage increase in overall cost per 1,000 cans when deviating from the 0.285 mm optimum ingoing gauge thickness.

[0019] The final resulting cup of the invention has the benefits of a thinner (and therefore lighter) base. Also, the material transferred from the base is able to contribute to maximising the sidewall height. In this way, the invention provides an increased enclosed cup volume for a given amount of metal - relative to known methods of manufacturing cup-sections for two-piece containers. Additionally, the cost of manufacturing each container (on a cost per tonne or unit volume basis) is reduced because the invention allows thicker (and therefore cheaper) gauge material to be used for the metal sheet used to form the cup.

[0020] By clamping an "annular region" is meant that either or both of the sidewall and the base are clamped either continuously or at spaced intervals in an annular manner. Although it is possible to clamp the sidewall alone, rather than the base (see figure 7), it is preferred that the annular clamping comprises clamping an annular region of the base of the cup (the enclosed portion then being that part of the base located radially inward of the clamped region) (see figures 6a and 6b).

[0021] Trials have been conducted using a clamping

element in the form of an annular ring having a highly polished clamping face pressing against the annular region of the base of the cup. However, it has been found that reduced clamping loads are possible to obtain the same stretching effect when using a clamping element with a clamping face that is textured. The texturing has the effect of roughening the surface of the clamping face and thereby increasing the gripping effect of the clamping element on the annular region of the base for a given clamping load. The textured clamping element is therefore better able to restrict or prevent metal flow from the clamped region during the stretching operation. By way of example, the surface roughening of the clamping face has been induced by subjecting an initially smooth clamping face to electric discharge machining (EDM), which erodes the surface of the clamping face to define a pitted, roughened surface.

[0022] Preferably, the stretching operation comprises providing a "stretch" punch and moving either or both of the "stretch" punch and the cup toward each other so that the "stretch" punch deforms and stretches the enclosed portion.

[0023] In its simplest form, the "stretch" punch is a single punch having an end face which, when urged into contact with the base of the cup, both deforms and stretches the base. Preferably, the end face of the "stretch" punch is provided with a non-planar profile, either or both of the "stretch" punch and the cup moved towards each other so that the "stretch" punch deforms and stretches the enclosed portion into a corresponding non-planar profile. Conveniently, the end face would be provided with a domed or part-spherical profile, which in use acts to stretch and deform the enclosed portion into a correspondingly domed or part-spherical profile. By way of example, figure 4 shows the variation in the base thickness in the stretched cup resulting from use of a single "stretch" punch provided with a domed profiled end face for a cup of approximately 47.5 mm radius (95 mm diameter). The material had an ingoing gauge thickness of 0.115 inches (2.9 mm), with the minimum base thickness after the stretching operation being 0.086 inches (2.2 mm), representing a 25% peak reduction in base thickness. In the example shown, the degree of base thinning resulting from the stretching operation was non-uniform across the diameter of the base. Varying the profile of the end face of the punch has been found to affect the base thickness profile and, in particular, the location of maximum base thinning. By way of example, in vertical section the end face of the punch may have compound radii or be oval in profile. To enable different levels of thinning to be achieved across the enclosed portion, the "stretch" punch preferably comprises an end face having one or more relief features. For example, the end face may include one or more recesses or cut-outs (see figure 9).

[0024] As an alternative to having a single punch, the "stretch" punch may instead comprise a punch *assembly*, the assembly comprising a first group of one or more

punches opposing one surface of the enclosed portion and a second group of one or more punches opposing the opposite surface of the enclosed portion, the stretching operation comprising moving either or both of the first and second groups towards each other to deform and stretch the enclosed portion. Such a punch assembly may, for example, allow the enclosed portion to be deformed into an undulating profile, which may allow the enclosed portion to be stretched in a more uniform manner than that shown in figure 4 (see the example shown in figure 8).

[0025] As a further alternative to using either a single punch or a punch assembly, the stretching operation may instead be achieved by spinning. For example, the spinning may comprise use of a profiled tool that is rotatably and/or pivotally mounted, the tool and enclosed portion of the cup being brought into contact with each other, with either or both of the profiled tool and cup being rotated and/or pivoted relative to each other such that profiled tool progressively profiles and stretches the enclosed portion.

[0026] The drawing operation on the stretched cup has the benefit of maximising the container height and volume for a given amount of raw material. The drawing operation is conveniently performed by drawing the cup through one or a succession of draw dies, to transfer material from the stretched and thinned base into the sidewall, thereby increasing the height of the sidewall and resulting in the base of the drawn cup having a thickness less than the ingoing gauge of the metal sheet.

[0027] The drawing operation may be performed using a bodymaker/press having one or a succession of draw dies. Typically, the drawing operation would comprise drawing the cup through one or a succession of draw dies, to draw material from the stretched and thinned base into the sidewall, thereby increasing the height of the sidewall and resulting in the base of the drawn cup having a thickness less than the ingoing gauge of the metal sheet.

[0028] Preferably, the cup which is fed into the stretching operation is formed by an initial drawing operation performed prior to the stretching operation, the initial drawing operation comprising drawing a metal sheet into a cup profile. In this case, the drawing operation following stretching would be a re-drawing operation.

[0029] For this initial drawing operation, preferably a blank is first cut from the metal sheet, the blank then drawn into a cup profile. Conveniently, the initial drawing operation comprises first slidably clamping the blank at a location between a draw die and a "draw" punch, the "draw" punch adapted to move through the draw die, either or both of the "draw" punch and draw die being co-axially moved towards each other so that the "draw" punch draws the blank against the forming surface of the draw die to form the cup.

[0030] By "slidably clamping" is meant that the clamping load during drawing is selected so as to permit the blank to slide, relative to whatever clamping means is

used (e.g. a draw pad), in response to the deforming action of the drawing die on the blank. An intention of this slidable clamping is to prevent or restrict wrinkling of the material during this initial drawing operation. The same principles apply to the (re-)drawing operation that follows the stretching operation.

[0031] This initial drawing operation to form the cup may simply be performed in a conventional cupping press using a combination of a "draw" punch and draw die. However, the initial drawing operation is not limited to use of a conventional draw punch/draw die arrangement. For example, the drawing operation may comprise blow-forming using compressed air/gases or liquids to draw the blank against the draw die or a mould into the shape of the cup. Again, these same alternatives may be used to perform the (re-)drawing operation that follows the stretching operation. In essence, the initial drawing and the (re-)drawing operations encompass any means of applying a drawing force.

[0032] A second aspect of the invention relates to an apparatus for working the method of the invention. Some of the features of such an apparatus have already been described above. However, for completeness, the apparatus claims are briefly discussed below. The term "apparatus" encompasses not only a single plant item, but also includes a collection of discrete plant items that, collectively, are able to work the claimed method of the invention (e.g. similar to the assembly line of a car plant, with successive operations performed by different items of plant).

[0033] According to the second aspect of the invention, there is provided an apparatus for manufacture of a metal cup, the apparatus comprising:

a clamping element for clamping a cup formed of metal sheet, the cup having a sidewall and an integral base, the clamping element adapted to clamp an annular region of either or both the sidewall and the base to define an enclosed portion which includes all or part of the base;

a stretch tool adapted to deform and stretch at least some of that part of the base which lies within the enclosed portion in a stretching operation to thereby increase the surface area and reduce the thickness of the base,

the clamping element further adapted to restrict or prevent metal flow from the clamped region into the enclosed portion during this stretching operation; and

means for drawing the cup to pull and transfer material from the stretched and thinned base into the sidewall to provide a cup having a base thickness less than that of the metal sheet prior to the stretching operation.

[0034] The clamping element may be in the form of a continuous annular sleeve; alternatively, it may be a collection of discrete clamping elements distributed in an

annular manner to act against either or both of the sidewall and the base.

[0035] As indicated in discussion of the method of the invention, preferably the clamping element is adapted to clamp an annular region of the base of the cup, with the enclosed portion being that part of the base located radially inward of the clamped annular region.

[0036] Preferably, the stretch tool comprises a "stretch" punch, the apparatus adapted to move either or both of the "stretch" punch and the cup toward each other so that the "stretch" punch deforms and stretches the enclosed portion. As indicated in discussion of the method of the invention, the "stretch" punch may simply be a single punch having an end face which, in use, is urged against the enclosed portion of the cup to perform the stretching operation. Trials have been performed using a single punch as the "stretch" punch, the end face of the single punch having a domed or generally part-spherical profile which, in use, stretches the enclosed portion into a correspondingly shaped domed or part-spherical profile. Alternatively, in vertical section the end face of the punch may have compound radii or be oval in profile. To enable different levels of thinning to be achieved across the enclosed portion, the "stretch" punch may preferably comprise an end face having one or more relief features. For example, the end face may include one or more recesses or cut-outs (see figure 9).

[0037] In an alternative embodiment, the "stretch" punch comprises a punch assembly, the assembly comprising a first group of one or more punches opposing one surface of the enclosed portion and a second group of one or more punches opposing the opposite surface of the enclosed portion, the first and second groups moveable towards each other to deform and stretch the enclosed portion.

[0038] As referred to in discussion of the method of the invention, the drawing operation is conveniently performed by drawing the cup through one or a succession of draw dies, to transfer material from the stretched and thinned base into the sidewall, thereby increasing the height of the sidewall and resulting in the base of the drawn cup having a thickness less than the ingoing gauge of the metal sheet. The means for drawing may preferably comprise a draw punch (or succession of punches) and corresponding draw die(s).

[0039] Preferably, the apparatus further comprises means for initially drawing a metal sheet to form the cup for the stretching operation. Conveniently, the means for initially drawing the metal sheet comprises a draw die, a "draw" punch and means for slidably clamping the metal sheet at a location between the draw die and the "draw" punch. Where an initial drawing operation is used to form the cup for the stretching operation, the drawing operation following stretching would be a re-drawing operation.

[0040] Furthermore, preferably the apparatus further comprises one or a succession of ironing dies to reduce the thickness of the sidewall and thereby increase the height of the sidewall.

[0041] The method and apparatus of the invention are not limited to a particular metal. They are particularly suitable for use with any metals commonly used in DWI (D&I) and DRD processes. Also, there is no limitation on the end use of the cup that results from the method and apparatus of the invention. Without limitation, the cups may be used in the manufacture of any type of container, whether for food, beverage or anything else. However, the invention is particularly beneficial for use in the manufacture of containers for food, especially with regard to the cost savings that can be made relative to known manufacturing techniques.

Brief Description of Figures in the Drawings

[0042] Figure 1 is a side elevation view of a container body of the background art resulting from a conventional DWI process. It shows the distribution of material in the base and sidewall regions of the container body.

[0043] Figure 2 is a graph showing in general terms how the net overall cost of manufacturing a typical two-piece metal container varies with the ingoing gauge of the sheet metal. The graph shows how reducing the thickness of the sidewall region (e.g. by ironing) has the effect of driving down the net overall cost.

[0044] Figure 3 is a graph corresponding to figure 2, but based on actual price data for UK-supplied tinplate.

[0045] Embodiments of the invention are illustrated in the following drawings, with reference to the accompanying description:

[0046] Figure 4 is a graphical representation of the variation in base thickness of a cup resulting from use of a "stretch" punch (according to the invention) having a domed profiled end face.

[0047] Figure 5a is a side elevation view of the tooling of a cupping press used to form a first stage cup from a sheet metal blank. The figure shows the tooling before the initial drawing operation has commenced.

[0048] Figure 5b corresponds to figure 5a, but on completion of the initial drawing operation to form the first stage cup.

[0049] Figure 6a is a side elevation view of a stretch rig used to perform the stretching operation of the invention. The figure shows the stretch rig before the stretching operation has commenced.

[0050] Figure 6b shows the stretch rig of figure 6a, but on completion of the stretching operation.

[0051] Figure 7 shows an alternative embodiment to that of figures 6a and 6b, in which the pre-stretched cup is clamped about its sidewall for the stretching operation.

[0052] Figure 8 shows an alternative embodiment of stretch punch to that shown in figures 6a and 6b.

[0053] Figure 9 shows a further alternative embodiment of stretch punch to those shown in figures 6a, 6b and 8, where the end face of the stretch punch includes various relief features.

[0054] Figures 10a-d show perspective views of a bodymaker assembly used to re-draw the stretched cup. The

figures show the operation of the bodymaker from start to finish of the stretching operation.

[0055] Figure 11 shows a detail view of the re-draw die used in the bodymaker of figures 10a-d.

5 [0056] Figure 12 shows the sheet metal blank at various stages during the method of the invention as it progresses from a planar sheet to a finished cup.

10 [0057] Figure 13 shows the use of the cup of the invention as part of a two-piece container.

Mode(s) for Carrying Out the Invention

Initial Drawing Operation

15 [0058] A cupping press 10 has a draw pad 11 and a draw die 12 (see figures 5a and 5b). A draw punch 13 is co-axial with the draw die 12, as indicated by common axis 14. A circumferential cutting element 15 surrounds the draw pad 11.

20 [0059] In use, a flat section of metal sheet 20 is held in position between opposing surfaces of the draw pad 11 and the draw die 12. Steel tin-plate (Temper 4) with an ingoing gauge thickness ($t_{in-going}$) of 0.280 mm has been used for the metal sheet 20. However, the invention is not limited to particular gauges or metals. The section of metal sheet 20 is typically cut from a roll of metal sheet (not shown). After the section of metal sheet 20 has been positioned, the circumferential cutting element 15 is moved downwards to cut a circular planar blank 21 out from the metal sheet (see figure 5a). The excess material is indicated by 22 on figure 5a.

25 [0060] After the blank 21 has been cut from the sheet 20, the draw punch 13 is moved axially downwards through the draw die 12 to progressively draw the planar blank against the forming surface 16 of the draw die into the profile of a cup 23 having a sidewall 24 and integral base 25. This drawing operation is shown in figure 5b, and includes a separate view of the drawn cup 23 when removed from the press 10. A detail view is included in figure 5a of the radius R_{12} at the junction between the end face of the draw die 12 and its forming surface 16. As for conventional drawing operations, the radius R_{12} and the load applied by the draw pad 11 to the periphery of the blank 21 are selected to permit the blank to slide radially inwards between the opposing surfaces of the draw pad 11 and draw die 12 and along forming surface 16 as the draw punch 13 moves progressively downwards to draw the blank into the cup 23. This ensures that the blank 21 is predominantly *drawn*, rather than *stretched* (thinned) (or worse, torn about the junction between the end face of the draw die and the forming surface). Dependent on the size of radius R_{12} and, to a lesser extent, the severity of the clamping load applied by the draw pad 11, the wall thickness of the cup 23 will be essentially unchanged from that of the ingoing gauge of the blank 21, i.e. negligible stretching or thinning should occur. However, in alternative embodiments of the invention, it is permissible for the load applied by the draw pad

11 to be sufficient that a *combination* of drawing and stretching occurs under the action of the draw punch 13. The cup 23 that results from this initial drawing operation is also referred to the "first stage cup".

Stretching Operation

[0061] Following the initial drawing operation shown in figures 5a and 5b, the drawn cup 23 is transferred to a stretch rig 30, an example of which is illustrated in figures 6a and 6b. The stretch rig 30 has two platens 31, 32 that are moveable relative to each other along parallel axes 33 under the action of loads applied through cylinders 34 (see figures 6a and 6b). The loads may be applied by any conventional means, e.g. pneumatically, hydraulically or through high-pressure nitrogen cylinders.

[0062] On platen 31 is mounted a stretch punch 35 and a clamping element in the form of an annular clamp ring 36. The annular clamp ring 36 is located radially outward of the stretch punch 35. The stretch punch 35 is provided with a domed end face (see figures 6a and 6b).

[0063] On platen 32 is mounted a cup holder 37. The cup holder 37 is a tubular insert having an annular end face 38 and an outer diameter corresponding to the internal diameter of the drawn cup 23 (see figures 6a and 6b). In use, the drawn cup 23 is mounted on the cup holder 37 so that the annular end face 38 contacts a corresponding annular region 26 of the cup's base 25 (see figures 6a and 6b). Loads are applied via cylinders 34 to move platens 31, 32 towards each other along axes 33 until the annular region 26 is clamped firmly in an annular manner between the planar surface of the clamp ring 36 and the annular end face 38 of the cup holder 37. The clamped annular region 26 defines an enclosed portion 27 of the cup. In the embodiment shown in figures 6a and 6b, the annular clamping thereby separates the base 25 into two discrete regions: the clamped annular region 26 and the enclosed portion 27.

[0064] The stretch punch 35 is then moved axially through the clamp ring 36 to progressively deform and stretch (thin) the enclosed portion 27 into a domed profile 28.

[0065] In the embodiment shown in the drawings, the enclosed portion 27 is domed inwardly 28 into the cup (see figure 6b). However, in an alternative embodiment, the enclosed portion 27 may instead be domed outwardly outside of the cup.

[0066] Ideally, the clamping loads applied during this stretching operation are sufficient to ensure that little or no material from the clamped annular region 26 (or the sidewall 24) flows into the enclosed portion 27 during stretching. This helps to maximise the amount of stretching and thinning that occurs in the domed region 28.

[0067] In summary, this stretching operation and the resulting thinning of the base 25 is critical to achieving the object of the invention, namely to make a cup or container body having a base thickness which is less than that of the ingoing gauge of the metal sheet.

[0068] In an alternative embodiment shown in figure 7, the sidewall 24 rather than the base 25 is clamped during the stretching operation. Figure 7 shows an annular region 26 of the sidewall adjacent the base being clamped between cup holder 370 and clamping element 360. Either or both of the cup holder 370 and clamping element 360 may be segmented to facilitate the clamping of the sidewall, and to accommodate cups of different sizes. The annular clamping of the sidewall 24 defines an enclosed portion 27 inward of the clamped annular region 26 (see figure 7). A stretch punch 35 is also indicated in figure 7. Note that other features of the stretch rig are excluded from figure 7 for ease of understanding.

[0069] In a further alternative embodiment, the single stretch punch 35 is replaced by a punch assembly 350 (as shown in figure 8). The punch assembly 350 has:

- i) a first group 351 of two annular punch elements 351 a,b surrounding a central core punch element 351 c; and
- ii) a second group 352 of two annular punch elements 352a,b.

[0070] For ease of understanding, figure 8 only shows the punch assembly 350 and the drawn cup 23. Although not shown on figure 8, in use, an annular region 26 of the cup's base 25 would be clamped during the stretching operation in a similar manner to the embodiment shown in figures 6a and 6b.

[0071] In use, the first and second groups of punch elements 352, 353 face opposing surfaces of the enclosed portion 27. The stretching operation is performed by moving both first and second groups of punch elements 351, 352 towards each other to deform and stretch (thin) the enclosed portion 27. The enclosed portion 27 is deformed into an undulating profile 29 (see figure 8).

[0072] In a further embodiment, a single stretch punch 35 has a number of relief features in the form of recesses/cut-outs 353 provided in its end face (see figure 9). In the embodiment shown, there is a central recess/cut-out surrounded by a single annular recess/cut-out. However, alternative configurations of recess/cut-out may be used.

(Re-)Drawing Operation on Stretched Cup

[0073] For the embodiment of the invention shown in figures 6a and 6b, the stretched cup with its thinned and domed region 28 in the base is transferred to a body-maker assembly 40 (see figures 10a to 10d). The body-maker assembly 40 comprises two halves 41, 42 (indicated by arrows in figures 10a to 10d).

[0074] The first half 41 of the bodymaker assembly 40 has a tubular re-draw punch 43 mounted on the same axis as circumferential clamp ring 44. As can be seen from figures 10a to 10d, the clamp ring 44 circumferentially surrounds the re-draw punch 43 like a sleeve. As will be understood from the following description and looking at figures 10a to 10d, the re-draw punch 43 is

moveable through and independently of the circumferential clamp ring 44.

[0075] The second half 42 of the bodymaker assembly 40 has a re-draw die 45. The re-draw die 45 has a tubular portion having an outer diameter corresponding to the internal diameter of the stretched cup 23 (see figure 10a). The re-draw die 45 has a forming surface 46 along its inner axial surface, which terminates in an annular end face 47 (see figures 10a to 10d). The annular end face 47 of the re-draw die 45 corresponds in width to that of the annular region 26 of the base of the stretched cup.

[0076] In use, the stretched cup 23 is first mounted on the re-draw die 45 (as shown on figure 10a). Then, as shown in figure 10b, the two halves 41, 42 of the bodymaker assembly 40 are moved axially relative to each other so that the annular region 26 of the base of the stretched cup is clamped between the annular end face 47 of the re-draw die 45 and the surface of the circumferential clamp ring 44.

[0077] Once clamped, the re-draw punch 43 is then forced axially through the clamp ring 44 and the re-draw die 45 (see arrow A on figures 10c and 10d) to progressively re-draw the material of the stretched cup along the forming surface 46 of the re-draw die. The use of the re-draw die 45 has two effects:

- i) to cause material from the sidewall 24 to be drawn radially inwards and then axially along the forming surface 46 of the re-draw die 45 (as indicated by arrows B on figures 10c and 10d). In this way, the cup is reduced in diameter (as indicated by comparing figure 10a with figure 10d); and
- ii) to cause the stretched and thinned material in the domed region 28 of the base to be progressively pulled out and transferred from the base into the reduced diameter sidewall (as indicated by arrows C on figures 10c and 10d). This has the effect of flattening the domed region 28 of the base (see especially figure 10d).

[0078] Figure 10d shows the final state of the re-drawn cup 23 when the re-draw punch 43 has reached the end of its stroke. It can clearly be seen that the formerly domed region 28 of the base has been pulled essentially flat, to provide a cup or container body 23 where the thickness of the base 25 is thinner than that of the ingoing blank 21. As stated earlier, this reduced thickness in the base 25 - and the consequent weight reduction - is enabled by the stretching operation performed previously.

[0079] As shown in the detail view of the re-draw die 45 in figure 11, the junction between the forming surface 46 and the annular end face 47 of the re-draw die is provided with a radius R_{45} in the range 1 to 3.2 mm. The provision of a radius R_{45} alleviates the otherwise sharp corner that would be present at the junction between the forming surface 46 and the annular end face 47, and thereby reduces the risk of the metal of the stretched cup 23 tearing when being re-drawn around this junction.

[0080] Note that although figures 10a to 10d show use of a tubular re-draw punch 43 having an annular end face, the punch may alternatively have a closed end face. The closed end face may be profiled to press a corresponding profile into the base of the cup.

[0081] The drawing operation described above and illustrated in figures 10a to 10d is known as reverse re-drawing. This is because the re-draw punch 43 is directed to invert the profile of the stretched cup. In effect, the re-draw punch reverses the direction of the material and turns the stretched cup inside out. This can be seen by comparing the cup profiles of figures 10a and 10d. Reverse re-drawing the cup in this context has the advantages of:

- i) preventing uncontrolled buckling of the domed region 28 of the base of the stretched cup (especially when using a re-draw punch having a closed end face); and
- ii) maximising transfer of material from the domed region 28 to the sidewalls 24.

[0082] Note that although the embodiment shown in figures 10a to 10d illustrates reverse re-drawing, conventional re-drawing would also work; i.e. where the re-draw punch acts in the opposite direction to reverse re-drawing and does not turn the cup inside out.

[0083] Figure 12 shows the changes undergone by the metal blank 21 from a) before any forming operations have been undertaken, to b) forming into the first stage cup in the cupping press 10, to c) the stretching and thinning operation performed in the stretch rig 30, to d) the re-drawn cup that results from the bodymaker assembly 40. A location on the domed region 28 of the stretched cup is indicated as X on figure 12. The figure illustrates the effect of the re-drawing operation in radially pulling out X to X'. The figure shows that the base of the cup at that location after stretching (t_{stretch}) (and after the re-drawing operation) has a reduced thickness relative to the ingoing gauge of the blank 21 ($t_{\text{in-going}}$), i.e. $t_{\text{stretch}} < t_{\text{in-going}}$. As previously stated, this thinning of the base is enabled by the stretching operation.

[0084] To maximise the height of the sidewall 24 of the cup with its thinned base, the re-drawn cup may also undergo ironing of the sidewalls by being drawn through a succession of ironing dies (not shown). This ironing operation has the effect of increasing the height and decreasing the thickness of the sidewall, and thereby maximising the enclosed volume of the cup.

[0085] Figure 13 shows a container 100 where the final resulting cup 23 has undergone an ironing operation to form container body 110. The container body 110 is flared outwardly 111 at its access opening. Can end 120 is provided with a seaming panel 121, the seaming panel enabling the can end to be fastened to the container body by seaming to the flared portion 111.

Claims

1. A method for manufacture of a metal cup, the method comprising the following operations:

i. a stretching operation (30) comprising taking a cup (23) having a sidewall (24) and an integral base (25), the cup formed of metal sheet (20, 21), clamping (36, 37) an annular region (26) of either or both the sidewall and the base to define an enclosed portion (27) which includes all or part of the base, and deforming and stretching (35) at least some of that part of the base which lies within the enclosed portion to thereby increase the surface area and reduce the thickness of the base, the annular clamping adapted to restrict or prevent metal flow from the clamped region into the enclosed portion during this stretching operation;

ii. a drawing operation (40) comprising drawing (43, 44, 45) the cup to pull and transfer material (B, C) from the stretched and thinned base into the sidewall to provide a cup having a base thickness less than that of the metal sheet prior to the stretching operation.

2. A method as claimed in claim 2:

wherein the annular clamping (36, 37) of the stretching operation (30) comprises clamping an annular region (26) of the base (25), the enclosed portion (27) being that part of the base located radially inward of the clamped region.

3. A method as claimed in either of claim 1 or 2:

wherein the annular clamping (36, 37) of the stretching operation (30) comprises using one or more clamping elements having a clamping face with a textured surface.

4. A method as claimed in any preceding claim:

wherein the stretching operation (30) comprises providing a "stretch" punch (35) and moving either or both of the "stretch" punch and the cup (23) toward each other so that the "stretch" punch deforms and stretches the enclosed portion (27).

5. A method as claimed in claim 4, wherein the "stretch" punch (35) comprises an end face having one or more relief features (353).

6. A method as claimed in either of claim 4 or 5, wherein the "stretch" punch comprises a punch assembly (350), the assembly comprising a first group of one or more punches (351) opposing one surface of the

enclosed portion (27) and a second group of one or more punches (352) opposing the opposite surface of the enclosed portion, the stretching operation comprising moving either or both of the first and second groups towards each other to deform and stretch the enclosed portion.

7. A method claimed in any preceding claim, comprising an initial drawing operation (10) performed before the stretching operation, the initial drawing operation comprising drawing (11, 12, 13) a metal sheet (21) to form the cup (23) for the stretching operation (30).

8. A method as claimed in any preceding claim, wherein the post-stretch drawing operation (40) comprises or is followed by passing the cup (23) through one or a succession of ironing dies to reduce the thickness of the sidewall (24) and thereby increase the height of the sidewall.

9. An apparatus for manufacture of a metal cup, the apparatus comprising:

a clamping element (36, 37) for clamping a cup (23) formed of metal sheet (20, 21), the cup having a sidewall (24) and an integral base (25), the clamping element adapted to clamp an annular region (26) of either or both the sidewall and the base to define an enclosed portion (27) which includes all or part of the base;

a stretch tool (30, 35) adapted to deform and stretch at least some of that part of the base which lies within the enclosed portion in a stretching operation to thereby increase the surface area and reduce the thickness of the base, the clamping element further adapted to restrict or prevent metal flow from the clamped region into the enclosed portion during this stretching operation; and

means for drawing the cup (40, 43, 44, 45) to pull and transfer material from the stretched and thinned base into the sidewall to provide a cup having a base thickness less than that of the metal sheet prior to the stretching operation.

10. An apparatus as claimed in claim 9, wherein the clamping element (36, 37) is adapted to clamp an annular region (26) of the base (25) of the cup (23).

11. An apparatus as claimed in either of claim 9 or 10, wherein the clamping element (36, 37) comprises a clamping face having a textured surface.

12. An apparatus as claimed in any one of claims 9 to 11, wherein the stretch tool (30, 35) comprises a "stretch" punch (35), the apparatus adapted to move either or both of the "stretch" punch and the cup (23) toward each other so that, in use, the "stretch" punch

deforms and stretches the enclosed portion (27).

13. An apparatus as claimed in claim 12, wherein the "stretch" punch (35) has an end face provided with a non-planar profile, the apparatus adapted to move either or both of the "stretch" punch and the cup (23) toward each other so that, in use, the "stretch" punch deforms and stretches the enclosed portion (27) into a corresponding non-planar profile.
14. An apparatus as claimed in either of claim 12 or 13, wherein the "stretch" punch (35) comprises an end face having one or more relief features (353).
15. An apparatus as claimed in any one of claims 12 to 14, wherein the "stretch" punch comprises a punch assembly (350), the assembly comprising a first group of one or more punches (351) opposing one surface of the enclosed portion (27) and a second group of one or more punches (352) opposing the opposite surface of the enclosed portion, the first and second groups moveable towards each other to, in use, deform and stretch the enclosed portion.
16. An apparatus as claimed in any one of claims 9 to 15, the apparatus further comprising means for initially drawing (10, 11, 12, 13) a metal sheet (20, 21) to form the cup for the stretching operation.
17. An apparatus as claimed in any one of claims 9 to 16, further comprising one or a succession of ironing dies to reduce the thickness of the sidewall (24) and thereby increase the height of the sidewall.
18. A container body (110) comprising a cup as formed by the method or apparatus of any of the preceding claims.
19. A container body (110) comprising a cup having an access opening, the cup formed of metal sheet and having a sidewall and integral base, wherein the base is a stretched base such that the thickness of the base is less than the ingoing gauge of the metal sheet used to form the cup.
20. A container (100) comprising the container body (110) of claim 19, further comprising a closure (120) fastened to the access opening of the container body.

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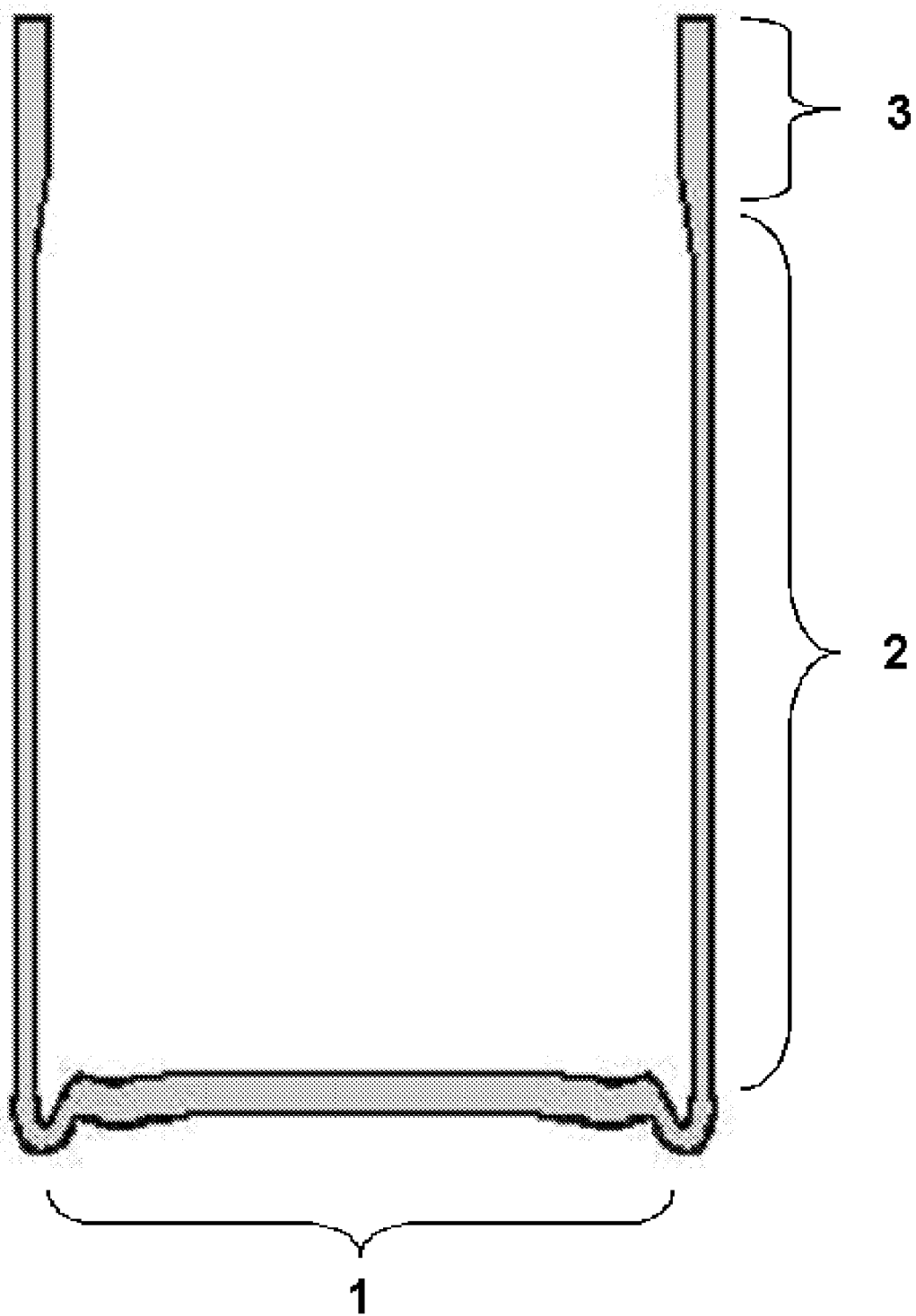


Figure 1

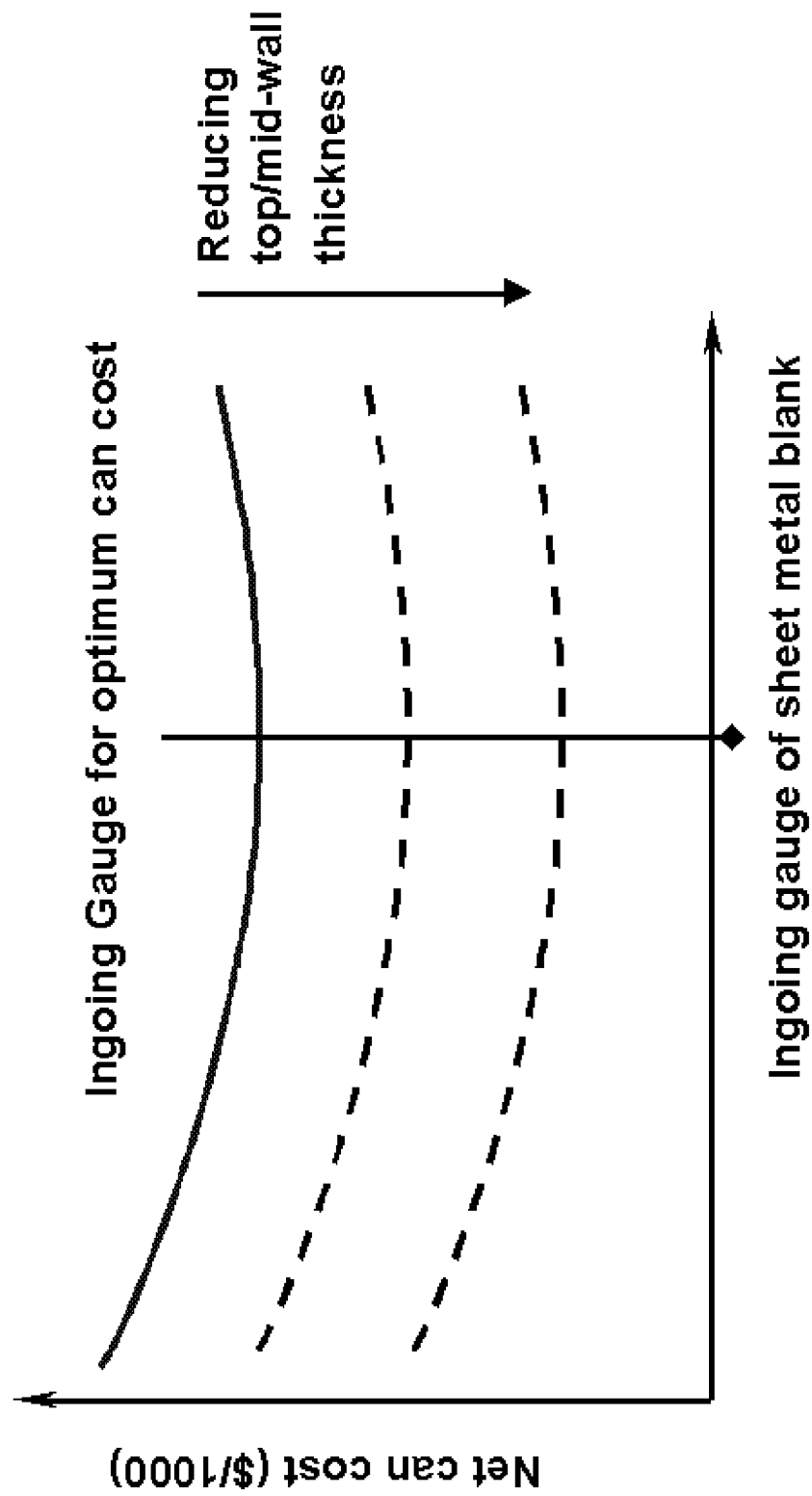


Figure 2

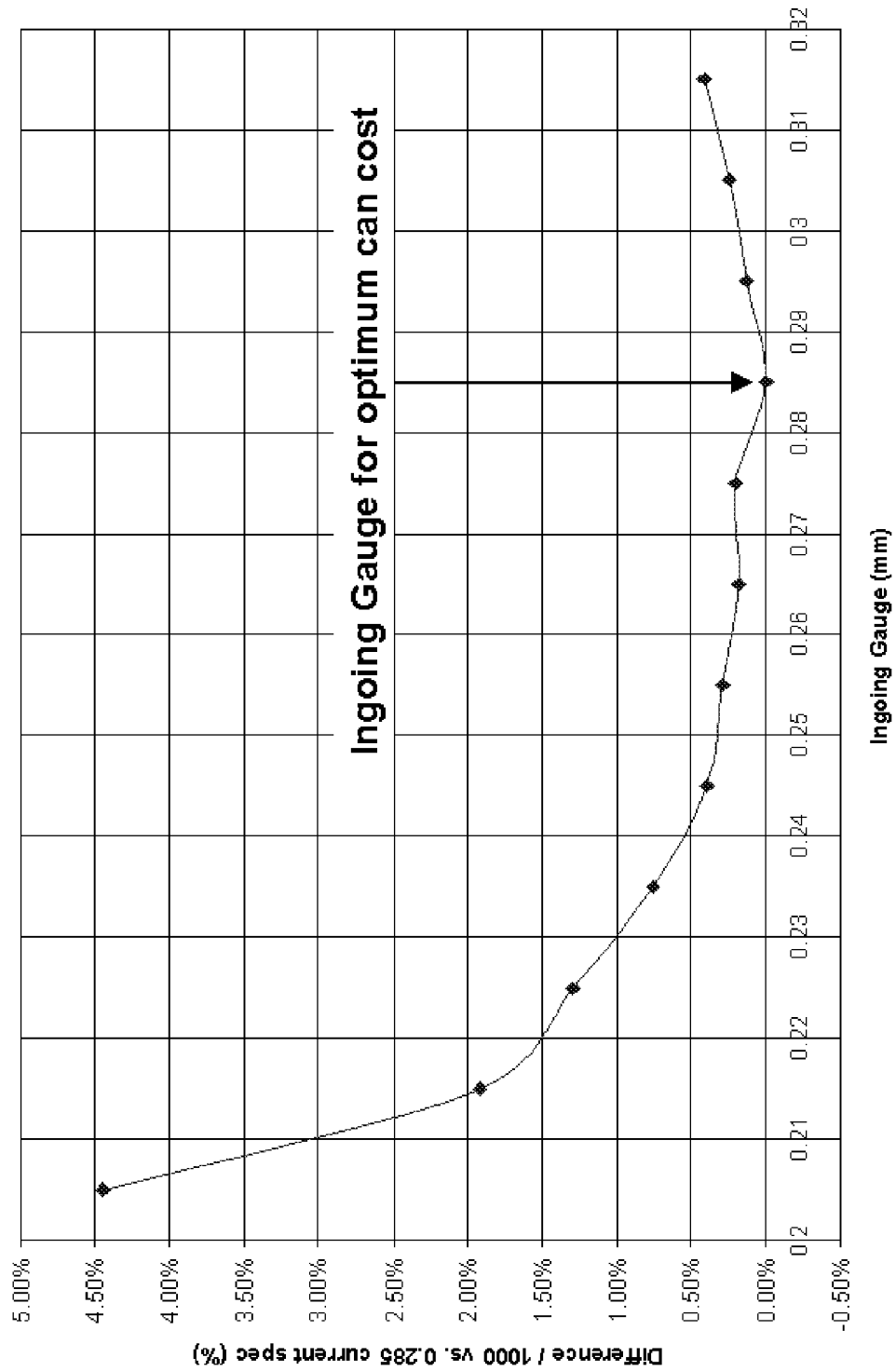
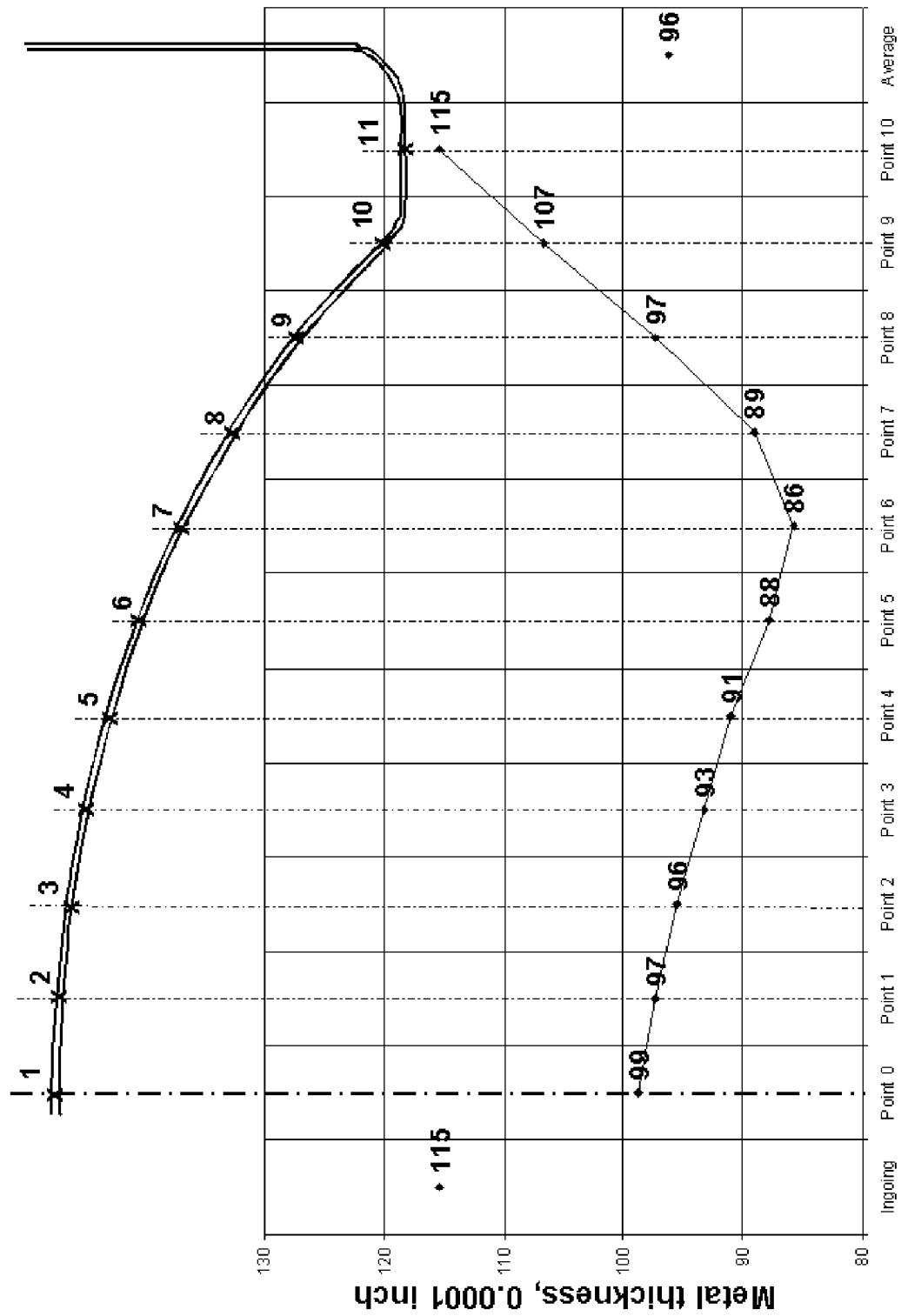


Figure 3



Measurement position on cup base

Figure 4

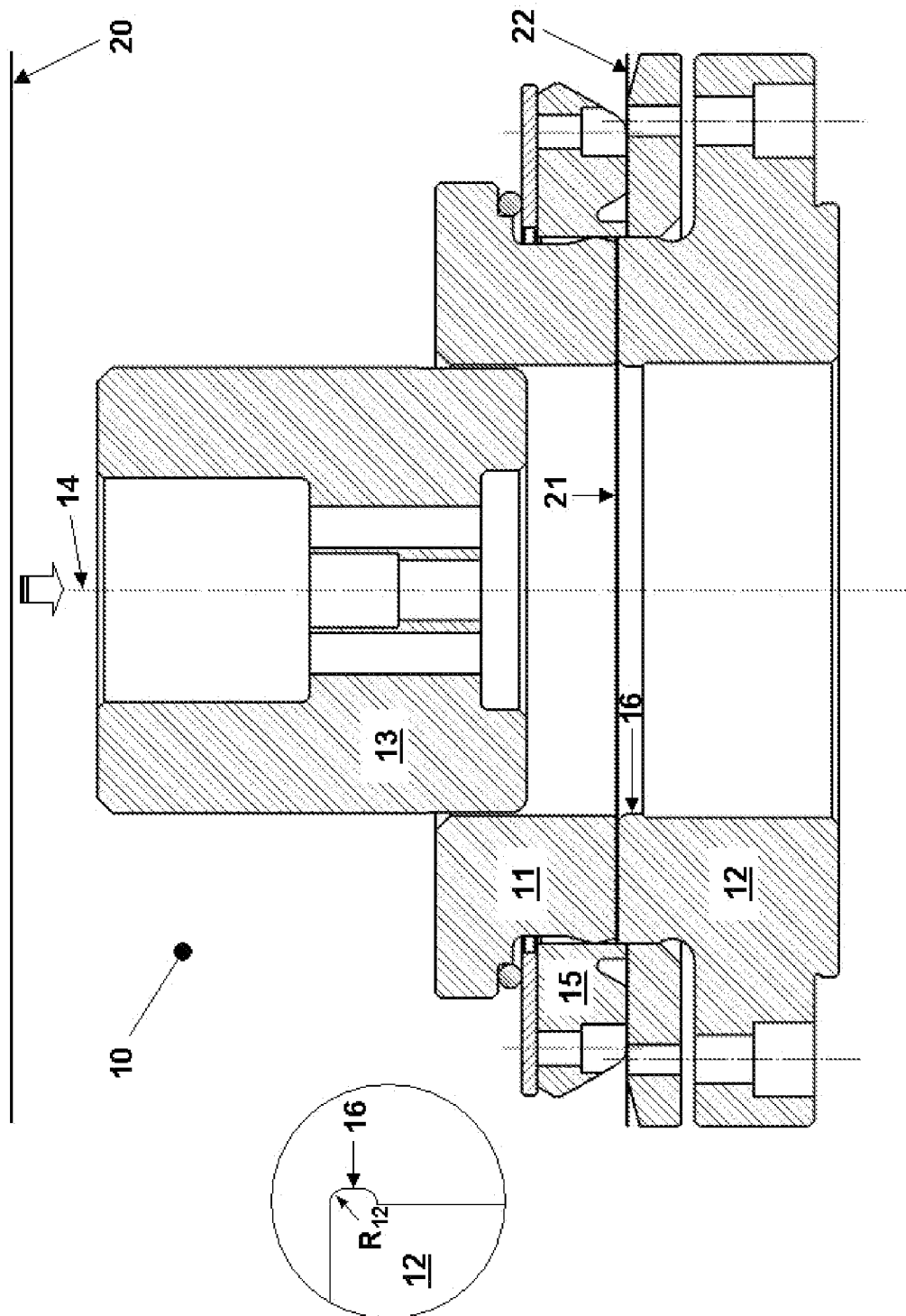


Figure 5a

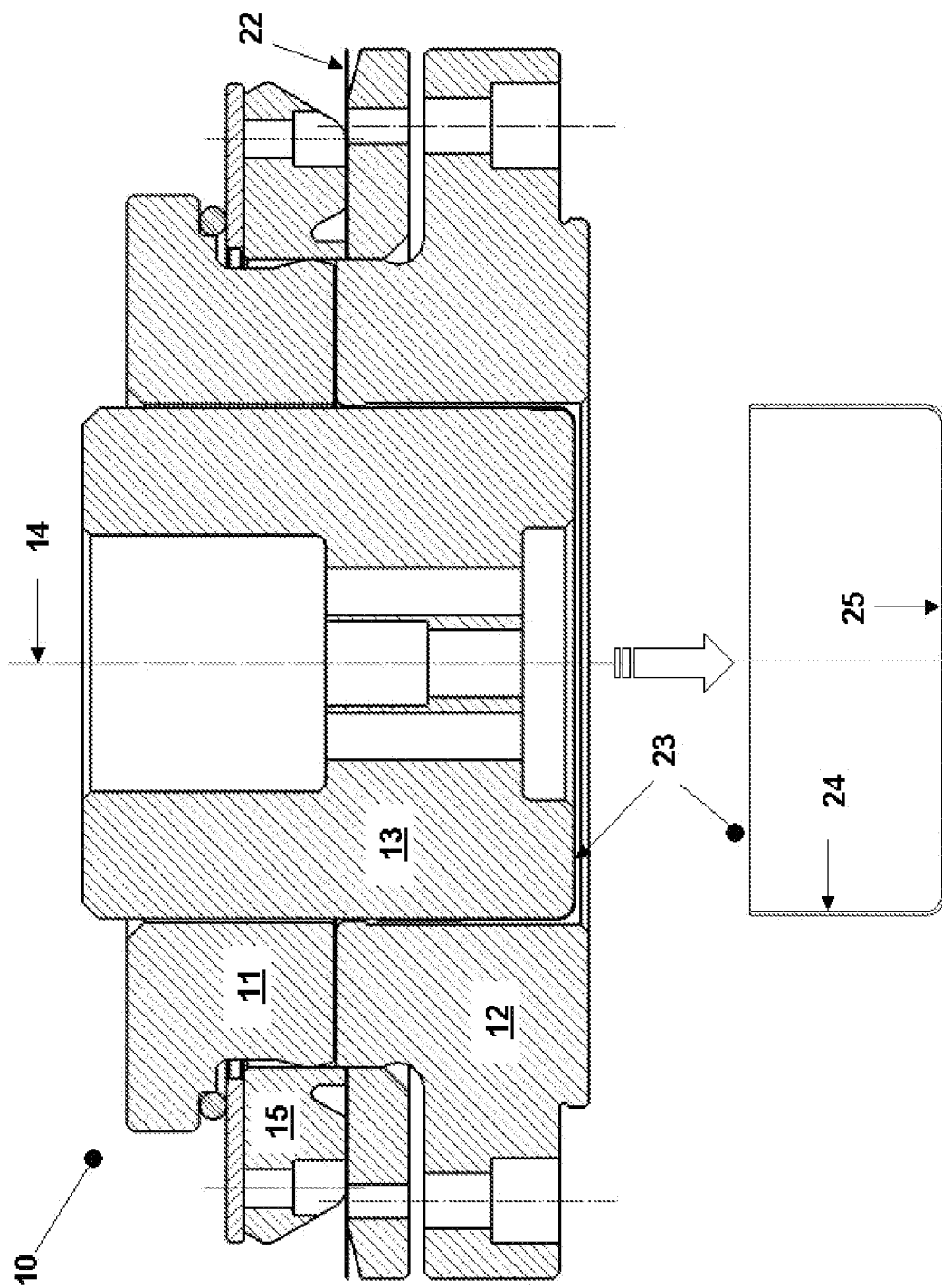


Figure 5b

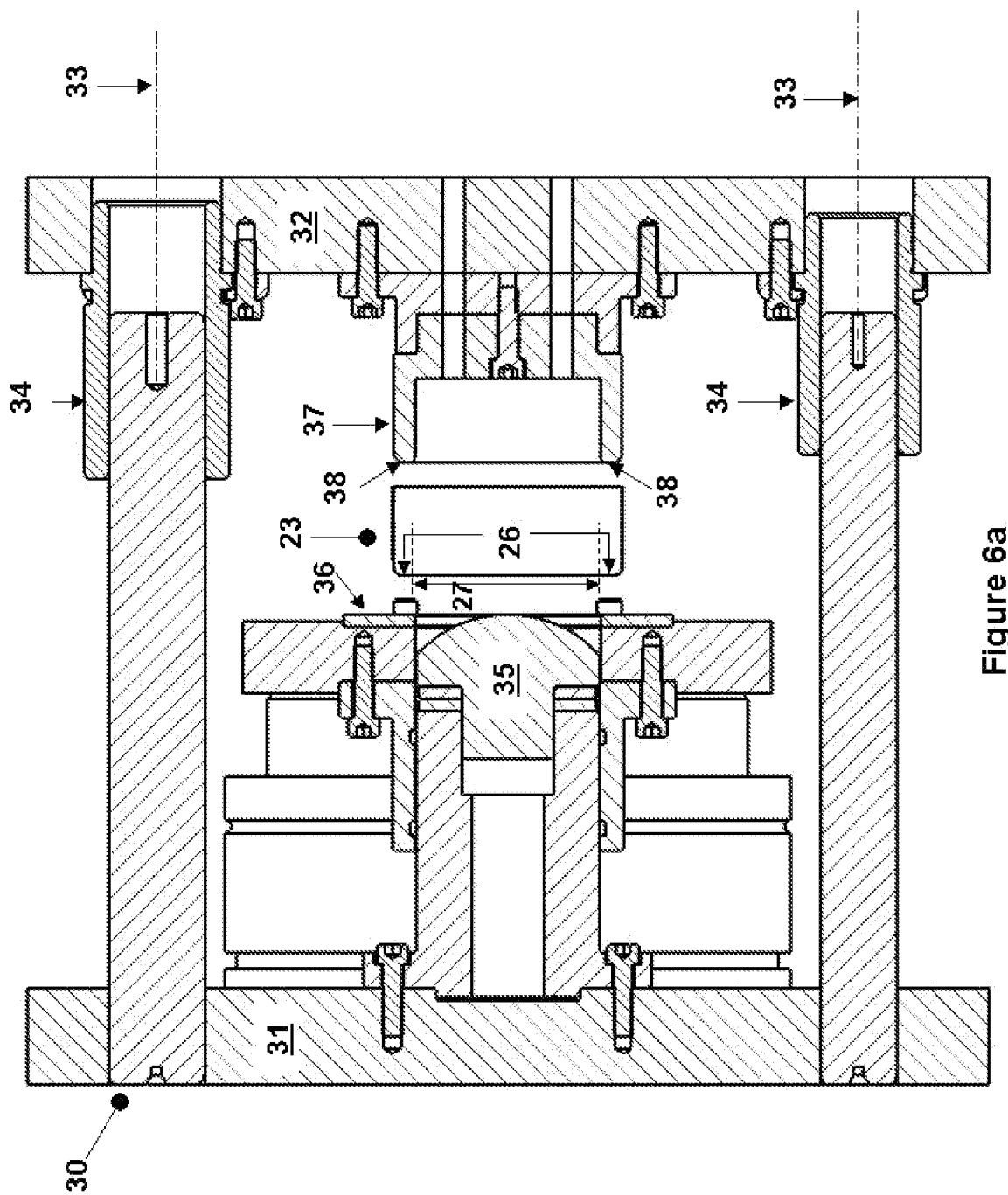


Figure 6a

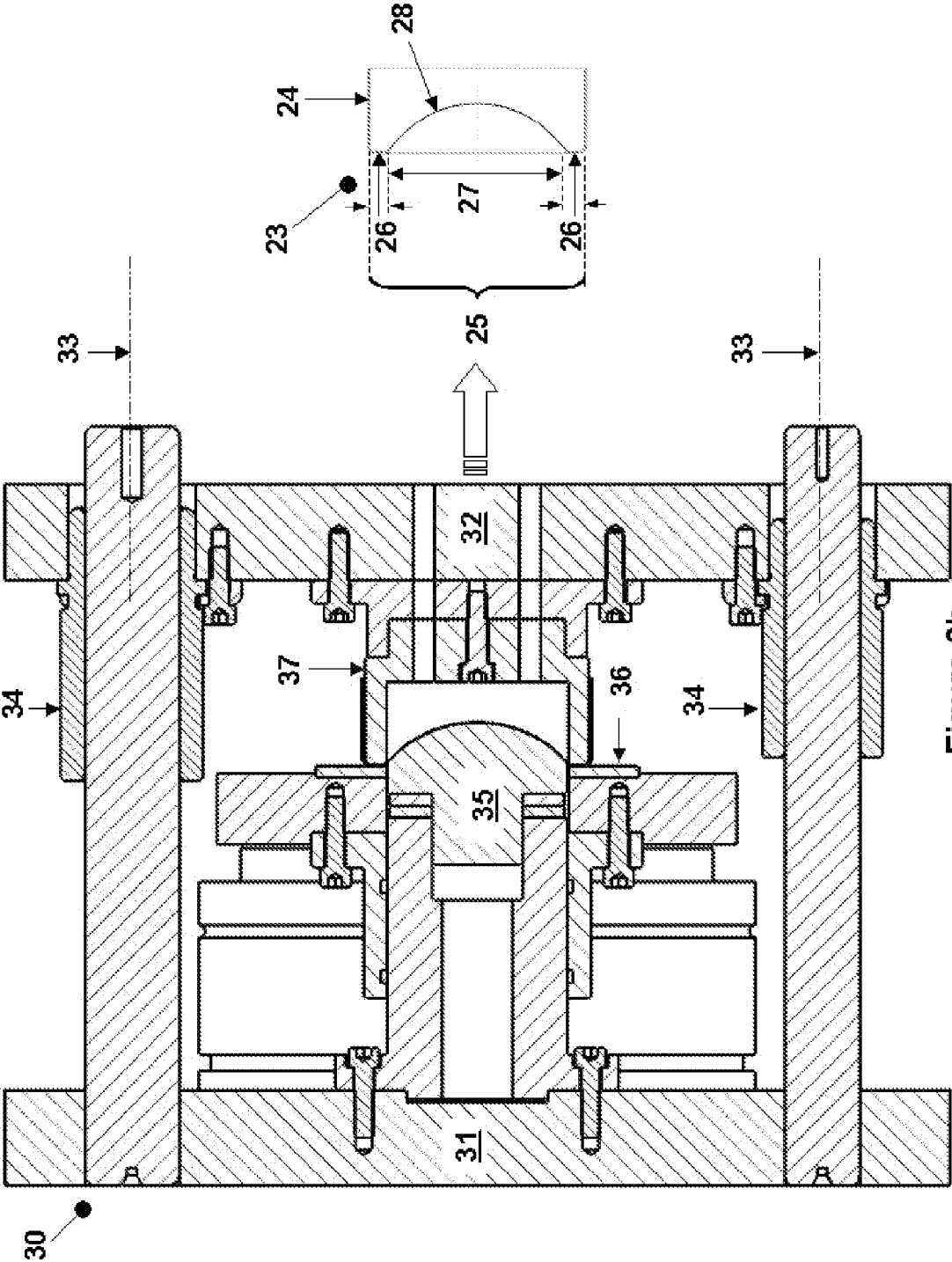


Figure 6b

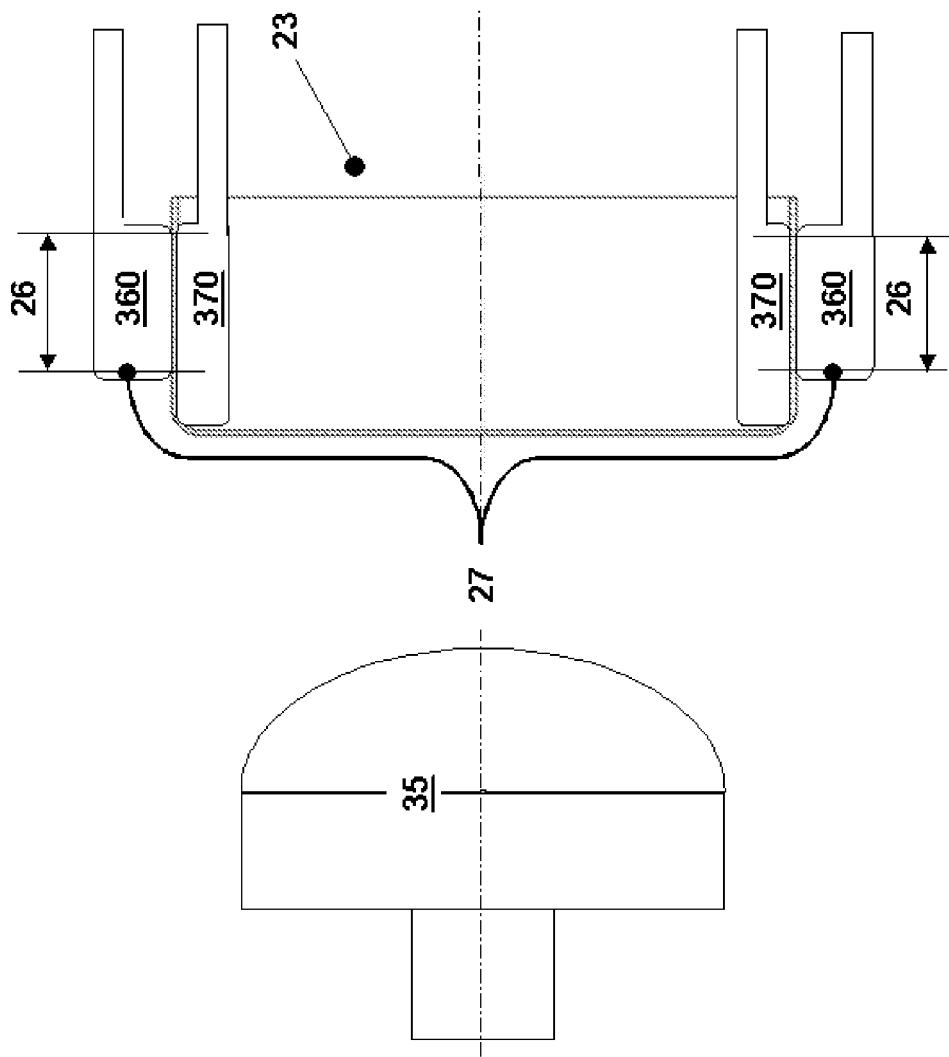


Figure 7

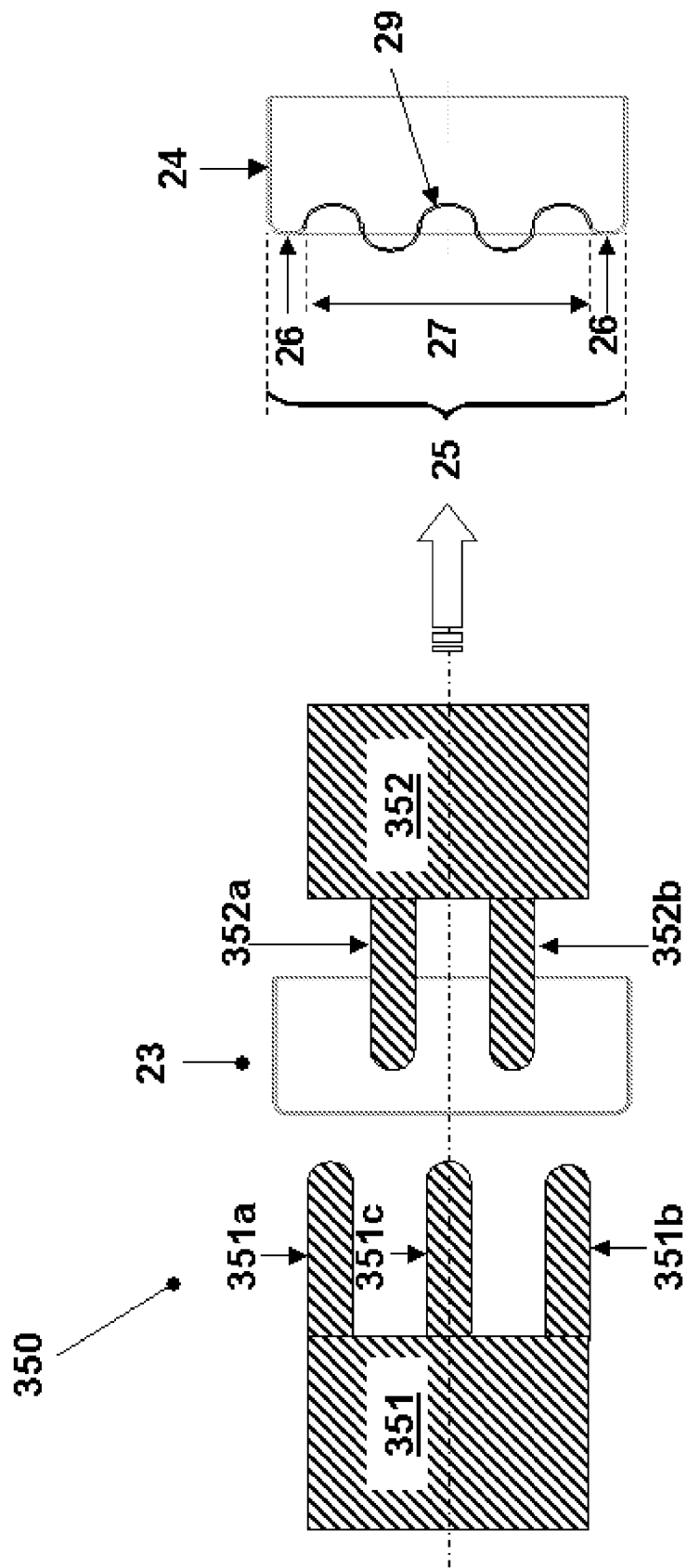


Figure 8

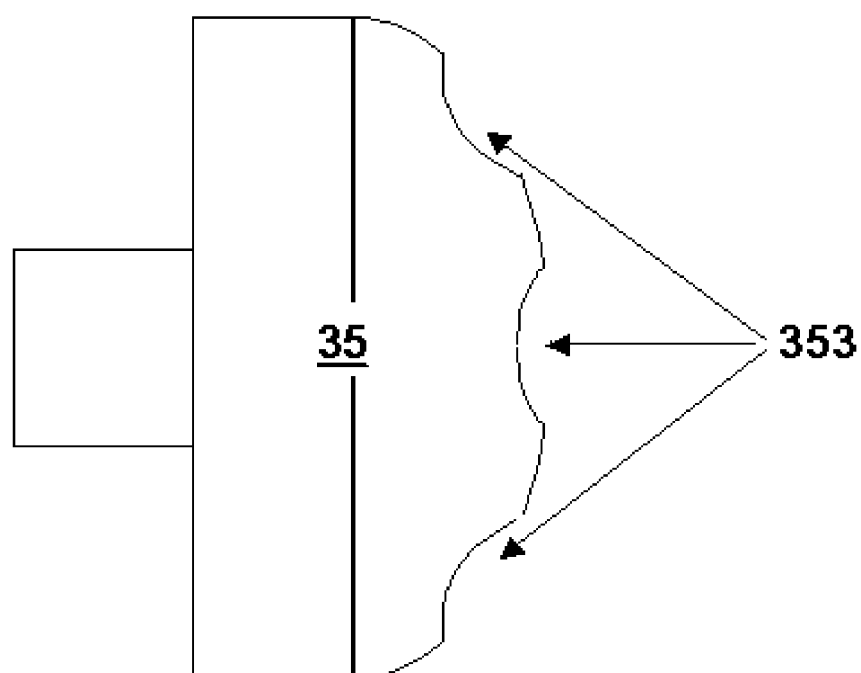


Figure 9

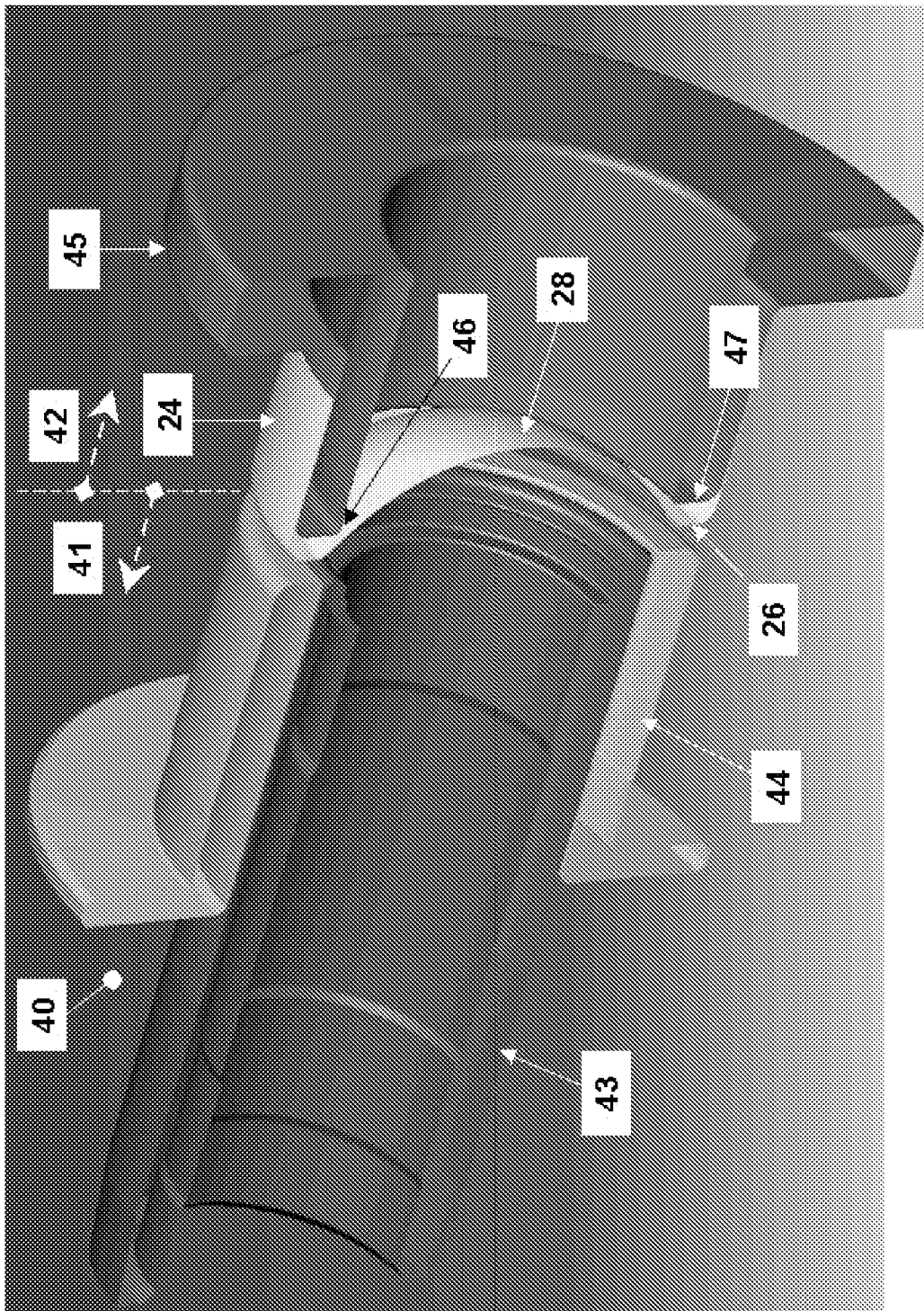


Figure 10a

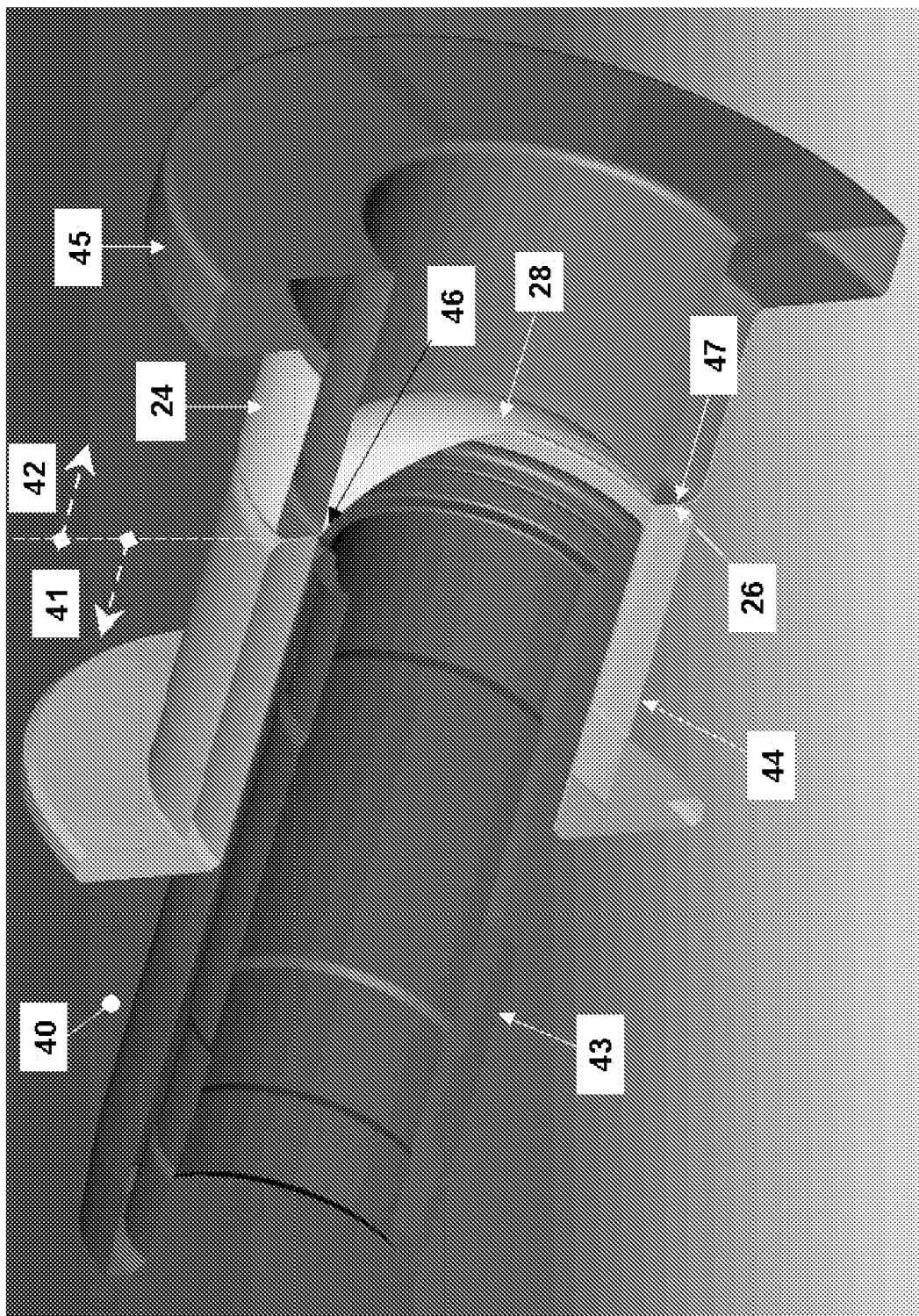


Figure 10b

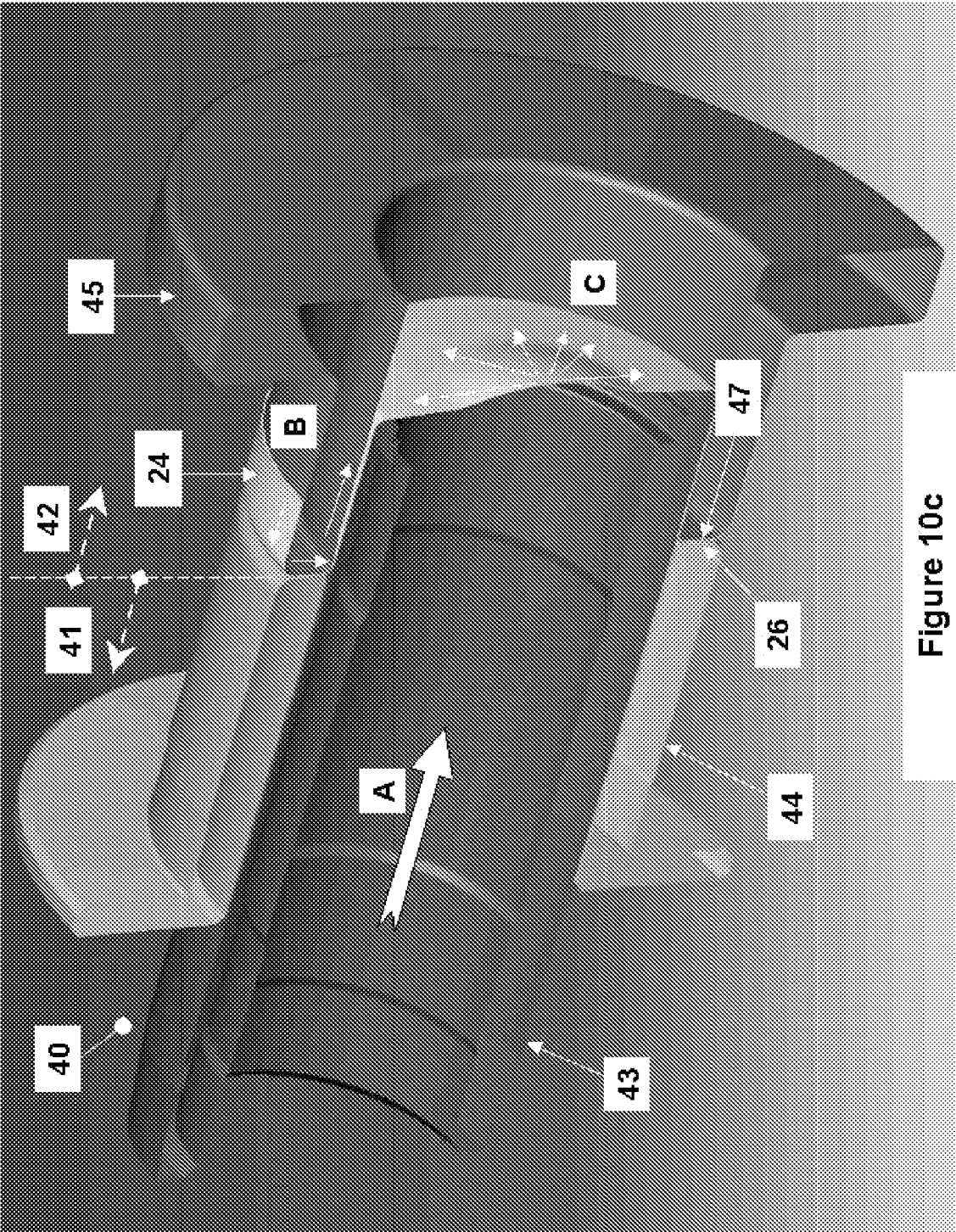


Figure 10c

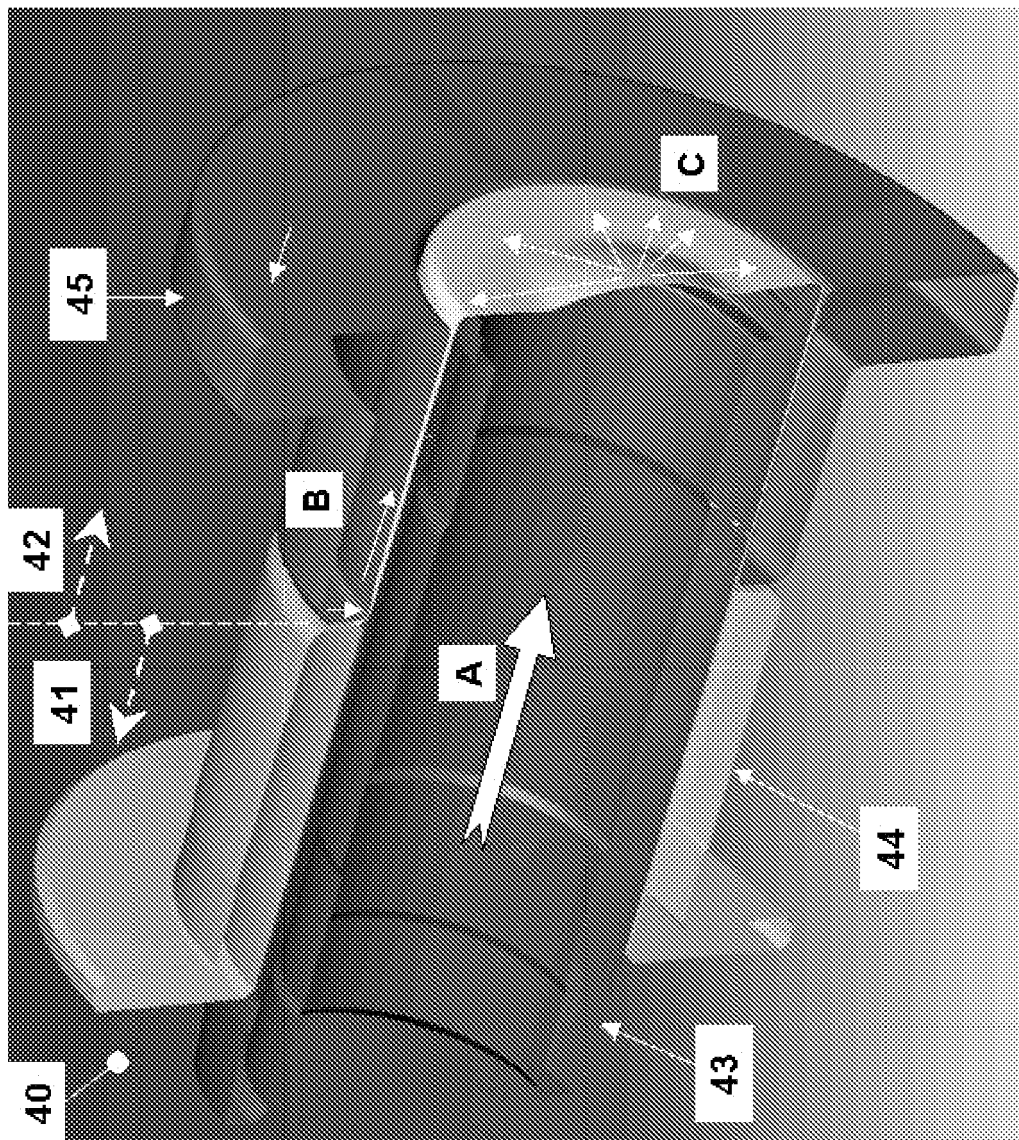


Figure 10d

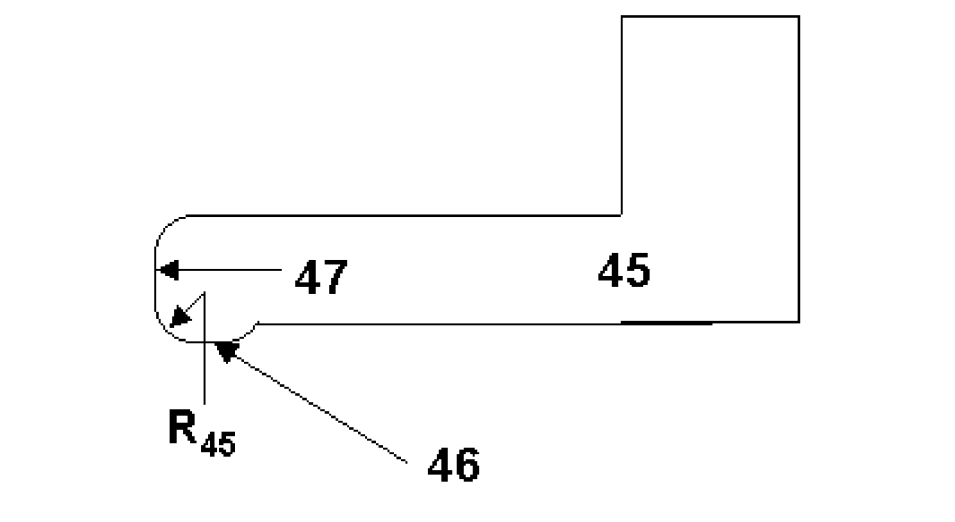


Figure 11

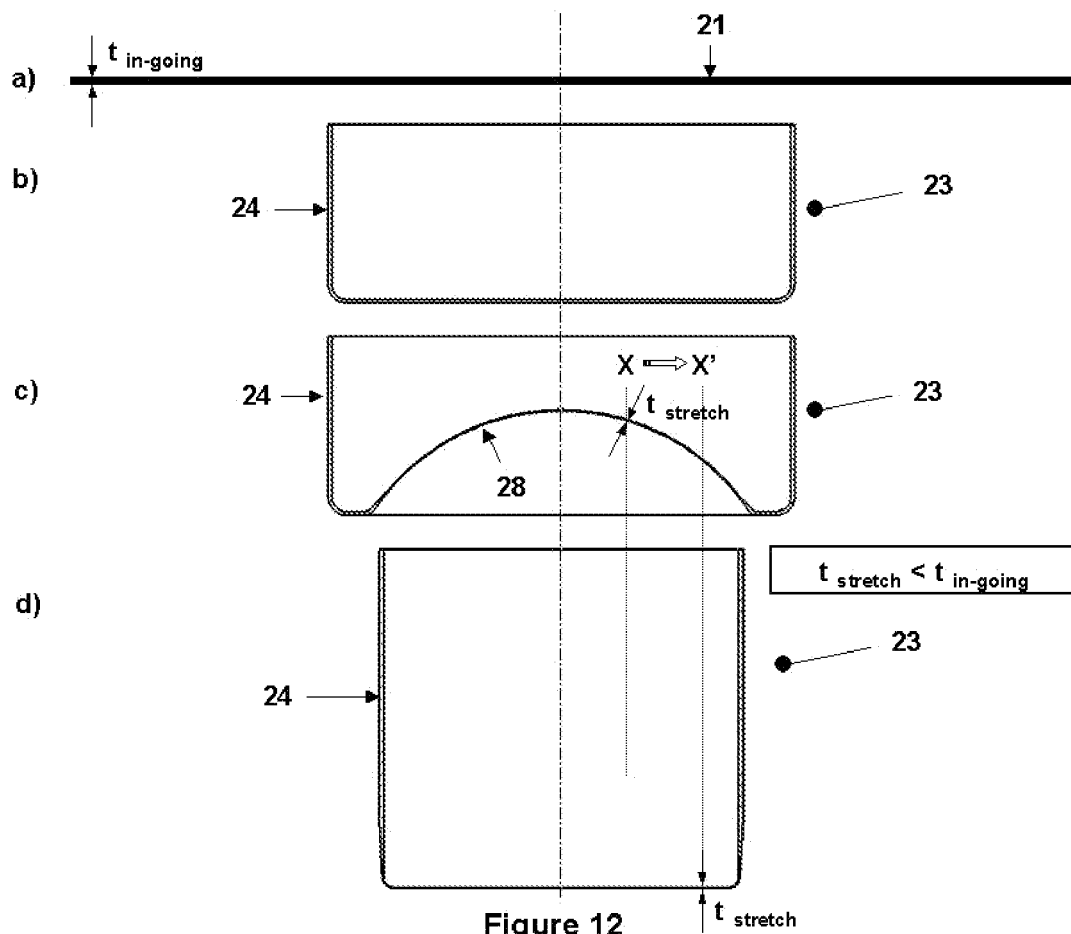


Figure 12

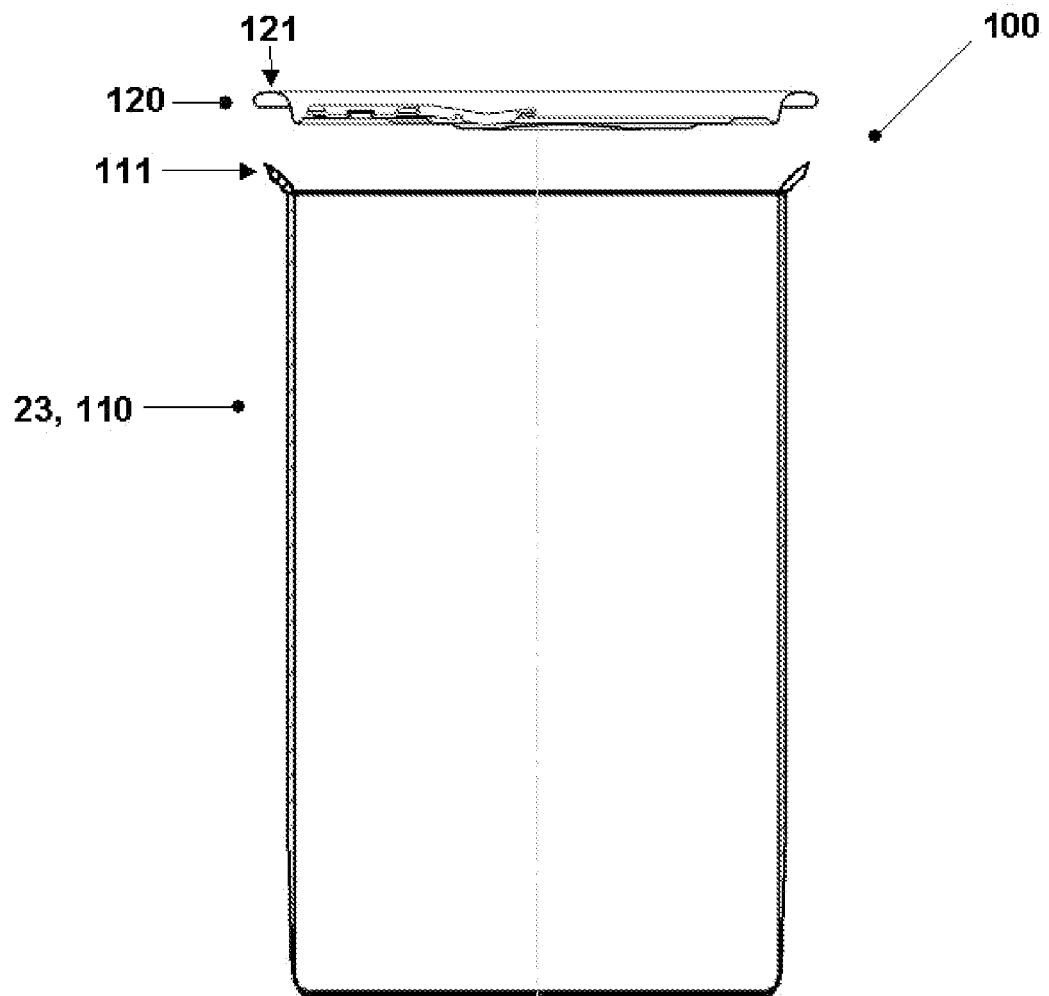


Figure 13



EUROPEAN SEARCH REPORT

Application Number
EP 10 15 2593

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 02/45882 A1 (CORUS UK LTD [GB]; BOWEN DAVID NEIL [GB]) 13 June 2002 (2002-06-13) * the whole document *	1,9,19	INV. B21D22/24 B21D22/28
A	US 2 602 411 A (SCHNELL MICHAEL S) 8 July 1952 (1952-07-08) * column 2, line 48 - column 3, line 52; figure *	1,9,19	
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			TECHNICAL FIELDS SEARCHED (IPC)
			B21D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 June 2010	Examiner Pieracci, Andrea
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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21-06-2010

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