Feb. 1, 1966 R. D. LURIE 3,231,937

DIE CENTER PAD

Filed Dec. 17, 1963 2 Sheets-Sheet 1

FIG. 2

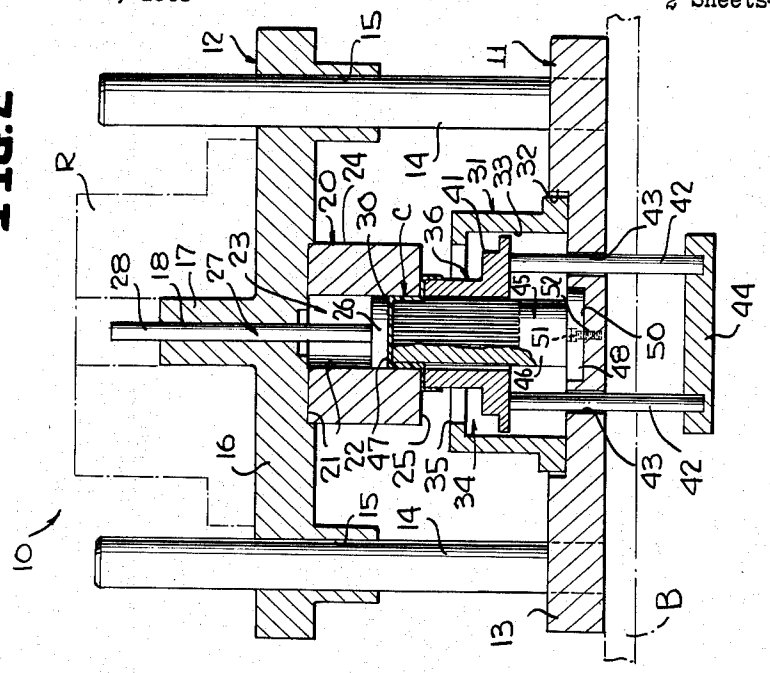
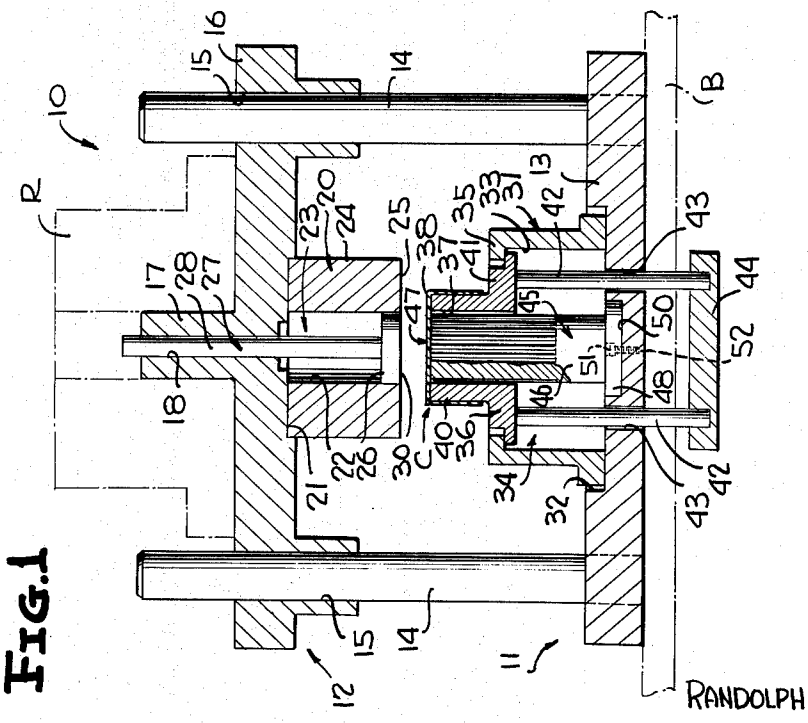


FIG. 1



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Feb. 1, 1966 R. D. LURIE 3,231,937

DIE CENTER PAD

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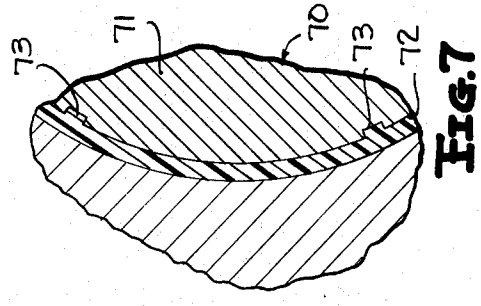


FIG. 7

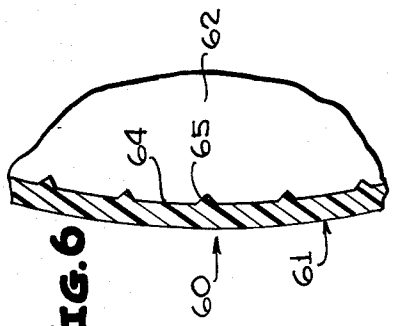


FIG. 6

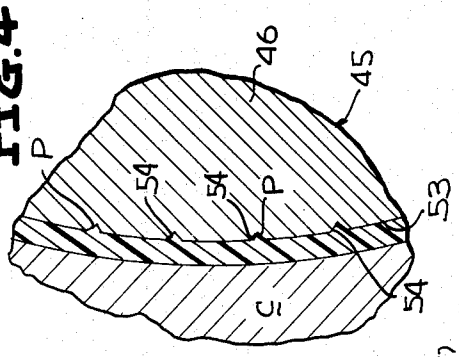


FIG. 4

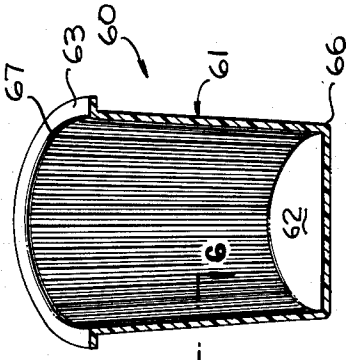


FIG. 5

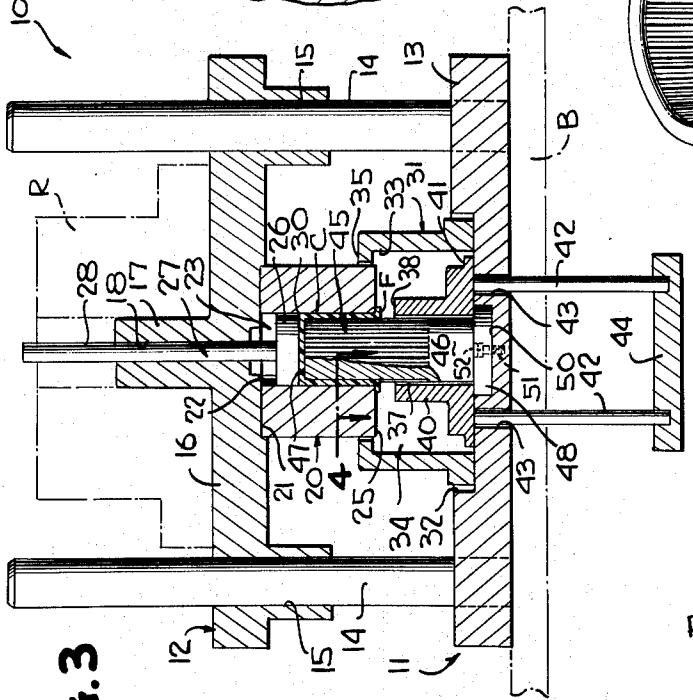


FIG. 3

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3,231,937

DIE CENTER PAD

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Filed Dec. 17, 1963, Ser. No. 331,249
6 Claims. (Cl. 18—19)

This invention relates to a novel die assembly for forming plastic containers, and in particular, to a novel die center pad which substantially eliminates the "necking" or thinning of the plastic material adjacent the bottom walls of plastic containers heretofore commonly formed by conventional die assemblies and redrawing methods.

Independent of the final shape or contour of a redrawn plastic container or body, a conventional deep-drawing process, which includes a redrawing operation, might generally consist of three basic operations.

The first operation forms the combined function of cutting a blank from suitable plastic material, such as polyethylene, to proper size and drawing this blank into a relatively shallow container body. During this first operation a flat sheet of material is placed between upper and lower portions of a conventional die assembly and the plastic material is clamped between a draw punch and a draw ring of the die assembly. Simultaneously with this clamping action, the plastic material is trimmed into a blank by the cutting action of the draw punch which forces the plastic material past a shear fitting closely around the outside of the draw punch, thus causing the plastic material to be cut cleanly and uniformly.

The portion of the blank which forms the container wall is drawn from the material which is clamped between the draw punch and the draw ring. The downward progress of the draw punch and the draw ring causes this material to be drawn into a narrow space between the draw punch and a conventional die center pad of the die assembly. At the completion of this first operation, the container body is withdrawn from the die assembly for subsequent operations. At this time, the container body comprises a generally shallow container wall joined by a radius portion to a bottom wall, and may also include an upper radially outwardly directed flange formed from the material clamped between the draw punch and the draw ring.

The second operation performs the function of converting the shallow drawn container body into a container body of greater depth and smaller diameter. The second operation redraws, to a greater depth, the container body which has been formed by the first operation.

In this second operation, the drawn container is placed in another conventional die assembly in a manner such that the body or wall of the container passes down over the outside surface of a draw ring and the inside surface of the container bottom wall rests against the end surfaces of a draw ring and a die center pad of the die assembly.

As the second operation begins, a central area of the container bottom wall is clamped between a conventional knock-out pad and the end surface of the die center pad. Immediately following this clamping action, the draw punch contacts the remainder of the material which forms the outer area of the container bottom wall of the drawn container. This contact by the draw punch causes a clamping pressure to be exerted between the draw punch and the draw ring.

During the progress of the second or redrawing operation, the portion of the material which is to form the wall or body of the redrawn container is drawn from the material clamped between the draw punch and the draw ring. This is accomplished by the operation of the

draw punch pushing the draw ring ahead of it in a conventional manner whereby the material is drawn from the ring of clamped material into the space between the draw punch and the die center pad, thus forming the wall or body of the redrawn container. As material is drawn from between the draw punch and the draw ring, new material is drawn from outside the draw ring into this clamped area to replace that material which has been removed. This process continues until all of the material outside of the draw ring has been drawn into the space between the draw punch and the draw ring.

At the completion of the redrawing or second operation, not all of the material is drawn into the space between the draw punch and the die center pad, and the material remaining between these latter elements forms a radially outwardly directed flange of the redrawn container.

The third operation generally consists of performing two functions. First, the flange of the redrawn container is shaped to the proper contour for receiving a closure, and secondly, the flange is trimmed to the exact dimensions required by such closure. This third operation forms no part of this invention and a further description thereof is considered unnecessary.

During each of the three operation heretofore described, the container tends to "neck down" or thin in a peripheral area of the container body adjacent the radium at the juncture of the container body or wall and the container bottom wall. This "necking" or thinning of the material adjacent a bottom wall of the container can occur during any one of the three aforementioned operations, but is most prevalent during the second or redrawing operation. As a result of the formation of this "neck" of thin material one of three things may happen to the redrawn container.

First, the material of the container may strain harden enough to cause a brittle break in the material. This may easily cause the bottom wall of the container body to be punched out during the redrawing operation.

Secondly, the "neck" of thinned material may propagate further along the container body or wall and/or the bottom wall of the container, thus rendering the container commercially useless.

Finally, the material of the container may strain harden in this "neck," but the tensile forces may be too weak to tear the material, thus forming a thin but relatively strong and highly oriented band around the container body.

This problem of thinning or "necking" may be solved in various ways as, for example, by increasing the number of redraws before the completion of the final container. However, it will be readily apparent that the increased number of redraws proportionally increases the cost of manufacturing such containers and this solution is relatively unsatisfactory from a commercial standpoint. This problem of thinning or "necking" may therefore be solved by providing a die which prevent excess elongation during the drawing or forming operation.

In accordance with this invention, it has been found that the elongation to yield (the additional length to which a ductile plastic material may be stretched before the onset of unstable viscous or plastic flow) of a tensile specimen, such as a plastic container during a drawing operation, goes through a minimum value at some relatively low value of strain rate i.e., the velocity at which a specimen is being strained divided by the original length of the specimen being strained. To produce a satisfactory draw, a die must provide a minimum value of elongation at relatively low strain rates, otherwise, should the desired elongation during a drawing or redrawing operation exceed the minimum value of elongation at such low

strain rates, the material suddenly yields and thins markedly to produce the "neck" heretofore described as the strain rate drops. It has been found in accordance with this invention that the provision of a plurality of closely spaced relieved areas in the form of elongated, parallel shallow grooves in the periphery of a die center pad of a die assembly prevents such undesired elongation during a drawing or a redrawing operation and prevents the above-noted conventional thinning or "necking" of container bodies during conventional drawing methods performed by conventional die apparatuses.

Therefore, in keeping with this invention, it is an object to provide a novel die center pad having a body provided with a plurality of closely spaced, elongated, relieved areas in the periphery of the body whereby the required elongation of a plastic container during a drawing or redrawing operation will not exceed the minimum value of elongation required to produce a satisfactory draw or redraw of the container, thus preventing the sudden yielding and marked thinning of material adjacent the juncture of conventionally drawn container bodies and the bottom walls thereof.

A further object of this invention is to provide a novel die center pad particularly adapted for redrawing plastic articles comprising an elongated body, the body including a peripheral surface, and the peripheral surface including a plurality of closely spaced elongated relieved areas extending substantially the length of the body whereby a plastic article drawn between the body and a draw punch axially aligned therewith is provided with a plurality of closely spaced elongated raised areas extending substantially the length of the article and prevents appreciable thinning and tearing thereof during a drawing operation.

Still another object of this invention is to provide a novel die center pad for redrawing plastic articles comprising an elongated cylindrical body, the body including an exterior circumferential surface, a plurality of relieved areas formed in the surface, and the number of relieved areas ranging between approximately five to one-hundred ten areas for each inch of circumference of the body.

A further object of this invention is to provide a novel die center pad of the type immediately above-described in which the relieved areas are extremely shallow and are parallel to each other and to the axis of the body.

A further object of this invention is to provide a novel method of producing a plastic container including the steps of forming a cylindrical container body terminating in a bottom wall and an upper elongated edge portion, and draw-forming between five to one hundred ten closely spaced narrow parallel elongated raised areas in each inch of circumference of the container body.

With the above and other objects in view that will hereinafter appear, the nature of the invention will be more clearly understood by reference to the following detailed description, the appended claims and the several views illustrated in the accompanying drawings.

In the drawings:

FIGURE 1 is a schematic sectional view of a die assembly including the novel die center pad of this invention and illustrates the position of a drawn container and various components of the die assembly prior to the initiation of a redrawing operation.

FIGURE 2 is a schematic sectional view of the die assembly of FIGURE 1, and illustrates an intermediate stage of the redrawing operation.

FIGURE 3 is a schematic sectional view of the die assembly of FIGURES 1 and 2, and illustrates the completion of the redrawing operation and the completed redrawn container.

FIGURE 4 is a highly enlarged fragmentary sectional view taken along line 4—4 of FIGURE 3, and illustrates a plurality of closely spaced parallel relieved areas in a peripheral surface of the die center pad and a plurality of closely spaced parallel raised areas in an internal surface of the container.

FIGURE 5 is an axial sectional view through a container redrawn in the die assembly of FIGURES 1 through 3 and illustrates the generally uniform wall thickness of the container and the numerous raised areas formed in the internal surface thereof.

FIGURE 6 is a highly enlarged fragmentary sectional view taken along line 6—6 of FIGURE 5, and more clearly illustrates the plurality of closely spaced elongated raised areas in the interior surface of the container.

FIGURE 7 is a highly enlarged fragmentary transverse sectional view taken through another die center pad of this invention on a line substantially identical to the line 4—4 of FIGURE 3, and illustrates a plurality of closely spaced parallel U-shaped relieved areas in a peripheral surface of the die center pad.

A die assembly including a novel die center pad constructed in accordance with this invention is best illustrated in FIGURES 1 through 3 of the drawings, and is generally designated by the reference numeral **10**.

The die assembly **10** comprises a lower die body **11** and an upper die body **12**. The lower and upper die bodies, **11** and **12** respectively, are arranged in axial alignment and are relatively reciprocally mounted in a conventional press in a manner well known in the prior art and forming no part of this novel invention.

The lower die body **11** is attached in a conventional manner to a bolster plate B which is in turn securely fastened to the conventional press (not shown) in a well known manner. The lower die body **11** is preferably attached to the bolster plate B by passing a plurality of bolts (not shown) through a plurality of openings (also not shown) in a base plate **13** of the lower die body **11**, and threadably engaging these bolts in associated threaded bores (not shown) in the bolster plate B.

A plurality of identical vertical guide pins **14** are secured to the base plate **13** of the lower die body **11**. The number of guide pins **14** may vary, but there are preferably four such guide pins **14** provided and each guide pin **14** is received in an identical vertical bore or opening **15** of an upper reciprocal plate **16** of the upper die body **12**. Each of the bores **15** may be provided with a conventional anti-friction bushing (not shown) to facilitate relative reciprocal sliding movement between the reciprocal plate **16** and each of the guide pins **14** during a redrawing operation of the die assembly **10**.

The upper reciprocal plate **16** of the upper die body **12** includes an upwardly directed axial stem **17** having an axial bore **18**. A conventional vertically reciprocal ram R of the press (not shown) surrounds the stem **17** in a manner clearly illustrated in FIGURES 1 through 3 of the drawings, and is secured to the upper reciprocal plate **16** of the upper die body **12** by a plurality of bolts (not shown) in much the same manner the base plate **13** of the lower die body **11** is secured to the bolster plate B.

A generally cylindrical tubular draw punch **20** is conventional secured in a downwardly opening circular recess **21** of the upper die body **12**. The draw punch **20** includes an inner circumferential wall **22** defining a guide bore or chamber **23**, an outer circumferential wall **24** and a lower annular end wall or face **25**.

A knock-out head **26** of a knock-out pad **27** is mounted for reciprocal movement in the guide bore **23** of the draw punch **20**. A stem **28** of the knock-out pad **27** is slidably received in the axial bore **18** of the stem **17** and projects outwardly thereof. The exposed upper end portion (unnumbered) of the stem **28** projecting outwardly from the bore **18** of the stem **17** is normally urged downwardly by a compression spring to the position illustrated in FIGURE 1 to normally maintain a circular end face or wall **30** of the knock-out head **26** flush with the annular face **25** of the draw punch **20**.

A generally cylindrical tubular retainer **31** is secured in a conventional manner in a circular recess **32** of the

base plate 13. The retainer 31 includes an inner circumferential wall 33 defining a guide bore or chamber 34. The inner circumferential wall 33 terminates at an inwardly directed peripheral flange 35 which forms a stop for limiting the upward reciprocal movement of a draw ring 36 reciprocally mounted in the chamber 34 of the retainer 31.

The draw ring 36 is in axial alignment with the draw punch 20 of the upper die body 12 and includes a vertical axial bore or opening 37 which is similarly in axial alignment with the guide bore 23 of the draw punch 20. An annular end face or wall 38 of the draw ring 36 opposes the annular end face 25 of the draw punch 20. An exterior or outer circumferential wall 40 of the draw ring 36 is contoured to mate with an internal surface or wall (unnumbered) of an inverted plastic container C is best illustrated in FIGURE 1 of the drawings. An annular flange 41 of the draw ring 36 normally abuts the under surface of the flange 35 of the retainer 31, thereby limiting the upward movement of the draw ring 36 with respect to the retainer 31 (FIGURE 1). A plurality of identical draw ring guide pins 42 are conventionally secured to and depend from the flange 41 of the draw ring 36. There are preferably four such draw ring guide pins 42, and each guide pin 42 passes through an identical vertical bore or opening 43 in the base plate 13 of the lower die body 11. Each of the draw ring guide pins 42 is secured to a conventional air cushion pressure pad 44. The air cushion pressure pad 44 is normally urged upwardly to the position illustrated in FIGURE 1 by a conventional piston-cylinder combination which is mounted below the bolster plate B of the conventional press (not shown), and by means of the draw ring guide pins 42, exerts pressure in opposition to the pressure exerted by the ram R during the operation of the press in a manner to be described more fully hereafter.

A novel die center pad 45 of this invention is secured to the base plate 13 of the lower die body 11 in axial alignment with the guide bore 23 of the draw punch 20 carried by the upper die body 12. The die center pad 45 comprises a generally cylindrical elongated body 46 terminating at one end portion in a generally circular end face 47 and at an opposite end portion in a generally circular securing flange 48. The flange 48 is received in an upwardly directed circular recess 50 of the base plate 13. A plurality of identical counterbored openings 51, only one of which is illustrated, are formed in the flange 48 of the die center pad 45 and an identical bolt 52 received in each of the counterbored openings 51 secures the die center pad 45 in the circular recess 50 of the base plate 13 in a manner clearly illustrated in FIGURES 1 through 3 of the drawings.

Referring specifically to FIGURE 4 of the drawings, the body 46 of the die center pad 45 includes a peripheral exterior surface 53 which is provided with a plurality of closely spaced relatively shallow relieved areas 54. The relieved areas 54 are identical parallel grooves or channels which extend substantially the entire length of the body 46 but terminate adjacent the flange 48 thereof, as is best illustrated in FIGURES 1 through 3 of the drawings. The length of each of the grooves 54 is at least as long as, and preferably longer than, the depth of the container C which is redrawn by the die assembly 10 in a manner to be described hereafter. Each of the grooves 54 is substantially V-shaped in transverse section (FIGURE 4) and the converging wall surfaces (unnumbered) defining each of the V-shaped grooves define an angle of approximately ninety degrees.

The depth of each of the grooves 54 is approximately 0.0005 inch and the number of such grooves varies in accordance with the diameter and circumference of the body 46 of the die center pad 45. There are preferably approximately between five to one hundred ten of such grooves 54 for each inch of circumference of the body 46. While this number of grooves per each inch of circumference is preferred, the maximum number of grooves is limited only by the maximum number of grooves which can be machined or formed in the peripheral surface 53 of the die center pad 45. The minimum number of grooves per inch of circumference of the die center pad 45 is similarly limited only by the minimum number of grooves necessary to achieve the objects of this invention, and five such grooves in each inch of circumference of the body 46 of the die center pad 45 have been found satisfactory.

A die center pad has been constructed in accordance with the die center pad 45 disclosed heretofore, and is an example of a die center pad which includes substantially the maximum number of grooves for each inch of circumference of the body of the die center pad. The working embodiment of the die center pad 45 includes a body having a length of approximately 5½ inches, a diameter of 1.8410 inches and a circumference of approximately 5.786 inches. The body of the die center pad was provided with 720 V-shaped grooves arranged in parallel relationship to each other and to the axis of the die center pad, and each of the grooves was approximately 4 inches in length. Adjacent grooves were spaced from each other a center-to-center distance of approximately .00803 inch or approximately one-half degree of arc between adjacent grooves or approximately 107.2 grooves per each inch of circumference of the body. The converging wall portions defining each of the grooves set off an angle of approximately ninety degrees and the depth of each groove was 0.0005 inch. The maximum width of the grooves was 0.01 inch.

The operation of the die center pad 45 in conjunction with the die assembly 10 will be best understood by first referring to FIGURE 1 of the drawings, to which attention is now directed. At the beginning of a cycle of the conventional press (not shown) the ram R thereof is reciprocated to a position above the position shown in FIGURE 1 to space the annular face 25 of the draw punch 20 a sufficient distance away from the annular face 38 of the draw ring 36 in order that the plastic container C can be positioned in the inverted position thereof as is clearly illustrated in this figure. The plastic container C has already been drawn in a die assembly similar to the die assembly 10 at which time the first operation heretofore described was performed to simultaneously cut a blank and draw this blank into the shallow container C.

The ram R is then reciprocated downwardly until the end face 30 of the knock-out pad 27 and the annular end face 25 of the draw punch 20 contacts the bottom wall (unnumbered) of the container C. Upon continued downward movement of the ram R a circular area of the bottom wall is clamped between the end face 30 of the knock-out head 26 and the end face 47 of the die center pad 45. Substantially simultaneously with this clamping action, the annular face 25 of the draw punch 20 exerts a clamping pressure against the remainder of the bottom wall of the container C by the force exerted between the annular end faces 25 and 38 of the respective draw punch 20 and the draw ring 36. The force exerted by the annular end face 38 of the draw ring 36 is that force transmitted to the draw ring 36 by the draw ring guide pins 42 from the conventional piston-cylinder "air cushion" combination urging the air cushion pressure pad 44 upwardly as viewed in FIGURE 1 in a conventional manner. At this point during the redrawing operation, there is no clamping action on the container wall or body (unnumbered) of the container C.

The further progress of the redrawing operation is illustrated in FIGURE 2. At this point of the redrawing operation, the central area of the bottom wall of the container C is still firmly clamped between the knock-out pad 27 and the end face 47 of the die center pad 45. This central area of the bottom wall of the container normally

takes no further part in the redrawing operation other than to give continuity to the container C.

The portion of the material which is to form the wall or body of the redrawn container is being drawn from the ring of material clamped between the opposed annular end faces **25** and **38** of the draw punch **20** and the draw ring **36** respectively. This ring of clamped material is continually changing throughout the progress of the redrawing operation. Initially, this ring of clamped material had consisted only of material which was part of the bottom wall of the original drawn container produced in the first operation. However, during the progress of the redrawing operation to the position illustrated in FIGURE 2 of the drawings, material is drawn from the ring of clamped material into the space between the die center pad **45** and the inner circumferential wall **22** of the draw punch **20** as the draw punch **20** is forced downwardly pushing the draw ring **36** downwardly against the pressure exerted by the "air cushion." The inner circumferential wall **22** of the draw punch **20** urges the material drawn from between the faces **25** and **38** into intimate engagement with the exterior peripheral surface **53** (FIGURE 4) of the die center pad **45**. As the material of the container C is urged against the body **46** of the die center pad **45**, the material at the inner surface of the container body or wall is urged or flowed into each of the plurality of closely spaced parallel relieved areas or grooves **54**, as is best illustrated in FIGURE 4 of the drawings. This forms a plurality of closely spaced parallel elongated raised portions or projections P on the inner surface of the container wall equal in number to the number of grooves **54** in the peripheral surface **53** of the die center pad **45**. The plurality of grooves **45** and the raised portions P formed thereby permit the required elongation of the container C during the redrawing operation, and prevents the elongation from exceeding a minimum value of elongation at which point the material of the container C would normally yield, thin and neck-down. The formation of the raised projections P continues until substantially all of the material outside of the draw ring **36** has been drawn into the space between the die center pad **45** and the inner circumferential wall **22** of the draw punch **20**, as shown in FIGURE 3 of the drawings.

In FIGURE 3, the redrawing operation is complete and the upper die body **12** of the die assembly **10** is ready to return to its upper (rest) position. It is this point at the extreme downward position of the ram R and the draw punch **20** which determines the depth of the finished container. At this point, it should be particularly noted that not all of the plastic material has been drawn into the space between the die center pad **45** and the internal circumferential wall **22** of the draw punch **20**, but rather, a flange F is left at the end of the container opposite the bottom wall thereof to which a closure or lid is adapted to be attached in a manner forming no part of this invention.

A container at the completion of the redrawing operation heretofore described is best illustrated in FIGURES 5 and 6 of the drawings and is generally designated by the reference numeral **60**. The redrawn container **60** comprises a body or wall **61** which tapers slightly upwardly from a bottom wall **62** and terminates in an radially outwardly directed flange **63**. An inner surface **64** (FIGURE 6) of the wall **61** is provided with a plurality of identical elongated closely spaced raised areas or projections **65**. The raised projections **65** are mirror images of the plurality of relieved areas **54** (FIGURE 4) in the die center pad **45**. However, the length of the raised projections **65** are slightly less than the length of the elongated grooves **54** because the grooves **54** are longer than the depth of the container at the completion of the redrawing operation, as is best illustrated in FIGURE 3 of the drawings. Each of the raised projections **65** thus extend from a radius portion **66** joining the bottom wall **62** to the wall **61** and terminate at a radius portion **67** joining the wall **61** to the radially outwardly directed flange **63**. The number of the raised projections **65** formed in the container **60** may vary, but again, there are preferably between five to one hundred ten such raised projections in each inch of circumference of the container **60**.

The working embodiment of the die center pad **45** was tested by redrawing drawn polycarbonate containers in the manner heretofore described. The drawn containers were originally drawn from sheet polycarbonate having a nominal 0.012 inch thickness and having opposite smooth surfaces. All attempts at redrawing this material in a die assembly including a conventional highly polished smooth surfaced die center pad resulted in unsatisfactory containers because the container wall and/or bottom always tore and/or thinner or neck-downed markedly. However, upon employing the grooved die center pad of this invention in the same die assembly and redrawing the same polycarbonate sheet, no difficulties were experienced in redrawing the containers, the containers showed no evidence of tearing, and no thinning or necking in either of the container walls or the container bottom was evident. Further rests were conducted by redrawing containers from an acrylonitrile-butadiene-styrene terpolymer. The material was a nominal 0.013 inch thick sheet which was smooth on both surfaces. All attempts at redrawing this material in a conventional highly polished, smooth surfaced die resulted in the production of unsatisfactory containers because the container bottoms always tore out. However, upon substituting the working embodiment of the die center pad of this invention into the same die assembly, no difficulty was experienced in redrawing containers from this material. These containers showed no evidence of tearing and/or thinning or necking in either the container wall or the container bottom wall.

Referring to FIGURE 7 of the drawings, another die center pad **70** constructed in accordance with this invention comprises a generally cylindrical body **71** having an exterior peripheral wall or surface **72**. The die center pad **70** is substantially identical to the die center pad **45** of FIGURE 4 and includes a circular securing flange (not shown) substantially identical to the flange **48** of the die center pad **45**. The exterior peripheral surface **72** of the body **71** is provided with a plurality of closely spaced parallel relieved areas or grooves **73**. Each of the grooves **73** is substantially U-shaped in transverse section and opens outwardly of the exterior peripheral surface **72** of the body **70**. The depth of each groove is approximately 0.0005 inch and there is preferably one such groove for each ten degrees of arc of the body **71**, and the maximum width of each of the U-shaped grooves is approximately 0.010 inch.

A working embodiment of the die center pad **70** of FIGURE 7 was constructed and tested. This die center pad comprised a body approximately 5½ inches in length and the length of each of the grooves in the peripheral surface thereof was approximately 4 inches long. The diameter of the body of the die center pad was 2.041 inches with a circumference of approximately 6.408 inches. Thirty-six identical U-shaped grooves were formed in the exterior peripheral surface of the die center pad body and adjacent grooves were spaced a center-to-center distance of ten degrees of arc or approximately 5.62 grooves in each inch of circumference of the body. The depth of each groove was approximately 0.0005 inch and the width of each groove was 0.010 inch.

It will be apparent from the foregoing, that there has been provided various forms of a novel die center pad wherein a plurality of closely spaced relieved areas or grooves formed in an exterior surface of the die

center pad prevents the formation of a "neck" of thin material in a container wall just slightly removed from the radius portion which joints the container wall to the bottom wall thereof during a redrawing operation. While this problem of thinning or "necking" has been solved by a provision of a plurality of relatively elongated, straight and parallel relieved areas or grooves, other grooved configurations are considered within the scope of this invention. For example, serpentine or spiral-like grooves might also be formed in the exterior surface of a die center pad, and such die center pads are considered to be within the scope of this invention.

Thus, while preferred forms and arrangements of the plurality of closely spaced grooves in the die center pads have been shown to illustrate this invention, it is to be understood that various changes in details and arrangements may be made without departing from the spirit and scope of the invention as defined in the appended claimed subject matter.

I claim:

1. In apparatus for cold drawing plastic sheet material into articles having smooth exterior surfaces and interior surfaces which include minute raised areas, including a male die center pad having an elongated body, a female die having a cavity for telescopically receiving the die center pad body during a drawing operation, means for normally positioning the plastic sheet material between the die center pad and the female die prior to relative movement therebetween, and means for moving said die center pad and female die relative to each other whereby the plastic sheet material is at least partially drawn from the normal position thereof to a position at least partially surrounding the die center pad body between an exterior surface of said body and the cavity of said female die, the improvement comprising a surface defining said cavity contoured to the general cross-sectional configuration of said body, said cavity surface being smooth and unbroken whereby the exterior surface of a drawn article is similarly smooth and unbroken, a plurality of elongated grooves formed in the exterior surface of said body and each of said grooves ranging in depth upwardly from about .0005 inch to a depth sufficient to prevent necking-down but insufficient to materially disfigure the drawn article whereby the interior surface of the article is provided with minute raised areas corresponding in shape and configuration to the die body grooves.

2. In apparatus for cold drawing plastic sheet material into articles having smooth exterior surfaces and interior surfaces which include minute raised areas including a male die center pad having an elongated body, a female die having a cavity for telescopically receiving the die center pad body during a drawing operation, means for normally positioning the plastic sheet material between the die center pad and the female die prior to relative movement therebetween, and means for moving said die center pad and female die relative to each other whereby the plastic sheet material is at least partially drawn from the normal position thereof to a position at least partially surrounding the die center pad body between an exterior surface of said body and the cavity of said female die, the improvement comprising a surface defining said cavity contoured to the general cross-sectional configuration of said body, said cavity surface being smooth and unbroken whereby the exterior surface of a drawn article is similarly smooth and unbroken, a plurality of elongated grooves formed in the exterior surface of said body, each of said grooves ranging in depth upwardly from about .0005 inch to a depth sufficient to prevent necking down of the article but insufficient to materially disfigure the article whereby the interior surface of the article is provided with minute raised areas corresponding in shape and configuration to the die center pad grooves and each of said grooves opens outwardly of the exterior surface of said body in a substantially V-shaped configuration.

3. In apparatus for cold drawing plastic sheet material into articles having smooth exterior surfaces and interior surfaces which include minute raised areas including a male die center pad having an elongated body, a female die having a cavity for telescopically receiving the die center pad body during a drawing operation, means for normally positioning the plastic sheet material between the die center pad and the female die prior to relative movement therebetween, and means for moving said die center pad and female die relative to each other whereby the plastic sheet material is at least partially drawn from the normal position thereof to a position at least partially surrounding the die center pad body between an exterior surface of said body and the cavity of said female die, the improvement comprising a surface defining said cavity contoured to the general cross-sectional configuration of said body, said cavity surface being smooth and unbroken whereby the exterior surface of a drawn article is similarly smooth and unbroken, a plurality of elongated grooves formed in the exterior surface of said body, each of said grooves ranging in depth upwardly from about .0005 inch to a depth sufficient to prevent necking down of the article, and the number of said grooves ranging between substantially five to one hundred ten grooves for each peripheral inch of said body.

4. In apparatus for cold drawing plastic sheet material into articles having smooth exterior surfaces and interior surfaces which include minute raised areas including a male die center pad having an elongated body, said body being generally cylindrical in configuration, a female die having a cavity for telescopically receiving the die center pad body during a drawing operation, means for positioning the plastic sheet material between the die center pad and the female die prior to relative movement therebetween, and means for moving said die center pad and female die relative to each other whereby the plastic sheet material is at least partially drawn from the normal position thereof to a position at least partially surrounding the die center pad body between an exterior surface of said body and the cavity of said female die, the improvement comprising a surface defining said cavity contoured to the general cross-sectional configuration of said body, said cavity surface being smooth and unbroken whereby the exterior surface of a drawn article is similarly smooth and unbroken, a plurality of elongated grooves formed in the exterior surfaces of said body, each of said grooves ranging in depth upwardly from about .0005 inch to a depth sufficient to prevent necking down of a drawn article but insufficient to materially disfigure the article whereby the interior surface of the drawn article is provided with minute raised areas corresponding in shape and configuration to the die body grooves, and each of said grooves is parallel to the longitudinal axis of said elongated body.

5. In apparatus for cold drawing plastic sheet material into articles having smooth exterior surfaces and interior surfaces which include minute raised areas including a male die center pad having an elongated body, said body being generally cylindrical in configuration, a female die having a cavity for telescopically receiving the die center pad body during a drawing operation, means for positioning the plastic sheet material between the die center pad and the female die prior to relative movement therebetween, and means for moving said die center pad and female die relative to each other whereby the plastic sheet material is at least partially drawn from the normal position thereof to a position at least partially surrounding the die center pad body between an exterior surface of said body and the cavity of said female die, the improvement comprising a surface defining said cavity contoured to the general cross-sectional configuration of said body, said cavity surface being smooth and unbroken whereby the exterior surface of a drawn article is similarly smooth and unbroken, a plurality of elongated grooves formed in

the exterior surfaces of said body, each of said grooves ranging in depth upwardly from about .0005 inch to a depth sufficient to prevent necking down of a drawn article but insufficient to materially disfigure the article whereby the interior surface of the drawn article is provided with minute raised areas corresponding in shape and configuration to the die body grooves, each of said grooves is parallel to the longitudinal axis of said elongated body, and each of said grooves opens outwardly of the exterior surface of said body in a substantially V-shaped configuration.

6. In apparatus for cold drawing plastic sheet material into articles having smooth exterior surfaces and interior surfaces which include minute raised areas including a male die center pad having an elongated body, said body being generally cylindrical in configuration, a female die having a cavity for telescopically receiving the die center pad body during a drawing operation, means for positioning the plastic sheet material between the die center pad and the female die prior to relative movement therebetween, and means for moving said die center pad and female die relative to each other whereby the plastic sheet material is at least partially drawn from the normal position thereof to a position at least partially surrounding the die center pad body between an exterior surface of said body and the cavity of said female die, the improvement comprising a surface defining said cavity contoured to the general cross-sectional configuration of said body, said cavity surface being smooth and unbroken whereby the exterior surface of a drawn article is similarly smooth and unbroken, a plurality of elongated grooves formed in the exterior surfaces of said body, each of said

grooves ranging in depth upwardly from about .0005 inch to a depth sufficient to prevent necking down of a drawn article but insufficiently to materially disfigure the article whereby the interior surface of the drawn article is provided with minute raised areas corresponding in shape and configuration to the die body grooves, each of said grooves is parallel to the longitudinal axis of said elongated body, each of said grooves opens outwardly of the exterior surface of said body in a substantially V-shaped configuration, and the number of said grooves ranging between five to one hundred ten grooves for each inch of circumference of said body.

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