Oct. 15, 1968 B. L. HOFFMAN ET AL 3,405,546

METHOD AND APPARATUS FOR PRODUCING BULGED SHAPES

Filed Sept. 27, 1965 5 Sheets-Sheet 1

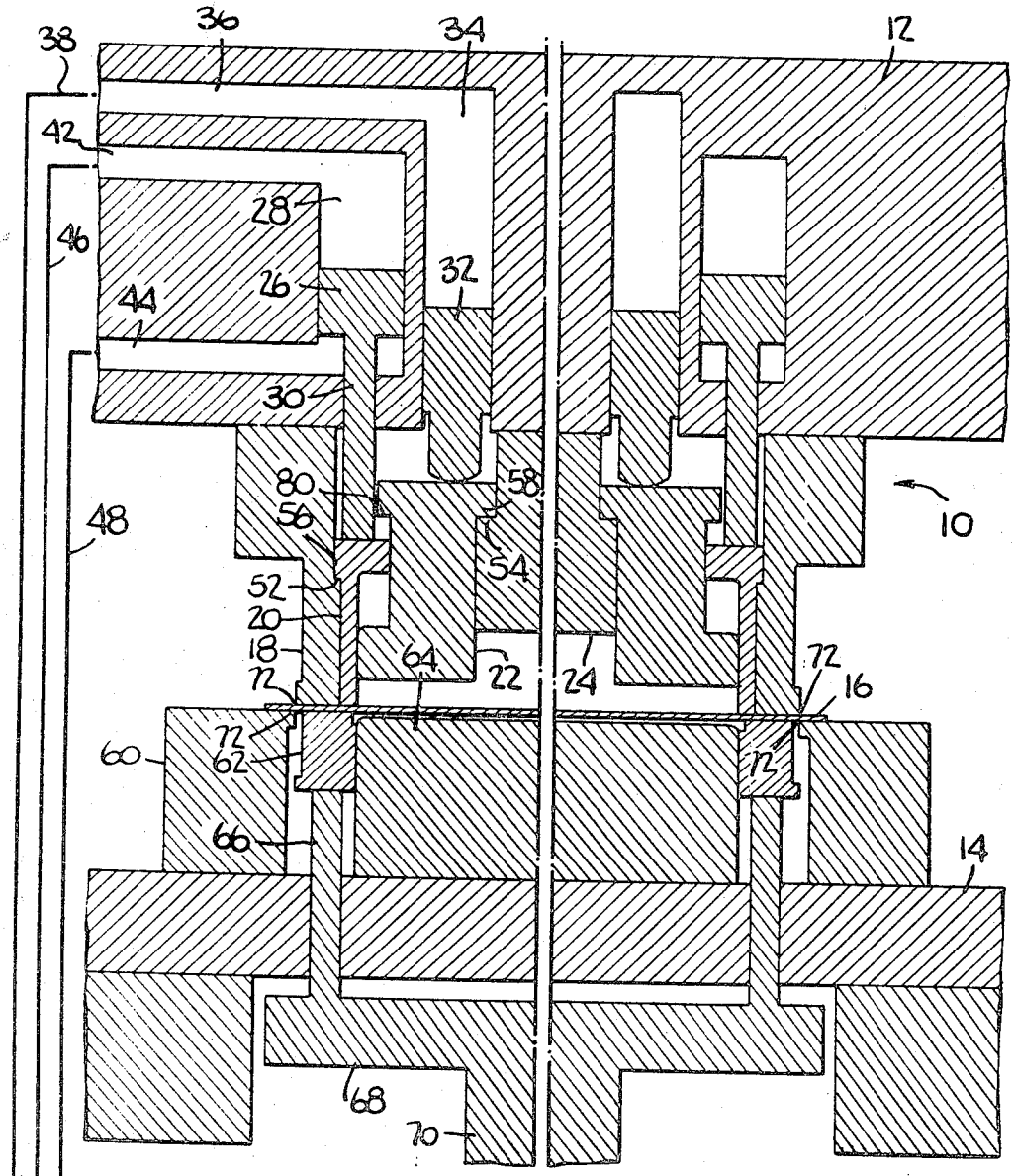
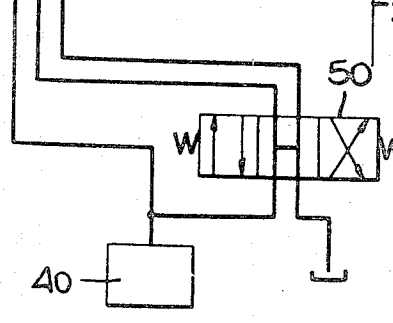


Fig. 1.



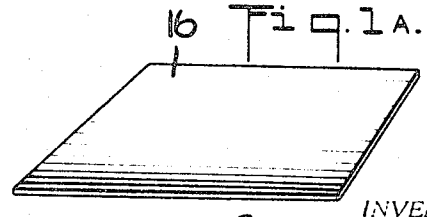


Fig. 1A.

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METHOD AND APPARATUS FOR PRODUCING BULGED SHAPES

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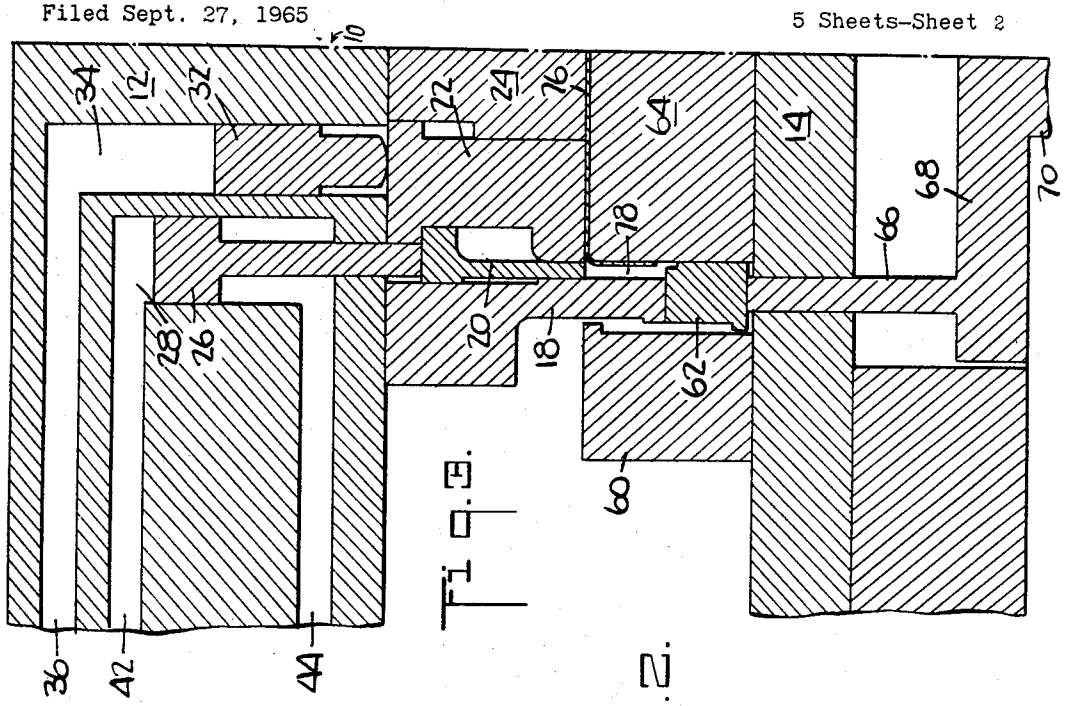


Fig. 2.

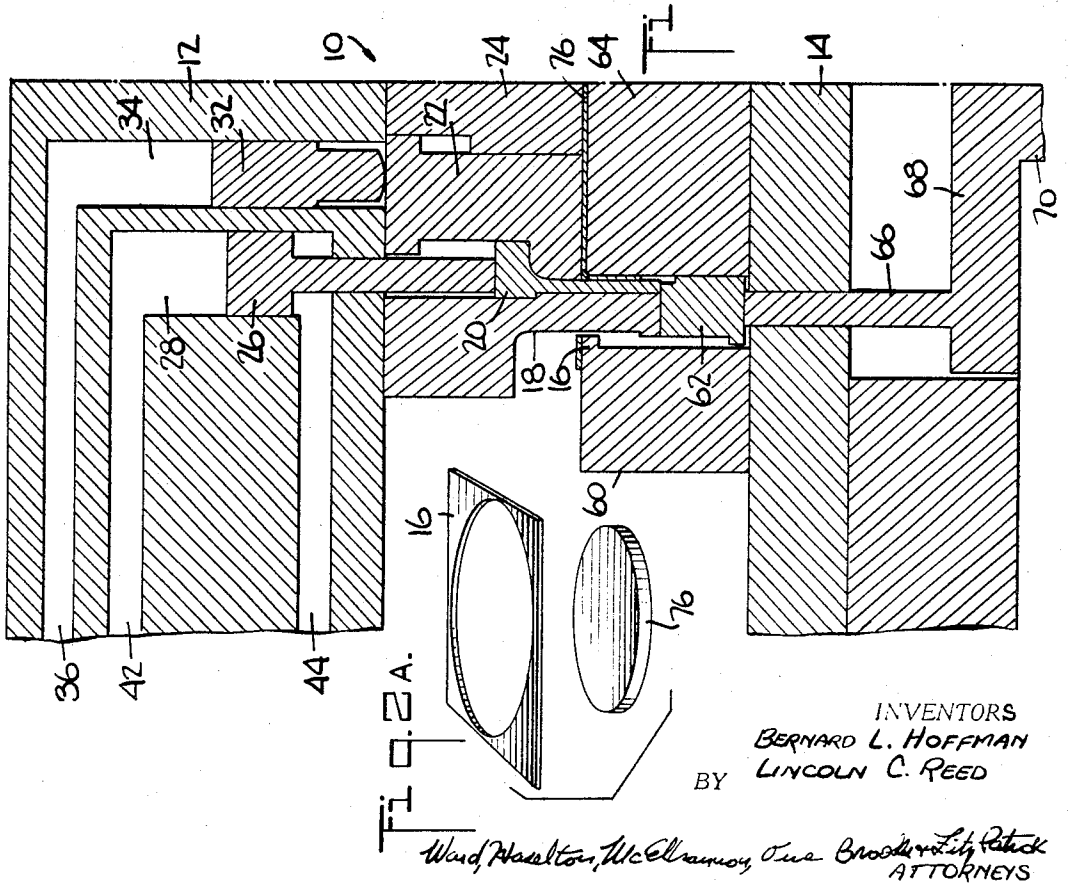


Fig. 2A.

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METHOD AND APPARATUS FOR PRODUCING BULGED SHAPES

Filed Sept. 27, 1965 5 Sheets-Sheet 3

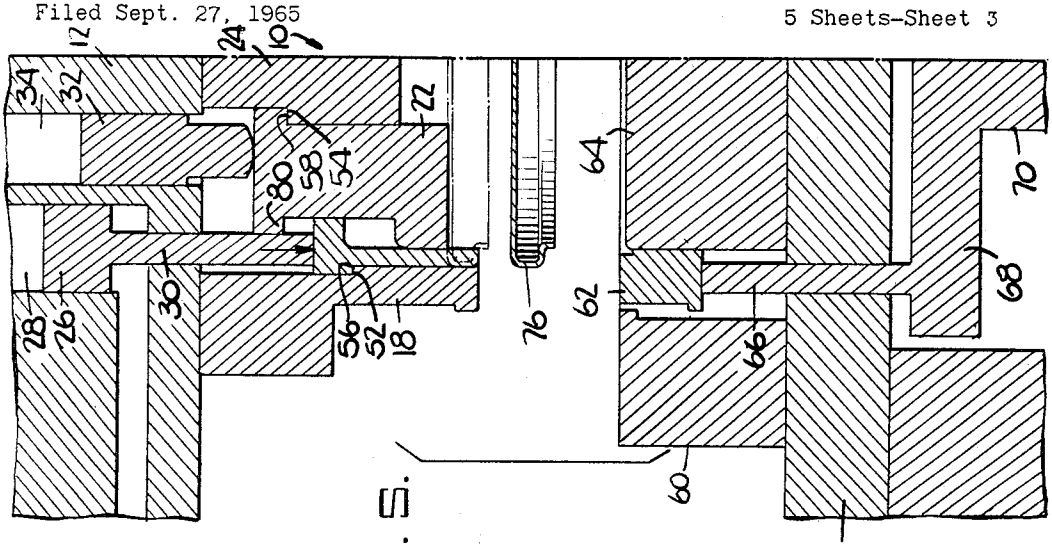
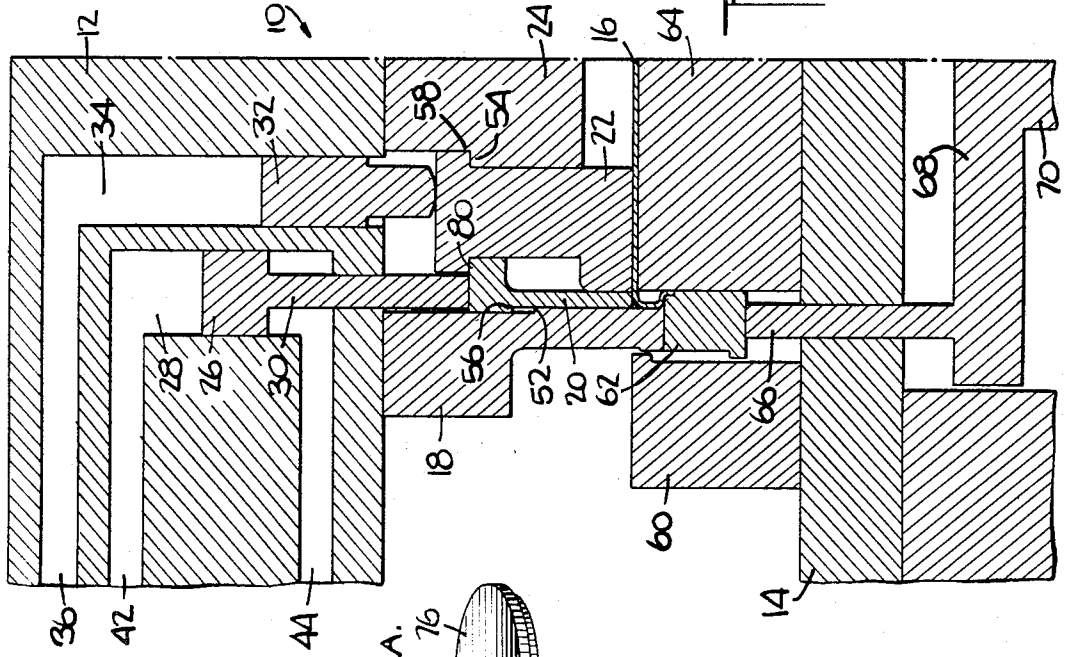


Fig. 5.

Fig. 4.



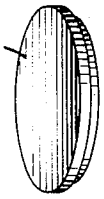


Fig. 4A.

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METHOD AND APPARATUS FOR PRODUCING BULGED SHAPES

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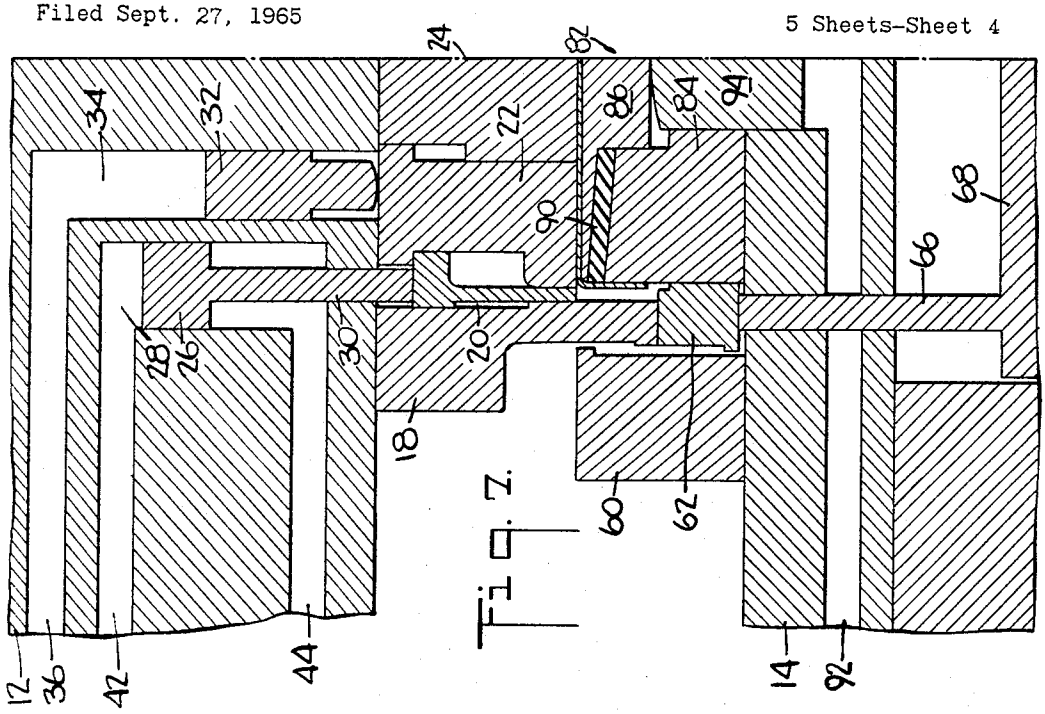


Fig. 7.

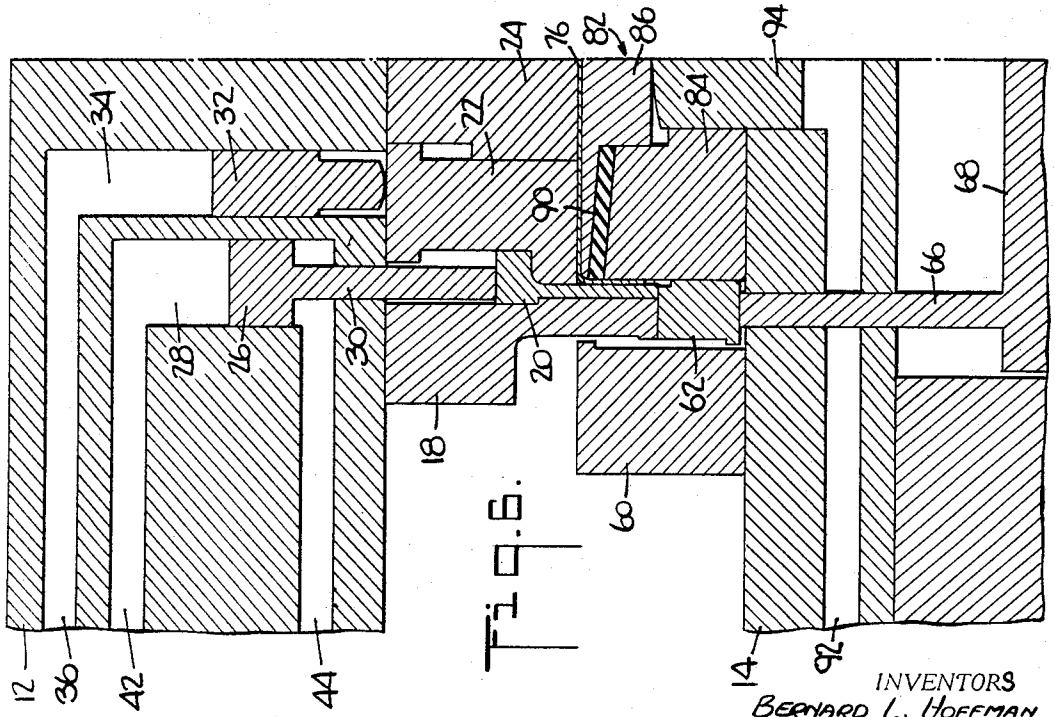


Fig. 6.

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METHOD AND APPARATUS FOR PRODUCING BULGED SHAPES

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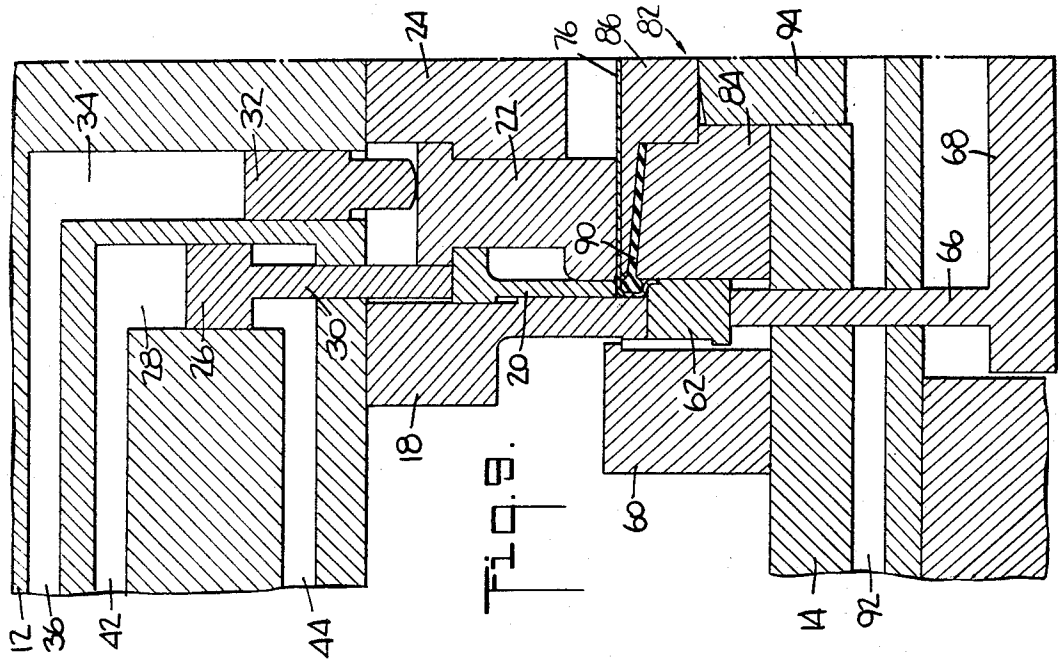


Fig. 8.

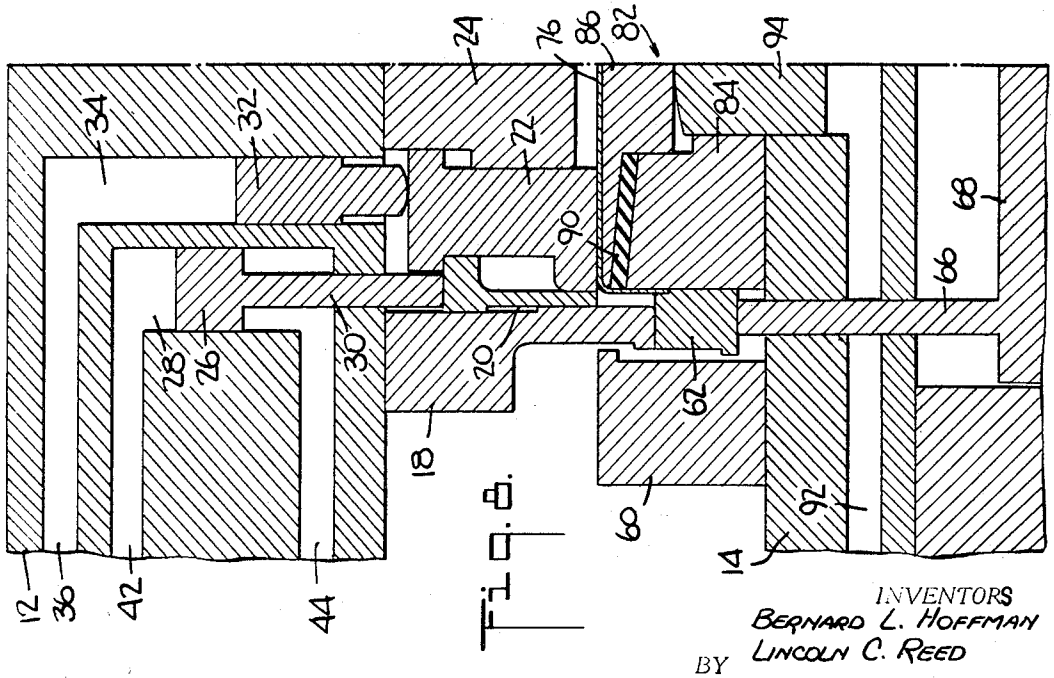


Fig. 8a.

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3,405,546

METHOD AND APPARATUS FOR PRODUCING BULGED SHAPES

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Filed Sept. 27, 1965, Ser. No. 490,222
9 Claims. (Cl. 72—348)

ABSTRACT OF THE DISCLOSURE

Press arrangements for producing bulged container shaped objects wherein a retractable forming ring first forms the container shaped object by passing over a central mandrel, and is then retracted to define an annular bulging region at a given location.

This invention relates to the forming of sheet metal and more particularly it concerns the production of bulged drawn objects.

Drawing and stamping of sheet metal to produce various shaped objects is well known. There are many advantages to such processes; and of late they have come into quite extensive use.

One drawback of known drawing and stamping techniques is that they do not lend themselves well to the production of bulged shapes. In the past, in order to form objects having a bulged configuration, the object had to be fully processed or at least finished by spinning as on a lathe type tool. Conventional stamping or drawing processes, while suitable for converting flat sheet metal into container shapes with straight (parallel) sides or outwardly flared sides, were incapable of converting flat metal workpieces into container shapes which had reverse tapers or which had internal cross sectional dimensions larger than the cross section of the mouth or top opening of the object being formed.

The reason why bulged shapes could not be produced in conventional stamping operations is that the mating die elements moved only along a single path (usually vertically) toward and away from each other. The formation of a bulged object, however, requires the movement of metal in two orthogonal directions i.e. vertically and laterally. Known dies which move only in a vertical direction cannot move metal laterally to form bulges; and even if they could, there would be a problem of extracting the expanded or laterally moved die out through the smaller opening at the mouth of the object after its formation.

The present invention makes possible the production of bulged shapes in drawn sheet metal objects in a single drawing operation. The present invention requires no specially complex die elements, nor does it require any intricate devices for obtaining lateral deformation of the metal.

According to the present invention, bulges are provided in sheet metal by providing the metal with complete lateral support on one side, and lateral support on the opposite side over all but the region of the bulge. The metal thus laterally supported is then subjected to compressive stresses in the plane of its extension. These stresses concentrate in the unsupported region where the bulge is to occur, with a consequent straining and bulging of the metal in this region.

As illustratively embodied, the present invention makes use of upper and lower die assemblies each having a plurality of extendible die elements. These die assemblies are first brought together so that their respective die elements form a sheet metal workpiece into a general container shape. This bringing together of the die elements

on the upper and lower die assemblies simultaneously serves to provide lateral support all along the inner and outer surfaces of the sides of the container shaped workpiece. One of the die elements is then retracted to remove lateral support from the region of the workpiece which is to be bulged. Thereafter the die assemblies continue to move toward each other with one pushing against the extreme edge of the workpiece to provide compression in its plane of extension. As a result, the workpiece will become bulged into the unsupported region vacated by the retracted die element.

The present invention, as will be described more fully hereinafter, in certain aspects makes special use of novel hydraulically retractible die elements and specially shaped die elements which apply compressive forces in a proper direction for controlled bulging.

The present invention in other aspects makes use of semi-fluid materials in a novel manner in the supporting region opposite the region to be bulged and causes this material to flow laterally to induce the bulging of the workpiece material in a more controlled manner.

There has thus been outlined rather broadly the more important features of the invention in order that the detailed description thereof that follows may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional features of the invention that will be described hereinafter and which will form the subject of the claims appended hereto. Those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized as a basis for the designing of other structures for carrying out the several purposes of the invention. It is important, therefore, that the claims be regarded as including such equivalent construction as do not depart from the spirit and scope of the invention.

Specific embodiments of the invention have been chosen for purposes of illustration and description, and are shown in the accompanying drawings, forming a part of the specification, wherein:

FIG. 1 is a fragmentary section view taken in elevation, along with a schematic hydraulic diagram illustrating an apparatus embodying the present invention as it appears at the beginning of its operation;

FIG. 1A is a perspective view showing a workpiece prior to entry into the apparatus of FIG. 1;

FIG. 2 is a fragmentary section view similar to FIG. 1 but showing only one-half of the apparatus of FIG. 1 as it appears after a first portion of its operation;

FIG. 2A is a perspective view of the workpiece of FIG. 1 as it appears at the stage of operation illustrated in FIG. 2;

FIG. 3 is a view, similar to FIG. 2, of the apparatus as it appears after a further portion of its operation;

FIG. 4 is a view, similar to FIG. 2, of the apparatus as it appears after a still further portion of its operation;

FIG. 4A is a perspective view of the workpiece of FIG. 1 as it appears at the stage of operation illustrated in FIG. 4;

FIG. 5 is a view, similar to FIG. 2, of the apparatus as it appears after its final stage of operation; and

FIGS. 6–9 are views similar to FIGS. 2–4 showing a modified version of the apparatus in various stages of its operation.

As shown in FIG. 1, there is provided a novel die assembly, indicated generally at **10**, and comprising upper and lower die shoes **12** and **14**, arranged in a press (not shown) so as to be moved toward and away from each other in a vertical direction.

The die shoes **12** and **14** have mounted on their mutually facing surfaces various fixed and movable die elements; and these die elements act upon a sheet metal

workpiece **16** positioned therebetween to perform various drawing and bulging operations to be described.

The various die elements are of circular configuration. Thus for purposes of detail, all central portions of the die assembly have been cut away in the illustrative drawings.

The various die elements on the upper die shoe **12** are arranged in concentric relationship; and beginning at the outside they include an upper shear ring element **18** fixed to the die shoe, a retractable die element **20** movable on the upper die shoe, an upper hold down ring **22**, movable on the die shoe, and an upper stop member **24** fixed centrally of the die shoe.

An annularly shaped retraction piston **26** is mounted for vertical reciprocal movement in a similarly shaped hydraulic passageway **28** in the upper die shoe **12**. This piston is formed with a rod **30** which extends out through the bottom of the upper die shoe **12** and connects with the retractable die element **20** to control the movements of this element on the upper die shoe.

There is also provided an annularly shaped hold down ring actuating piston **32** arranged in a similarly shaped hydraulic passageway **34** in the upper die shoe **12**; and this piston is connected to control the movements of the upper hold down ring **22** with respect to the upper die shoe **12**.

The hydraulic passageway **34** for the hold down ring actuating piston **32** is connected at the upper end thereof through a first hydraulic channel **36** and a first hydraulic supply line **38** to a pressurized hydraulic supply unit, indicated schematically at **40**. This unit may be of the type described in a copending application entitled Pressurized Fluid Supply System, Ser. No. 340,439, filed Jan. 27, 1964. Its essential purpose is to maintain sufficient fluid in the hydraulic channel **36** and the passageway **34** to force the hold down ring actuating piston **32** downwardly during an initial portion of the closing of the die shoes; and when the resistance against the upper hold down ring **22** reaches a certain value, for example, sufficient to raise the hydraulic pressure above 4500 p.s.i., then the hydraulic supply unit **40** will admit the fluid displaced by the retracting piston **32** while maintaining the 4500 p.s.i. pressure.

The other hydraulic passageway **28** for the retraction piston **26** is connected at its upper and lower ends respectively through second and third hydraulic channels **42** and **44** and associated hydraulic supply lines **46** and **48** and a double action control valve **50** to the hydraulic supply unit **40**. Initially the valve **50** is set as shown in FIG. 1 so that high pressure is directed through the second hydraulic channel **42** to the top of the retraction piston **26** causing it to force down the retractable die element **20**. Thereafter, the valve **50** is switched so that high pressure is applied to the under side of the retraction piston **26** causing it to rise and retract the retractable die element **20**.

It will be noted from the drawings that the upper shear ring element **18** and the upper stop member **24**, both of which are fixed to the upper die shoe **12**, are each provided with overhanging lips **52** and **54** which are engaged respectively by flanges **56** and **58** on the upper hold down ring **22** and the retractable die element **20** to restrict their movements with respect to the upper die shoe **12**.

The die elements on the lower die shoe **14** are also arranged in concentric relationship and are coaxially aligned with their counterparts on the upper die shoe **12** for intermeshing therewith as the shoes are brought together. These lower shoe die elements, beginning at the outside, include a lower shear ring element **60**, a bulging ring element **62** and a central forming mandrel **64**. The lower shear ring element **60** and the central forming mandrel **64** are both fixed to the upper face of the lower die shoe **14**, while the bulging ring element **62** is reciprocally movable thereon. There are provided for this purpose a number of bulging ring support rods **66** which extend from the bottom of the bulging die element **62** to a yoke **68** which is moved by a common bulging die piston **70**. Hydraulic means, as described above in connection with the upper die shoe **12**, are provided to actuate the bulging die piston **70**.

As stated above, the various die elements are dimensioned and arranged to fit into intermeshing relationship as the die shoes **12** and **14** are moved together. Thus, the retractable die element **20** on the upper shoe **12** is dimensioned to fit over the central forming mandrel **64** on the lower die shoe **14**, but with sufficient clearance to allow a partially formed workpiece to extend therebetween. Also, the upper and lower shear ring elements **18** and **60** are provided with closely mating shear corners **72** which cooperate to trim the workpiece **16** prior to forming. Further, the bulging die element **62** is provided with a step corner cutout about its upper inside corner to control the bulging operation as hereinafter described.

During operation of the device, the upper and lower die shoes **12** and **14** are closed or brought together about the workpiece **16**. The cross sectional area of the bulging die piston **70** is smaller than the area of the retraction piston **26**. Thus, during the initial portion of the die shoe closure movement, the bulging die element **62** yields to the force of the upper shear ring element **18** and the retractable die element **20** as these two elements descend into the annular region between the central forming mandrel **64** and the lower shear ring element **60**.

The workpiece **16**, which initially may be of rectangular configuration as shown in FIG. 1A, is sheared by the shear corners **72** of the shear ring element **60**. As the die shoes continue to come together, as illustrated in FIG. 2, the bulging die element **62** cooperates with the upper shear ring element **18** and the retractable die element **20** to squeeze the workpiece between it and them as it is forced down by them. This serves to maintain the workpiece material flat as it is being worked over the central forming mandrel **64** into an inverted cup shaped member as indicated at **76** in FIG. 2A. This serves to prevent wrinkling and thus ensures a uniform smooth surfaced end product.

At this point in the operation of the device, the die shoes **12** and **14** are brought together to their fullest extent. The control valve **50** is then operated to reverse the application of hydraulic pressure from the second hydraulic channel **42** to the third channel **44**. This reversal in application of hydraulic pressure to the retraction piston **26** acts to force it upward along with the retractable die element **20** as shown in FIG. 3. The retraction of the retractable die element **20** leaves a void **78**, for the bulging die element **62** continues to be held down by the upper shear ring element **18**.

The bulging operation takes place upon opening of the die shoes **12** and **14**. During this opening, as illustrated in FIG. 4, the upper shear ring element **18**, which is fixed to the upper die shoe **12**, is raised along with the upper die shoe. This allows the bulging die element **62** to move upwardly with it. The corner cutout **74** of the bulging die element eventually engages the lower edge of the inverted cup shaped member **76** formed from the workpiece **16**. The upward movement of the bulging die element thus exerts a compressive stress on the wall of the cup shaped member **76** in its plane of extension. This compressive stress is maintained on top of the cup shaped member **76** even while the die shoes are being opened due to the continuous hydraulic pressure in the first hydraulic channel operating through the hold down ring actuating piston **32** to force the upper hold down ring **22** against the upper surface of the member **76**. An outer flange **80** on the hold down ring engages the retractable die element **20** causing its lower edge to remain flush with the lower edge of the hold down ring **22** so that the configuration of the void **78** remains the same during the opening of the die shoes.

It will be noted that at this point, the entire inner surface of the cup shaped member **76** is laterally supported by the central forming mandrel **64**. Also, the upper regions of the member **76** are supported by the hold down ring **22** and the retractable die element **20**; and the lower region of the outside surface of the cup shaped member is supported by the step corner cutout **74** of the bulging die element. Thus, the only laterally unsupported region of the cup shaped member is at the void **78** into which a bulge is to be formed.

As the die shoes continue to open and compressive stress continues to be applied through the upward movement of the bulging die element **62** acting upon the lower edge of the inverted cup shaped member **76**, the member begins to bulge out into the void **78** as shown in FIG. 4 so that it attains the bulged configuration shown in FIG. 4A.

Once the die shoes **12** and **14** have completely opened, the finished bulged product or cup shaped member **76** is wedged within the upper shear ring **18** as shown by the dotted lines of FIG. 5. The finished product can be ejected from the machine simply by operating the control valve **50** to cause the retractable die element to move down upon the top of the finished element as shown in solid outline in FIG. 5. The apparatus is then in condition to receive another workpiece.

FIGS. 6–9 show a modified version of the apparatus in its various stages of operation corresponding, in general, to those stages of operation as illustrated in FIGS. 2–5. According to this modified version, there is provided on the lower die shoe **14** in place of the central forming mandrel **64**, a two-piece forming mandrel assembly **82**. This assembly comprises a fixed ring shaped member **84** and a movable central member **86**. The central movable member includes a flange **88** which extends out above the top of the fixed ring shaped member **84**. The space between the flange **88** and the top of the fixed ring shaped member **84** is filled with an elastomeric material **90**. Such materials are solid but resiliently flowable; and they are of constant volume. Thus, as the flange **88** of the central movable member **86** is pressed down upon the fixed ring shaped member **84**, the elastomeric material **90** will flow laterally out from between them.

There is also provided a fourth hydraulic channel **92** in the lower die shoe **14** in communication with a piston **94** which acts upwardly upon the central movable member **86**.

During the closing movement of the die shoes **12** and **14**, the piston **94** is subjected to high hydraulic pressure to maintain the central movable member **86** up from the fixed ring shaped member **84**. Operation of the apparatus, as illustrated in FIGS. 6 and 7, is identical with the earlier described version as illustrated in FIGS. 2 and 3. Thus, as shown in FIG. 6, the die shoes **12** and **14** are brought together with the retractable element **20** and the upper shear ring **18** together forcing down the bulging die element **62** while forming a flat sheet metal workpiece into an inverted cup shaped member **76**. Thereafter, as shown in FIG. 7, the retractable die element **20** is retracted to leave a void **78** into which the cup shaped member **76** is to be bulged. Thereafter, the die shoes are opened as shown in FIG. 8 so that the bulging die element begins to raise as aforedescribed.

At this point in operation, and while the die shoes are still opening, an hydraulic control valve (not shown) is actuated to reduce the pressure in the fourth hydraulic channel **92**. This allows the piston **94** to yield to the downward force of the upper hold down ring **22**. As a result, the flange **88** of the central movable member **86** is pressed down upon the fixed ring shaped member **84** causing the elastomeric material **90** to be squeezed out behind the workpiece material to enhance the bulging effect and to ensure that the bulged portion of the workpiece material will fully follow the contours of the void **78**. After the die shoes are fully opened, of course, the central movable member **86** will rise to its normal position and the elastomeric material **90** will return to the region between the flange **88** and the top of the fixed ring shaped member **84**.

Having thus described our invention with particular reference to the preferred forms thereof, it will be obvious to those skilled in the art to which the invention pertains, after understanding our invention, that various changes and modifications may be made therein without departing from the spirit and scope of our invention, as defined by the claims appended thereto.

What is claimed as new and desired to be secured by Letters Patent is:

1. Apparatus for producing bulged container shaped objects from sheet material, said apparatus comprising, an inner die member having outer end and side surfaces for providing substantially complete support for the interior surfaces of a container shaped object to be formed, a hold down member mounted to press against said sheet material and hold it down against the end of said inner die member, a retractable forming ring dimensioned to extend closely about said inner die member, means arranged to drive said retractable ring down fully over sheet material held by said hold down member and to draw said sheet material into a container shaped about and lying flatly against said inner die member, said driving means being arranged to retract said forming ring subsequent to its drawing operation while said hold down member continues to press against said sheet material so as to define a giving bulging cavity, a ring shaped bulging element closely embracing said inner die member and having an outwardly extending edge which engages the top edge of the container shaped material on said inner die member and means for urging said bulging element up toward said hold down member by an amount sufficient to bulge said sheet material into the configuration of said cavity.

2. Apparatus for producing bulged container shaped objects from sheet material, said apparatus comprising, first and second die shoes mounted for relative movement along a given path toward and away from each other, an inner die member fixedly mounted on one of said shoes and extending out toward the other, said inner die member having outer end and side surfaces for substantially completely supporting the internal surfaces of a container shaped object formed thereover, a hold down member yieldably biased to extend outwardly from the other shoe toward the outer end of said inner die member for clamping sheet material therebetween as said die shoes are brought together, a retractable ring dimensioned to fit over said inner die member with sufficient clearance to draw sheet material down over and closely against said inner die member, means mounting said retractable ring to move with said other shoe to come down over sheet material and draw same to a container shape over and fully against said inner die member upon closure of said die shoes and thereafter to retract said ring off from said inner die member while said shoes remain closed, a ring shaped bulging member dimensioned to fit closely about said inner die member and formed with an inner circumferential step for engaging the edge of a container shaped object drawn over said inner die member, said bulging member further including a lateral surface extending up from said step to provide lateral support over a portion of the outer side surface of the container shaped object, means yieldably biasing said bulging member to extend outwardly from said one shoe toward said retractable ring, and a bulging member hold down element extending from said other die shoe and dimensioned to engage and depress said bulging member upon closure of said die shoes, whereby, when said die shoes are closed, said retractable ring forms sheet material into a container configuration over said inner die member while said bulging member hold down element depresses said bulging member, and thereafter, following retention of the retractable ring, when said die shoes are opened, said hold down

member continues to force said container configuration onto said inner die member while said bulging element moves upwardly to engage the edge of said container configuration for producing bulging of same.

3. Apparatus for bulging container shaped objects said apparatus comprising, upper and lower die shoes mounted for reciprocal movement along a given path toward and away from each other, an inner die member mounted to extend from one of said shoes and having outer end and lateral surfaces which fit inside and provide substantially compete support for the inner bottom and side surfaces, respectively, of a container shaped object, hold down means mounted to extend from the other shoe and to engage the outer bottom of said container shaped object to hold it down over said inner shaped member, said hold down means comprising an extensible die element and yieldably biased mounting means urging said element toward an extended position toward inner die member, ring means arranged to provide lateral support circumferentially about and part way along the outer side surface of said container shaped object, means controlling the longitudinal position of said ring means so that it will define the upper limit of a bulge to be formed about said object, a ring shaped bulging element closely embracing said inner die member and having an outwardly extending edge which engages the top edge of said container shaped object, further yieldably biased mounting means arranged to urge said bulging element toward said other shoe, and secondary hold down means separate from said ring means and fixedly mounted on said other shoe in a position to engage and depress said bulging element upon closure of said shoes while allowing reverse movement of said bulging element upon opening of said shoes while said hold down means extends to maintain said container shaped object in position over said inner die member.

4. Apparatus for bulging sheet metal objects, comprising, upper and lower die shoes, a central forming mandrel extending from one of said die shoes, an upper hold down mandrel extending from the other of said die shoes and aligned with said inner forming mandrel, a retractable die element dimensioned to fit around said inner forming mandrel for drawing sheet material thereover, said retractable die element being mounted for longitudinal reciprocal movement on said other die shoe and enclosing said hold down member, means associated with said other die shoe for controlling retraction and protraction of said retractable die element, and a bulging element on said one die shoe immediately surrounding and embracing said inner forming mandrel, said bulging die element having a first surface which engages the edge of a container shaped object drawn over said inner forming mandrel and further having a lateral surface extending longitudinally from said edge catching surface in a direction parallel to the lateral edges of said inner forming mandrel to provide lateral support to a portion of the outer edges of an object drawn over said inner forming mandrel, and means for causing longitudinal movement of said bulging die element along said forming mandrel after retraction from said retractable die element.

5. Apparatus for forming bulged container shaped objects comprising means for drawing a container shaped object from sheet metal including an inner mandrel and an outer forming ring, said forming ring being dimensioned and arranged to draw sheet material closely over said mandrel to lie against the end and sides of the mandrel means for holding said container shaped object onto said mandrel following such forming ring retraction, and a bulging element comprising a bulging ring closely fitted about said mandrel and movable therealong to engage the edge of said container shaped object and apply compressive stress to the sides of said object for causing an outward bulging thereof into the region voided by the retraction of said outer forming ring.

6. Apparatus as in claim 5 wherein said bulging ring has a first radially extending surface for engaging the edge of said container shaped object and a longitudinal surface extending out from said radially extending surface in parallel relationship with the sides of said inner mandrel to define a narrow slot into which the edge region of the container shaped object extends.

7. A method for producing from flat sheet material, a container shaped object having an annular bulge, said method comprising the steps of drawing said sheet material tightly over a central mandrel by means of a close fitting ring while holding the central portion of said material against the end of said mandrel, and, while maintaining the central portion of said material against the end of said mandrel, withdrawing said ring to form a bulging cavity and forcing the drawn edge of said material back along the surface of said mandrel to bulge said material into said cavity so as to cause the bulged material to assume the shape of said cavity.

8. In apparatus for forming from flat sheet material, a container shaped object having an annular bulge, the combination of a composite central forming mandrel over which a container shaped object may be drawn and a bulging ring which fits closely about the mandrel to engage the edges of the container shaped object so drawn to push them back along the side surfaces of the mandrel to produce a bulging of the object, said composite central forming mandrel comprising a central member and an outer ring shaped member arranged coaxially for separately controlled longitudinal movement, said central member having an outer flange like formation which extends over the end of the ring shaped member to define between the two a compressible annular cavity, and an elastomeric substance filling said cavity.

9. Apparatus as in claim 8 further including a forming ring for initially drawing a container shaped object from flat sheet material down over said mandrel and means for maintaining said central member and said outer ring shaped member in a fixed axial displacement during movement of said forming ring.

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