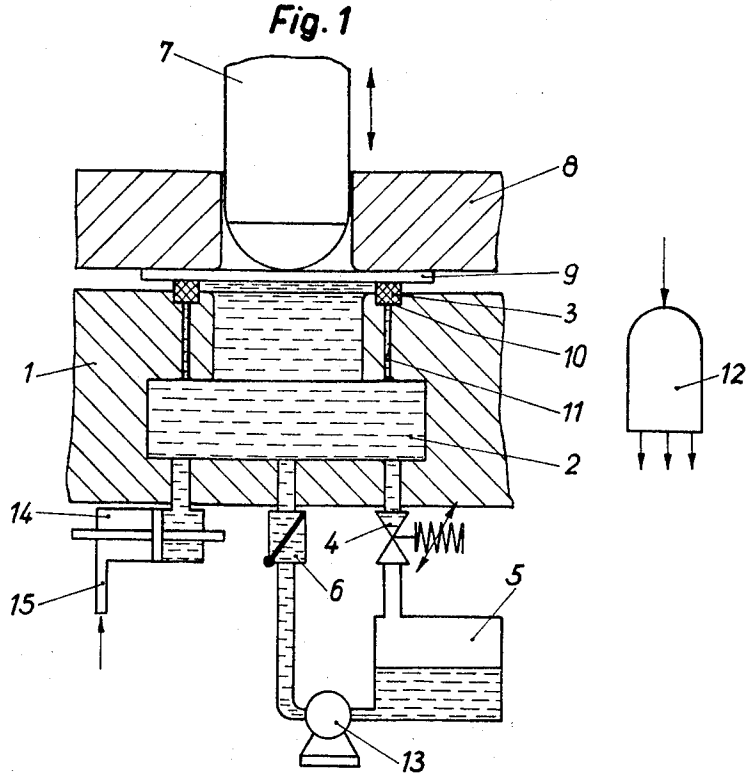
Nov. 22, 1966 E. BURK 3,286,496

APPARATUS FOR HYDRAULIC DEEP-DRAWING OF SHEET METAL

Original Filed July 3, 1962 7 Sheets-Sheet 1

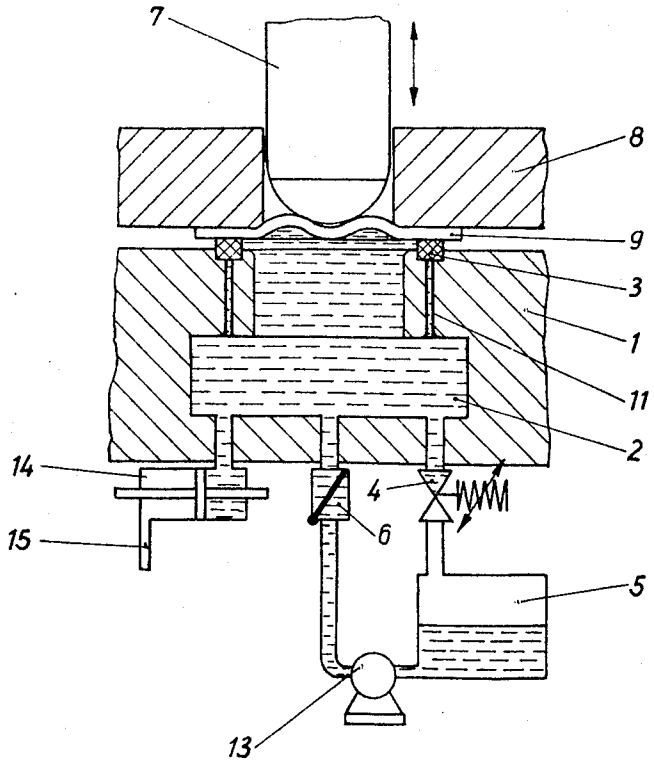
Fig. 1



APPARATUS FOR HYDRAULIC DEEP-DRAWING OF SHEET METAL

Original Filed July 3, 1962 7 Sheets-Sheet 2

Fig. 2



Nov. 22, 1966 E. BURK 3,286,496

APPARATUS FOR HYDRAULIC DEEP-DRAWING OF SHEET METAL

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Fig. 3

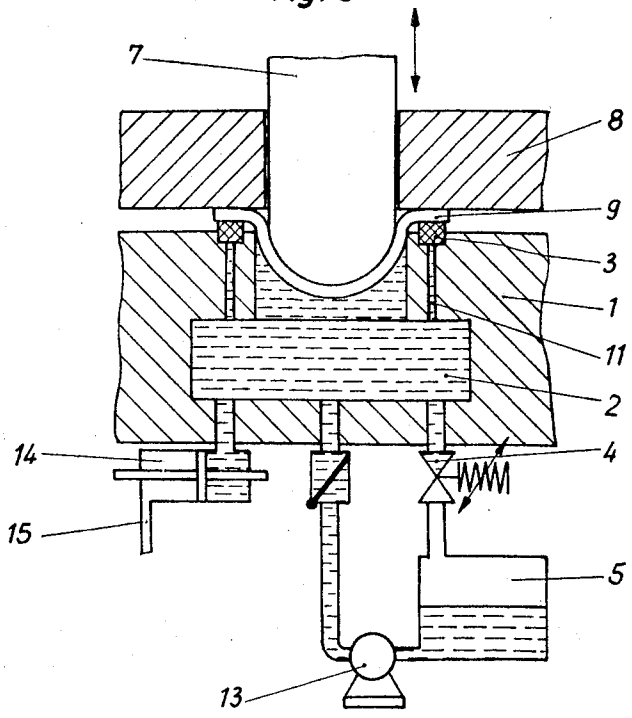
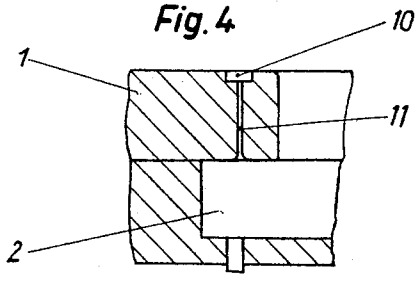


Fig. 4



APPARATUS FOR HYDRAULIC DEEP-DRAWING OF SHEET METAL

Original Filed July 3, 1962 7 Sheets-Sheet 4

Fig. 5

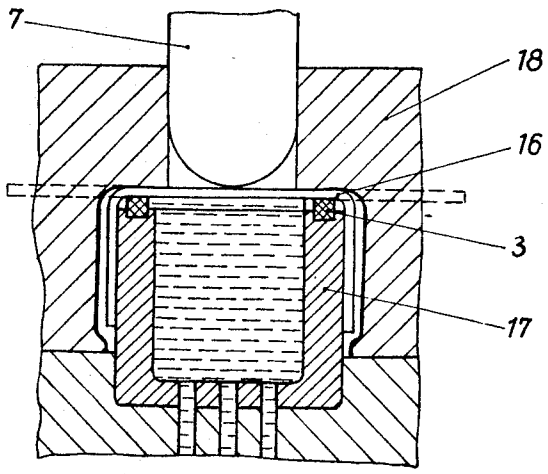
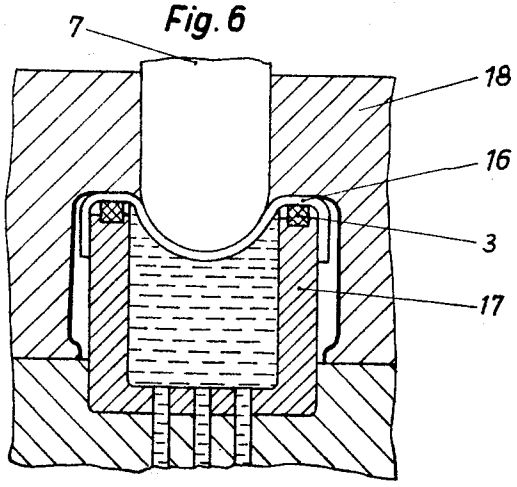


Fig. 6



APPARATUS FOR HYDRAULIC DEEP-DRAWING OF SHEET METAL

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Fig. 7

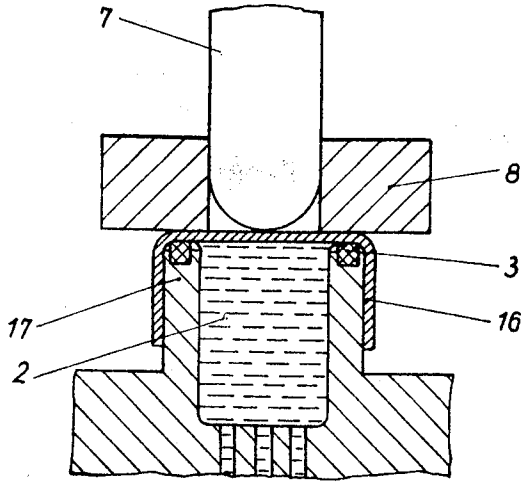
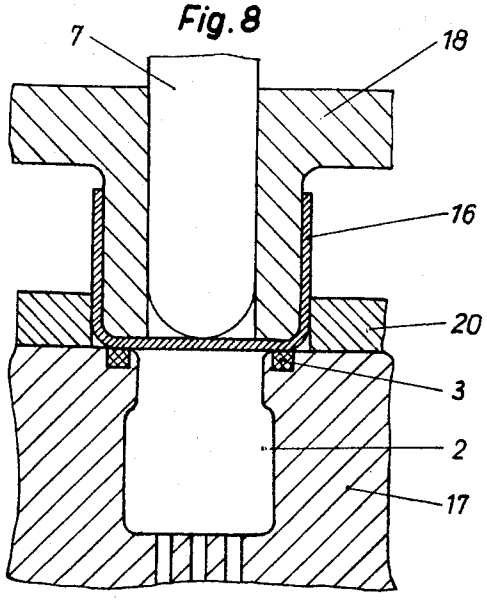


Fig. 8



APPARATUS FOR HYDRAULIC DEEP-DRAWING OF SHEET METAL

Original Filed July 3, 1962 7 Sheets-Sheet 6

Fig.9

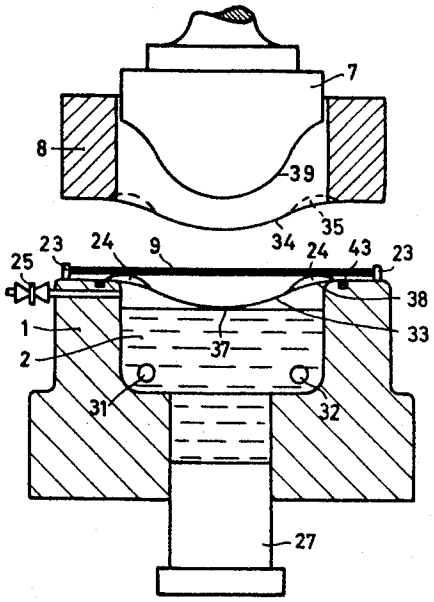


Fig.10

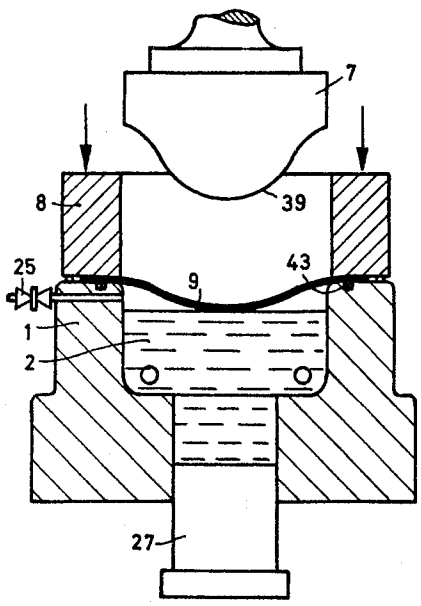


Fig.11

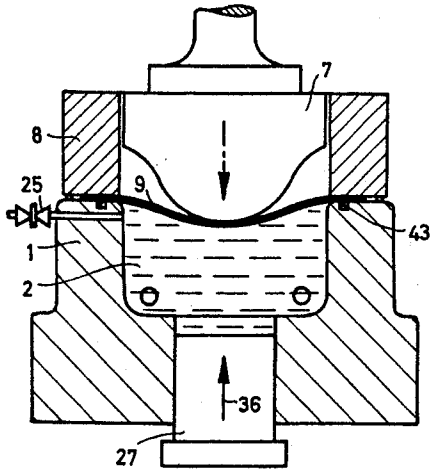
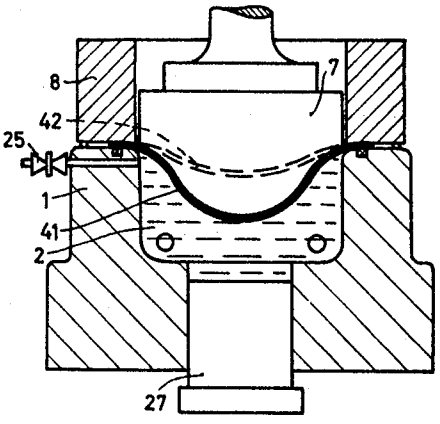


Fig.12



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APPARATUS FOR HYDRAULIC DEEP-DRAWING OF SHEET METAL

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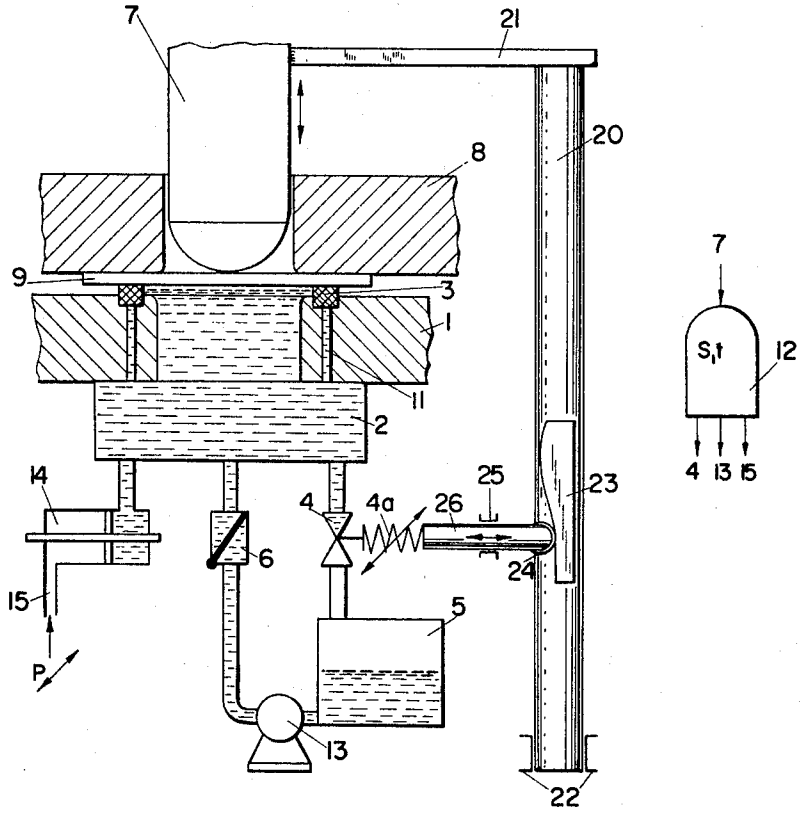


FIG. 13

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3,286,496

Patented Nov. 22, 1966

3,286,496

APPARATUS FOR HYDRAULIC DEEP-DRAWING OF SHEET METAL

Eugen Burk, Traunstein, Germany, assignor to Siemens-Electrogerate Aktiengesellschaft, Berlin and Munich, Germany, a corporation of Germany

Original application July 3, 1962, Ser. No. 207,311, now Patent No. 3,208,255, dated Sept. 28, 1965. Divided and this application May 4, 1965, Ser. No. 453,131

Claims priority, application Germany, July 7, 1961, S 74,709; May 23, 1962, S 79,575

9 Claims. (Cl. 72—54)

This application is a division of my copending application Serial No. 207,311, filed July 3, 1962, now issued as Patent No. 3,208,255.

My invention relates to the deep-drawing of sheet material from blanks or pre-shaped workpieces into cup-, shell-, or cuff-shaped products.

The deep-drawing of conical or irregularly shaped workpieces often encounters difficulties. According to the conventional cupping method, a blank is placed upon the die ring when the punch press is open, and during closing of the press a hold-down ring or retainer is set upon the blank under a certain pressure until the blank is drawn by the punch, whose motion follows that of the retainer, into the drawing gap beneath the retainer. This conventional method requires for each particular workpiece shape a pair of male and female die members accurately machined to matching shapes and suitable only for a given sheet-metal thickness. Furthermore, there is the danger that wrinkling or buckling may occur at the edges of the product being drawn.

Other known deep-drawing methods are the fluid-bag process (Wheelon) and the rubber-punch process. According to these, a fluid-filled rubber gas or a punch made of massive rubber is placed upon the blank and forced into the matrix or form block. These methods do away with a machined male shaping member and also minimize or avoid wrinkling but have the disadvantages that after setting the plunger upon the blank, the shaping pressure acts upon the matrix or die ring, thus greatly aggravating the difficulties of drawing the sheet-metal blank during the initial stage of operation. In these prior-art deep-drawing methods described, it is considered particularly disadvantageous that the die or form block constitutes a rather expensive mold of female type and that each shape to be produced requires providing a particular rubber bag or plunger, aside from the fact that the wear of the rubber bag or rubber plunger is relatively great.

Also known are deep-drawing methods according to which a liquid-filled space covered by a rubber diaphragm serves as a matrix, and the blank is deformed into the covered matrix liquid by means of a male punch.

This latter method, however, requires a special machine. The wear and consumption of diaphragms is inconveniently great. The drawing depth is relatively limited to a great extent by the yieldability and stability of the diaphragm; pre-drawn workpieces cannot be subsequently subjected to further drawing operation, and the drawing of cuffs, i.e. reversely bent or re-entrant shapes, is infeasible.

It is an object of my invention to provide hydraulic deep-drawing methods and means that eliminate to a great extent the above-mentioned disadvantages heretofore encountered.

To this end, and in accordance with a feature of my invention the hydraulic deep-drawing method is performed in such a manner that the liquid acts as a matrix or form block and forces the blank material over and around the active surface portion of the drawing punch, thereby contributing essentially to giving the product the desired

deep-drawn shape. According to another feature of my invention, the pressure imposed upon the drawing punch or upon the liquid of the matrix which acts also as a shaping medium, is varied in correlation to or dependence upon the punch travel. More specifically, it is preferable to control the punch travel as well as the pressure acting upon the matrix liquid by a common program controller for simultaneous and properly correlated performance.

It is further preferable to place a sealing ring of pliable soft or resilient material, for example leather, copper or the like into a groove of the matrix upper portion to act as a seal between the annular retainer, the blank and the surface of the matrix liquid. During the drawing operation, the sealing ring is held in place under spring pressure or under the pressure of the drawing liquid, thus being pressed against the bottom side of the blank being deformed to the desired shape.

A method embodying the above-mentioned features of the invention is advantageously distinct from the known drawing methods, particularly by virtue of the fact that no rubber diaphragm is required and that a considerably greater degree of deformation can be obtained by a single stroke of drawing operation. Furthermore, the surface of the blank facing the pressure liquid is not subjected to mechanical stresses during the drawing operation so that in most cases a subsequent surface machining, such as polishing, grinding or the like, is no longer necessary. Also in many cases, any coatings for improving the surface conditions of the product can be provided on the blank before subjecting it to the drawing operation.

According to another feature of my invention, the manufacture of drawn products having a non-planer flange is made possible by controlling the liquid level in the pressure container. According to a more specific, preferred feature relating to the last-mentioned modification of the invention, the drawing ridge of the form block (die) and the bottom edge of the retainer are adapted to the desired curvature of the flange on the workpiece to be produced.

The drawing of the workpiece is initiated by first placing the blank upon the form block and the retainer upon the blank, so that the blank is located between the curved portions of retainer and form block that mutually determine the desired curvature in the flange of the workpiece after it is finished; and only thereafter is the pressure liquid supplied into the portion of the pressure container located between the highest point and the lowest point of the curving drawing edge of the form block. When performing this method, it is preferbale to fill the pressure container with liquid, prior to setting down of the retainer, only up to a level corresponding approximately to the lowest point of the drawing edge. However, another way of proceeding is to fill the pressure container with liquid only after the retainer is placed upon the blank.

In the apparatus according to the invention, the pressure container is vented by suitable valves or sliders while the pressure liquid is being supplied. The filling of the pressure container, or the filling of that particular portion of the pressure container which is still free of liquid prior to placing the retainer upon the blank, can be effected by means of a piston entering into the pressure container or into an auxiliary cylinder or other container communicating with the pressure container. The operations described can be performed with single or multiple-operation presses, and the pressure in the hydraulic pressure container that receives the matrix liquid can be controlled in dependence upon the position of the drawing punch.

The above-mentioned and other objects, advantages and features of my invention, said features being set

forth with particularity in the claims annexed hereto, will be apparent from, and will be mentioned in the following with reference to the embodiments of deep-drawing equipment according to the invention illustrated by way of example on the accompanying drawings in which:

FIG. 1 is a sectional and partly schematical elevation view of a hydraulic drawing tool according to the invention prior to the drawing operation proper.

FIG. 2 is a similar view and shows the same tool during an intermediate state of drawing operation.

FIG. 3 shows the same drawing tool at the end of the drawing stroke; and

FIG. 4 is a fragmentary view separately illustrating in section a portion of the same drawing tool.

FIG. 5 shows in section a hydraulic cuff-drawing tool prior to the cuff-drawing step.

FIG. 6 shows the same tool as FIG. 5 at the end of the cuff-drawing stroke.

FIG. 7 is a sectional view of a deep-drawing tool for use with pre-drawn workpieces.

FIG. 8 shows in section another deep-drawing tool for pre-drawn workpieces.

FIGS. 9 to 12 show in section one and the same drawing tool for producing a workpiece with a wavy flange, in respectively progressively different stages of operation.

FIG. 13 is a schematic circuit diagram of a control device shown in conjunction with a deep-drawing tool according to FIGS. 1 to 4.

The tool according to FIGS. 1 to 4 comprises a lower portion **1** which constitutes the form block or die and forms a container **2** for pressure liquid. The inner diameter in the working portion of the form block **1** is in accordance with the outer diameter of the workpiece to be produced. A sealing ring **3** surrounds the top opening of the form block **1** and is placed into an annular groove **10** which communicates with the pressure container **2** through a duct **11** (FIG 4). The sealing ring **3** (FIGS. 1 to 3) preferably consists of elastic material such as leather or rubber and may be provided with a metal cover layer. During operation, the sealing ring **3** or gasket is pressed by its own resiliency or by additional springs (not shown) placed upon the bottom of the groove **10**, against the blank **9** of sheet metal that is to be drawn to a cup-shaped configuration. An adjustable or regulated pressure valve **4** communicates with the pressure container **2**. A pump **13** serves for pumping the liquid from a collecting tank **5** into the pressure container **2** through a check valve **6** located in the pressure line of the pump.

The upper portion of the drawing tool comprises a punch **7** whose lower surface corresponds to the inner shape of the cup to be drawn, and a hold-down member or retainer **8**. In single-operation presses, the retainer **8** is moved downward against and onto the previously inserted blank **9** when the punch **7** commences its downward motion, or the retainer is first moved downward upon the blank **9** and then latched in proper position. In double-acting punch presses, the retainer **8** may be fastened to an actuating tappet, these modes and means for setting the retainer upon the blank being well known and generally used in conventional presses.

As mentioned, when the press is open, the blank **9** is inserted between the then lifted retainer **8** and the gasket ring **3**. Thereafter the press is put into operation. The punch **7** is moved downwardly against the blank **9**. Simultaneously the pressure-liquid container **2** and the space above it are filled with liquid under pressure by operation of the pump **13**. When the form block is completely filled with liquid and the punch **7** commences to bend the blank **9** downwardly, the air pressure acting upon the hydraulic actuator **14** is increased so that the liquid in the die block acts as a matrix, as will be further described hereinafter. A timing relay, preferably a program controller, as schematically indicated at **12** in FIG. 1, controls the pressure in the pressure container **2** in accordance with, or in dependence upon the travel of the punch **7**. As mentioned, this is preferably done by applying pneumatic pressure through pipe **15** and cylinder **14**, or upon a plurality of such actuator cylinders jointly supplied with air pressure and acting in hydraulic parallel relation (not shown) upon the pressure space **2**. The pressure control and regulation can also be affected directly at the central control valve **4**. In lieu of one or more parallel operating pressure-equalizing cylinders **14**, a battery of such cylinders or pressure storage devices may be provided which, if desired, can be operated with respectively different pressures, and which can be switched on selectively.

The cupping operation proceeds as follows.

When the press is open, the blank **9** is placed coaxially upon the die block **1**, the latter being filled with pressure liquid. After the punch press is switched on and commences operation, the retainer **8** presses upon the blank to close off the container space **2**, thus forming it into a pressure space **2** within the die block **1**. Due to the subsequent entering of the punch **7**, the pre-selected pressure becomes built up in the pressure space **2** and forces the blank **9** against the surface of the punch with the result that the blank material, particularly if a conical shape is involved, bulges somewhat upwardly in the marginal zones. The drawing operation then takes place not by the action of the die edge but essentially by the liquid under pressure from below (FIG. 2). The adjustment of the amount of the upward deformation imparted to the blank at the stage represented in FIG. 2 is effected by correspondingly adjusting or regulating the pressure in the pressure space **2**. During the return stroke of the press, the liquid forced into the collecting tank **5** during the drawing operation is pumped back into the tube by means of the pump **13**. A new working cycle can now be started.

The cross section of the die block **1** and punch **7** need not be circular or oval but may also be given polygonal or any other desired shape. The invention is thus applicable for manufacture of a variety of products, for example boiler bottoms, reflectors for searchlights, hoods, for flatirons, and enclosures of any kind, taking advantage of the relatively low material and tool cost and the saving in time afforded by the novel deep-drawing method.

In order to obtain the highest feasible degree of deformation in a single drawing stroke, it is often desirable to operate on the so-called cuff-drawing principle. FIGS. 5 and 6 illustrate a hydraulic cuff-drawing tool in which the workpiece is first pre-drawn to the shape shown at **16** in FIG. 5 and is then hydraulically drawn to a re-entrant or cuff shape. It will be understood that in other respects the tool according to FIG. 5 is provided with hydraulic control devices as described above with reference to FIG. 1.

The operating method during cuff-drawing is as follows. The blank is first placed flat upon the sealing gasket **3** of the die block **17**, in the position shown by broken lines in FIG. 5. At this stage, the retainer **18** as well as the punch **7** are located above the blank. When the retainer **18** is pressed downward into the position of FIG. 5, the blank is initially pre-drawn by the downward travel of the inwardly protruding edge **19** of the retainer **18**. In this manner the blank is deformed to the cup shape of the workpiece **16** shown in FIG. 5. Thereafter, the drawing operation is continued by the punch **7** which now presses against the workpiece **16** in the downward direction (FIG. 6), acting against the cushion of pressure liquid contained in the pressure chamber of the die block **17**. During this portion of the operation, representing the cuffing step proper, the enclosed liquid again operates as a matrix which forces the material of the workpiece against the downwardly convex front surface of the punch.

If parts already pre-drawn to cup shape are to be cuff-drawn by the method according to the invention, a particularly simple drawing tool is sufficient, as will be recog-

nized from FIG. 7. The pre-drawn, cup-shaped workpiece **16** is placed upside down over a neck portion of the die block **17** and is forced by the retainer **8** against the gasket seal **3**. During subsequent downward travel of the punch **7**, the workpiece **16** is cuffed and thereby given re-entrant shape against the matrix formed by the liquid in pressure space **2**, in the same manner as explained above with reference to FIGS. 5 and 6.

In the embodiment shown in FIG. 8, the pre-drawn workpiece **16** is placed upon the neck portion of the retainer **18** that surrounds the punch **7** and is laterally held in position by a centering ring **20**. The desired shaping of the bottom of workpiece **16** is effected by depressing the punch **7** against the pressure of the liquid enclosed in the pressure **2** formed by the die block **17**, in the manner already explained above.

FIGS. 9 to 12 illustrate different stages of a drawing operation relating to the production of a hollow workpiece having a wavy flange portion. As will be recognized from FIG. 9, the die block **1** forms a pressure space **2** for hydraulic liquid. The pressure space is provided with an inlet valve **31** and an outlet valve **32**. The drawing edge **33** of the die block **1** has a curved shape in accordance with the desired flange curvature of the finished workpiece. The same curvature is present in the bottom edge **34** of the retainer **8**. The pressure liquid fills the space **2** up to a level located at about the lowest point **37** of the drawing edge **33**.

When starting the process, the blank **9** is placed upon the upper edge of the drawing bulge **24** of the die block **1**, as shown in FIG. 9, and the blank is secured in position by pins **23** inserted in block **1**. The lower portion of the retainer **8** is provided with recesses **35** mating the drawing bulges **24** of the die block **1**.

When thereafter the retainer **8** is placed upon the blank **9** (FIG. 10), the marginal portions of the blank are deformed in order to be shaped to the desired curving flange. As soon as the retainer **8** is tightly placed upon the die block **1** on all sides, the pressure space **2** within the die block becomes sealed pressure-tight to liquid. This takes place due to the presence of sealing gasket **43** located between the retainer **8** and the die block **1**.

As soon as the pressure space is thus sealed, a piston **27** in the bottom portion of the die block is moved upwardly as indicated by an arrow **36** in FIG. 11. This forces the liquid to enter into the space located between the lowest point **37** and the highest point **38** of the drawing edge **33**. The air previously contained in this space escapes through a magnetically controlled slide valve **25** or other suitable venting means. As soon as the pressure space **2** is filled with pressure liquid up to the blank **9**, the hydraulic deep-drawing process proper commences. The punch **7** presses the blank downwardly. Simultaneously, the pressure liquid acts as a matrix and forces the blank against the lower surface **39** of the punch **7**, this surface being shaped in accordance with the hollow space which the finished workpiece is to form.

At the end of the deep-drawing operation (FIG. 12) the resulting product **41** has generally the shape of a cup with an arcuate flange **42**.

This method is suitable for producing such products as the fenders of automobiles and other drawn products with a non-planar flange, and in most cases requires only one drawing stroke for shaping a planar blank into the ultimate shape desired.

Workpieces with a non-planar flange or workpieces with an only slightly curved flange can also be produced with single-operation presses. In this case the retainer **8** and the punch **7** are forced downwardly, not in sequence by respectively separate drive means, but the retainer **8** is elastically or resiliently mounted on the plunger **7**, for example by springs (not shown), so that when the plunger performs its downward stroke, the retainer **8** is first set upon the blank **9** and then becomes elastically displaced with respect to the punch as the punch continues its downward travel. Since the spring force may not be sufficient for so displacing the retainer, particularly at relatively high pressures prevailing in the pressure space **2** of the die block, it is advisable to latch the retainer **8** by means of sliders or like latching means (not shown) after it has thus been set upon the blank **9**.

One embodiment of the means for controlling the pressure in the pressure space **2**, in correlation to or dependence upon the travel position of the drawing punch **7**, is shown in FIG. 13. Also applicable for such pressure control purposes are various valves of the slider or piston type in conjunction with linkage rods, chain drives, rack drives and the like transmission mechanisms.

A preferred embodiment of the control means for varying the liquid pressure in dependence upon the travel distance of the plunger will be described by way of example with reference to FIG. 13. Connected with the plunger **7** by a bar **21** is a rail **20** guided for vertical movement in a bearing **22**. The rail **20** moves downwardly and upwardly in synchronism with the plunger **71**. Fastened on the rail **20** is a cam member **23** which is engaged by a follower roller **24** journalled on a horizontal tappet **26** guided within a bearing **25**. Between the valve **4** and tappet **26**, a variable pressure spring **4***a* is disposed which can be adjusted to set the spring force and thus the desired opening of valve **4** at a given position of cam **23**. Thus, during downward and upward displacement of the rail **20**, the cam member **23** causes the valve **4** to be adjusted so that the pressure of the matrix liquid in container space **2** is controlled in the desired sense depending upon the travel of the plunger **7**.

The method and equipment according to the invention afford the deep-drawing of sheet metal workpieces consisting for example of steel, copper, brass or the like, as well as of sheet material consisting of plastic, for example Plexiglas. The pressure liquid may also be used for heating the blank either by providing heating means (not shown) for the pressure liquid in the die block, or by supplying the pressure liquid in hot condition to the pressure space within the die block. The cheapest way of performing the method is to employ water as the pressure liquid. If desired, however, other liquids such as oil can be used.

To those skilled in the art, it will be obvious, upon a study of this disclosure, that my invention permits of a great variety of modifications with respect to the mode of operation as well as to details of the deep-drawing tools to be used and hence can be given embodiments other than as particularly illustrated and described herein, without departing from the essential features of my invention and within the scope of the claims annexed hereto.

I claim:

1. A drawing press for hydraulically deep-drawing sheet material from blank or pre-shaped workpieces, comprising a container defining a space for holding liquid under pressure, said container having a surface for supporting the workpiece so that the workpiece forms a closure for said container, said container being provided with a groove in its upper portion, and a resilient sealing member of soft material within said groove to form said workpiece supporting surface, retainer means movable toward and away from said container surface for sealingly holding the workpiece thereagainst, a male die movable toward and away from said container for pressing the workpiece against the liquid container therein, and program control means for controlling the pressure and flow of said liquid into said space in dependence upon the working stroke travel of said male die.

2. A press according to claim **1**, including duct means connecting said container space with said groove for transmitting liquid pressure from said space to said sealing member for pressing the latter against the bottom side of the workpiece by the pressure of said liquid.

3. Press according to claim 1, said retainer means having a portion thereof forming a drawing ring having an internal diameter larger than the outer diameter of said container for pre-drawing the outer edges of said workpiece down around the walls of said container into inverted cup shape.

4. Press according to claim 1, adapted for deep-drawing pre-drawn cup-shaped workpieces, including means for locating a pre-drawn cup-shaped workpiece coaxially on said container.

5. Press according to claim 4, the outer peripheral wall of said container forming said locating means, whereby the pre-drawn cup-shaped workpiece can be positioned with its outer edges directed downwardly and surrounding said container.

6. Press according to claim 1, said container and said retainer means having cooperating curved mating surfaces, and means for controlling the liquid level in said container space in sequence to below and then above said mating surfaces for drawing hollow workpieces having a non-planar flange.

7. Press according to claim 6, said container forming a die block having a drawing edge, the bottom edge of said retainer means being shaped in accordance with the desired curvature of a flange of the workpiece to be produced, said retainer means and said die block in mating position defining an interspace beneath said workpiece and above the liquid level between the highest point of said drawing edge and the lowest point of said drawing edge, said control means having a mechanism for controlling the motion of said retainer means toward said container to rest upon the workpiece so as to determine together with the die block said flange curvature and then to open said valve means to introduce pressure liquid into said interspace.

8. Hydraulic deep-drawing press according to claim 7, said control means including means for introducing liquid into said pressure space prior to lowering of said retainer means and up to about the lowest point of said drawing edge of said die block.

9. Hydraulic deep-drawing press according to claim 8, said means for introducing liquid comprising piston means communicating with said container space.

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CHARLES W. LANHAM, *Primary Examiner.*

R. J. HERBST, *Examiner.*