HYDRAULIC DIE ASSEMBLY FOR THE FORMING OF SHEET MATERIAL

Lawrence E. Day

INVENTOR.

BY

Hill, Sherman, Messoe, Cross & Thompson

ATTORNEYS
ABSTRACT OF THE DISCLOSURE

An hydraulic die assembly for installation in a conventional press for the hydraulic forming of sheet material, such as metal, in which the die assembly includes a distensible diaphragm through which hydraulic pressure is transmitted to stretch and form a work blank to the shape of a die cavity. The die assembly includes an upper die, forming a downwardly opening die cavity and having a marginal plane downwardly facing surface; a floating draw ring having a cylindrical bore opening toward said die cavity and having a marginal upwardly facing plane surface confronting that of the die; a stationary piston in the bore; a flexible diaphragm secured to the top of the draw ring, extending over the bore opening and clamped between said confronting plane surfaces; and a pressure transmitting hydraulic fluid confined in said bore between said piston and said diaphragm and in contact with both thereof; whereby with sheet material clamped between said confronting plane surfaces between said diaphragm and said die cavity, fluid pressure is transmitted through said diaphragm to stretch and shape said sheet material to the form of said die cavity.

This invention relates to an hydraulic die assembly for installation in a conventional press for the hydraulic forming of sheet material such as metal. More particularly, the invention relates to a die assembly that includes a flexible or distensible wall through which hydraulic pressure is transmitted to draw a work blank to the desired shape. Existing presses such as are used in the drawing of or shaping of sheets of metal and other materials can be further simply and inexpensively adapted for the hydraulic shaping of such sheets by the installation in such presses of the hydraulic die assembly of my invention. It is therefore an important object of my invention to provide an hydraulic die assembly that can be readily installed in an existing press to convert the same into equipment for the hydraulic drawing of sheet material into the desired shape.

It is a further important object of my invention to provide improved hydraulic die means employing a flexible or distensible wall for the more efficient shaping of sheet material than when the shaping is accomplished by a purely mechanical die in a drawing operation.

Other and further important objects of this invention will become apparent from the following description and the accompanying drawings, wherein similar reference numerals are used to designate like parts and, in which:

FIGURE 1 is a top plan view with parts broken away, of the left half of the lower portion of an hydraulic die assembly embodying the principles of my invention;

FIGURE 2 is a cross-sectional view, with parts in elevation, taken substantially along the line II—II of FIGURE 1 but with the upper portion of the die assembly in cooperative relationship with the lower portion for the hydraulic forming of a work piece;

FIGURE 3 is a cross-sectional view taken substantially along the line III—III of FIGURE 2, with parts shown in elevation;

FIGURE 4 is a vertical sectional view, similar to FIGURE 3, illustrating the relationship of the parts of the die assembly prior to the closing of the press;

FIGURE 5 is a fragmentary sectional view, similar to that of FIGURE 3, illustrating the position of the flexible or distensible wall of the hydraulic die at an intermediate stage of the forming operation; and

FIGURE 6 is a vertical sectional view, generally similar to FIGURE 2 but illustrating a modification of my hydraulic die assembly for use in forming shapes having a reentrant end contour.

As shown in FIGS. 1-5, inclusive, the reference numerals 10 indicate generally an hydraulic die assembly embodying the principles of my invention. Said hydraulic die assembly 10 is adapted to be installed in an existing press between an upper press ram 11 and a lower bolster 212, both of which are illustrated in FIG. 3 rather schematically and fragmentarily.

While described as associated with presses of conventional or existing types, it will be understood that the hydraulic die assembly of my invention can be used with various types of equipment, both vertical- and horizontal-acting, that include relatively movable, power-operated members similar in nature and operation to the press ram, or punch, and the bolster, or bed-plate, of a conventional punch press. With regard to the power requirements of the press or other similar equipment that may be used with my hydraulic die assembly, this, of course, will vary in accordance with the particular sheet material to be shaped and the magnitude of the forces required to form the desired shape. However, where high tensile, drawing quality, steel blanks are used from 0.090 to 0.125 inch in thickness, as in the forming of an automotive vehicle bumper and the like, pressures of 1600 tons capacity or over would typically be required for the shaping operations.

With particular reference to FIG. 3, the press ram 11 carries at its lower end a plate or shell 12, on which is mounted a die 13, hereinafter sometimes referred to as the upper die. As illustrated, the die 13 is mounted in a downwardly facing recess 14 in the lower face of the punch shoe 12, the die 13 being held in said recess in part by force-fitting shims 15 and in part by wedging members 65 and bolt means 68 later to be described. Fluid pressure is provided with a downwardly opening cavity 16, the forming walls 17 of which are of the desired contour and dimensions to impart to a blank, indicated by the reference numeral 18 (FIG. 4), the shape to which it is to be formed.

The die assembly 10 includes a lower die shoe 19, herein termed a draw ring holder, which is positioned on and bottomed against the bolster 212. Said bolster 212 is provided with a plurality of bores 20, and the draw ring holder 19 is provided with other bores 21 aligned with said bores 20 for the passage thereof of transfer pins 22, sometimes called air pins. Said pins 22 abut at their lower ends against a pad 23 arranged for vertical movement within a chamber 24 formed beneath a bolster 212 in an air pad device 25. As is well understood, the pad 23 is supported by air, or other gas or oil, or a combination of air and hydraulic media, maintained under pressure within an extension of the chamber 24 below the air pad 23.

The pressure, whether hydraulic, pneumatic, or a combination of the two, maintained within the extension of the chamber 24 below the air pad 23 will generally be a constant pressure, but one capable of adjustment, either automatically or manually. Downward movement of the press ram 11, of course, acts through the punch shoe 12, die 13, draw ring 26 and pins 22 against the pad 24, as will later more fully appear. The draw ring 26, or "floating ring" as it is sometimes termed herein, is carried upon the upper ends of the pins 22. As illustrated, said
draw ring 26 has lower side flanges 27 that rest against the upper ends of said pins 22. The pins 22 are not attracted to the rod 21, and each pin is freely received and guided by the continuous bores provided by the aligned bores 20 and 21.

Said draw ring 26 is provided along a longitudinal median line with a plurality of relatively large diameter, central bores 31 (three in number, as illustrated) that are preferably cylindrical and that extend vertically completely through the draw ring 26. The draw ring 26 is illustrated as having a total in all of seven bores of which said three central bores 31 are identical in all respects. The other bores, 32 and 32a are arranged outwardsly of the bores 31, one group being shown in FIGS. 1 and 2 on the left side of the draw ring. The bores 32 and 32a are of a different size and arrangement from the bores 31 for a purpose that will later on appear. Inasmuch as each of the three bores 31 is identical, only one need be described herein.

Again, as best shown in FIGS. 3 and 4, the bore 31 therein illustrated has a lower, enlarged cylindrical portion 33 into which is snugly fitted a cylinder sleeve 34. A retaining ring 35, suitably secured to the underside of the draw ring 26 and interfitting with the lower shouldered end of the cylinder sleeve 34, as at 37, serves to retain the sleeve in the bore 31, and enables the lubricating piston 36 to close the lower open end of the cylinder sleeve 34.

The lower end of each of the pistons 36 is provided with an annular groove 38, into which extends with clearance, an annular intumescence 39, provided on a retaining ring 40. Said retaining ring 40 is suitably secured to the upper surface of the draw ring holder 19 by plates 41 and by other means, not shown. A slight amount of clearance is provided between the intumescence 39 and the corresponding wall of the piston groove 38, and, additionally, the groove 38 is so made that it is essentially a stationary piston and is so described, it is self-aligning with respect to the axis of the co-axial cylinder sleeve 34. This is accomplished by providing each piston 36 with a lower segmental spherical convex surface 42 and providing a conforming concave surface 43 on a seating disc 44 mounted therebelow in an oversize cylindrical recess 45 formed in the draw ring holder 19. Thus, during relative movement between each piston 36 and the draw ring 26 there is automatic self-aligning as between the piston 36 and its cylinder 34.

The draw ring 26 is provided with a recess or groove 46 in the surface 47 of said draw ring for receiving the reinforced peripheral edge 48 of a flexible and/or distensible diaphragm 49. Said groove 46 lies outside of and includes the several through-bores 31, 32 and 32a so that said diaphragm 49 extends completely across the open upper ends of said bores and also, of course, spans the projected opening of the die cavity 16 in the upper die 13.

The diaphragm 49 may be made of rubber or other suitable elastic material, but it need not be elastic so long as it is sufficiently flexible to conform to the die cavity wall contour. The peripheral edge 48 of said diaphragm 49 is provided with a mounting ring 50 of hard rubber steel, or other hard composition in the form of an endless strip, preferably rectangular in cross-section, around three sides of which, including the underside, the peripheral margin 48 of the diaphragm 49 is wrapped and, preferably, while said peripheral margin is bonded. The thus reinforced periphery 48 of the diaphragm 49 is positioned and held in the receiving groove 46, and preferably locked therein by means of bolts 150 threaded into the mounting ring 50 with their head ends retained in countersink 151 in the draw ring 26.

Each of the bores 31, 32 and 32a forms a receptacle above the floating piston 49 that is open at the top except for the diaphragm 49 and the receptacles so formed are in open flow communication with each other beneath the diaphragm 49. An hydraulic fluid, indicated generally by the reference numeral 51, during normal operation of my device, usually lies in the space below the diaphragm 49, including the bores 31, 32 and 32a and, the diaphragm permitting it, the space thereabove connecting the upper open ends of the bores. For clarity, the hydraulic fluid has not been shown in some figures of the drawings.

The hydraulic fluid is preferably oil or any other fluid normally liquid at room and operating temperatures. Means for introducing an hydraulic liquid into the draw ring 26 include one or more feed lines 52 connected through a coupling and nipple assembly 53 to a passageway 54 in the wall of the draw ring 26 that opens into a bore 31 or 32. In order to insure complete filling of the space beneath the diaphragm 49 when the filling takes place while the diaphragm 49 is in its normal, at-rest condition (FIG. 4), means are provided for carrying off the surplus hydraulic fluid and also any air or other gas that might be entrapped beneath the diaphragm 49. Such means include tubing 55 having an upturned angular portion 56 open at its upper end 57. Said tubing 55 is connected through suitable couplings 58 to an outer discharge line 59. Means 60 serve to seal the outer end of the passageway 61 provided in the wall of the draw ring 26 for the hydraulic fluid and guide 33. As illustrated in FIG. 4, the upper open end 57 of the venting tubing 55 is so positioned as to be approximately at the level of the upper open end of each bore so that with the diaphragm 49 at rest, the mid-portion of the diaphragm drapes over said upper open end 57. This insures sufficient hydraulic fluid in the system to operate properly and at the same time insures the venting of any surplus of the hydraulic fluid and any air or gas that may have collected under the diaphragm 49.

Some of the more general features of construction will now be described with reference to FIGS. 1 and 2. The punch shoe 12 has already been described as having a recess 14 in which the upper die 13 is mounted. As illustrated in FIG. 2 the securement of the upper die 13 in said recess 14 is accomplished in part by wedge-shaped members 65 at the ends of said die 13, which wedge shaped members 65 are adapted to be drawn into tight wedging engagement with confronting surfaces 66 and 67, respectively, of the die 13 and the punch shoe 12 by bolts 68. Another feature of construction that seems to require no detailed discussion is the provision of confronting wear plates 69 and 70 for accommodating relative sliding vertical movement between the punch 12 and its holder 19. Additionally, the floating draw ring 26 is supported at its ends by pins, similar to the transfer pins already described, that lie along a longitudinal median plane of the die assembly. Said pin 71, like the pins 22 abut at their lower ends the air pad 23 and extend into supporting relation with the draw ring 26. As shown, the upper ends of said pin 71 pass through sleeves 72 inserted in corresponding bores in the lower wall of the draw ring holder 19, with the upper extremities of said pins extending into recesses in the lower surface of a plate 73 on the underside of the draw ring 26. The dotted lines 74 (FIGS. 1 and 2) represent merely the cavities in the casting forming the floating draw ring and serve to reduce the total overall weight of the ring.

In order to prevent leakage of the hydraulic fluid between the opposed walls of the cylinder sleeves 34 and the pistons 36, each of said pistons 36 is provided with an annular outer groove 90 at its upper end for reception of a seal ring 91.

As indicated previously, and as best illustrated in FIG. 2, there is a different arrangement of bores in the draw ring 26 at the lengthwise ends of the draw ring. Instead of a single bore 31 above each piston 36 there is a smaller bore 36a below each piston 36 and, additionally, a pair of even smaller supplemen-

bores 32c opening at their lower ends closely.
adjacent the inner wall of the cylinder sleeve 31a. These supplemental bores 32a supply hydraulic fluid from the space above the punch 103 to the diaphragm 49 near the ends thereof. This provision of the smaller diameter bores 32 and the even smaller diameter bores 32a is to insure a supply of the hydraulic fluid at the ends of the diaphragm 49 right from the start of the die closing and hydraulic forming operation.

In the modification of my hydraulic die assembly shown in FIG. 6, changes in the construction and arrangement of the upper die and the draw ring are provided in order to make possible the hydraulic forming of articles having in their finished form reentrant curves or profiles. Such an article is indicated by the reference numeral 100 and the reentrant curve at an end thereof by the reference numeral 101. In the following description of the modification of my invention illustrated in FIG. 6, the same reference numerals as previously used will be used in referring to like parts or elements while different reference numerals will be applied to those parts or elements that have been modified in structure or function. It will be understood, of course, that the hydraulic die assembly of FIG. 6 is adapted to be positioned between the press ram and bolster of a usual conventional press in the same manner as previously described.

The hydraulic die assembly 100, comprises a punch shoe 103 forming the same function as the punch shoe 12 but of different form and construction to cooperate with an upper sectional die 104 of different form and construction from the die 14. Said die 104 comprises an intermediate section 105 and a pair of end sections 106. Since each of the end sections 106 is a reverse image of one other, one need be described. The end 106 shown in FIG. 6 has an inner slanting face 107 adapted to abut against a similarly slanting face 108 of the intermediate die section 105 when the assembly is in its operative relationship. This is brought about by a cam section later to be described.

When the press ram is in its raised position, the punch shoe 103 is also raised to a position spaced above draw ring 120, and the end section 106 is at that stage moved outwardly by means including an air cylinder schematically indicated by the reference numeral 109. Said air cylinder is suitably carried in a recessed portion of the underside of the punch shoe 103 and includes a piston (not shown) attached to a rod 110 projecting from the outer end of said cylinder 105. Said rod 110, in turn, is connected at its outer end to a dog 111 slidable mounted in a guideway or gib 112. Said dog 111 has a dependent portion 113 on one end engaging in the upper portion of the corresponding die end section 106 to move the same from its assembled relationship with the intermediate die portion 105, as illustrated in FIG. 6, to an extreme left-hand position (as viewed in FIG. 6) determined by the length of travel of the piston in the air cylinder 109. While not illustrated, it will be understood that the die end section 106 is moved by the operation of the air cylinder 109 to its extreme left-hand position only when the press is open and the draw ring, indicated generally by the reference numeral 120 is separated from the upper sectional die 104 by a distance sufficient to make possible this movement of the die end section 106.

The lower die shoe 114 has upstanding end flanges 115, of which only one is illustrated. Each of said end flanges 115 is provided along its inner surface with an upstanding step 116 extending toward the inside of the die cavity and with an inner vertical guide or slide plate 117. The die end section 106 is provided with an upper vertically arranged guide or slide plate 118 for sliding movement relative to the plate 117, and with a lower inwardly angled guide or slide plate 119 for camming coaction with said guide plate 116. During closing movement of the press, starting with the punch shoe 103 and the lower die shoe 114 separated from one another by the maximum distance permitted, the guide plates 119 first come into contact with the guide plates 116 at the start of such closing movement and the relationship of said guide plates, the die end section 106 is moved inwardly toward the intermediate die section 105. When the surfaces 117 and 118 comes into abutment as a result of such inward movement of the die end 106, said guide plates 119 have ridden off of the cooperating guide plates 116 and the guide plates 118 and 117 are maintained in relative sliding relationship during the continued closing movement of the press. Additionally, a vertical guide or slide plate 121 provided at each end of the draw ring 120 is automatically brought into contact with the lower extent of the corresponding vertical guide plate 117 on the lower die shoe 114.

In order to insure alignment between the punch shoe 103 and the lower die shoe 114, said punch shoe is provided with a dependent flange 124 at each end, on the inside surface of which is positioned a vertical wear or guide plate 125 for relatively sliding movement in contact with a similar vertical wear or guide plate 126 positioned on the outer end of each of the flanges 115. As each of the die end sections 106 moves inwardly, the air is compressed within the cylinder 109, with the result that the die end sections 106 are held under some outwardly directed pressure against the vertical slides or guide ways 117. This relationship continues as the punch shoe 103 is again opened, during which movement the die end sections 106 are again free to move outwardly as the inclined surfaces of the guide plates 119 and 116 are again brought into mating relationship. When the opening movement is complete, the die end sections 106 are free of the reentrant ends 101 of the article 100 and the article can be removed from the intermediate die portion 105 or can be permitted merely to drop therefrom.

In the modification illustrated in FIG. 6, the diaphragm, indicated generally by the reference numeral 130 except for size and shape is the same as the diaphragm 49 that has previously been described. Said diaphragm 130 is also similarly provided with a reinforced peripheral edge 131 that includes an endless band or ring 132 of hard rubber, steel, or composition material, to which the margin of the diaphragm is suitably bonded. The draw ring 120 is provided with an outer peripheral groove 133 against the lower and inner walls of which said diaphragm periphery 131 is held. A hold-down pressure is exerted against said reinforced periphery 131 when the die end sections 106 are moved inwardly, or toward one another, since after completion of such movement, an inner wall of said diaphragm 130 and die end sections 106 are free of the recessed ends 101 of the article 100 and the article can be removed from the intermediate die portion 105 or can be permitted merely to drop therefrom.

With the closing movement of the press complete, as illustrated in FIG. 6, pressure has been transmitted through the hydraulic fluid 51 and through the distended diaphragm 130 to form the work piece 100 to the shape of the composite die 104 composed of the intermediate die section 105 and the two end die sections 106.

The operation of my hydraulic die assembly as illustrated in FIGS. 1-5, inclusive, is as follows:

With the assembly in the position illustrated in FIG. 4, namely, with the punch ram 11 at the top of its stroke, the draw ring holder 19 bottomed against the bolster 212 and the upper die 13 separated from the draw ring 26, a work blank 18 is placed over the diaphragm 49 to rest against the upper surface 47 of the draw ring 26. At this starting stage of the operation, the draw ring is in a floating position by means of the transfer pins 22 and 71. This means that each cylinder sleeve 33, while sealed at its lower end by the upper portion of the corresponding stationary piston 36, forms with the upper portion of the corresponding bore 31 a common hydraulic fluid receptacle extending beneath the diaphragm 49 and enclosed thereby. As the press ram 11 moves downwardly into press-closing relationship, contact is first established.
between the lower surface of the upper die 13 and the periphery of the blank 18. Continued pressure between these surfaces serves to hold the peripheral reinforced edge 48 of the diaphragm 49 in place against pressure tending to push the diaphragm 49 upwardly by virtue of forces transmitted by the hydraulic fluid 51. This condition is illustrated in FIG. 5, wherein the position of the diaphragm 49 is at the stage of upward and uniform flexing at which it first comes in contact with the lowermost portion, indicated by the reference numeral 75 of the contoured wall of the die cavity 16.

At this stage of the operation of the press, the downward force exerted by the press ram 11 is greater than that of the upwardly acting forces exerted through the air pad 23 and transfer pins 22 and 71 to hold the draw ring 26 in its uppermost position (FIG. 4). A complete seal between the upper die 13 and the floating draw ring 26 through the medium of the blank 18 and the reinforced edge 48 of the diaphragm 49 is thereby established. During continued downward movement of the draw ring 26 relating to the stationary pistons 36 further upward flexing of the diaphragm 49 occurs due to forces transmitted therewith by the hydraulic fluid 51 until complete shaping of the blank 18 to its final form, indicated by the reference numeral 80 (FIG. 3), is reached. At this stage, the closing pressure of the press ram has overcome the upward pressure of air supporting the air pad 23, with the result that the draw ring 26 reaches its lowest position (also as illustrated in FIG. 3). Simultaneously, substantially all of the hydraulic fluid from the space originally defined by the cylinder sleeves 34 has been displaced by the pistons 36 into the upper portion of the common receptacle including the upper bore portions 31, and the forces transferred through the hydraulic fluid 51 and through the diaphragm 49 have finally shaped the work blank into the shape of the die cavity 16.

In the case of a die cavity having in cross section a profile, or contour, that varies as greatly as that illustrated in FIGS. 3, 4 and 5, the hydraulic forming of the work piece by the operation of my hydraulic die assembly just described is much more efficient than where purely mechanical dies are used in the drawing and shaping of a work piece. This can best be appreciated by an understanding of what takes place in the hydraulic forming operation. In the first stage, as illustrated in FIG. 5, the diaphragm 49 under the pressure of the hydraulic fluid first flexes upwardly into contact with the portion 75 of the profile of the die cavity that is lowermost. At the end of this initial stage of the shaping operation, the stresses set up in the work piece 18 are fairly uniform across the diaphragm-supported extent of the work blank. In contrast, where mechanical dies are used, the stresses set up in the work piece at an early stage of the forming operation are not at all uniform but vary greatly and are very high initially at the points of maximum change in the angle of the contour or profile of the male die. This is due to the fact that the highest projection in the profile of the male die first engages the work blank and initiates the drawing operation where the severity of the drawing is greatest. In the case of my hydraulic forming operation, however, there is first a rather gradual and uniform stressing of the work blank and it is only in the latter stages of the shaping operation that the work blank is subjected to the deepest drawing and therefore to the most severe stresses. The result is that where work pieces are shaped hydraulically in accordance with my invention, there is less tendency to stress metal (or other material) of the blank beyond its elastic limit and thereby cause a rupture or crack in the work piece.

While the diaphragm 49 may be of any suitable flexible and dessitious sheet material, it is preferably formed of rubber, either natural or synthetic, and typically has a Durrometer hardness ranging from about 30 to 80. In general, it is sufficient if the diaphragm has the ability to stretch in all directions by at least 20% of its original dimensions. The diaphragm need not be elastic but is preferably capable of returning to substantially its original state after being distorted as flexed.

If the mounting ring 50 that serves to reinforce the periphery 48 of the diaphragm is formed of rubber, either natural or synthetic, a hard rubber is used having preferably a Durometer reading in the neighborhood of 75. The mounting ring or strip 50 is preferably bonded to the margin of the diaphragm 49 throughout its extent to facilitate the handling of the diaphragm as a unit. As previously stated, the diaphragm is preferably locked in place.

During the forming operation there may be some inward movement of metal from the margin of the work blank, but this is minor in amount and merely incidental to the forming operation. After the completion of the forming operation the remaining marginal portion is sheared or otherwise removed from the shaped article. It will be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of the present invention.

I claim as my invention:

1. An hydraulic die assembly adapted to be mounted between a press bolster and a press ram for the hydraulic forming of sheet material, said die assembly comprising:
   a. a die cavity forming means and said draw ring toward said draw ring holder forces are transmitted through said hydraulic fluid to said diaphragm capable of stretching and shaping sheet material spanning said die cavity and held between said die cavity forming means and said draw ring;
   b. a stationary piston in said bore, a flexible diaphragm secured to the top of said draw ring and extending over said bore opening, and a pressure transmitting hydraulic fluid confined in said bore between said piston and said diaphragm and in contact with both thereof;
   c. whereby upon downward movement of said die cavity forming means and said draw ring toward said draw ring holder forces are transmitted through said hydraulic fluid to said diaphragm;

2. An hydraulic die assembly as defined by claim 1, wherein
   a. said flexible diaphragm has a reinforced edge and said draw ring has a recess surrounding said bore opening and receiving said reinforced edge;
   b. an hydraulic die assembly as defined by claim 1, wherein said piston has a convex lower surface and said draw ring has a conforming concave surface against which said convex lower surface abuts;
   c. an hydraulic die assembly as defined by claim 1, wherein means are provided for introducing hydraulic fluid into said bore and separate means extending into said bore to a point below but adjacent the diaphragm and within said bore opening are provided for venting gas and excess fluid from beneath said diaphragm;

5. An hydraulic die assembly as defined by claim 1 wherein
   a. a plurality of bores and associated pistons are provided and said diaphragm extends over all of said bore openings with my invention;

6. An hydraulic die assembly adapted to be mounted between two members relatively movable toward and away from each other for the hydraulic forming of sheet material, said die assembly comprising:
   a. a die cavity forming means associated with one of said members with the die cavity opening toward the other of said members and with a marginal downward facing plane surface, a draw ring holder between said members,
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a floating draw ring mounted in said holder and having a bore therein extending through a marginal upwardly facing plane surface confronting said downwardly facing plane surface, a stationary piston in said bore in fluid sealing relationship to the wall thereof with the bore opening away from said piston toward said die cavity, a flexible diaphragm extending across said bore opening and carried by said draw ring, and a pressure transmitting fluid confined in said bore between said piston and diaphragm and in contact with both thereof, said die cavity forming means and said floating ring upon movement of said members toward each other being first brought into assembled relation with said diaphragm therebetween and upon continued movement of said members toward each other, said hydraulic fluid being placed under pressure against said diaphragm to flex the same into forming relation to said die cavity whereby, with sheet material clamped between said downwardly and upwardly confronting plane surfaces and with such sheet material between said diaphragm and said die cavity opening, fluid pressure is transmitted through said diaphragm to stretch and shape such sheet material to the form of said die cavity.

7. An hydraulic die assembly as defined by claim 6 wherein means are provided for automatically aligning said piston and said bored.

8. An hydraulic die assembly as defined by claim 7 wherein said automatic aligning means include mating segmental spherical surfaces between the confronting portions of said piston and said draw ring holder.

9. An hydraulic die assembly as defined by claim 6 wherein air cushion means are provided for floating said draw ring.

10. An hydraulic die assembly as defined by claim 9 wherein said air cushion means include pins floating said draw ring.

11. An hydraulic die assembly for use with a conventional press between an upper punch ram and a lower bolster against which the die assembly is bottomed upon closure of the press whereby adapting the press to the forming of a work blank by hydraulic pressure applied to the blank through a flexible wall, said die assembly comprising:

means providing a die cavity for shaping the work blank, means positioning said first means on said punch ram with said cavity opening downwardly, draw ring holding means bottomed on said bolster, a floating draw ring guided by said draw ring holding means, said draw ring having a bore therethrough the lower portion thereof providing a cylinder, a flexible distensible wall having a reinforced edge held against the top of said draw ring with said diaphragm extending across said bore, a stationary piston in said cylinder backed by said bolster, and a hydraulic fluid in said bore above said piston, whereby upon closure of said press pressure upon said hydraulic fluid is transmitted through said flexible diaphragm to deform a work blank to the shape of the die cavity.

12. An hydraulic die assembly as defined by claim 11 wherein air cushion means are associated with said bolster and said means include pins supporting said draw ring for holding said draw ring in an initially floating position prior to the closure of said press.

13. An hydraulic die assembly as defined by claim 12 wherein said piston and said draw ring holder are provided with confronting segmental spherical surfaces ensuring automatic alignment of said piston and said cylinder during relative movement therebetween.

14. An hydraulic die assembly as defined by claim 11 wherein means are provided for venting gas and excess hydraulic fluid from the bore space beneath said diaphragm.

15. An hydraulic die assembly as defined by claim 14 wherein said venting means include a tube passing through the wall of said bore and having an upper open end near the top of said bore and against which said diaphragm can rest when not distended by pressure thereon.

16. An hydraulic die assembly for association with a conventional press including an upper press punch ram and a lower stationary bolster towards which said ram is movable upon closure of said press, thereby adapting said press to the forming of a work blank by hydraulic pressure transmitted to the work blank through a flexible distensible diaphragm, said die assembly comprising:

means adapted to be carried by said punch ram providing a die cavity that opens downwardly, draw ring holding means bottomed against said bolster, a draw ring floatingly mounted in said holding means and having a bore therethrough providing a cylinder in the lower portion of said draw ring, a flexible distensible diaphragm carried by said draw ring and extending across the open top of said bore, a stationary piston in said cylinder backed by said bolster, air cushion means for association with said bolster having members secured to said draw ring for holding said ring in a floating position prior to closure of said press, and a hydraulic fluid in said bore above said piston for transmitting pressure to said diaphragm whereby when a work blank is positioned on said draw ring above said diaphragm and said press is closed said first mentioned means are first brought into closed relationship with said draw ring and said means and draw ring are thereafter together moved downwardly to thereby create a pressure on said hydraulic fluid that is sufficient when transmitted through said diaphragm to said blank to form the latter to the shape of said die cavity.

17. An hydraulic die assembly as defined by claim 16 wherein said piston and a confronting backing portion of said bolster are provided with confronting segmental spherical surfaces to effect automatic alignment of said piston with said cylinder during relative movement therebetween.

18. An hydraulic die assembly as defined by claim 16 wherein a plurality of bores, cylinders and associated pistons are provided, said draw ring has a continuous groove in an upper surface thereof enclosing all of said bores and said diaphragm has a reinforced peripheral edge mounted in said groove and adapted to be held therein by the pressure exerted by said first mentioned means against said peripheral edge during closing of said press.

19. An hydraulic die assembly as defined by claim 16 wherein means including a tubing opening beneath said dia-
phragm in said bore near the top thereof are provided for venting surplus hydraulic fluid and entrapped air.

20. An hydraulic die assembly as defined by claim 16, wherein said first mentioned means and said draw ring are provided with cooperating angular slides guiding said means and draw ring during downward movement into closing relationship.

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