

[54] **HYDRAULIC PRESSURE CONTROL APPARATUS**
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[52] **U.S. Cl.**.....72/351
[51] **Int. Cl.**.....**B21d 26/14**
[58] **Field of Search**.....267/11 A, 64 A; 72/351

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[57] **ABSTRACT**

A stamping apparatus includes a pressure pad means for supporting a blank and a movable upper die portion for shaping the blank. Hydraulic cushion means yieldably opposes movement of the pressure pad means during shaping of the blank in response to movement of the upper die through a work stroke. At a predetermined point in the work stroke, an expansion chamber, connected by passageways to the hydraulic cushion means, expands at a rate sufficient to release the hydraulic pressure in the hydraulic cushion means such that the yieldable opposition of the hydraulic cushion means is removed.

22 Claims, 14 Drawing Figures

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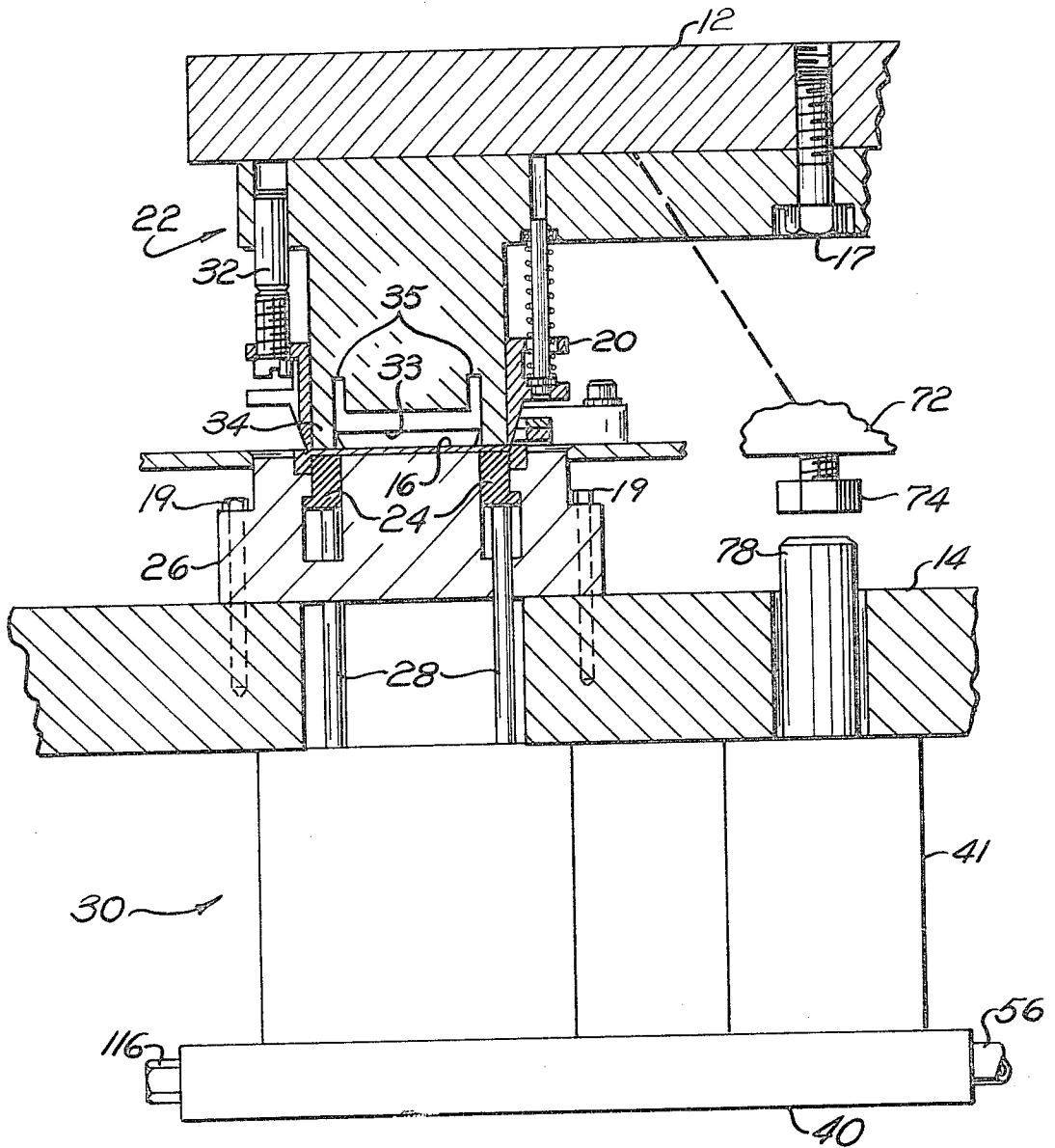


FIG. 1

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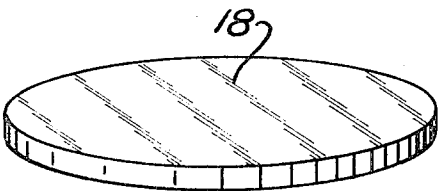


FIG. 3

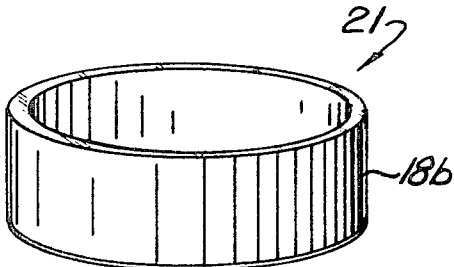


FIG. 4

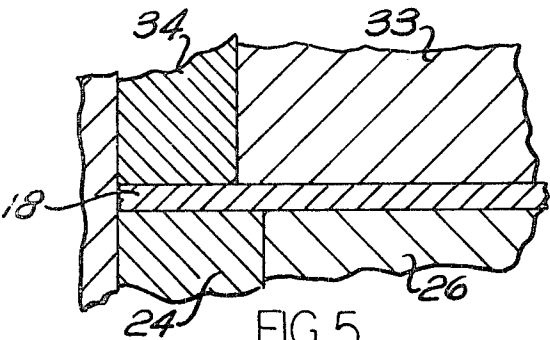


FIG. 5

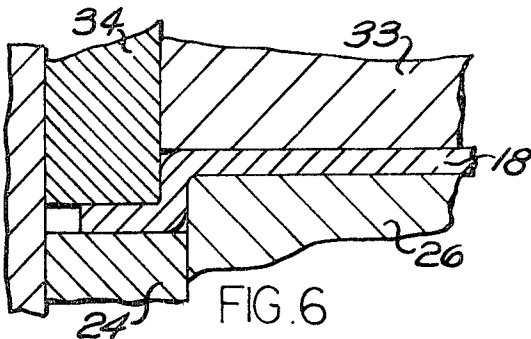


FIG. 6

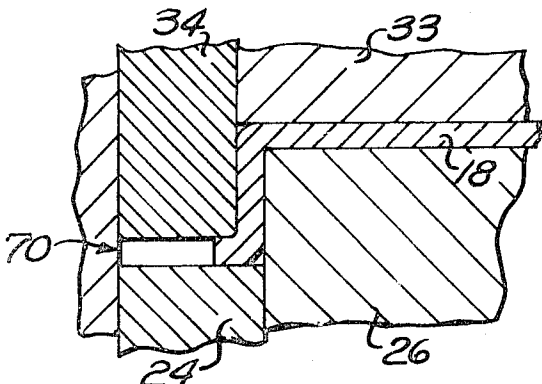


FIG. 7

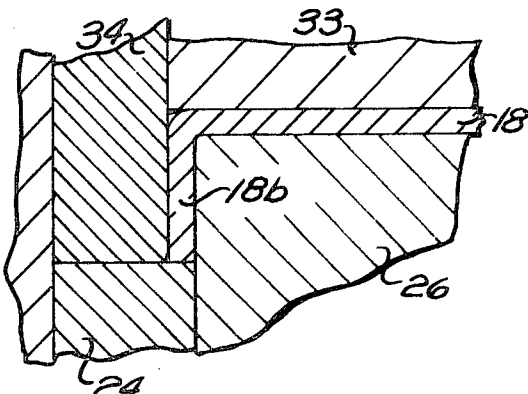


FIG. 8

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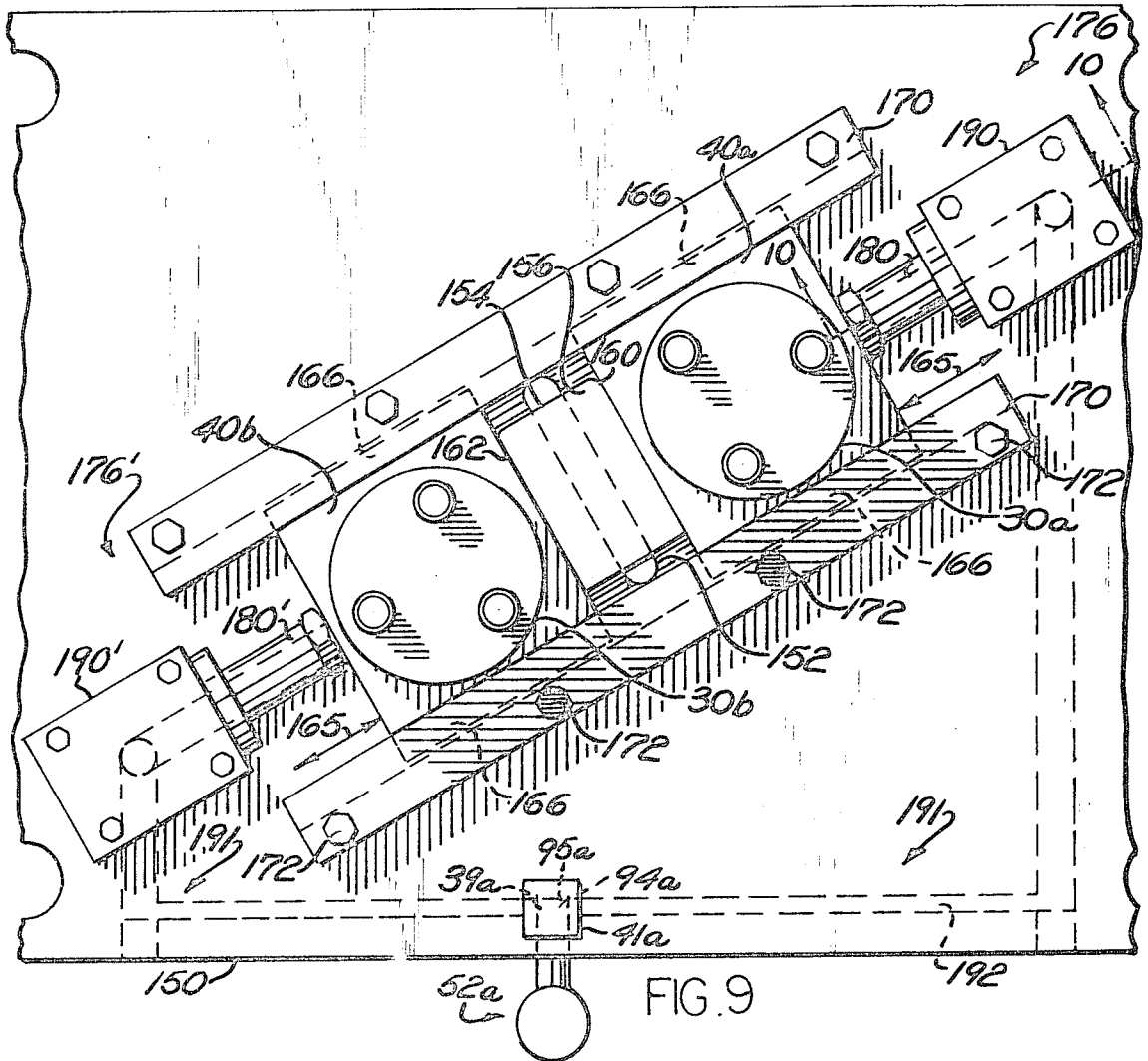


FIG. 9

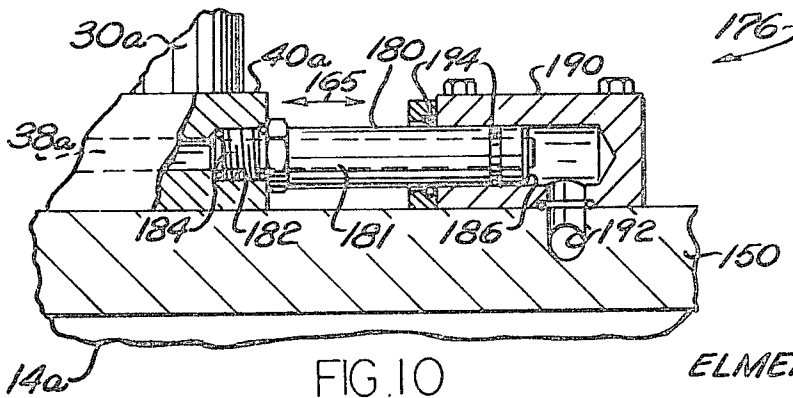


FIG. 10

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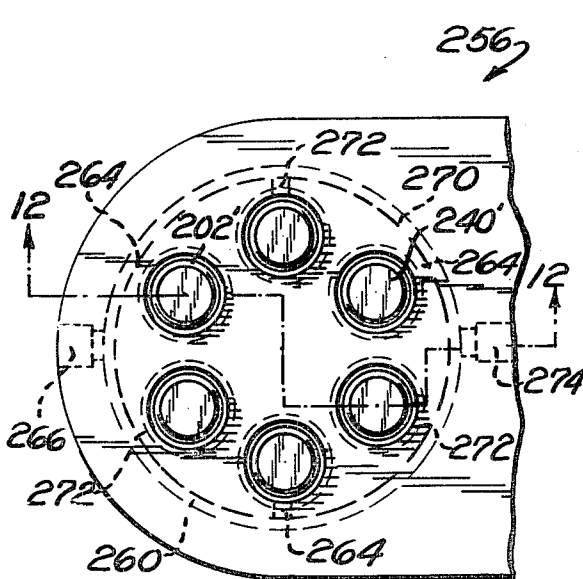


FIG. 11

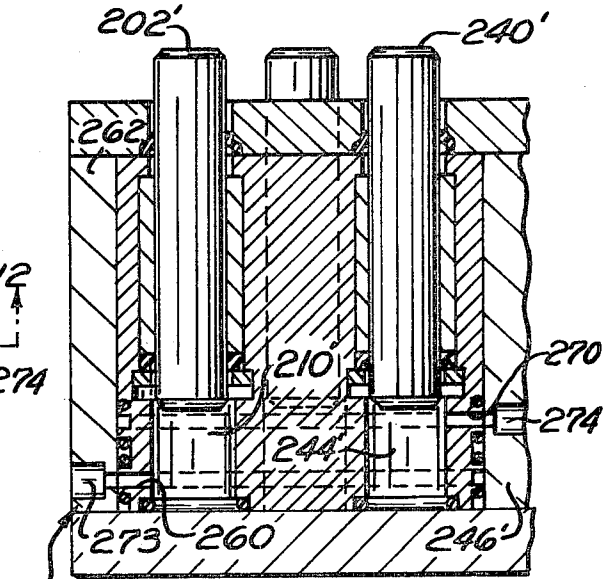


FIG. 12

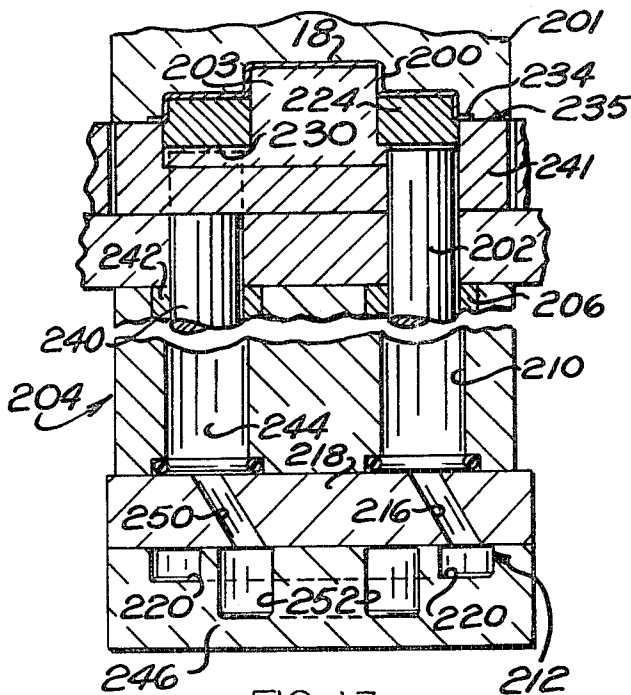


FIG. 13

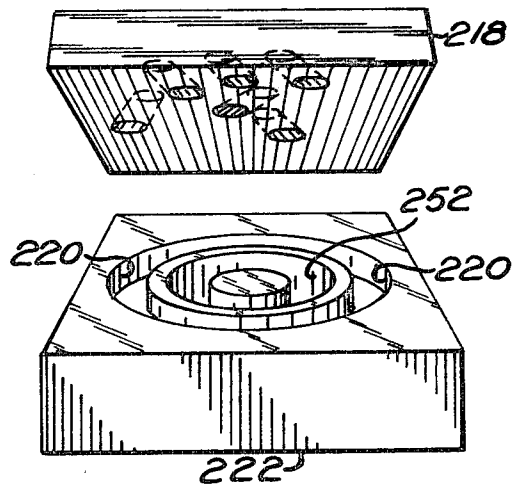


FIG. 14

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HYDRAULIC PRESSURE CONTROL APPARATUS

The present invention relates to a stamping apparatus including a hydraulic cushion for yieldably biasing a pressure pad against a member while the latter moves through a work stroke and in which the pressure in the cushion is released after the member has moved through a predetermined part of the work stroke.

A stamping apparatus to draw sheet material from its flat blank shape into a shell commonly involves the use of a pressure pad. The pressure pad is used to hold the flow of the material against the die as the blank is drawn to form the shell.

If the yieldable opposing force on the pressure pad is not great enough, or the force is prematurely removed, the peripheral material of the blank will not flow into a smooth shell, but will wrinkle and may be subsequently torn in the shaping process. On the other hand, when excessive force is applied to the pressure pad or the force is not removed after the shell is partially formed, the shell wall section may be substantially changed during shaping of the shell and in addition "whiskering" and tearing of the peripheral material may occur.

Pressure control is particularly important in the closure industry where the material used for caps or covers is prefinished. One surface is coated with a plastic coating which becomes the "inside" of the cap and the other surface is printed with the necessary lettering, trademark, or other marking and becomes the outside.

When a blank of such material is formed into a cuplike shell, a small amount of plastic coating is stripped and appears as "hairs or whiskers" in the finished parts and these must be removed before succeeding operations.

If the opposing force applied to the pressure pad is removed at precisely a predetermined point during the forming of the shells, the hairs, whiskers or shreds are eliminated.

The apparatuses of the prior art have generally proved unsatisfactory for various reasons in releasing the pressure in the pressure pad at a predetermined point in the forming of the shell.

In the stamping apparatus disclosed herein, an expansion chamber is connected by passageways to the hydraulic cushion. A hydraulic fluid supply connected to the hydraulic cushion provides a yieldable opposing hydraulic force to a movement of the pressure pad. These passageways remain substantially constant in volume when hydraulic pressure is applied to or removed from the hydraulic cushion to allow the hydraulic pressure in the hydraulic cushion to release without a response lag. After movement of the die for forming the workpiece through a predetermined distance, the expansion chamber is expanded with the continued movement of the die in its work stroke at a rate sufficient to release the hydraulic pressure in the hydraulic cushion. Thus, the yieldable opposition of the pressure pad to the direction of movement of the upper die portion during shaping of the sheet material is removed such that the sheet material blank is properly formed thereby.

In some phases of the stamping industry, two or more shells are required to be formed simultaneously during each press stroke. The size of the dies required to form various shapes also necessarily change and therefore, the center distance between the dies must also change. Since this center distance must be variable, the center distance between the corresponding hydraulic cushions for each die must change a corresponding distance.

The stamping apparatus of the present invention provides for changing the center distance between these corresponding hydraulic cushions without disconnecting the hydraulic system which reduces the time required to make a die change. In addition, the interconnecting passageways between the hydraulic cushion and the fluid pressure supply and expansion chamber are provided in rigid bodies to obtain a substantially instantaneous hydraulic pressure release.

Accordingly it is an object of this invention to provide a new and improved apparatus in which a blank is held against a die

during a forming operation by a pressure pad urged toward the die by means of a hydraulic cushioning means which yieldably opposes movement of the die, the apparatus being such that the hydraulic pressure in the cushioning means can be relieved after a portion of the work stroke has been completed with a minimum of time lag so that the pressure pad while moving with the die will no longer apply a significant holding force to the workpiece.

Another object of the present invention is to provide a new and improved method and apparatus for releasing pressure in hydraulic cushioning means of a forming apparatus as the ram of the apparatus is moving through its work stroke and is displacing pressure fluid from the cushioning means, in which apparatus and method a chamber in fluid communication with the cushioning means is expanded to receive fluid displaced from the cushioning means and to release the pressure therein and preferably to establish a negative pressure in the cushioning means.

It is yet another object of this invention to provide a stamping apparatus having an expansion chamber connected to a hydraulic cushion and adapted to be mechanically expanded after a die is moved through a predetermined distance to remove the fluid pressure in the hydraulic cushion such that the pressure pad no longer yieldably opposes movement.

It is yet another object of this invention to connect a hydraulic cushion to an expansion chamber and a fluid pressure supply by substantially rigid bodies having passageways therein to allow hydraulic fluid to flow therebetween to accommodate for substantially instantaneous pressure release of the fluid pressure in the hydraulic cushion.

It is yet another object of the present invention to provide a hydraulic cushion having a plunger mounted in a fluid cushion body having plastic material interposed therebetween to decrease friction and the tendency for scratches to occur between the hydraulic cushion body and the plunger.

Yet another object of the invention is the provision of a hydraulic cushion adapted to provide individual yieldable opposing forces to a plurality of pressure pads such that each yieldable opposing force is removed from its corresponding individual predetermined distance of movement of the upper die portion.

It is yet another object of the present invention to provide a stamping apparatus having a plurality of hydraulic cushions wherein the distance between the hydraulic cushions are adjustable while remaining in constant communication with a hydraulic fluid supply and expansion chamber by a solid member having a passageway therein.

Still further objects, advantages and features of the present invention will be apparent to those skilled in the art to which it relates from the following detailed description made with reference to the accompanying drawings; forming a part of the specification and in which:

FIG. 1 is a fragmentary sectional view of a stamping press for forming a sheet of material and schematically embodying the present invention;

FIG. 2 is a fragmentary sectional view of the hydraulic cushion and pressure control device shown in FIG. 1;

FIG. 3 is a perspective view of a blank of sheet material to be formed;

FIG. 4 is a perspective view of the sheet of material shown in FIG. 3 formed into a shell;

FIG. 5 is an exploded view of the forming portion of FIG. 1 showing the relative positions of the upper and lower die portions and sheet material blank as they come in contact with each other during the work stroke of the upper die portion;

FIG. 6 shows the relative positions of the parts shown in FIG. 5 after initial movement of the upper die portion and corresponding movement of the pressure pad to partially form the shell of FIG. 4;

FIG. 7 shows the relative positions of the parts shown in FIG. 5 at a predetermined distance where the yieldable opposing force on the pressure pad is removed;

FIG. 8 shows the relative positions of the parts shown in FIG. 5 upon completion of the work cycle of the upper die portion showing a properly formed shell;

FIG. 9 shows two hydraulic cushions mounted on a base mounting plate such that the distance between them may be varied;

FIG. 10 is a fragmentary sectional view taken along line 10—10 of FIG. 9 showing a telescopic fluid connection which allows the hydraulic cushions of FIG. 9 to be movable relative to each other without disconnecting the hydraulic cushions;

FIG. 11 is a top view of a hydraulic cushion having a plurality of plungers for biasing two pressure pads;

FIG. 12 is a sectional view of FIG. 11 taken along line 12—12 of FIG. 11 and showing the porting therein;

FIG. 13 is a fragmentary sectional view of yet another hydraulic cushion which is adapted to bias two pressure pads showing the passages therein; and

FIG. 14 is a perspective view of the base and baseplate of the fluid cushion shown in FIG. 13 in perspective.

The present invention is illustrated as embodied in a stamping apparatus for forming a cuplike shell from a sheet of material. In forming the shell, sheet material is supported on a pressure pad which encircles a lower die over which the material is to be drawn by a cooperating upper die. A hydraulic cushion is provided to yieldably oppose movement of the pressure pad by the upper die portion during formation of the shell. This yieldable opposition of the pressure pad against the upper die portion is created by hydraulic pressure in the hydraulic cushion for controlling the sheet material during its formation. But this opposing force is preferably removed after partial formation of the shell if the shell is to be properly formed. An expansion chamber is provided in communication with the hydraulic cushion and is expanded with the movement of the upper die when the pressure is to be released so as to relieve the pressure in the hydraulic cushion. To further facilitate the removal of pressure in the hydraulic cushion, the hydraulic pressure is preferably disconnected.

Referring to FIG. 1, a stamping press 10 is partially shown and has a lower mounting plate 14 and a ram 12 which moves from an open position with respect to the lower mounting plate 14 through a work stroke and returns to the open position to form sheet material 16. The sheet material 16 is partially supported on a lower die portion 26 which is connected to the lower mounting plate 14 of the stamping press 10 by the threaded fasteners 19. The sheet material 16 is also supported by a pressure pad 24 which is supported by the plungers 28 of a hydraulic cushion 30 mounted to the lower mounting plate 14. The sheet material 16 may be supplied in a strip or sheet stock and sheared to a blank shape 18 as shown in FIG. 3 by movement of the ram through its work stroke.

The blank 18 is sheared from the sheet material 16 by a shearing plate 20 mounted on the upper die generally indicated at 22, which is connected to the ram 12 by threaded fasteners 19. As the ram 12 begins movement through its work stroke, the sheet is sheared into the blank form 18 as shown in FIG. 3 by the shearing plate 20. After the shearing of the blank form 18 is accomplished, the shearing plate 20 will slide on its mounting pins 32 which are slidably received in the upper die 22.

At this point in the downward work stroke of the ram 12, the holddown pad 33 which is slidably supported on the upper die 22 and biased away from the first member 22 by a pair of springs 35, holds the sheet material 16 against the lower die portion 26. Thus, the blank form 18 is controlled such that it will not move relative to either the upper die 22 or the lower die 26.

At the position shown in FIG. 5, the holddown pad 33 is in contact with the blank 18 and opposed by the lower die portion 26 which is also in contact with the blank 18. The upper die portion 34 is in contact with the peripheral surface of the blank 18 and yieldably opposed from moving downwardly by the pressure pad 24.

The yieldable opposition of the pressure pad 24 is applied by a hydraulic cushion 30 as a result of hydraulic fluid supplied under pressure to the hydraulic cushion chambers 37 of the respective plungers 28, as shown by FIG. 2. The hydraulic fluid pressure acts on the lower ends 28a of the plungers 28 to provide a yieldably opposing upward force which may be overcome by a sufficient downward force on the plungers 28. Thus, as long as hydraulic pressure exists in the hydraulic cushion chambers 37, a yieldable opposing force exists but when the pressure is removed, the force is also removed. The hydraulic fluid under pressure is supplied to the cushion chambers 37 by means of a passageway, generally noted 38, in the base plate 40 to which the hydraulic cushion is mounted. The number of plungers 28 provided by the hydraulic cushion 30 may vary depending on the die design required to form the specified shell. Each of the plungers 28 of the improved construction are mounted in respective apertures 29 of hydraulic cushion body 25. Plastic sleeves 31 are inserted in each aperture 29 and receive their respective plungers 28 therein. The plungers 28 are hardened, polished and coated with a low friction compound such as polytetrafluoroethylene resin. This improved construction allows the plungers 28 to move with respect to the hydraulic cushion body 25 with a minimum of frictional resistance. In addition, the tendency for scratches to occur on the plungers 28 is substantially reduced.

Pressure control device 41 is also mounted on the base plate 40 and has a passageway 39 in communication with the passageway 38 of the base plate 40 such that the hydraulic pressure may be supplied from the hydraulic pressure supply 52 to the hydraulic cushion chambers 37. An aperture 44 is provided in the body of the pressure control device 41 and adapted to receive the floating piston 46 having an opening 48 therein which defines a portion of the passage 39 through which hydraulic fluid may be supplied to the hydraulic cushion chambers 37. The baseplate 40 has a hydraulic pressure passageway 50 in communication with the passageway 39 such that hydraulic pressure may be supplied from the hydraulic pressure supply 52. Thus, the fluid pressure passageway 54, including passageways 50, 39, and 38, connects the cushion chambers 37 with the hydraulic pressure supply 52.

The hydraulic pressure supply 52 may include any conventional means of supplying pressurized fluid to conduit 56. The hydraulic pressure supply 52 as shown further includes an accumulator 58 to maintain a substantially constant pressure in the hydraulic fluid pressure supply 52. Thus, pressure surges and fluctuations in the hydraulic pressure supplied by the hydraulic pressure supply 52 are minimized to provide for consistent operation of the stamping apparatus of the immediate invention. It should be understood that the accumulator 58 may be of any conventional construction known to those skilled in the art and is provided to maintain a more constant pressure relationship of the fluid pressure supply 52.

As the ram 12 continues to descend through its work stroke, the upper die portion 34 begins to shape the blank 18 as best shown in FIG. 6. During this downward movement, the pressure pad 24 moves downward with the upper die portion 34, but is maintained in yieldable opposition to movement of the upper die 22 by the hydraulic pressure. In this manner, the peripheral material of the blank 18 is held in compression between the upper die portion 34 and the pressure pad 24 and controlled during formation of the shell 21.

As the pressure pad 24 descends with the upper die portion 34, the plungers 28 move downward in their complementary cushion chambers 37 such that the volume of the cushion chambers 37 is decreased. Throughout this movement though, the pressure supplied to the cushion chamber 37 by the hydraulic pressure supply 52 remains constant such that the yieldable opposing force created by the hydraulic cushion 30 remains constant.

This constant yieldable opposing force by the pressure pad 24 against the upper die portion 34 continues to exist until a predetermined distance 70, as shown in FIG. 7, is reached.

After movement of the ram 12 through the predetermined

distance 70 of its work stroke, the yieldable opposing force is removed. A member 72 is attached to the ram 12 and has a contact member connected thereto such as a threaded fastener 74. The predetermined distance 70 is determined by the position of the threaded fastener 74 with respect to the extending rod 78 of the pressure control device. It should be understood that the contact member 74 may be adjusted such that the predetermined distance 70 at which the yieldably opposing force is removed may be varied.

Thus, as the ram 12 moves through its work stroke, the contact member 74 will contact the extending rod 78 and force the extending rod 78 into a position such that the piston 82 attached to the extending rod 78 will block the aperture 48 of floating piston 46 such that the hydraulic pressure from the hydraulic pressure supply 52 is effectively disconnected from the cushion chambers 37 of the hydraulic cushion 30. The extending rod 78 is received in an aperture 84 in the pressure control device 41 with suitable bearing 88 interposed therebetween. A seal 85 is provided such that the hydraulic fluid under pressure cannot escape therefrom. The piston 82, integral with the extending rod 78, is slidably received in the aperture 44 of the valve body 42 and has suitable bearing member 90 and sealing means 91 interposed therebetween.

An expansion chamber 94 is provided by an opening 96 in the valve body 42. The piston 82 includes a movable wall portion or shoulder 83 which defines a portion of the expansion chamber 94 and is adapted to expand the expansion chamber 94 as the extending rod 78 and piston 82 move in response to the downward movement of the ram 12 through its work stroke. The expansion chamber 94 is connected to the cushion chamber 37 by passageway 95 which includes passageway 38 in the baseplate 40. As the piston 82 is moved, movable wall portion 83 of the expansion chamber 94 moves correspondingly such that the expansion chamber 94 expands to include a portion of the body 42 defined by aperture 44. When the predetermined distance 70 of the upper die portion 34 is traveled by the ram 12, the contact surface 100 of piston 82 contacts the contact surface 102 of floating piston 46 to block the passage 54 connecting the hydraulic pressure supply 52 to the cushion chambers 37 such that the hydraulic pressure supply 52 is disconnected from the hydraulic cushion chambers 37.

A spring 106 provides an initial bias for holding the floating piston 46 in its upper position as shown in FIG. 2. In such a position the retaining member 109 engages a counterbored surface of the aperture 44 to prohibit further upward movement of the floating piston 46. A suitable hydraulic pressure sealing means 107 and bearing member 108 is provided between the floating piston 46 and the aperture 44 to allow free movement of the floating piston 46 in the aperture 44 while prohibiting hydraulic fluid from the hydraulic fluid supply to pass around the floating piston 46. Thus, hydraulic fluid from the hydraulic fluid supply is required to flow through the aperture 44 of the floating piston 46 in order to create a pressure in the hydraulic cushion chambers 37.

In order to better complete formation of the shell 21 as shown in FIG. 4 from the blank 18 as shown in FIG. 8, the yieldable opposing force of the pressure pad 24 must be removed at the predetermined distance 70 of the work stroke of the ram 12, as shown in FIG. 7. Thus, when the upper die portion 34 completes the formation of the blank 18, as shown in FIG. 8, a smooth shell will be formed having peripheral walls 18b which are substantially free of wrinkles, tears and significant changes in the wall section.

As the upper die portion 34 moves from the predetermined distance 70 to complete its work stroke, the pressure pad 24 continues to move in the same direction as the upper die portion 34, but no longer provides a yieldable opposing force. Consequently, the plungers 28 continue to move in the same direction and continue to displace fluid in the hydraulic cushion chambers 37.

The piston 82 and the floating piston 46 move a corresponding distance in response to the contact member 74. As the

piston 82 so moves, the rate of expansion of the expansion chamber 94 is greater than the volume of hydraulic fluid displaced by the plungers 28 in hydraulic cushion chambers 37. Since the expansion chamber 94 is in communication with the hydraulic cushion chambers 37 through passageway 95, the hydraulic pressure in the hydraulic cushion chambers 37 will continue to be relieved by such expansion. Thus, the yieldable opposing force created on the plungers 28 by hydraulic fluid pressure thereon is removed through the remainder of the work stroke of the ram 12.

It should be understood that the rate of expansion of the expansion chamber 94 may be equal to the rate of contraction of the hydraulic cushion cylinders 37 if the initial pressure created by the hydraulic pressure supply 52 before it is disconnected from the hydraulic cushion 30 is removed. On the other hand, if the rate of expansion is greater than the rate of contraction of the hydraulic cushion chambers 37, the hydraulic fluid contained in the hydraulic cushion chambers 37 will be "sucked" out of the hydraulic cushion chambers 37. Thus, a "vacuum" will be created on the plungers 28 and tend to pull the plungers 28 in the direction of movement of the upper die portion 34 when shaping the blank 18.

But it should be apparent to those skilled in the art that the hydraulic pressure supply 52 need not be completely disconnected from the hydraulic cushion 30 in order to release the hydraulic fluid pressure in the cushion cylinder if the expansion chamber 94 expands at any rate sufficient to remove such pressure.

Once the blank 18 is formed into a shell 21, as shown in FIG. 4, the ram 12 will move in an upward direction to return to its original position. As the ram 12 so moves, the contact member 74 allows the extending rod 78 to return to its original position. This return movement is accomplished by the hydraulic pressure from the hydraulic fluid pressure supply 52 through the aperture 48 of passageway 39 creating an upward force on the piston 82. As the piston 82 returns to its original position, the spring 106 urges floating piston 46 to return to its original position. When the floating piston 46 has reached its original position, a retaining member 109 prohibits further upward movement of the floating piston 46.

The piston 82 continues to move in an upward direction due to the hydraulic pressure created by the hydraulic fluid supply 52. Throughout the upward movement of the piston 82, the expansion chamber 94 returns to its original volume. The hydraulic fluid is supplied to the hydraulic cushion chambers 37 under pressure and returns the plungers 28 to their original position by creating an upward force on the lower ends 28a of the plungers 28. When the piston 82 returns to its original position, hydraulic pressure is supplied by the hydraulic pressure supply means through the hydraulic pressure passageway 54 to the hydraulic cushion chambers 37 to continue upward movement of the plungers 28 until the plungers 28, and consequently the pressure pad 24, return to their respective original positions.

It should be understood that as the pressure pad 24 returns to its original position, it may act as a stripper to remove the shell 21 formed by the blank 18 from the lower die 26. After ejection of the shell, the sheet material 16 may be advanced and the operational sequence aforementioned continued repeatedly.

It should be noted that both the hydraulic pressure passageway 54 and the passageway 95 are each of a sufficient size to allow free flow of hydraulic fluid and are defined by rigid bodies such that when hydraulic pressure is exerted, they do not enlarge or expand. This provides for a more instantaneous pressure release on the hydraulic cushion 30 by decreasing the time lag associated with the contraction of the hydraulic pressure passageway 54 and the passageway 95 when hydraulic pressure is removed since their normal contraction during this change in pressure would act as an accumulator in the system.

It should be understood that any fluid such as a gas could be used in such a hydraulic system hereinabove described. The

pressure control apparatus of the immediate invention could be utilized to reduce the pressure in such a fluid system in response to movement of the ram through a predetermined portion of its work stroke as described above.

In order to facilitate charging of the hydraulic cushion chambers 37, a threaded plug 116 engages an extension 118 of passageway 38 and may be removed when hydraulic fluid is supplied by the hydraulic pressure supply 52 to charge the system. When the plungers 28 are in the down position such that they fill the hydraulic cushion chambers 37, hydraulic fluid may be supplied to the assembly to substantially fill it. When the system is full, the threaded plug 116 is threadedly engaged with passageway extension 118 to seal the system from leakage therethrough.

Thus, it may be seen that a stamping apparatus which allows a blank 18 to be shaped into a shell 21 having a wall portion 18a which is substantially free from wrinkles, tears, and rough edges is provided. In order to accomplish this result, the present invention provides a stamping apparatus wherein a pressure pad 24 supports the peripheral area of a blank 18 and an upper die portion 34 is provided for shaping the blank 18. A hydraulic cushion 30 contacts the pressure pad 24 to provide a yieldable opposing force to the movement of the upper die portion 34 as it shapes the material through the predetermined distance 70. The yieldable opposing force is created by hydraulic pressure from a hydraulic pressure supply 52 acting on the lower ends 28a of the plungers 38 in the hydraulic cushion 30. After the upper die portion 34 has moved through the predetermined distance 70, an expansion chamber 94 which is connected by passageway 95 to the hydraulic cushion 30 expands to remove the yieldable opposing force on the pressure pad 24 during the remainder of the work stroke of the upper die portion 34 such that a shell 21 is provided without detrimental wrinkling, cross-sectional changes or rough edges.

When two shells are required to be formed during one work stroke of the press, a pair of upper and lower dies will be required to be mounted in the stamping press. Consequently, a corresponding pair of hydraulic cushions will be required to provide their corresponding pressure pads with a force which yieldably opposes movement of the upper dies during a portion of the work stroke of the upper dies. It should be understood that the operation of each of these upper and lower die portions will operate in the same manner as described hereinabove in connection with FIGS. 1-8. Since the shapes may be changed, the size of the dies and consequently their center distances may change.

For ease of description, the suffixes *a* and *b* will be used in connection with the common numerals of those shown in FIGS. 1-8.

To change the positions of the hydraulic cushion cylinders 30a and 30b, as best shown in FIG. 9, with respect to each other while maintaining them in a centered relationship with respect to their corresponding pressure pads, a cushion base mounting plate 150 is attached to the lower mounting plate 14a of a stamping press. The base mounting plate 150 has a slot 152 to receive an extension 154 of a center spacer block 156.

When locating the hydraulic cushion cylinders 30a and 30b with respect to their corresponding lower die portions, the spacer block 156 is positioned such that its extension 154 is received by the slot 152. The ground surfaces 160 and 162 are provided on the spacer block 156 such that when the hydraulic cushion chambers 30a and 30b are in communication with these surfaces 160 and 162, respectively, they will be centered with respect to their corresponding lower and upper die portions and corresponding pressure pad. Thus, the distance between the surfaces 160 and 162 determines the center distance of the hydraulic cushions 30a and 30b when so positioned. It will be understood that various spacer blocks 156 may be used having different distances between surfaces 160 and 162 to provide for correspondingly different centers of the hydraulic cushion cylinders 30a and 30b when the dies are changed to provide for manufacture of a different shell.

In order to prohibit the hydraulic cushions 30a and 30b from relative movement with respect to the baseplate 150, cushion bases 40a and 40b are provided respectively with ear portions 166 thereon. The baseplates 40a and 40b are slidably mounted on the base mounting plate 150 in a direction 165 and 166, respectively since the ears 166 of baseplates 40a and 40b are retained by rails 170. The rails 170 are attached to the base mounting plate 150 by means of threaded fasteners 172. When the threaded fasteners 172 are loosened, the hydraulic cushions 30a and 30b may be moved along the line of direction 165 to position them against surfaces 160 and 162 of the spacer block 156. In this manner, the hydraulic cushions 30a and 30b may be properly centered with respect to their respective die portions. When the hydraulic cushions 30a and 30b are properly positioned, the threaded fasteners 172 are tightened such that they are retained on the base mounting plate 150.

The construction shown in FIGS. 9 and 10 includes novel fluid connections between the hydraulic cushions 30a and 30b and the base mounting plate 150. When the hydraulic cushions 30a and 30b are slid along direction 165 while retained by the rails 170, the fluid connections 176 and 176' do not require that the hydraulic system be disconnected to effect such movement. For ease of description, only the hydraulic connection 176 will be described in detail as shown in FIG. 10, but it should be understood that the fluid connection 176' has corresponding parts and operates in a manner similar to the fluid connection 176.

Fluid connection 176 includes a tube 180 of solid material which is suitably attached to the baseplate 40a of hydraulic cushion 30a. A threaded aperture 182 is provided in baseplate 40a to threadedly engage a threaded end portion 184 of the tube 180 to effect a fluidtight seal therewith. Thus, the passageway 181 of the tube 180 is in communication with the passageway 38a in the baseplate 40a.

The tube 180 is telescopically received in an aperture 186 of the interconnecting block 190. The interconnecting block 190 is attached to the base mounting plate 150 and provides for an interconnection between a passageway 192 in the base mounting plate 150 and a passageway 181 of the tube 180. Suitable sealing means 194 are provided between the tube 180 and the aperture 186 to prohibit leakage of hydraulic fluid under pressure.

Hydraulic pressure may be supplied by the hydraulic pressure supply 52a which is of a construction similar to the hydraulic pressure supply 52. The hydraulic pressure is supplied to a pressure control device 41a which operates in a manner as described hereinabove in connection with the pressure control device 41. It must be understood, though, that the volume of the expanding chamber 94a of the pressure control device 41a is sufficient to release the pressure in both hydraulic cushions 30a and 30b. It should also be apparent that a number of pressure control devices similar to the construction as described in connection with pressure control device 41 may be used in a similar manner to release the yieldably opposing force on the pressure pad.

The passageways 95a and 39a extending from the pressure control device 41a flow to a common passageway 191 which includes passageway 192 in the block 190, the passageway 181, and the passageway 192' in the block 190'. Thus, the common passageway 191 may apply pressure to or remove pressure from the hydraulic cushions 30a and 30b. The operational cycle of this device is similar to that above described in connection with the hydraulic cushion 30 and valve 41.

It should be pointed out that the hydraulic cushion cylinders 30a and 30b may be moved respectively with each other such that their centers are adjusted without disconnecting their connections to the hydraulic system above described. These connections include passageways defined by solid members throughout which allows for an instantaneous pressure release on the hydraulic cushions 30a and 30b by the valve 41'. The response time of this system is minimized since the members defining the hydraulic passageway 191 will not expand when hydraulic pressure is applied thereto or contract when the fluid pressure is removed therefrom.

When it is desirous for a blank to be formed in a shape having two sidewalls, it is necessary to have two pressure pads. The upper die 201, shown schematically in FIG. 13 and constructed in a manner known by those skilled in the art, urges the blank 18 against the lower die 203 and subsequently forms the blank 18 as shown in FIG. 13.

As the upper die 201 descends, a sidewall 200 is formed. At a first predetermined distance the first pressure pad 224 is relieved of its yieldable opposing force to the downward movement of the upper die 224 for reasons hereinabove set forth in connection with FIGS. 1-8.

This yieldable opposing force on the pressure pad 224 is created by the plungers 202 of the hydraulic cushion means 204. These plungers 202 are received in the apertures 206 as described in connection with the plungers 28 mounted in the hydraulic cushion 30. Hydraulic fluid under pressure in the chambers 210 of the hydraulic cushion 204 creates the yieldably opposing force on the plungers 202. The hydraulic pressure is supplied to the chambers 210 by a passageway 212 through a pressure control device similar in construction to the pressure control device 41 which is adapted to release pressure after the sidewall 200 has been partially formed and operates in a manner in conjunction with the plungers 202 similar to the operation of the apparatus shown in FIG. 2. Thus, the first pressure control device removes the yieldable opposing force on the first pressure pad 230 in response to movement of the upper die portion 201 through a first predetermined distance.

It should be understood that the passageway 212 connecting the first chambers 210 of the hydraulic cushion 204 to the hydraulic pressure supply includes a number of passageways 216 corresponding to each of chambers 210 in base 218, as shown in perspective in FIG. 14. These passageways 216 are in communication with a first annular groove 220 in the base block 222. The first annular groove 220 is connect to a pressure control device having a construction similar to that as shown by the pressure control device 41 as is apparent from the above.

After the yieldable opposing force on the pressure pad 224 has been removed, the sidewall 200 will continue to be formed until the pressure pad 224 bottoms out against surface 230 of lower die 203. At this point, the pressure pad 224 remains fixed with respect to the lower die 203 and the upper die 201 continues to descend and deform the blank 18 such that a second sidewall 234 is formed.

Throughout a portion of the downward movement of the upper die 201 the pressure pad 241 yieldably opposes the downward movement of the upper die 201 such that the blank is controlled.

The pressure pad 241 is supported by the plungers 240 which are received in apertures 242 of hydraulic cushion 204 and of a similar construction to that mentioned in connection with the hydraulic cushion 30. Hydraulic cushion chambers 244 are provided to receive hydraulic fluid under pressure and create a yieldable opposing force on the plungers 240 which in turn transfer the force to the pressure pad 241. The hydraulic fluid is supplied through a passageway 246 which includes a passageway 250 in the base plate 218 which is connected to a second annular groove 252 in the base block 22, as best shown in perspective in FIG. 14. This annular groove 252 is connected to a second pressure control device constructed in accordance with the pressure control device 41 hereinabove described with a suitable hydraulic pressure supply associated therewith. After movement of the upper die 201 through a second predetermined distance as indicated at 235 in FIG. 13, it is desirable to remove the yieldable opposing force created by the fluid pressure in the hydraulic cushion chambers 244. Thus, the second pressure control device constructed in accordance with pressure control device 41 hereinabove described releases the pressure in the hydraulic cushion chambers 244 through passageway 246 in response to the downward movement of the upper die 201 through a second predetermined distance 202. This allows for complete formation of a shell having sidewalls 200 and 234 with a minimum number of wrinkled, cracked, or burred edges.

An alternative design for the passageways for a hydraulic cushion to form a shell having two sidewalls is shown in FIGS. 11 and 12. For ease of description, parts shown in FIGS. 11 and 12 which are common to parts shown in FIGS. 13 and 14 will be denoted by primed numerals. Thus, the plungers 202' and 240' operate in a similar manner as described in connection with plungers 202 and 240 correspondingly.

The passageway 212' included a peripheral annular groove 260 extending about the periphery of the hydraulic cushion body 262 of the valve 256 such that it is in communication with each of the three fluid chambers 210' through corresponding passageways 264. The passageway 212' further includes an outlet 273 which is in turn connected to a first valve constructed in accordance with the valve 41 as described hereinabove and adapted to be actuated as hereinabove described in connection with hydraulic chambers 210.

A second annular groove 270 is included in passageway 246'. The hydraulic cushion chambers 244' are in communication with the annular groove 270 by means of passageways 272 connecting them therebetween. The passageway 246' further includes an outlet 274 which is in turn connected to a second valve constructed in accordance with the valve 41 as hereinabove described in connection with hydraulic chambers 244.

It should be understood that the hydraulic cushions representatively shown in FIGS. 11-14 could also be advantageously used wherever it is desirable to have a pressure pad with rings which apply different pressure.

From the foregoing, it should be apparent that a stamping apparatus has been provided with a pressure pad 24 for supporting sheet material 16 thereon and a movable upper die 22 having a movable upper die portion 34 for shaping the sheet material 16 supported on the pressure pad 24. A hydraulic cushion 30 provides a yieldable opposing force on the pressure pad 24 to movement of the upper die portion 34 during shaping of the sheet material 16. This yieldable opposing force is created by means of hydraulic pressure supplied to the hydraulic cushion 30. An expansion chamber 96 is connected to the hydraulic cushion 30 by passageway 95 and is expandable after movement of the upper die portion 34 through a predetermined distance 70 at a rate sufficient to relieve the hydraulic pressure in the hydraulic cushion 30. Thus, after the upper die portion 34 has moved through the predetermined distance 70, the yieldable opposition by the hydraulic cushion 30 to movement of the pressure pad 24 in the direction of movement of the upper die portion 34 during shaping of the sheet material 16 is removed.

Having described my invention, I claim:

1. In a machine, a first member movable in one direction along a path, hydraulic cushion means adapted to provide a yieldable opposing force to said member during a portion of its movement along said path, a hydraulic pressure supply for supplying hydraulic pressure to said hydraulic cushion means for creating the yieldable opposing force, expansion chamber means defining an expansion chamber connected in fluid communication with said hydraulic cushion means, and actuating means for expanding said chamber to completely remove the hydraulic pressure from said hydraulic cushion means after said first member has moved through a predetermined portion of said path, said actuating means including means for expanding said chamber at a rate sufficient to reduce the hydraulic pressure in said hydraulic cushion means to a pressure which is equal to or less than ambient pressure.

2. In a machine having pressure pad means for supporting material and a first member for shaping the material supported on said pressure pad means, hydraulic cushion means yieldably opposing movement of said pressure pad means in the one direction by hydraulic pressure from a hydraulic pressure supply, said first member upon movement effecting movement of said pressure pad means during shaping of the material, and pressure control means for instantaneously and completely relieving the yieldable opposition of said hydraulic cushion means, said pressure control means including expansion chamber means connected by passageways to said

hydraulic cushion means and expandable after said first member moves through a predetermined portion of the work stroke to provide an increase in volume greater than the volume of fluid displaced by said hydraulic cushion means during movement of said pressure pad means such that the yieldable opposition by said hydraulic cushion means is completely relieved.

3. A method for forming material partially supported by pressure pad means with a movable upper die portion for forming the material comprising providing hydraulic pressure from a hydraulic pressure supply to hydraulic cushion means through a pressure passage for yieldably opposing motion of said pressure pad means in a direction opposite the direction of movement of the upper die portion when the material is formed, and after movement of said pressure pad through a predetermined portion of the work stroke expanding the volume of an expansion chamber connected to said hydraulic cushion means at a volumetric rate which is greater than the volumetric rate of displacement of hydraulic fluid from said hydraulic cushion means such that the yieldable opposition to movement of said pressure pad means is completely removed.

4. In a machine as defined in claim 1 wherein said hydraulic cushion means includes at least one cushion chamber adapted to receive hydraulic fluid under pressure, said one cushion chamber having a volume dependent on the position of said first member along said path, said expansion chamber means including a movable wall portion to vary the volume of said expansion chamber, said one cushion chamber being connected to said expansion chamber by passageways therebetween, said expansion chamber being expanded at a rate greater than the rate of contraction of the volume of said one cushion chamber on movement of said first member through said predetermined portion of said path such that the yieldable opposition by said hydraulic cushion means is completely relieved and the hydraulic pressure in said hydraulic cushion means is reduced to a pressure which is below ambient pressure.

5. In a machine as defined in claim 1 having means providing a passageway connecting said hydraulic pressure supply to said hydraulic cushion means, said passageway being restricted after movement of said member through said predetermined portion of said path.

6. In a machine as defined in claim 5 having a passageway connecting said hydraulic pressure supply to said hydraulic cushion means, and further comprising pressure control means for blocking said passageway after movement of said first member through said predetermined portion of said path to disconnect the hydraulic pressure supply from said hydraulic cushion means.

7. In a machine as defined in claim 1 wherein said expansion chamber is expanded at a rate such that said hydraulic cushion means is urged in the direction opposite to said one direction.

8. A machine as defined in claim 4 wherein said passageways are defined by at least one substantially rigid body such that the volume of said passageways remains substantially constant upon removal of fluid pressure to allow a substantially instantaneous pressure release of the hydraulic pressure in said one hydraulic cushion means.

9. In a machine as defined in claim 4 wherein a fluid chamber consists of said one cushion chamber, passageways connecting said one cushion chamber to said expansion chamber, said fluid chamber having an increasing volume after movement of said upper die portion through the predetermined portion of said path such that the yieldable urging of said pressure pad means in a direction opposite to the movement of said upper die portion is completely removed at the predetermined distance.

10. In a machine as defined in claim 2 having a pressure passageway from said hydraulic pressure supply to said hydraulic cushion means, said pressure control means restricting said pressure passageway upon movement of said first member through a predetermined portion of the work stroke.

11. In a machine as defined in claim 2 wherein said pressure control means includes means to disconnect the hydraulic pressure supply from said hydraulic cushion means upon movement of said movable die portion through the predetermined portion of the work stroke.

12. In a machine as defined in claim 2 and including pressure control means having means defining a pressure passageway therethrough connecting the hydraulic pressure supply with said hydraulic cushion means and a piston movable upon movement of said first member through said predetermined portion of said work stroke to block the pressure passageway in response to movement of said first member to disconnect said hydraulic pressure supply from said hydraulic cushion means.

13. In a machine as defined in claim 2 wherein said pressure control means includes a piston, a floating piston, a pressure passageway connecting the hydraulic pressure supply with said hydraulic cushion means, a body having an aperture therein adapted to receive said piston and said floating piston, said floating piston defining a portion of said pressure passageway, said expansion chamber having a movable wall portion consisting of a portion of said piston, said piston operable from one position in response to movement of said first member through the predetermined portion of the work stroke to block said pressure passageway and operable to provide for the expansion of said expansion chamber from its original volume to receive the fluid displaced by said hydraulic cushion means.

14. In a machine as defined in claim 13 wherein said piston is adapted to block said pressure passageway portion defined by said floating piston at a contact position in response to movement of said first member through the predetermined portion of the work stroke, said piston and said floating piston remaining in contact throughout the remainder of the work stroke of said first member such that the hydraulic pressure supply remains disconnected from said hydraulic cushion means through the remainder of the work stroke.

15. In a machine as defined in claim 14 wherein said pressure control means includes biasing means to return said floating piston to said contact position during the upward stroke of said first member.

16. In a machine as defined in claim 13 wherein said piston is returned to said one position by the hydraulic pressure from said hydraulic pressure supply during the upward stroke of said first member such that the volume of said expansion chamber returns to a volume less than said original volume such that said pressure passageway is no longer blocked by said piston.

17. In a machine as defined in claim 13 wherein said pressure pad means includes a plurality of pressure pads, said hydraulic cushion means including a corresponding plurality of hydraulic cushions, said pressure control means including a corresponding plurality of pressure control devices, each of said corresponding hydraulic cushions connected to one of said corresponding pressure control devices and its corresponding pressure pad means.

18. In a machine as defined in claim 13 wherein said pressure pad means includes a first and a second part, said hydraulic cushion means having housing means including a base member having apertures therein, hydraulic plungers adapted to be slidably received by said apertures of said housing means, at least one portion of said hydraulic plungers having one end thereof in contact with said first part of said pressure pad means and at least another portion of said hydraulic plungers having one end thereof in contact with said second part of said pressure pad means, said housing means having a first and second annular groove therein, said pressure control means including a first pressure control device connected to said first annular groove and a second pressure control device connected to said second annular groove, said first pressure control device adapted to actuate in response to movement of said first member through a first predetermined portion of the work stroke and said second pressure control device adapted

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to actuate in response to movement of said upper die portion through a second predetermined portion of the work stroke.

19. In a machine as defined in claim 2 wherein said hydraulic cushion means includes plunger means, and a hydraulic cushion body having at least one aperture therein adapted to receive said plunger means, said plunger means adapted to have fluid pressure acting on one end portion thereof to provide for said yieldable opposition.

20. A method for forming material as defined in claim 3 which includes restricting said pressure passage upon movement of said pressure pad through a predetermined portion of its work stroke.

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21. A method for forming material as defined in claim 20 in which restricting said pressure passage includes blocking said pressure passage such that the hydraulic pressure supply is disconnected from said hydraulic cushion means.

22. A method for forming material as defined in claim 3 in which expanding said expansion chamber includes expanding the volume of said expansion chamber at a rate greater than the rate of volume displaced by said hydraulic cushion means such that the yieldable opposition to movement of said pressure pad means is completely removed.

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