July 9, 1968 R. A. MYERS 3,391,559

DIAPHRAGM TYPE HYDRAULIC PRESS

Filed Nov. 10, 1965 2 Sheets-Sheet 1

Fig. 1

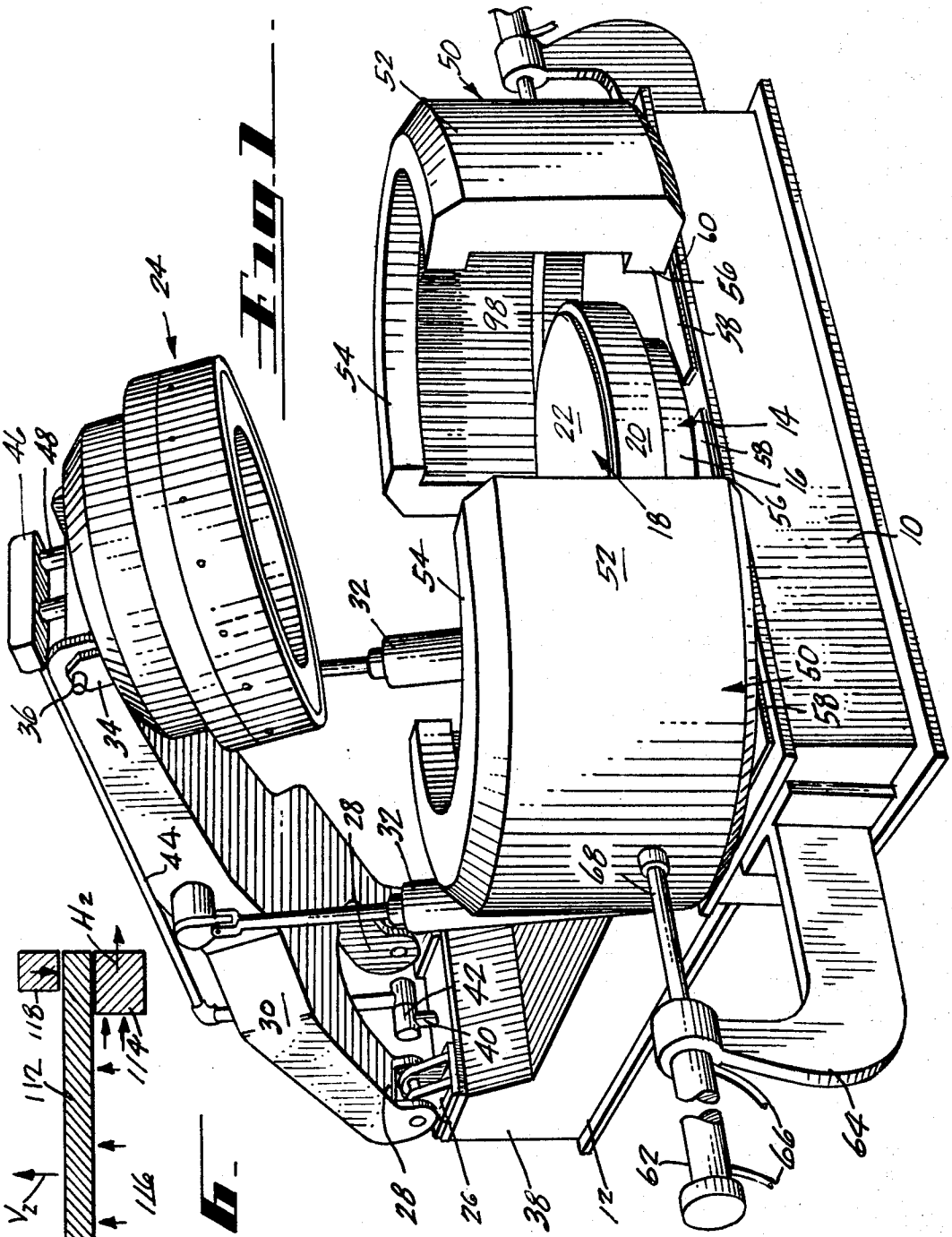


Fig. 6

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DIAPHRAGM TYPE HYDRAULIC PRESS

Filed Nov. 10, 1965 2 Sheets-Sheet 2

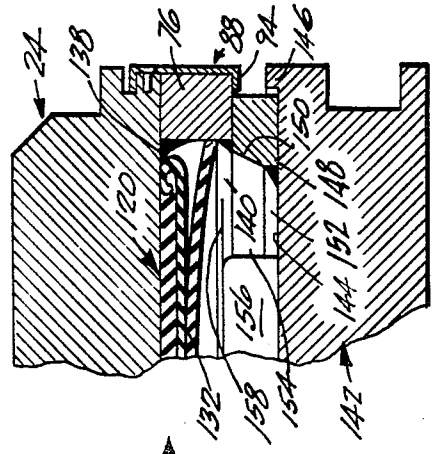


Fig. 4

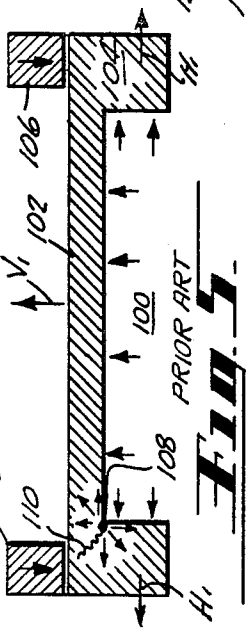


Fig. 5
PRIOR ART

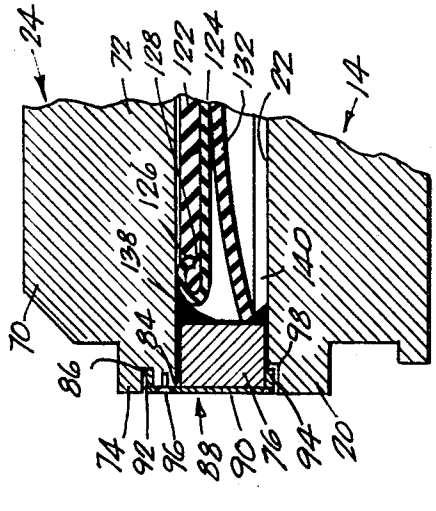


Fig. 7

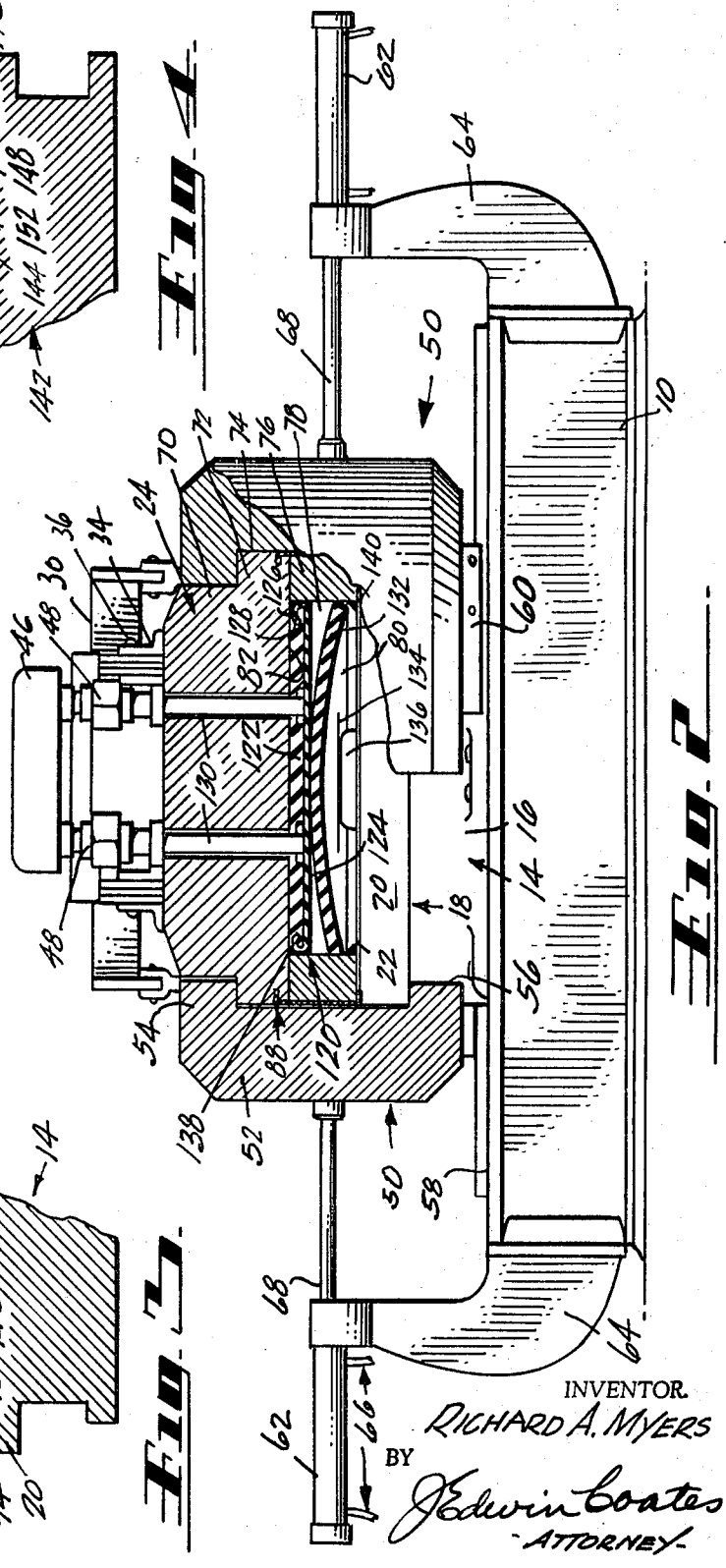


Fig. 2

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3,391,559

DIAPHRAGM TYPE HYDRAULIC PRESS

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16 Claims. (Cl. 72—63)

ABSTRACT OF THE DISCLOSURE

Sheet metal forming press with an enclosed chamber to hold form block and sheet of metal. Rubber or other yieldable diaphragm or wall is pressurally urged toward workpiece to form it about the form block. Chamber is defined by head platen, base platen, and tension ring means which constitute the side walls of the chamber. In form shown, clamp rings grip margins of platens to prevent vertical separation during forming operation. Tension ring means may be one or more rings of metal which are free to expand or contract radially independently of the platens in response to variations in the forming pressure. The tension rings absorb the radial pressure load and the platens absorb the vertical pressure load separately to prevent concentrated bending strains in inside corners of integral cavity.

This invention lies in the field of hydraulic diaphragm type presses in which the main body members of such a press define, during a forming operation, a completely enclosed cavity or chamber containing a form block and a workpiece of sheet metal to be formed thereon together with an expansible diaphragm adapted to apply hydraulic forming pressure to the workpiece. The invention is directed particularly to a construction and arrangement of such a press in which the hoop tension stresses in the surrounding wall are isolated or segregated from the vertical load stresses applied to the body portions defining the upper and lower walls of the cavity so that corner bending stress concentrations are avoided.

Various types of hydraulic sheet metal forming presses are now in use which utilize the generally similar principle of confining a sheet metal workpiece on a form block within a cavity or chamber of the press body having generally horizontally extending upper and lower walls and a surrounding side wall which is integral with one of the other walls, usually the upper one. This provides an upper body member with a downwardly opening cavity and a generally flat lower body member, separable from each other for loading and unloading. The work is supported by the bottom wall. A hydraulically expansible container, usually comprising a metal plate and an elastomeric diaphragm joined at their edges, is mounted adjacent the upper wall and extends across the width of the cavity. An elastomeric pad is mounted directly beneath the container or bag and also extends across the width of the cavity. A hydraulic pump is used to force oil or other liquid into the container to expand it and force the pad down toward the lower wall until it contacts the workpiece and forces it to conform to the surface of the form block.

When the bag is fully expanded, there is substantially uniform hydraulic pressure exerted against every portion of the interior of the chamber. In most cases the working pressure is 5000 p.s.i., and in some presses it is as high as 10,000 p.s.i. Thus it will be seen that the vertical and radial loads are extremely high. The vertical separation loads are taken by various means such as tension

bolts, clamps, and the like. The radial loads are taken by the side wall which expands and develops hoop tension. This expansion is resisted by the integral connection with the upper body member and corner bending loads are developed which result in very high stress concentrations at the inner corners of the junction between the upper member and the side wall. Since the load is applied and withdrawn during each forming operation there is a continuously repeated stress reversal which produces fatique failure at the junction. While cracks may be repaired by welding, this is a very unsatisfactory solution, so the press part is normally scrapped and replaced. This is very expensive and time consuming, and the temporary loss of use of the press adds further expense.

The present invention completely overcomes this major and very expensive disadvantage of presses of conventional design. Generally speaking, it consists in providing a construction in which the upper and lower members absorb only the vertical loads, which may be converted into beam bending stresses, and the side wall is made independent of the upper and lower members so that it can expand independently under radial loads and convert them into hoop tension without producing any corner bending stresses.

The press disclosed herein, by way of example, embodies the invention in a simple but highly satisfactory arrangement. In general, the press comprises a base on which is rigidly fixed a lower platen having a horizontally extending upper face which is preferably flat. An upper platen is movably carried by the base for movement between an upper, inoperative position for loading and unloading and a lower operative position in which it is spaced a predetermined distance above the lower platen. In operative position, its lower face extends horizontally and is also preferably flat. Both platens are substantially circular in planform and have flange-like margins adapted to be engaged by means for preventing vertical separation.

In order to provide the downwardly opening cavity to receive the forming unit a tension ring is attached to the upper platen. This ring is annular in planform and has a uniform cross section throughout its periphery to preclude stress concentrations. The connection is accomplished by the use of a support ring which is wrapped substantially around the lower part of the margin of the upper platen and fixedly secured thereto. The lower edge of the support ring is formed with an inwardly extending flange which underlies the outer edge of the tension ring and supports it just in contact with the lower face of the platen. Thus the tension ring will not separate vertically from the platen but is free to expand and contract radially under forming loads. The support ring is sufficiently larger than the tension ring to provide adequate clearance for expansion of the latter.

The cavity formed by the joining of the tension ring to the upper platen houses the hydraulically expansible bag and the forming pad in normal fashion, and the upper face of the lower platen provides the support for one or more workpieces and form means or blocks. When the upper platen is lowered to operative position the tension ring is brought into contact with the lower platen to constitute a side wall and define with the two platens a forming chamber. A pair of clamps are movably mounted on the base and each consists of an arcuate member of channel shaped cross section with upright webs and inwardly directed flanges. The flanges are spaced just far enough apart to encompass the flange-like margins of the platens, and when the clamps are moved to operative position their flanges overlie and underlie these margins to take the vertical loads and prevent vertical separation of the platens during the forming operation.

A hydraulic system for the press includes a fluid reservoir, a pump, and conduit means leading to the upper platen to force fluid into the bag and expand it. When the bag expands, it forces the forming pad down toward the lower platen and into contact with the workpiece to force it to conform to the surface of the form means or block. Sufficient fluid is introduced to fill all of the voids in the chamber, and the hydraulic pressure is substantially uniform against all of the interior surfaces. The pressure against the upper and lower platens is entirely vertical and is resisted by the clamps. The radial pressure is absorbed entirely by the tension ring which expands slightly and converts the force into hoop tension. Since the tension ring is not locked to either platen, its expansion movement is independent, and no corner bending forces can be developed. Stress concentrations are eliminated and fatigue failure is avoided.

Various other advantages and features of novelty will become apparent as the description proceeds in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view of a press embodying the invention;

FIG. 2 is an elevational view, partly in section, of the press of this invention;

FIG. 3 is a sectional view in elevation to an enlarged scale, showing certain details of the invention;

FIG. 4 is a view similar to FIG. 3 showing a modified form of the invention; and

FIGS. 5 and 6 are diagrammatic illustrations of the different stress effects in the known construction and the new construction.

The presently preferred form of press incorporating the features of the invention is illustrated in simplified form in FIG. 1, in which an elongate structural steel base **10** is provided with a hollow lateral extension **12**. Fixedly mounted in a central position on the base is a lower platen **14** having a supporting body portion **16** and a head portion **18**. The latter is circular in planform and overhangs the body portion to present a flange-like margin **20**. The face **22** extends horizontally and is preferably flat. Upper, or head, platen **24**, shown in more detail in FIG. 2, is also circular in planform and is movably mounted on the base for movement from the inoperative loading and unloading position of FIG. 1 to the operative forming position of FIG. 2. Extension **12** carries pivot brackets **26** to which are pivotally connected the rearward extremities **28** of arm **30**, the latter being raised and lowered as desired by hydraulic jacks **32**. Platen **24** is provided with ears **34** which are pivotally connected by pins **36** to the forward free end of arm **30**.

The enlarged portion **38** of extension **12** contains a fluid reservoir and pump means, not shown, to provide hydraulic power for the various functions of the press. Fluid for the forming operation is supplied to platen **24** through conduit **40**, swivel joint **42**, conduit **44**, header **46**, and conduits **48**. Swivel joint **42** is aligned with the pivotal connection of arm **30**.

When platen **24** is lowered to the operative forming position of FIG. 2, the two platens are locked against vertical separation by a pair of clamp members **50**. Each of these members is arcuate in planform and channel shaped in cross section, having upright webs **52** and upper and lower inwardly extending flanges **54** and **56** which engage above and below the margins of the platens. The upper surface of base **10** is provided with guide tracks **58** extending longitudinally, and the clamp members **50** are provided with track engaging means **60** to guide the movement of the clamp members rectilinearly on the tracks toward and away from the platens. The movement is provided by hydraulic servo motors **62** carried on brackets **64** secured to the ends of base **10**. The servo motors are supplied with pressure fluid through conduits **66** and the inner ends of their piston rods **68** are connected to the outer walls of the clamp members.

Turning now to FIG. 2 where the press is shown in closed position ready for a forming operation, it will be seen that the upper platen **24** is very similar to the lower platen. It has an upper body portion **70** and a lower head portion **72** which is larger than portion **70** to form a flange-like margin **74**. A tension ring **76** is connected to platen **24** in a depending position to form with face **82** a cavity **78** for the reception of the forming unit, and the two platens and the tension ring cooperate to define a closed forming chamber **80**.

The manner in which tension ring **76** is connected to platen **24** is shown in enlarged detail in FIG. 3. The lower portion of the flange-like margin **74** is slightly reduced in diameter at **84** and is further provided with an annular groove **86**. Support ring **88** has a channel shaped cross section with an upright web **90**, an upper flange **92** extending inwardly, and a lower flange **94** extending inwardly. Ring **88** is wrapped around margin **74** with its flange **92** seated in groove **86** and its free ends in juxtaposition but not joined. A series of peripherally spaced machine screws **96** retain the ring against displacement, and the engagement of flange **92** in groove **86** transmits the gravity load of ring **76**.

Flange **94** underlies the outer margin of ring **76**, supporting it in a position just in contact with face **82** of the platen **24** so that there is no significant clearance, but the ring is free to move radially independently of the platen. The inner diameter of support ring **88** is sufficiently larger than the outer diameter of tension ring **76** to provide adequate clearance for the maximum expansion of the latter under any design working load. Since ring **76** works under tension it is important to avoid notch effects, so flange **94** extends below its rectangular cross section. To close the chamber **80** tightly for the forming operation ring **76** must also contact margin **20** of the lower platen **14** in tight relation. Therefore a shallow undercut **98** is formed in the edge of margin **20** to provide adequate clearance for flange **94**. This is permissible because this is not a high stress area in margin **20**.

The diameter of margin **74** is reduced at **84** to the extent necessary to accommodate the thickness of support ring **88**. Therefore the webs **52** of clamp members **50** can be moved into close contact with the maximum diameters of margins **74** and **20**. The spacing of flanges **54** and **56** corresponds, to tolerance limits, with the total height of the assembly of the tension ring and the two platen margins so that when the clamp members are closed as in FIG. 2 there is maximum area of contact for transfer of stress.

The difference in the effect of forming loads on conventional construction and on the new construction is diagrammatically illustrated in FIGS. 5 and 6. Both cases represent the head portion of a press having a cavity in which hydraulic pressure is applied uniformly to all of the interior walls. In the conventional construction shown in FIG. 5 a cavity **100** is formed by a flat head member **102** and a depending and surrounding side wall **104** integral with the head member **102**. The margin of the head member is restrained against vertical movement by a ring or series of blocks **106**. It will be seen that the resultant V_1 of the vertical fluid pressure applies a beam load to head member **102** which is counteracted by the downward force of member **106**. The resultant H_1 of the horizontal or radial fluid pressure tends to expand side wall **104** but, since the wall is integral with member **102**, it is not free to expand radially and force H_1 applies a bending moment about the corner zone where member **102** is restrained by ring **106**. The result is that at the inside corner indicated at **108** tension forces of varying magnitude are present in all directions as indicated by the arrows. These tensions are applied and relieved with each operation of the press, and the repeated concentration of tension stresses in this notch type inner corner leads to early fatigue failure resulting in cracks such as indicated at **110**, which force scrapping of the part.

In the construction of FIG. 6, the head member **112** is a simple platform and the side wall **114** is a tension ring freely slidable with respect to member **112** and cooperating with it to define the cavity **116**. Ring **118** restrains member **112** against vertical movement when the resultant vertical force V_2 is applied to it, and the member reacts in simple beam bending. The resultant H_2 of the horizontal or radial fluid pressure is absorbed by wall or ring **114** in hoop tension. Since the ring is independent of member **112** it expands in response to the load and no corner bending forces are built up. There is no notch effect to produce stress concentrations and the simple stresses in the two parts, although high, are easy to calculate and to resist. Thus the source of corner fatigue cracks is eliminated.

Returning to FIG. 2, it will be seen that cavity **78** contains an expansible pressure-fluid receiving container or bag **120** made up preferably of a circular flat plate **122** of metal and an elastomeric diaphragm **124**, the latter extending around the margin of plate **122** and having a bead **126** seated in a groove **128** in the upper surface of the plate. The plate lies adjacent face **82** of platen **24** and is held in position by conduits **130** which are continuations of conduits **48** passing through the platen and the plate and secured to the latter. The container **120** extends substantially entirely across the diameter of the cavity and, when pressure fluid is pumped in through conduits **130**, the diaphragm stretches and expands downwardly with its marginal portions contacting the inner wall of tension ring **76**.

A resilient, elastomeric, pressure-applying pad **132** extends across the cavity **78** immediately beneath container **120**. It is preferably made of rubber or neoprene of about **70** Shore hardness and is held in place as shown by virture of being slightly larger in diameter than the cavity and being forced into place to bind on the cavity wall. If desired, it may additionally be secured to the central portion of the diaphragm by a non-drying tacky or adhesive material. The pad is forced down by the expanding container or bag **120** toward upper face **22** of lower platen **18** until it contacts workpiece **134** mounted on form means or block **136** seated on face **122**. Continued expansion of the container forces the margins of the workpiece down around the side walls of the form block until it conforms to the surface of the form block.

Although the upper and lower platen and the tension ring are held tightly together during the forming operation, the small tolerance variations and the distortions resulting from the high loads usually produce small finite clearances sufficient to permit extrusion of rubber and similar materials under the very high fluid pressures. Therefore a seal ring **138** is provided at the junction of platen **24** and tension ring **76**. This metallic ring, preferably aluminum, is generally triangular in cross section with a concave inclined face to match the curvature of the diaphragm. Since it is elastic and of small cross sectional area the fluid pressure forces it tightly against both the platen and the tension ring. It is force fitted into the tension ring and follows it in expansion and contraction.

Another seal ring **140** is force fitted into the lower end of tension ring **76** to seal the junction of the tension ring with lower platen **18** and functions in the same way as ring **138**. It has a simple triangular cross section. In addition to the sealing function it also assists in retaining pad **132** in place.

It will be noted that piston rod **68** of servo motor **62** is attached to the outer wall of clamp member **50** and that there are no holes or other discontinuities in the inner wall of web **52** to cause stress concentrations. The tension loads in this wall are very high and stress concentrations here would have serious consequences.

In some fields of work it is necessary to use rather high form blocks requiring more vertical space than is shown at **80** in FIG. 2. The added space has been obtained in some installations by providing a bowl shaped depression

in the upper face of the lower platen, but such construction results in the same difficulty with corner bending stress concentrations as in upper platens. The present invention provides a similar solution for this problem. A modified press is illustrated in FIG. 4 in which the upper platen **24**, tension ring **76**, support ring **88**, expansible container **120**, pad **132**, and seal rings **138** and **140** are the same as those of FIGS. 2 and 3.

The bowl-shaped depression is achieved by providing a modified lower platen **142** which has an upper flat face **144** and an upstanding marginal flange **146**. A second tension ring **148** is mounted on face **144** and is of slightly smaller diameter than flange **146** to allow freedom of movement for radial expansion. It is also of smaller diameter than the flange **94** of the support ring to provide similar radial clearance. The inner diameter of ring **148** is made smaller than that of tension ring **76** so that it will underlie the seal ring **140** and it has a sloping inner wall **150** to receive the pad. The lower end of wall **150** is made cylindrical and a third seal ring **152** is force fitted therein to serve in the same way as the other seal rings. The combination produces a deep cavity **154** to receive the high form block **156** and its workpiece **158**.

The flange **146** provides adequate clearance for any radial exansion of ring **148** under forming loads and at the same time prevents accidental lateral displacement of the ring. It is not necessary to secure the ring against vertical separation from its platen because it is not raised, lowered, or tilted during any phase of normal operation of the press.

While only single form blocks and workpieces are shown, it is obvious that the press in either form is capable of forming several workpieces at one time, the capacity being limited only by the relative sizes of the workpieces and the forming cavity. It will be seen that the novel press herein disclosed will accomplish all of the functions of conventional diaphragm type presses while eliminating the major factor which contributes to their short lives.

It will be apparent to those skilled in the art that various changes and modifications may be made in the construction and arrangement of parts as disclosed without departing from the spirit of the invention, and it is intended that all such changes and modifications shall be embraced within the scope of the following claims.

I claim:

1. Apparatus for conforming sheet metal to predetermined shapes on form means, comprising: an elongate base; a lower platen fixedly mounted generally centrally on said base and having a horizontally extending upper face to receive a sheet metal workpiece on form means; said lower platen being generally circular in planform with a flange-like margin; an upper platen having a lower face and movably connected to said base for movement between an upper inoperative position and a lower operative position in which its lower face extends horizontally in spaced relation directly above said lower platen; said upper platen being generally circular in planform with a flange-like margin or substantially the same diameter as that of the lower platen; an annular tension ring of substantially the same diameter as the platens secured to the upper platen to move vertically therewith but with freedom of radial movement with respect thereto; said tension ring cooperating with said upper platen to define a cavity and being in juxtaposition with the lower platen in operative position to convert the cavity to an enclosed forming chamber; an expansible, pressure-fluid receiving container in said cavity adjacent to the upper platen; a resilient, pressure-applying pad in said cavity adjacent to the container and movable thereby toward said lower platen to apply forming pressure to a workpiece; a pair of clamp members arcuate in planform and channel shaped in cross section having upright webs and inwardly extending upper and lower flanges; guide tracks extending longitudinally of said base; track engaging means

on each clamp member to provide longitudinal guided movement; and servo motor means at the ends of said base connected to said clamp members to move them horizontally between inoperative position free of said platens and operative position in which the upper and lower flanges respectively overlie and underlie the margins of said upper and lower platens to prevent vertical separation during a forming operation.

2. Apparatus for conforming sheet metal to predetermined shapes on form means, comprising: a lower platen having a horizontally extending upper face to receive a sheet metal workpiece on form means; an upper platen having a horizontally extending lower face and located directly above said lower platen and vertically spaced therefrom; endless tension ring means having an inner surface and located between said platens and in juxtaposition therewith in operative position to define an enclosed pressure chamber; the inner surface of said tension ring means comprising substantially the entire vertical wall extent of said chamber; an expansible pressure-fluid receiving container adjacent to said upper platen and extending across said chamber; a resilient, pressure-applying pad in said chamber beneath and adjacent to said container and movable thereby toward said lower platen to apply forming pressure to a workpiece; and said tension ring means being independently radially expansible and contractible with respect to said platens in response to variations in forming pressure in said chamber; and said apparatus including means to prevent vertical separation of said ring means and platens during a forming operation.

3. Apparatus as claimed in claim 2; said tension ring means being annular in planform to define an annular pressure chamber and being of constant cross section at all points around the periphery to achieve uniform hoop tension stress per unit area throughout the periphery during a forming operation.

4. Apparatus as claimed in claim 2; said tension ring means comprising a pair of tension rings; one ring being associated with the upper platen to provide a cavity to receive the pressure-fluid receiving container and the pressure-applying pad; and the other ring being associated with the lower platen to provide a cavity to receive form means and a workpiece.

5. Apparatus as claimed in claim 2; one of said platens being movable with respect to the other to expose the upper face of the lower platen for loading and unloading of form means and workpieces.

6. Apparatus as claimed in claim 2; said means to prevent vertical separation comprising a plurality of clamp members each having a generally channel shaped cross section with upright webs and horizontally extending upper and lower flanges; said clamp members being movable between inoperative position free of said platens and operative position in which the upper and lower flanges respectively overlie and underlie upper and lower marginal portions of said platens.

7. Apparatus as claimed in claim 2; and in addition, a seal ring in said chamber at the juncture of the tension ring means and the upper platen to prevent extrusion of the container therebetween; and a seal ring in said chamber at the juncture of the tension ring means and the lower platen to prevent extrusion of the pad therebetween.

8. Apparatus as claimed in claim 7; said seal rings being metallic and being press-fitted into said tension ring means to remain in firm engagement therewith during expansion and contraction under working loads.

9. Apparatus as claimed in claim 2; said tension ring means comprising an annular tension ring having a uniform generally rectangular cross section; and means secured to said upper platen and loosely engaging said ring to hold it vertically substantially in contact with said upper platen while permitting relative radial movement to accommodate peripheral and radial expansion of said ring under working loads.

10. Apparatus as claimed in claim 9; said upper platen being circular in planform and of substantially the same diameter as said tension ring; and said means to hold said tension ring comprising a support ring substantially surrounding said upper platen and fixedly secured thereto and having an inwardly directed flange at its lower end to underlie said tension ring and support it adjacent to said upper platen.

11. Apparatus as claimed in claim 10; the upper marginal corner of the lower platen being undercut to provide clearance for the flange of said support ring to insure direct contact of said tension ring with the lower platen and minimize extrusion clearances.

12. A press head for use in metal forming presses of the type which utilize fluid expansible containers for developing forming pressure, comprising: a head platen having a generally horizontal extending lower face and having a generally circular margin; a member depending from the margin of said platen to define therewith a downwardly opening cavity to receive a fluid expansible container; said member comprising an annular tension ring of substantially the same diameter as the platen and having a uniform cross section throughout its peripheral extent to eliminate stress concentrations; said ring being in direct contact with the lower face of said platen but separate therefrom to provide for radial expansion of said ring independently of said platen and total separation of radial pressure loads absorbed by said ring from vertical pressure loads absorbed by said platen; and means fixedly secured to said platen and slidably connected to said ring to maintain the latter in direct contact with the platen while permitting limited radial movement of said ring.

13. A press head as claimed in claim 12; said means to maintain the ring in contact with the platen comprising a support ring substantially surrounding said platen and fixedly secured thereto; said support ring having an inwardly extending flange at its lower edge underlying said tension ring; said support ring being sufficiently larger than said tension ring to provide clearance for the maximum radial expansion of said tension ring under working loads.

14. A press head as claimed in claim 13; said platen having an annular groove in its marginal side wall; and said support ring having an inwardly extending flange at its upper margin seated in said groove to transfer the gravity load of said tension ring to said platen.

15. Apparatus for conforming sheet metal to predetermined shape on form means, comprising: a lower platen having a generally horizontally extending upper face and having a horizontal planar margin; an upper platen having a generally horizontally extending lower face and having a horizontal planar margin; said upper platen being located directly above said lower platen and vertically spaced therefrom with said margins in vertical registry; endless tension ring means located between said platens and having upper and lower surfaces in juxtaposition with the margins of said upper and lower platens when in operative position to define an enclosed pressure chamber; said tension ring means having an inner surface which comprises substantially the entire vertical wall extent of said chamber; yieldable wall means extending horizontally across said chamber and dividing it into first and second compartments; said first compartment being adapted to receive a sheet metal workpiece on form means; and means to supply pressure fluid to said second compartment to move said yieldable wall means toward said first compartment to apply forming pressure to a workpiece therein; said tension ring means being independently radially expansible and contractible with respect to said platens in response to variations in forming pressure in said chamber; and said apparatus including means to prevent vertical separation of said ring means and platens during a forming operation.

16. A press head for use in metal forming presses, comprising a head platen having a generally horizontally ex-

tending lower face and a generally circular margin; an annular tension ring carried by said platen and extending below the lower face thereof to define with said face a downwardly opening cavity constituting a cylindrical pressure chamber; said tension ring having an upper marginal portion in juxtaposition to the margin of said platen but separate therefrom to provide for radial expansion and contraction of said ring independently of said platen and total separation of radial pressure loads absorbed by said ring from vertical pressure loads absorbed by said platen; and means secured to said platen and said ring to maintain them in constant vertical relation while permitting limited radial movement of said ring with respect to said platen.

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