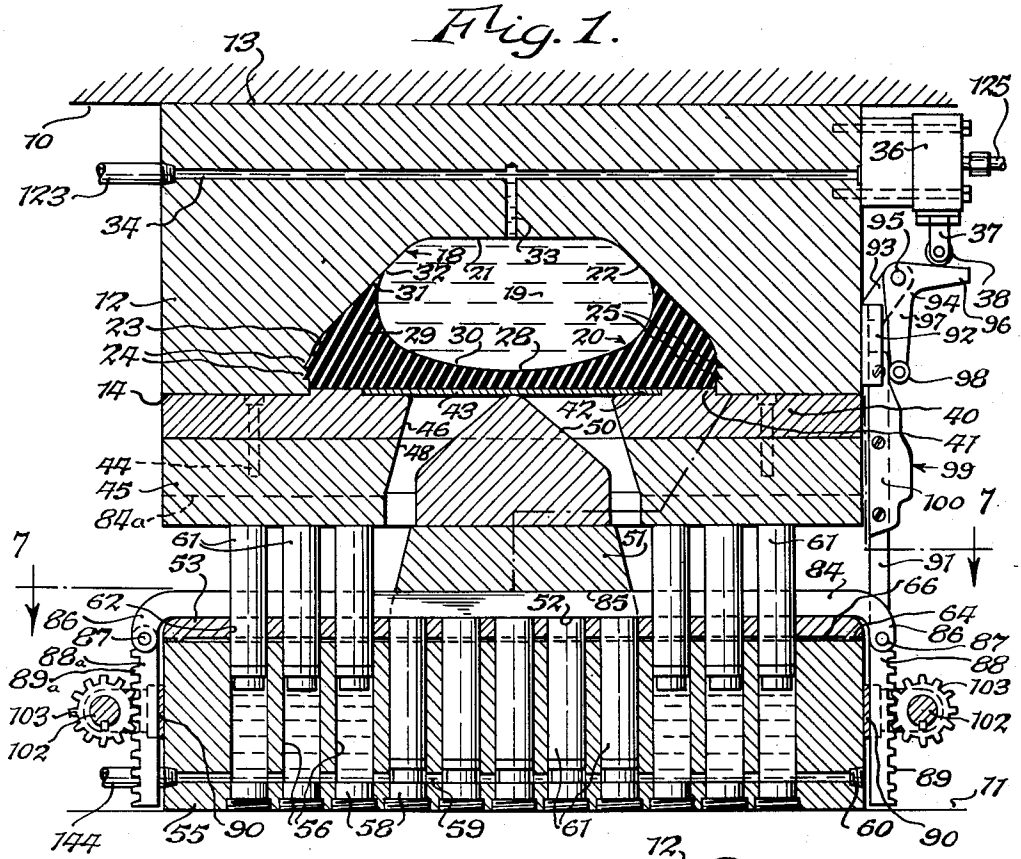
March 5, 1957 O. HOFFMANN 2,783,728

APPARATUS FOR PRESSING SHEET METAL SHAPES

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Fig. 1.



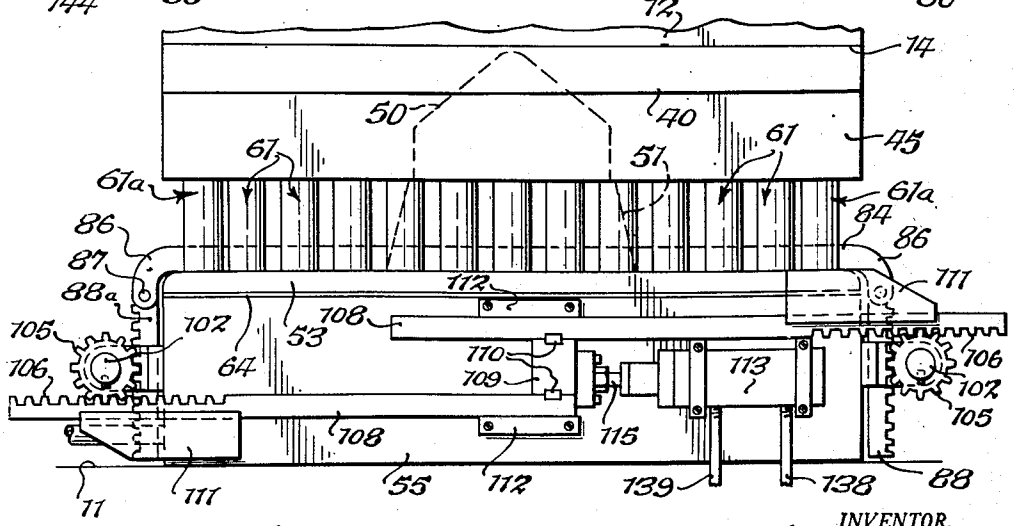


Fig. 2.

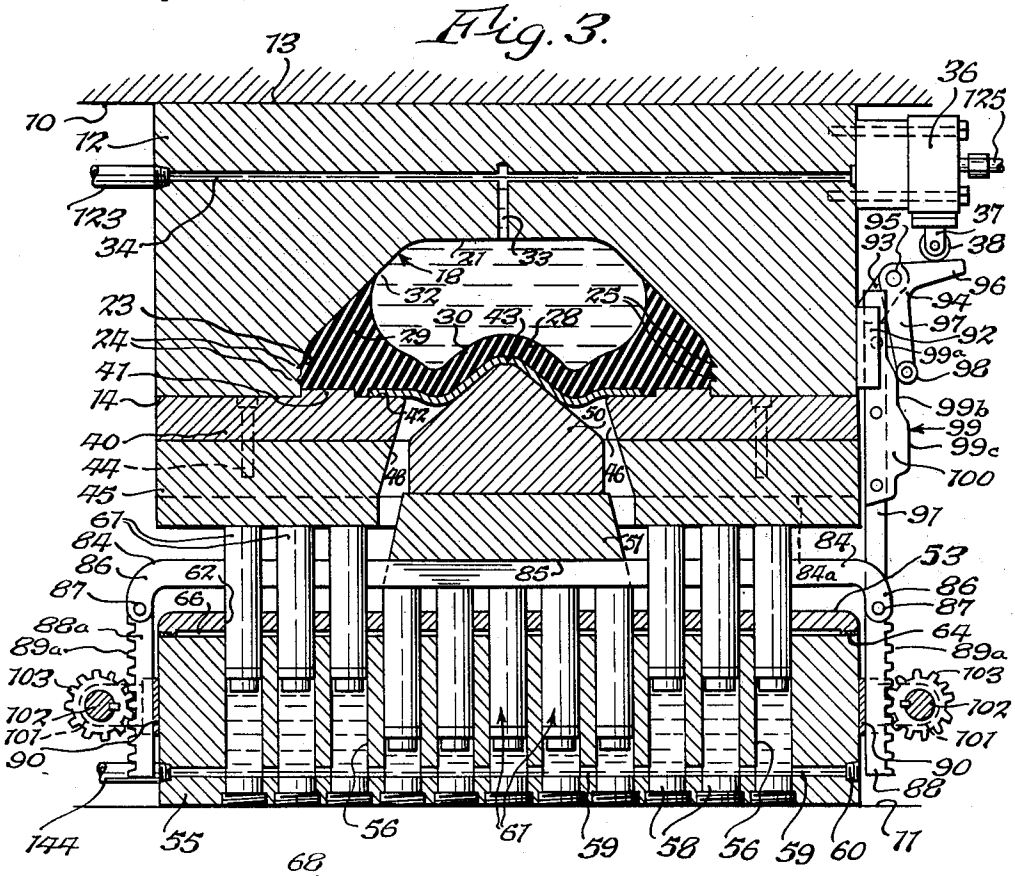
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APPARATUS FOR PRESSING SHEET METAL SHAPES

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Fig. 3.



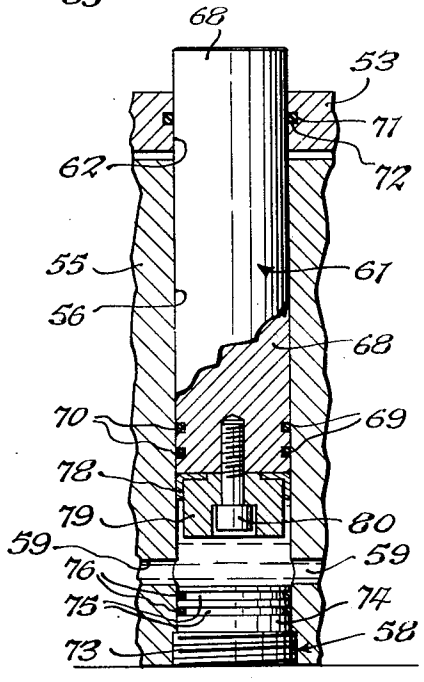


Fig. 4.

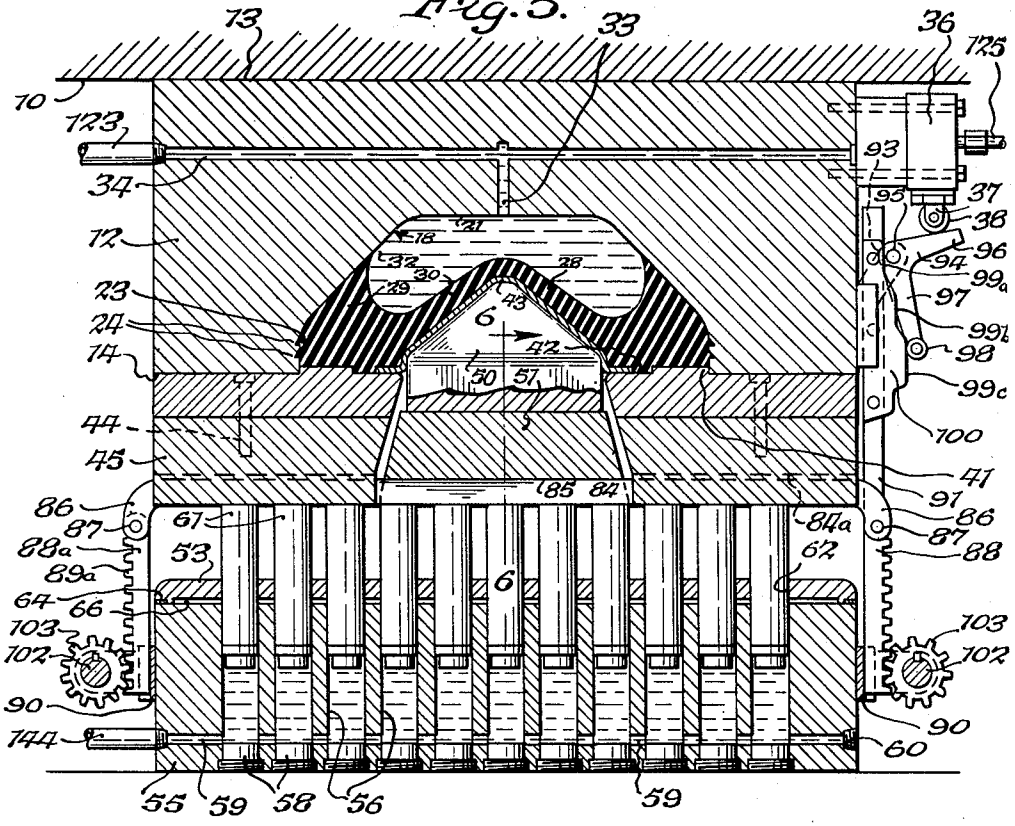
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APPARATUS FOR PRESSING SHEET METAL SHAPES

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Fig. 5.



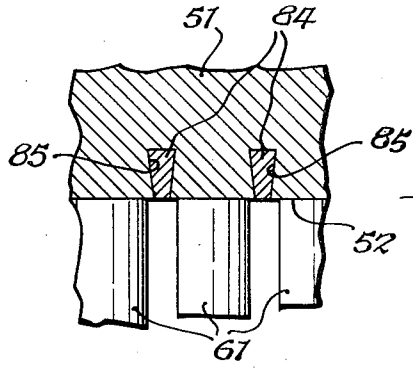


Fig. 6.

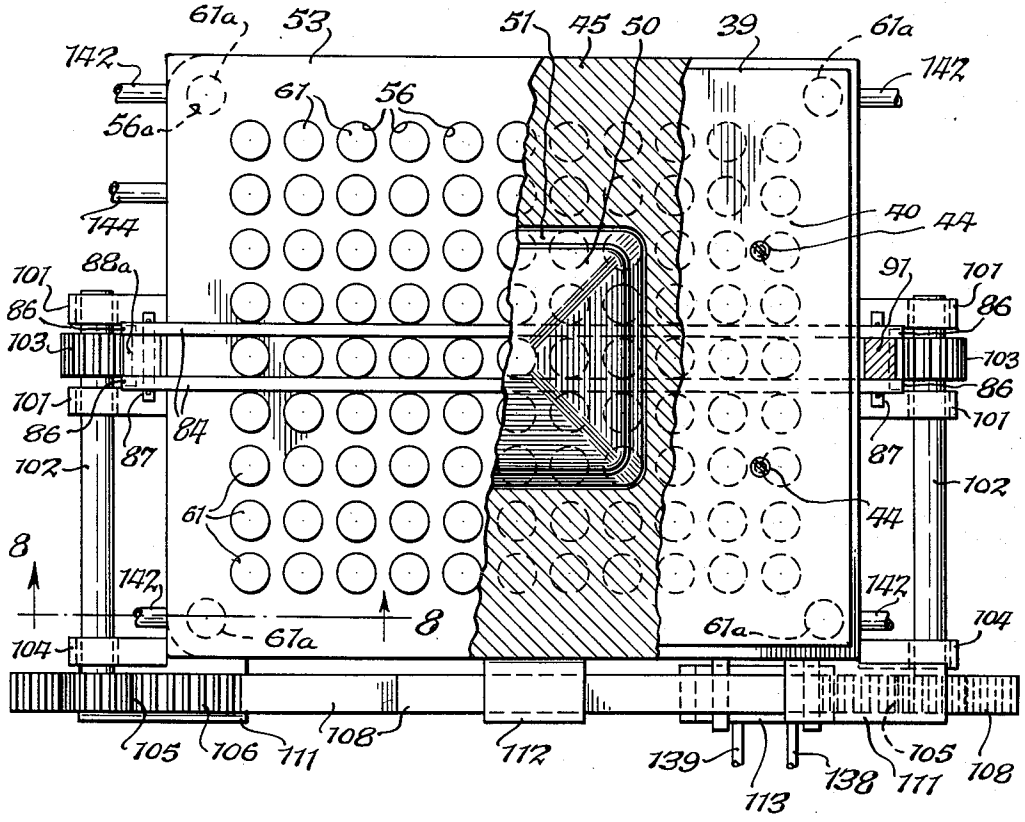
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APPARATUS FOR PRESSING SHEET METAL SHAPES

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Fig. 7.



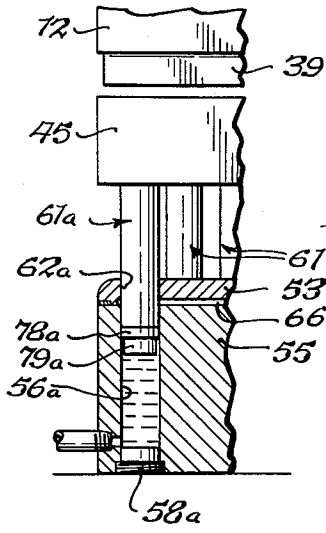


Fig. 8.

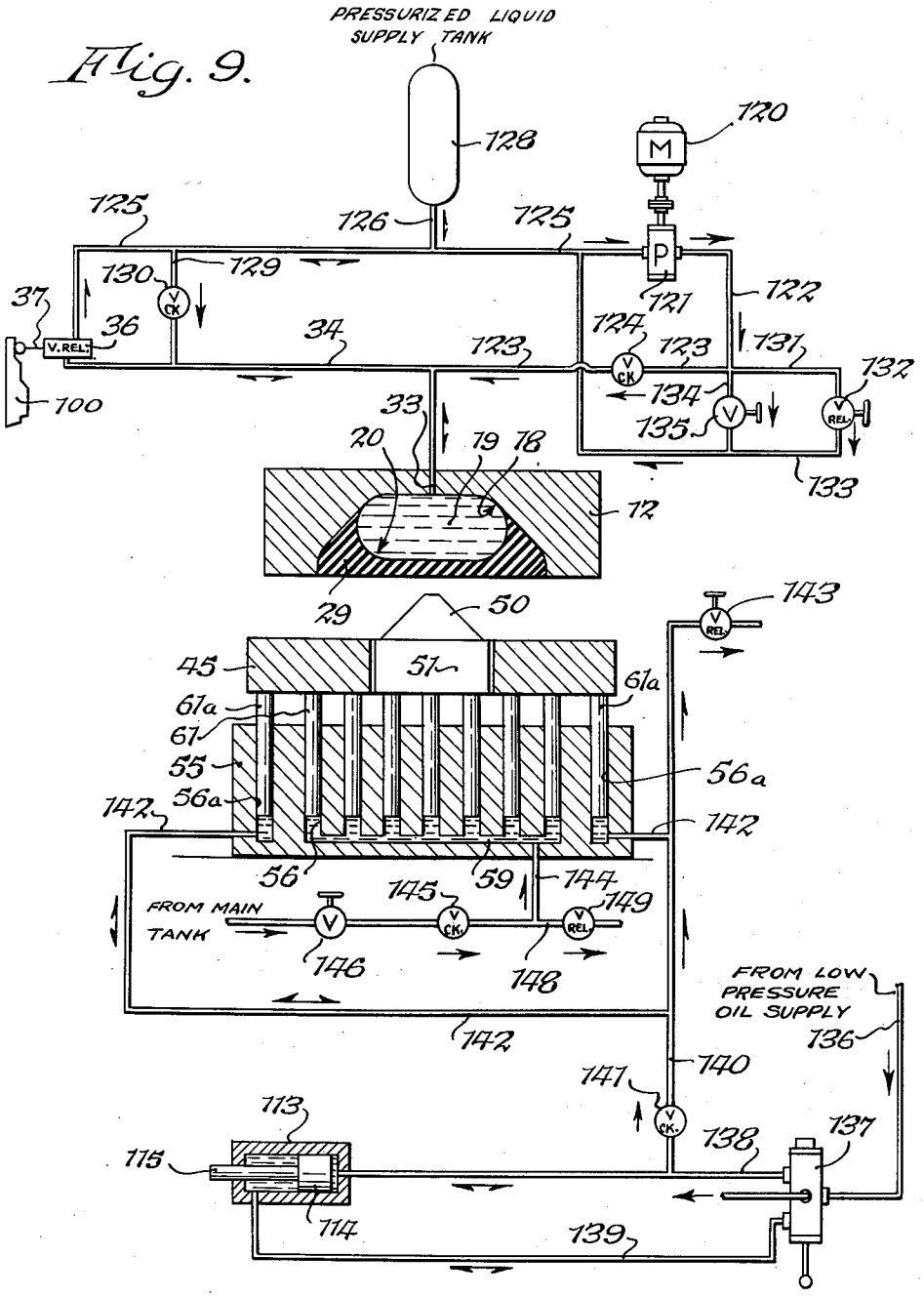
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APPARATUS FOR PRESSING SHEET METAL SHAPES

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Fig. 9.



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2,783,728

APPARATUS FOR PRESSING SHEET METAL SHAPES

Otto Hoffmann, Kenmore, N. Y., assignor to Lake Erie Engineering Corporation, Buffalo, N. Y., a corporation of New York

Application September 12, 1951, Serial No. 246,229

3 Claims. (Cl. 113—44)

This invention relates to apparatus for pressing sheet metal shapes and more particularly to a unit for this purpose adapted to be inserted between the movable platen or ram and stationary platen of any standard hydraulic press of suitable size.

The invention generally relates to that type of apparatus in which the blank is placed against a resilient pad or cushion, such as rubber backed with a liquid, and in which a punch forces the blank into the body against controlled relief of the liquid so that the body wraps the blank around the punch to form it to a corresponding shape. Such apparatus is particularly useful with unusual or complicated shapes which can be formed in one operation with such apparatus but which would require a number of separate operations with a corresponding large number of dies if done with male and female metal dies.

It is one of the principal objects of the invention to provide such apparatus in the form of a unit of low height and which can be readily inserted between the movable platen or ram and fixed platen of any standard metal forming press of suitable size, this eliminating the necessity of acquiring a special press for this particular type of pressing operation.

Another object is to provide such a unit which can be used with standard presses having relatively small separation, or so called daylight opening of its ram and stationary platen.

Another object is to provide such a pressing unit including a liquid backed rubber body, in which the rubber body is not subject to tearing or impairment in use.

Another object is to provide such a unit which is self-adapting to different sizes of punches and in which the full capacity of the press is used with all sizes of punches. Thus with the unit, for a given press speed, with small punches used in pressing small shapes the speed of the punch is automatically increased proportionally to the size of the punch to use the full capacity of the press.

Another object is to provide a simple and reliable relief valve and a mechanism for controlling the relief valve which is a part of the unit and which controls the back pressure of the liquid to suit changes in the form of the punch, the formation of sharp corners requiring higher pressure.

Another object is to provide such a unit in which the punch is automatically provided with full, uniformly distributed support over its entire area.

Another object is to provide such a unit which operates under high pressure, such as 6,000 to 10,000 pounds per square inch or more.

Another object is to provide a simple and positive stripper mechanism for stripping the finished workpiece from the punch.

Another object is to provide a simple mechanism for elevating the blank holder of the unit during the press opening cycle.

Other objects and advantages of the invention will be

apparent from the following description and drawings in which:

Fig. 1 is a vertical section through the ram of a hydraulic press and showing interposed between this movable platen or ram and the lower stationary platen of the press a unit for pressing sheet metal shapes and which embodies the present invention. In this view the parts are shown in the position occupied at the start of the pressing stroke.

Fig. 2 is a side elevational view thereof.

Fig. 3 is a view similar to Fig. 1 but showing the position of the parts and a corresponding deformation of the blank at the middle of the pressing stroke.

Fig. 4 is an enlarged fragmentary vertical sectional view through one of a multiplicity of plungers, this view being typical of all of the plungers employed to elevate and support the blank bolster and plunger bolster of the unit.

Fig. 5 is a view similar to Figs. 1 and 3 and shows the position of the parts on completion of the pressing stroke and showing the blank fully formed to the desired shape.

Fig. 6 is an enlarged fragmentary vertical section taken on line 6—6, Fig. 5.

Fig. 7 is a horizontal section, partly in elevation, taken generally on line 7—7, Fig. 1, parts being broken away.

Fig. 8 is a fragmentary vertical section taken on line 8—8, Fig. 7.

Fig. 9 is a diagrammatic representation of the hydraulic circuit of the unit embodying the present invention.

A feature of the invention is that the apparatus for pressing sheet metal shapes is embodied in a low, relatively broad unit adapted to be interposed between the movable platen or ram 10 and stationary platen 11 of any standard hydraulic press having a sufficient opening to receive the unit. The unit comprises an upper rubber pad or cushion holder 12 secured to the ram 10 of the press and which is preferably in the form of a rectangular casting having an upper flat face 13 which engages the lower face of the ram 10. This pad or cushion holder 12 is provided in the center of its lower face 14 with a large pocket or recess extending upwardly therefrom and which forms a chamber 18 containing a body of oil 19. The oil 19 is retained in this chamber 18 by a rubber pad or cushion 20 and for this purpose the recess or chamber 18 is bell-shaped having an upper face 21 of relatively small diameter from which a frusto-conical side wall 22 flares downwardly and outwardly and the lower end of this frusto-conical side wall 22 terminating in a generally vertical annular wall 23 which extends to the lower flat face 14 of the pad or cushion holder. This lower annular wall 23 of the chamber 18 is also provided with annular channels 24 which are preferably of saw tooth form and have horizontal lower faces against which annular beads 25 around the perimeter of the rubber cushion 20 fit so as to hold the cushion 20 within the recess or chamber 18.

To prevent tearing or rupture of this rubber cushion 20 and to provide adequate contact between this rubber cushion and the internal side walls 22, 23 of the pad or cushion holder 12, this central part of the rubber pad or cushion 20 is in the form of a relatively thin section 28 while its marginal portion 29 is thickened to provide a thick marginal rim the perimeter of which corresponds to the internal frusto-conical and vertical faces 22, 23 of the pad or cushion holder 12. In the undistorted condition of this rubber pad or cushion 20 shown in Fig. 1, this shape of this rubber pad or cushion is provided by forming it with a central bowl shaped recess 30 which terminates in a thin rim 31 of upwardly diminishing cross section, this rim, in turn, terminating in a feather edge

32. It will be seen that the pressure of the fluid body 19 tends to press the upwardly tapering feather edged rim 32 of the cushion 20 against the internal frustoconical side wall 22 of the chamber or recess 18 and hence provide a seal against the escape of fluid between the walls of this pocket or chamber 18 and the perimeter of the rubber pad or cushion 20.

The movement of the liquid 19 into and out of the chamber 18 is through a vertical bore 33 communicating with a horizontal bore 34 one end of which is connected with a line 123, as later described, and the other end of which communicates with a relief valve 36 which is of such form as to restrict the escape of fluid from this chamber in accordance with the vertical position of a plunger 37 depending from the valve 36 and carrying a roller 38. The relief valve is such that the higher the position of its plunger 37 the less is its resistance to the escape of the liquid 19 from the chamber 18 and this relief valve is controlled automatically in a manner hereinafter described in detail.

A blank plate 40 is shown as provided with a central annular raised portion 41 which fits within the lower rim portion of the recess or pocket 18 for the rubber pad or cushion 20 and the central part of this raised portion 41 is recessed, as indicated at 42, to provide an indented surface on which the blank 43 is placed.

The blank plate is secured, as by screws 44, to the upper face of a blank bolster 45 which is of flat rectangular form. The blank plate 40 and blank bolster 45 are provided centrally with registering openings 46 and 48, respectively, these openings jointly forming a downwardly and outwardly enlarging through opening in which the punch 50 is arranged.

This punch 50 is externally shaped to correspond to the shape of the pressed piece and is shown as having a pyramidal upper portion from the lower edge of which vertical side walls extend downwardly. This punch is secured in any suitable manner (not shown) on a punch bolster 51 and this punch bolster has a lower horizontal flat face 52 adapted to be supported on the horizontal top plate 53 of a multiple cylinder bolster 55.

This multiple cylinder bolster 55 is provided with a multiplicity of vertical bores or cylinders extending therethrough, these bores or cylinders 56, as best shown in Fig. 7, being arranged in uniformly spaced relation and in uniformly spaced rows extending parallel with the four sides of the multiple cylinder bolster 55. Each of these bores or cylinders 56 is plugged at its lower end, as indicated at 58, and the lower ends of all of these bores or cylinders 56 are in communication with each other through a multiplicity of horizontal bores 59 provided through the multiple cylinder bloster 55 in communication with the bores or cylinders 56 and the opposite ends of each of these horizontal bores 59 being plugged, as indicated at 60 one end of one of these bores, however, being connected with a line 144 as set forth later in a detailed description of the hydraulic circuit. Each of these vertical bores or cylinders 56 has fitted therein a plunger indicated generally at 61, these plungers also extending through bores 62 provided in the top plate 53 for the multiple cylinder bolster 55, a rim gasket 64 being interposed between the rim of this top plate 53 and the multiple cylinder bolster 55 so as to provide a chamber 66 for receiving any oil leaking past the pistons 61. The oil so leaking into this chamber 66 can be drained in any suitable manner (not shown).

Fig. 4 illustrates the construction of a typical piston 61 and the manner in which it is fitted within its vertical cylinder 56 of the multiple cylinder bolster 55 and its bore 62 in the top plate 53. From this section it will be seen that each piston 61 is in the form of a solid metal cylinder 68 having a pair of annular radially outwardly opening grooves 69 at its lower end and each receiving a rubber ring 70 which is of circular form in cross section. Similarly each bore 62 of the top plate 53 is provided with an annular groove 71 receiving a rubber ring 72 which is round in cross section. Similarly, to prevent leakage past each of the plugs 58, each of these plugs is in the form of a screw plug 73 at its lower end and is provided with an unthreaded cylindrical portion 74 extending upwardly into the corresponding vertical cylinder 56 and provided with a pair of radially outwardly opening annular grooves 75 each receiving a rubber ring 76 which is round in cross section. A cup washer 78 is secured to the lower end of each of the pistons 61 by means of a holder 79 and a retaining screw 80.

The relief valve 36 is shown as controlled by a mechanism constructed as follows:

The numeral 84 represents a pair of parallel cross bars each anchored in and projecting outwardly from the punch bolster 51 to a position beyond the opposite sides of the multiple cylinder bolster 55. To secure such anchorage, as best illustrated in Fig. 6, each of these bars 84 is prefereably of upwardly diverging wedge shaped or keystone form in cross section and is fitted in a correspondingly wedge shaped groove 85 extending transversely across the bottom of the punch bolster 51. In the extreme upward position of the punch bolster 51, the ends of these bars 84 enter slots 84*a* in the blank bolster 45, these slots being provided merely to provide clearance for these bars 84.

Each end of each of these cross bars 84 is shown as provided with a downturned end 86 to one pair of which downturned ends is pivoted, as at 87, a rack 88 having outwardly facing teeth 89. Between the opposite pair of downturned ends 86 of these cross bars 84 is pivoted, as at 87, a rack 88*a* also having outwardly facing teeth 89*a*. Each rack 88 and 88*a* is guided for vertical movement in a guide 90 suitably secured to the corresponding side of the multiple cylinder bolster 55. The rack 88 is distinguished from the rack 88*a* only in that it is longer and has an upward extension 91 which projects above the pivot 87. This upward extension 91 of the rack 88, as best shown in Figs. 1, 3 or 5, is received in a guide 92 one side of which is formed to provide an upwardly and outwardly projecting arm 93 to the end of which the central part of a bell crank lever 94 is pivoted, as indicated at 95. The upper hroizontal arm 96 of this bell crank lever engages the roller 38 of the plunger 37 of the relief valve 36. The depending arm 97 of the bell crank lever 94 carries a roller 98 in contact with the working face 99 of a cam plate 100. This cam plate is suitably secured to one side of the upward extension 91 of the rack 88 and its working face 99 is formed to correspond to the shape of the part being pressed. Thus in forming a sharp corner a greater degree of back pressure is required and hence when the blank 43 engages such a sharp corner of the punch 50 the roller 98 will encounter a salient part of the working face 99 of the cam 100 so as to lift the plunger 38 of the relief valve 36 and thereby restrict to a greater degree the escape of fluid from the chamber 18 and build up a higher back pressure in this chamber.

It will be seen that since the bell crank lever 94 and relief valve 36 move with the cushion holder 12 forming, with its liquid backed cushion 19, 20, the female part of the die, and that since the cam plate 100 moves with the punch 50 and its punch bolster 51, the movement of the cam plate 100 relative to the bell crank lever 94 is the same as the relative movement of the punch 50 and workpiece 43. In other words, the cam plate 100 has the same differential movement relative to the bell crank lever 94 as the punch 50 has to the cushion holder 12, this differential movement being established by the displacement of the oil from under the pistons 61 supporting the blank bolster 45 to raise the pistons 61 supporting the punch 50 and which relative movement, in each case, represents a differential of the movement of the ram 10 and fixed platen 11 of the press. Accordingly it will be seen that the cam 100 can be shaped to conform to the requirements of the punch 50. For the shape of the

punch 50 illustrated, the working face 99 of the cam 100 is shown as having a leading receding face 99*a*, an intermediate salient face 99*b*, and a higher trailing salient face 99*c*.

A mechanism for stripping the workpiece 43 from the punch 50 is also provided, this stripping mechanism being constructed as follows:

Each of the guides 90 for the racks 88, 88*a* is provided with a pair of arms 101 in which is journalled one end of a shaft 102. A gear 103 is keyed to each of these shafts 102 and the opposite end of each of these shafts is journalled in a bracket 104. Beyond the bracket 104 a pinion 105 is fixed to the corresponding shaft 102 and each of these pinions 105, as best shown in Fig. 2, meshes with the teeth 106 of a rack 108. The back of the rack 108 at the left, as viewed in Fig. 2, is arranged below its pinion 105 and hence with its teeth 106 extending upwardly. The rack 108 at the right of Fig. 2 is arranged above its pinion 105 and hence with its teeth facing downwardly. At their adjacent ends these racks are interconnected by a block 109 through suitable keys 110. The outer end of each of these racks 108 is guided by a guide 111 suitably secured to the multiple cylinder bolster 55 and slidingly engaging the back of its rack 108. The adjacent ends of the racks 108 are also engaged by guides 112 which have sliding bearing surfaces in opposing relation with each other and engaging the backs of the corresponding racks 108. A horizontal stripper cylinder 113 is secured to the side of the multiple cylinder bolster 55 which carries these guides 111, 112 and is arranged parallel with the racks 108 and in line with the block 109 connecting these racks. The stripper piston 114 (Fig. 9) within the stripper cylinder is connected by a piston rod 115 with this block 109 which connects the two racks 108. It will therefore be seen that introduction of fluid pressure into the stripper cylinder 113 moves the connected racks 108 to the right or to the left as viewed in Fig. 2. For this purpose, as described later in detail in the description of the hydraulic circuit, Fig. 9, the opposite ends of the stripper cylinder 113 connect with oil lines 138 and 139. In the elevated position of the press ram 10, as for example in Fig. 1, it will be seen that introduction of fluid pressure through line 138 (Figs. 2 and 9) moves the piston 114 and piston rod 115 in the stripper cylinder 113 to the left as viewed in Fig. 2. This, through the connecting block 109, moves the racks 108 to the left and rotates the left hand pinion 105 and its shaft 102 clockwise as viewed in Fig. 2 and the right hand pinion 105 and its shaft 102 counterclockwise, as viewed in this same figure. Referring to Fig. 1, this rotates the left hand pinion 103 clockwise and the right hand pinion 103 counterclockwise thereby to pull down the racks 88, 88*a*, cross bars 84, punch bolster 51 and punch 50, thereby to strip the finished workpiece 43 from the punch.

Particularly with a small punch 50 and punch holder 51 it is necessary to provide means for raising the blank bolster 45 as the ram 10 of the press rises and thereby bring the position of the parts to the position illustrated in Fig. 1. For this purpose four cylinders 56*a* are provided in the multiple cylinder bolster 55 one at each corner thereof. Each of these corner cylinders receives a corner piston 61*a*. The lower end of each of the cylinders 56*a* is closed by a plug 58*a* and each piston 61*a* extends through a bore 62*a* in the cover plate 53. These corner pistons 61*a* and the cylinders 56*a* are identical in construction with the other pistons 61 and their cylinders 56 and hence the same reference numerals have been applied and distinguished by the suffix "*a*."

Referring to the diagrammatic hydraulic circuit illustrated in Fig. 9, the numeral 120 represents a small electric motor continuously driving a high pressure pump 121 delivering oil under pressure from its outlet line 122 to a series of branches. One of these branches, indicated at 123, contains a check valve 124 opening in the direction of flow of the pumped liquid and connects with the lines or bores 33, 34 between the chamber 18 behind the rubber cushion 20 and the relief valve 36. The relief valve 36 discharges into the return line 125 connecting with the inlet of the pump 121, this return line also connecting, through a branch 126, with a small pressurized oil supply tank 128. A line 129 including a check valve 130 is connected across the lines 34 and 125, this check valve opening toward the cushion chamber 18. Another branch 131 of the pump outlet line 122 connects with a relief valve 132 discharging through a line 133 to the pump inlet line 125. A third branch 134 of the pump outlet line 122 connects with the return line 133 and contains a valve 135 which can be actuated manually or automatically.

The lower or bolster part of the unit has a separate hydraulic circuit including a supply line 136 from a low pressure pump (not shown) and connecting with a four way valve 137 which can be manually moved to connect in one position the low pressure supply line 136 with a line 138 leading to one end of the stripper cylinder 113 and at the same time connects a line 139 from the opposite end of this stripper cylinder 113 with an exhaust indicated by a broken off pipe and which in another position connects both lines 138 and 139 with the exhaust indicated by a broken off pipe. A branch line 140 containing a check valve 141 connects with four branches 142 leading to the corner cylinders 56*a*. This check valve 141 opens toward the cylinders 56*a*. The line 140 terminates in a relief valve 143 which discharges through an exhaust indicated by a broken off pipe.

For maintaining oil in the interconnected cylinders 56, a line 144 connects these cylinders with the main tank, this line including a check valve 145 which opens toward the cylinders 56 and also a manual valve 146. A branch 148 of the line 144 leads to a relief valve 149 discharging through an exhaust indicated by a broken off pipe.

In the operation of the apparatus as above described, the ram 10 of the press is raised high enough to separate the pad or cushion holder 12 from the blank plate 40 sufficiently far to permit removal of the formed workpiece 43 and to insert a blank workpiece 43 in the recess 42 of the blank plate 40.

In this fully open position of the press ram 10 and the unit forming the subject of the present invention, the blank bolster 45 and the blank plate 40 carried thereby are supported in the elevated position shown in Fig. 1 on the four corner pistons 61*a* (Figs. 7 and 8) by oil trapped in the corner cylinders 56*a* by the check valve 141 and relief valve 143 (Fig. 9). At this time the group of pistons 61 supporting the punch bolster 51 are bottomed in their cylinders 56 as illustrated in Fig. 1. Also sufficient oil is maintained in the cylinders 56 to support the group of pistons 61 carrying the blank bolster 45 in the full up position shown in Fig. 1 at this time. This oil can be replenished by opening the valve 146.

Also in this fully open position of the press ram 10 and the unit forming the subject of the present invention, the valve 135 (Fig. 9) is open and the pump 121 delivery is being recirculated through lines 122, 134, 133, and 125 back to its inlet. At this time the pad cavity 18 has been filled from the pressurized oil supply tank 128 through the check valve 130.

The ram 10 of the press is brought down so as to bring the lower face 14 of the pad or cushion holder 12 into contact with the upper face of the outer part of the blank plate 40 and so as to bring the central raised part 41 of this blank plate 40 into mating relation with the lower part of the pocket or recess 18 of the pad or cushion holder 12 and the upper face of this raised part 41 into contact with the bottom face of the rim portion 29 of the rubber pad or cushion 20. This position of the parts is illustrated in Fig. 1. At this time also the upper extremity of the punch 50 is in closely spaced relation to the blank 43 as also illustrated in Fig. 1. Following

this, the valve 135 is closed to permit pressure from the pump 121 to build up in the chamber 18 behind the rubber cushion 20. This pressure is determined by the setting of the relief valve 36. Thus, at this position of the parts the relief valve 36 is held at the desired setting by virtue of the roller 98 of the bell crank lever 94 riding on the upper receding part 99*a* of the working face 99 of the cam 100 and hence holding the plunger 37 of the relief valve in a corresponding downwardly projected position.

The continued downward movement of the ram 10, forces the four corner pistons 61*a* down and these pistons force the oil from their cylinders 56*a* through the lines 142 and 140 and out through the relief valve 143 (Fig. 9), the check valve 141 remaining closed under such pressure. This maintains close contact between the blank plate 40 and the cushion holder 12 during the initial part of the downward movement of the ram. This continued downward movement of the ram 10 of the press also, through the pad or cushion holder 12, blank plate 40, and blank bolster 45, causes downward movement of the several plungers 61 in contact with the under face of this blank bolster. This displaces liquid from the group of cylinders 56 containing these pistons, through the bores 59, to the cylinders 58 containing the group of pistons 61 in contact with the underside of the punch bolster 51. Accordingly the punch bolster 51 is elevated and the blank or workpiece 43 is deformed by the punch 50 as a function of the combined downward movement of the blank or workpiece and the upward movement of the punch 50. The halfway position of the parts is illustrated in Fig. 3. At this time the four way valve 137 (Fig. 9) is in neutral position in which both lines 138 and 139 are connected to its exhaust indicated by the broken off pipe so that the piston 114 in the stripper cylinder 113 is free to move without interference, this movement of the piston 114 at this time being away from the closed end of the stripper cylinder 113.

In the unit as illustrated the blank bolster 45 and punch bolster 51 are of such size that twenty-five of the pistons 61 contact the punch bolster 51 and seventy-four of these pistons 61 contact the blank bolster 45, the ratio of contact being therefore approximately three to one. Accordingly, with the example illustrated, a downward movement of the ram 10 of one-quarter of an inch would couse an upward movement of the punch bolster 51 of three quarters of an inch. However since the workpiece or blank 43 has moved downwardly one-quarter inch during this three-quarter inch upward movement of the punch 50, the total effective movement of the punch 50 relative to the workpiece 43 is one inch as a result of the assumed one-quarter inch downward movement of the ram 10.

This ratio will change when different relative sizes of blank bolsters 45 and punch bolsters 51 are substituted for those illustrated, this being a feature of the invention. Thus if the punch 50 and punch bolster 51 were smaller and the blank bolster 45 larger, fewer pistons 61 would support the punch bolster and a larger number of pistons 61 would support the blank bolster. Accordingly the downward movement of the blank bolster supporting pistons 61 would displace a greater amount of liquid than in the example as illustrated and hence the punch bolster supporting pistons 61 would be moved upwardly at a more rapid rate. Therefore the smaller the punch 50 and its bolster 51, the more rapid the relative movement of the punch 50 and workpiece or blank 43 and hence the full capacity of the press can be used regardless of whether large or small pieces are being formed.

As the punch 50 so moves upwardly relative to the workpiece or blank 43, the liquid backed rubber cushion 20, 19 causes the blank 43 to be wrapped around this punch 50 and to take the form of the punch. To do this the blank 43 and punch 50 must enter the liquid backed cushion 20, 19, as illustrated in Figs. 3 and 5, and to permit this, liquid must be relieved from the cavity 18 and this relief should be controlled to provide the optimum back pressure corresponding to the work being done by the punch 50 at any particular time. Thus as a sharp corner is produced in the blank 43 the back pressure of the liquid 19 should be higher than when a shallow deformation of the blank is being made. Since at this time, as previously explained, the valve 135 (Fig. 9) is closed, this variable back pressure is under control of the relief valve 36 and its controlling cam 100, the working face 99 of this controlling cam being shaped to conform to the shape of the particular punch 50 being used.

The control of this relief valve 36 is as follows:

The assumed one-quarter inch downward movement of the ram 10 effects a similar downward movement of the relief valve 36 and its bell crank lever 94. The assumed resultant upward movement of three-quarters of an inch of the punch bolster 51 effects a corresponding upward movement of the two horizontal bars 84 keyed to this punch bolster and projecting outwardly therefrom. This raises the rack 88 so as to elevate the cam plate 100 secured to the upper end of this rack 88 a corresponding distance. Accordingly the bell crank lever 94 and relief valve 36 move with the holder 12 for the cushion 19, 20 which forms the female part of the die and the cam plate 100 moves with the punch 50, and since the movement of the punch 50 relative to the cushion holder 12 is a differential of the movement of the ram 10 and platen 11 of the press, the cam plate 100 has this same differential movement relative to the bell crank lever 94 and relief valve 36.

As described, the cam plate shown is provided with an initial receding position 99*a* which, through the bell crank lever 94, holds the relief valve 36 in such position that a relatively low back pressure is maintained in the cavity 18 during the initial part of the pressing stroke. At this time the workpiece 43 is being pressed over the pyramidal top part of the punch 50 and relatively small back pressure is required for this shallow deformation. However in forming the angular corner between the base of the pyramidal top of the punch and its side walls greater back pressure is required and at this time the roller 98 of the bell crank lever rides upon the intermediate salient part 99*b* of the cam plate 100 and hence moves the plunger 37 of the relief valve 36 upwardly to establish a higher back pressure in the chamber 18. In forming the final flange or rim (Fig. 5) on the workpiece a still higher back pressure is required and at this time the roller 98 rides up on the trailing salient 99*c* of the cam plate 100. This operates to elevate the plunger 37 still higher and close the relief valve still further and establish this still higher back pressure in the cavity 18. The exhaust oil from the relief valve 36 in providing this controlled back pressure in the cavity 18 returns to the pressurized oil supply tank through the lines 125 and 126 (Fig. 9). Each punch 50 will, of course, have an individual cam plate 100 shaped to conform to it, the punch and cam plate shown being merely illustrative.

On the completion of the pressing stroke the parts are in the position shown in Fig. 5 and the blank 43 fully formed. The ram 10 of the press is then raised to effect its return stroke and at the same time the four way valve 137 (Fig. 9) is shifted to connect the low pressure pump supply line 136 with the line 138 and to connect the line 139 with the exhaust indicated by a broken off pipe.

As the ram 10 and cushion holder 12 rise, oil under pressure is therefore admitted to the corner cylinders 56*a* from low pressure pump line 136, four way valve 137, lines 138, 140 and check valve 141 and branch lines 142 to the corner cylinders 56*a*. This oil pressure in these corner cylinders 56*a* causes the plungers 61*a* therein to rise and since the upper ends of these corner plungers contact the under face of the blank bolster 45, this blank

bolster is elevated to follow the rising ram **10** of the press and the cushion holder **12**.

As the blank bolster **45** is so lifted by the corner plungers **61***a*, the punch **50** and punch bolster **51** is pulled down by the piston **114** in the stripper cylinder **113**, this downward movement of the punch **50** and punch bolster **51** moving downwardly the plungers **61** supporting the punch **50** and punch bolster **51** and displacing the oil in their cylinders **56** through the bores **59** to the cylinders **56** containing the plungers **61** contacting with the blank bolster **45**. Accordingly the plungers **61** under the blank bolster **45** are caused to follow the blank bolster **45** in the upward movement caused by the introduction of oil under pressure to the corner cylinders **56***a*. This movement of the plungers **61** continues until those supporting the punch bolster **51** bottom as illustrated in Fig. 1.

This pulling downward of the punch bolster **51** to strip the finished workpiece from the punch is effected through the four way valve **137** (Fig. 9) which, as previously explained, during the return stroke of the press and unit connects the low pressure pump line **136** with the line **138**, and the line **139** with its exhaust indicated by a broken off pipe. In this position of the four way valve **137** oil under pressure is accordingly admitted to the dead end of the stripper cylinder **113** and the piston **114** and piston rod **115** therein is moved to the left as viewed in Fig. 2. Through the connecting block **109** this moves the racks **108** to the left and rotates the left hand pinion **105** and its shaft **102** clockwise as viewed in Fig. 2 and the right hand pinion **105** and its shaft **102** counterclockwise as viewed in this same figure. Referring to Fig. 1, this rotates the left hand pinion **103** clockwise and the right hand pinion **103** counterclockwise thereby to pull down the racks **88**, **88***a*, cross bars **84**, punch bolster **51** and punch **50** thereby to strip the finished workpiece **43** from the punch.

The continued elevation of the ram **10** of the press and the cushion holder **12** continues until the cushion holder **12** is separated sufficiently far from the blank plate **40** to permit removal of the finished workpiece **43** and replacement of the blank. This completes the cycle of the press as described.

It will be noted that since the arms **84** project from opposite sides of the punch bolster **51** and are connected at opposite ends to separate racks **88**, **88***a* which jointly connect with the stripper piston **114**, the punch bolster is maintained in a horizontal position at all elevations, this being an important feature of the invention.

Such oil as leaks past the pistons **61**, **61***a* passes to the chamber **66** and is drained. Such oil is replaced by opening the valve **146** (Fig. 9) which admits oil to the cylinders **56**, **56***a*.

From the foregoing it will be seen that the present invention, which is capable of being in the form of a special press, is also capable of being embodied in a small unit which will fit a standard hydraulic press thereby obviating the necessity of requiring a special press for the particular type of metal forming contemplated by the

invention. The invention also accomplishes the different obectives set forth.

I claim:

1. Forming apparatus for interposition between the relatively movable platens of a press, comprising a cylinder bolster mounted on one of said platens and having a generally flat face opposing the other platen and a multiplicity of substantially uniformly spaced liquid cylinders distributed in all directions over the central area of said generally flat face of the bolster and opening toward the other platen, a plunger in each of said cylinders and having a portion projecting from the open ends thereof, a blank bolster mounted on the projecting ends of certain of said plungers and having a central opening extending therethrough in line with other of said plungers, a punch in said opening, a punch bolster carrying said punch and mounted on the projecting ends of said other of said plungers, a cushion holder mounted on the other of said platens in line with said blank bolster and having a cavity in line with said punch, and a resilient pad in said cavity, the bodies of liquid in said cylinders being interconnected whereby movement of said certain of said plungers is transmitted to said other of said plungers from said blank bolster to said punch bolster whereby the selection of the relative sizes of said blank and punch bolsters and the relative number of plungers contacted thereby will determine the speed and force of said punch against said resilient pad.

2. Forming apparatus as set forth in claim 1 wherein said cylinder bolster has another series of spaced cylinders opening toward said other platen, a piston in each of said last cylinders, and means for supplying fluid under pressure to said last cylinders independent of said liquid distributing cylinders to separate said blank bolster from said cylinder bolster.

3. Forming apparatus as set forth in claim 1 wherein means are provided for stripping the workpiece from the punch, comprising a piston and cylinder operatively interposed between said cylinder bolster and punch and arranged to draw said punch toward said cylinder bolster.

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