Aug. 5, 1952 R. B. SCHULZE ET AL 2,605,731

APPARATUS FOR FORMING SHEET MATERIAL UNDER CONTROLLED PRESSURE

Filed Dec. 16, 1948 2 SHEETS—SHEET 1

Fig. 1.

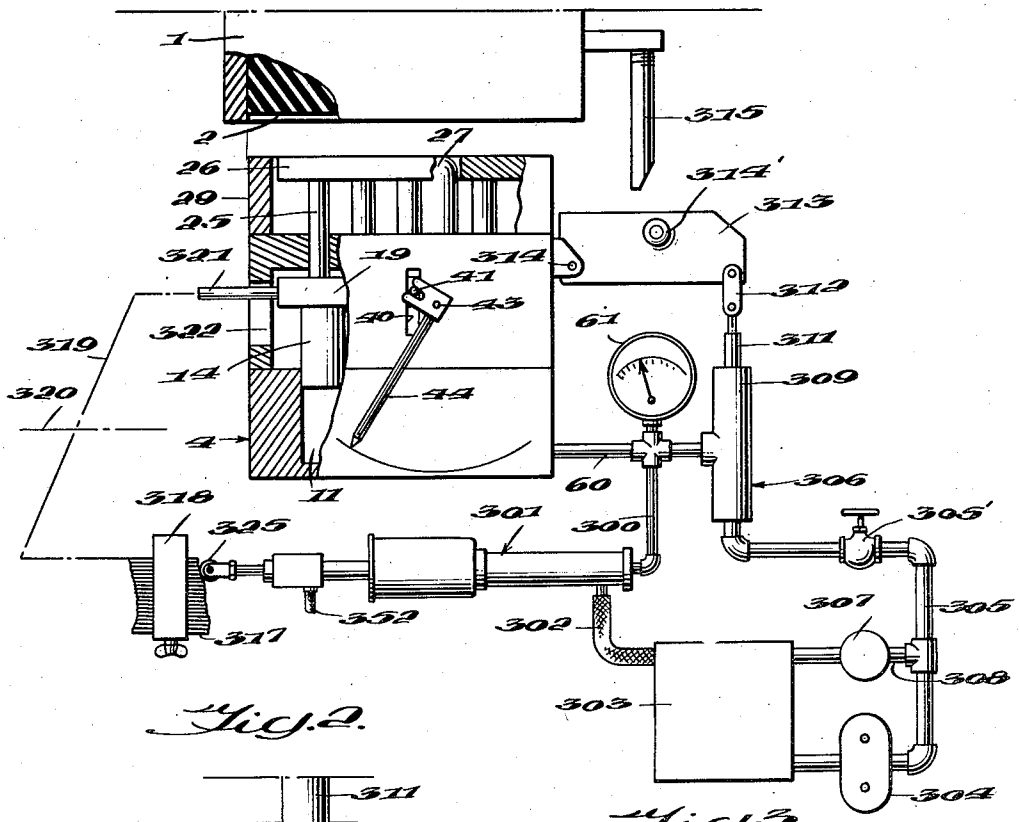


Fig. 2.

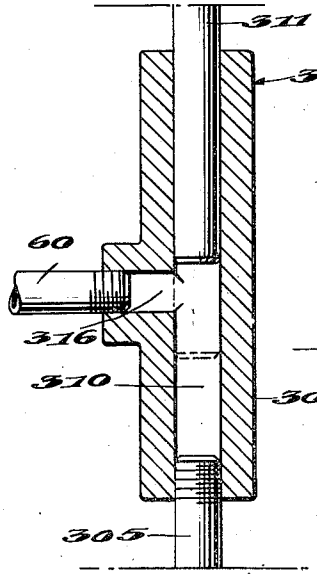
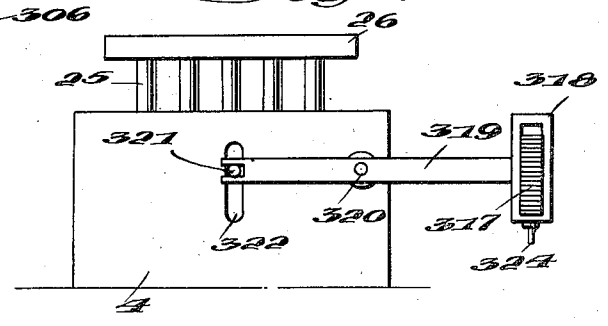


Fig. 3.



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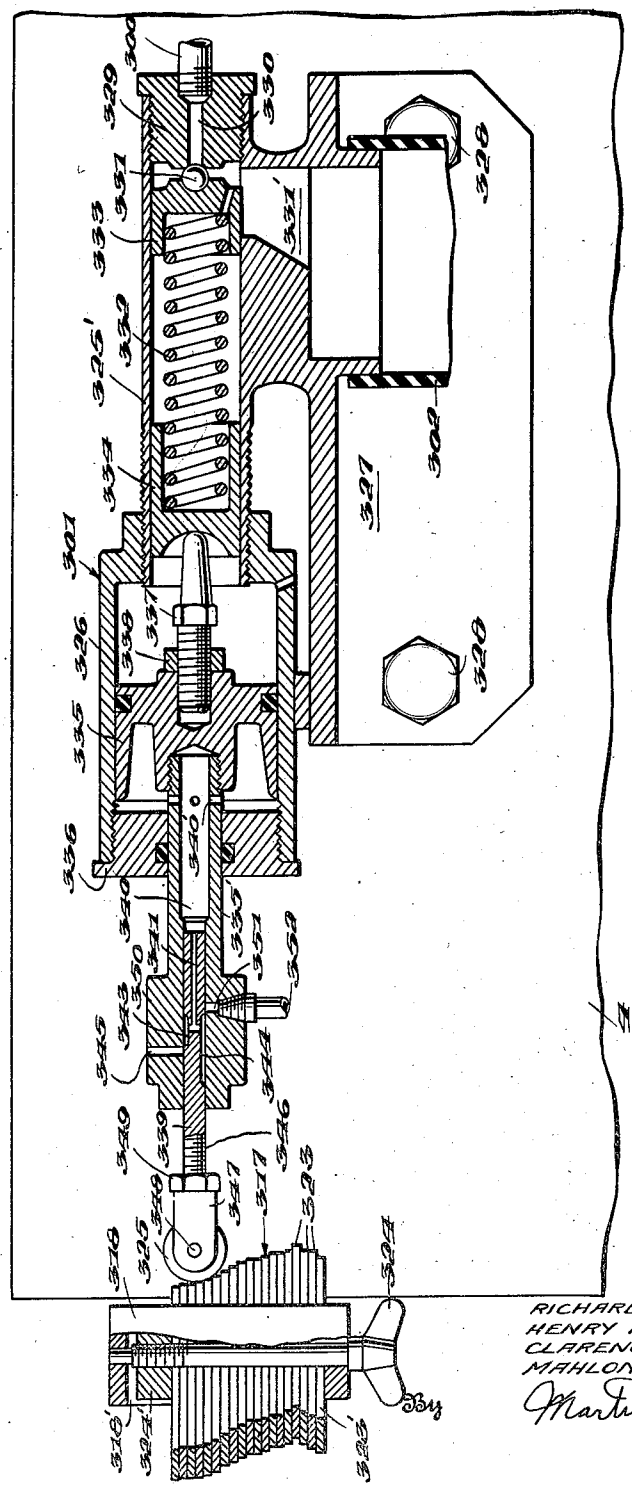

Fig. 4.

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2,605,731

APPARATUS FOR FORMING SHEET MATERIAL UNDER CONTROLLED PRESSURE

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Application December 16, 1948, Serial No. 65,552

4 Claims. (Cl. 113—44)

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This application is a continuation-in-part of our co-pending application S. N. 30,766, filed June 3, 1948, and entitled "Method and Apparatus for Controlled Pressure Forming of Sheet Material."

This invention relates to an apparatus to be used in conjunction with a conventional hydraulic press for the purpose of shaping parts of sheet metal, or similar material, over a form block or die. The invention relates to improved structure and techniques involving the rubber forming process for metal which has been previously used with some success in limited applications. The inherent disadvantage of known rubber pressure pad forming operations is that the parts formed are limited to large radius curvatures and shallow depths of form. It is possible by known apparatus to form reinforcing ribs and beads, and punch out lightening holes from plane area, but where it is required to make a deep flange or draw, the sheet metal wrinkles so badly that hand operations are usually required if the part is to be used at all.

It is an object of this invention to provide apparatus for forming sheet metal to compound curvatures and with deep drawn flanges by the use of a rubber pressure pad and a form block, and wherein means is provided for maintaining the pressure pad under predetermined back pressure throughout the forming operation to preclude wrinkling or tearing of the metal being formed.

A further object of this invention is to provide, in apparatus of the above-mentioned type, means for automatically, variably controlling the back pressure in a predetermined manner in accordance with the progress of the forming operation.

Another object is to provide in such forming apparatus means for producing a back pressure against said rubber pressure pad by fluid pressure derived from the downward movement of the forming head, the pressure being automatically regulated by a single cam-controlled, variable pressure-relief valve in accordance with the progress of the forming operation.

Another object of this invention is to provide in a forming machine of the above mentioned type, a pressure control cam mounted to move in accordance with the progress of the forming operation and comprising a plurality of individually adjustable cam elements which together form the effective contour of said cam, whereby the cam shape, and hence the back-pressures controlled thereby, can be readily varied, to facilitate setting up the machine for any particular forming operation.

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A still further object is to provide a cam-controlled, variable pressure-relief valve wherein a relatively light cam structure can be employed to positively control high pressures over a relatively wide range.

Another object is to provide hydraulically actuated means for stripping the formed article from the die, the stripping means being controlled by the position of the forming head so as to delay the stripping action until after the rubber pad in the head has been raised out of contact with the formed article.

A still further object is to provide a templet surrounding the die block and depressable against the action of fluid pressure means in the base for applying back-pressure to the rubber pad in the head during the forming operation, and means for supplying fluid to said fluid pressure means after said forming operation is completed to again raise said templet, whereby said templet also serves to strip the formed article from the die block.

Further and other objects of this invention will become apparent from the description of the accompanying drawings which form a part of this disclosure and wherein like numerals refer to like parts.

In the drawings:

Figure 1 is a somewhat diagrammatic view of the forming machine together with its associated pressure regulating equipment.

Figure 2 is a sectional view of a stripper control valve used therewith.

Figure 3 is an end view of the machine with certain parts omitted, showing the manner in which the control cam is mounted thereon.

Figure 4 is a sectional view of the cam-actuated back-pressure control valve unit used with the machine.

In Figures 1 to 4 is shown a forming machine using a single, cam-controlled, back-pressure valve to vary the forming pressure as desired and incorporating means for automatically stripping the finished work from the die block.

Referring first to Figure 1, which is a diagrammatic showing of the device, there is shown the head 1 with its rubber pad 2. Base assembly 4 includes the cylinders 11 with mating pistons 14 supporting on their upper ends movable platform 19. Platform 19 carries a templet 26 by means of posts 25 slidable through suitable openings in the upper portion of base 4. Templet 26 closely surrounds die block 27, rigidly supported by the base, the upper surfaces of the die block and of the templet normally lying in substantially the same plane. Filler block 29,

rigidly supported on the base, surrounds templet 26.

As fully described in our co-pending applications S. N. 30,766, head 1 is adapted to be secured to the upper movable platen of a conventional hydraulic press while base assembly 4 is rigidly mounted on the base or bed of the press. Reference may also be made to said application for details of construction of the above described elements, the corresponding parts therein having similar reference numerals to those in the instant application.

A conduit 60 carries hydraulic fluid to or from the cylinders 11 as controlled by the cam-controlled, back-pressure valve unit 301 and the stripper control valve 306. Conduit 60 is connected to back-pressure valve 301 by conduit 300. An exhaust line 302 runs from the valve unit 301 to a reservoir 303. A pump 304 is adapted to draw fluid from this reservoir and discharge it at relatively low pressure into low pressure line 305 leading to the stripper control valve 306. A manually operable shut-off valve 305' is provided in line 305 to cut out the automatic stripping operation when desired. A pressure relief valve 307 in by-pass line 308 limits the pressure that can obtain in line 305. Stripper control valve 306 communicates directly with conduit 60 leading to the cylinders 11. A suitable pressure gage 61 is provided on conduit 60.

Also, as in the earlier device, a pointer 44, pivoted at 43 to the base 4, is provided to indicate the extent of movement of templet 26 relative to the die block. The pointer is actuated by a stud 41 carried by platform 19 and extending outwardly through a slot 40 in the front side of the base 4 and into engagement with the offset bifurcated end of pointer 44.

The stripper control valve (see Figures 1 and 2) consists of a body 309 suitably rigidly supported from the base 4 and having a vertical bore 310 extending therethrough and communicating at its lower end with low pressure line 305. Conduit 60 terminates in a port 316 opening into the side of the bore 310. A plunger 311 slidable in bore 310, is connected by links 312 to a lever 313 pivotally supported as at 314 from the base 4. Lever 313 carries a roller 314' adapted to be engaged by an actuator 315 rigidly carried by the head 1. The actuator is so adjusted relative to the head and the roller 314' as to move plunger 311 downwardly to close off port 316 just before the head engages the piece to be formed, and to maintain this position of the plunger until the head moves away from the die-block after the forming operation has been completed. Thus during the forming operation, the flow of fluid from the cylinders 11 is under the sole control of the cam-controlled, back-pressure valve unit 301.

The cam-controlled, back-pressure valve unit 301 consists essentially of a cam-controlled, follow-up type of air booster for applying variable loading to the compression spring of a ball-type pressure relief valve. This valve unit 301 is controlled by a roller 325 riding on a cam 317 carried in a slotted holder 318. The cam and its holder are mounted for movement proportional to the downward movement of the templet 26 relative to the die block, by the means shown in Figure 3.

A lever arm 319, rigidly carrying the cam holder 318 at its outer end, is pivotally mounted as at 320 on the left hand side of the base 4. The inner end of this lever is bifurcated and engages the outer end of a stud 321 mounted in movable platform 19 and extending outwardly through a slot 322 in the side of base member 4. Thus, as the platform and templet move downwardly during the forming operation, the cam will move upwardly, its profile determining the position of the roller 325 at any particular time.

The cam itself is made up of a plurality of relatively thin, slotted plates 323 stacked within the slot 318' of holder 318 and clamped therein by wing bolt 324 which extends through the slots 323' in the plates 323 and into threaded engagement with clamping block 324'. Plates 323 have their end edges in position to engage the valve actuating roller 325. By loosening wing bolt 324 and sliding the individual plates 325 toward or away from the roller, the shape of the cam can be readily varied to control the back pressure in the manner desired for any particular forming operation.

The back-pressure control valve itself comprises a valve housing 325' threaded into the end of booster cylinder 326, both being rigidly carried by a bracket 327 bolted to the front face of base 4 by bolts 328 passing through the bracket and suitable spacer sleeves (not shown). Housing 325' is closed at the end opposite cylinder 326 by a cap 329 having a longitudinally extending bore 330 therethrough to which conduit 300 is connected. The inner end of bore 330 is adapted to be closed by a ball valve 331 urged thereagainst by compression spring 332 acting between plugs 333 and 334 slidable within housing 325'. An opening 331' through the lower wall of the housing and the bracket 327 connects the space between plug 333 and cap 329 to the exhaust line 302.

Booster cylinder 326 carries therein a piston 335 having a hollow piston rod 335' extending oppositely from the valve housing, out through a suitable seal in cap 336. The piston 335 also threadedly carries a stud 337 extending into engagement with plug 334. A nut 338 serves to lock the stud in the desired position of extension from the piston 335.

The hollow interior 340 of the piston rod 335' communicates with the interior of the cylinder 326 by means of ports 340' adjacent the piston. Slidable within the outer enlarged portion 350 of the piston rod is a valve stem 339 having a longitudinally extending passageway 341 communicating with the interior 340 of the piston rod and connected by suitable cross ports to a circumferential groove or necked portion 343 in the outer periphery of the stem. Exhaust port 345 and inlet port 351, in opposite walls of the piston rod, are arranged so that the spacing therebetween longitudinally of the stem is just greater than the width of the groove 343. The side of the stem facing the inlet port 351 has a flat 344 formed therein to effectively increase the width of the groove 343 on that side. Flexible air line 352 supplied compressed air to inlet port 351.

The outer end 346 of the valve stem threadedly carried a bifurcated roller bracket 347 carrying the roller 325 on pin 348 in position to ride on the ends of the cam plates 323. Bracket 347 is locked in desired position on the stem by lock nut 349.

With this construction, it can be seen that as cam 317 moves roller 325 and valve stem 339 to the right, annular groove 343 will be moved opposite inlet port 351 with the result that air will

be forced into cylinder 326 through passages 341, 340, and 340'. This will cause piston 335 to similarly move to the right to increase the compression of spring 332. The air pressure will also act against the inner end of the stem to maintain the roller in constant engagement with the cam. As the piston moves to the right, it, of course, moves the piston rod also to the right until ports 351 and 345 are again both closed as the rod reaches a new position, spaced to the right from the Figure 4 position an amount equal to the initial movement of stem 346 and roller 325. The compression of the spring will have, therefore, been increased by an amount proportional to the original movement of the cam roller.

If, on the other hand, the cam shape at a particular place is such as to tend to move away from the roller, the stem will be forced to follow the cam by the air under pressure in the cylinder, thus causing groove 343 to move opposite the exhaust port 345. Air will then be exhausted from within the cylinder and the piston will move to the left under the action of spring 332. As the piston and its rod move to the left, the port 345 will again be cut off as it is moved beyond the left edge of groove 343. Meanwhile the spring, in expanding, has reduced its compression force to an extent proportional to the left hand movement of the cam roller.

It can thus be seen that the spring tension against ball valve 331 will be automatically varied in direct relation to the shape of the cam and that, since the valve port 330 is in direct communication with the fluid in the base cylinders 11, the back pressure of the fluid resisting downward movement of the templet can be positively and continuously controlled to follow any desired pressure curve as the forming proceeds. The fluid, after passing through the back-pressure valve, is conducted through passage 331' and exhaust line 302 to the reservoir.

Operation

Figure 1 shows the parts of the machine in position to start a forming operation. Valves 305' and 306 are open at this time and cylinders 11 are filled with low pressure fluid thus supporting pistons 14, platform 19, posts 25 and templet 26 in their uppermost positions, with the upper surface of templet 26 substantially flush with the top of die block 27. Ball valve 331 is held against its seat at the inner end of passage 330 by a spring force proportional to the position of the cam roller 325 as determined by the upper portion of the cam 317.

A blank to be formed is placed in proper position on the die clock and templet and the press is actuated to lower the head. Just before the head engages the blank, actuator 315 engages roller 314' to rock lever 313 so as to force plunger 311 downwardly against the low pressure fluid to a position cutting off port 316 as indicated by dotted lines in Figure 2. Thus the only path of escape for the fluid in cylinders 11 is through conduits 60 and 300 and past the spring-loaded back-pressure control valve 301.

As the rubber block 2 in the head engages the blank and templet, the pressure of the trapped fluid in cylinders 11 will build up to a valve proportional to the loading of the valve spring 332 which in turn is determined by the portion of the cam 317 then engaging the roller 325. This back pressure results in placing the rubber pad under a corresponding pressure before any actual forming of the blank begins.

When this initial desired pressure is reached, the back pressure valve will open to let fluid flow from cylinders 11 to the reservoir by way of conduits 60, 300, 330, 331' and 302. The templet together with platform 19, pistons 14 and posts 25, will then gradually be depressed as the forming operation proceeds and cam 317 will move proportionately upwardly past the roller 325, regulating the pressure in the system in accordance with the shape of the cam. At any instant the gage 61 will indicate the pressure in the system and the pointer 44 will show the distance that the templet has been depressed.

Thus throughout the forming operation the blank being formed will be subject to a predetermined pressure applied between the rubber block and the templet or the die block as the case may be, causing the metal to flow smoothly, without wrinkling or cracking as it assumes the desired shape.

When the end of the forming stroke has been reached, the head is started upwardly in the usual fashion to prepare for another cycle. Meanwhile, the pistons 14, together with platform 19 and templet 26, will remain in lowered position since stripper valve 306 will still be held closed by the actuator 315 and no pressure fluid can enter the cylinders. However, just after the head clears the top of the die block, actuator 315 will move away from the roller 314' on lever 313, permitting the plunger 311 to return to its upper position shown in Figures 1 and 2 and to open port 316 to the low pressure line 305. Fluid will, therefore, flow into the cylinders, moving the templet upwardly to strip the formed piece from the die and to prepare for another cycle of operation.

The use of the air booster cylinder to control the spring pressure on the ball valve makes it possible to automatically control the extremely high back-pressure, essential for satisfactory forming, by a relatively simple and light-weight cam exerting but a relatively light pressure against its roller follower. Yet, extreme smoothness of control over a rather wide range of pressures is readily obtainable.

Moreover, with this arrangement the problem of setting up the machine for any particular job is materially simplified. In setting up the machine for a new job, shut-off valve 305' is manually closed to cut out the automatic stripping operation. The press can then be stopped at any stage in the cycle and opened for inspection of the blank being formed. This is possible since the back-pressure transmitted to the rubber in the head is controlled by the cam in predetermined relation to the position of the templet relative to the die block, rather than merely by the resistance of the blank to the forming operation, and even when the cycle is stopped and again started, the pressure at a particular point in the cycle will always be substantially the same. If cracks or wrinkles are found to be starting at any point in the operation, the cam plate or plates 323, corresponding to that point in the cycle, can be extended or retracted in the holder to increase or decrease the back-pressure as necessary to cause proper flow of the metal. The same partially formed blank (if not seriously cracked or wrinkled) can be reinserted in the machine and the press actuated to a later stage in the cycle and another check made. Thus, by going through a complete cycle in small steps,

checking the article being formed and making any indicated correction in the cam shape at the end of each step, the proper cam shape for any particular job can be quickly determined. Once determined for a particular job, the cam shape can be recorded or a templet made to facilitate setting up the same or similar jobs in the future. However, even without such a templet, an operator soon learns, from having previously observed the effect of changes in back-pressure on the forming of particular sizes and shapes of articles, to initially set the cam plates for any particular job so that no further adjustment of the cam, or, at the most, but relatively slight adjustment thereof will be necessary to produce formed articles completely free of cracks, wrinkles, or other flaws. Once the cam is properly adjusted for a particular job, valve **305'** is of course again opened to restore the automatic stripping action and the machine is ready for use.

While but a single embodiment is specifically shown and described in this specification, it is believed obvious that many changes may be made in the arrangement of parts without departing from the principle and spirit of this invention as set forth in the appended claims and the claims are not therefore to be unnecessarily restricted in scope.

We claim as our invention:

1. In an apparatus for forming a metal blank, and including a base member, a die block adapted to be supported from said base member, and a power actuated head member movable toward said base member throughout the forming operation for forming said blank over said die block, said head member comprising a rigid box-like housing of constant predetermined volume, the side thereof facing said base being open, and a pad of rubber-like, resilient material substantially filling said housing, and means carried by said base and adapted to mate with and form a movable wall for the open side of said housing to completely confine said resilient material throughout the forming operation and including said die block and a templet closely surrounding said die block and adapted to support a blank to be formed over said die block and mounted for movement relative to said die block in accordance with the progress of the forming, said resilient pad being coextensive with said die block and said templet and constituting the sole medium for forming said blank over and around said die block, fluid pressure means for opposing movement of said templet as said head moves toward said base during the forming operation whereby to produce corresponding forming pressure throughout said pad, a variable pressure relief valve for regulating the fluid pressure within said pressure means, said valve being selectively operable to either increase or decrease the pressure to any predetermined value at any stage of the forming operation and control means including an element movable with the templet for continuously controlling the pressure setting of said valve in a predetermined manner throughout the forming operation, whereby the forming pressure of said pad against said blank may be accordingly controlled, said movable element comprising a cam, and said variable pressure-control valve including a housing having a pressure port connected to the fluid pressure means and an exhaust port, means resiliently opposing the flow of fluid from said pressure port to said exhaust port and including a loading spring means within said housing, a booster cylinder rigid with said housing having a piston axially movable therein and engaging said spring means for controlling the loading thereof, a piston rod for said piston having a hollow interior communicating with the inside of said booster cylinder and having axially spaced inlet and exhaust ports in the outer portions thereof, means for connecting said inlet port to a source of pressure fluid, a valve stem axially slidable in the hollow interior of said piston rod and having portions adapted to block off communication between both of said ports and said hollow interior or selectively to block either port while providing communication between the other port and the hollow interior, and means on said valve stem for engaging said cam means whereby the position of said piston and the loading of said spring will vary in accordance with the contour of said cam to correspondingly vary the pressure of said pad against said blank.

2. In an apparatus for forming a metal blank, and including a base member, a die block adapted to be supported from said base member, and a power actuated head member movable toward said base member throughout the forming operation for forming said blank over said die block, said head member comprising a rigid box-like housing of constant predetermined volume, the side thereof facing said base being open, and a pad of rubber-like, resilient material substantially filling said housing, and means carried by said base and adapted to mate with and form a movable wall for the open side of said housing to completely confine said resilient material throughout the forming operation and including said die block and a templet surrounding said die block and adapted to support a blank to be formed over said die block and mounted for movement relative to said die block in accordance with the progress of the forming, said resilient pad being co-extensive with said die block and said templet and constituting the sole medium for forming said blank over and around said die block, fluid pressure means for resisting movement of said templet as said head moves toward said base during the forming operation whereby to produce corresponding forming pressure throughout said pad, a variable pressure relief valve for regulating the fluid pressure within said pressure means, said valve being selectively operable to either increase or decrease the pressure to any predetermined value at any stage of the forming operation and including a seat, and a valve member adapted to coact with said seat to resist the flow of fluid from said pressure means, and a fluid pressure booster chamber having a movable wall thereof acting against said valve member and urging it toward said seat in accordance with the pressure in said chamber, and control means for continuously controlling the pressure setting of said valve in a predetermined manner throughout the forming operation, whereby the forming pressure of said pad against said blank may be accordingly controlled and comprising a manually adjustable, variable contour cam movable with said templet, a booster pressure control valve in fluid communication with said booster chamber and with a source of fluid pressure and including a movable control member for regulating the flow of pressure fluid to and from said chamber in accordance with the position of said control member and the pressure in said chamber whereby to cause the pressure in said chamber to correspond to the position of said control member, and a cam follower contacting said cam and operatively connected to said control member for controlling the position of said control member in accordance with the

contour of said cam throughout the forming operation.

3. In an apparatus for forming a metal blank, and including a base member, a die block adapted to be supported from said base member, and a power actuated head member movable toward said base member throughout the forming operation for forming said blank over said die block, said head member comprising a rigid box-like housing of constant predetermined volume, the side thereof facing said base being open, and a pad of rubber-like, resilient material substantially filling said housing, and means carried by said base and adapted to mate with and form a movable wall for the open side of said housing to completely confine said resilient material throughout the forming operation and including said die block and a templet surrounding said die block and adapted to support a blank to be formed over said die block and mounted for movement relative to said die block in accordance with the progress of the forming, said resilient pad being co-extensive with said die block and said templet and constituting the sole medium for forming said blank over and around said die block, fluid pressure means for resisting movement of said templet as said head moves toward said base during the forming operation whereby to produce corresponding forming pressure throughout said pad, a variable pressure relief valve for regulating the fluid pressure within said pressure means, said valve being selectively operable to either increase or decrease the pressure to any predetermined value at any stage of the forming operation and including a seat, and a valve member adapted to coact with said seat to resist the flow of fluid from said pressure means, and a fluid pressure booster chamber having a movable wall thereof acting against said valve member and urging it toward said seat in accordance with the pressure in said chamber, and control means for continuously controlling the pressure setting of said valve in a predetermined manner throughout the forming operation, whereby the forming pressure of said pad against said blank may be accordingly controlled and comprising a manually adjustable, variable contour cam movable with said templet, a booster pressure control valve in fluid communication with such booster chamber and with a source of fluid pressure and including a movable control member for regulating the flow of pressure fluid to and from said chamber in accordance with the position of said control member and the pressure in said chamber whereby to cause the pressure in said chamber to correspond to the position of said control member, and a cam follower contacting said cam and operatively connected to said control member for controlling the position of said control member in accordance with the contour of said cam throughout the forming operation, the fluid communication between said chamber and said booster control valve being so arranged that the chamber pressure reacts against said control member so as to urge said follower against said cam.

4. In an apparatus for forming a metal blank, and including a base member, a die block adapted to be supported from said base member, and a power actuated head member movable toward said base member throughout the forming operation for forming said blank over said die block, said head member comprising a rigid box-like housing of constant predetermined volume, the side thereof facing said base being open, and a pad of rubber-like, resilient material substantially filling said housing, and means carried by said base and adapted to mate with and form a movable wall for the open side of said housing to completely confine said resilient material throughout the forming operation and including said die block and a templet surrounding said die block and adapted to support a blank to be formed over said die block and mounted for movement relative to said die block in accordance with the progress of the forming, said resilient pad being co-extensive with said die block and said templet and constituting the sole medium for forming said blank over and around said die block, fluid pressure means for resisting movement of said templet as said head moves toward said base during the forming operation whereby to produce corresponding forming pressure throughout said pad, a variable pressure relief valve for regulating the fluid pressure within said pressure means, said valve being selectively operable to either increase or decrease the pressure to any predetermined value at any stage of the forming operation and including a seat, and a valve member adapted to coact with said seat to resist the flow of fluid from said pressure means, and a fluid pressure booster chamber having a movable wall thereof acting against said valve member and urging it toward said seat in accordance with the pressure in said chamber, and control means for continuously controlling the pressure setting of said valve in a predetermined manner throughout the forming operation, whereby the forming pressure of said pad against said blank may be accordingly controlled and comprising a cam movable with said templet, and means for controlling the pressure in said chamber in accordance with the contour of said cam and including a cam follower engaging said cam and a booster control valve connected to said chamber and to a source of fluid pressure, said booster control valve having a stem member operatively connected to said follower for movement therewith and a valve member coacting with said stem member to control the flow of pressure fluid to and from said chamber, said last mentioned valve member being movable relative to said stem member in response to the pressure in said chamber whereby to maintain said pressure at a value corresponding to the position of said stem.

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