

- [54] **FORMING APPARATUS FOR HYDRAULIC PRESS**
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- [22] Filed: **Dec. 5, 1969**
- [21] Appl. No.: **882,652**
- [30] **Foreign Application Priority Data**  
Dec. 9, 1968 Sweden..... 16777/68
- [52] U.S. Cl.....72/63
- [51] Int. Cl.....B21d 22/12
- [58] Field of Search.....72/63

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[57] **ABSTRACT**

In a hydraulic forming tool of the diaphragm type, the punch and the work holder or die member are rigidly mounted on separate pistons that move in communicated cylinders, so that downward movement of one effects upward movement of the other by reason of displacement of fluid from the bottom of one of said cylinders to the bottom of the other. Adequate forming force is assured by metering outflow of fluid from the upper portion of the cylinder having the upgoing piston.

- [56] **References Cited**
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- 2,783,728 3/1957 Hoffmann.....72/63

11 Claims, 6 Drawing Figures

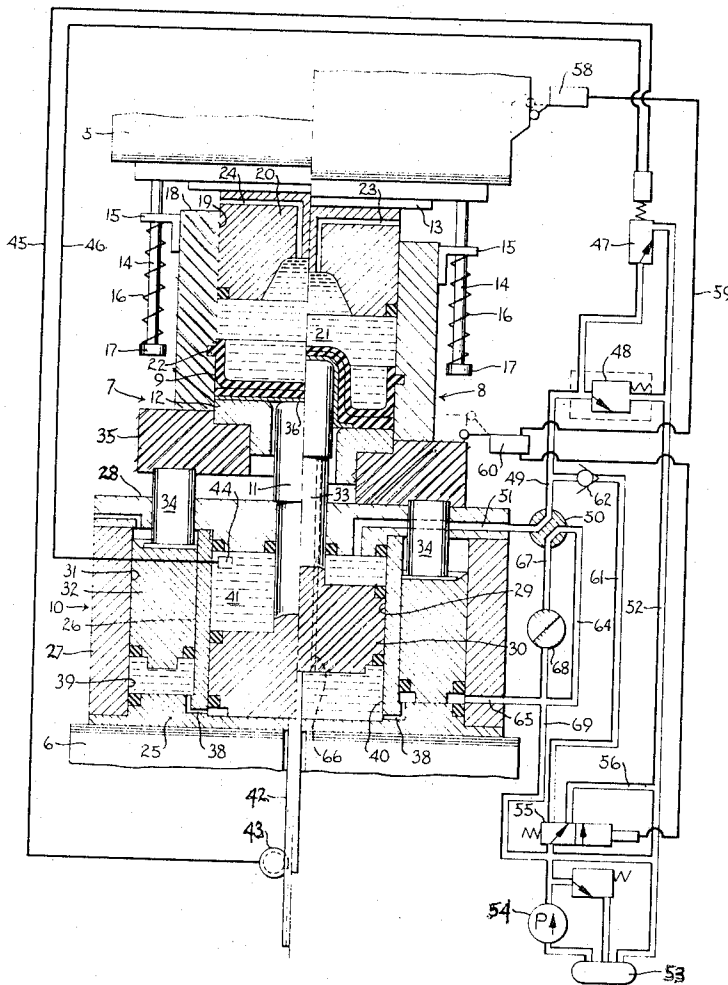
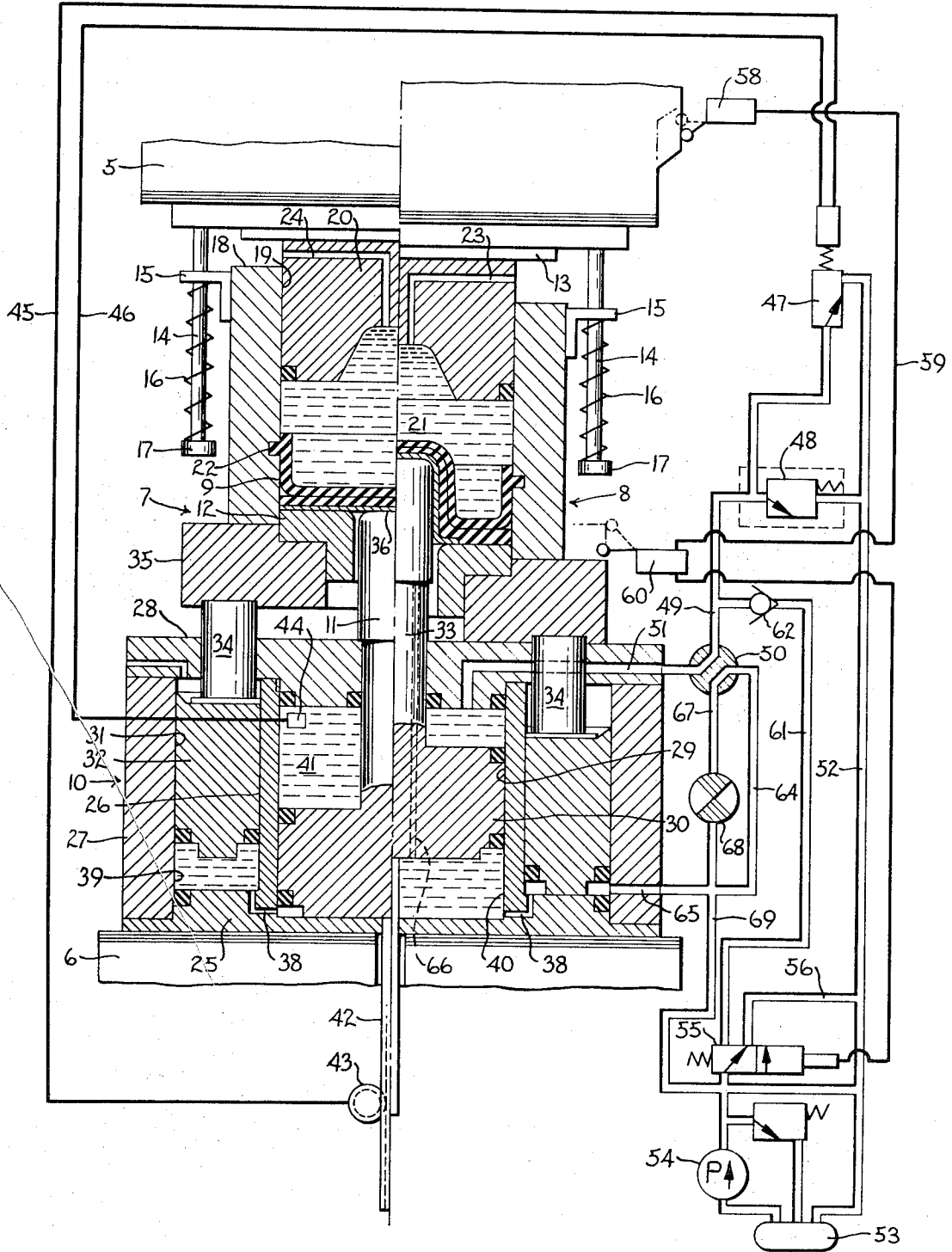
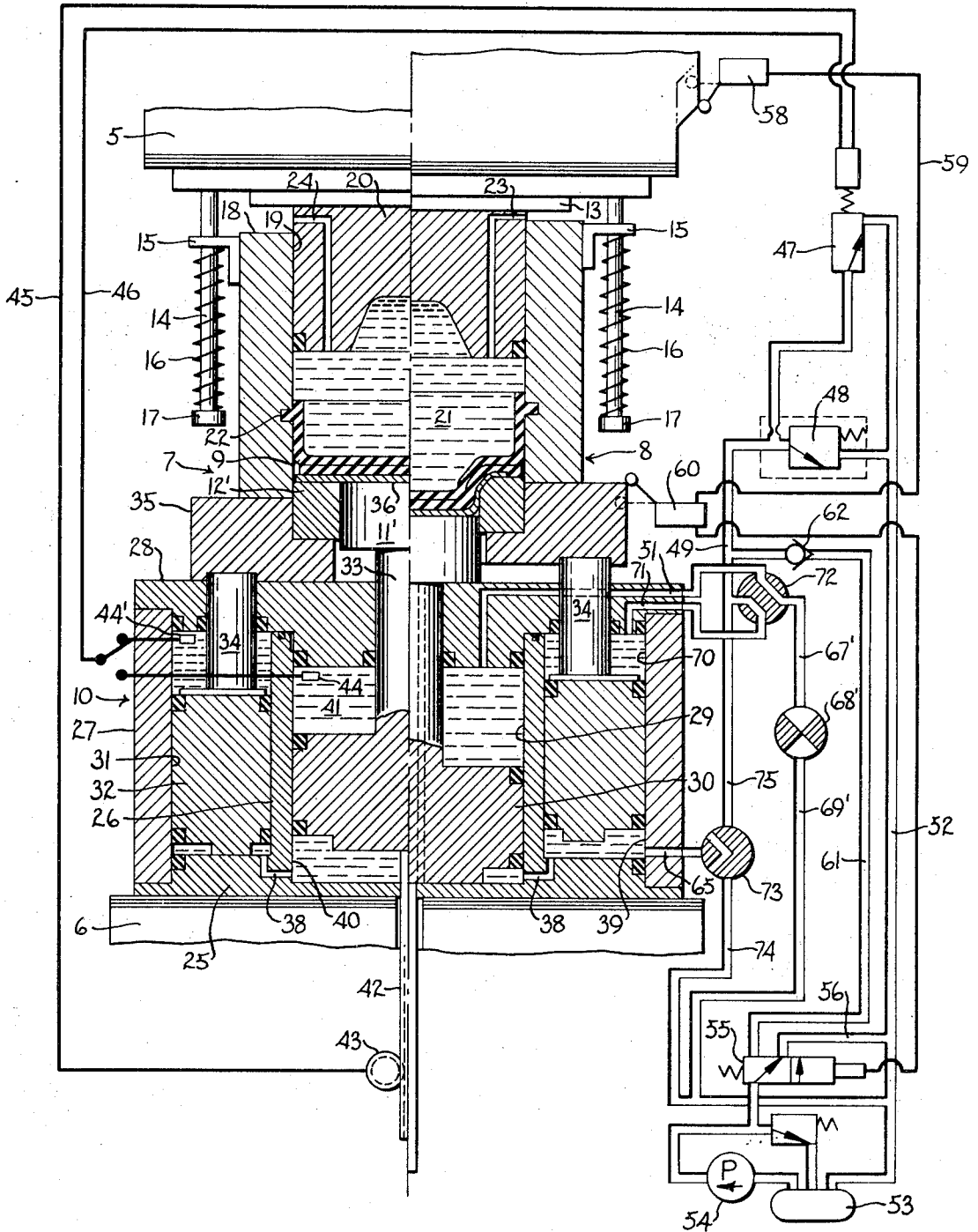


FIG. 1.



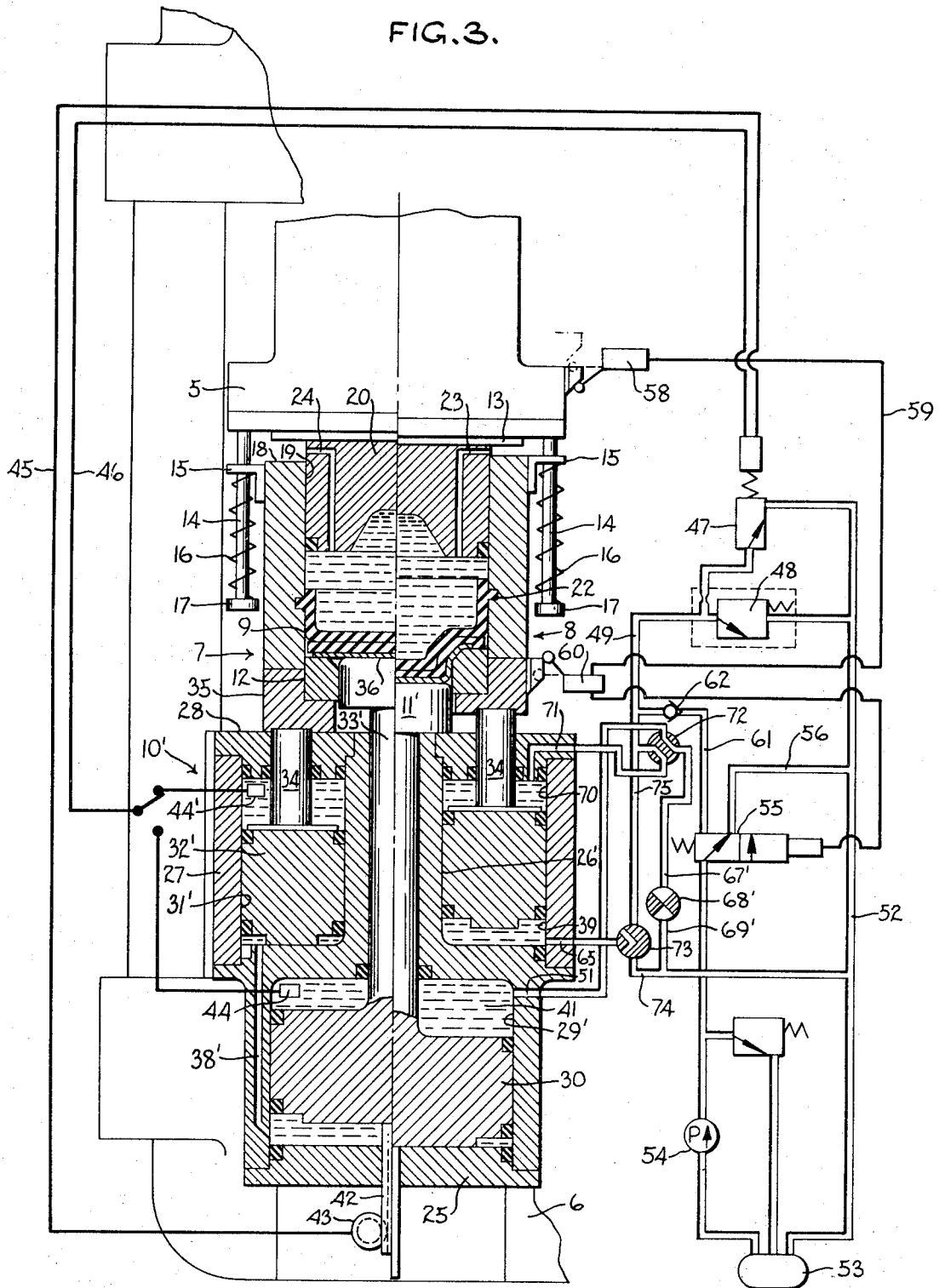
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FIG. 2.



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FIG. 3.



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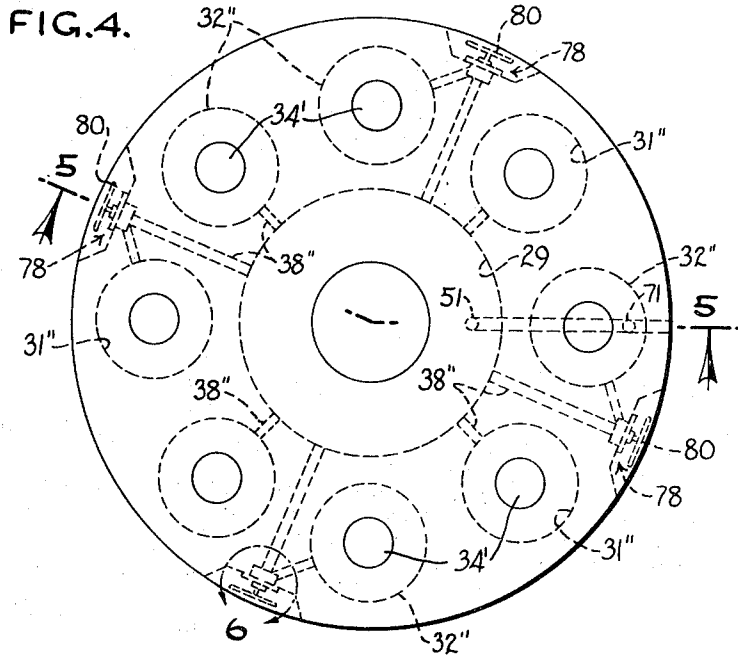


FIG. 5.

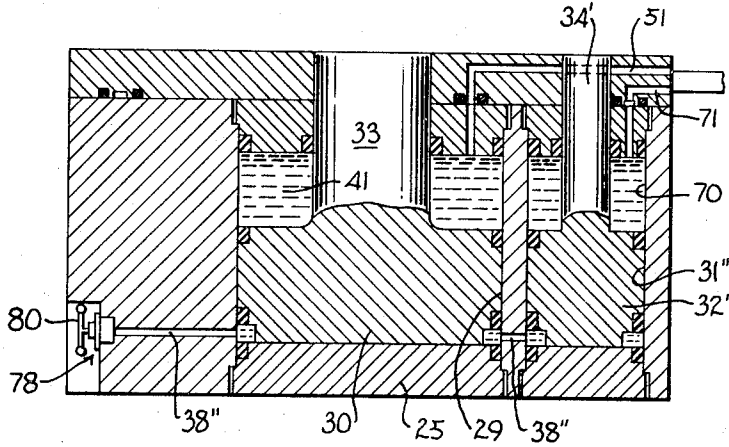
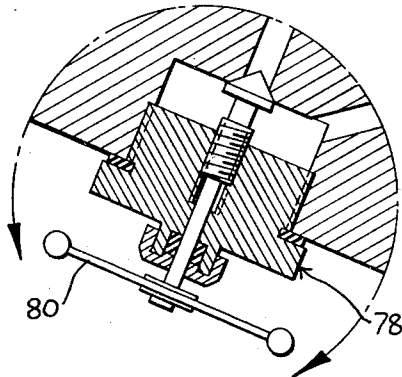


FIG. 6.



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## FORMING APPARATUS FOR HYDRAULIC PRESS

This invention concerns hydraulic forming tools used with presses for the forming of sheet metal blanks; and the invention is related more particularly to hydraulic forming tools of the type comprising a body which defines a pressure chamber that is closed at its bottom by a resilient diaphragm, a rigid blank holder beneath the body that cooperates with the diaphragm to clampingly confine marginal edge portions of a workpiece, and a central punch which is movable relative to the blank holder and which cooperates with the diaphragm in forming the central portion of the workpiece.

Forming tools of the general type to which this invention relates are disclosed, for example, in U.S. Pat. No. 3,392,563, to H. Möller, and U.S. Pat. No. 3,115,858 to C. L. Mitchell. Such a forming tool can be built into a press as an integral part thereof or can comprise a separate attachment for use in conventional presses.

Particularly where a forming tool of the character described is designed as an attachment, it has often happened heretofore that either the stroke of the press or the space between the press jaws was insufficient, when the attachment was received between them, to leave room for withdrawal of formed parts from between the diaphragm and the rigid tool members that cooperated with it. This was particularly true with tools for deep-drawn parts, since with prior tools of the character described the length of the press stroke had to be equal to about twice the depth of the finished workpiece to accommodate both the working portion of the stroke and an additional amount of stroke that opened the press for workpiece unloading.

For best economy in press operation the press should have as fast a motion as possible during formation of deep-drawn parts. The power required by a press depends not only upon the force that it must exert during the forming operation but also upon the speed at which drawing is effected, hence a press must have a certain size for formation of any particular part, or else its production rate must be reduced to an uneconomically slow speed.

With the foregoing considerations in mind it is a general object of this invention to provide a forming tool of the character described which can be either an integral part of a press or an accessory for a press and which requires substantially less press jaw travel and jaw gap for a given draw depth than prior forming tools of this general kind, and which therefore enables the forming of deeply drawn workpieces with the use of a substantially smaller press than was heretofore needed for that purpose.

It is also an object of this invention to provide a hydraulic forming tool of the character described that utilizes press power very efficiently, so as to make possible the production of relatively deeply drawn workpieces at an economically high rate with the use of a press having a relatively small stroke.

It is also an object of this invention to provide a hydraulic forming tool of the character described which effectively increases the jaw stroke of a forming press, is capable of being used for both punch forming and die forming, and also provides for powered automatic withdrawal of the punch from the workpiece or the workpiece from the die.

With these observations and objectives in mind, the manner in which the invention achieves its purpose will be appreciated from the following description and the accompanying drawings, which exemplify the invention, it being understood that such changes in the precise method of practicing the invention and in the specific apparatus disclosed herein may be made as come within the scope of the appended claims.

The accompanying drawings illustrate several complete examples of embodiments of the invention constructed according to the best modes so far devised for the practical application of the principles thereof, and in which:

FIG. 1 is a vertical sectional view of a hydraulic forming tool embodying the principles of this invention, shown in the left-hand half of the figure in its condition at the beginning of a forming stroke and in the right-hand half of the figure in its condition at the end of a forming stroke;

FIG. 2 is a view generally similar to FIG. 1 but illustrating a modified embodiment of the invention;

FIG. 3 is another view generally similar to FIG. 1 but illustrating a further modified embodiment of the invention;

FIG. 4 is a horizontal sectional view of a still further modified embodiment of the invention;

FIG. 5 is a sectional view taken on the plane of the line 5—5 in FIG. 4; and

FIG. 6 is a detailed horizontal sectional view on an enlarged scale of the area embraced by the line 6 in FIG. 4.

Referring now to the accompanying drawings, the numerals 5 and 6 respectively designate the upper and lower jaws of a press that is equipped with a forming tool embodying the principles of this invention, which forming tool is designated generally by 7 and is shown for purposes of illustration as an accessory attachment for the press. The forming tool 7 comprises, in general, an upper element 8 that defines a pressure chamber which is enclosed by a resilient diaphragm 9 at its bottom, and a lower element 10 comprising a rigid central punch 11 and a rigid annular work holder 12 which concentrically surrounds the punch.

The upper element 8 comprises an outer cylindrical body member 18 having a bore 19 therethrough and which is carried by the press head for limited motion up and down relative to it, a plunger or piston 20 which is sealingly slidable in the upper portion of the bore 19 and which is rigidly but removably secured to the press head, and the resilient diaphragm 9, which extends across the bore 19 in the body member 18 near the bottom thereof.

The piston or plunger 20 is secured to a mounting plate 18 on the underside of the upper press jaw or press head 5. The mounting plate also has long studs 14 extending downwardly from it to mount the cylindrical body member 18 for up-and-down motion relative to the press head 5 and the plunger 20. These studs extend through guide holes in brackets 15 that project laterally from the upper portion of the cylindrical outer body member, and the latter is biased upwardly by means of compression springs 16, one surrounding each stud and reacting between the bracket 15 and a head 17 on the bottom of the stud.

The diaphragm 9 is substantially cup shaped, having a cylindrical sidewall and a flat bottom wall, and it is securely held in the bore 19 in the body member 18 by means of a radially outwardly projecting circumferential rib or land 22 on its sidewall that is received in a closely fitting groove in the body member that opens inwardly to its bore. As is conventional, a clamping ring (not shown) engages the inner surface of the diaphragm sidewall to maintain the land 22 engaged in the groove.

The pressure chamber 21 that is conjointly defined by the body member 18, the plunger 20 and the diaphragm 9 can be filled with hydraulic fluid through a normally closed filler passage 23. A normally closed vent passage 24 permits air to bleed out of the chamber as it is filled.

It will be observed that the outer cylindrical body member 18, in being able to move axially relative to the plunger 20, can accommodate changes in volume of the pressure chamber 21 due to upward flexing displacement of the central portion of the diaphragm into it. It will also be noted that the force which the pressure fluid in the chamber 21 exerts upon the diaphragm in reaction to such flexing displacement is to some extent determined by the biasing force exerted by the springs 16. The plunger 20 can be formed, as shown, with a cavity in its underside that provides adequate space for such diaphragm flexing.

The press table or lower jaw 6 of the press supports the lower element 10 of the forming tool, which comprises a bottom wall member 25, concentric inner and outer annular upright wall members 26 and 27, respectively, and a top wall member 28. The several wall members just mentioned cooperate to define an inner cylinder 29, in which a plunger-like inner piston 30 is slidable, and an annular outer cylinder 31, concentrically surrounding the inner cylinder and in which an annular outer piston 32 is slidable.

The inner piston 30 has a reduced diameter coaxial stem portion 33 which can be integral with its body portion 33 which can be integral with its body portion and which projects with a slidable sealing fit through a hole in the top wall member 28. The punch 11 is rigidly secured to the top of this stem. Compression rods or struts 34 project upwardly from the annular outer piston 32 at circumferentially spaced intervals around it and extend with a slidable sealing fit through holes in the top wall member 28. To the upper ends of these struts is rigidly attached an annular tool holder 35 on which the work holder 12 is readily removably carried. Since the actual forming of a workpiece is performed by the work holder 12 and the punch 11 in cooperation with the diaphragm 9, it is intended that work holders 12 of different shapes will be interchangeably mounted on the tool holder 35, and the connection between the punch 11 and the piston stem 33 can also be such as to permit punches to be readily interchanged.

To provide for motion of the punch and work holder in opposite directions during a forming operation, the inner cylinder 29 is communicated with the outer annular cylinder 31 by means of passages 38 in the bottom wall member 25 through which hydraulic fluid can flow relatively freely.

When the press is open, with the press head or upper press jaw 5 fully raised, there is a substantial spacing between the work holder 12 and the bottom of the upper element 8, through which a finished formed workpiece can be removed from the press and a new sheet metal blank 36 can be set in place. With the press open, the top of the punch 11 is at the level of the top surface of the work holder 12, and the bottom of the punch can rest on the top surface of the top wall member 28; but the bottom surface of the tool holder 35 is spaced above the upper surface of the top wall member.

With a blank 36 in place, the press head is lowered. At the left side of FIG. 1 there is illustrated what can be regarded as a press-closed condition, in which the diaphragm 9 has just flatwise engaged the blank, and the punch 11 and work holder 12 still remain in their initial conditions. With continued descent of the press head, the work holder now moves downwardly, but with sufficient resistance to downward motion so that it cooperates with the diaphragm in clampingly confining the marginal edge portions of the blank. At the same time, the punch moves upwardly, cooperating with the central portion of the diaphragm in forming the blank.

The reason the punch moves upwardly as the work holder descends is that downward motion of the annular outer piston 32 displaces hydraulic fluid out of the chamber 39 beneath it, and through the passages 38 in the bottom wall member into the chamber 40 that comprises the bottom portion of the inner cylinder 29, raising the inner piston 30. Such displacement of fluid from the outer cylinder to the inner one can take place because the area of the work holder 12 that is engaged by the diaphragm, and against which the pressurized fluid in the upper pressure chamber 21 effectively reacts, is substantially greater than the corresponding area of the punch 11. Since the area of the annular outer piston 32 that acts upon fluid in the bottom chamber 39 is substantially greater than the corresponding area of the inner piston 30, the punch moves up faster and farther than the work holder moves down. Thus in the example illustrated in FIG. 1, the effective area of the outer annular piston is twice that of the inner piston, and therefore the punch moves upwardly relative to the press table 6 through twice the distance that the work holder 12 moves downwardly. This is to say that the working stroke of the forming tool is triple the working stroke of the press.

It has already been mentioned that reaction force which fluid in the upper pressure chamber 21 exerts upon the diaphragm 9 is influenced by the biasing force of the springs 16. However, the pressure in that chamber is also materially influenced by the rate of upward motion of the punch (or, what is really the same thing, of downward motion of the work holder) since this determines the extent to which the springs 16 will be compressed at any instant during the working stroke. Hence the pressure in the chamber 21 is controlled by

regulating the rate at which the punch is permitted to move upwardly, and this, in turn, is accomplished by metering the displacement of hydraulic fluid out of a pressure chamber 41 in the top of the inner cylinder 29, above the punch-actuating piston 30. Such metering also serves to regulate the clamping force that the diaphragm and the blank holder exert upon the marginal edge portion of the blank, inasmuch as it determines the resistance of the work holder to downward motion.

Fluid outflow from the chamber 41 is controlled automatically, partially in response to the rate of upward motion of the punch, as detected by a rate-responsive motion transducer or sensor 43, and partially in response to the fluid pressure prevailing in the chamber 41, as detected by a pressure transducer 44 that is mounted in said chamber, on a wall thereof. The motion sensor 43 can be actuated by a rod 42 or the like that is attached to the punch 11 or its piston 30 to be moved lengthwise in unison with the punch.

The respective electrical outputs of the motion and pressure sensors are fed, by way of conductors 45 and 46, to an electroresponsive pilot valve 47 which in turn governs a pressure control valve 48. The pressure control valve is connected in a metered flow duct 49 that is communicated, through a four-port two-position valve 50, with a passage 51 in the top wall member 28, which passage in turn communicates with the chamber 41. Hence the rate at which fluid is permitted to flow out of the chamber 41 during upward movement of the inner piston 30 is determined by the pressure control valve 48 in accordance with rate and pressure values detected by the sensors 43 and 44.

From the pressure control valve 48 the expelled fluid flows by way of a return fluid duct 52 to a fluid reservoir 53.

At the conclusion of the forming operation, after the press head has returned to its fully raised position, hydraulic fluid is fed back into the pressure chamber 41 to force the punch-actuating piston 30 back down to its initial position, and the work holder 12 is concomitantly moved back up to its initial position as a result of displacement of fluid out of the chamber 40 and into the chamber 39 through the passages 38.

For such refilling of the chamber 41 there is a pump 54 or other fluid pressure source that has its inlet communicated with the reservoir 53 and its outlet connected with an electrically actuated two-position valve 55. Except during the time that the tool is actually in its return stroke, the two-position valve 55 is in a normal unenergized condition in which it communicates the pump outlet with a bypass duct 56 that leads into the return fluid duct 52, for return of the pump output to the reservoir 53. When the press head reaches the top of its stroke at the end of its operating cycle, it closes a switch 58 that is connected with the actuator of the two-position valve 55 by means of a conductor 59 in which there is a then-closed switch 60. Such closure of the switch 58 energizes the actuator of the two-position valve 55, and said valve shifts to a position in which the pump outlet is communicated with the duct 49 by way of a duct 61 and a check valve 62, and thence, by way of the four-port two-position valve 50 and the passage 51, with the chamber 41.

When the tool holder 35 reaches its fully raised position, it actuates the switch 60 to its open position, breaking the circuit through the conductor 59 that energizes the actuator for the two-position valve 55, and that valve then returns under bias to its normal position in which it directs the pump output back to the reservoir.

It will be seen that the valve 55 remains in its normal position all through the subsequent forming stroke because at least one of the switches 58 or 60 always remains open from the time the press head begins to descend until it returns to its fully raised position.

For filling hydraulic fluid into the chambers 39 and 40 at the bottoms of the inner and outer cylinders 29 and 31, the four-port two-position valve 50 is manually rotated through 90° from its illustrated position, so that it communicates the duct 49 with a duct 64 that leads to a filler passage 65 in the outer annular wall member 27. The actuator of the two-position

valve 55 is then energized (as by manual actuation of a separate switch, not shown) to shift that valve to its position in which the output of the pump 54 is directed to flow successively through duct 61, check valve 62 the four-port valve 50, and duct 64 to the filler passage 65. A closable vent for bleeding air out of the chambers 39 and 40 is of course provided and can comprise a passage 66 extending up through the stem portion 33 of the inner piston.

For draining the lower chambers 39 and 40 there is a duct 67 which communicates the four-port two-position valve 50 with a manually controllable normally closed shutoff valve 68. From the shutoff valve a duct 69 leads to the return fluid duct 52. Hence the chambers 39 and 40 can be drained by leaving the four-port valve 50 in its normal (illustrated) position and opening the shutoff valve 68. Similarly, the chamber 41 in the upper portion of the inner cylinder can be drained by rotating the four-port valve 50 through 90° from its illustrated position, to communicate the passage 51 with the duct 67, then opening the shutoff valve 68 and forcing the tool holder 35 down to raise the inner piston 30.

FIG. 2 illustrates essentially the same tool apparatus as FIG. 1, but adapted for so-called die forming, with an appropriately different punch 11' and work holder 12' installed thereon. In this case the punch 11' does not participate actively in the formation of the workpiece, but instead serves to define the bottom surface of the cavity of a die, the remainder of which is defined by the work holder 12'; and instead of being flexed upwardly into the upper pressure chamber 21 by the rigid tool parts, the diaphragm 9 is forced downwardly into the die cavity thus defined, to serve, in effect, as the male member of the forming tool.

For this type of work the tool holder 35 is in a lowered position at the beginning of each forming cycle (see the left half of FIG. 2), and it can rest on the top wall member 28, while the punch, which is axially short, again has its top surface flush with that of the work holder 12' but has its bottom surface spaced a substantial distance above the top of the top wall member 28.

Die forming is usually employed for the shaping of relatively wide, shallow workpieces, and therefore the punch 11' has a top surface area which is large relative to the top surface area of the work holder 12'. For this reason the work holder can be forced to rise in consequence of downward movement of the punch.

In this case, to adapt the tool for die forming as well as punch forming, its hydraulic circuit is somewhat modified, inasmuch as die forming requires that the chamber 70 above the annular outer piston 32 contain hydraulic fluid, and the outflow of such fluid out of said chamber must be metered as the annular piston is raised during the forming stroke. There must also be a pressure sensor 44' in the upper annular chamber 70, and means for selectively connecting the pilot valve 47 with either that sensor or the pressure sensor 44 in the upper portion of the inner cylinder, depending upon the type of work to be done.

A passage 71 leads through the top wall member 28 from the upper annular chamber 70, and a four-port two-position valve 72 provides for selectively communicating either said passage 71, or the passage 51 that leads to the chamber 41, with the metered outflow duct 49 that leads to the pressure control valve 48. Whichever of the two upper chambers 41 or 70 is not thus communicated with the pressure control valve 48 is connected through the four-port two-position valve 72 with a duct 67' that leads to a normally closed manually positionable shutoff valve 68'. The shutoff valve 68' is in turn connected with a duct 69' that leads to the return fluid line 52; hence opening of said shutoff valve provides for draining either of the chambers 41 or 70, depending upon the position of the four-port valve 72.

The passage 65 in the annular sidewall member 27, through which the communicated bottom chambers 39 and 40 can be filled and drained, is controlled by a three-position valve 73 that is normally closed. In one of its open positions the three-

position valve communicates the passage 65 with a duct 74 that leads to the return fluid duct 52, for draining the bottom chambers; and in its other open position it communicates the passage 65 with a duct 75 through which pressure fluid from the pump outlet can be filled into the bottom chambers by way of the electroresponsive two-position valve 55, a duct 61, the check valve 62, and a portion of the duct 49 that communicates the check valve with the duct 75.

The modified embodiment of the invention that is shown in FIG. 3, which is illustrated in its adaptation for die forming, is especially desirable where it is important to have compactness in directions transverse to press head travel but where there is a reasonably large gap between the press jaws, or where the press table can have a substantially deep well. In this case the inner cylinder 29' is located below the annular outer cylinder 31'. If there is a recess or well in the press table 6, the portion of the lower element 10' that defines the inner cylinder 29' can have a reduced diameter to be receivable in the well.

The stem portion 33' of the inner piston 30, upon which the punch 11' is secured, is necessarily rather long, extending with a slidable sealing fit up through a tubular upright wall 26' that defines the inner circumferential surface of the annular cylinder 31'. The tool holder 35 is again secured on upright struts 34 that project up from the annular piston 32' at circumferentially spaced intervals, through the top wall member 28. The passage 38' that communicates the lower portions of cylinders 29' and 31' with one another is naturally a vertical one along most of its length, and is mainly formed in the sidewall of the inner cylinder 29'. In all other respects the embodiment of the invention illustrated in FIG. 3 is like that shown in FIG. 2.

FIGS. 4-6 illustrate an embodiment of the invention having a plurality of conventional cylinders 31'' instead of a single annular outer cylinder, the cylinders 31'' being located in a ring around the inner cylinder 29, as best seen in FIG. 4. Each of said cylinders 31'' is provided with a piston 32'' that has an upwardly projecting stem portion 34' which can be regarded as the counterpart of one of the struts 34 in the previously described embodiments of the invention. By reason of the fact that the several stem portions 34' are rigidly secured to the tool holder 35, the several pistons 32'' are constrained to move up and down in unison.

Individual passages 38'' in the bottom wall member 25'', one for each of the outer cylinders 31'', communicate with the latter at their bottoms with the bottom of the inner cylinder 29. At least certain of these passages, as may be seen from FIGS. 4 and 6, are controlled by shutoff valves 78 having manual actuators 80, such as handwheels, that are accessible at the exterior of the tool. By opening or closing various of the valves 78, the stroke of the tool holder can be varied in relation to that of the punch, to adjust the apparatus in accordance with the type of work to be performed and the depth intended for the finished workpiece.

From the foregoing description taken with the accompanying drawings it will be apparent that this invention provides a forming tool for hydraulic presses that is both very efficient and very versatile, and whereby the effective stroke of a forming press can be very substantially increased.

Those skilled in the art will appreciate that the invention can be embodied in forms other than as herein disclosed for purposes of illustration.

The invention is defined by the following claims:

1. Forming apparatus for a press having a pair of jaws, one of which is arranged for closing and opening motion toward and from the other, said forming apparatus being of the type comprising a pair of rigid tool parts carried by one jaw of the press and cooperable with a resilient forming element carried by the other jaw, one of said rigid tool parts being substantially annular and in surrounding relation to the other, and said rigid tool parts being movable relative to one another in the directions of closing and opening motion of said jaw, said forming apparatus being characterized by:



- A. body means connectable with said one jaw of the press and defining first and second cylinder means which are in substantially concentric relation to one another and which are communicated with one another near their ends remote from the resilient forming element so that fluid can flow substantially freely between their said end portions;
- B. first piston means slidable in the first cylinder means and rigidly connected with one of said rigid tool parts to be moved toward said end of the first cylinder means upon closing motion of the movable press jaw, thereby displacing fluid into the second cylinder means from the first cylinder means;
- C. second piston means slidable in the second cylinder means and which is moved toward the resilient forming element by fluid displaced into said second cylinder means;
- D. means
  - 1. providing a rigid connection between said second piston means and the other rigid tool part and
  - 2. cooperating with the second piston means to define, in the other end portion of said second cylinder means, a chamber which varies in volume with movement of said second piston means; and
- E. means providing for throttled flow of fluid from said chamber to yieldingly resist movement of said second piston means toward the resilient forming element and concomitantly resist motion of said one rigid tool part in the direction away from the resilient forming element, thereby maintaining the resilient forming element engaged under substantial force with a blank overlying both of said rigid tool parts.
- 2. The forming apparatus of claim 1, further characterized by:
  - one of said cylinder means and its piston means being annular and concentrically surrounding the other cylinder means.
- 3. The forming apparatus of claim 1, further characterized by:
  - A. one of said cylinder means comprising a plurality of cylinders at circumferentially spaced intervals around the other cylinder means; and
  - B. the piston means for said one cylinder means comprising a plurality of pistons, one for each of said plurality of cylinders.
- 4. The forming apparatus of claim 3, wherein said means providing for substantially free flow of fluid between the first and second cylinder means comprises means defining a plurality of passages, one connecting each of said plurality of cylinders with said other cylinder means, further characterized by:
  - means for selectively blocking at least certain of said passages, for changing the effective volume of said one cylinder means and thereby changing the relative strokes of the tool parts.
- 5. The forming apparatus of claim 1, further characterized by:
  - A. one of said cylinder means being located below the other;
  - B. the piston means of said one cylinder means being connected with its tool part by a substantially elongated coaxial stem; and
  - C. the other of said cylinder means and its piston means being annular and surrounding said stem.
- 6. The forming apparatus of claim 1, further characterized by:
  - A. said means providing for throttled flow of fluid from said chamber comprising a flow-restricting device;
  - B. means providing a source of pressurized fluid; and
  - C. a flow-directing valve communicated with said chamber and alternatively communicable with
    - 1. said flow-restricting device and

- 2. said pressurized fluid source means to provide for refilling the upper portion of the second cylinder means after a cycle of closing and opening motion of the press jaws by which a workpiece is formed, thus effecting return movement of the second piston means and concomitant return movement of the first piston means.
- 7. The forming apparatus of claim 6, further characterized by:
  - A. first control means connected with the flow-directing valve and operatively so associated with a part connected with the forming apparatus as to cause the flow-directing valve to be communicated with said pressurized fluid source means in consequence of movement of said one press jaw away from the other to its fully open position; and
  - B. second control means connected with the flow-directing valve and operatively associated with a part that moves in unison with one of said piston means for causing the flow-directing valve to be communicated with said flow-restricting device when the first piston means attains a predetermined position in its return motion.
- 8. The forming apparatus of claim 6, further characterized by:
  - A. a pressure-responsive transducer in the upper portion of the second cylinder means for producing an output which is a function of fluid pressure therein;
  - B. a rate-responsive transducer operatively associated with one of said tool parts for producing an output which is a function of the rate at which said tool part moves; and
  - C. said flow-restricting device being connected with said pressure-responsive transducer and with said rate-responsive transducer and being responsive to their outputs.
- 9. The forming apparatus of claim 1 wherein said resilient forming element comprises:
  - A. a substantially cylindrical pressure chamber member having a bore therethrough and which is carried by said other jaw of the press for limited motion toward and from the same in the directions of opening and closing motions of the press;
  - B. a plunger fixed to said other jaw of the press and sealingly slidably received in said bore in the pressure chamber member to close one end portion of the same;
  - C. a resilient diaphragm extending across the bore in said pressure chamber member near the other end thereof and cooperating with said member and the plunger to define a pressure fluid chamber; and
  - D. means yieldingly biasing the pressure chamber member in the direction toward said other jaw to maintain fluid in said fluid chamber under pressure.
- 10. Forming apparatus for a press having a pair of jaws arranged for relative closing and opening movement, said forming apparatus being of the type comprising a resilient diaphragm carried by one jaw of the press and a pair of relatively movable rigid tool parts carried by the other jaw for cooperation with the diaphragm, one of said rigid tool parts being substantially annular and in surrounding relation to the other, said forming apparatus being characterized by:
  - A. a substantially cylindrical pressure chamber member having a bore therethrough and which is carried by said one jaw of the press for limited axial motion toward and from the same in the directions of jaw motions, said diaphragm extending sealingly across the bore in said pressure chamber member near the end thereof remote from said one jaw;
  - B. a plunger fixed to said one jaw and sealingly slidably received in said bore to close the other end thereof;
  - C. means yieldingly biasing the pressure chamber member in the direction toward said one jaw to maintain fluid in said bore under pressure;
  - D. means providing a motion-transmitting connection between said rigid tool parts whereby the force which the diaphragm exerts upon them through a blank to be formed, upon closing motion of the jaws, effects motion

of one of said rigid tool parts in the direction toward said other jaw and motion of the other one in the opposite direction; and

E. means for yieldingly resisting motion of the rigid tool parts in their said directions, to thereby maintain a substantially high pressure in the fluid in said bore and concomitantly maintain forming force upon a blank interposed between the diaphragm and the tool parts, the last-named means comprising:

- 1. a plunger rigidly connected with one of the tool parts to move in unison therewith,
- 2. means in fixed relation to said other jaw cooperating with said plunger to define a variable-volume pressure chamber, and

3. means providing for throttled flow of fluid out of said variable-volume pressure chamber.

11. The forming apparatus of claim 10, wherein said rigid tool parts have normal positions from which they are displaced in consequence of closing motion of the jaws, further characterized by:

F. pump means connectable with said variable-volume pressure chamber in bypass relation to said means providing for the throttled flow of fluid therefrom, for effecting return motion of the rigid tool parts to their normal positions upon completion of a cycle of closing and opening motion of the jaws.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,635,061

Dated January 18, 1972

Inventor(s) Nils Folke Rydell

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2 line 31; " 18 " should be --13--

Column 3 line 3; Delete "which can be integral with its body portion" (second occurrence) before --and--

Column 6 line 46: Delete "with" after --communicate--

Claim 6 (Subpar. C (2) lines 2-3) Column 8 line 2  
"the upper portion of the second cylinder means"  
should read -- chamber--

Signed and sealed this 4th day of July 1972.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.  
Attesting Officer

ROBERT GOTTSCHALK  
Commissioner of Patents