March 20, 1951 A. E. CALDWELL 2,545,570

HYDRAULIC FORMING MACHINE

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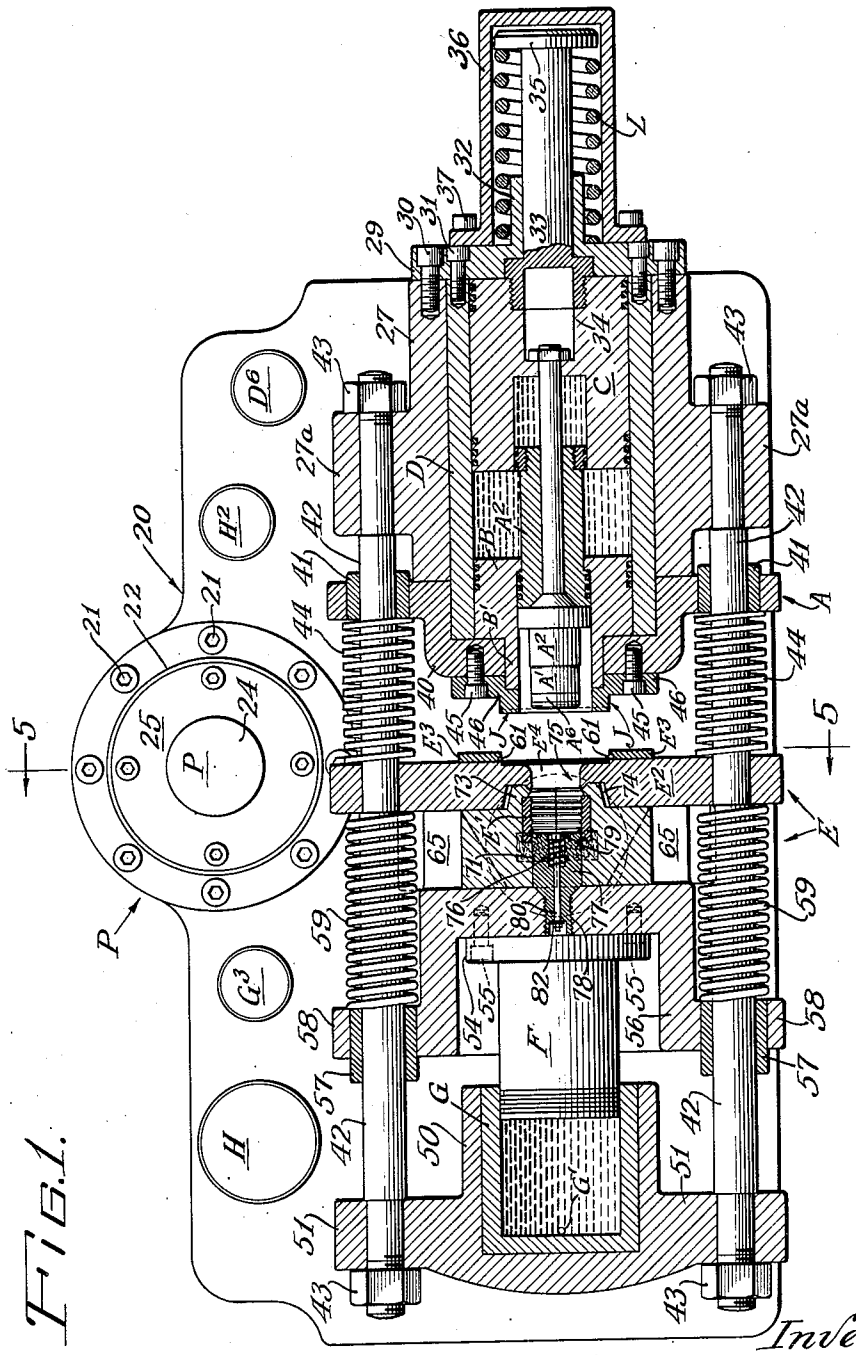


FIG. 1.

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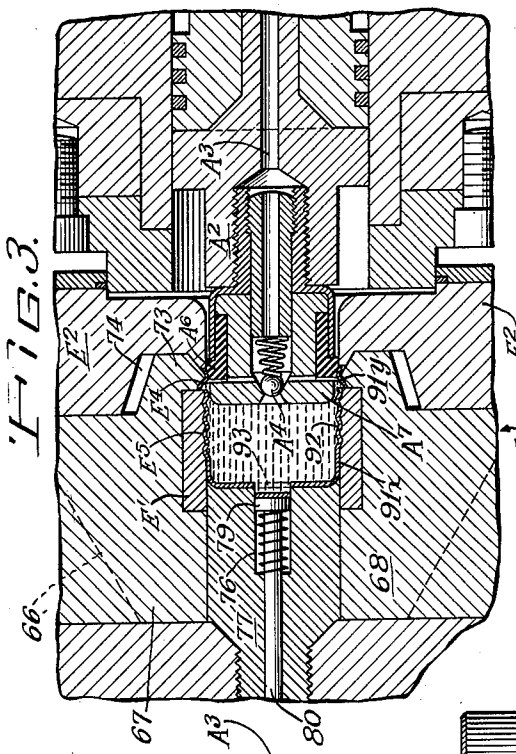


FIG. 3.

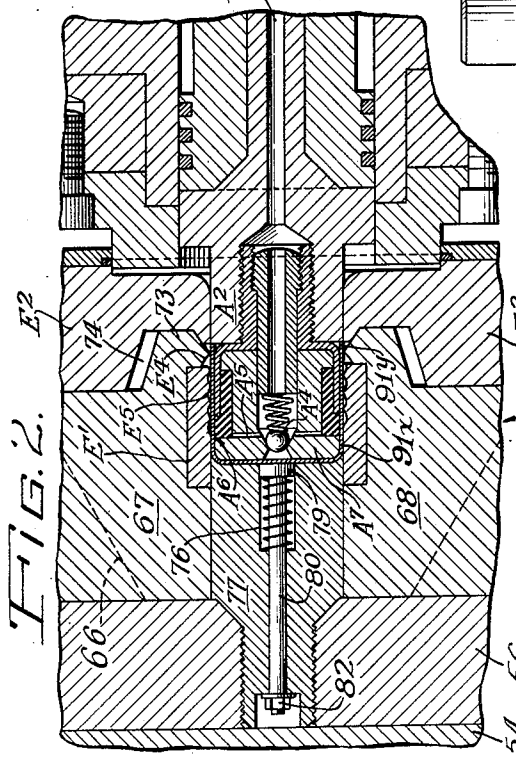


FIG. 2.

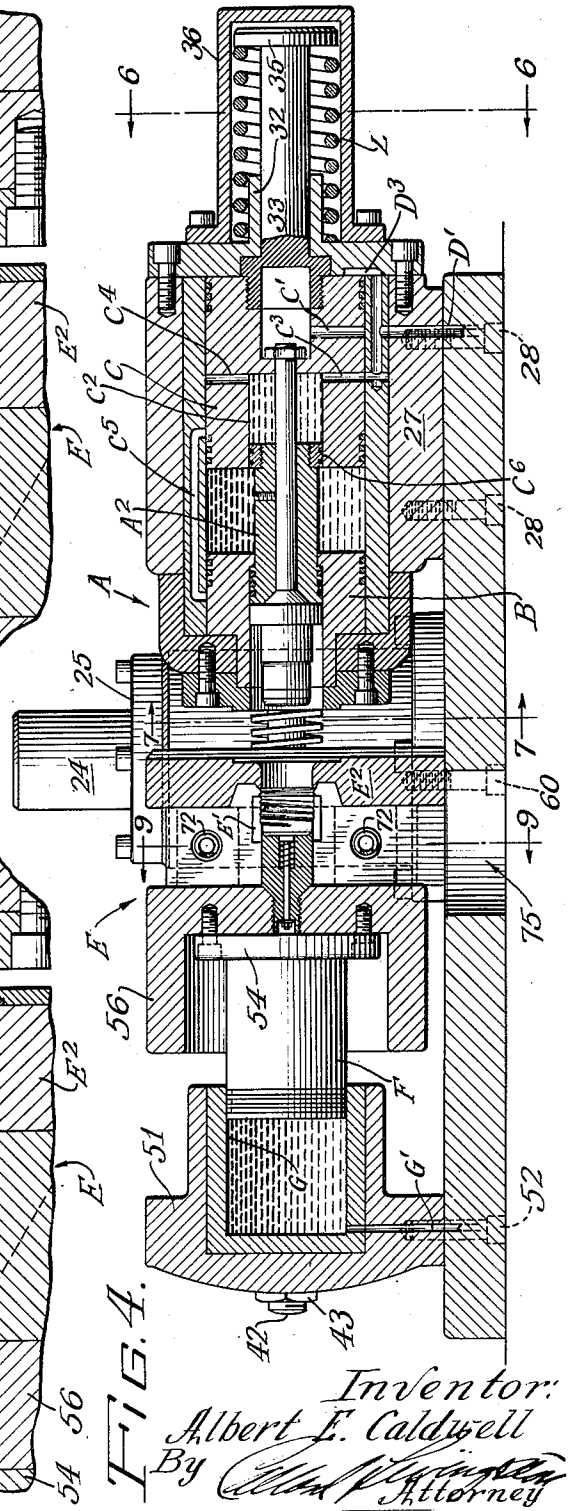


FIG. 4.

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Fig. 5.

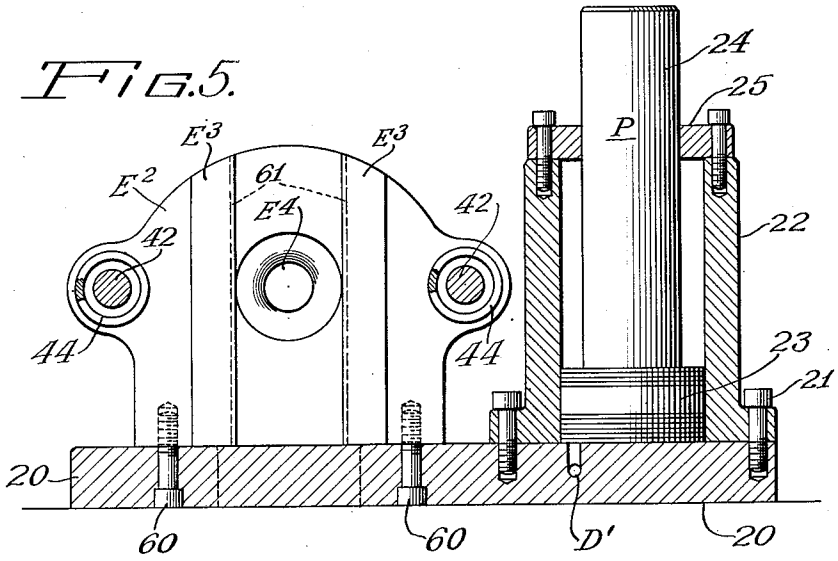
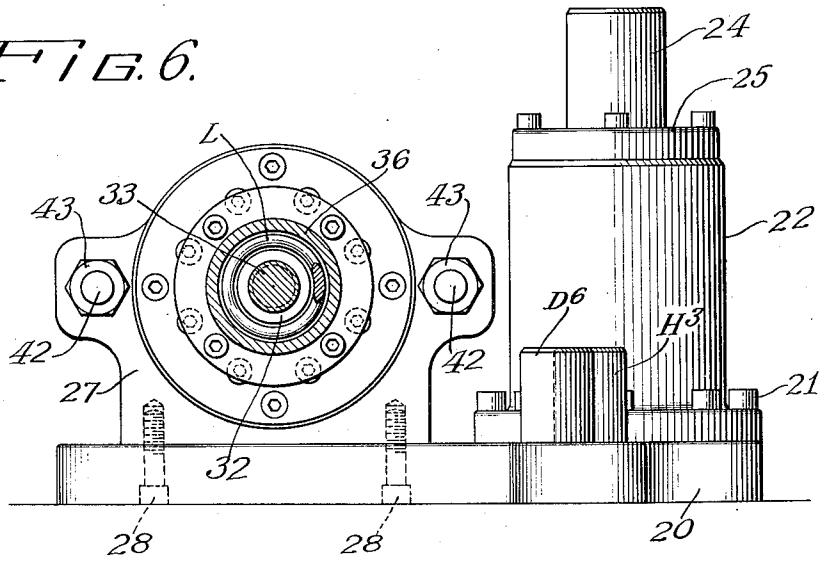


Fig. 6.



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FIG. 7.

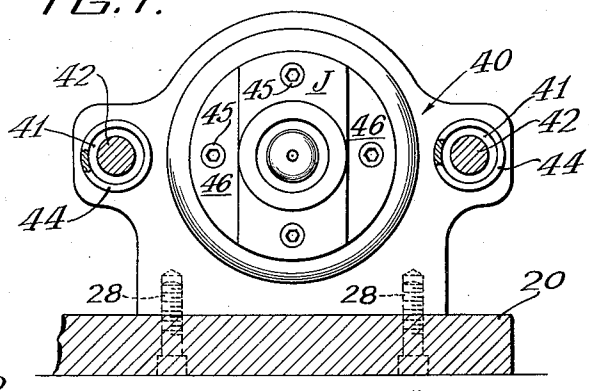


FIG. 8.

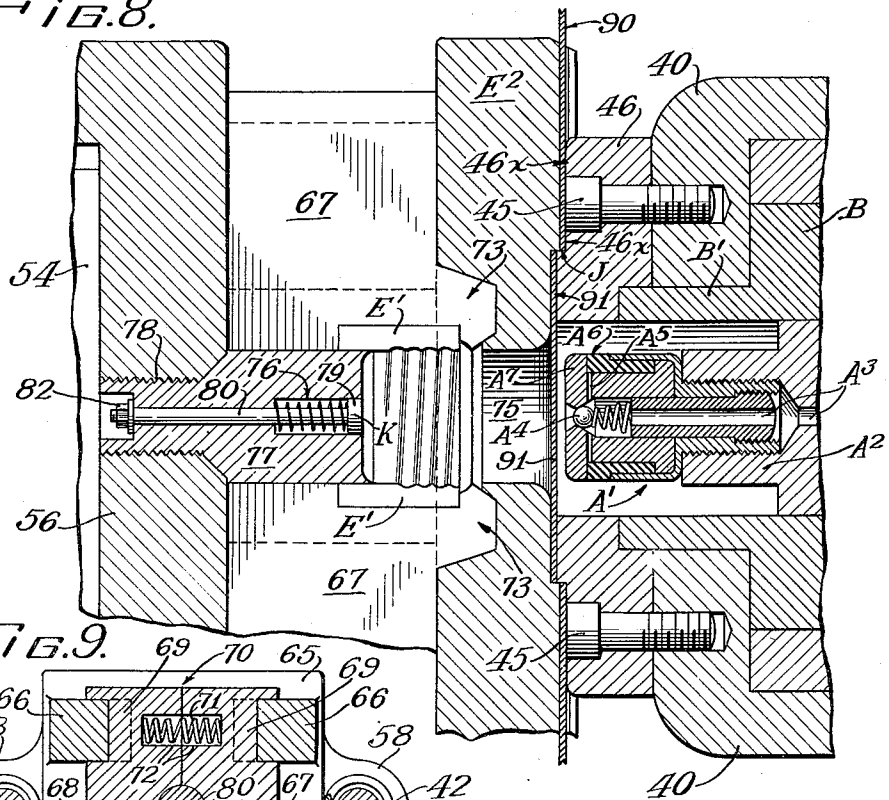
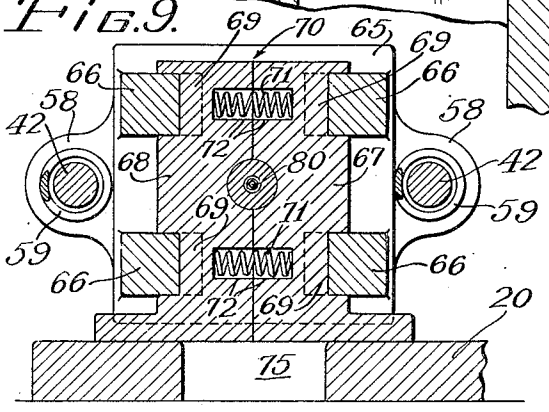


FIG. 9.



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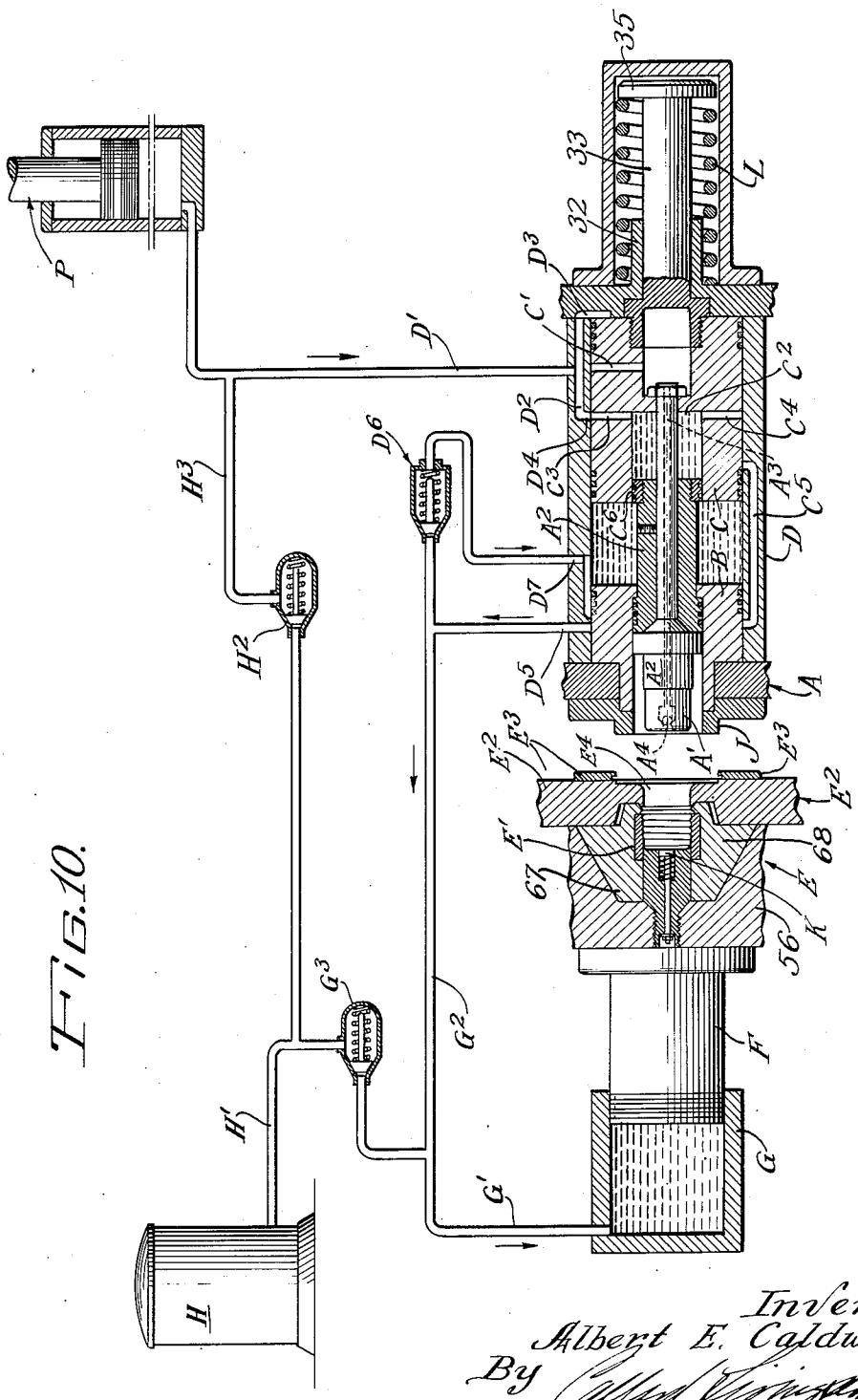


Fig. 10.

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Patented Mar. 20, 1951 2,545,570

UNITED STATES PATENT OFFICE

2,545,570

HYDRAULIC FORMING MACHINE

Albert Earl Caldwell, Chicago, Ill., assignor to Raymond T. Moloney, Chicago, Ill.

Application January 10, 1945, Serial No. 572,177

1 Claim. (Cl. 113—45)

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This invention pertains to the metal-working arts, particularly die-stamping, punching, and forming apparatus and methods.

It is a principal object of the invention to provide a mechano-hydraulic forming machine adapted to be used in conjunction with an ordinary punch press and capable of automatically performing a sequence of punching, stamping, and forming operations of predetermined character, which would otherwise have to be performed manually or by relatively complicated and expensive machines and processes in the known art.

More particularly, the invention provides a forming machine consisting of a plurality of cooperating mechanical and hydraulic die and fluid-displacement means, and automatic flow-control means therefor, acting to punch metal from stock, pre-form the punching by piston-displaced die means, additionally form the resulting stamping by direct hydraulic displacement of the stamping metal, and performing still further punching operations on the object thus formed by direct fluid displacement, all in rapid succession and by a relatively small, unitary device adapted to receive its principal operating power from a punch press.

Viewed from another aspect, the invention provides a method and unitary mechanism for effectuating the method which consists of a plurality of pistons, cooperating die means, and a closed system of fluid control valves and by-passing connections and means coacting to cause a predetermined sequence of operations upon metal stock to form and punch cup-like objects.

Detailed aspects of novelty in the device relate to the construction and operation of certain compound piston means; to the utilization of bodily displacement and fluid displacement of metal stock in a certain order to permit multiple forming operations in a single die; to certain fluid-by-passing means for controlling the sequence of forming operations; to the utilization of the metal stock itself for gauging purposes in the automatic operation of the device; and to specific details of the construction and operation of the means for carrying out the method disclosed, all of which will appear as the following description proceeds in view of the annexed drawings, in which:

Fig. 1 is a top plan view of the forming machine, with the main driving piston shown partly in section;

Fig. 2 is an enlarged sectional fragment through the main die and die piston with the

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die piston fully advanced in a pre-forming operation;

Fig. 3 is a detail similar to Fig. 2, showing the die piston partly retracted preparatory to further forming operations;

Fig. 4 is a vertical median section through the forming pistons of Fig. 1;

Fig. 5 is an elevational view along lines 5—5 of Fig. 1, looking at the female die unit;

Fig. 6 is a vertical section along lines 6—6 of Fig. 4, with parts in elevation, looking at the outer end of the male die unit;

Fig. 7 is a vertical section anlong lines 7—7 of Fig. 4, looking into the male die unit;

Fig. 8 is an enlarged sectional fragment through the male and female dies, similar to Figs. 2 and 3, but showing the metal stock punched and gauged, ready for pre-forming;

Fig. 9 is a sectional detail through the split female die, along lines 9—9 of Fig. 4;

Fig. 10 is a sectional operating diagram.

The invention is best understood by way of a generalized introductory explanation of its operation in view of Fig. 10, wherein a male die section A, carried by a compound piston means B—C in cylinder D, is adapted to move into engagement with a companion or female die section E, carried on piston means F moving in cylinder G.

Within die unit E is the female die proper, E' (in the shape of a threaded cylinder, for example), and within die unit A is a male die A' carried on forming piston A^2, which works inside of piston B, and which is also an extension of piston C.

Also part of female die section E is a stock bed E^2 with stock guides E^3 and pre-forming passage E^4.

A fluid passage D' communicates from a working or pressure cylinder P directly to by-pass duct D^2 in cylinder D; this duct opens at D^3 behind main piston C, and at D^4 at a point along the path of travel of piston C. Duct D^5 leads from a point of normal closure by piston B into female die-closing piston cylinder G via ducts G^2, G'.

For initial operation (Fig. 10) raising of piston P draws oil from sump H through duct H', valve H^2 (as well as residual oil, after the device has been operating, from other parts, as will appear hereinafter), and upon the compression stroke of piston P all valves are closed, so that oil through by-pass port D^4 drives die piston A^2 forward (to the left) into the normally extended condition shown in Fig. 10 by action of oil enter-

ing chamber C^2 through passage C^3. Also, oil entering at D^3 drives main piston C and its split-piston section B forward (to the left) as a unit by reason of the fact that oil is trapped in the chamber between these two main pistons B and C.

However, as soon as piston B opens port D^5, the oil coupling between B and C by-passes to cylinder G via ducts G', G^2 and urges forward (to the right) the female die-closing piston F so that the female die section will be in the condition shown in Fig. 10.

Meanwhile, metal stock will have been fed by any suitable means into the stock and punching bed guides E^3, and the aforesaid initial movement of piston B (until port D^5 is opened) causes the male punching die section J to engage this stock and punch out the desired piece of stock. During this operation, piston C continues to move forward after piston B has stopped, in consequence of which piston A^2 drives its male forming die portion A' into the metal punching carrying the latter into the forming sections E^4, E', thus forming up a cup-shaped article.

When piston C has moved far enough to register by-pass duct C' with port D^4, movement of C stops, because the oil under pressure now is by-passed through duct A^3 inside piston A^2, and the by-passed oil escapes from around a special rubber piston ring or skirt (not seen in Fig. 10; see Fig. 3 at A^6), later to be described, and into the now preformed stamping, with the result that the forming piston A^2 now backs out of the female die part E', but remains sealed, by means of said special rubber skirt, in die part E^4, while oil continues to escape into the cup-shaped stamping.

The aforesaid backing-out of piston A^2 is made possible by registration of duct C^4 with duct C^5, permitting the oil in chamber C^2 to expand in between main pistons B and C and through port D^5 and valve G^3 into the sump.

Fluid pressure continues to be exerted upon the interior of the preformed cup through duct A^3, in consequence of which screw threads are formed in this cup by forcing of the metal wall stock thereof into the threading cut into the female die; such formation of the threads takes place while the male die part A' is receding, and the recessive movement of A', A^2 stops before the oil seal by the rubber skirt is broken, so that as the pressure continues, still further forming operations are effected, as for example the punching out of stock from the bottom of the cup into the cavity of a small backing-up piston K, to make a desired hole in the article.

At this juncture, the compression stroke of the working piston P is completed. By retraction of this piston, a suction is created at the check valve A^4 in the nose of the male die, via ducts A^3, C', D^4, withdrawing the oil from the completed stamping or cup, and when the distributed pressures in the system are relieved, certain spring means, including spring L, plus suction at D^3, retracts the compound piston means A, B, C, valve D^6 opening to permit refilling of the chamber between B and C, since D^5 is quickly closed and a suction is created between B and C.

As a further result of raising piston P, oil is withdrawn from cylinder G, retracting piston F and the female die unit, so that the latter is caused to open and discharge the finished article.

Detailed construction and operation

Referring to Fig. 1, a view looking down on the device, there is provided a heavy base casting **20**, upon which is bolted, as at **21**, the cylinder **22** for the working piston P, consisting of the piston proper, **23**, and drive rod **24**, secured by plate **25** bolted to the cylinder (see Fig. 5). Reservoir H, and valves H^2, G^3, D^6, heretofore described, are threaded into this base plate, as in Fig. 1, and the ducts, such as D', G', G^2, H', H^3 are conveniently drilled into said base plate, as for example duct D' or G' in Figs. 4 and 5.

Continuing with Fig. 1, the cylinder jacket D is mounted in a casting **27**, bolted as at **28** (Figs. 4 and 6); an end plate **29** is bolted at **30** to casting **27**, and as at **31** to jacket D.

End plate **29** has a sleeve **32** in which piston rod **33** works, this rod being oil-sealed and threadably rigid, as at **34**, with piston C, and terminating in a flanged head **35**, against which bears spring L. A cap casting **36** is bolted as at **37** to plate **29**.

At the opposite or inner end of the foregoing compound piston unit (Fig. 1), there is provided a recessed head plate **40** having a central passage which fits over the reduced end B' of piston B, and also having diametrically opposite wings with passages in which are slide bearings **41** riding on rods **42** respectively seated at one end in bosses **27***a* of the casting **27**, and at their opposite ends in flange portions **51** of the mounting for cylinder G. Nuts **43** secure rods **42**. Compression springs **44** on rods **42** between head plate **40** and stock bed E^2 normally keep the male unit A opened, toward the right, from bed E^2.

A male blanking die **46** (the die proper being indicated at J), interfitted centrally with piston extension B', is bolted to head plate **40** as at **45** (see also Fig. 7). Further details of this die structure appear hereinafter.

As in Fig. 1, the punching or blanking piston B is bored to receive the left piston end of retracting piston A^2 and its die part A', while the opposite or right-hand piston end C^6 of A^2 works in the bore of chamber C^2 formed in main piston C. The control ports inclusively indicated by characters C' etc. and D^3 etc., heretofore referred to, are seen in part in Fig. 4.

The female die piston cylinder G (Fig. 1) is shrunk into a shell **50** having flange portions **51** through which the guide rods **42** project for engagement with retaining nuts **43**, the shell being bolted to base **20** as at **52**, Fig. 4.

Piston F for the female die (Fig. 1) has a flanged end **54** bolted as at **55** in the recess of a carrier casting **56** having slide bearing sleeves **57** in opposite flange portions **58** of the casting, said sleeves sliding on rods **42**, and the piston and carrier part normally being urged to the left by compression springs **59** on rods **42**, acting against said flange portions and against the stationary guide plate E^2, to open the split female die.

As viewed in Fig. 1, stock guide plate E^2 has partial rigidifying support from rods **42**, and the plate is also bolted as at **60** to the base plate, Figs. 4 and 5.

Referring particularly to Fig. 5, guide plate E^2 is provided with opposite stock guiding and blanking ribs E^3, undercut as at **61** to receive metal stock, and flanking an initial forming cavity E^4 in said plate.

The main female die is of the split variety, consisting (Fig. 9) of a carrying block **65**, which is part of carrier casting **56** on piston means F, having pairs of tapered keying bosses **66** projected horizontally therefrom, split die-holder blocks **67** and **68**, each having correspondingly tapered keyways **69** interfitting bosses **66**, being

adapted to split or separate along a vertical line 70 under urgence of springs 71 in cavities 72 therein.

The female die proper, E', likewise splits along a line conforming to line 70; this does not appear in Fig. 9, but is seen in Figs. 1 and 2, for example, one each of these main die sections being fitted into one of the carrier block sections 67 or 68.

Carrier block sections 67 and 68 have conical nose portions 73 closably fitting into complementary formations in seat 74 on guide plate E^2 when the female die section is urged forward by piston F; but when the latter piston is retracted, springs 71 spread apart the die sections 67, 68 (Figs. 1 and 9) along line 70, so that the formed article may drop out and pass down through discharge opening 75 in the base plate 20.

Additional punching means includes a cavity 76 in sealing plunger 77 (Figs. 1 and 8), threadedly secured as at 78 in the carrier casting shell 56; this cavity 76 leads into the bottom of the cavity of die E' and contains a punch or backing plunger 79 (also indicated at K, Fig. 1) on rod 80 slidable in plunger 77, a spring 81 normally urging the backing plunger into register with the bottom of the die cavity as in Fig. 8.

In the operation of the device, referring again to Fig. 10, piston F is retracted into its cylinder G at the beginning of the cycle, it being understood that piston F is shown otherwise, that is, in advanced position in Fig. 10 for illustrative purposes; and the male die unit A is also withdrawn from plate E^2, as actually shown in Fig. 10.

By retraction of the working piston P, negative pressure is created throughout the system, and valves D^6, G^3 and H^2 open as necessary, depending upon the actual distribution of oil in the several branches, inclusive of losses in E', and accordingly, the die-opening piston F will be retracted from the position shown in Fig. 10, while the male compound-piston unit A will be restored to the condition shown in Fig. 10, filling the cavity between pistons B and C with oil via duct D^7. With the retraction of F, the female die sections 67, 68, E' open by action of springs 71 (Fig. 9) dropping out any previously formed article.

Upon descent of the working piston P, valves D^6, G^3, H^2 are closed, and a small quantity of oil enters chamber C^2 through D^2, D^4 and C^3, causing piston part C^6 to be driven forward to the normal condition of Fig. 10, whereupon oil then enters through D^3 behind piston C and drives the entire compound piston assembly forward, since oil is trapped between B and C, and in chamber C^2. Meanwhile, metal stock will have been fed by any suitable means, not shown (usually part of the punch press with which the device is intended to be used) into stock guides 61 in plate E^2.

As soon as piston B passes and opens port D^5, the trapped oil between B and C passes via duct G^2—G' into the female die cylinder G, thus driving the entire female die assembly E back toward the stock guide E^2, again closing the female die blocks 67, 68 through wedge action of conical nose parts 73 in 74 (Fig. 1) and similar wedging action of tapered bosses 66 in slots 69, so that the female die is conditioned for reception of the blank, as in Fig. 10.

Meanwhile, as in Fig. 8, the male section continues to advance until the blanking die J or 46 is driven into the stock shearing off the blank 91.

At this juncture, an important gauging action occurs through the formation of the male blanking die 46 with accurately recessed portions 46X (Fig. 8) adapted to bear against a substantial area of the stock strip 90, whereby the advance of the blanking die part J is limited to prevent deforming or crushing of the blank owing to probable variations in the thickness of the stock. Thus, the remnant of the blanked stock is held and utilized as a gauge means by providing gauge surfaces on both the male and female blanking and guide parts.

Continuing with the operation of the device, the piston C will by now have advanced the main male die A' fully into the metal blank, as in Fig. 2, at which time, control ports C', D^4 (Fig. 10) will be in register, thus arresting further advance of piston C and by-passing the oil into duct A^3 within the backing-off piston A^2. Also, ports C^4, C^5 will be in register permitting this piston A^2 to back off, since oil from chamber C^2 can now escape via C^4 and C^5 and D^5 to line G^2, valve G^3 and thence into sump H. The oil by-passed through A^3 is permitted to escape through a small duct A^5 in the head A^7 of the male die A' and thence around the edge of the rubber ring or skirt A^6 into the cavity of the now partly formed-up article in E', piston A^2 backing off for this purpose as oil leaves chamber C^2, until the head of the male die occupies the position shown in Fig. 3.

In Fig. 2 it will be observed that the now formed blank 91X is cup-shaped with its rim parts 91Y projecting beyond an undercut E^4 in the plate E^2, but that the side walls of the cup are not yet extruded into the threading cavities E^5 of the female die.

As the male die backs off, the oil under pressure from duct A^3 forces the metal stock into thread formations E^5 forming threads 92 in the cup, and at the end of travel, rim parts 91Y are sheared off by pressure of the oil, as in Fig. 3; however, the oil still remains sealed in by action of the rubber skirt A^6, and continued pressure of the oil punches out a hole 93 against the backing plunger K or 79, thus completing the forming operations upon the illustrative cup article.

By again retracting the working piston P, the sensitive ball valve A^4 will open and the small quantity of oil in the female die part E' will at once be drawn back into passages A^3, D'. Almost simultaneously piston B will be restored by action of springs 44, closing port D^5, whereupon valve D^6 will open and permit retraction of piston C and withdrawal of the oil therebehind from port D^3, since oil is replacing the vacuum between B and C by opening of valve D^6. Moreover, piston F will also be retracted, opening the female die to discharge the completed article through passage 75.

It will occur to those skilled in the art that changes in various structural and functional details may be made in the illustrative embodiment described without departing from the spirit of the invention, and that the device may be adapted to form articles of character differing from that specified, by reason of which it is the intention to include within the scope of the invention all such changes and adaptations as shall fairly come within the appended claim.

I claim:

In a hydraulic forming machine, compound blanking and forming dies, hydraulic means including compound piston means comprising a unit for actuating certain of said dies and including a first piston movable to effect coaction

of said blanking dies, a second piston and fluid means coupling the same for predetermined movement to move said first piston for blanking movement as aforesaid, a third piston moved by said second piston into a blank following blanking movement as aforesaid to form up said blank, by-passing port means controlled by movement of said second piston after forming said blank to inject fluid under pressure into said formed blank, fluid means coupling said second and third pistons for forming operation by the third piston as aforesaid, by-pass port means controlled by movement of said second piston after forming said blank to uncouple said second and third pistons, said third piston partially withdrawing from said formed blank by action of fluid by-passed by said first-mentioned by-pass port means to effect said injection, said injection being under pressure to effect further forming operations on said formed blank, and means operating responsive to negative pressure in said hydraulic means for withdrawing said injected fluid and restoring said dies to an initial condition.

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