HYDRAULIC FORMING MACHINE

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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 mechno-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, whereby, 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 the 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 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 along 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 5, 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. They are best understood by way of the 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'' 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''' with stock guides E''' and pre-forming passage E'''

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

For initial operation (Fig. 10) raising of piston P draws oil from sump H through duct H', valve H'' (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'' drives die piston A' forward (to the left) into the normally extended condition shown in Fig. 10 by action of oil enter-
ing chamber C² through passage C¹. Also, oil entering at D¹ drives main piston C and its split pistons 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 D⁰, the oil coupling between B and C by-passes to cylinder G via ducts G¹, G² 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 E¹, and the aforesaid initial movement of piston B (until port D² 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 A² drives its male forming die portion A¹ into the metal punching carrying the latter into the forming sections E¹, E², thus forming up a cup-shaped article.

When piston C has moved far enough to register by-pass duct C¹ with port D⁴, movement of C stops, because the oil under pressure now is by-passed through duct A² inside piston A², and the by-passed oil escapes from around a special rubber piston ring or sleeve (not shown in Fig. 10; see Fig. 3 at A⁰) later to be described, and into the now preformed stamping, with the result that the forming piston A² now backs out of the female die part E¹, but remains sealed, by means of said special rubber skirt, in die part E¹, while oil continues to escape into the cup-shaped stamping.

The aforesaid backing-out of piston A² is made possible by registration of duct C¹ with duct C⁴, permitting the oil in chamber C² to expand in between main pistons B and C and through port D⁴ and valve G² into the sump.

Fluid pressure continues to be exerted upon the interior of the preformed cup through duct A², 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. Further formation of the threads takes place while the male die part A¹ is receding, and the recessive movement of A¹, A² 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 A⁴ in the nose of the male die, via ducts A², C¹, D³, 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 D³, retracts the compound piston means A, B, C, valve D⁰ opening to permit refilling of the chamber between B and C, since D³ 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 H², G², D⁰, heretofore described, are threaded into this base plate, as in Fig. 1, and the ducts, such as D¹, G¹, G², H, H² are conveniently drilled into said base plate, as for example duct D¹ or G¹ 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 33, 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 far enough to register by-pass duct C¹ with port D⁴, movement of C stops, because the oil under pressure now is by-passed through duct A² inside piston A², and the by-passed oil escapes from around a special rubber piston ring or sleeve (not shown in Fig. 10; see Fig. 3 at A⁰) later to be described, and into the now preformed stamping, with the result that the forming piston A² now backs out of the female die part E¹, but remains sealed, by means of said special rubber skirt, in die part E¹, while oil continues to escape into the cup-shaped stamping.

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Detailed construction and operation

Referring to Fig. 1, a view looking down on the device, there is provided a heavy base casting 20,
adapted to split or separate along a vertical line T4 under urging of springs T1 in cavities T2 therein.

The female die proper, E', likewise splits along a line conforming to line T6; 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 closely fitting into complementary formations in seat T4 on guide plate 55 when the female die section is urged forward by piston P; but when the latter piston is retracted, springs 74 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 T5 in the base plate 20.

Additional punching means includes a cavity T6 in sealing plunger 77 (Figs. 1 and 8), threadedly secured as at T5 in the carrier casting shell 55; this cavity T6 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 83, slides 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 P is shown otherwise, that is, in an advanced position in Fig. 10 for illustrative purposes; and the male die unit A is also withdrawn from plate E', as actually shown in Fig. 10.

By retraction of the working piston P, negative pressure is created throughout the system, and valves D6, G2 and H2 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 D5. With the retraction of F, the female die sections 67, 68, E' open by action of springs T1 (Fig. 9) dropping out any previously formed article.

Upon descent of the working piston P, valves D6, D8, G2, G3 and H2 are closed, and a small quantity of oil enters chamber C3 through D8, D3 and D5, causing piston part C3 to be driven forward to the normal condition of Fig. 10, whereupon oil then enters through D3 behind piston C and drives the entire compound piston assembly forward, since oil is trapped between B and C, and in chamber C2. 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 E5.

As soon as piston B passes and opens port D5, the trapped oil between B and C passes via duct G2→G3 into the female die cylinder G, thus driving the entire female die assembly E towards the stock guide E1, again closing the female die blocks 67, 68 through wedge action of conical nose parts 73 in 74 (Fig. 11) and similar wedging action of tapered bosses 66 in slots 68, so that the female die is conditioned for reception of the blank.

Meanwhile, as in Fig. 8, the male section continues to advance until the blanking die J or G6 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 G6 with accurately recessed portions G6-X (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 C5, D4 (Fig. 10) will be in register, thus arresting further advance of piston C and by-passing the oil into duct A5 within the backing-off piston A2. Also, ports C4, C9 will be in register permitting this piston A2 to back off, since oil from chamber G5 can now escape via C5 and C9 and D5 to line G2, valve G3 and thence into sump H. The oil by-passed through A3 is permitted to escape through a small duct A4 in the head A' of the male die A' and thence around the edge of the rubber ring or skirt A2 into the cavity of the now partly formed-up article in E', piston A2' backing off for this purpose as oil leaves chamber C5, 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 91 is cup-shaped with its rim parts 91 Y projecting beyond an undercut E3 in the plate E5, but that the side walls of the cup are not yet extruded into the throughing cavities E5 of the female die.

As the male die backs off, the oil under pressure from duct A5 forces the metal stock to thread formations E5 forming threads 92 in the cup, and at the end of travel, rim parts 91 Y are sheared off by pressure of the oil, as in Fig. 5; however, the oil still remains sealed in by action of the rubber skirt A5, and continued pressure of the oil punches out a hole 93 against the backing plunger K or T5, thus completing the forming operations upon the illustrative cup article.

By again retracting the working piston F, the sensitive ball valve A5 will open, and the small quantity of oil in the female die part E' will at once be drawn back into passages A5, D3. Almost simultaneously piston B will be restored by action of springs 44, closing port D3, whereupon valve D3 will open and permit retraction of piston C and withdrawal of the oil therefrom from port D5, since oil is replacing the vacuum between B and C by opening of valve D5. Moreover, piston F will also be retracted, opening the female die to discharge the completed article through passage T5.

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 the above disclosure. It is to be included 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, 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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