May 31, 1932. W. ERNST 1,861,337

HYDRAULIC METAL DRAWING PRESS

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Fig. 1.

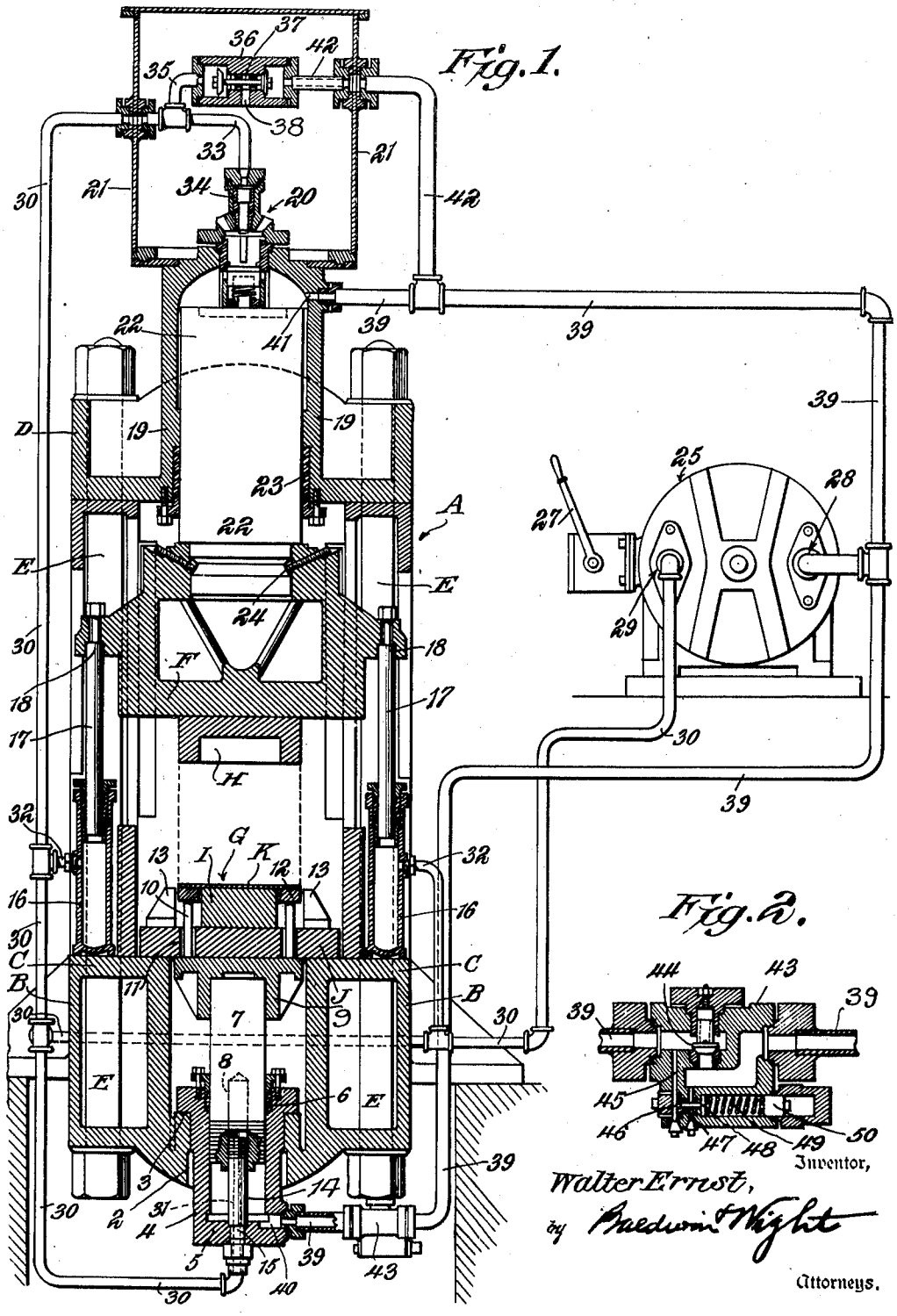


Fig. 2.

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HYDRAULIC METAL DRAWING PRESS

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This invention relates to hydraulic drawing presses and more particularly to drawing presses including male and female dies, one of which is attached to a stationary table fixed to the press frame and the other of which is carried by a platen mounted on the press frame for reciprocatory movements toward and away from the stationary die, and in which press there is provided a hydraulically operated die cushion for clamping the work against the moving die and thus holding the work in proper position relative to the dies during the drawing operation.

When shaping metal into various forms by the drawing process, it is customary to employ a pair of dies consisting of a female die and a male die, one being fixed to a stationary part of the press and the other being carried by the press platen and adapted to move toward and away from the fixed die so that the male die enters the female die and shapes or draws a blank placed on the fixed die to the desired form. When the drawing operation requires what is known as a "deep draw", there is a tendency for the blank to wrinkle. In order to overcome this tendency, various devices known as "blank holders" have been used to yieldingly clamp the blank against the female die. Some of these previously used blank holders have been operated by mechanical means including links and toggles, others by spring loaded devices and still others by air or hydraulic pressure loaded pistons or rams. The chief disadvantage of all such devices heretofore used is that each time the nature of the drawing operation is changed, as, for instance, when a heavier or lighter blank is to be drawn, or when a different set of dies is to be used, the blank holder operating means must be adjusted so that the blank holding means may clamp the blank under a pressure best suited for the particular drawing operation to be performed.

The object of the present invention is to provide in a drawing press a die cushion, or blank holder, so arranged that the pressure exerted by the blank holder will always be proportional to, or in other words bear a constant ratio to the pressure exerted on the blank by the moving die, so that the blank will automatically be clamped against the female die under only such pressure as is necessary for preventing wrinkling of the blank, and means adjustable to vary the pressure ratio as desired.

Another object of the invention is to provide in a drawing press of the character stated a main cylinder, a drawing pressure applying ram for operating one die member, a novel form of die cushion or blank holder including a cushioning cylinder and ram for applying blank holding pressure, means for supplying fluid under pressure to the main cylinder for moving the ram therein, and hydraulic connections between the cylinders for maintaining constant the ratio of the blank holding pressure to the drawing pressure in said cylinders, and connections including a valve for permitting substantially free flow of fluid in one direction between the cylinders and having means capable of adjustment for at times permitting a variable restricted flow of fluid in the opposite direction between the cylinders whereby the pressure ratios may be varied.

Other objects will in part be obvious and in part pointed out hereinafter.

To the attainment of the aforesaid objects and ends the invention resides in the novel details of construction, combination and arrangement of parts all of which will be first fully described in the following detailed description and then be particularly pointed out in the appended claims, and illustrated in the accompanying drawings in which

Figure 1 is a somewhat diagrammatic central vertical section of one form of hydraulic drawing press embodying my invention;

Figure 2 is an enlarged detailed longitudinal section of the pressure ratio control valve.

In connection with presses of the type herein described, it has been customary to employ a variable discharge, reversible pump of the type described in U. S. Letters Patent 1,250,170 of December 18, 1917, granted to Hele-Shaw et al. Pumps of this type are provided with a cross-head and control rods, the shifting of which reverses the flow of fluid in the hydraulic circuit, the reversals

producing the reciprocatory motion of the press platen.

The invention may be embodied in various types of hydraulic presses, but in the accompanying drawings it is illustrated in connection with a press of the four column downward pressure type.

Referring to the drawings, there is shown a hydraulic press A having a base B, a stationary table C, a press head D connected to said table by four strain rods E, a reciprocatory platen or movable die support F, and a die cushioning mechanism generally designated G.

The die support F is guided on the strain rods E in the usual manner. An annular female die H is secured to the underside of the platen, which in effect is a movable support for said die, and in alignment with the female die is a male die or punch I, said punch being secured to a bolster plate or support J fixedly mounted on the press table and located directly over an opening therein. A circular sheet metal blank K is shown in Figure 1 as being positioned on the punch and the die cushion preparatory to being drawn.

The press frame base is provided with a central opening 1 forming a die cushion well, and also a central bore 2 surrounded by an annular supporting shoulder 3 and accommodating a cushioning cylinder 4. The cylinder 4 is closed at its lower end by a wall 5 and is opened at its upper end and gland equipped as at 6 to accommodate the cushioning ram 7 which operates in and projects upwardly from said cylinder.

The cushioning ram 7 is provided with a central bore 8, the purpose of which will become apparent as the description progresses, and thus the ram 7 is provided at its lower end with an annular pressure face. A head or yoke 9 is carried by the upper end of the ram 7, and connected to said yoke, by means of pins 10 extending through openings 11 in the die support or bolster plate J, is a blank holder or clamping ring 12 concentrically arranged around the male die or punch I. This clamping ring is preferably of substantially the same inside and outside diameters as the female die H and it will be apparent that, when the latter descends and passes over the punch, the blank K which is positioned on the clamping ring will be clamped between the latter and the lower face of the female die. A plurality of vertically disposed guide standards 13 bolted to the bolster plate and arranged circumferentially around the clamping ring guides the said ring during its reciprocatory movements, thus relieving the pins 10 of any lateral thrust to which said pins might otherwise be subjected. A plunger stem 14 snugly fits the bore 8 in the ram 7 and is stationarily secured as at 15 in a bore provided in the cylinder wall 5.

Push-back or die return cylinders 16 are supported on the base table C, the plungers 17 thereof extending upwardly from the cylinders and being secured as at 18 to the platen F.

A main cylinder 19 is carried by the press head D and communicates through the usual surge valve 20 positioned in its upper otherwise closed wall with the surge tank 21 which is supported upon the main cylinder in the usual manner.

A main ram 22 operates in the main cylinder and projects through the gland equipment 23 provided therefor, and this ram is secured as at 24 to the platen F.

In this illustration I have diagrammatically indicated a reversible pump 25 of the Hele-Shaw type referred to hereinbefore and which includes the usual shiftable control means 27 by which the pump may be caused to operate in one direction or another in the usual manner. The pump includes the usual combined inlet and outlet ports 28 and 29.

The port 29 of the pump is connected by pipe lines 30 and the plunger stem bore 31 with the bore 8 of the cushioning ram 7, by connections 32 with the push-back cylinder 16, by the connection 33 with the valve opening plunger chamber 34 of the surge valve 20, and by the connection 35 with one end of a pressure compensator valve 36. The valve 36 is equipped with an alternately active double valve 37 which is automatically shifted by the dominant pressure in either of the connections 35 or 42 to open communication, through the centrally disposed valve port 38, between the surge tank 21 and the connection 35 or 42 non-dominant at the particular time.

The other pump port 28 is connected by pipe lines 39 and through the port 40 with the cushioning cylinder 4, through the port 41 with the upper end of the main cyliner 19, and through the connection 42 with the remaining end of the compensator valve 36. A pressure ratio control valve 43 is interposed in the pipe line 39 and forms an important part of my present invention. It will be observed that the pipe line 39 otherwise directly connects the cylinders 19 and 4, so that the rams 22 and 7 are subjected to the same unit pressure thus providing for a constant pressure ratio in the cylinders 19 and 4.

The valve 43 is shown in detail in Figure 2 and includes a fluid flow passage equipped with a free back check valve 44 which permits substantially free flow of fluid through the valve toward the cylinder 4 but serves to prevent free return of that fluid from the cylinder 4. The valve is also provided with a restricted duct 45 which communicates with a cross duct 46 and therethrough with a final restricted duct 47, said ducts 45, 46 and 47 collectively providing a restricted fluid return passage shunted around the check valve

44. The cross duct 46 accommodates a plug valve 48 which is spring loaded as at 49 as to be normally held across the duct 47 thus closing return communication through the ducts 45, 46 and 47, but capable of yielding to pressures to which the ducts 45 and 46 may be subjected. The valve is also provided with a manually adjustable means 50 by which the spring load to which the valve 48 is subjected may be varied.

As above stated the cushioning cylinder 4 and the pressing cylinder 19 are always in communication, and it is therefore apparent that the unit pressure in the cushioning cylinder will always be the same as that in the pressing cylinder. The cushioning ram 7 is of smaller diameter than the pressing ram 22 so that the total pressure exerted upwardly on the annular pressure face of the cushioning ram will be at all times less than the pressure exerted upon the pressing ram, and as a result the clamping ring 12 will be forced downwardly by the female die when the die descends. Because of the communication between the cushioning cylinder 4 and the main pressing cylinder 19, the total effective pressure exerted on the cushioning ram 7 will always bear the same ratio to the total effective pressure exerted on the main pressing ram 22. In other words, when the drawing pressure is large and results in a marked tendency for the blank to wrinkle, the pressure exerted upon the blank by the clamping means will also be large and wrinkling of the blank will be effectively prevented. When the drawing pressure is relatively small, the clamping pressure will be relatively small and the blank will not be unnecessarily squeezed.

In operation assume the press to be in the position illustrated in Figure 1 of the drawings. By utilizing the manual control 27, the pump control devices may be adjusted to cause the pump to discharge fluid under pressure through the port 28 into pipe line 39 thus supplying pressure through the port 41 into the main cylinder 19 and through the passage of the valve 43 controlled by the back check valve 44 and through port 40 into the cushioning cylinder 4, thus providing for a fluid pressure cushioning resistance in the cylinder 4 and ram moving pressure in the cylinder 19. As the main ram 22 descends under action of gravity, during the first portion of its downward travel before resistance to its movement is encountered, the evacuation of the cylinder portion above the ram effected by downward travel of the ram is greater than the ability of the pump to supply fluid to this evacuated space and the surge valve 20 will automatically open to allow fluid to flow into the cylinder from the surge tank 21 in the usual manner. The volume of fluid to be supplied by the pump to the upper portion of the main cylinder 19 being greater than the volume which the pump can draw from the booster cylinders 16 and pipe line 30, fluid from the surge tank 21 will be drawn in through the valve port 38 and the opening in the valve at the left hand side communicating through the connection 35 with the pipe line 30 as may be necessary. It will be understood, of course, that when the pump 25 is delivering fluid through the pipe line 39 the pressure in the connection 42 will dominate pressure in connection 35 and cause the valve 37 to be shifted to the position shown in Figure 1 to permit the fluid circulation just referred to.

As the main ram 22 proceeds downwardly and the female die H moves into contact with the blank K, further movement of the platen and the die will be resisted, first, by the resistance to bending of the blank which is supported on the fixed punch I, and secondly, by the clamping ring 12 contacting with the blank K, the clamping ring being yieldingly urged upwardly by pressure in the cushioning cylinder 4. When the female die first engages the blank, the pressure in the cushioning cylinder is small, being due only to the static head of the fluid in the surge tank 21.

During the drawing of the blank the building up of pressure in the main cylinder 19, by reason of the open communication with the cushioning cylinder 4 through port 41, pipe line 39, valve 43—44 and port 40, has resulted in a proportional increase in pressure in the cushioning cylinder 4, the blank being thereby clamped between the clamping ring 12 and the female die by a force proportional to the drawing pressure, that is, the ratio of the blank holding pressure to the drawing pressure is constant for all values of drawing pressure, and wrinkling of the blank is thereby prevented.

By now utilizing the manual control 27 to effect a reversal of the pump, pressure will be supplied through port 29, lines 30 and connections 32 to the push-back cylinders 16 so as to bring about a return of the platen to its elevated position. The pipe line 39 now becomes the low pressure line, the pump drawing fluid from that source, and the pipe line 30 becomes the high pressure line. In view of the difference in areas of the push back rams 17 and the main ram 22, the former being relatively very small, the push back equipment will tend to move the ram 22 upwardly faster than the now suction pipe line 39 can effect the necessary evacuation of the main cylinder 19 above the main ram. Thus pressure will be built up in the upper end of the main cylinder 19 which will tend to hold the surge valve closed at a time when it is particularly desirable that it be opened to relieve the fluid pressure thus built up in the upper end of the main cylinder. At this time, however, the pressure built up in the pipe line

30 will first act through the connection 35 to move the valve 37 to a position opposite that disclosed in Figure 1, and which will open communication between the tank 21 and pump suction line 39 through the port 38 and connection 42.

This adjustment of the valve 37 will bring about a reduction in pressure in the upper end of the main cylinder 19 and after this is accomplished the pressure in the pipe line 30 will act through the connection 33 to force downwardly the plunger in the chamber 34, thus gradually forcing open the surge valve to properly relieve pressure in the upper end of the main cylinder without shock to the system.

By thus gradually opening the surge valve the hydraulic system and all connections thereof, including the valve equipment 43—50, are relieved of the sudden shock which would be occasioned by any sudden opening of the surge valve 20 and smooth operation of the press and of the cylinder pressure ratio controlling valve mechanism 43—50 is assured.

During the main ram return movement above described, the fluid pressure in the pipe line 30 will also be directed, through the plunger stem bore 31, against the closed upper end of the cushioning ram bore 8 serving to move the ram 7 and the yoke 9 upwardly to its normal position illustrated in Figure 1, contact of the yoke with the underface of the bolster plate 7 serving to limit the upward movement of the ram. It will be observed by reference to Figure 1 that the pins 10 are of such a length that when the yoke 9 has been forced into engagement with the underface of the bolster plate J, the upper face of the clamping ring 12 will lie in substantially the same plane as the upper face of the punch or male die I.

From the foregoing description it will be apparent to those skilled in the art that I have provided a hydraulically actuated press working in unison with hydraulically actuated blank holding means in which the pressing means and the blank holding means are actuated by the same pressing fluid as used in the main cylinder. In my improved construction, hydraulic pressure is applied to the main cylinder and also to the die cushioning means through a check valve equipment which affords substantially free communication between the cylinder of the pressing mechanism and the cylinder included as a part of the die cushioning means in one direction, but which provides for an adjustable restricted fluid communication between these cylinders in the opposite direction.

In this press equipment pressure in the die cushioning cylinder is generated in two ways. It is generated by the pump which applies its pressure to the main cylinder and also to the die cushioning cylinder. Furthermore, this pressure may be intensified, if desired, by adjustment of the relief valve 48—50. In this case the pressure is generated by the force exerted by the main ram 22. The fluid expelled is returned back to the main cylinder of the press which is a distinct operating advantage inasmuch as this additional fluid helps to increase the speed of the main ram travel. Furthermore, a power saving is effected inasmuch as this fluid instead of having to be expanded to atmospheric pressure, is expanded to the main ram pressure only and the difference between main ram pressure and atmospheric pressure is utilized.

It will be obvious that by properly adjusting the spring load on the relief valve 48 it is possible to produce an initial pressure in the cushioning cylinder 4 so that at the start of the drawing operation there will be a certain pressure in the cushioning cylinder 4 before pressure is being developed in the main cylinder 19. This is a desirable feature inasmuch as it prevents wrinkling of stock when the drawing operation starts. Furthermore, by tightening the relief valve it is possible to change the ratio between the drawing pressure and the cushioning pressure, and increase the cushioning pressure if desired.

If the spring load on the relief valve 48 is entirely released the maximum of free communication possible between the cylinders in respective directions is provided for and the pressure in the main and cushioning cylinders 19 and 14 will bear what might be termed a zero pressure ratio and by increasing the load on the valve 48 this pressure ratio may be varied.

While I have discussed my invention in use upon one form of drawing press and in association with one form of reversible pump it is to be understood that the invention may be applied to various forms of press and used in association with various types of pumps found suitable for accomplishing the desired purposes and my invention comprehends all such modified applications of the invention as may come within the scope of the appended claims.

From the foregoing description taken in connection with the accompanying drawings it is thought that the novel details of construction, the manner of use and the advantages of my invention will be readily apparent to those skilled in the art to which it relates.

I claim:

1. In a drawing press including a movable die and a movable blank holder; the combination with hydraulic actuating means for bringing about relative movement between said die and holder, of a source of fluid pressure connected to said means: hydraulic cushioning means associated with said blank holder for yieldably urging said blank holder towards said die during a drawing operation;

hydraulic connections providing communication between said actuating means during the drawing operation and said cushioning means for maintaining at a constant ratio the hydraulic pressures therein, and means for varying said pressure ratio.

2. In a drawing press including a reciprocatory die and a movable blank holder, the combination with hydraulic actuating means for reciprocating said die towards and away from said holder; of a source of fluid pressure connected to said actuating means; hydraulic cushioning means associated with said blank holder for yieldingly urging said blank holder towards said die during movement of the die towards said holder, and for moving the blank holder towards the die while the die is moving away from said holder, hydraulic connections between said hydraulically actuated die moving means and said hydraulic cushioning means for maintaining at a constant ratio the hydraulic pressures therein, and means for varying said pressure ratio.

3. In a drawing press, including a press frame, the combination with a pair of die supports mounted on the frame, one of said supports being movable towards and away from the other; of hydraulic actuating means for effecting alternate drawing and return strokes of said movable support, said actuating means including a main pressing cylinder; a die fixed to each support; a source of fluid pressure; means forming with the pressing cylinder and with said source of fluid pressure a hydraulic circuit; a blank holder adapted to clamp a blank against one of the dies; a cushioning cylinder; hydraulically actuated means mounted for reciprocation in said cushioning cylinder and connected to said blank holder for resisting movement of said holder during the drawing stroke; hydraulic connections between the pressing cylinder and the cushioning cylinder for maintaining proportionate pressures therein; and means in the hydraulic connections between the pressing and cushioning cylinders adjustable for varying the proportionate pressures.

4. In a drawing press, a main cylinder, a press ram operable in the main cylinder, a cushioning cylinder, a cushioning ram operable in the cushioning cylinder, a hydraulic pressure circuit including a reversible pump and pipe lines and means to adjust the pump to cause the rams to move relatively for drawing and cushioning or for returning them to their normal position, said circuit including a pressure communicating pipe connecting the cylinders to provide a constant ratio of the pressures therein, and a valve for permitting free flow of pressure through the pipe in one direction and adjustably restricted flow of pressure therein in the opposite direction whereby variations in the ratio of pressures in said cylinders may be effected.

5. In a drawing press including a reciprocatory die and a movable blank holder, the combination with hydraulic actuating means for reciprocating said die towards and away from said holder; of a source of fluid pressure connected to said actuating means; hydraulic cushioning means associated with said blank holder for yieldingly urging said blank holder towards said die during movement of the die towards said holder, and for moving the blank holder towards the die while the die is moving away from said holder, hydraulic connections between said hydraulically actuated die moving means and said hydraulic cushioning means for maintaining at a constant ratio the hydraulic pressures therein, said hydraulic connections including a valve permitting free hydraulic pressure communication in one direction and adjustably restricted hydraulic pressure communication in the opposite direction whereby said ratio of hydraulic pressures may be varied.

6. In a drawing press, including a press frame, the combination with a pair of die supports mounted on the frame, one of said supports being movable towards and away from the other; of hydraulic actuating means for effecting alternate drawing and return strokes of said movable support, said actuating means including a main pressing cylinder; a die fixed to each support; a source of fluid pressure; means forming with the pressing cylinder and with said source of fluid pressure a hydraulic circuit; a blank holder adapted to clamp a blank against one of the dies; a cushioning cylinder; hydraulically actuated means mounted for reciprocation in said cushioning cylinder and connected to said blank holder for resisting movement of said holder during the drawing stroke; hydraulic connections between the pressing cylinder and the cushioning cylinder for maintaining proportionate pressures therein; and a pressure ratio control valve in the hydraulic connections between the pressing and cushioning cylinders including a free check valve opening in one direction and an adjustably restricted check valve opening in the opposite direction whereby said proportionate pressures may be varied.

7. In a drawing press, a main cylinder, a press ram operable in the main cylinder, a cushioning cylinder, a cushioning ram operable in the cushioning cylinder, a hydraulic pressure circuit including a reversible pump and pipe lines and means to adjust the pump to cause the rams to move relatively for drawing and cushioning or for returning them to their normal position, said circuit including a pressure communicating pipe connecting the cylinders to provide a constant ratio of the pressures therein, and a valve equipment in said pipe including a check valve affording free pressure flow in one direction, a second check valve affording

restricted pressure flow in the opposite direction, and means for varying the restrictive effect of said second check valve.

8. In a drawing press, a cushioning cylinder, a ram operable in and projecting from the cylinder, a hydraulic connection to said cylinder for applying hydraulic pressure to the ram to cause it to yieldingly resist draw pressing action, said ram having a central bore therein, a plunger stem stationarily supported in the cylinder and extending into the central bore in said ram for sliding movements relative to said ram, said stem having a bore therethrough opening into the bore in said ram, and a hydraulic connection to the bore in said stem for applying hydraulic pressure through the stem bore to said ram bore to return said ram to its normal position after it has yielded to draw pressing action engagement.

9. In a drawing press, a cushioning cylinder, a ram operable in and projecting from the cylinder, a hydraulic connection to said cylinder for applying hydraulic pressure to the ram to cause it to yieldingly resist draw pressing action, said ram having a central bore therein, a plunger stem stationarily supported in the cylinder and extending into the central bore in said ram for sliding movements relative to said ram, said stem having a bore therethrough opening into the bore in said ram, and a hydraulic connection to said stem bore for applying hydraulic pressure through the stem bore to said ram bore to return said ram to its normal position after it has yielded to draw pressing action engagement, said hydraulic pressure applying means being connected so that pressure applied to the ram is withdrawn from the ram bore and pressure applied to the bore is withdrawn from the ram.

10. In a drawing press, a main cylinder, a surge tank, a surge valve capable of being opened to open communication between the tank and the main cylinder, a large area press ram operable in the main cylinder, a push back cylinder, a small area return ram connected with the press ram to effect return movement thereof, a cushioning cylinder, a cushioning ram operable in the cushioning cylinder, a hydraulic pressure circuit including a reversible pump and pipe lines and means to adjust the pump to cause the rams to move relatively for drawing and cushioning or for returning them to their normal position, said circuit including a pressure communicating pipe connecting the cylinders to provide a constant ratio of the pressures therein, and a valve for permitting free flow of pressure through the pipe in one direction and adjustably restricted flow of pressure therein in the opposite direction whereby variations in the ratio of pressures in said cylinders may be effected, said pressure circuit including means responsive to pressure in the main cylinder for first relieving that pressure and thereafter to effect a gradual opening of the surge valve.

In testimony whereof, I have hereunto subscribed my name.

WALTER ERNST.