July 14, 1942. H. F. MacMILLIN ET AL 2,289,584

METAL STRETCHING PRESS

Filed March 25, 1940 3 Sheets-Sheet 1

FIG. 1

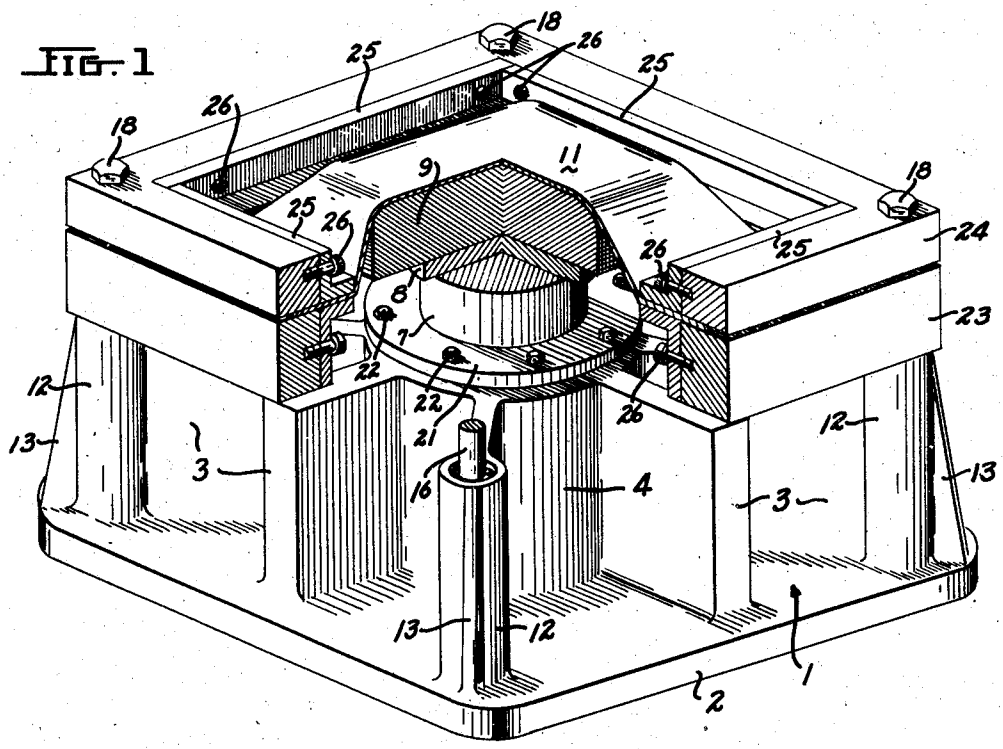
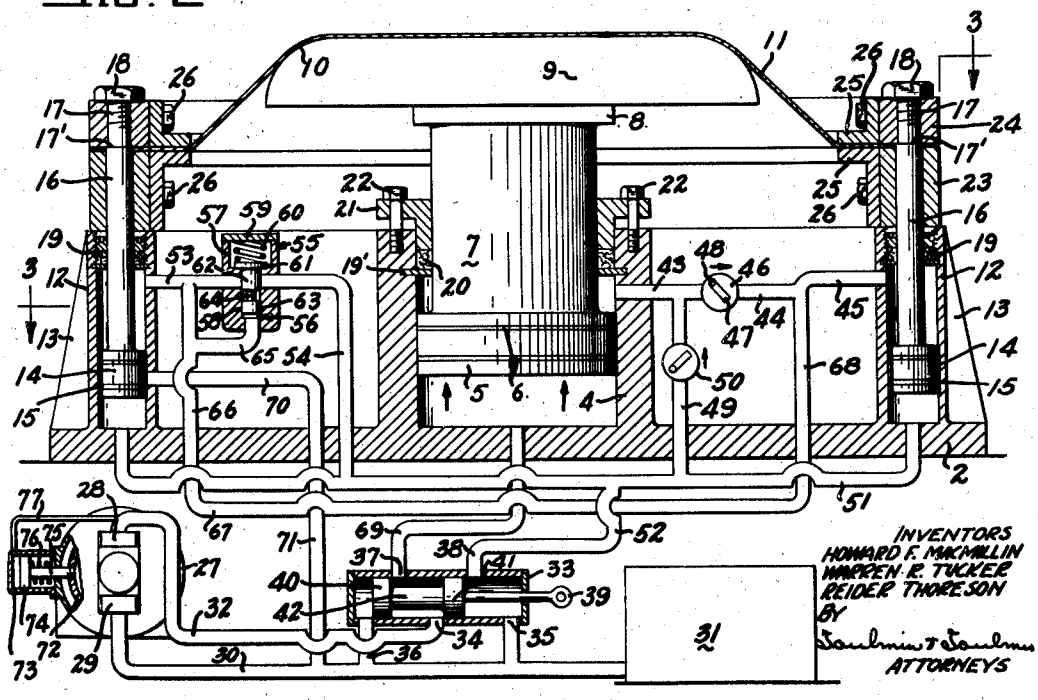


FIG. 2



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FIG. 3

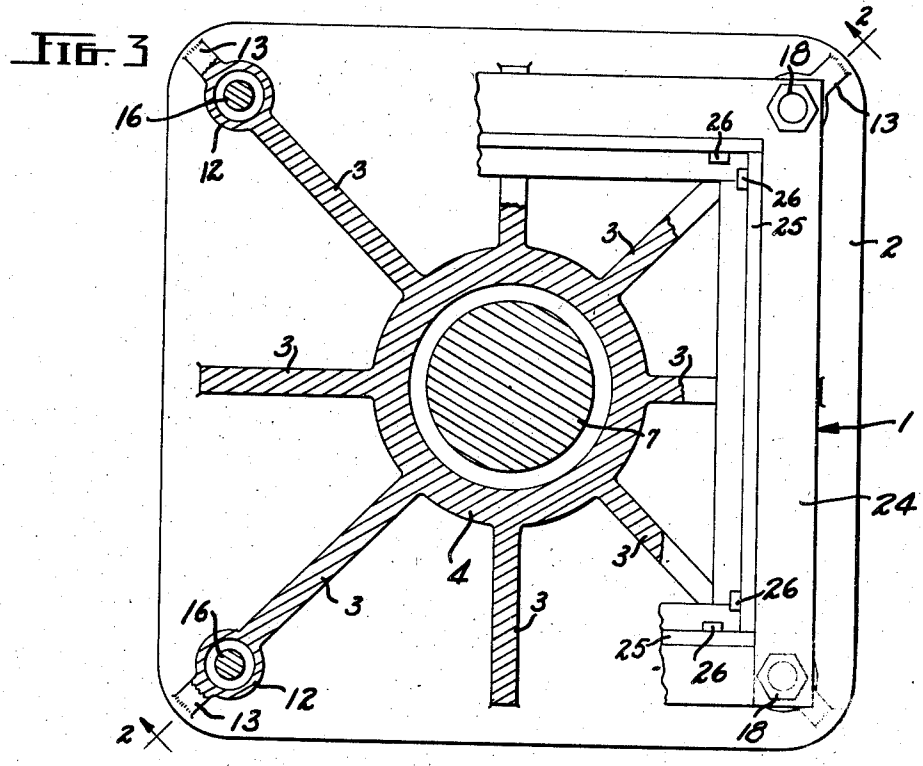
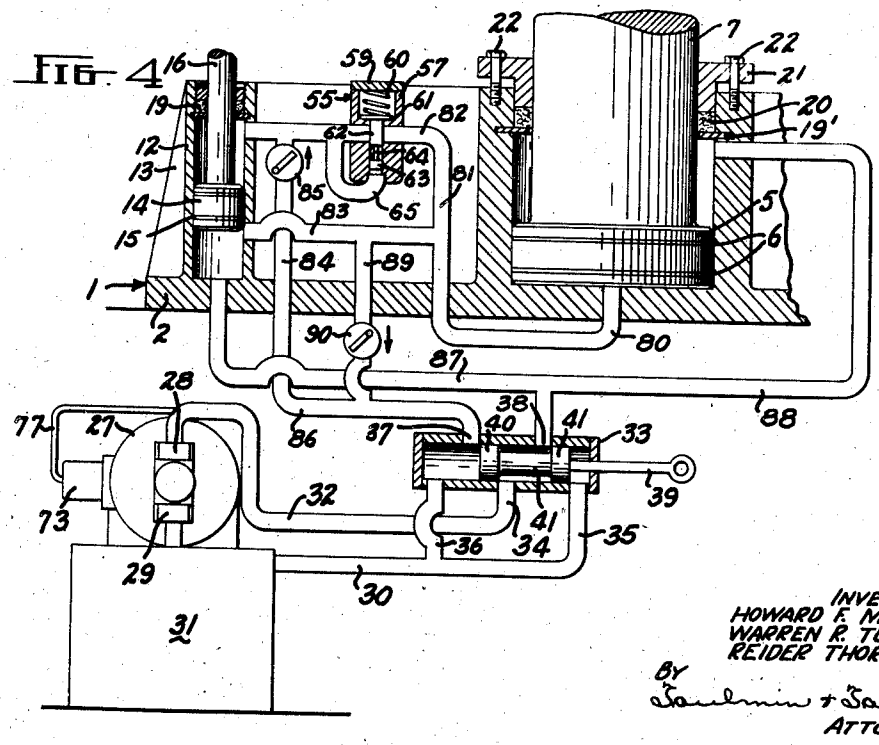


FIG. 4



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METAL STRETCHING PRESS

Filed March 25, 1940 3 Sheets-Sheet 3

FIG. 5

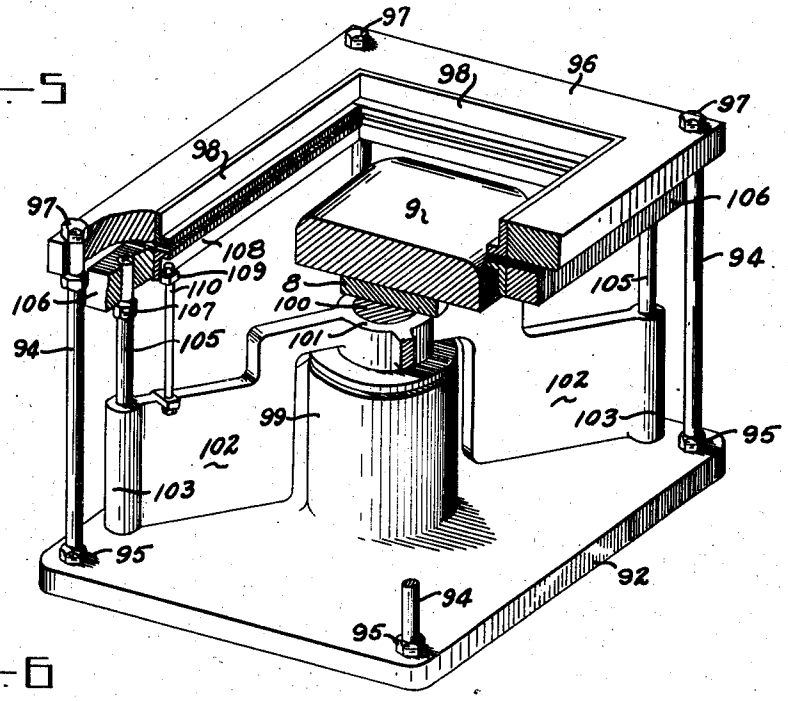
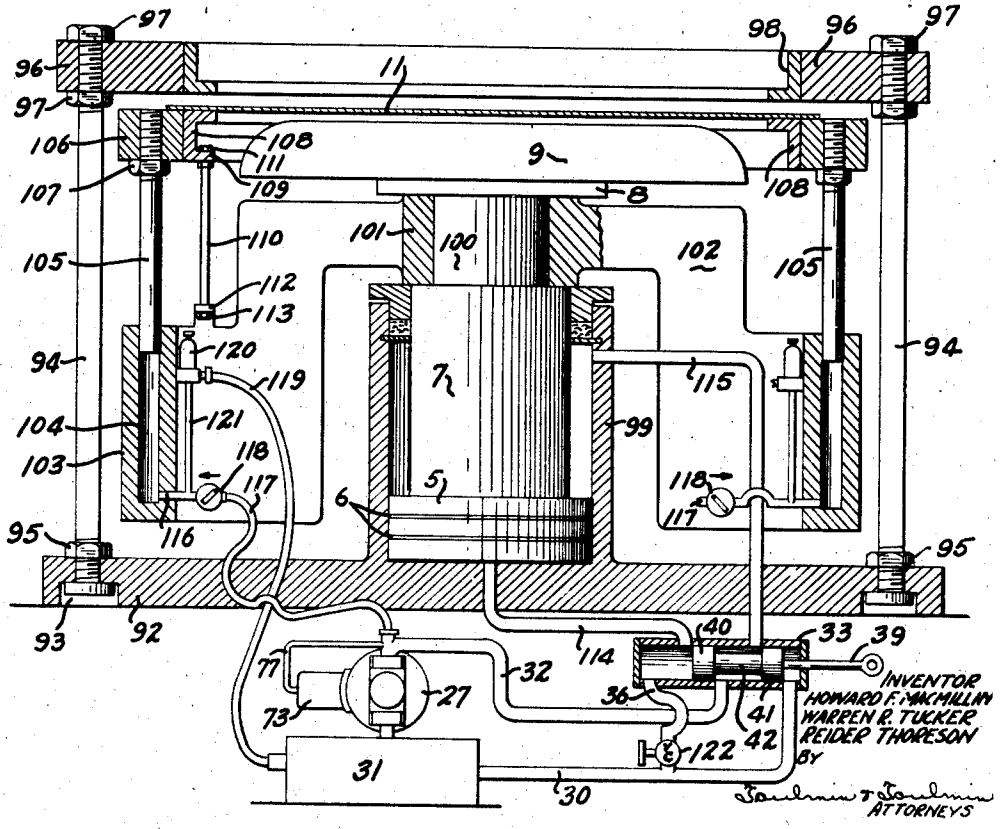


FIG. 6



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METAL STRETCHING PRESS

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Application March 25, 1940, Serial No. 325,780

9 Claims. (Cl. 113—45)

The present invention relates to hydraulic presses, and particularly to presses of the type that employ mechanism for clamping the workpiece to the press.

In certain forms of hydraulic drawing presses it is sometimes necessary to clamp the sheet of metal to the bed or top plate of the press. Various methods for doing this have been proposed, and practically all of these methods depend on the use of clamping or gripping forces derived from pneumatic cylinders, electric motors or hand-power-operated through levers. The use of these forces obviously requires a source of energy different from that employed in the press, which adds to the expense of the press as a whole, also to the installation and to the complexity of operation. Furthermore, the power-multiplying levers are often of a complicated mechanical character due to the manner and direction in which the force is applied.

Presses of this general type quite frequently require precise timing between the clamping and pressing forces, particularly to insure that the gripping effect is provided before the metal is worked. Obviously, this timing requirement is difficult to achieve and maintain, where separate sources of energy are employed for the gripping and pressing operations.

Another precaution which must be taken is to insure that the clamping effect is not withdrawn until the punch of the press has broken contact with the metal. Moreover, in so-called "stretching" presses in which certain slippage of the metal is permitted and required to accommodate the drawing or forming operation, it is often difficult to make the necessary adjustments of the prior-art clamps to not only insure proper timing but also the proper amount of slippage, and it is harder yet to change the adjustments of the clamps individually to produce local pressing effects.

The primary object of the present invention is to provide a hydraulic press which is adapted to grip the work with or without slippage, and to eliminate all of the disadvantages in connection with prior-art presses of this general character.

Another object is to provide a press in which the gripping or blank holder jaws are acted upon by the same source of power which is employed for operating the press.

A further object is to provide a hydraulic press in which the clamping effects are obtained by direct hydraulic pressure, thus insuring perfect coordination between the press and the work-clamping mechanism. Only a single source of hydraulic power is required for these two purposes, so that when pressure is applied to the fluid of the press the clamping mechanism is simultaneously subjected to the pressure of the same fluid.

A still further object is to provide a hydraulic press in which the workpiece is gripped at a number of different areas throughout the surface of the workpiece, and ready adjustment may be made of the final clamping effects at the various clamping positions.

In carrying out the above objects there is provided a number of hydraulically actuated pistons for applying pressure to a similar number of clamps or gripping devices spaced about the workpiece and receiving their power from the same source of pressure fluid which operates the press. Each of these pistons reciprocates in cylinders, the pressure of which may be adjusted as a whole or individually in order to provide the necessary general or special clamping effects.

Other objects and features will be apparent as the specification is perused in connection with the accompanying drawings.

In the drawings:

Figure 1 is a perspective view, with a part broken away and in section, of a hydraulic press, improved in accordance with the present invention.

Figure 2 is a lateral section taken across the press shown in Figure 1 and along the line 2—2 in Figure 3, but with the plunger in elevation and the hydraulic circuit shown schematically.

Figure 3 is a view taken along the line 3—3 in Figure 2, and showing the relation between the press plunger and the cylinder in which the plunger operates.

Figure 4 is a fragmentary sectional view of a press similar to that shown in the preceding figures, except employing a different form of hydraulic circuit. The latter is illustrated by diagram.

Figure 5 is a perspective view, partly broken away, of still another modification of the improved press.

Figure 6 is a sectional view taken along the line 6—6 in Figure 5, except that the press and immediately associated apparatus are shown in elevation. Figure 6 employs a different form of hydraulic circuit from that illustrated in Figures 2 and 4.

Referring more particularly to the press shown in Figures 1, 2 and 3, the numeral 1 designates

in general the bed of the press. This bed is provided at the bottom with a base 2, of rectangular configuration, from which extend upwardly, preferably midway between opposite edges of the base, a number of webs 3. These webs radiate outwardly from a hub or cylinder 4 integrally joined to the base. The interior of the cylinder wall is preferably ground, and receives a piston 5 provided with the usual rings 6, the piston being carried by a plunger 7 to which is secured at the upper end a platen 8. The latter detachably carries a punch 9, having rounded edges, as indicated at 10, and of a configuration determined by the shape of the article, indicated at 11, which is being pressed.

The base 2 is provided at each corner thereof with an upstanding cylinder 12, preferably formed integral with the base, as by casting, these cylinders being reenforced by the triangular webs 13. Each cylinder contains a reciprocatory piston 14 with rings 15 and carried by the piston rod 16, which is provided with a top threaded portion of smaller diameter than the lower or main portion, to leave a shoulder 17'. A nut 18 is provided on the threaded portion. The piston 14 is provided with the usual packing material and gland, indicated generally at 19. The centrally positioned piston 5 is provided with a washer 19', packing material 20 and a packing gland 21 which can be drawn toward the cylinder 4 by the bolts 22, thus compressing the packing material. As indicated in the drawings, the cylinders 12 terminate at the same height, and on top of these cylinders there is positioned a hollow rectangular frame 23, termed the top plate, having openings through which the rods 16 extend.

Directly above the top plate 23 but spaced therefrom by the thickness of the metal sheet 11, and resting on the shoulders 17', there is a gripping plate 24 having a configuration similar to that of the top plate. The clamping nuts 18 bear against the upper surface of the gripping plate so that as downward pressure is applied to these nuts the plate 24 serves to clamp the metal sheet 11 to the top plate 23. As illustrated more clearly in Figures 1 and 2, the plates 23 and 24 constitute a frame with large rectangular openings therein which are adapted to receive the sheet metal while it is being formed to the required shape. There is a number of die strips 25 detachably secured to the interior surfaces of the plates 23, 24, as for example, by means of bolts 26. These strips are preferably made of hardened steel, and may have any form and dimensions, depending on the configuration of the metal article 11. These strips may advantageously take the form of an angular bar, as illustrated, one leg of which is wide enough to receive the bolts 26.

For operating the press there is provided a single one-way hydraulic pump 27, which may be actuated by an electric motor (not shown). The outlet of the pump is indicated at 28 and the inlet at 29. The latter is connected, through a metal conduit 30, with a tank 31 containing a suitable fluid, for example oil. The outlet of the pump is connected through a metal conduit 32 with a four-way valve 33, of any suitable and well known type. The high pressure ingress to the valve is indicated at 34 and the low pressure egress at 35. There is also a low pressure pipe 36. The high pressure discharge pipes are shown at 37 and 38. The valve 33 contains a piston rod 39 which is secured to a pair of pistons 40 and 41, respectively, joined together by a rod 42. The pistons 40 and 41 are spacially related in such a way as to control the passage of the pressure fluid to and from the valve, in accordance with longitudinal movements of the rod 39 and for purposes which will be explained presently. This rod may be pivotally secured to any convenient form of hand or automatic operating mechanism, such as a lever system or the movable core of an electromagnet or a crank driven by a motor. In any of these cases the rod 39 is adapted to be moved in a horizontal direction at a predetermined time and for a predetermined distance, depending on the operation desired of the press.

There is a conduit, represented by three different lengths of pipe 43, 44 and 45, extending from a position at the back of the piston 5, through the cylinder walls 4 and 12, to a position at the back of the piston 14. In the length of pipe 44 a check valve 46 is provided. This valve is of the one-way type and of any suitable and well known construction. As illustrated, the actuating element of the valve is constituted of a vane 47 pivoted at 48, the arrangement being such that fluid can pass from left to right through the pipe length 44, as indicated by the arrow, but not in the reverse direction.

Extending from the pipe section 43 there is a pipe 49 containing a check valve 50, which is so arranged as to permit fluid to pass upwardly through the pipe (as seen in Figure 2) but not in the downward direction. The pipe 49 communicates with a horizontally positioned pipe 51, the ends of which terminate at the lower surface of two oppositely positioned cylinders 12, directly under the pistons 14. It will be understood, since there are four cylinders 12, that there are two sets of pipes 51, of which only one has been illustrated, with a cross connection conduit between the two pipes in order to assure the same pressure throughout the two pipes and therefore the same pressure applied to the under sides of all of the pistons 14. The pipes 51 are connected through a conduit 52 to the upper side of the valve 33. There is a horizontal length of pipe 53 extending from a position in back of the left-hand piston 14 which communicates with a vertical length of pipe 54, and terminates in the pipe 51.

An admission valve 55 is inserted in the horizontal length of pipe 53. This admission valve is of any suitable and well known construction and has for its purpose the passage of pressure fluid from left to right through the pipe 53 when the pressure in the pipe is in excess of a predetermined pressure. The valve may be constituted, as a typical form, of a cylinder 56 containing two chambers, one of which is indicated at 57 and is of greater diameter than the other, indicated at 58. The top of the valve is closed by a plate 59. A compression spring 60 is positioned in the chamber of larger diameter, one end of this spring bearing against a collar 61 which is carried on a piston 62. Beneath the piston there is a second piston 63 separated from the first piston by an undercut portion 64.

The valve 55 has an opening at the bottom which receives an upturned pipe 65. The arrangment is such that when the pressure in the pipe 65 is below a predetermined amount the pistons 62, 63 remain in the position as showr in Figure 2, in which the upper piston closes off the pipe 53, thus preventing the passage of any fluid through the pipe. On the other hand vhen

the pressure in the pipe 66 exceeds a predetermined amount, the piston 63 is caused to move upwardly against the restraining action of the spring 60, and this in turn, causes the upper piston 62 to move into the upper chamber 55, leaving the undercut portion 64 in the pathway constituting the pipe 53. Since the diameter of this undercut portion 64 is less than the internal diameter of the pipe 53, fluid under pressure can now pass through the pipe 53. The function of the admission valve 55 with respect to the remaining elements of the system will be explained in connection with the operation of the device as a whole.

There is a pipe 66 which terminates in the pipe 53 at a position between the valve 55 and the cylinder 12, this pipe 66 being connected through a horizontal pipe length 67 to a vertical pipe length 68. The latter joins with the two horizontal pipe sections 44, 45. A pipe 69 is taken from the lower interior surface of the cylinder 4, i. e. at the lower side of the piston 5, to the top of the valve 33, where it terminates in the fluid egress 35. There is a horizontal length of pipe 70 terminating at the left-hand end at the cylinder 12 and positioned above the bottom of the cylinder for an appreciable distance, the purpose of which will appear presently. The right-hand end of the pipe 70 connects with a vertical pipe 71 which terminates at the bottom in the low pressure pipe 30.

While this pipe system has been described mainly in connection with only a pair of cylinders 12, it will be understood that the pipe connections which are made to the right-hand cylinder are also made to the cylinder in back of the right-hand cylinder, and the same thing is true with respect to the pipe connections made to the left-hand cylinder. Similar pipes are provided with lateral extensions in order to assure that the same pressure prevails throughout the different corresponding cylinders. Obviously, if desired, the pipe network can be so designed as to necessitate only one admission valve 55 and only one set of check valves 47 and 50, these valves serving to perform their special function in the corresponding pipe lines of the entire system.

The hydraulic pump 27 is preferably of the radial piston type, in which the movement of the pistons is controlled by a flow or shift ring indicated in a fragmentary manner by the reference character 72. Extending outwardly from one side of the pump there is a hollow cylindrical casing 73 which contains a piston 74 carried by a rod 75, which is attached to the shaft ring 72. The piston 74 bears against a compression spring 76 which surrounds the rod 75, and is seated against a stationary thrust plate (not shown). A pipe 77 is taken off the left-hand end of the casing 73, i. e. between the piston 74 and the end of the casing, and connects with the high pressure outlet 28 of the pump. The purpose of the casing 73 and the contained mechanism is to stop the discharge of the pump by causing the piston 74 to move to the right against the spring 76, and returning the shift ring 72 to neutral when the pressure in the pipe 77 is higher than a predetermined pressure. Thus the unit 73 constitutes a pressure safety device, as will be further explained hereinafter.

Operation

Assume that it is desired to draw out or form the sheet of metal 11 into a dish-shaped configuration. The punch 9 is first designed, either by calculation or experiment, to produce this configuration when the plunger 7 is operated. The rod 39 of the four-way valve is moved to the right, and assuming that the hydraulic pump 27 is being operated, pressure fluid will pass through the pipe 32, through the valve 33, into the pipe 52, and from there is admitted to the lowermost portion of each cylinder 12 through the pipe 51. This pressure fluid will cause the pistons 14 to elevate and the rod 16 will, in turn, cause the gripping plate 24 to move upwardly away from the plate 23 because the plate 24 rests on the shoulders 17'.

As the pistons 14 continue to move upwardly, at least one of them will eventually uncover the opening in the pipe 70 which is connected to the low pressure pipe 30, and in effect, will cause the discharge of the high pressure fluid back to the tank. The pistons 14 will thereupon drop a slight amount until they cover the pipe 70, and will be maintained in this position by the pressure fluid flowing through the pipes 51. Thus the pistons 14 will float or flutter at this elevated position, holding the gripping plate 24 at a considerable height above the top plate 23. The edges of the metal sheet 11 can then be readily inserted in this deep space between the plates 23 and 24, and when properly positioned the clamping pistons are drawn downwardly by admitting pressure fluid to the upper sides of the pistons and exhausting the fluid from the lower sides thereof. This operation is accomplished by moving the rod 39 to the left in the position shown in Figure 2. It will be noted under these conditions that the pipes 51 are connected directly to the tank 31, through the pipe 52, the valve 33 and the pipe 35. Pressure fluid is admitted through the pipe 32 into the valve 33, and through the pipe 69 to the under side of the main piston 5.

This pressure fluid will cause the piston 5 to elevate, but before the punch 9 has actually contacted with the under side of the metal sheet 11, the fluid which is trapped between the upper side of the piston 5 and the washer 19' (introduced through the immediately preceding operation) is placed under pressure and this pressure fluid passes through the pipe sections 43, 44 and 45 into a pair of cylinders 12 above the pistons 14, and another portion of this fluid will pass through the pipes 66, 67 and 53, into the other pair of cylinders above their respective pistons. The effect of this pressure fluid is to cause all of the pistons 14 to move downwardly, carrying with them the gripping plate 24, due to the compression stresses exercised at the clamping nuts 18. As the piston 5 continues its upward movement the pressure of the fluid in the cylinders 12 becomes greater and greater, causing increased clamping effects at the nuts 18 so that by the time the punch actually contacts with the metal sheet all four edges of the sheet are firmly held between the plates 23 and 24. The plunger 7 continues its upward movement, causing a deformation of the metal sheet to a shape dependent on the configuration of the punch and the shape of the die strips 25.

In drawing operations of this character it is usually desirable, but not always, to permit a small amount of slippage between the metal sheet and the gripping plates. For this reason it is necessary that the clamping effects of the pistons 14 shall not be greater than a predetermined maximum. This desirable result is brought

about in a novel manner by the use of the admission valve 55. As the pressure builds up at the back of the pistons 14 and has reached a predetermined value to permit the proper amount of slippage at the gripping surfaces, any excess pressure will cause fluid passing through the pipe 53 and through the upper portion of the pipe 66 to pass into the pipe 65, and this excess pressure will cause an upward movement of the piston 63 of the valve 55. The piston 62 will move upwardly against the spring 60 and into the chamber 57, and the undercut portion 64 will now be presented to the pipe 53. Thus the excess pressure fluid can immediately pass through the pipe 53, through the valve 57, down through the pipe section 54, and exhaust through the pipe 52 and the valve 33 to the tank 31. As soon as the excess pressure fluid is relieved through the admission valve 55 the piston 62 will descend to its initial position directly in line with the pipe 53, thus maintaining the pressure in the upper portions of the cylinders 12 at a predetermined value.

As the piston 5 is continuing its work on the metal sheet 11 it will eventally reach its uppermost limit of movement, and this may be determined in a number of ways. The operator, for example. may observe the height to which the central portion of the metal sheet has been raised by any convenient reference point or measuring device, and when satisfied that the sheet has been completely formed he may cause the rod 39 to be moved to the right, which will cause the plunger 7 to descend, as will be explained presently. However, there is illustrated a pressure-operated means for reversing the travel of the plunger, and this is effected through the pump 27.

Assume that the piston has just reached its maximum upward travel and tends to go higher. The pressure of the trapped fluid back of the piston becomes excessive, and this imparts an excessive pressure load at the pump. The resulting excess fluid passes from the outlet 28, through the pipe 77, to the left-hand side of the piston 74, causing the shift ring 72 to move back to neutral against the action of the spring 26. Under these conditions, as is well known, the output of the pump is reduced to zero, thus relieving the excess back pressure at the main piston. When the operator has observed that the pressure safety device has operated he can immediately cause the rod 39 to be moved to the right to exhaust the pressure fluid from the under side of the piston 5. It is obvious that if desired an automatically operating mechanical or hydraulic system may be employed for moving the rod 39 at the same time that the piston 74 in the pressure safety device 73 is operated.

Upon movement of the rod 39 to the right the pipe 69 is now presented directly to the tank 31, through the valve 33 and the pipe section 36, thus permitting the fluid in the lower portion of the main cylinder to be exhausted. On the other hand, pressure fluid from the pipe 32 (assuming that piston 74 has been moved to the left on reduction of the excess pressure, permitting the flow ring 72 to be shifted away from neutral by the spring 76) flows through the valve 33, into the pipe 52. From there the pressure fluid passes upwardly through the pipe 49, the pipe section 43, into the space at the back of the piston 5, thus causing the piston to descend and break contact with the metal article 11. It will be noted that under these conditions the pressure of the fluid is still being maintained at the back of the piston 14, due to the fact that the admission valve 55 maintains the pipe 53 closed to pressures below a predetermined amount. Consequently, clamping pressure is still being exercised by the piston rods 16 even after the punch 9 starts to descend.

In addition to providing pressure fluid to the upper side of the piston 5, as explained above, fluid is also introduced into the pipes 51, which causes the pistons 14 to move upwardly and to elevate the plate 24 from the plate 23. However, it will be understood that the pistons 14 do not move upwardly immediately after pressure fluid is introduced into the pipes 51 because there is a greater pressure on the opposite sides of the pistons urging the pistons downwardly, due to the pressure setting of the valve 55. Thus the clamps remain set until the punch 9 has descended an appreciable distance, or at least until it has become stripped from the metal article, at which time the pressure built up at the under side of the piston is greater than the back pressure at the upper side of each piston.

As the plunger continues to descend the pistons 14 will continue to rise until they reach their uppermost elevated position, determined by the level of the pipes 70. The article 11 may be then readily maneuvered out of position between the plates 23 and 24, notwithstanding the fact that the edges of the formed article extend under the die strips 25. It is obvious that the amount of space between the plates 23, 24 necessary to permit removal of the formed article depends on the shape of the article, and this space may be adjusted by raising the position at which the vent pipe 70 enters the cylinder 12.

From the foregoing it is apparent that there is disclosed an improved form of hydraulic press in which the clamps are actuated from the same source of hydraulic energy as operates the main press. The clamping mechanism is entirely automatic in its operation since it is controlled by the same valve as controls the transmission of pressure fluid to the main press, and further that the arrangement is such that the clamping effect is made effective at a time prior to actual contact between the punch and the metal sheet during the upward movement of the plunger, and is maintained at its proper value for a predetermined length of time after the punch has stripped itself from the finished article. It is also apparent that a very careful adjustment may be obtained through the valve 55 to provide not only the clamping effects necessary to hold the metal sheet 11 without slippage, but also to provide a predetermined amount of slippage in order to facilitate the drawing or stretching of the metal.

The use of the rectangular gripping plate 24 permits a fabrication of all kinds of complicated shapes of the metal article, since the metal sheet is held throughout its entire boundaries. It will be understood that, if desired, the plates 23 and 24 may assume any other shape than rectangular, such as circular or elliptical, or indeed may constitute simply a pair of heavy strips or bars so as to hold only two edges of the metal sheet. Changes in the configuration of the metal article may be readily accommodated by simply replacing the die strips 25 by other strips of suitable shape and size. It will be further noted that, due to the manner in which the spaces at the upper sides of the pistons 14 are all connected together through the common conduit 44 lead-

ing from the upper side of the main piston 5, the pressures causing the pistons 14 to move into clamping position are all equal. This results in an equal distribution of the compression stresses exercised throughout the plate 24 on the metal sheet 11.

In Figure 4 a modified form of hydraulic circuit is shown. Whereas in the circuit illustrated in Figure 2 the clamping pressure applied to the rear of the pistons 14 is obtained from the compression effects at the rear of the main piston 5, in Figure 4 these clamping effects are obtained directly from the pump. Moreover, in Figure 4 a pipe is taken from the rear side of the clamping pistons 14 to the under or working side of the piston 5, with a pressure limit valve placed in this pipe so as to assure that the main piston will not elevate until a predetermined pressure has been built up in the clamping cylinders.

Referring in detail to Figure 4, it will be noted that the pump 27 is mounted directly on the fluid tank 31 so as to reduce the length of pipe necessary between the intake of the pump and the tank. As in the case of Figure 2, there is a four-way valve 33 employed, in which the high pressure ingress from the pump is indicated at 34 and the low pressure egress at 35 and 36. The high pressure discharge pipes are indicated at 37 and 38. Similar elements in this figure are given the same corresponding numbers as in Figure 2.

A pipe 80 is taken from the lower portion of the main piston cylinder, this pipe extending upwardly as indicated at 81, and then horizontally at 82, passing through the admission valve 55 to a position at the rear of the clamping piston 14. From the vertically extending pipe 81 there is a horizontal pipe 83, which connects with the clamping cylinder at a position to the front of the clamping piston 14 and at a distance upwardly from the base 2. There is also a vertical pipe 84 connected through a check valve 85 at the top to the pipe 82 at a position between the admission valve and the clamping cylinder. The lower end of pipe 84 is extended through a horizontal length, indicated at 86, which connects with the high pressure discharge pipe 37. The other high pressure discharge pipe 38 connects through branch pipe lines 87 and 88 to the lowermost portion of the clamping cylinder 12 and to the rear of the main piston 5, respectively. As shown on the drawings there is also a short length of pipe 89 connected between the two horizontal pipes 83 and 86 through a check valve 90.

The position of the main piston is shown as having completed its downward stroke, and the clamping pistons 14 as having been elevated to raise the gripping plate 24 to such a position as to enable the previously formed article to be removed and a new sheet of metal 11 placed in position between the plates 23 and 24. Assuming that the pump 27 is delivering high pressure fluid through the pipe 32 and that it is desired to start the main piston 5 on its upward working stroke, the rod 39 is moved to the left in any suitable manner, automatically or manually through the use of levers, a motor or electro-magnet. Under these circumstances high pressure fluid passes through the valve 33, through the pipe 86 and the check valve 85 (noting that the vane of the check valve is pivoted to permit upward flow of fluid), into the space to the rear of the piston cylinders 14. It will be understood that there are four such cylinders and that suitable lateral connections are made from the various pipes shown in Figure 4 to assure the instantaneous admission of fluid to all of the clamping cylinders. This fluid, after filling up the spaces in the clamping cylinders, will cause the pistons 14 to move downwardly and permit a lowering of the gripping plate 24, eventually causing the nuts 18 firmly to clamp the plate 24 and its die strips 25 against the metal sheet 11.

When sufficient pressure has been built up at the rear of the pistons 14, in the manner described, the excess fluid from the pump, or rather the pressure exerted thereby, is effective through the pipe 65 (depending on the pressure adjustment of the spring 60) to move the pistons 62 (Figure 2) out of the path of the pipe 82, as in the case of Figure 2. The undercut portion 64 of the admission valve is presented to the pipe 82, allowing easy access for the surplus pressure fluid to pass through the admission valve, through pipes 81 and 80 to the lower side of the main piston 5. It is apparent that as long as the pressure to the rear of the clamping pistons 14 remains as great as the pressure for which the admission valve 55 is set, all of the output from the pump will be passed through the valve to the working side of the main piston 5, causing the plunger 7 to be elevated. It will be understood that if for any reason the pressure in the upper portions of the clamping cylinders becomes less than that necessary to operate the admission valve, fluid is admitted to the clamping cylinders until the pressure has been restored to the predetermined value, at which time the excess pressure fluid will be bypassed through the valve into the main cylinder. As the plunger 7 continues to rise the punch 9 (Figure 2) contacts with the metal sheet 11 and forms the sheet into an article of desired shape, as was explained in connection with Figure 2.

Upon completion of the pressing or forming operation, as may be either automatically determined or visually observed by the operator, the latter either moves or causes to be moved the rod 39 to the right, which is the position shown in Figure 4. Under these circumstances the high pressure discharge of the pump is now admitted to the discharge pipe 38 and a portion of the pressure fluid is introduced into the main cylinder to the rear of the piston 5, and the other portion into the clamping cylinders below the pistons 14. It will be noted that the pipe 80, which communicates with the lower portion of the main cylinder, is now connected through the check valve 90 and the four-way valve 33 to the low pressure pipe 36. Thus, all of the pressure is removed from the lower surface of the piston 5, permitting the plunger 7 readily to descend. In order to prevent an abrupt downward movement of the piston it may be desirable to insert a choke valve (not shown) in the pipe 36, which restricts the rate of flow of pressure fluid therethrough. High pressure fluid travels through the pipes 38 and 88 to the space at the rear of the main piston 5, forcing the plunger 7 and the punch carried thereby downwardly and thus breaking the mechanical contact between the punch and the under side of the formed metal article.

In view of the fact that the plunger 7 tends to descend rather quickly, thus increasing the space at the rear of the piston 5 at a rapid rate, most of the pressure fluid delivered by the pump

is transmitted through the pipe 88 and a very little through the pipe 87. However, as the pressure at the rear of the main piston increases more and more, pressure fluid is transmitted through the pipe 87, causing the clamping pistons 14 to ascend. As in the case of Figure 2, these pistons will elevate to a height determined by the position of the horizontal pipe 83, which in effect, causes the pressure fluid to be exhausted through the line 89 and the valve 33, into the low pressure pipe 30. The clamping pistons 14 will therefore float or fluctuate between the position of the pipe 83 and the lower end of the clamping cylinders.

When the pistons have reached this "floating" position, the gripping plate 24, which is carried on the shoulders of the clamping plungers 16, will have reached its greatest distance removed from the plate 23 to enable the formed article 11 to be maneuvered out from between the plates 23, 24. It is apparent that the width of the space between the plates 23, 24 can be made as great as desired, depending on the shape of the formed article, by simply changing the position of the horizontal pipe 83 with respect to the lower surfaces of the cylinders 12. After the formed article has been removed a new metal sheet can be readily inserted into position because the plunger 7 will have moved to its lower limit of travel, at which time the operator will cause the pistons 40, 41 to be moved to the left, thus applying first a clamping force to the plungers 16 and then an upward movement of the main plunger 7.

As in the case of Figure 2, there is preferably provided a pressure safety device 73 attached to the pump, the purpose of which is to shift the flow control ring in the pump to neutral when excess pressure has been developed anywhere within the hydraulic system during either the upward or downward movements of the clamping plungers 16 or the pressing plunger 7. It will be evident that by assuring the main piston 5 would not be moved upwardly until a predetermined pressure has developed at the rear of the clamping cylinders 14, a clamping pressure is always applied to the plate 24 and therefore on the metal sheet 11 before the punch 9 reaches the under side of the metal sheet. In view of the fact that the admission valve 55 is essentially a one-way element, the pressure built up at the rear of the clamping pistons will be maintained for an appreciable length of time after the plunger 7 has started its downward movement, thus assuring the proper amount of clamping pressure at the work when the punch 9 breaks mechanical contact (i. e. is stripped) with the under side of the formed article. This residual back pressure is relieved only when the clamping cylinders 14 are forced upwardly for a considerable distance, causing some of the fluid to the rear of the pistons 14 to be passed through the admission valve 55 and through the horizontal pipe 83 to the opposite side of each piston 14.

It is further evident that the admission valve 55 may be so designed or regulated as to provide any desired clamping pressure at the pistons 14 so as to permit the proper amount of slippage of the sheet 11 with respect to the plate 24 to accommodate the necessary stretch of the metal during the forming operation. If desired, the clamping pressure may be made so high as to prevent any slippage whatever. In any case, equal pressures are applied to all of the clamping pistons, assuring equal clamping effects at the plate 24 and therefore a perfectly symmetrical formed article.

In Figures 5 and 6 there is shown still another embodiment of the present invention, the main differences being the manner in which the gripping plate moves with respect to the top plate, and also the feature of maintaining the pistons of the clamping cylinders practically stationary while moving the clamping cylinders wih respect to the pistons. The press is confined to a frame constituted of a flat base member 92 of rectangular configuration, having countersunk holes 93 at the corners thereof for receiving the heads of a number of strain rods 94, threaded at each end. These rods are firmly secured to the base 92 by nuts 95, and their upper ends carry a top plate 96 secured in position by pairs of nuts 97. The top plate has a rectangular opening which is adapted to receive die strips 98, bolted or otherwise secured thereto. The base member 92 is provided with an upstanding cylinder 99 at the center, in which a piston 5 and plunger 7 are adapted to reciprocate. The plunger 7 has a turned-down shoulder 100 at the top, and this shoulder portion carries the usual platen 8 and the punch 9.

Surrounding the shouldered portion and rigidly secured thereto there is a hub 101, from which radiate, at equi-distant positions, four wing-shaped members 102 which take the general form of an S-configuration, and are constituted of flat pieces of metal terminating in a number of cylinders 103. These cylinders are bored, as indicated at 104, from the top and closed at the bottom. The bores 104 slidably receive pistons 105, which are threaded at the top into a rectangular gripping plate 106. Nuts 107 may be employed to assure rigid contact between the plungers and the plate. The plate 106 has a rectangular opening similar to the top plate 98, and the sides of the opening are adapted to detachably receive die strips 108 which may be secured as by bolts thereto.

These die strips are provided not only with inwardly projecting die surfaces, as in the case of the other embodiments, but also with an additional lip 109. These lips 109 contain openings which receive guide rods 110 which are firmly secured to the lips by nuts 111. The lower ends of the rods 110 move through openings which are provided in extensions 112 formed on the wing members 102. The rods at the bottom may carry nuts 113. The arrangement is such that the wing members 102 are adapted to slide upwardly over the rods 110, the nuts 113 assisting in determining the lower limit of travel of the wing elements.

The hydraulic system includes the pump 27, the oil tank 31, the four-way valve 33 and the high pressure line 32 and the low pressure line 30, as in the previous embodiments. There is a pipe 114 extending from the upper surface of the valve 33 to the lower end of the cylinder 99.

A length of pipe 115 connects the space to the rear of the piston 5 with the upper surface of the valve 33. There is a fluid inlet opening 116 at the lowermost portion of each clamping cylinder 103, and this opening is connected to the high pressure side of the pump through a flexible pipe 117 and a check valve 118. It will be noted that this valve is so arranged as to permit fluid to pass inwardly toward the bore 104 of the clamping cylinders. It will be understood that communication is made between the high pressure side of the pump and the lower portions

of all of the clamping cylinders through their respective check valves 118. A flexible pipe 119 is taken from the low pressure side of the pump or the oil tank 31, through an adjustable pressure relief valve 120 and a short length of pipe 121, to the opening 116. This valve may be conveniently secured to the upper portion of the cylinder in order to facilitate adjustment. As in the case of the previous embodiments, there is a choke valve 122 positioned in the low pressure line 36 leading from the valve 33.

The parts in Figures 5 and 6 are shown at the instant that the main piston 5 has reached its lower limit of travel, and it is assumed that the finished article formed by the previous pressing operation has been removed from the machine. A fresh metal sheet 11 is placed in position within the space between the die strips 25 and 108. The operator then causes the rod 39 of the four-way valve to be moved to the left, causing high pressure fluid to be introduced into the pipe 114. As the pressure below the main piston increases, the plunger 7 will rise and will carry the wing members 102 upwardly together with the clamping cylinders 103. These cylinders have been previously filled with fluid through the conduit 117 and the check valves 118. Consequently, as the cylinders move with respect to the plungers 105 the fluid within the bores 104 is immediately placed under pressure, causing the plungers to move upwardly and to press the gripping plate 106 against the work 11, thus holding the metal sheet firmly between the plates 98 and 106. Continued upward movement of the plunger causes the plungers 105 to be pressed upwardly with greater force, thereby increasing the clamping effect at the metal sheet.

In the event that this pressure becomes excessive, surplus fluid in the bores 104 is permitted to pass from the inlets 116 into the vertical pipes 121 where they operate the relief valves 120, and this fluid is then permitted to return to the tank through the conduits 119. The clamping effect at the plates 106 and 98 is entirely completed at the time the plunger 7 is moved to such a height as to cause the punch 9 to contact with the metal sheet. Continued movement of the punch will cause the required deformation of the metal sheet, in accordance with the shape and size of the opening between the upper die strips 25 and as also determined by the shape of the punch. It is apparent that during the upward movement of the plunger 7 the wings 102 slide upwardly over the guide rods 110. The fluid which is entrapped at the rear side of the piston 5 finds ready access to the low pressure side of the pump or a tank through the pipes 115 and 30. When the punch has reached its upper limit of travel, as determined by the operator or in any other suitable manner, the rod 39 is moved to the right, which is the position shown in Figure 6. Under these conditions high pressure fluid passes from the pipe 32 to the pipe 115 which leads to the rear side of the piston 5. At the same time the space in front of the piston is in communication with the tank through the pipes 114, 36, the choke valve 122 and the pipe 30. The choke valve 122 is for the purpose of limiting the rate at which the fluid is exhausted from the front side of the main piston during the downward movement of that piston.

As the plunger 7 moves downwardly, due to the pressure fluid passing through the pipe 115, it carries with it the punch 9 and the wings 102. The cylinders 103 carried by the wings also move downwardly, which tends to reduce the pressure of the fluid in the bores 104. However, it will be noted that these bores are always in communication with the high pressure side of the pump through the flexible pipes 117, and further that the only way the fluid can escape is through the relief valves 120 which are set to operate only above a predetermined pressure. Consequently, while the pressure is reduced to some extent by the movement downwardly of the cylinders 103, nevertheless there is sufficient pressure still exercised on the plungers 105 to maintain sufficient clamping effect between the plates 98 and 106 when the punch 9 breaks contact with the formed metal article. As the plunger 7 continues its downward movement the cylinders 103 travel downwardly a corresponding distance, which eventually will reduce the pressure of the contained fluid to such a value as to permit the plate 106 to descend of its own weight. Such a condition is under the direct control of the adjustments accorded the relief valves 120, and preferably takes place only after the punch 9 has moved an appreciable distance away from the work.

Thus it is evident that clamping pressure is assured at a time prior to when the punch 9 contacts the metal sheet during the working stroke and is also maintained for a sufficient length of time after the punch starts to descend. It is further apparent that the time relation between these clamping effects and the movement of the punch can be accurately correlated and adjusted by proper control of the pressure relief valves 120. The adjustment of these valves also affects the intensity of the clamping force so that any degree of gripping action may be obtained in order to permit slippage between the metal sheet and the clamping plates, or firmly to hold the sheet without any slippage whatsoever. It is further evident that by the use of the individual relief valves 120 for each clamping cylinder, any special and local clamping effect can be obtained, for example, by adjusting one or more of these valves to be actuated at a different relief pressure than the remaining valves.

It will be understood that we desire to comprehend within our invention such modifications as come within the scope of the claims and the invention.

Having thus fully described our invention, what we claim as new and desire to secure by Letters Patent, is:

1. A hydraulic press comprising main and work-clamping cylinders, pistons in said cylinders, a punch carried by the piston in the main cylinder and a clamping plate carried by the piston in the work-clamping cylinder, a metal sheet resting on the press and held in position by said clamping plate, said punch serving to press the metal sheet into a desired shape, means comprising a single source of pressure fluid and a control valve for operating the pistons in timed relation during the working and retracting strokes, and means for preventing contact between the punch and the metal sheet until the piston in the clamping cylinder and the clamping plate carried thereby have moved into clamping position, said means including a direct fluid connection between the back pressure space of the main cylinder and the working pressure space of the clamping cylinders.

2. A hydraulic press comprising a pair of parallelly disposed plates adapted to receive and

clamp the edges of a metal sheet therebetween, said plates having openings in alignment, a cylinder under the aligned openings and containing a piston, a punch carried by the piston and adapted to press the unclamped portion of the metal sheet through said openings, means for changing the size and configuration of said openings whereby the shape and size of the formed metal article are changed, said means comprising strips of metal of predetermined size and shape detachably secured to the sides of said openings, a source of pressure fluid for operating said piston, and means including fluid obtained directly from the back pressure space of said cylinder for applying clamping pressure to said plates.

3. A hydraulic press comprising a pair of parallelly disposed plates adapted to receive and clamp the edges of a metal sheet therebetween, said plates having openings in alignment, a main cylinder in line with said openings and containing a piston, a punch carried by said piston and adapted to press the unclamped portion of the metal sheet through said openings to form an article, a plurality of auxiliary cylinders symmetrically disposed about said plates and on the same side of the metal sheet as the main cylinder, said auxiliary cylinders containing plungers secured at one end to one of the clamping plates and at the other end to pistons which reciprocate in the auxiliary cylinders, the plungers in the auxiliary cylinders being adapted to move only in a direction opposite the direction in which the piston in the main cylinder moves, and means including a source of hydraulic energy for forcing the main piston in the direction of said metal sheet for forming the article, said means also serving to move the pistons in the auxiliary cylinders away from the sheet to cause said plates to grip the sheet during the forming operation.

4. A hydraulic press comprising a pair of parallelly disposed plates adapted to receive and clamp the edges of a metal sheet therebetween, said plates having openings in alignment, a main cylinder in line with said openings and containing a piston, a punch carried by said piston and adapted to press the unclamped portion of the metal sheet through said openings to form an article, a plurality of auxiliary cylinders symmetrically disposed about said plates and on the same side of the metal sheet as the main cylinder, said auxiliary cylinders containing plungers secured at one end to one of the clamping plates and at the other end to pistons which reciprocate in the auxiliary cylinders, the plungers in the auxiliary cylinders being adapted to move only in a direction opposite the direction in which the piston in the main cylinder moves, means including a source of hydraulic energy for forcing the main piston in the direction of said metal sheet for forming the article, said means also serving to move the pistons in the auxiliary cylinders away from the sheet to cause said plates to grip the sheet during the forming operation, and means for reversing the movement of the pistons in the main and auxiliary cylinders to cause the punch to leave the formed article and thereafter to cause the clamping plates to be moved with respect to one another to permit the formed article to be removed from the press.

5. A hydraulic press comprising main and auxiliary cylinders, said cylinders containing pistons all actuated by a common source of pressure fluid, the auxiliary piston being secured to a plate which serves to clamp a metal sheet to the press, the main cylinder piston carrying a punch which serves to press the metal sheet into an article of predetermined shape, the pistons in said auxiliary cylinders being adapted to move only in a direction opposite the direction in which the piston in the main cylinder moves, means for applying the fluid to said cylinders such that the metal sheet is clamped against the press before the punch contacts with the sheet, and means for reversing the stroke of all of said pistons whereby the punch is retracted from the formed article and thereafter the article is released from the press.

6. A hydraulic press comprising main and work-clamping cylinders, pistons in said cylinders, means including fluid conduits between said cylinders for causing the actuation of the piston in the work-clamping cylinder when the back pressure on the piston in the main cylinder reaches a predetermined value, and means for maintaining working pressure in the clamping cylinders for a definite amount of time after the back pressure in the main cylinder has been relieved.

7. A hydraulic press comprising main and work-clamping cylinders, pistons in said cylinders, means including fluid conduits between said cylinders for causing the actuation of the piston in the work-clamping cylinder when the back pressure on the piston in the main cylinder reaches a predetermined value, means for maintaining working pressure in the clamping cylinders for a definite amount of time after the back pressure in the main cylinder has been relieved, and a control valve for relieving the working pressure in the clamping cylinders to withdraw the clamping effects from the workpiece.

8. A hydraulic press comprising a main pressing cylinder and an auxiliary clamping cylinder, a piston in each of said cylinders, a punch carried by the main piston for forming a metal sheet into a desired shape, a clamping plate carried by the clamping piston for holding the sheet in position during the forming process, a source of pressure fluid and a cotrol valve therefor, said valve being provided with high pressure and low pressure openings which communicate with said source, a piston in said valve, said valve also being provided with a pair of openings A, B which are adapted to be an ingress and egress respectively for the fluid in an alternate manner dependent on the position of the piston within said valve, a conduit extending from opening A to the working side of the main piston, a conduit C extending from opening B to the rear side of the clamping piston, a conduit D extending between the rear side of the main piston to the working side of the clamping piston, a conduit E extending between the working side of the clamping piston and the conduit C, a conduit F extending from the clamping cylinder to the low pressure side of the source of fluid, and means positioned in the conduit E for assuring a predetermined pressure of the fluid on the working side of the clamping pistons before the pressure of the fluid in the main cylinder is sufficient to cause the punch to contact the metal sheet.

9. A hydraulic press comprising a main pressing cylinder and an auxiliary clamping cylinder, a piston in each of said cylinders, a punch carried by the main piston for forming a metal sheet into a desired shape, a clamping plate

carried by the clamping piston for holding the sheet in position during the forming process, a source of pressure fluid and a control valve therefor, said valve being provided with high pressure and low pressure openings which communicate with said source, a piston in said valve, said valve also being provided with a pair of openings A, B which are adapted to be an ingress and egress respectively for the fluid in an alternate manner dependent on the position of the piston within said valve, a conduit extending from opening A to the working side of the main piston, a conduit C extending from opening B to the rear side of the clamping piston, a conduit D extending between the rear side of the main piston to the working side of the clamping piston, a conduit E extending between the working side of the clamping piston and the conduit C, a conduit F extending from the clamping cylinder to the low pressure side of the source of fluid, and means positioned in the conduit E for assuring a predetermined pressure of the fluid on the working side of the clamping pistons before the pressure of the fluid in the main cylinder is sufficient to cause the punch to contact the metal sheet, said means comprising an admission valve adjusted to open the passageway through conduit E when the working pressure on the clamping piston has reached a predetermined pressure whereby the clamping pressure is limited to said predetermined pressure.

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