

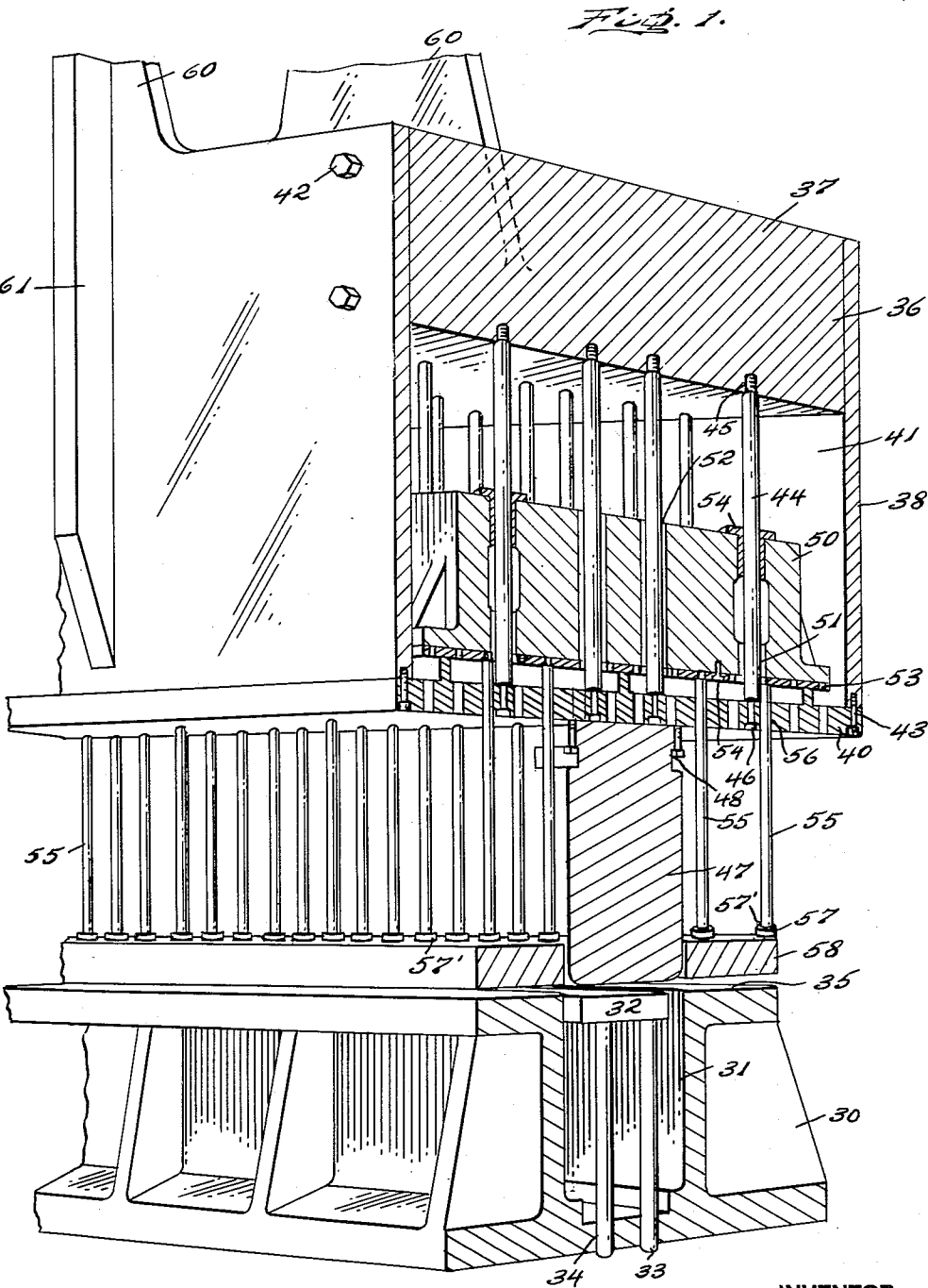
May 15, 1956

B. JAPIKSE
HYDRAULIC PRESS

2,745,366

Filed June 10, 1952

13 Sheets-Sheet 1



INVENTOR
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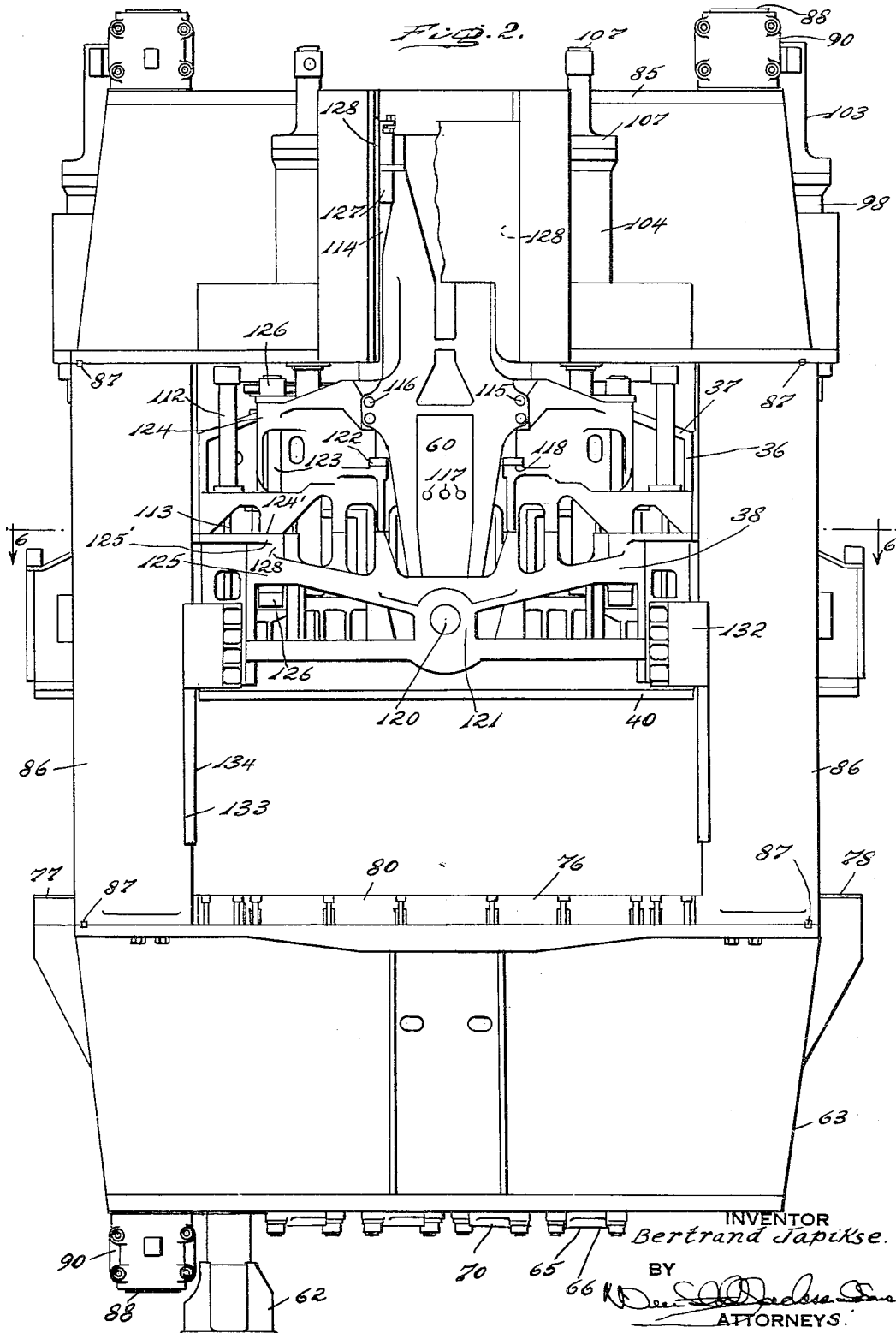
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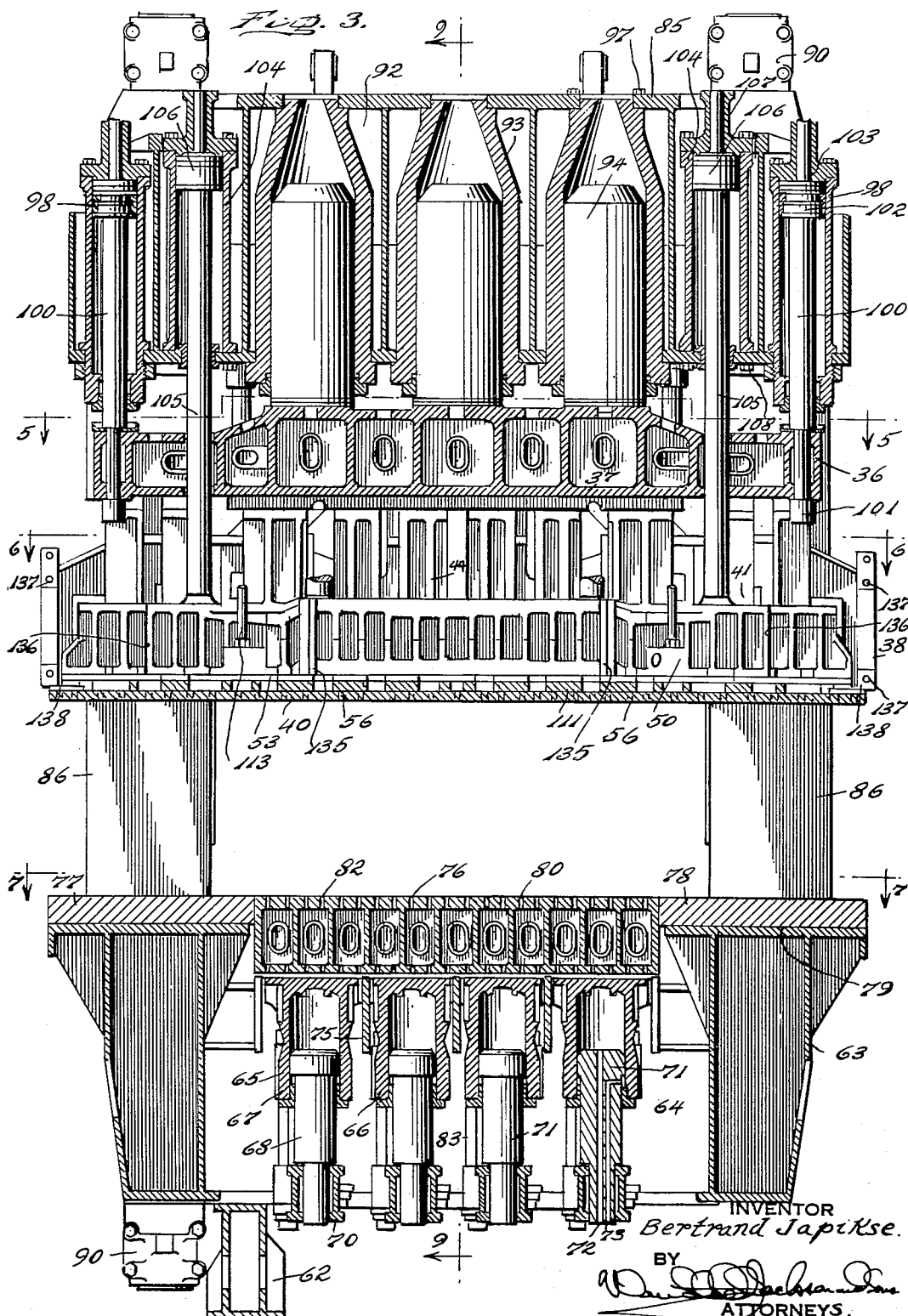
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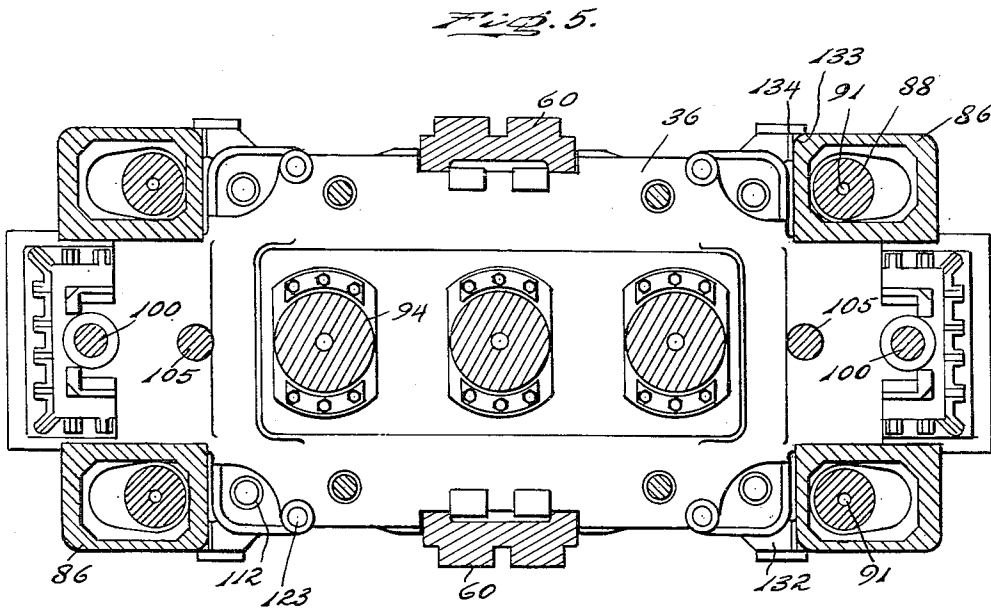
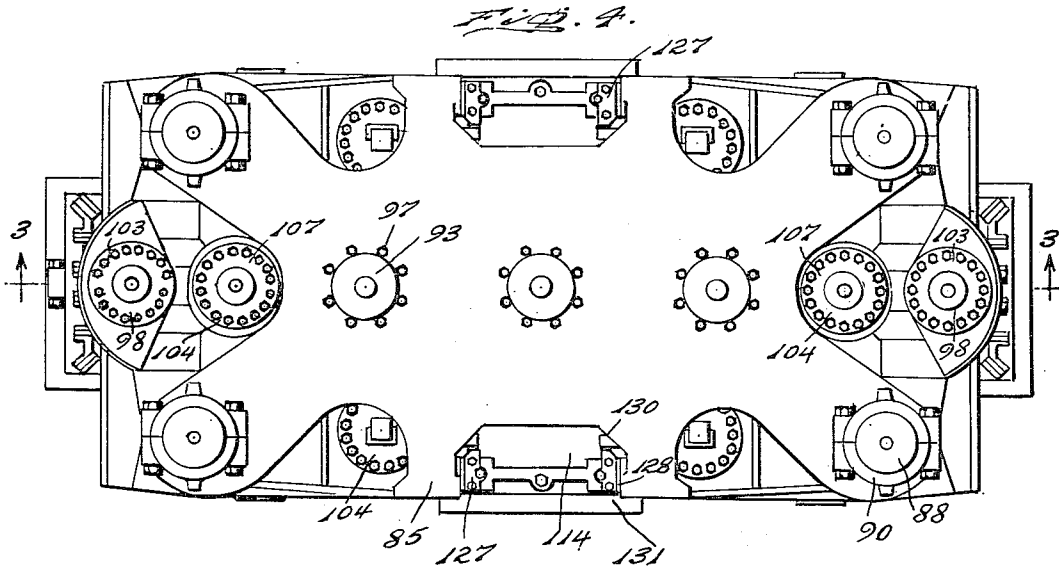
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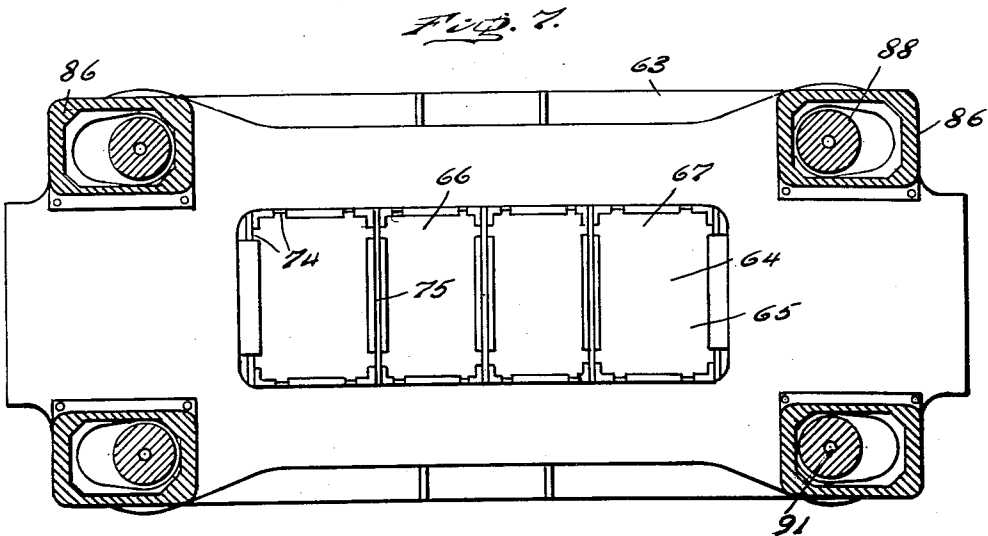
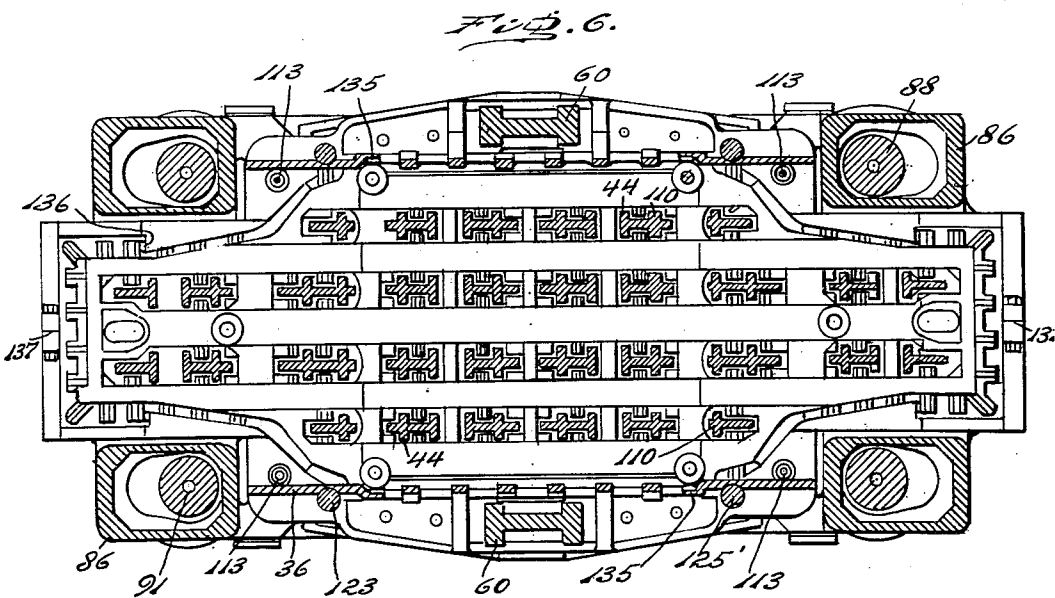
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Filed June 10, 1952

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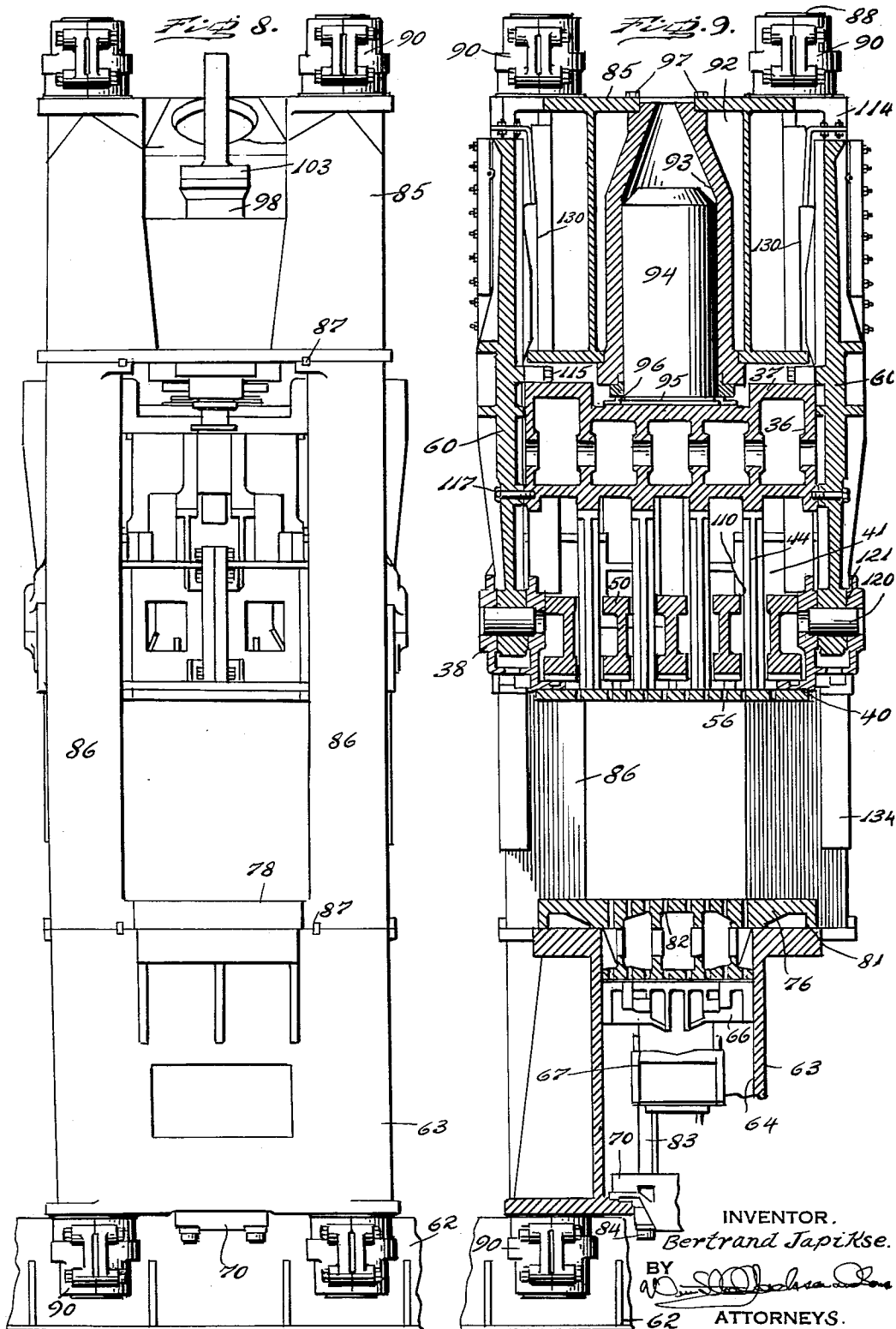
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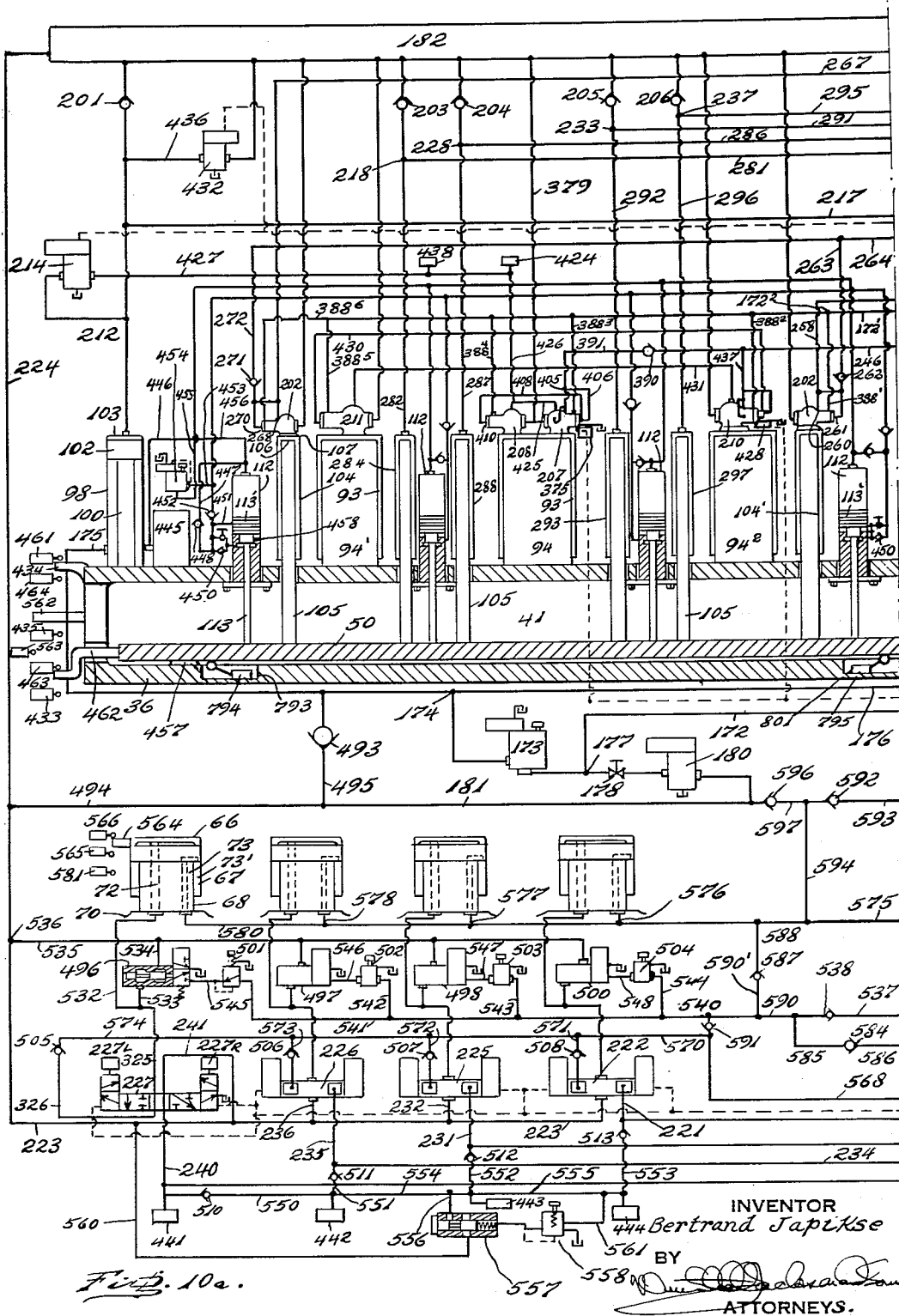
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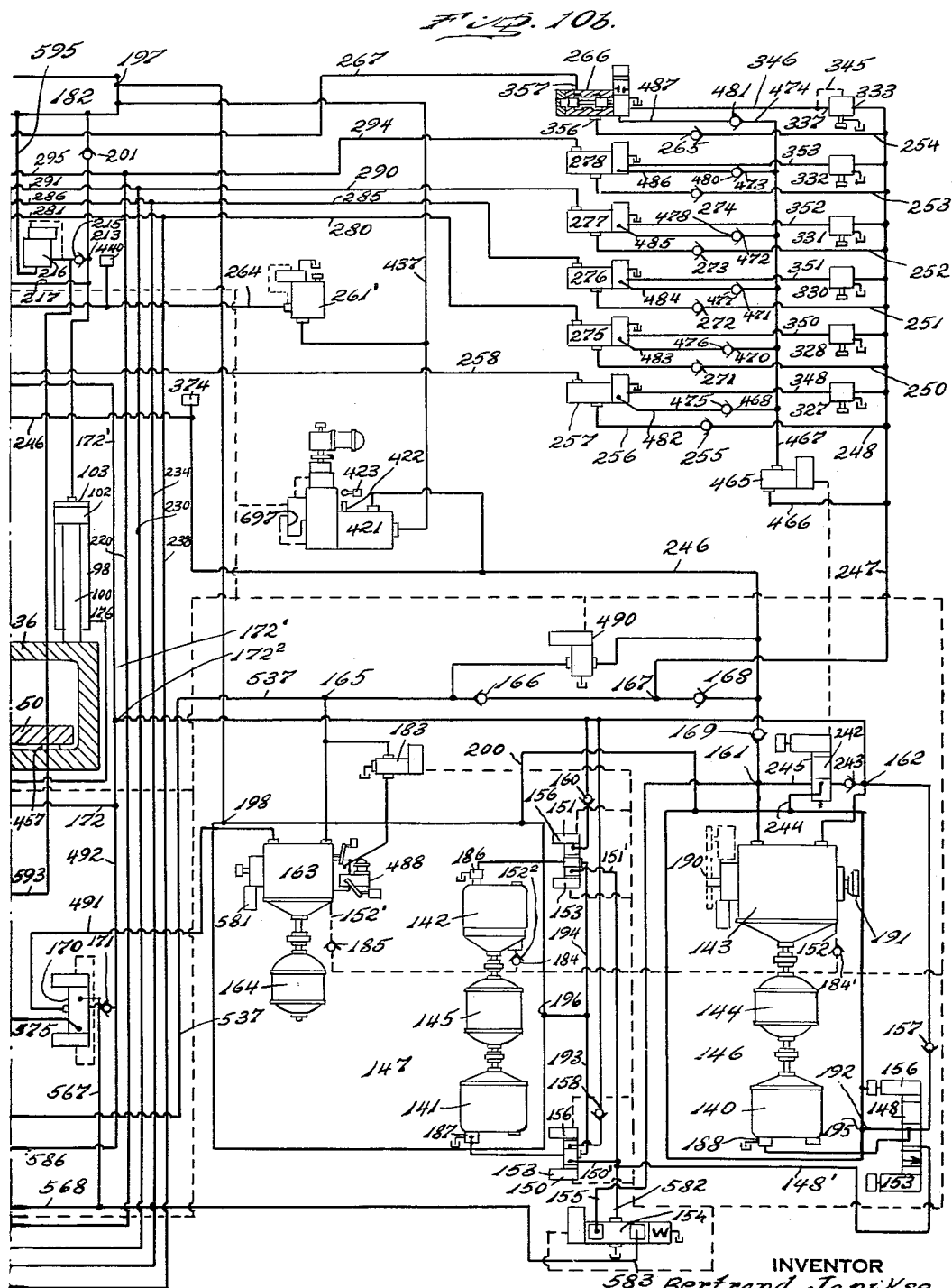
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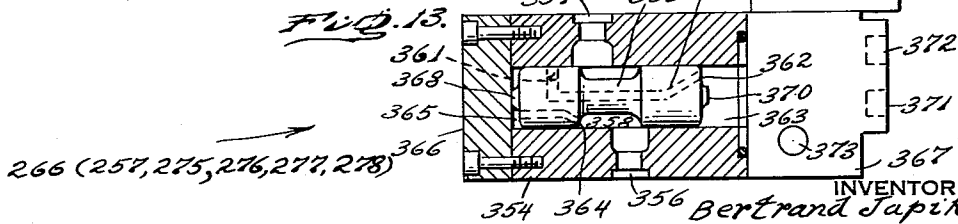
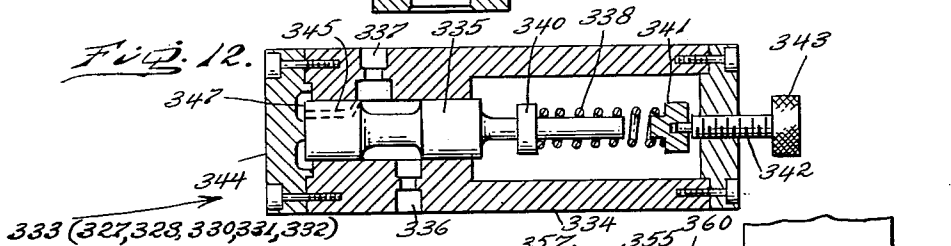
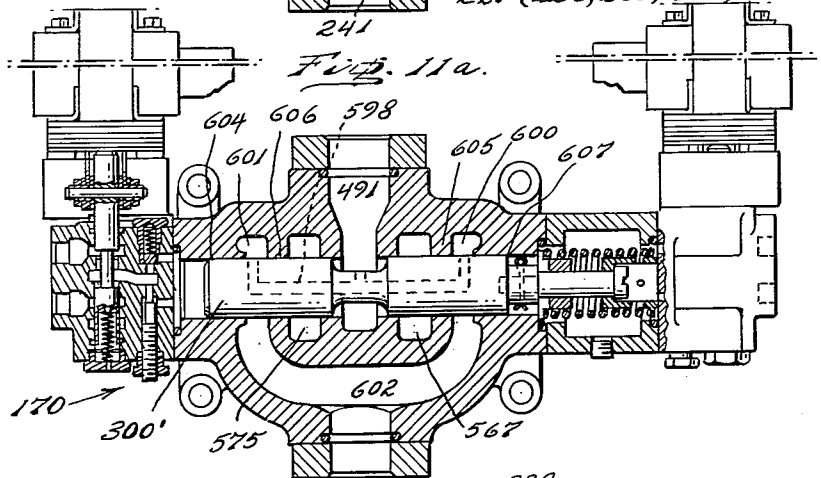
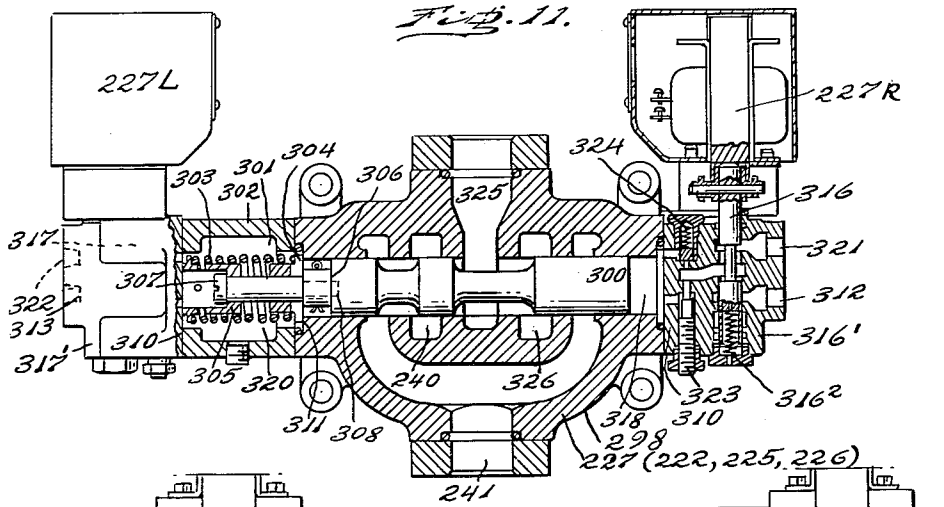
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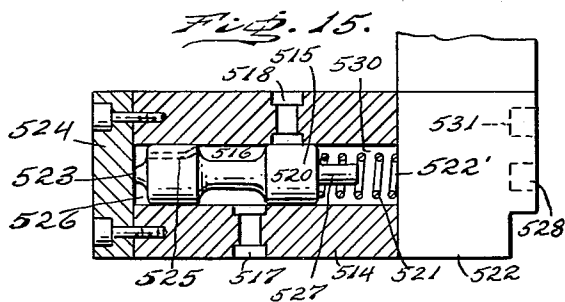
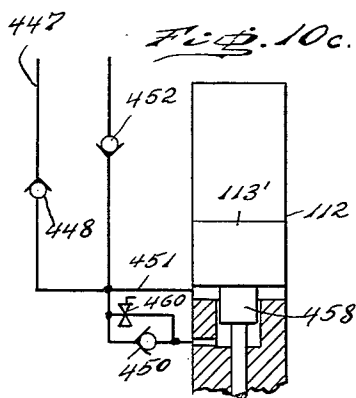
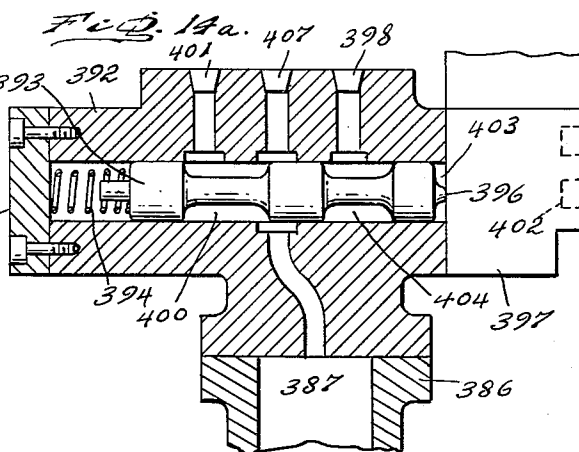
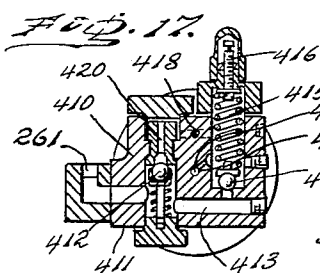
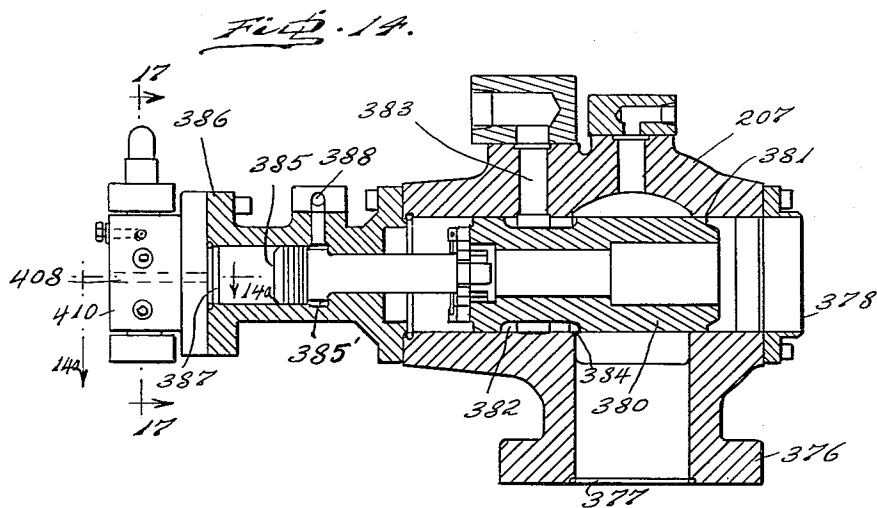
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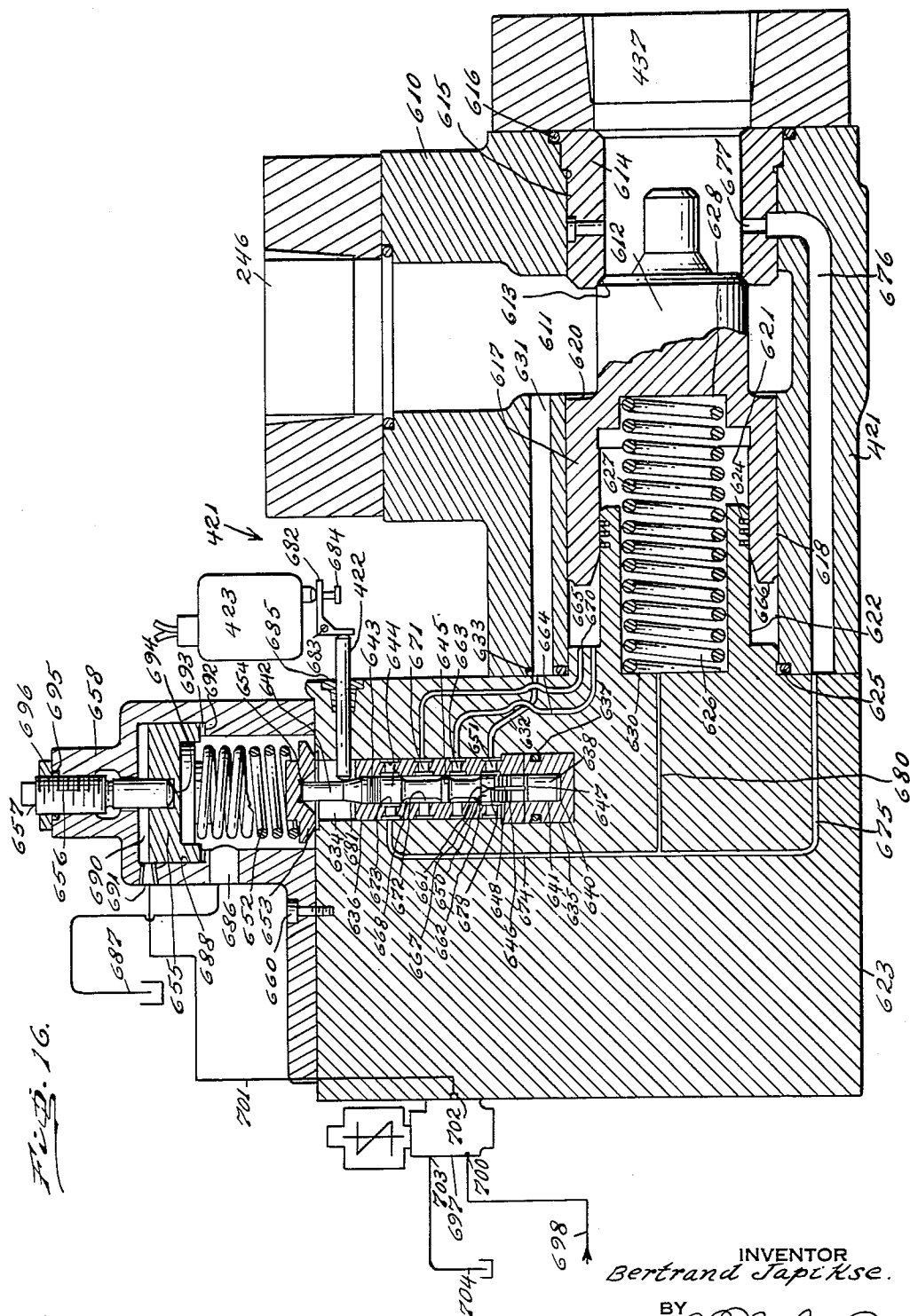
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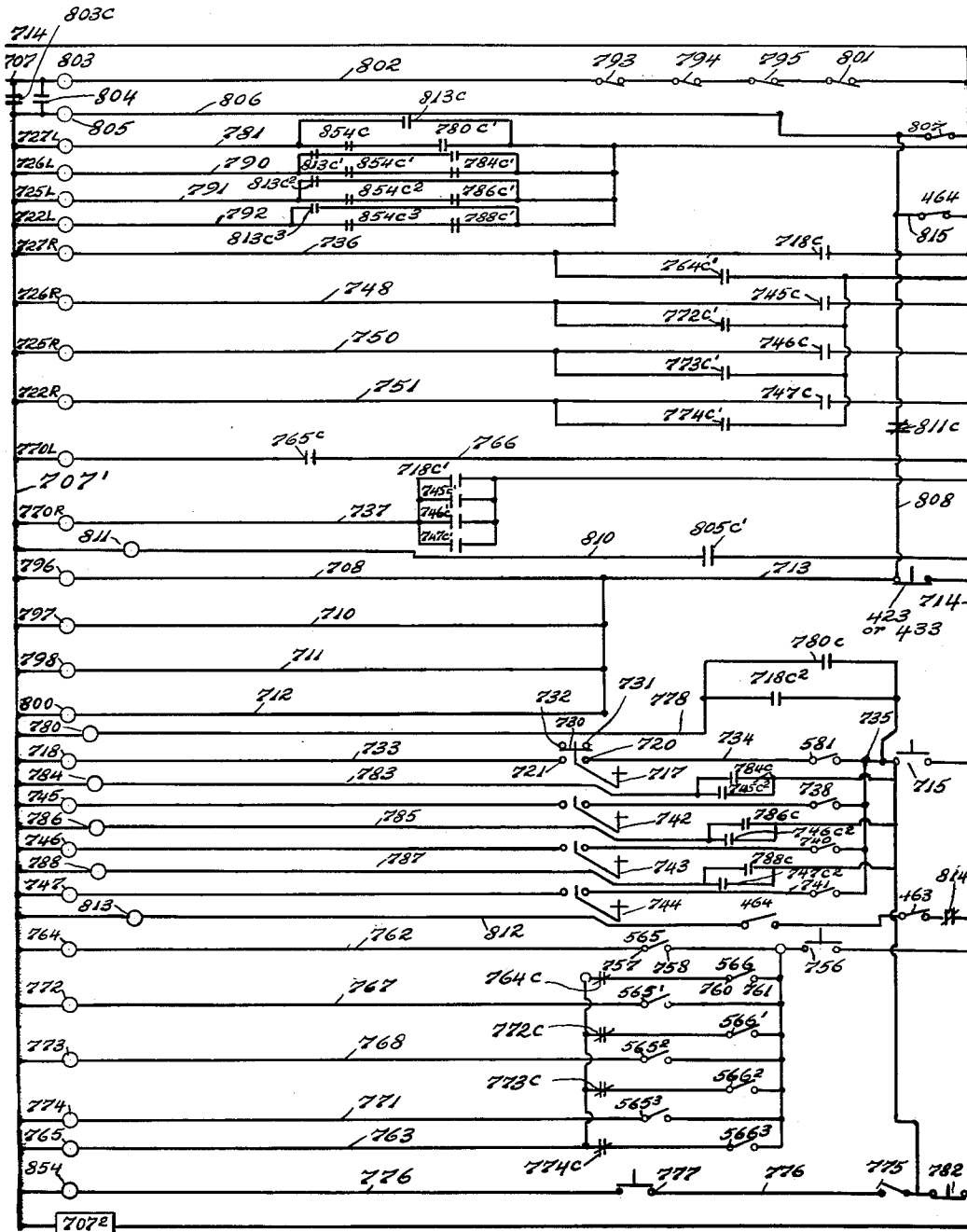
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Fig. 18.



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Fig. 19.

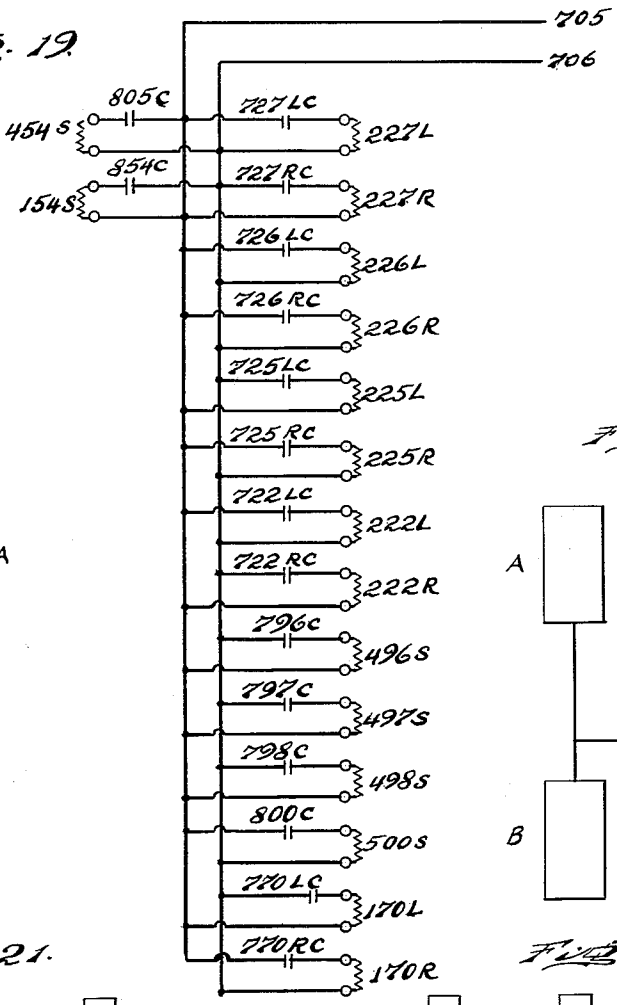


Fig. 20.

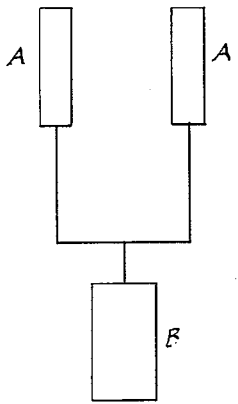


Fig. 22.

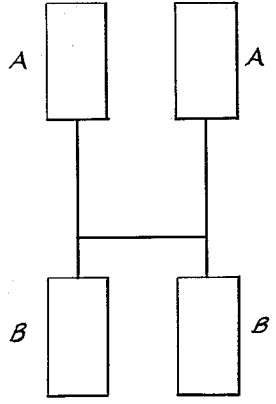


Fig. 21.

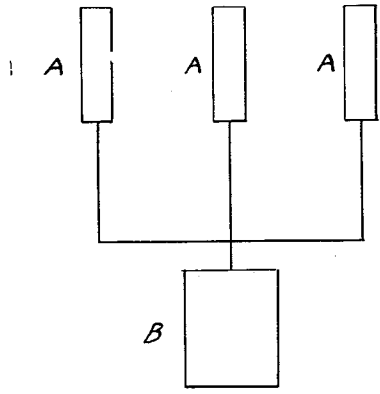
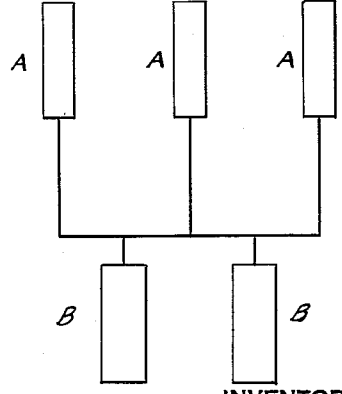


Fig. 23.



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HYDRAULIC PRESS

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Application June 10, 1952, Serial No. 292,645

17 Claims. (Cl. 113—45)

The present invention relates to hydraulic presses, and particularly to metal working presses such as drawing presses.

A purpose of the invention is to permit the use of a relatively light bolster plate on the main slide while providing adequate support, by making the main slide of hollow construction, suitably comprising a relatively heavy body, a relatively light bolster plate in spaced relation to the body and bolster-supporting posts connected to the body and to the bolster plate and distributed over the bolster plate. This construction permits location of the blank holder slide relatively close to the work, and shortens the members transmitting the load from the blank holder slide to the blank holder.

A further purpose is to make the main slide of box construction with an open interior, having posts, interconnecting a relatively heavy body and a relatively light bolster plate, and with sides and ends also interconnecting the body and the bolster plate.

A further purpose is to provide a blank holder slide in the space between the body and the bolster plate of the main slide, moving the blank holder slide with respect to the bolster plate, and where desired guiding the blank holder slide on certain of the posts which support the bolster plate from the body.

A further purpose is to extend relatively stiff stalks from the main slide in the direction of the crown, to guide the stalks both in the longitudinal and transverse horizontal directions on the crown, and to guide the main slide on housings extending between the crown and the base or bed of the press, so as to prevent distortion of the housings and the main slide and provide an inverted T-shaped guide for the main slide.

A further purpose is to employ one or more stalks extending outwardly (upwardly) from the main slide and guiding on the crown, with auxiliary guides of the main slide on the housings, in combination with a hollow main slide having a blank holder slide in the interior of the main slide and with posts supporting the bolster plate from the body of the main slide.

A further purpose is to construct the main slide from a body and separate front and back members, with interconnections between the body and the front and back members near the ends of the front and back members and a stalk or stalks extending toward the crown and secured at one end to a front or back member and at intermediate points to the body, the slide being guided by guiding the stalk or stalks and also by guiding the slide itself on the housings.

A further purpose is to provide cooperating openings between the body and the front and back members of the main slide and to interconnect by tension rods extending through the openings.

A further purpose is to locate a clevis in each of the front and back members and to engage the lower end of the stalk in the clevis by a pin.

A further purpose is to provide pads on the side of the bolster plate adjoining the blank holder slide which dis-

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tribute pressure between the bolster plate and the blank holder slide when the two come together.

A further purpose is to employ an auxiliary blank holder cylinder and ram, or a plurality of the same, acting between the main slide and the blank holder slide in order to absorb the shock when the main slide and blank holder slide move relatively toward one another into engagement.

A further purpose is to restrict the flow of hydraulic liquid from the auxiliary cylinder or cylinders to obtain a cushion effect.

A further purpose is to cut off flow of hydraulic fluid from the auxiliary cylinder or cylinders by a valve or valves to make the blank holder slide retreat with the main slide in spaced relation thereto.

A further purpose is to trap hydraulic liquid in the blank holder cylinder or cylinders to stall upward movement of the blank holder slide and force the draw slide or main slide upward with respect to the stalled blank holder slide.

A further purpose is to release the stalling pressure in the auxiliary blank holder cylinders when chokes at the ends of the strokes have engaged for damping the possible dropping of the blank holder slide and then permitting final complete lifting of the blank holder slide together with the draw slide, as for stripping.

A further purpose is to employ a double acting pull back cylinder and ram on the main slide, with valve means controlling escape of hydraulic liquid from the pull back cylinder on the side from which the liquid is displaced when the main slide advances forward, with an automatic control put in action by the main slide for closing the valve means as the main slide advances toward the work, and desirably to utilize this application with a blank holder slide movable in the hollow of the main slide and at a proper time moving with the main slide.

A further purpose is to employ several blank holder cylinders and to interpose separate valves between the pump means and the blank holder cylinders, the valves being responsive in opening to drop in pressure in any individual blank holder cylinder to a level below that predetermined for that blank holder cylinder and in closing responsive to attainment of the predetermined pressure in an individual blank holder cylinder, the predetermined levels of pressure being different for the different blank holder cylinders.

A further purpose is to supplement the forward pressure of the main ram or rams by forward pressure exerted in double acting pull back cylinders.

A further purpose is to connect the main cylinders and the forward acting ends of the pull back cylinders to the pump means in succession, desirably locking the pressure in the pull back cylinders until the pressure in a succeeding main cylinder builds up to a predetermined value, and then desirably releasing the pressure in the pull back cylinders.

A further purpose is to employ auxiliary blank holder cylinders and rams operating between the main slide and the blank holder slide to act as supporting columns to additionally support the blank holder slide at a plurality of points.

A further purpose is to energize the auxiliary blank holder cylinders to push the blank holder slide toward the work as the main slide is withdrawn by the pull back cylinders.

A further purpose is to provide a throttled valve in connection with each auxiliary blank holder cylinder closed by relative approach of the main slide to the blank holder slide and throttle escape of hydraulic liquid from the auxiliary blank holder cylinders, the throttled valve preferably being of needle valve and orifice type.

A further purpose is to employ a relief valve upwardly connected to the blank holder cylinder when the main slide moves toward contact with the blank holder slide, so that the main slide can retract the blank holder slide.

A further purpose is to supply pressure to the cushion cylinders through a pressure control valve having a setting individual to each cushion, so as to permit the cushions to maintain different pressures.

A further purpose is to make up a closed hydraulic circuit between one or more of the cushioned cylinders and one or more of the blank holder cylinders, desirably using cylinders in which the effective ram area at the cushion end of the closed circuit, equals the effective ram area at the blank holder cylinder end.

A further purpose is to interconnect one group of less than all of the blank holder cylinders (desirably one) at the end of which hydraulic liquid is displaced on movement toward the work to one group of less than all of the cushion cylinders (desirably one) at the end which causes movement away from the work into a closed circuit, and interconnect another group of less than all the blank holder cylinders (desirably one) at the end of which hydraulic liquid is displaced on movement toward the work to another group of less than all of the cushion cylinders (desirably one) at the end which causes movement away from the work, the effective ram areas of blank holder cylinders and cushion cylinders in each closed circuit desirably being the same.

A further purpose is to interconnect one group of less than all the blank holder cylinders (desirably one) at the end at which hydraulic liquid is displaced on movement away from the work to one group of less than all of the cushion cylinders (desirably one) at the end which causes movement toward the work into a closed circuit, and to interconnect another group of less than all the blank holder cylinders (desirably one) at the end at which hydraulic liquid is displaced on movement away from the work to another group of less than all the cushion cylinders (desirably one) at the end which causes movement toward the work into a closed circuit, desirably having the same effective ram areas on the cushion cylinders and blank holder cylinders in each closed circuit.

A further purpose is to employ one cushion cylinder and one blank holder cylinder in each of the above groups.

A further purpose is to guide the main slide in T formation, to mount the blank holder slide in the hollow of the main slide and in certain positions move the blank holder slide while it is in contact with the main slide, and to interconnect the respective blank holder cylinders and cushion cylinders in closed circuits so as to assure that the cushions will maintain the proper relation to the main slide and the blank holder slide.

A further purpose is to use the displacement of the rapidly lowering blank holder rams to measure the outward displacement of the cushion cylinders.

A further purpose is to use the displacement of the blank holder rams while lifting to control the locations of the lifting stroke of the cushions and produce the lifting for stripping action of the cushions.

A further purpose in triple action is to use the measuring feature for rapidly lowering the cushions in preparation for the upward draw stroke.

A further purpose is to provide the cushions with an outwardly acting pressing area independently of the cushion resistance area.

A further purpose is to make the cushions double acting and to use both cushion areas when the cushions move down.

A further purpose is to decompress the hydraulic liquid in the cushions at the time that the main cylinder liquid is decompressed and before raising the main cylinder ram to avoid the tendency of the cushion to creep due to the compressibility of the hydraulic liquid.

A further purpose is to place safety switches in a safety

shut-off circuit and to make the switches act between the blank holder slide and the main slide so as to prevent operation of the press in case the parallelism of the blank holder slide and main slide is destroyed by distortion.

A further purpose is to obtain adequate protection against distortion of the various slides and related structure in very large hydraulic presses.

Further purposes appear in the specification and in the claims.

In the drawings I have chosen to illustrate a few only of the numerous embodiments in which my invention may appear, selecting the forms shown from the standpoints of convenience in illustration, satisfactory operation and clear demonstration of the principles involved.

Figure 1 is a fragmentary diagrammatic perspective partly in vertical section from front to back, showing the novel construction of the main slide and blank holder slide and the tools employed in accordance with the present invention.

Figures 2 to 19 inclusive, illustrate a variation in the device of Figure 1, showing the preferred embodiment.

Figure 2 is a front elevation of the preferred form, omitting structure in the lower right hand corner at the bottom of one of the tension rods. A portion of the front of the press is broken away to show the guiding of one of the stalks.

Figure 3 is a central vertical section of the press of Figure 2, omitting the structure in the lower right hand corner, the section being taken on the line 3—3 of Figure 4. The piping to the cushion rams has also been omitted.

Figure 4 is a top plan view of the device of Figure 2.

Figure 5 is a plan section on the line 5—5 of Figure 3.

Figure 6 is a plan section on the line 6—6 of Figure 3.

Figure 7 is a plan section on the line 7—7 of Figure 3, but having the bottom bolster removed.

Figure 8 is a side elevation of the press of the invention, omitting a portion of the supporting structure under the bed.

Figure 9 is a vertical section on the line 9—9 of Figure 3, omitting structure in the lower right hand corner.

Figures 10^a and 10^b are portions of a single diagrammatic view showing the hydraulic system employed in the preferred embodiment, Figure 10^a showing the left hand part and Figure 10^b showing the right hand part.

Figure 10^c is an enlarged fragment of Figure 10^a.

Figure 11 is a diagrammatic central longitudinal section of valve 277, with one of the solenoids and one of the pilot valves shown in elevation.

Figure 11^a is a diagrammatic central section of valve 170 with the solenoids and one pilot valve shown in elevation.

Figure 12 is a diagrammatic longitudinal section of valve 333.

Figure 13 is a diagrammatic central longitudinal section of valve 266 with the pilot valve shown in elevation and the solenoid partially omitted.

Figure 14 is a diagrammatic central section of valve 207 with the structure at one end shown in elevation.

Figure 14^a is an enlarged diagrammatic central section of a variant form of control mechanism for the valve of Figure 14. The view is turned 90° in placement on the sheet.

Figure 15 is a diagrammatic central longitudinal section partly in side elevation of the valve 514.

Figure 16 is a diagrammatic central longitudinal section of valve 421.

Figure 17 is a section on the line 17—17 of Figure 14.

Figures 18 and 19 are circuit diagrams useful in explaining the invention.

Figures 20 to 23 are block diagrams showing closed hydraulic circuit connections between various groupings of blank holder cylinders and cushion cylinders.

In the drawings like numerals refer to like parts throughout.

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Describing in illustration but not in limitation and referring to the drawings:

The hydraulic medium is generally referred to herein as hydraulic liquid, although it is sometimes designated as hydraulic fluid with similar meaning.

The need has existed particularly in the aircraft industry for metal forming presses such as deep drawing presses of larger load capacities than those heretofore generally available for such purposes. In many of these applications it is also desirable to have a very large press area. These requirements greatly increase the danger of distortion in normal press operation and especially in off-center loading.

The present invention is designed primarily for deep drawing presses, but many of the principles involved are applicable to presses intended for other purposes. The preferred embodiment is being successfully applied to a press of 8000 tons capacity, effecting great savings in weight and space of operating parts over those which would be required with older designs.

In accordance with the invention, the main slide, often referred to as the draw slide, has been separated into a body of relatively heavy construction and a spaced bolster plate of relatively light construction and the two spaced parts have been interconnected by posts distributed over the area of the main slide. This provides space between the bolster plate and the body in which the blank holder slide can be located, and in fact in some cases advantage is taken of the posts to guide the blank holder slide. The box-like character of the main slide is completed by front and back and side members interconnecting the body and the bolster plate.

By the construction just described, it is possible to use comparatively short pressure pins to transmit the load from the blank holder slide to the blank holder, avoiding long pressure pins extending the full thickness of the main slide.

In order to guide the main slide, reliance is no longer placed upon guiding principally on tension rods or posts, which are likely to distort and cause distortion of cooperating parts of the stationary structure, and jam the slides. One or more relatively stiff stalks extend from the main slide, preferably at the front and back, and the main slide is guided by guides positioned on the lateral and also the longitudinal sides of the stalks at the crown, and also by auxiliary guides on the slide guiding on housings which extend between the crown and the base or bed. Thus the guiding of the main slide is of inverted T formation, giving ample protection against jamming of the main slide.

In some portions of the press cycle, the blank holder slide engages against pads on the side of the bolster plate remote from the work, and this assures uniform distribution of any forces acting between the main slide and the blank holder slide.

The main slide is desirably made up of a body and front and back members, which are joined together at the ends of the front and back members, suitably by tension rods extending through openings. The stalks desirably are connected at their ends to the front or back members and intermediate their ends to the body. The connection between the front and back members and the lower ends of the stalks is desirably accomplished by a clevis on the front or back member which is secured to the stalks by a pin extending through an opening in the stalk.

The tendency for impact to occur between the blank holder slide and the main slide is prevented by one or more auxiliary cylinders and rams acting between the blank holder slide and the main slide. Throttling devices in the auxiliary blank holder cylinders suitably become effective as the slides come close together.

In some phases of the operating cycles a valve is closed to cut off flow from each auxiliary cylinder so that the

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blank holder slide will retract with and in spaced relation to the main slide.

The pull back cylinders are desirably made double acting, and a very useful feature of the invention is the provision of valve means to control the escape of hydraulic liquid from the pull-back cylinders on the side from which liquid is displaced when the main slide advances, with an automatic control put in action by advance of the main slide for closing the valve means as the main slide advances toward the work.

The various blank holder cylinders are supplied with fluid pressure which is desirably set at a level individual for each blank holder cylinder. For this purpose valves are interposed between the pump means and each blank holder cylinder and each valve is responsive in opening to the drop in pressure in an individual blank holder cylinder to a level below that predetermined for that blank holder cylinder and in closing to attainment of the predetermined pressure in an individual blank holder cylinder, the predetermined levels of the pressure being different for the different blank holder cylinders.

In a very large press of the character under discussion, I find it very desirable to use the upper areas of the double acting pull-back cylinders to supplement the main pressing cylinders to give a maximum of main pressure where desired. The main pressure source is desirably connected in succession to the main cylinders and to the upper areas of the pull-back cylinders and preferably the pressure is locked in the pull-back cylinders until the pressure in a succeeding main cylinder builds up to a predetermined value and then the pressure in the pull-back cylinders may if desired be released.

For producing unusual parts, it is at times desirable to lock the hydraulic liquid in the auxiliary blank holder cylinders, according to the invention, so that the auxiliary blank holder cylinders will function as supporting columns for the blank holder slide.

In other sequences, when the main slide is being retracted, pressure may be applied to the blank holder cylinders, and release valves in the blank holder cylinders release liquid when the main slide in retraction forces the blank holder slide to retract. When, during this upward travel the main slide moves close to the blank holder slide a throttling device such as a needle valve, preferably, acts in the blank holder cylinder to provide a cushioning action.

In accordance with one aspect of the invention, the cushion cylinders are connected to the blank holder cylinders individually or in groups. The connection may be made from the end into which hydraulic liquid is displaced, on movement of the blank holder ram toward the work, to the cushion cylinder or cylinders, at the end which discharges liquid during movement away from the work for the purpose of controlling or measuring the downward displacement of the cushion cylinders during rapid lowering of the blank holder rams.

On the other hand the connection may be made from the blank holder cylinder or cylinders at the end from which hydraulic liquid is displaced on movement away from the work to the cushion cylinder or cylinders at the end which causes movement toward the work, so that the displacement of the blank holder rams while lifting will produce lifting and stripping by the cushion and will control or measure the lengths of the lifting strokes of the cushions.

In the preferred embodiment the blank holder ram area in each closed circuit will equal the cushion ram area, and in any case the two areas should have a predetermined relationship so that the movements of the blank holder slide and cushions will be interrelated as desired. Since an inverted T guide is provided for the main slide and since the blank holder slide in some portions of the stroke will often move with the main slide, the precision of this guiding is carried through the hydraulic intercon-

nection from the blank holder cylinders to the cushions.

In some cases the measuring feature is used for rapidly lowering the cushions in preparation for the upward draw stroke in triple action, thus assuring that the cushions start the upward draw stroke from the proper positions.

The cushions have a downward pressing area independently of their resisting area which is very useful. When the cushions move, in some cases both of the pressure areas of the cushions will act, one for resisting and the other for measuring the permitted movement.

Thus the cushions not only perform the functions of resisting, but also travel downward by pressure on their pull-back areas, travel upward by pump action in triple action and travel upward by delivering hydraulic liquid in measured quantities to the blank holder cylinders in the corresponding closed circuits for retracting and stripping.

In order to avoid creeping of the cushions, the liquid in the cushions is decompressed at substantially the same time as that in the main slide cylinders is decompressed.

The cushions will desirably have individual pressure settings and relief valves which function automatically when the cushion pressure rises above the predetermined level.

In order to guard against damage to the press in case of distortion as in grossly excessive off-center loading, switches are provided between the blank holder slide and the main slide which become effective on misalignment as to give a signal or render the press inoperative until the difficulty is corrected.

Detailed description

The general construction which may be employed in the present invention is illustrated generally in Figure 1, it being understood that Figure 1 shows certain desirable features with the elimination of mechanism which appears in the other form. Figure 1 is to be regarded as a diagrammatic showing, omitting the bed, the crown, the upright members, the hydraulic system and other structural parts of the press. It will be evident from the description that the principles there illustrated can be applied in a press without using the features of the hydraulic system later to be discussed.

As illustrated in Figure 1, a bottom die 30 rests upon the bed of the press (not shown), and includes a female die forming portion 31, and a cushion pressure plate member 32, which is supported from the cushion (not shown in Figure 1) by cushion pins 33 extending through openings 34 in the bottom die 30. The bottom die 30 has an upper clamping face 35 which cooperates with the clamping die, to be described later.

A main or draw slide 36 is preferably built up of composite elements, comprising a main body 37, side members 38 and a face plate or bolster 40. The face plate is spaced from the body to provide an inner recess 41, the whole being generally of box construction. Suitable interconnection of the side elements 38 with the body 37 is provided as by bolts 42, and the bolster is held in place on the side members by bolts 43.

It will be noted that the bolster 40 is of proportionately thin section, and the bolster is enabled to support the load due to widely distributed column supports provided by posts 44, which are interconnected as by threading at 45 into the draw slide main body 37, and are bolted at 46 to the bolster. It will be evident that the frequency of positioning of the posts in both directions may be varied to suit the requirements of load and other conditions.

The bolster supports any suitable tooling, in this case illustrated as a male die 47 suitably secured to the bottom of the bolster by bolts 48. It will be understood that the male die 47 cooperates with the female die portion 31 and that any of a wide variety of forms of dies will be used depending upon the character of work which is being

formed, or the character of pressing operation performed, in case the press is not used for forming.

A blank holder slide 50 operates in the recess 41 provided at the interior of the main slide 36. The blank holder slide in this form guides on the posts 44, and openings are provided through the blank holder slide into which fit guiding bushings 51 engaging and sliding on some of the posts 44. In those locations where guiding is unnecessary, clearance is provided at 52 between the blank holder slide openings and the posts, it being understood that guiding bushings can be employed on as many posts as desired.

On the lower face of the blank holder slide, wear plates 53 are provided, suitably bolted to the blank holder slide at 54. It will be understood that the question of whether the wear plates are in several separate components or a single piece will depend upon the design and the size of the press. The wear plates are of course optional in the sense that they merely protect the face of the blank holder slide.

The wear plates have tapped openings which receive the threaded upper ends of blank holder pressure pins 55 which extend downwardly through openings 56 in the bolster. At the lower ends the blank holder pressure pins 55 are interconnected by bolted collars 57 and screws 57' with a blank holder die 58 which cooperates with the clamping face 35 on the lower die. It will be understood that the arrangement and positioning of the blank holder pressure pins 55 will depend upon the configuration of the blank holder die, and therefore upon the tooling of the particular work, the practice being to distribute the blank holder pressure pins endlessly around the punch with a spacing adequate to sustain the pressure and adequately support the blank holder die.

Where the blank holder die is of substantial width, as in the form shown, it is desirable to use one or more rows of blank holder pressure pins outside of the row which immediately surrounds the punch.

It will be understood that the construction of the blank holder slide and die with the interconnecting blank holder pressure pins permits the use of a relatively thin section of blank holder die in a heavy press, so that you can perform a deeper draw operation within the daylight or working space limits of a particular press, since less of the working space is occupied by the blank holder dies, and the cost of the blank holder die is minimized.

It will be understood that the relatively thin bolster permits comparatively short blank holder slide pressure pins to be used, so that there is less danger of buckling the blank holder slide pressure pins. It will also be evident that the reduction of the thickness of the bolster represents an economy in manufacturing, and also reduces the cost of the side members 38, since they are only a portion of the supporting structure of the bolster, the balance of the loads being borne by the posts 44. It will also be evident that the side members are stressed essentially in compression only, since the bolster is no longer functioning as an arch as in prior practice.

The bolster will be provided with an overall distribution of blank holder pin holes, so that the bolster will conform to any desired tooling arrangement and therefore any desired location of the pressure pins.

The main or draw slide 36 in the form of Figure 1 is provided with stalks 60 at the front and back, which extend upwardly and toward their upper end (Figure 2) carry guides 127 which engage ways in the crown. It will be understood that the stalk may be formed of a single element or fabricated of components as desired. In Figure 1 each stalk has a vertically extending stiffening rib 61, protruding toward the front or back of the press.

While the stalks as shown are at the front and back of the draw slide, it will be understood that a single stalk, positioned for example in the center, may be used, or that any other desired arrangement of the stalks may

be employed, for example a plurality at the front and a plurality at the back.

Considering now the preferred embodiment of the invention as illustrated in Figures 2 to 9 inclusive, the press is mounted on bases 62 which support a bed 63 having a cushion opening 64 which contains a cushion 65 made up of four separate units 66. Each of the cushion units 66 comprises a cushion cylinder 67 cooperating with and engaging a cushion ram 68 which is upstanding from a yoke 70 anchored at opposite ends in the bed. The ram is of double acting construction as shown at the right in Figure 3, having a piston 71 and provided with bores 72 and 73 communicating respectively with the large and the auxiliary lowering areas of the piston.

As best seen in Figure 7, the upper portions of the individual cushion cylinders 67 have a rectangular configuration which engages guides 74 adjacent to the corners within the cushion opening 64 of the bed, and supported in some cases by separate plates or ribs 75 extending front to back across the cushion opening and forming an integral part of the bed.

The main or bottom bolster 76 is made in three sections, as best seen in Figure 3, the sections 77 and 78 at the sides resting directly on the front and back portions of the bed at 79.

The middle section 80 of the bolster is depressed at the center to provide additional depth of section as shown in Figure 9 and rests upon the front and back portions of the bed at 81. The middle bolster section has cushion pin openings 82 through both the top and bottom sections of the bolster which receive the cushion pins 33 as already described in connection with Figure 1. The cushion pins rest upon the upper pressure areas of the cushion cylinders.

In Figures 3 and 9 the lower die and cushion tooling are omitted for the sake of simplicity, but will rest directly upon the bolster, and may take the form shown in Figure 1.

As shown in Figure 9, stop rods 83 extend downwardly from the cushion cylinders through the yokes 70 and have limiting nuts 84 at the lower ends to prevent the cushion cylinders from rising beyond their limiting stroke in the upward direction. The nuts 84 move down with the stop rods 83 during downward travel of the respective cushion cylinders.

A crown 85 of the press is supported by housings 86 at the four corners, and the housings are aligned with respect to the bed and crown by keys 87. Tension rods 88 extend through the housings, and carry nuts 90 at the top and bottom. In order to provide prestressing of the tension rods, they are suitably heated before the nuts are preliminarily drawn up, and then prestressed by shrinkage. The heating can conveniently be accomplished by passing steam or other heating medium through openings 91 in the tension rods.

The crown is recessed at 92 (Figures 3 and 9) to provide space and mounting for main ram cylinders 93 (of which three are provided in the particular design shown). The main ram cylinders may have any desired distribution, but in the preferred form are in line along the center of the press. Main rams 94 are placed in cooperative relation in the main ram cylinders, and the main rams as a group are connected with the main or draw slide 36 at their lower ends. The main rams are recessed at 95 (Figure 9), and clips 96 are engaged in the recess and bolted to the draw slide.

The main ram cylinders are secured to the crown by bolts 97 at the top (Figures 3 and 4).

At the ends of the crown, pull-back cylinders 98 are positioned (two are provided in the preferred embodiment), and the pull-back cylinders contain cooperating rams 100 which have reduced diameters extending through the draw slide 36 and are held to the draw slide by nuts 101. The rams carry double acting pistons 102, one di-

rection of piston motion being used for pull-back purposes and the other direction of piston motion being used to supplement the main rams. The cylinders are closed by heads 103.

The blank holder slide 50 in Figures 3 and 9 operates in the recess 41 between the main body 37, the bolster 40 and the side members 38, all of the main draw slide. The blank holder slide receives its downward pressure from blank holder cylinders 104 (of which six are shown in the preferred form), and the cylinders cooperate with blank holder rams 105 which are interconnected to the blank holder slide at their lower ends. The rams 105 carry single acting pistons 106 which cooperate with the cylinders. Heads 107 close the upper ends of the cylinders. The blank holder cylinders are bolted to the crown at 108 (Figure 3).

The blank holder slide has openings 110 (Figure 6) at intervals throughout the area, and posts 44 extend through the openings from the body 37 of the draw slide to the bolster 40, supporting the bolster in the manner described in connection with Figure 1. As in the form of Figure 1, the bolster is of proportionally thin section.

The bolster has blank holder pressure pin openings 56 as described in Figure 1, and blank holder pressure pins pass through these openings as described in connection with Figure 1 (the blank holder die and the blank holder pressure pins are omitted in the showing of Figures 2 to 9 for the purpose of clarity in illustration).

The bolster 40 has a series of pressure pads 111 (Figure 3) distributed over its upper surface, and permitting substantially uniform contact between wear plate 53 on the blank holder slide and the bolster 40. This wide area of contact is useful in permitting the pull-back cylinders to withdraw the blank holder slide along with the draw slide, and also in permitting the blank holder cylinders to apply supplemental pressure to the draw slide when operating on a single action cycle.

It will also be evident that a true bearing of the blank holder slide on the draw slide is important from the standpoint of obtaining uniformity of travel of the blank holder die during the approach stroke and also of the cushions.

Preferably at the corners of the draw slide, auxiliary blank holder cylinders 112 are mounted on the draw slide, and contain cooperating piston rods 113, which extend downwardly to and are bolted into the blank holder slide 50. The piston rods 113 carry pistons 113' (Figure 10^a) at the upper end, and are single acting, the lower ends only of the pistons being used.

The auxiliary blank holder cylinders 112 may desirably be employed as cushioning cylinders during the pull-back stroke, to prevent the draw slide, when moving upward, from bumping the blank holder slide which at that time will be substantially stationary.

For this purpose each of the auxiliary blank holder cylinders is provided with a hydraulic cushioning device of customary design, such as a choke 451 and a check valve 450 (Figure 10^a), to permit free return as later described.

The auxiliary blank holder cylinders may also be used to provide a hydraulic lock between the blank holder slide and the draw slide at a time on the retraction stroke when it is desired to have the draw slide and blank holder slides start their upward travels together. For this purpose it is merely necessary to trap oil below the piston of the auxiliary blank holder cylinders as later explained.

At the front and back of the draw slide, stalks 60 are mounted and extend upwardly into openings 114 in the crown. The stalks are essentially vertically elongated members, which may be fabricated in any suitable manner, although in the preferred embodiment they are castings of more or less I-beam cross section with changing cross sectional dimensions. Each stalk is secured both to the draw slide body 37 and to one of the side members 38 by bolting at 115, 116 and 117 (Figures 2 and 9) to the draw slide body, and rests upon lugs 118 extending

outwardly from the body. At the lower end of the stalk is connected by pin 120 into a clevis portion 121 of side member 38 of the draw slide. The bolting of the stalk to the body of the draw slide maintains a vertical alignment which can be corrected by shimming between the lugs and the stalk, whereas the pin engagement properly occurs at the bottom of the stalk and the side member. To aid in establishing a tight relation between the draw slide body and the side members, spacer blocks 122 (Figure 2) are interposed between the stalk 60 and the lugs 118.

The body of the draw slide is secured to the side members 38 at the corners by tie rods 123 which extend from lugs 124 on the body to lugs 125 on the side members.

The tie rods carry nuts 126 at the ends, and are preferably prestressed by heating and shrinking and are in addition, tightly fitted in the engaging holes 124' and 125' to act as shear pins to resist transverse forces.

Each stalk at the top carries adjustable guide shoes 127, adjustable in both forward and rearward, and right and left directions according to conventional gibb construction, which engage guideways 128, 130 and 131 respectively, which guide left and right and front and back respectively. The guideways extend from a point adjacent the bottom surface of the crown to a point even with or below the top of the crown and the guide shoes on the stalk are not required to extend above the top of the crown.

At the corner of the side members 38 of the draw slide, guides 132 are secured (Figures 2, 5), which guide in both directions against guideways 133 and 134 on the housings 86. The guides are preferably of the conventional gibb construction, permitting accurate maintenance of guiding contact.

It will be evident therefore that the draw slide is guided at all four corners of each stalk at the top, and also at the four corners of the draw slide proper at the bottom, with relatively wide vertical spacing between the upper guiding and the lower guiding, so as to maintain great accuracy in vertical alignment. Since the stalks are located desirably at the front and back, it will also be understood that there is great accuracy in guiding against out-of-parallelism in a front-to-back relationship.

The blank holder slide, moving inside the draw slide, is guided by liners 135 between the vertically engaging surfaces of the draw slide and the blank holder slide for front-to-back relationship (Figure 6) and liners 136 similarly placed at the ends for right to left alignment. It will be evident that the guiding described for the blank holder slide in the draw slide makes it unnecessary to guide the blank holder slide on the draw slide posts as described in Figure 1, but that the guiding shown in Figure 6 is an alternate construction and optionally the guiding means of Figure 1 can supplement that of Figure 6.

The two side members 38 of Figure 1 are in the form of Figures 2 to 9 carried into the space between the housings and beyond the housings at the end of the press and bolted together at 137 and to the bolster at 138 (Figures 3 and 6).

Hydraulic system

A suitable source of hydraulic fluid under pressure, desirably oil, is provided. In the preferred embodiment as illustrated in Figure 10^b, invariable delivery pumps 140, 141 and 142 and variable delivery and reversible discharge pump 143 are suitably driven as by motors 144 and 145. Suction oil is delivered to the pumps from suction tanks 146 and 147 through inlet connections not shown. The discharge from pumps 140, 141 and 142 takes place through valves 148, 150 and 151 (Figure 10^b) which are preferably double solenoid and hydraulic pilot operated spring centered type as shown in detail in Figure 11 except that plunger 300 is of regular commercial design to give the directions of flow as described. The pilot pressure as shown by the dotted lines comes

from a source 152 of pilot pressure at pump 143 and from sources 152' and 152² at pumps 163 and 142 through check valves 184', 185 and 184. The valves 148, 150 and 151, when actuated by solenoids 153 connect through lines 148', 150' and 151' into line 582 and then through single solenoid hydraulic pilot operated and spring returned valve 154, to discharge through line 155 to contribute at 161 to the performance of the downward operation of the press.

Valves 148, 150 and 151 if thrown in the opposite direction by solenoids 156 will deliver hydraulic liquid (oil) through check valves 157, 158 and 160 for the upward movement of the press.

The variable delivery pump 143 joins at 161 with the output from the other pumps for the downward movement of the press. The variable delivery pump 143 alternately discharges for pull-back purposes through connection 162 which joins the pull-back deliveries of the other pumps.

Internal pilot control of the variable delivery pump 143 permits selection of discharge in either direction as well known in the art.

A further variable delivery and reversible discharge pump 163, driven by motor 164, connects at 167 through connection 165 and check valve 166 with the down stroke delivery of the other pumps after the latter have discharged through check valves 168 and 169. Pull-back delivery from variable pump 163 passes through double solenoid and hydraulic pilot operated spring centered valve 170 (Figure 10^b, shown in detail in Figure 11^a) and through check valve 171 to join the pull-back delivery of the other pumps at 172. From connection 172 the oil passes through solenoid and hydraulic pilot operated foot valve 173 (Figure 10^a) into connection 174 from which it branches into the two pull-back cylinders 98 at connections 175 and 176 (Figures 10^a and 10^b). The foot valve as well known in the art embodies a free lifting check valve providing free flow in the direction from pump towards pull-back cylinders, with a solenoid and hydraulic pilot device added for pilot operating of the valve to permit unobstructed reverse flow of the oil. It is also equipped with a built-in relief valve to permit resistance flow in the reverse direction if the check valve is seated.

At 177 (Figure 10^a) the connection branches through needle flow control valve 178 and solenoid and hydraulic pilot operated and spring returned two-way valve 180 into return connection 181 (and 124), whereby hydraulic liquid is permitted to flow into the overhead surge or quick refill and exhaust tank 182 (Figures 10^a and 10^b). This valve is opened during the rapid downward stroke of the press to permit accelerated closing of the press. The speed of the closing can be regulated by the setting of valve 178.

The pump 163 is further equipped with automatic compensating control 488 which automatically reduces the discharge of the pump to match the demand when maximum preset pressure has been developed at the down stroke discharge port of the pump, as well known. By use of single solenoid and hydraulic pilot operated and spring returned two-way valve 183 (Figure 10^b) this pressure compensating feature may be either connected or disconnected from the system.

Pumps 143 and 163 are each equipped with two built-in safety or maximum pressure relief valves (one for each direction of discharge) and these relief valves discharge into the suction connections of the pumps.

Pumps 140, 141 and 142 have safety or maximum pressure relief valve protection through valves 186, 187 and 188 which have respective external returns to the suction tanks. The volumetric displacement of pump 143 may be adjusted by speed control stem 190 for controlling the downward speeds of the press or by adjusting control knob 191 for controlling the pull-back speed of the press. These speed controls are well known in the art. Further speed control beyond the capacity of pump

143 is obtained by by-passing one or more of pumps 140, 141 and 142 by not energizing the respective solenoids of valves 148, 150 and 151, as these valves are designed to by-pass the respective pump deliveries when placed in neutral position, at which time the hydraulic liquid will flow through connections 192, 193 and 194 into the respective suction tanks at 195 and 196.

The surge tank 182 is placed at the highest elevation in the system and receives the major portion of the hydraulic liquid discharged by the press during the return stroke. It is further provided with an overflow baffle at 197 (Figure 10^b) which permits return of excess hydraulic liquid from the surge tank into the suction tank at 198 and by means of connecting pipe 200 (below the liquid level) equal levels are automatically maintained in the two suction tanks. The surge tank 182 will then be filled to an adequate level to permit prefilling of the various press cylinders as needed during the rapid filling of the press.

During the rapid downward movement of the press the upper areas of the pull-back cylinders are filled by hydraulic liquid flowing under gravity through check valves 201 (Figures 10^a and 10^b). The two end blank holder cylinders are filled by hydraulic liquid flowing under gravity from the surge tank through pilot operated surge valves 202 (Figure 10^a) of well known character.

The four remaining blank holder cylinders (two in front and two in back) are filled by hydraulic liquid flowing under gravity through check valves 203, 204, 205 and 206. The central main cylinder is prefilled by gravity hydraulic liquid from the surge tank by pilot operated surge valves 207 and 208 (Figure 10^a) and the remaining two main cylinders are likewise prefilled by hydraulic liquid flowing under gravity from the surge tank through surge valves 210 and 211. For further illustration of these surge valves see Figure 14.

The pilot operated surge valves 202, 207, 208, 210 and 211 are of the sliding piston type and are positively opened by hydraulic pilot pressure and at the proper interval in the cycle they are positively closed by hydraulic pilot pressure.

During the lifting of the press, these valves are opened by hydraulic pilot pressure, therefore permitting free return of hydraulic liquid from the cylinders to the surge tank. The return of hydraulic liquid from the upper portions of the pull-back cylinders takes place via connections 212 (Figure 10^a) and 213 (Figure 10^b) through single solenoid and hydraulic pilot operated lapped piston type spring returned valve 432 (Figure 10^a) and via check valve 215 and single solenoid and hydraulic pilot operated foot valve type spring closed two-way 216 (Figure 10^b) (which is held closed by hydraulic line pressure and spring pressure combined; it is allowed to open by low system pressure when the hydraulic closing pressure is released).

Line 217 serves as an equalizing line for uniform return flow through the valves 432 and 216. Valve 216 fulfills essentially the same function as valve 432 except that its relief valve portion protects the connected portion of the system against excessive pressure in case of over-pressure due to valve failure as well known. The valves 432 and 216 are well known in the art.

One of the four front and rear blank holder cylinders is discharged to the surge tank through connections 296, 237, 295 (Figure 10^a), 220 (Figure 10^b) and 221 (Figure 10^a) into double solenoid hydraulic pilot operated and spring centered four-way valve 222 (described more fully in connection with Figure 11). When de-energized this valve is in its neutral position and permits flow from connection 221 to connection 223 and 224 into the surge tank (Figure 10^a).

Valves, 222, 225, 226 and 227 are identical in their design and functions. The other three of the four front and back blank holder cylinders discharge into the surge tank respectively through connections 287, 228, 286, 234, 235, valve 226, connections 236 to connections 223 and 224; also through connections 292, 233, 291, 230,

231, valve 225, connection 232 to connections 223 and 224; also through connections 282, 218, 281, 238, 240, valve 227, connection 241 into connections 223 and 224.

Variable pump 143 has a built-in solenoid operated automatic control for selecting the volumetric delivery of the pump, embodying two solenoids and a spring centering device so arranged that three distinct settings can be obtained, as well known in the art, namely full preset return volume, full preset pressing volume, and an intermediate partial pressing volume. By selecting the desired settings the pump is not only capable of lowering and raising the slides of the press at selected speed, but in addition permits a selection of pressing speed independent of the rapid closing speed. During the idling time when the press is not in use but the motors are operating, the minimum delivery of the pump towards pressing is by-passed through single solenoid hydraulic pilot operated spring returned two-way valve 242. When deenergized this valve by-pass delivery from connection 161 through valve 242 and connection 244 into suction tank 146 (Figure 10^b).

After the press has been closed rapidly to a predetermined level, a limit switch 435 is tripped whereby valve 173 is closed, causing trapping of hydraulic liquid in the lower portions of pull-back cylinders 98, thereby causing decelerating of the downward movement of the draw and blank holder slides simultaneously.

Pumps 140, 141, 142 and 143 and pump 163 will now discharge simultaneously through connections 167 and 247 (Figure 10^b), thence through the respective connections 248, 250, 251, 252, 253 and 254 for delivering pressure hydraulic liquid to the six blank holder cylinders.

From connection 248 hydraulic liquid will flow through check valve 255, connection 256, two-way valve 257 (later described in connection with Figure 13) and connection 258 to surge valve 202 into which it is connected by ports 260 and 261. Port 260 is blocked while port 261 connects into a hydraulic pilot cylinder. Valve 261' (Figure 10^b) which is of single solenoid and hydraulic pilot operated two-way foot valve type as well known has been closed at this time, thus preventing escape of pressure via check valve 262 and passages 263 and 264 (Figures 10^a and 10^b). Hence operating pressure will be generated at port 261, causing the shifting and closing of the valve plunger in valve 202. The motion of this valve plunger causes opening of the valve port at 260, thereby permitting entry of hydraulic liquid into the blank holder cylinder which is connected to valve 202.

A duplicate function takes place from connection 254 through check valve 265, two-way valve 266, connection 267 into ports 268 and 270 with pressure escape prevented through check valve 271 and passage 272 by the same valve 261' which is closed in this position, and in this case pressure on port 270 will cause shifting of the valve plunger in connected surge valve 202, permitting entry of pressure fluid from port 268 into the connected blank holder cylinder, thus causing downward travel of the blank holder slide by pressure on these blank holder cylinders, while the draw slide is forced to descend with the blank holder slide until contact is made between the blank holder die and the work which is placed upon the lower die.

The other four blank holder cylinders receive pressure in like fashion from connections 250, 251, 252 and 253 through check valves 271, 272, 273 and 274 respectively, thence through two-way valves 275, 276, 277 and 278 respectively (later described in relation to Figure 13), and connections 280, 281, 218, 282 to cylinder 284, connections 285, 286, 228 and 287 into cylinder 288, connections 290, 291, 233, 292 into cylinder 293, also through connections 294, 295, 237 and 296 into cylinder 297. At this time side connections 220, 230,

234 and 238 are closed, preventing escape of oil pressure by the positions of valves 222, 225, 226, and 227.

These valves 222, 225, 226 and 227 are illustrated in detail in Figure 11 and consist of a body 298 with valve plunger 300 movable therein, with self-centering spring device 301, consisting of a housing 302, a helical compression spring 303, a spring seat 304 and a spring seat 305. Spring seat 304 bears against plunger projection 306. Plunger 300 and spring seat 305 are held against spring 303 under compression by bolt 307 which is connected to the end of the plunger by threaded portion 308.

Movement of piston 300 to the right causes compression of spring 303 by a force applied through the bolt 307, at which time spring seat 305 is pulled away from supporting face 310. Releasing the shifting force from the piston, allows the spring to return the piston to center position at which time the spring seat 305 will again bear against the supporting face 310.

Movement of the piston to the left will cause compression of the spring by the action of spring seat 304 which will then move away from supporting face 311 and likewise release of the moving force will cause return of the piston until the spring seat bears against face 311. Thus after movement in either direction the spring will centralize the valve piston. Shifting forces either to the right or left may be applied hydraulically from a hydraulic pilot system (not shown in Figure 11) applied through valve ports 312 or 313 and by energizing electric solenoids 227R or 227L to move pilot valve plungers 316 or 317 respectively. Pilot pressure may be applied into operating cylinder 318 or 320 as the case may be to drive the main valve piston 300 either to the left or to the right. When deenergized, the solenoid pilot valves 316' and 317' permit release of pressure from pilot cylinders 318 and 320 to outlets 321 or 322 respectively. In each pilot valve body a needle valve 323 is provided to permit throttling of the forward shifting speed of the valve piston 300 in the respective direction, while check valve 324 permits unobstructed reverse movement. The pilot valve is constantly held in the position to close off pilot pressure on the adjoining end of the main valve plunger by return spiral compression spring 316 acting on the pilot valve.

In the deenergized or centralized position of valve 227 (Figures 10a and 11) the valve piston 300 permits flow of hydraulic liquid between connections 240 and 241 and at the same time the valve permits flow of hydraulic liquid between passages 325 and 326. When the main valve is energized (solenoid 227L energized) with the piston shifted to the right, the main valve permits flow between passages 325 and 326, but passages 240 and 241 are blocked so that there is no connection between these two. When the valve is energized with the piston shifted to the left (solenoid 227R energized), passages 325 and 240 are interconnected to permit flow of hydraulic liquid between them, but passages 326 and 241 are blocked, preventing flow in that direction. Valves 226, 225 and 222 are arranged for duplicate flow combinations to their respective connections, similar to those just described with particular relation to valve 227. At the time of building blank holder pressure, valves 225, 226 and 227 are positioned with their valve pistons shifted to the right, thereby preventing escape of fluid pressure being delivered to the blank holder cylinders, through these valves.

When blank holder pressure is being developed in the six cylinders 104, 284, 288, 293, 297 and 104', through valves 257, 275, 276, 277, 278 and 266, hydraulic liquid pressure is at the same time applied to pilot relief valves 327, 328, 330, 331 and 333 (Figure 10b) as shown more in detail in Figure 12.

These valves which are illustrated in Figure 12 consist of a body 334 containing a lapped piston two-way type plunger 335 which normally interconnects ports 336 and 337 and is arranged to disconnect flow between those

two ports when the plunger is actuated. This plunger is normally held in its inactive position by a helical compression spring 338 bearing on spring seats 340 and 341. Spring seat 341 is held by adjustable set screw 342 having adjusting knob 343. The plunger is held in its inactive position against valve cap 344 which is machined to form a pressure chamber which receives pressure from port 337 through passage 345 in the valve plunger, so that when pressure is developed in blank holder cylinder 104 and in passage 267, the same pressure is developed in line 346 (Figure 10b), into port 337 and through passage 345 against the lifting area 347 and when this pressure becomes sufficiently high to balance the pressure exerted by spring 338 it will cause outward movement of plunger 335 and when the pressure reaches a predetermined value it will shut off the flow between ports 336 and 337. The pressure at which the flow ceases is controllable by adjusting the setting of set screw 342. Valves 327, 328, 330, 331 and 332 function in like manner as valve 333 and receive their respective control pressures through respective passages 348, 350, 351, 352 and 353 from the pressure lines to the respective blank holder cylinders.

Figure 13 illustrates in detail valves 257, 275, 276, 277, 278 and 266.

The two-way valve 266 consists of a body 354 having a lapped piston type valve plunger 355 which is arranged for lateral movement in the valve body subject to hydraulic pressure applied laterally to its ends but is not restrained by any spring. The valve body has inlet and outlet ports 356 and 357 and when the plunger is positioned to its extreme right it prevents flow between these two ports but when the plunger is shifted to its extreme opposite position, that is to the left, flow between ports 356 and 357 is permitted through passage 358. The valve plunger is also provided with an internal drilled passage 360 leading from a point 361 on the periphery of the large left end, through the center of the piston to an outlet 362 into pilot pressure area 363. The valve piston 355 has in addition a drilled passage 364 leading from space 358 to the left pilot pressure chamber 365. This lateral pressure chamber is enclosed across the end of the valve body by valve cap 366, while pilot pressure area 363 is sealed across the right end of the valve body by the body of solenoid operated pilot valve 367 which is a device which duplicates one of the solenoid pilot valves of Figure 11, already described.

Valve plunger 355 is provided with projecting areas 368 and 370 for limiting its travel in opposite directions against the faces of valve cap 366 and pilot valve body 367. The pilot valve body is provided with a pilot pressure port 371 and a drain port 372, also with an auxiliary pressure port 373. The valve body is so arranged that port 373 is permanently connected to area 363. When the solenoid of this pilot valve is deenergized, port 371 is also connected to area 363, but when the solenoid of this device is energized, port 371 is disconnected from area 363 by internal blocking of the pilot valve. In this device port 372 serves only as a slippage drain to prevent accumulation of hydraulic liquid which passes valve clearances, from building up pressure in the inside parts of the valve body but this port has no other function in the operation of the valve. Valves 257, 275, 276, 277 and 278 are identical with valves 266 in design and function and are equipped with like pilot devices. While blank holder pressure is being developed in the blank holder cylinders, flow takes place through valve 266 from port 356 to port 357. At the same time pressure is admitted into passage 360 from line 247 by way of valve 333, line 346, pilot valve 367 and area 363. The effect is that when the pressure in valve 333 against area 347 (Figure 12) forces closing of valve 333, the supply of control pressure in area 363 is no longer continued thereby permitting an increasing pressure through passages 358 and 364 to apply a pressure in area 365 which overcomes the forces against area 363 and to cause a shifting of valve plunger 355

to the right thereby shutting off further delivery of hydraulic liquid pressure into passage 357 and to the respective blank holder cylinder 104. At the same time port 361 opens, equalizing pressures in line 267, passages 358, 360, 346 and into area 347 of valve 333. A loss of pressure in the blank holder cylinder will therefore permit reversal of the valve 333 and subsequently of valve 266 so pressure will then be readmitted and the pressure will therefore be automatically maintained in the blank holder cylinder as long as a higher pressure is maintained on line 247 than that corresponding to the spring setting of valve 333 and its corresponding counterparts and likewise the other five blank holder cylinders receive their respective settings according to the settings of their respective control valves. These individual pressures will be established and maintained in the six blank holder cylinders independent of each other.

Single stage draw on double action

When I refer to single stage, I mean operation with only one main cylinder or several simultaneously (in double stage, one or several simultaneous second main cylinders are brought into subsequent or "stage" operation).

When the blank holder pressures have all been established as above described, the pressure in lines 247 and 246 (Figure 10^b) will reach their maximum values as preset by the pressure controls, and pressure will be developed against pressure switch 374 (Figure 10^b) which causes the energizing of a control solenoid 375 which operates prefill surge valve 207 (Figure 10^a) by means of a hydraulic device. Valve 207 which is illustrated in Figure 14 (as modified by the use of the control head of Figure 14^a instead of the head actually shown in Figure 14) consists of a body 376 which has a high pressure connection 377 which is connected to main cylinder 93; also a low pressure connection 378 which is connected by means of line 379 to surge tank 182. The passage between connections 377 and 378 may be opened or closed by piston 380. This piston travels in a horizontal path in a closely fitted bored passage 381. The piston is in addition provided with an annular recess 382 which is always connected to passage 383 and permits flow from passage 383 to passage 377 by means of opening 384 when the piston 380 is in its forward position, that is when there is no passage between ports 377 and 378. The piston is operated by means of a double acting hydraulic plunger 385 which operates in a control cylinder 386 so arranged that when operating pressure is applied to chamber 387 the main piston is moved forward. Piston 385 is also provided with an annular pressure area 385' whereby the main piston is retracted when control pressure is applied to port 388. When the main piston is thus retracted, hydraulic liquid is permitted to flow freely between the surge tank 182 and the main center cylinder 93 but when the main piston is moved forward pump pressure is allowed to enter the main cylinder 93 from the main pumps 141, 142, 143 and 140 by passages 246, check valve 390, passage 391, port 383 and passages 382, 384 and 377 (Figures 10^a, 10^b and 14).

To the end face of control cylinder 386 is attached a valve body 392 (Figure 14^a, instead of the structure shown at the left in Figure 14) containing a lapped piston-type valve plunger 393 which is normally spring off-set by spiral compression spring 394 acting against cap 395. By the spring the end face 396 of the plunger is normally held against the striking face of solenoid operated pilot valve 397, of well known type (similar to Figure 11). In this position pilot pressure which is available on port 398 is not permitted to enter the control chamber 387 of the surge valve. This chamber is at this time connected through passage 400 to drain connection 401. Solenoid operated pilot valve 397 receives its pilot pressure through port 402 which is normally closed but when energized the valve permits flow of low pressure pilot liquid from

port 402 into chamber 403 which causes displacement of valve plunger 393 against the pressure of spring 394 until the passage from chamber 387 to port 401 has been shut off and subsequently a new connection is established from port 398 through connection 404 into the chamber 387. The high pressure required on port 398 is obtained from the main pressure system by branching from line 391 at point 405 and through line 406 (Figure 10^a). Energizing of the solenoid of pilot valve 397 therefore will admit low pressure pilot pressure to operate plunger 393, in turn permitting high pressure to shift the surge valve which disconnects the main cylinder 93 from the surge tank and subsequently permits high pressure to flow into the main cylinder from port 383. The same high pilot pressure is applied simultaneously through passage 407 and pipe 408 into a control head simultaneously through passage 407 and pipe 408 into a control head 410 of surge valve 208 (Figure 10^a). Surge valve 208 is identical with surge valve 207 except that it is not equipped with the solenoid pilot valve 397 or the high pressure pilot valve 392 but instead thereof has a plain closed end with single pipe connection 410. Valve 208 will therefore be shifted simultaneously with valve 207. Pump pressure is available at valve 208 through connecting line 425. The pumps will now deliver fluid into the main cylinder 93 and force ram 94 with draw slide 36 downwardly to preform the draw stroke of the press and develop such pressing force as is required to perform the drawing operation. If the press controls are preset to operate the press on a single stage draw cycle only, escape of pressure fluid is prevented through connections 426 and 427 by valve 214; which is closed at this time, and the pressure will then be built up to a preset value against valve 421 (Figure 10^b) which is equipped with a tripping device 422 which responds to increase of pressure and trips limit switch 423 (Figures 10^b and 16).

This is a conventional device (and is later described in detail in Figure 16) consisting essentially of a spring loaded relief valve with electric motor control for adjusting the spring setting of the valve, also equipped with a hydraulic pilot system whereby the spring tension may be quickly increased to a preset high value preventing the valve from opening (thus "locking" the valve) when operated under normal working pressure. It is further arranged so movement of the valve plunger in response to increasing pressure causes the tripping of the device 422 when the desired pressure has been developed.

The loading of this valve is locked hydraulically as described during the time that blank holder pressure was being developed but when pressure limit switch 374 was tripped the device was unlocked to permit response of this valve to the pressure for tripping the switch when the desired pressure was reached.

Surge valves 202 are of the same construction as valve 207 (Figure 14) except that pilot valves 392 and 397 are omitted and in their place is mounted a pilot control head which requires a preset minimum pilot pressure to be applied for operating the valve, while the pilot fluid may be exhausted without restriction.

This control head 410 is illustrated in Figure 17 which is a modified section of Figure 14. From connection 261 on this control head, hydraulic liquid enters the body 411 under a check valve 412 and then flows through passage 413 into relief valve assembly 414 which has a spiral compression spring 415 with a preset tension obtained from adjusting screw 416 and so arranged that when a preset control pressure has been established against valve member 417 it will cause same to lift permitting hydraulic liquid flow through connection 408 into chamber 387 (Figure 14) of surge valve 202 and causing this valve to shift thus closing the passage between the surge tank and cylinder 104 or 104'.

The check valve 412 is provided to permit free return movement of the surge valve when it is later desired to

open the valve when reversing the press, at which time flow takes place from chamber 387 through passages 418 and 420.

The pressure liquid for opening the surge valves by applying pressure to port 388 is supplied when the pump deliveries are directed into the pull-back system. From this system a connection 172' (Figure 10^b) branches at 172² and leads to port 388 through branch lines 388', 388², 388³, 388⁴, 388⁵, and 388⁶.

Double action two-stage cycle control

If it is desired to operate the press on a two-stage cycle, namely when the pressure of the first stage is insufficient to complete the draw, the pressure valve 421 (Figure 10^b) is not unlocked at the time limit switch 374 is tripped, but the pressure is developed against ram 94 in the same manner as above described and will increase by the action of the pumps until pressure switch 424 (Figure 10^a) is tripped. This pressure switch receives its pressure through passages 425 and 426 and at this time valve 214 (Figure 10^a) is closed to prevent escape of pressure through line 427. When pressure switch 424 is tripped, solenoid 428 is energized on surge valve 210. This surge valve is identical with surge valve 207 and now functions in the same manner as the surge valve 207 functioned in the first stage of the operation and this valve energizes through line 430 surge valve 211 which receives its pressure fluid from the pumps through cross passage 431, thus permitting valve 211 to function in the same manner as valve 208 functioned previously at the first stage of the operation. Thus the second stage main rams 94' and 94² will now receive pressure to increase the tonnage developed by the press. While initial pressure is being developed on rams 94' and 94², loss of hydraulic fluid from ram 94 is prevented through check valve 390 and the pressure in this cylinder is only permitted to decrease by expansion of hydraulic liquid therein in response to downward movement of the blank holder slide due to initial pressure increase over rams 94' and 94², and after the pressures have become equalized in the three main cylinders they will increase simultaneously. Such downward movement can occur only in response to increased tonnage developed in the press, thus movement in the press must be continuous, only there is a decrease in the speed. When pressure switch 424 was tripped, the hydraulic locking device of valve 421 was again released so that during this second and final stage of operation reversal will take place by tripping switch 423 in response to the pressure developed on valve 421 in accordance with the setting of its controls.

Alternate first stage double action cycle

In order to obtain more selectivity of control, the particular press here described is arranged with an alternate first stage pressure step whereby a higher first stage operating tonnage is available, with of course correspondingly reduced pressing speed, since the maximum speed obtainable is a function of the maximum pumping capacity built into the press and the ram area subjected to pressure. With this alternate first stage control the rapid closing and blank holder clamping operations are the same as above described and pressure switch 374 likewise causes the starting of the first stage draw operation, but at this time valve 214 which is electric solenoid and hydraulic pilot operated is now preset to be open and valve 432 which is a valve of the same type as valve 214 is preset to be closed, valve 216 is also closed, with the result that when hydraulic liquid from the four main pumps 140, 141, 142 and 143 is pumped into the center main cylinder 93, it is also pumped through lines 426, 427, 212 and 217 into the two upper pressure chambers 103 of pull-back cylinders 98. The effect is to apply pressure over a larger ram and piston area; therefore with a predetermined maximum unit working pressure, a higher pressing tonnage is developed at inversely slower speed.

If it is desired to operate the press on first stage only, the reversal will subsequently take place when sufficient pressure has been developed against valve 421 to trip limit switch 423.

Alternate two stage double action cycle

The higher first stage tonnage feature may also be used in the two-stage cycle. This is especially advantageous when a heavy draw operation requires a tonnage in excess of that which can be developed with the low first stage tonnage, and the same is to be followed by a coining or sizing operation requiring close to full tonnage capacity of the press. It is then possible to perform the draw operation with reasonably high speed on increased first stage capacity and when the dies are nearly closed solid the high coining pressure can be applied, whereas the operation would have to be done entirely at slow second stage speed if only the lower first stage pressure were available.

For this operation the valves are set during the first stage operation the same as described above for the high first stage tonnage. Valve 214 is open, valves 432 and 216 are closed, but valve 421 is not unlocked hydraulically by the action of pressure switch 374. When full working pressure has been developed on the center ram, pressure switch 424 will trip, causing the energizing of solenoid 428, causing application of pressure on rams 94' and 94², and at the same time valve 214 will be closed while valve 432 will also remain closed. The effect is that from this time on pressure will be applied through the main rams 94, 94' and 94² and no hydraulic liquid from the pump can be applied any longer on areas 103 of the pull back cylinders. The hydraulic liquid which has been pumped into the area 103, however, has been trapped and pressure is not instantaneously released, thus preventing a momentary pressure drop when shifting from first to second stage, but when the pressure developed upon rams 94' and 94² exceeds that which had previously been developed on areas 103, the three main rams will exert total pressing tonnage and further increases in pressure will be developed on those three rams until the full maximum desired value has been obtained. During the remainder of the pressing cycle the chambers 103 over pistons 102 will fill by gravity hydraulic liquid from surge tank 182 through check valve 201, thus preventing cavitation. To complete this cycle it is of course again required that valve 421 be hydraulically unlocked at the time of tripping pressure switch 424 so that reversal will take place automatically at the proper pressure setting.

Limitation of draw stroke in the various cycles

In the above description it has been stated that the press will continue its draw stroke until a preset maximum pressure has been developed. Another method of limiting the draw stroke is by the position of a limit switch which is tripped at a suitable interval by the position of the draw slide. This switch is indicated by 433 (Figure 10^a) and is tripped by cam 434. The deceleration of the moving parts or slides shortly before the blank holder die makes contact with the work is operated by the same or a similar cam which operates limit switch 435.

Decompression of hydraulic liquid prior to reversal of press

When either limit switch 423 or 433 has been tripped, the hydraulic liquid becomes decompressed from the main cylinders prior to starting the reversal of the press. By tripping either of these switches, solenoids 375 and 428 are deenergized, causing loss of pressure in chambers 387 of surge valves 207, 208, 210 and 211, but this does not immediately cause opening of these valves. The center main cylinder still remains connected through passages 425 and 426 to valve 214, which opens at this time and permits flow into passage 212 from which the hydraulic liquid may be discharged through passage 436 into valve

432 which has also opened, thus permitting decompression from the center main cylinder to the surge tank.

The right hand main cylinder becomes decompressed through valve 210 and passage 437, thence check valve 390 and passage 391 where the discharging hydraulic liquid combines with that being discharged from the central main cylinder and will then flow through the same channel via valves 214 and 432 into the surge tank. The left hand main cylinder discharges at this time through its surge valve 211 and passage 431 into surge valve 210 from where it discharges together with the hydraulic liquid from the right hand main cylinder. If at the time of decompression, compressed liquid is available in the areas 103 of the pull-back cylinders, they will likewise discharge through valve 432 into the surge tank. In the meantime, the discharge from the invariable delivery pumps 140, 141 and 142 are being by-passed through the central positions of valves 148, 150 and 151 through their respective return lines 192, 193, 194 and 196 to the suction tanks. Pump 143 retains its control setting, therefore continues to pump hydraulic liquid into passage 161, but valve 242 has been deenergized, permitting the delivery from pump 143 to be by-passed through passages 243 and 244 to the suction tank.

Alternate methods of stripping work from dies

The press permits stripping or ejecting work from the dies by two alternate methods. The first method is one whereby in the double action cycle the edges of the formed or drawn part are restrained temporarily by the blank holder die while the punch is lifted out by the draw slide. After the punch has fully cleared the work, the part is raised from the lower die by the return action of the cushion.

The alternate method of stripping is especially useful when parts are to be removed from the punch which are difficult to separate due to air pressure causing the part to cling to the punch and where it is difficult to break the vacuum between the punch and the pressed part. For such parts, a reversal of the lifting sequences is possible, namely, the punch and blank holder slides are raised simultaneously through a relatively short distance after which they are stopped manually and held in their relative positions. By manual means using a suitable prying tool, the edges of the work are then pried loose to permit air to flow between the punch and the part until the part drops off and drops back into the cavity in the lower die. The press is subsequently opened to its full open position and during the latter part of the lifting strokes the cushions are raised for lifting the work from the lower die.

In the first stripping method it is desirable to maintain pressure on the blank holder cylinders during the initial part of the stripping operation, and for this reason the blank holder pump 163 remains on pressing stroke until after the draw slide has begun to lift. The blank holder pressure is then released either by the setting of a timer or by a limit switch, which in either case is so arranged that the blank holder pressures on the six blank holder cylinders are released before the draw slide begins to pick up the blank holder slide. Decompression of hydraulic liquid from the four blank holder cylinders 284, 288, 293 and 297 takes place by returning valves 222, 225, 226 and 227 to their centered positions, at which time hydraulic liquid will flow from blank holder cylinder 284 via passage 282, 218, 281, 238 and 240, thence through the valve and then through passages 241, 223, 536 and 224 to the surge tank, and like flow occurs through the respective valves from the other three main blank holder cylinders. At the same time control 581 of pump 163 is deenergized, stopping fluid displacement from this pump.

From blank holder cylinders 164 and 104', decompression takes place by flow of oil through surge valve 202, passage 268, check valve 271, lines 272 and 264 from the cylinder 104, and through surge valve 202, passage 260,

check valve 262, lines 263 and 264 from the cylinder 104' into valve 261' which is electrically opened for this purpose, and then through passage 437 into the surge tank.

For decompression prior to the alternate stripping cycle requiring simultaneous lifting of blank holder and draw slides at the start of the opening stroke, it is merely required that the centering of valves 222, 225, 226 and 227 and the opening of valve 261' occur simultaneously with the decompression of the main cylinders.

Reversal of press

If the press is set up to reverse according to the first manner described, namely that in which the draw slide lifts ahead of the blank holder slide, the fact that pressure has been lowered in the system to a satisfactory extent is indicated by the tripping of pressure switch 438 (Figure 10^a). Since the preferred design, herein described, embodies six blank holder cylinders, and sufficient stripping pressure may be maintained by four blank holder cylinders, I find that it simplifies the controls to decompress the two end blank holder cylinders simultaneously with the main cylinders. Sufficient pressure drop in these two cylinders 104 and 104' is indicated by the tripping of pressure switch 440 (Figure 10^b). These switches are placed in those hydraulic circuits from which pressure must be removed, before the draw slide can lift and when they reach a low setting of say approximately 80 to 125 p. s. i. they establish electrical circuits which initiate the upward movement of the press, namely cause energizing of the reversal solenoid of the control of pump 143 permitting same to discharge into line 162, also energizing the solenoids of valves 148, 150 and 151 permitting discharge of hydraulic liquid through check valves 157, 158 and 160, all of which will join with the discharge from pump 143 into passages 172², 172 and thence through 177 and electrically operated foot valve 173, which now acts as a check valve permitting flow into passage 174 and thence through passages 175 and 176 into the lower or annular areas of the two pull-back cylinders 98, causing upward movement of the draw slide.

Pressure switches 441, 442, 443 and 444 are provided to establish electrical circuits upon sufficiently lowering blank holder pressures in cylinders 284, 288, 293 and 297 respectively. Completing these circuits permits proceeding with the upward stroke of the drawslide at the appropriate time in the regular stripping cycle. In the alternate stripping cycle these switches together with switches 438 and 440 must simultaneously establish their circuits before upward travel may begin.

At the same time that this circuit is established, control 581 is energized in the opposite direction, causing pump 163 to deliver hydraulic liquid into line 491, thence through centered valve 170, check valve 171 and line 492 to join this delivery with that of the other four pumps 140, 141, 142 and 143 at 172 thus increasing the lifting speed of the press.

It will be noted that during the draw stroke the pistons 113' and piston rods 113 of the auxiliary cylinders 112 remained stationary with the blank holder slide 50. At this time the draw slide 36 descended, pulling with it the auxiliary cylinders 112, creating a void below each of the four pistons 113'. The space above pistons 113' is filled with hydraulic liquid and connected with an auxiliary tank 445 through line 446. (The hydraulic connections to the auxiliary cylinders are completed for the left auxiliary cylinder in Figure 10^a and in Figure 10^c, but for lack of space are not completed for the remaining auxiliary cylinders, which use similar connections.)

The void below piston 113' is being filled during the down stroke of the draw slide by transfer of hydraulic liquid from above piston 113' through passage 447, check valve 448 and line 451 or check valve 450 (see Figures 10^a and 10^c).

During the upward stroke of the draw slide this same hydraulic liquid is expelled through passage 451, check

valve 452, line 453 and electric solenoid and high pressure hydraulic pilot operated two-way valve 454. This valve incorporates a relief valve for safety purposes and is similar to valve 261, but the main part of this valve is kept open during this entire cycle. After leaving this valve the hydraulic liquid is returned through passages 455 and 456 to the upper areas of cylinders 112 and since the displacement of the upper volumes of these cylinders exceeds the lower volumes, additional hydraulic liquid is sucked from the tank 445 through passages 446 and 456 into the upper cylinder spaces. When the draw slide has travelled a return stroke which is almost as long as the actual draw stroke, the supporting or striking faces 457 of the draw slide almost meet the bottom face of the blank holder slide and will soon start lifting the blank holder slide. In order to avoid an impact at the time of the meeting of these two faces each auxiliary cylinder is provided with a conventional choking collar 458. This collar is provided with needle valve control 460 whereby the resistance of hydraulic liquid flowing from the lower annular area of the auxiliary cylinders may be so restricted that the draw slide will start lifting the blank holder slide upon the now trapped hydraulic liquid, thus accelerating the blank holder slide while hydraulic liquid continues to flow from the auxiliary cylinder through the needle valves 460 at a reducing rate of speed. The effect, therefore, is that the draw slide picks up the blank holder slide gradually and after travelling a few additional inches the blank holder slide will rest upon the striking faces 457, following which the two slides will travel upward simultaneously by the action of the pull-back cylinders alone.

The same type of control is provided on all four auxiliary cylinders, each with its own individual choke adjustment to permit full regulation of the acceleration desired.

The simultaneous lifting of the slides together will continue until the draw slide has reached its desired and preset maximum elevation, at which time limit switch 461 is tripped, causing deenergizing of all controls which remain energized up to this time, thereby causing bypassing of the three invariable delivery main pumps through their respective valves 148, 150, 151, also the by-passing of pump 143 through valve 242 and the neutralizing of pump 163 so the slides will stop and remain in their elevated positions until a new cycle is initiated.

Alternate stripping procedure

By presetting of a selector switch, the press may be set to operate in the alternate stripping sequence as described above and in this case the first requirement following decompression is that all six pressure switches 438, 440, 441, 442, 443 and 444 indicate sufficiently low pressure before the lifting operation can begin. The signal given by these pressure switches to permit reversal now causes the shifting of valve 454 (Figure 10*) to the closed position so no hydraulic liquid can escape from the lower areas of pistons 113', the result of which is that when the draw slide is now lifted the blank holder slide must travel up simultaneously with the relative spacing retained as it was established at the end of the draw stroke. Any work which tends to cling to the punch will therefore remain on the punch and travel up with the draw slide. A preferred way is then to stop the press after the slides have lifted a short distance of only a few inches after which the work is pried loose from the punch and allowed to drop back or may be caught by hand or other external means.

The press is then again started up causing the two slides to travel upwardly and they will remain in the existing relation to each other until the blank holder slide has nearly reached its elevated position. The blank holder slide is provided with its own cam 462 which trips at this time limit switch 463, causing the shifting of plungers in valves 222, 225, 226, and 227 to the right, thereby blocking the discharge from passages 221, 231, 235 and

240 which in turn traps the hydraulic liquid remaining in the four blank holder cylinders 284, 288, 293 and 297, thereby stalling the blank holder slide preferably just below its proper elevated position. The draw slide will continue to travel upwardly by the action of the pull-back cylinders and will now cause forcing hydraulic liquid out of the areas below pistons 113' through the relief valve portion of valve 454 (Figure 10a), thus permitting the draw slide to complete its upward stroke. When the draw slide has nearly reached its own elevated position, its cam 434 trips another limit switch 464 which opens valve 454 and at the same time returning valves 222, 225, 226 and 227 to their centered position, thus permitting the free return of the blank holder slide to its fully elevated position simultaneously with the draw slide and both to stop when cam 434 trips limit switch 461. By tripping limit switch 464 close to the end of the upstroke of the draw slide, advantage is again taken of the cushioning effect in the auxiliary cylinders so that valve 454 may be safely opened at this time without danger of sudden dropping of the blank holder slide.

While this stripping cycle is especially desirable for drawing light gauge sections with large areas which are subject to clinging to the punch by vacuum, the same operating sequence can, if desired, be used for lifting out any work, and if the middle sections are sufficiently heavy so no damage is done by mechanical stripping, the press can continue to travel up and the stripping can occur simply by the continued upward movement of the punch after the blank holder die has been stalled. In this case the work is not lifted out of the lower die by the cushion but is ordinarily caught by the operator while it falls off the punch or supported on timbers or a handling tray which is slid between the die and the work before it drops down.

An alternate arrangement is possible by having the cushions follow the punch with a few inches clearance to lift work after it has dropped back upon the lower die. This will occur when combining the single action strip-stripping operation with the above.

Single action cycle

When operating the press on single stage cycle, (that is with the main ram and blank holder rams always together) the blank holder and draw slides travel simultaneously as in a single unit and the blank holder slide remains constantly supported upon pads 457. The various rams travel down with the respective slides and prefilling of the cylinders takes place in the same manner as during the closing stroke of the double action cycle. The auxiliary cylinders 112 are inactive during this cycle. The rapid closing stroke during single action takes place in the same manner as during the double action cycle. Decelerating by limit switch 433 likewise takes place in the same manner. After decelerating has taken place, pressure is applied to the blank holder cylinders for closing the upper die against the work and the only difference is that now there is but one die which is attached to the draw slide face and the downward movement of the draw slide occurs because the pumps deliver oil into the blank holder cylinders causing the blank holder slide to travel down and pushing the draw slide downwardly through pads 457. At this time hydraulic liquid is trapped in the lower annular areas of the pullback cylinders and is locked against valve 173 with suitable relief through the relief valve portion of this valve.

When the control of the press is thus set up for single action operation, electric solenoid and pilot operated two-way valve 465 (Figure 10b) is energized to permit flow of oil from line 247 through line 466, valve 465 and line 467 with branches 468, 470, 471, 472, 473 and 474, through check valves 475, 476, 477, 478, 480 and 481, then through lines 482, 483, 484, 485, 486 and 487 and through passages 373 (Figure 13) in pilot valves 367 into chambers 363 of the respective valves 257, 275, 276, 277, 278 and 266. These valves are now energized preventing pres-

sure escape through ports 371 of the pilot valves and the direct pressure against the right end face of plungers 355 prevents shifting and closing of this valve, thus maintaining passage from 356 to 357. Therefore the deliveries from the five pumps are maintained through passage 247 with its various branches through check valves 255, 271, 272, 273, 274 and 265 and through the two-way valves 257, 275, 276, 277, 278 and 266 to build equal pressure on all six blank holder cylinders. If it is desired to operate the press in single action on single stage only, valve 421 is hydraulically unlocked at the time the slow-down limit switch trips so reversal will take place when the desired pressure has been developed in the six blank holder cylinders.

If it is desired to operate the press on a two stage cycle, the cycle will occur exactly the same as above described for single stage up to the time the press stalls with full tonnage on the blank holder cylinders. However, at the time of tripping slow down limit switch 433, valve 421 is not hydraulically unlocked. Prior to the stalling of the press under blank holder pressure, pressure switch 374 was tripped, which causes energizing of solenoid 375 with closing of surge valves 207 and 208 and pressure application on the center ram 94. At the same time, valve 421 was hydraulically unlocked. Pressure is now applied to the six blank holder cylinders and the central main ram simultaneously, thus developing the second stage pressure of the single action operation. Momentary escape of compressed hydraulic liquid from the blank holder cylinders is prevented during the transition period through check valves 255, 271, 272, 273, 274 and 265 (Figure 10b) and when the desired operating pressure has been developed simultaneously in the six blank holder cylinders and the center main cylinder pressure actuated switch 423 (Figure 10b) will trip to cause reversal. If it is desired to operate the press on a single action cycle through three stages, thereby utilizing the maximum total of the six blank holder cylinders and the three main cylinders combined, the hydraulic lock of valve 421 is not released when tripping pressure switch 374, but just before stalling of the press on the second stage, pressure switch 424 is tripped which causes the energizing of solenoid 428 and cutting in of pressure on rams 94' and 94², also causing the unlocking of valve 421 so that automatic reversal will take place during the third stage of pressure application.

"Holding" pressure—single action

In order to obtain maximum speed of operation with a given size (gallons per minute displacement) of hydraulic power system, it is naturally desirable to operate the press for maximum tonnage at maximum hydraulic working pressure. The maximum working pressure developed by a pump of the type described can usually be higher when operating a press on a fast cycle of quick building pressure and quick release than on a cycle where pressure must be maintained during extended periods.

A press which is designed to operate normally on a fast cycle without maintaining pressures would therefore normally be designed to operate at higher unit working pressures than one which is designed to operate normally on long cycles with full pressure sustained over long periods. When a press must fulfill both functions it has often been necessary to sacrifice speed in order to obtain lower working pressures for the holding cycle. In the design here described, another provision has been made whereby a larger ram area is provided for the holding cycles than for the fast draw cycles and the circuit is so designed that when it is required to operate a press at full tonnage while holding the pressure for extended periods the upper areas 103 of the two pull back cylinders 98 are cut in simultaneously with the application of the third stage. In this particular design the control provides that when the press is set for holding cycles the maximum working pressures for the first and second stage are lower by the proportional amount (approx-

mately 10%) and for the third stage the full tonnage is variable and at this time the two areas 103 are cut in at the same time that areas 94' and 94² are cut in. For this purpose, valves 432 and 216 are then closed and valve 214 is open (Figures 10^a and 10^b). While holding pressure in this manner, it would be undesirable to blow off the full displacement of the five pumps through relief valve 421 and instead thereof pumps 140, 141 and 142 are automatically bypassed through valves 148, 150 and 151 when limit switch 433 is tripped near the extreme end of the downward stroke of the press. Pump 143 will by-pass through valve 242 which valve is de-energized at this time and pump 163 will maintain the holding pressure. For this purpose this pump is provided with an automatic compensating control 488 of commercial type which automatically adjusts the delivery of this pump to equal the slippage losses of the system. Since this control is not desired during the other cycles of the press, a valve 183 is provided which is electric solenoid and hydraulic pilot operated but which is closed during all other cycles and is opened only during the holding stage of the single action cycle. For instance, if the press is to be operated on a holding cycle of the first stage range this valve will open when the first stage of operation is cut in. If the press is to hold pressure in the second stage range, this valve is opened only when the second stage of operation is cut in and likewise when the press is to be operated in the third stage range, this valve is cut in only in the third stage.

An electric solenoid and hydraulically operated two-way valve 490 is provided between connections 165 and 246 for the purpose of equalizing pressures and joining pump deliveries during the down stroke of the single action cycle. This valve is maintained open as long as the press is operated on a single action cycle.

To decompress the press in the single action cycle following completion of the pressing operation, the same valves are opened as in the double action cycle where the blank holder cylinders are decompressed simultaneously with the main cylinders, thus causing complete decompression of all downward acting cylinders and all six pressure switches 438, 440, 441, 442, 443 and 444 (Figures 10a and 10b) act simultaneously to register minimum residual pressure before the reversal can begin. As soon as these pressures have all been lowered to say between 80 and 125 p. s. i., the press will being reversal by delivery of hydraulic liquid from all five pumps simultaneously through connections 162 for pumps 140, 141, 142 and 143 and for pump 163 through line 491, valve 170, check valve 171 and line 492 into the common connection 172 where the deliveries of all five pumps are combined and thence in the usual manner by connection 177, valve 173 acting as a check valve and connections 174, 175 and 176 into the two pull back cylinders causing lifting of the slides. At this time valve 170 is in the centered position. The slides of the press will continue to lift until limit switch 461 has been tripped stopping the upward motion of the press and it will remain in its lifted position until a new cycle is started.

When the press is operated on the single action cycle using a rubber pad as female die member, the decompression of the hydraulic liquid is accompanied by considerable upward movement of the press slides due to the release of energy from the rubber. Since no hydraulic liquid is being pumped into the pull back cylinders during this interval, cavitation could occur in the pull back cylinders and to prevent this occurrence a check valve 493 (Figure 10a) is provided which permits filling this void from the surge tank through lines 224, 494 and 495.

Cushions

Each cushion has its own hydraulic control system, separate from those of the other cushions. These controls comprise the double solenoid and hydraulic pilot operated, spring centered four-way valves 222, 225, 226 and 227 (Figure 10a) as illustrated on Figure 11, electric

solenoid and hydraulic pilot operated spring offset two-way type valves 496, 497, 498, 500 with their pressure adjustment pilot valves 501, 502, 503 and 504 and check valves 505, 506, 507 and 508 with inter-connecting piping.

Valves 496, 497, 498 and 500 are as shown in detail in Figure 15. These valves consist of a body 514, with lapped piston type plunger 515 having an annular external passage 516 which normally is out of registry with ports 517 and 518, the connection between these ports being prevented by the solid cylindrical end 520 of the valve plunger. The valve plunger is normally held to the left by the action of a helical compression spring 521 which at one end bears against the end face of the valve plunger and at the other end bears against the abutting face of a pilot solenoid valve body 522 similar to 316' in Figure 11. The opposite end of the valve plunger bears at 523 against the abutting face of the valve cap 524. The large left end of the valve plunger is provided with a passage 525, permitting pressure fluid to enter the pressure chamber 526 at the end. A positive stop in the form of extension 527 is provided on the valve plunger to prevent overtravel and in its extreme right hand position will bear against the abutting face 522' of the pilot valve body.

The electric solenoid pilot valve 522 is provided with a pressure port 528, receives its pressure through pilot relief valve 501, 502, 503 or 504 and when the solenoid is deenergized no flow is permitted from port 528 into the right hand control pressure chamber 530 of valve body 514. At this time control chamber 530 is connected through port 531 to a drain connection which is connected to a suitable port on either the surge or suction tank (selection is optional and unimportant). When the solenoid of this device is energized, port 528 is connected to chamber 530 and port 531 is internally blocked.

Spring 521 is of light construction and is so proportioned that when no hydraulic pressure is applied to chamber 530 the hydraulic liquid in cushion cylinder 66 and passages 532 and 533 to port 517 is prevented from escaping if only the weight of cushion cylinder 66 and the die member placed upon the same exerts a downward pressure upon the hydraulic liquid. However, if a greater downward force is exerted, the pressure on this hydraulic liquid which is applied through passage 525 to chamber 526 will cause the valve plunger (Figure 15) to move against spring 521 and hydraulic liquid will escape through port 518 and thence through passages 534 and 535 to line 224 and then to the surge tank. In this position the device therefore is suitable only for supporting the weight of the moving parts of the respective cushions and the die weight normally placed upon the same.

When pressure is applied to the blank holder cylinders, pressure from pump 163 is also admitted through connection 165, line 537, check valve 538, lines 590, 540 and branches 541, 542, 543 and 544 to the respective valves 501, 502, 503 and 504.

These valves are of the type illustrated in Figure 12, having their inlet connections 541, 542, 543 or 544 into port 336. Port 337 is connected by passages 545, 546, 547 or 548 to port 528 of Figure 15. When pressure is thus applied by the pump through valves 501, 502, 503 and 504 and provided the solenoids of pilot valves 522 are energized, control pressures are introduced into chambers 530. The control pressure is variable at each valve 496, 497, 498, or 500 according to the adjustments of valves 501, 502, 503 and 504 in the same manner as the earlier described valves of Figure 12 serve to control the setting of pressures in valves of Figure 13. Thus the control pressures in chambers 530 are adjustable, thereby controlling the flow from ports 517 to ports 518 (Figure 15). If additional pressure is applied to the dies on top of cylinders 66 by the action of the press, the pressures developed in the cushion cylinders are therefore controlled by the actions of valves of Figure 15 and

as determined by the settings of valves 501, 502, 503 and 504. When the solenoid of a valve of Figure 15 is deenergized, chamber 530, however, is exhausted, limiting the resistance pressure to that of spring 521 only.

Line 532 is connected through line 325 to valve 227 (as illustrated on Figure 11) and in the centered position of this valve line 325 is connected through the valve to line 326 and the hydraulic liquid is there trapped against check valve 505. Likewise check valves 506, 507, and 508 fulfill the same functions for the other three cushions. When the plunger of Figure 11 is shifted to the right, the cushion connections to this valve remain unchanged, but when the valve of Figure 11 is shifted to the left, line 325 becomes connected to lines 240, 238, 281, 218 and 282 thereby interconnecting the cushion with blank holder cylinder 284. In like manner the other valves 226, 225 and 222 interconnect the other three cushions with the respective blank holder cylinders. The hydraulic system between one cushion cylinder and one blank holder cylinder now becomes a closed system, having no escape means as long as pressure in the cushion cylinder does not exceed the pressure setting of the respective valves 501, 502, 503 or 504. Check valves 271, 272, 273, 274, together with check valves 470, 471, 472 and 473 and with pilot valves 328, 330, 331 and 332 (in either single or double action operation) prevent escape of pressure through respective lines 280, 285, 290 or 294. When such connections are made, the downward movement of the blank holder slide serves as a means to control the downward movement of the cushion cylinders or vice versa the upward movement of the blank holder slide will then control the upward movement of the cushions and by proper proportioning, either equal strokes or designed ratios of strokes between the blank holder slide and cushion cylinders can be obtained. When all or several of the cushion valves 227, 226, 225 and 222 are simultaneously positioned for this function, it follows also that the length of strokes travelled by the respective cushions must be identical, inasmuch as the movements of the blank holder rams must follow the movement of the blank holder slide and the same is controlled during the rapid closing and return strokes by the movement of the draw slide and the latter is held in parallelism with the bed by the action of the T guide.

Check valves 510, 511, 512 and 513 (Figure 10a) are connected to the respective blank holder connections 240, 235, 231 and 221 and the discharge connections of these check valves are interconnected by lines 550, 551, 552, 553, 554, 555 and 556 to relief valve 557. This relief valve is of the same type as the valve of Figure 15 connected with the pilot relief valve of Figure 12 identified in Figure 10a as 558 and with discharge line 560 to the surge tank. This relief valve receives its loading pressure from the same pressure source as the main relief valve 557, namely by branch connection 561. This relief valve with check valves are provided only as safety protection against overloading of the blank holder cylinder connections in case of malfunctioning of valves or controls.

It will be evident, of course, that the hydraulic connections between the blank holder cylinders at the end at which hydraulic liquid is displaced on movement toward the work and the cushion cylinders at the end which causes movement away from the work may associate unequal numbers of blank holder cylinders and cushion cylinders, or may associate the blank holder cylinders and cushion cylinders in groups including more than one of each and less than all of each.

Figures 20 to 23 are block diagrams showing at A blank holder cylinders at the end at which hydraulic liquid is displaced on movement toward the work and at B cushion cylinders at the end which causes movement away from the work, the blocks merely indicating cylinder volumes, and no attempts being made to show the actual constructions.

Figure 20 shows two blank holder cylinders A in a closed circuit hydraulic connection to one cushion cylinder B, the total effective area of the two blank holder cylinders being the same as the effective area of the cushion cylinder. Merely to suggest that any number of blank holder cylinders may be connected with a particular cushion cylinder or cushion cylinders, Figure 21 shows three blank holder cylinders A connected in closed circuit to one cushion cylinder, the effective areas of the three blank holder cylinders being the same as that of the one cushion cylinder.

In some cases a plurality of blank holder cylinders will be connected in closed circuit with a plurality of cushion cylinders. Figure 22 shows two blank holder cylinders A in hydraulic closed circuit with two cushion cylinders B, the effective areas of the two blank holder cylinders being the same as the effective areas of the two cushion cylinders.

Figure 23 shows three blank holder cylinders A hydraulically connected in closed circuit with two cushion cylinders B, the effective areas of the three blank holder cylinders being the same as the effective areas of the two cushion cylinder areas.

It will be evident that in all of these cases the connections are from the blank holder cylinders at the end at which hydraulic liquid is displaced on movement toward the work to the cushion cylinders at the end which causes movement away from the work. It will also be evident that Figures 20 to 23 show groups of less than all of the blank holder cylinders and less than all of the cushion cylinders, or in some cases the machine may embody but one of such groups.

Cushion operation in single action cycle

During the single action draw cycle the cushions are normally used as resistance members whereby a constant upward pressure must be maintained against the die members during the downward stroke of the press. For this purpose valves 227, 266, 225 and 222 remain in their neutral positions and hydraulic loading pressure is applied by the blank holder pump 163 through line 537 in the manner previously described, whereby each of the relief valves 496, 497, 498 and 500 are preset to their respective control pressures so that when the draw takes place and the left cushion is forced down hydraulic liquid is displaced from the main cushion cylinder area through passage 72 and lines 532 and 533 through valve 496 against preset loading, then through lines 534, 535 and 224 to the surge tank.

Valves 497, 498 and 500 control the same function for the other three cushions. When the draw stroke is completed the cushions will all stop at their respective positions determined by the positions to which they have been forced down. At the time of decompression of the main hydraulic system the solenoids of the pilot valves of Figure 15 are likewise deenergized momentarily to cause decompression of high pressure hydraulic liquid entrapped in the respective cushion cylinders. By so doing the cushions will remain in their lowered positions when the press is reversed without an upward creep due to expansion of compressed hydraulic liquid, thereby avoiding possible injury to the drawn part. Because of the built-in compressed value of springs 521 (Figure 15) the cushions are prevented however from drifting downwardly.

When the reversal of the press starts, the solenoids of valves per Figure 15 are again energized so pressure may again be developed in the cushion system.

After the press has opened the desired distance, which may be from zero travel up to the point where slow-down limit switch 435 is reset, a separate cam 562 on the draw slide, which has its own separate adjustment, trips limit switch 563 (Figure 10a) which initiates the raising of the cushions. For this purpose those of valves 227, 226, 225 and 222 which connect to cushions which require lifting are energized so their plungers are shifted to the left. For

valve 227 this permits flow from line 240 to line 325, thus permitting a blank holder ram to deliver hydraulic liquid to the respective cushion cylinder and causing the raising of that cushion. The same action occurs in any other cushion which at this time requires lifting.

Shortly before the cushions reach their fully raised positions, a cam 564 on each cushion trips a limit switch 565 for each cushion which causes deenergizing and centering of the respective four-way valve; for the left cushion this is valve 227. This will cause stopping of the cushion just before it reaches its elevated position (at which time another limit switch 566 has not yet been tripped by cam 564) permitting energizing of valve 170 to cause delivery of hydraulic liquid from pump 163 through passage 491, then through valve 170 into lines 567 and 568 and then through line 570 with branches 571, 572, 573 and 574 into check valves 508, 507, 506 and 505, thereby permitting delivery of blank holder pump fluid through the respective four-way valves of Figure 11 and connecting passages to the main areas of the respective cushion cylinders. The blank holder pump will thus complete the lifting of each cushion after the blank holder rams have raised the cushions nearly to their full elevated positions. When the blank holder cylinders reach their extreme upward positions limit switch 566 (one on each cushion) cuts off the respective pump connection but if the cushion should drift down between cycles the connection from the blank holder pump will again be cut in, when that cushion will again be raised to its elevated position. Each cushion is provided with a cam and like set of limit switches (they are shown for only one cushion).

By these actions, the work which rests on the cushion die is lifted up during the upward stroke of the cushion and may then be removed by hand.

Functioning of cushions in double action

The cushions may be used as resistance cushions during the draw stroke in the same manner as in the single action cycle and during the upward stroke they may again be used for stripping or lifting-out purposes. However, in the cycle whereby the blank holder slide stays down while the draw slide lifts, it is necessary that the lifting action of the cushion be delayed until the blank holder slide has begun to rise. Therefore, in this cycle it is preferable to interlock the lifting of the cushions so it starts simultaneously with the resetting of limit switch 435 during the up stroke.

In a double action cycle the resistance action of the cushion during the down stroke is not usually required and the cushions may often be conveniently lowered by setting their resistance pressure controls to low values and then forcing the cushions down by the use of a few cushion pins 33. However, it is at times desirable to lower the cushion ahead of the work so that no restraining pressure whatsoever is applied by the cushion upon the work while the draw takes place. When this is required the solenoid control of the valves per Figure 15 is energized for those cushions which must descend in this manner and at the same time the plungers of valves per Figure 11 (valves 227, 226, 225 and 222) are shifted to the left for the same cushions. For this valve combination the respective cushion cylinder areas are again interconnected with the blank holder cylinders and during the rapid down stroke of the press the voids created by the blank holder rams in their cylinders will act as measuring means for measuring the downward movements of the respective cushions. In order to supplement gravity with the downward movements of the cushions at the proper speeds, valve 170 is energized in such manner as to provide fluid flow from pump 163 through line 491, then through valve 170 and then through line 575 and connections 576, 577, 578 and 580 to pull down areas 73' which are provided in the cushion cylinders. At this time the stroke control 581 of pump 163 is automatically preset to deliver hydraulic

liquid into line 491 (this control is conventional, similar to that already described).

The pump 163 is proportioned to deliver a volume of hydraulic liquid to the pull down areas of cushion cylinders in excess of the requirements for full speed downward travel and excess hydraulic liquid delivered is returned to suction tank 147 through a relief valve which is built into pump 163 as well known. Thus a positive downward force is always available to assure that the downward movement of the cushions keeps in step with the downward travel of the blank holder slide.

After the cushions have been lowered through the desired distance (it should normally be a distance equal to or slightly in excess of the depth of draw to be produced) each cushion will trip a respective limit switch 581, thereby returning the respective valve of Figure 11 (227, 226, 225 or 222) to its centered position, which will cause the stopping of that cushion and will hold it there until upward travel is required during the return stroke of the press.

The draw will subsequently take place in the usual procedure, after which decompression will take place in the regular manner and during the upstroke the cushions will lift up the work while being synchronized with the upward movement of the blank holder rams in the same manner as if the cushions had been forced down against resistance. It is understood of course that a combination of cycles may be set up whereby some cushions are lowered rapidly in advance of the work, while other cushions may act as resistance cushions, all in the same cycle, as desired.

For special operations in single action cycles the cushions are likewise lowered ahead of the work in like manner. Such requirements may occur when performing blanking operations.

Cushions in triple action cycle

In a triple action cycle the first part of the pressing cycle occurs in the same manner as in a double action cycle, namely, after rapid closing, the clamping pressures are applied followed by a draw operation. At the completion of the downward draw stroke in a triple action cycle the press will not reverse, but the draw slide will stop and the cushions will then perform a third pressure stroke or a triple action draw consisting of an upward draw stroke while the main draw punch remains in its lowered position to provide resistance against which the upward draw stroke of the cushion can exert its pressure.

For this operation, those cushions which are to provide the triple action upward draw stroke are lowered rapidly through a distance equal to or slightly in excess of the length of the downward draw stroke, during the rapid closing of the press. Other cushions as desired are likewise lowered rapidly for stripping purposes or they may act as resistance cushions during the down stroke of the press. In either case the cushions are controlled for their respective cycles in precisely the same manner as in the previous cycles for the same actions. After the downward draw has been completed, the blank holder pump 163 will maintain blank holder pressure as before and the main pump 143 will maintain main ram pressure by discharging its delivery through valve 421 which now acts as a relief valve at its preset value, thus both main and blank holder pressures are maintained (where desired, an optional arrangement is to release the blank holder pressures if advantageous, to permit a certain amount of creep of the blank while the upward draw is being performed). When pressure actuated limit switch 423 (Figure 10b) trips in response to the preset pressure on valve 421, valve 154 is shifted by energizing its one solenoid and moving its main plunger against the action of a spring. It is essentially like the valve of Figure 11 with the left-hand solenoid operated pilot valve left off and omitting spring seat 304. Screw 307 is also omitted and the open-

ing left by removing the lefthand pilot valve is closed by a blind flange.

Line 582 is connected to port 325, line 155 is connected to port 326 and line 583 is connected to port 240. The valve plunger 300 is in this case so proportioned that there is never any liquid flow to port 241, except from leakage past the plunger clearances. For this reason port 241 is a drain connection to either the surge or suction tank. When the solenoid of the pilot valve is deenergized, the valve permits liquid flow from port 325 to port 326 and port 240 is blocked. When the solenoid is energized, the valve permits liquid flow from 325 to port 240, while port 241 is blocked.

One or more of pumps 140, 141 and 142 will now deliver hydraulic liquid through their respective valves 148, 150, and 151 and through valve 154 with hydraulic liquid flowing from connection 582 to 583 and then through line 568 to check valves 505, 506, 507 and 508, whereby hydraulic liquid will be supplied through valves of Figure 11 (222, 225, 226 and 227) to all of those cushions which are in lowered positions and the dies of which are not in intimate contact with the upper dies, causing those cushions to travel upwardly under pressure and when suitable dies are used, the required drawing operations are performed by this movement. Each cushion will stall when it reaches a solid support either at the end of the cushion stroke or when the dies are solid, metal to metal, with the work between them. The maximum pressure for this upward draw operation is controllable by the setting of valves 501, 502, 503 and 504 (Figure 10a) the lowest setting governing the maximum pressure developed. The draw speed may be regulated by cutting in one, two or three of the pumps 140, 141 and 142 and is also a function of the number of cushions used. Where desired, a variable delivery pump is used to give further refinement in upward draw speed control of the cushions.

After all cushions have travelled upward through their maximum possible strokes, the cycle will stop and where desired will be reversed automatically by the action of a pressure responsive switch (not shown), or manually as in the case of the illustration by pressing a reversal push button. This reversal first causes decompression of the cushion pressures by returning valve 154 to its original position and bypassing pumps 140, 141 and 152 through their respective valves 148, 150 and 151 and at the same time releasing the cushion pressures through valves 496, 497, 498 and 500 by deenergizing their solenoids in the same manner as previously described for the single action cycle. When these pressures have been suitably lowered, the main cylinder volumes are decompressed in the usual manner. The interval between decompressing of the cushions and decompressing of the main cylinders is controlled at the designer's option by a timing device or by a pressure responsive device (not shown), or in a manually controlled cycle by the operator simply watching a pressure gauge.

The reversal of the press follows and will occur in the same manner as in the double action cycle with selection of either sequences of lifting blank holder and draw slide and the cushions will be raised through their respective strokes in the same manner as described in the double action cycles and it will be noted that inasmuch as the cushions were pressed upwardly against the work, the lifting of the part will start with all cushions acting uniformly while the interlocking between cushions and blank holder slides will again maintain parallelism of movement.

General: for all cycles

The hydraulic circuit includes in addition a number of check valves which have not been previously described, which have the following purposes:

Check valve 584 with connections 585 and 586 connect respectively to lines 590 and 492. The purpose of this

check valve is to provide pressure loading means for relief valves 500, 498, 497 and 496 during the reverse stroke of the press while pressure is applied to the pull back system. This feature prevents loss of hydraulic liquid from the blank holder cylinders while being circulated to the cushions during the lifting stroke.

Check valve 587 with connections 583 and 590' provides control pressure for the same purpose during the rapid closing of the press while the cushions are being lowered. Check valve 591 which connects between lines 540 and 570 also fulfills the same function of providing control pressure to the same valves during the triple action draw stroke, also during the final lifting of the cushions to their uppermost positions by pump 163 when the press is idling. Check valve 592 with connection 593 to valve 216 and connection 594 to line 575 provide a safety relief against developing excessive pressures in the return areas of the cushion cylinders or in their pipe connections. If excessive pressure should be developed due to valve control failure, the excess hydraulic liquid will be released via connection 594, check valve 592, line 593, through valve 216 which has a built in relief valve as previously described and from there the hydraulic liquid will return to the surge tank via connection 595. Check valve 596 with connecting lines 597 and 181 serve to permit free flow of hydraulic liquid from surge tank 182 through line 224, thence through lines 494 and 181, check valve 596 and connections 597 and 594 to the return connections of the four cushions to prevent cavitation, when the cushions are at any time lowered by manual bleeding out of hydraulic liquid from the main area or by gravity drift due to hydraulic liquid slippage or leakage while the press is shut down.

It will be understood that the dotted lines all represent the distribution of the pilot control pressure fluid.

Figure 11a shows valve 170 and is generally like Figure 11 but with the variations sketched on Figure 11a and described below.

This valve is similar to the valve of Figure 11 with the exception that it has a differently proportioned main plunger 300' arranged to provide in its central position a passage from port 491 through internal plunger drilling 598 into body cavities 600 and 601 which are interconnected at 602 and lead to check valve 171. In this position ports 575 and 567 are closed. When the plunger is shifted to the left, flow is permitted from port 491 to port 575 while the internal passage 598 is blocked against valve body lands 604 and 605, thereby blocking passages 602 and 567. In the extreme right position the valve plunger permits flow from port 491 to port 567 while the passage 598 is blocked against valve body lands 606 and 607, thus preventing flow of hydraulic liquid into passages 575 and 602. The solenoid pilot valves and the centering spring of Figure 11a are like those of Figure 11, but reversed left-to-right.

The construction of valve 421 will be better understood by referring to Figure 16, which discloses its internal structure.

The valve consists of a main body 610 having a pressure chamber 611 which receives its supply of hydraulic liquid through connection 246 and is closed by a plunger 612 which has an annular sealing area 613 which closes against seat 614. This seat is fitted into the main body by tightly fitting into bore 615 and is further sealed by seal ring 616. When the plunger is thus seated escape of hydraulic liquid is prevented towards connection 437.

The valve plunger 612 is additionally provided with an extension 617 which is closely but slidably fitted into the main body at 618 and provides a projecting area 620 which is of annular shape so that pressure applied to chamber 611 tends to force this valve plunger to the left. The valve plunger is of hollow construction having a chamber 621 into which is closely but slidably fitted a projection 622 of control body 623 which is provided with piston rings 624 for sealing with respect to the internal

bore of plunger 612. The control body 623 is sealed against the main body by sealing ring 625. The extension 622 is of hollow construction, having a cavity 626 into which is placed a helical compression spring 627 which extends into the cavity 621 and at its right end bears against abutting face 628 of plunger 612, while at the opposite end the spring bears against face 630 of the control head. Spring 627 is of light construction and provides only enough clamping pressure between the seat face 613 of the plunger and seat 614 to make a seal when low pressure is applied to the valve. The spring itself, however, will not prevent lifting of the valve plunger away from the seat when pressures exceeding approximately 40 to 80 p. s. i. are applied against face 620.

Body 610 is further provided with a passage 631 which connects from chamber 611 to passage 632 of control body 623 and where the two bodies join at the juncture of these two passages a seal 633 is provided.

Passage 632 leads into a bore chamber 634 into which is inserted a control cylinder 635, and a valve body 636.

The control cylinder 635 is sealed within the control body by sealing ring 637 and contains a spacer 638 with shims 640. The spacer 638 is snugly held in bore 641 and by means of the shims provides a positive type adjustable stop for the normal position of valve plunger 642. Valve plunger 642 is snugly but slidably fitted into valve body 636 in lapped bore 643. This valve plunger has three lands 644, 645 and 646. The valve body 636 is so closely fitted into bore 634 that harmful slippage is prevented. Parts 635 and 636 are inserted from the bottom but for the purpose of illustration the necessary access openings with valve cap, seal, and the like are not shown.

Valve plunger 642 normally bears against spacer 638 at 647 and plunger 642 is provided with longitudinal notches or slashed ports 648 which are in constant connection with annular recess 650 which connects through passage 651 in valve body 636 to passage 632, so that the same pressure as in chamber 611 exists against the lower end face 647 of pilot valve plunger 642.

This pilot valve plunger is held down by helical compression spring 652 acting through spring seat 653 against the upper face 654 of valve plunger 642, and this spring is held at its upper end by spring seat 655 which is positioned by set screw 656 which has at its upper end flat faces 657 for adjustment by wrench. Screw 656 is held in cap 658 which is attached to the control body by bolts 660.

By adjusting the setting of set screw 656 the force exerted by spring 652 is changed, therefore the resistance of plunger 642 against lifting under hydraulic pressure can also be changed. Pressure applied through passage 632 to face 647 is also admitted through notch 661 into recess 662 of plunger 642 from which it is admitted through passage 663 of valve body 636 and passage 664 of control body 623 into the annular pressure area 665 of the main body, where it exerts a closing pressure against face 666 of the main valve plunger 612. The area 666 is equal to or slightly larger than area 620, thus as long as valve plunger 642 remains in its lowest position the main plunger 612 remains seated due to the pressure exerted by spring 627 plus, at the designer's option, any additional forward force which he may provide due to the differential in areas between areas 666 and 620. The valve will therefore remain seated regardless of the value of pressure in chamber 611 as long as plunger 642 is seated against spacer 638.

When the pressure against face 647 exceeds the downward pressure from spring 652, plunger 642 begins to lift, thereby shutting off the passage through notch 661 and land 650, and will then seal against the portion 667 of the bore of valve body 636 so no further hydraulic liquid is delivered to chamber 665. At the same time land 644 has moved up with respect to portion 668 of valve body 636 to provide an opening for hydraulic liquid

flow which will take place from chamber 665 through passage 670 in the control body 623 and through passage 671 in valve body 636, then through annular passage 672 which leads to the newly established opening at 668 and then through passage 673 in valve body 636 from which the hydraulic liquid flows through passages 674, 675, 676 and 677 into the discharge port of the main body from which it is returned through connection 437 to the surge tank.

The result of the lifting of plunger 642 therefore is to prevent further delivery of hydraulic liquid pressure to the annular area 666, at the same time metering out hydraulic liquid from this area to the drain connection, thus limiting the maximum pressure which can exist in chamber 665 against area 666, therefore limiting the holding pressure which prevents lifting of plunger 612 off the seat. The setting of spring tension on spring 652 therefore is a measure for the maximum pressure which may be developed in chamber 611 and when that pressure is exceeded valve plunger 612 will move away from its seat, permitting hydraulic liquid flow from chamber 611 to drain passage 437 and preventing further increase of pressure in the hydraulic system.

A further refinement exists in the form of one or more slashes or grooved ports 678 in the lower land 650 of plunger 642 extending between grooves 648 and notches 661. These slashes are preferably of less cross section than slashes 648 and are definitely of smaller cross section than provided by notches 661. The effect of these slashes is to maintain a small delivery of hydraulic liquid under pressure to chamber 665 while this chamber is at the same time vented through passages 670, 671, 672 and the opening between body portion 663 and land 644. By sustaining a small supply of pressure liquid to chamber 665 at this time, a damping effect is obtained to permit smoother lifting of plunger 612 away from its seat and to prevent rapid movement accompanied by sudden surges. When functioning in this manner the valve therefore fulfills the function of a relief valve, relieving the system of excess hydraulic liquid delivered by the pumps while maintaining a fixed pressure.

Drain passage 680 is provided between spring chamber 626 and return passage 675 to drain off slippage hydraulic liquid which might enter from chamber 665 through the clearance of piston 624.

Plunger 642 is further provided with a tapered area 681 which engages stem 422 in such manner that when plunger 642 begins to lift it forces stem 422 outwardly and by means of bell crank 682 which is pivoted at 683 and through adjusting screw 684, it causes limit switch 423 to trip. A hydraulic seal 685 is provided around stem 422 to prevent external wastage of slippage liquid. Slippage hydraulic liquid is returned to the supply tank through port 686 and line 687. The tapered face on plunger 642 with stem 422, bell crank 684 and micro switch 423 provide the pressure responsive means which causes the tripping of the necessary electric controls for initiating decompression of the various press cylinders prior to the reversal of the press and occurs at the same time that or immediately before the suitable maximum pressure has been developed in the chamber 611, which leads to opening of plunger 612 so that the valve functions as a pressure relief control during the time of shifting the electrical and hydraulic controls, that is, during the intervals prior to the actual starting of decompression. After decompression has begun and the pressure has been sufficiently lowered, plunger 642 will return to its normal position and the spring mechanism within limit switch 423 will cause the return of bell crank 682 and stem 422 to their normal positions, or in an alternate design a separate spring may be provided externally for this purpose.

The spring seat 655 (Figure 16) is built like a hydraulic piston being closely fitted at 688 in a bored portion of cap 658 which forms a cylinder 690 with pres-

sure connection 691. A positive stop for the downward travel of the spring seat (piston) 655 is provided at 692, thus permitting the spring seat to travel downwardly under hydraulic pressure through distance 693. In actual construction the cap 658 is made in two sections which are bolted together to permit assembling of the spring cap above the stop surface 692. The upward stroke of spring seat 655 acting as a hydraulic piston is limited by the end face 694 of set screw 656. The set screw 656 is sealed in the cylinder portion of cap 658 by seal 695 and gland 696.

An electric solenoid and pilot operated three-way valve 697 of the same type (316') as shown in Figure 11 is bolted to the left end of control body 623. This valve receives its control pilot pressure through line 698 at port 700 which is normally closed by the action of the valve. At this time port 702 is connected to drain port 703 which is connected to one of the hydraulic liquid reservoirs through passage 704. Port 702 is connected through passage 701 and port 691 to cylinder 690. At this time the valve will therefore act as previously described. However, when the solenoid of valve 697 is energized, port 700 will be connected to port 702 and port 703 will be blocked, thereby permitting control pressure from line 698 to enter line 701 and pressure will be applied into cylinder 690 thereby forcing spring seat and piston 655 downward against piston stop 692. In this position spring 652 will be loaded to exert upon valve plunger 642 such force that it will not lift under the normal operating pressures of the hydraulic press. Therefore valve plunger 612 will likewise be prevented from lifting, the result being that energizing the solenoid of pilot valve 697 causes the valve to be locked hydraulically, except that it can still open under a predetermined higher hydraulic pressure, thus permitting the device to function as a safety valve for the hydraulic system, as well.

Electric circuit

In the description of the electrical circuit, those features which are conventional in presses of this type will be eliminated, and are simply indicated in Figure 18 as 707, and the description will be confined to the novel features.

Figure 19 shows the power supply to the valve solenoids and Figure 18 shows the operating relays and interlocks.

Power is received preferably from terminals 705 and 706 connected to an alternating current system of commercial frequency, distribution and voltage (although if desired direct current may be used).

Control current is received preferably from terminals 707 and 714, likewise connected to an alternating current system of commercial frequency, distribution and voltage (although, if desired, direct current may be used).

Valve 227 is operated by two solenoids 227L and 227R (designating left and right hand operating solenoids) which operate the valve through the respective hydraulic pilot valves previously described and illustrated in Figure 11. Solenoid 227L becomes energized when contact 727LC is closed. This contact is part of a relay which has magnet coil 727L of Figure 18, of conventional form. Solenoid 227R becomes energized when contact 727RC is closed which forms part of a relay having magnet coil 727R. Likewise solenoids 226L and 226R operate valve 226, solenoids 225L and 225R operate valve 225 and solenoids 222L and 222R operate valve 222. These solenoids become energized when respective contacts 726LC, 726RC, 725LC, 725RC, 722LC and 722RC are closed and each of these form part of an individual relay with respective magnet coil 726L, 726R, 725L, 725R, 722L and 722R. In each case the contact is closed upon energizing of the respective magnet coil.

Two way type relief valve 496 which is electric solenoid and hydraulic pilot operated has solenoid 496S

plunger of valve 227 to the left which causes the required interconnecting of the large cylinder area of the respective cushion with the corresponding blank holding ram area so that upward movement of the blank holder slide causes lifting of that cushion resulting in stripping of work from the lower die.

When the cushion has been raised nearly to its full upward position, limit switch 565 is reset, opening branch circuit 762 and deenergizing relay 764, resulting in deenergizing of solenoid 227R and centering of valve 227, thereby disconnecting that cushion from its blank holder cylinder. The deenergizing of coil 764 also causes the closing of contact 764C, whereby branch circuit 763 is now energized through limit switch 566, thereby energizing relay magnet coil 765 which closes contact 765C in branch circuit 766 and energizing relay magnet coil 770L which in turn closes contact 770LC on the same relay, thereby energizing solenoid 170L and shifting the plunger of valve 170 to the right, thereby applying hydraulic liquid from pump 163 through check valve 505 and through valve 227 into the cushion to complete its lifting. When the cushion is fully raised, limit switch 566, which is of the micro-switch type, trips to open the circuit between terminals 760 and 761, thereby breaking the branch circuit 763 and allowing valve 170 to return to its centered position, providing its delivery is not required for the final raising of the other cushions. For this purpose as well as to provide the complete stripping operations of the other three cushions, circuits are provided through the respective limit switches in the form of branch circuits 767, 768 and 771 with relay magnet coils 772, 773 and 774 and the respective relays have normally closed contacts 772C, 773C and 774C, which are placed in series with the respective limit switches 566', 566², and 566³ for the closing of branch circuit 763. The same relays are also provided with normally open contacts 772C', 773C' and 774C' for the selective closing of circuits 748, 750 and 751 which govern the return of the other three cushions acting from valves 226, 225 and 222.

Triple action cycle

For admitting pressure from pumps 140, 141 and 142 to the main areas of the cushion cylinders during the upward draw strokes in triple action cycles valve 154 is provided as previously described and this valve is operated at such time by the energizing of its single electric solenoid 154S (Figure 19) and this solenoid is energized when contact 854C is closed, and which is part of the relay which has magnet coil 854 in Figure 18.

When the press control is set up to operate in triple action, a selector switch 775 is manually closed and left in this preset position to energize circuit branch 776. This circuit branch is also provided with a switch 777 which is either manually operated or interlocked with limit switches 423 or 433, so that when the desired stroke has been travelled or the desired pressure has been reached on the draw slide, contact 777 is closed, thereby energizing relay magnet coil 854 and through the proper steps, described above, energizing solenoid 154S and shifting the plunger of valve 154 to the right and thereby admitting pressure fluid from pumps 140, 141 and 142 through passages 583 and 568 and through the various branches through check valves 505, 506, 507 and 508. The pressure is therefore available at valves 227, 226, 225 and 222. Assuming that maintained contact switch 717 had been preset for rapid lowering of the first cushion, namely through valve 227, the fact that relay magnet coil 718 was energized during the down stroke of the press, had closed branch circuit 778 through normally open contact 718C², on that relay, thereby energizing magnet coil 780 which will interlock and remain energized by the closing of its normally open contact 780C. This relay will also close normally open contact 780C' in branch circuit 781. In series with this

contact is also a normally open contact 854C which was closed by energizing of its magnet coil 854, the result being the energizing of circuit 781 and relay magnet coil 727L, causing the shifting of valve 227 to the right, thereby permitting flow of hydraulic liquid from passage 326 to passage 325, allowing the pumps 140, 141 and 143 to deliver hydraulic liquid into the first cushion cylinder and pressing it upward to perform the upward draw or triple action draw operation. Upon completion of the upward draw, branch circuit 776 is opened by the manual opening of normally closed switch 782, causing the deenergizing of solenoid 227L and centering of valve 227. Following completion of the triple action functions, and during the upward stroke of the press, switch 715 is again opened, thus breaking the held-in circuits 778.

For the purpose of operating the other cushions in like manner to the one described, a branch circuit 783 is provided with relay magnet coil 784 and holding contact 784C in parallel with which is contact 745C² which is operated by relay magnet coil 745, also branch circuit 785 with relay magnet coil 786 and holding contact 786C and parallel therewith contact 746C² and finally branch circuit 787 and magnet coil 788 with holding contact 788C and in parallel therewith contact 747C² operated by relay magnet coil 747. Likewise in parallel with the branch circuit 781 for relay magnet coil 727L there is a branch circuit 790 for relay magnet coil 726L which has in series a normally open contact 854C' and a normally open contact 784C', also a branch circuit 791 for relay magnet coil 725L which has in series a normally open contact 854C² and a normally open contact 786C', and finally a branch circuit 792 for relay magnet coil 722L which has in series a normally open contact 854C³ and a normally open contact 788C'. Contacts 854C, 854C', 854C² and 854C³ are all operated by relay magnet coil 854; contact 784C' is operated by relay magnet coil 784; contact 786C' is operated by relay magnet coil 786; and contact 788C' is operated by relay magnet coil 788. Switch 715 is again used to open the held-in circuits 783, 785 and 787 during the upward travel of the press.

Safety control for parallel movement of blank holder slide

For the purpose of insuring that the movement of the blank holder slide and cushion cylinders occurs in true parallelism with the top face of the bed of the press, it is, of course, required that the blank holder slide follow precisely the movement of the draw slide. This will normally occur due to its weight as it will follow the draw slide by gravity and in many cases also by the pressures exerted. If, due to binding of mechanical parts or due to the use of improperly built dies, the blank holder slide should at any time tilt, the T guides of the draw slide would no longer control the movement of the blank holder slide. In order to determine this condition and to prevent the operation of the press when this occurs, four limit switches are provided, two placed at the left end of the draw slide and two placed at the right end thereof, 793 and 794, 795 and 801 (Figures 10a and 18). These switches travel with the draw slide and their actuating rollers are in contact with the bottom face of the blank holder slide, which holds them in a depressed position as long as the blank holder slide face bears upon pads 457. If the blank holder slide should tilt away from the pads or in any other way separate away from same, one or more switches will trip, opening the circuits. These switches 793, 794, 795 and 801 as shown in Figure 18 are wired in series in branch circuit 802 which also includes relay magnet coil 803 which carries a normally open contact 803C which when opened interrupts the power supply from feeder line 707. It is required, therefore, that the four microswitches be closed at all times in order to permit functioning of

which is energized when contact 796C is closed. This contact is part of a relay having magnet coil 796; likewise valves 497, 498 and 500 are operated by solenoids 497S, 498S and 500S respectively, which are energized when respective contacts 797C, 798C and 800C are closed, and each of these contacts is part of an individual relay with respective magnet coil 797, 798 or 800. In each case the magnet coil must be energized in order to close the contact.

Valve 170 which is illustrated in Figure 11a is operated by two solenoids for shifting the valve plunger to left and right. The lefthand solenoid is indicated by 170L and the righthand one is identified as 170R. Solenoid 170L is energized when contact 770LC is closed, which takes place when magnet coil 770L of the same relay is energized and likewise solenoid 170R is energized when contact 770RC is closed by energizing magnet coil 770R of its relay.

During the entire operation of the press, the solenoids of valves 496, 497, 498 and 500 remain energized for controlled high pressure settings except during the decompression periods. Referring to Figure 18, magnet coils 796, 797, 798 and 800 receive their current from feeder 707 through contact 863C and feeder 707' to the respective magnet coils, then through parallel wires 708, 710, 711 and 712 to a common line 713 and then through the normally closed reversal device which may be of manually operated type or pressure responsive type or limit switch type such as devices 423 or 433 connecting to return line 714 to the source as above described.

When it is desired to lower one or more cushions rapidly simultaneously with the rapid closing of the press, one or more of valves 227, 226, 225 and 222 will be operated as previously described. For this description, we will consider valve 227 alone, the valve plunger of which will be shifted to the left by energizing solenoid 227R.

When the electric circuits are made which initiate the downward stroke of the press, a contact 715 is closed (Figure 18). This is of the type which remains closed during the down stroke of the cycle by conventional interlocks forming part of the conventional press circuit (or by manual manipulation as desired).

In series with this contact 715 are also provided a limit switch 581 and a two-position maintained contact push button switch 717 as well as the magnet coil 718 of a control relay. The maintained contact push button switch 717 has two buttons and one pair of contacts 720 and 721. It has one contact bar 730. In those operating cycles when the cushion is not to be lowered during the rapid closing of the press, the switch 717 is positioned such that the contact bar 730 rests against two supporting posts 731 and 732 and the circuit between contacts 720 and 721 is open. When it is desired to operate the valve 227 for the rapid lowering of the cushion during the closing stroke of the press, the push button device 717 is tripped to the opposite position whereby the contact bar closes the circuit between contacts 720 and 721. The switch is therefore in its closed position for the conditions I am now considering and current will therefore flow from supply 707' through coil 718, wire 733, contact bar 730, wire 734, switch 581, wire 735, contact 715 to return line 714, thus energizing magnet coil 718 and tripping its relay, thereby closing normally open contact 728C of that relay. This contact is mounted in series with magnet coil 727R completing circuit branch 736 and energizing magnet coil 727R which energizes solenoid 227R as desired, thereby causing the upper part of the respective cushion cylinder to be directly connected to the related blank holder cylinder so the two can descend simultaneously in the manner previously described. At the same time, another contact 718C' of relay 718 closes a circuit branch 737 through magnet coil 770R, whereby solenoid 170R is energized which shifts valve 170 of Figure 11a to the left so hydraulic

liquid pressure from pump 163 is applied to the pull-down area 67 of all the cushions, forcing the same cushion to follow with the downward movement of the corresponding blank holder ram.

When this cushion has descended through the desired length of stroke, limit switch 581 is tripped, opening its circuit, thereby deenergizing magnet coil 718 and in turn deenergizing circuit branches 736 and 737 which causes deenergizing of solenoids 227R and 170R, thereby centralizing valves 227 and 170, thus stopping further downward movement of the respective cushion, at the same time permitting further filling of the corresponding blank holder cylinder in the usual manner from the surge tank through the respective check valve. In the same manner as described for valve 227, like circuits are provided for operating valves 226, 225 and 222, using limit switches 738, 740 or 741, maintained contact push button switches 742, 743, 744, relays with magnet coils 745, 746 or 747 and with contacts 745C, 746C, 747C, thereby closing circuit branches 748, 750 and 751 for energizing respectively valves 226, 225 and 222 through the usual steps. Together with the energizing of either of these circuits, one or more of contacts 745C', 746C' or 747C' are closed to energize branch circuit 737 for the appropriate energizing of solenoid 170R. Thus when several cushions are being lowered simultaneously, solenoid 170R remains energized until the last cushion has reached its predetermined lowered position.

Stripping operations

When it is desired during the upstroke of the press to raise one or more of the cushions, the same is accomplished as previously described by the interlocking of the upper or main cushion cylinder area with the respective blank holder ram area by the positioning of the valves of Figure 11 (227, 226, 225 or 222). This is accomplished by energizing of solenoid 227R, 226R, 225R or 222R during the proper interval of the press operation.

During the downward stroke of the press, the cushions which are to be used for stripping purposes were lowered either rapidly during the fast closing stroke or as resistance cushions under the downward urge of the draw slide. During the initial downward movement of the cushions the respective limit switches 565, 565', 565² and 565³ are closed, and limit switches 566, 566', 566² and 566³ are also closed.

During the upward stroke, the signal to commence stripping is given by the conventional electrical control equipment or by manual action and in the single action cycle may occur by tripping limit switch 563 at any time following the completion of decompression of hydraulic liquid but not later than the resetting of slow-down limit switch 435. In the regular double action cycle it is to be done either simultaneously with or at approximately the same time as the resetting of the same limit switch 435 as previously described. In the alternate double action cycle it is to occur after the drawslide has lifted by only a short distance, by tripping limit switch 563.

The tripping of either limit switch or other controlling equipment closes a contact 756 (Figure 18) which will operate those cushion circuits which are preset for stripping functions. For valve 227 this is accomplished by the previous tripping (closing) of limit switches 565 and 566. Switch 565 is now closed between contacts 757 and 758, thus causing the immediate energizing of branch circuit 762. Switch 566 is closed between contacts 760 and 761. Branch circuit 763, however, is not energized because normally closed contact 764C has been opened by the energizing of relay magnet coil 764 when branch 762 became energized. The energizing of relay 764 causes the simultaneous energizing of normally open contact 764C' of the same relay, thereby energizing relay magnet coil 727R and in turn shifting the valve

the press. The conventional operating circuit 707² of the press is likewise connected so contact 803C must be closed to permit operating the machine. There is one exception, that when double action draw takes place, separation between the bottom face of the blank holder slide and pads 457 is required, and for this purpose the press operating circuit is provided with a holding contact 804 which will close at the appropriate time to permit continuing of the press operation irrespective of the opening of contact 803C.

Alternate stripping sequence by raising draw and blank holder slides simultaneously during the initial opening of press

Following the decompression of hydraulic liquid from all press cylinders simultaneously as previously described, valve 454 must be closed to trap hydraulic liquid in the annular or supporting areas below pistons 113' of auxiliary cylinders 112. For safety purposes it is preferable that this valve 454 be of a normally closed type so that by deenergizing the solenoid, the hydraulic liquid becomes entrapped and upon energizing the solenoid, the valve opens, therefore in the conventional sequences of this press the solenoid 454S (Figure 19) of this valve is energized continuously. In the special sequence which is now being described, the solenoid 454S must be deenergized prior to lifting of the slides and this may be done at any time during the period of decompression. However, for maximum safety it is preferable to accomplish this at the time decompression is started to allow adequate time for the closing of the valve.

This solenoid 454S is energized by closing contact 805C (Figure 19) on a relay having magnet coil 805 which operates in branch circuit 806. Normally during all of the cycles this circuit is completed through normally closed selector switch 807 so that coil 805 and solenoid 454S are continually energized. When desired to operate on the special cycle now under discussion, selector switch 807 is opened manually and remains open during these cycles. Relay magnet coil 805 will then be energized during the down stroke on the press by receiving current through normally closed contact 423 and connecting circuit 808, but when decompression is initiated by the opening of contact 423, magnet coil 805 will become deenergized (at this time circuit 815 of limit switch 464 is open, because the press slides are in lowered positions). The deenergizing of magnet coil 805 causes the closing of a normally open contact 805C' in branch circuit 810 which energizes magnet coil 811 and this in turn opens a normally closed contact 811C in circuit 808 to prevent reenergizing of relay magnet coil 805 prematurely.

The upward stroke of the press will then commence with the various conventional controls set for the lifting of the draw and blank holder slides and because relay 805 has deenergized solenoid 454S, valve 454 is closed, causing the lifting of the blank holder slide by hydraulic liquid which is entrapped in the lower portion of cylinders 112 so that the two slides lift simultaneously.

If it is desired to interrupt the lifting stroke at any point, this may be done by the manual manipulation of the press controls and restarting may again be performed by the manual manipulation of the usual controls.

When the blank holder slide has reached a position near its full upper level, it trips limit switch 463 as previously described, causing the locking of hydraulic liquid in the four blank holder cylinders. For this purpose valves 227, 226, 225 and 222 are shifted with their plungers to the right by energizing solenoids 227L, 226L and 222L, requiring the energizing of relay magnet coils 727L, 726L, 725L and 722L. When limit switch 463 in circuit 812 closes, that branch circuit is closed (limit switch 464 being closed at this time) energizing relay magnet coil 813 which closes contacts 813C, 813C', 813C² and 813C³, thereby energizing the required relay magnet coils and

causing the required shifting of the valves. An interlocking contact 814 is provided in circuit 812 which is interlocked with the usual control circuit 707² to make circuit 812 inoperative during the usual press cycles, also during the downward stroke of the present cycle. Valves 227, 226, 225 and 222 having been energized to the right and the hydraulic liquid in the respective blank holder cylinders having been blocked, requires that with continued upward movement of the draw slide, hydraulic liquid is forced out through the relief valve portion of valve 454 while holding the blank holder slide in its fixed position.

When the draw slide has thus advanced and nearly reaches the level where pads 457 will contact the bottom face of the blank holder slide, limit switch 464 is tripped and its contact opened by cam 434 on the draw slide. This limit switch is placed in circuit 812, causing deenergizing of relay magnet coil 813, opening of contacts 813C, 813C' and 813C² and 813C³ and through the various sequences this causes the centering of valves 227, 226, 225 and 222, thus permitting further upward movement of the blank holder slide. Simultaneously herewith relay magnet coil 805 becomes again energized by the closing of a second circuit in limit switch 464, which is of the double pole double throw type, closing the branch circuit 815 which connects with branch circuit 806, thus reenergizing coil 805, thereby reenergizing solenoid 454S and opening valve 454, also deenergizing circuit 810. The auxiliary pistons 113' having entered their cushioning ranges are now supporting the blank holder slide resiliently and during continued upward movement of the draw slide the blank holder slide is simultaneously raised to its full upward position, at which time it will rest upon pads 457. By this time limit switch 461 has been tripped, opening all of the remaining press cycle control circuits and causing decelerating and stopping of the upward press motion.

In view of my invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of my invention without copying the structure shown, and I therefore claim all such insofar as they fall within the reasonable spirit and scope of my claim.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a hydraulic press, a main ram, a main cylinder for the main ram, a draw slide comprising a main stress-carrying body relatively adjacent to and operatively connected to the main ram, a relatively light bolster plate in spaced relation to the body and more remote from the main ram, having single openings distributed over its area, bolster-supporting posts connected to the body and to the bolster plate and distributed over the bolster plate, a blank holder slide substantially continuous over the pressing area, interposed between the body and the bolster plate and having small openings through which the bolster-supporting posts extend, a blank holder cylinder and ram operatively connected to the blank holder slide, a blank holder die located on the side of the bolster plate remote from the main ram and having an opening, pins extending from the blank holder slide to the blank holder die through the openings in the bolster and distributed over the blank holder die, and a punch mounted on the bolster and extending into the opening in the blank holder die, whereby the pressure pins extend through the bolster plate but not through the main body of the draw slide.

2. A hydraulic press according to claim 1, having plates at the sides interconnecting the main body of the draw slide and the bolster plate, the blankholder slide being enclosed in a box construction formed by the bolster plate, the main body of the draw slide and the side plates.

3. In a hydraulic press, a frame including a crown, a base, interconnecting housings with tie rods, a main cylinder and ram operatively interconnected with the frame, a draw slide comprising a main stress-carrying body relatively adjacent to and operatively connected to the main

ram, a relatively light bolster plate in spaced relation to the body and more remote from the main ram, having small openings distributed over its area, bolster-supporting posts connected to the body and to the bolster plate and distributed over the bolster plate, and side plates interconnecting the main body with the bolster plate, a blankholder slide substantially continuous over the pressing area, interposed between the body and the bolster plate and having small openings through which the bolster-supporting posts extend, a blankholder cylinder and ram operatively connected to the blankholder slide, a blankholder die located on the side of the bolster plate remote from the main ram and having an opening, pins extending from the blankholder slide to the blankholder die through the openings in the bolster and distributed over the blankholder die, a punch mounted on the bolster and extending into the opening in the blankholder die, auxiliary blankholder cylinders and rams operatively interconnected between the draw slide and the blankholder slide, valve means for closing fluid flow from the auxiliary blankholder cylinders, a stalk extending from the main slide toward the crown, guides on the crown guiding the stalk transversely and longitudinally, guides on the main slide guiding on the housings, a plurality of cushions opposed to different areas of the draw slide, cushion cylinders and rams operatively connected to the respective cushions, hydraulic connections including valve means which, while the press is closing, are operative to connect in a closed circuit between one group of at least one blank holder cylinder at the end at which hydraulic liquid is displaced when the blank holder slide moves toward the work to one cushion cylinder at the end which causes movement away from the work, hydraulic connections including valve means which, while the press is closing, are operative to connect in a closed circuit between another group of at least one blank holder cylinder at the end at which hydraulic liquid is displaced when the blankholder slide moves toward the work to another cushion cylinder at the end which causes movement away from the work, the cushions having secondary areas adapted to cause the cushions to follow the displacement of hydraulic fluid from the cushion areas, hydraulic connections including valve means, which, while the press is opening, are operative to connect in a closed circuit between one group of at least one blank holder cylinder at the end at which hydraulic liquid is displaced when the blank holder slide moves away from the work and one cushion cylinder at the end which causes movement toward the work, hydraulic connections including valve means which, while the press is opening, are operative to connect in closed circuit between another group of at least one blank holder cylinder at the end at which hydraulic liquid is displaced when the blankholder slide moves toward the work and another cylinder at the end which causes movement toward the work, hydraulic means for closing the draw slide and the blank holder slide in unison and for developing blank holder pressure, an electric circuit operatively connected to the hydraulic means, and safety means including a plurality of electric switches acting between the draw slide and the blankholder slide, operative on abnormal spacing of the blankholder slide and the draw slide at any point of switch location to stop press operation, and separate valve means associated with the hydraulic means for decompressing the main cylinder and simultaneously but separately decompressing the cushion cylinder.

4. A hydraulic press according to claim 1, having guideway means vertically extending between the main stress carrying body and the bolster plate of the draw slide, and guides vertically aligned and cooperating with the guideway means located on the blankholder slide and guiding on the guideway means.

5. A hydraulic press according to claim 1, in which the bolster supporting posts extend in the direction of the axis of motion of the main slide, having guides positioned on

the blankholder slide at interior locations, extending in the direction of said axis and engaging and guiding on at least certain of the bolster supporting posts.

6. A hydraulic press according to claim 1, in combination with an auxiliary cylinder and ram operatively connected between the draw slide and the blankholder slide, a hydraulic system for the auxiliary cylinder, receiving its energy from relative motion of the draw slide and the blankholder slide and means in the hydraulic system for restricting the flow of hydraulic liquid from the auxiliary cylinder and thereby absorbing energy of contact of the draw slide and the blankholder slide engaging one another.

7. A hydraulic press according to claim 1, in combination with an auxiliary cylinder and ram operatively interconnected between the draw slide and the blankholder slide, a hydraulic system for the auxiliary slide receiving its energy from relative motion of the draw slide and the blankholder slide, and valve means in the hydraulic system for cutting off flow of hydraulic liquid from the auxiliary cylinder to make the blankholder retract in spaced relation to the main slide after having first absorbed the energy of contact.

8. A hydraulic press according to claim 1, in combination with a plurality of auxiliary blankholder cylinders and rams operatively connected respectively between the draw slide and the blankholder slide at a plurality of spaced positions over the area of the blankholder slide and extending in the direction of the axis of motion of the draw slide, a hydraulic system for the auxiliary blankholder cylinders receiving its energy by relative motion between the draw slide and the blankholder slide, valve means controlling escape of hydraulic liquid in the hydraulic system from the blankholder cylinders, and means for closing the valve means when the draw slide is under pressure to prevent the escape of hydraulic liquid and make the liquid in the blankholder cylinders act as supporting columns for the blankholder slides.

9. A hydraulic press according to claim 1, in combination with a frame including a crown, a base, an interconnecting housing with tie rods, a stalk extending from the draw slide toward the crown, guides on the crown guiding the stalk transversely and longitudinally and extending in the direction of the axis of motion of the draw slide, a plurality of cushions opposed to the draw slide, cushion cylinders and rams operatively connected to the respective cushions, hydraulic systems for the cushions, there being a plurality of blankholder cylinders and rams, hydraulic systems for the blankholder cylinders, valve means operative while the press is closing for connecting in a closed circuit the hydraulic system of at least one blankholder cylinder at the end at which hydraulic liquid enters the blank holder cylinder when the blankholder slide moves toward the work and the hydraulic system of at least one cushion cylinder at the end which permits movement away from the work, valve means operative while the press is closing for connecting in a closed circuit the hydraulic system of another group including at least one blankholder cylinder at the end at which hydraulic liquid enters the blankholder cylinder when the blankholder slide moves toward the work and the hydraulic system of at least another cushion cylinder at the end which permits movement away from the work, thereby maintaining uniform alignment of the several cushions during operation.

10. A hydraulic press according to claim 1, in combination with a frame including a crown, a base and interconnecting housings with tie rods, a stalk extending from the draw slide toward the crown, guides on the crown extending in the direction of the axis of motion of the draw slide guiding the stalk transversely and longitudinally, there being a plurality of blankholder cylinders and rams operatively connected to the blankholder slides, the blankholder slide in one position engaging the bolster plate substantially over its area, a plurality of cushions

opposed to different areas of the draw slide, a plurality of cushion cylinders and rams operatively connected to the respective cushions, hydraulic systems for the blankholder cylinders, hydraulic systems for the cushion cylinders, valve means operative while the press is opening for connecting in a closed circuit the hydraulic system of at least one blankholder cylinder at the end at which hydraulic liquid is expelled when the blankholder slide moves away from the work and the hydraulic system of at least one cushion cylinder at the end which causes movement toward the work, and valve means operative while the press is closing for connecting in a closed circuit the hydraulic system of at least one blankholder cylinder at the end at which hydraulic liquid is expelled when the blankholder slide moves away from the work and the hydraulic system of at least another cushion cylinder at the end which causes movement toward the work, whereby the several cushions operate in unison maintaining uniform alignment.

11. In a hydraulic press, a draw slide, a main cylinder and ram operatively connected to the draw slide, a hydraulic system for the main cylinder, an electrically operated release valve in the hydraulic system of the main cylinder, a blankholder slide movable in the press in predetermined relation with the draw slide, a hydraulic system for the blankholder slide adapted to advance the blankholder slide in unison with the advance of the draw slide and to develop blankholder pressure, an electric circuit operatively connected to the electrically operated valve, and switch means in the electric circuit including a plurality of electric switches having operating elements which actively engage between the draw slide and the blankholder slide, and which respond by change of switch position when a predetermined spacing is established between the blankholder slide and the main slide at a point of location of any one of the switches, the switches being operative to energize the electrically operated valve and stop the press when a predetermined abnormal spacing at any switch occurs.

12. In a hydraulic press, a draw slide having a body, a spaced bolster plate and a plurality of interconnecting posts, a main cylinder and ram operatively connected to the draw slide, a hydraulic system for the main cylinder, an electrically operated release valve in the hydraulic system for the main cylinder, a blankholder slide between the body and the bolster plate, a stalk extending from the draw slide away from the bolster plate, a frame including a crown, a base and interconnecting housings with tie rods, hydraulic means for operating the blankholder slide and moving it forward in unison with the draw slide to develop blankholder pressure, an electric safety circuit including the electrically operated valve, and a plurality of safety switches in the electric safety circuit having operating mechanism which engages between the main slide and the blankholder slide, and which is operative on establishment of a predetermined abnormal spacing between the blankholder slide and the main slide at any point of switch location to stop operation of the press.

13. In a double acting hydraulic press, a draw slide, a blankholder slide in one phase following the motion of the draw slide, a plurality of blankholder cylinders and rams operatively connected to the blankholder slide, a hydraulic system including a source of liquid under pressure and a source of slack liquid for the blankholder cylinders, a plurality of cushions, a plurality of cushion cylinders and rams operatively connected to the cushions, relief valve means for the respective cushions, a first liquid system connecting in a closed circuit at least one blankholder cylinder at the end at which hydraulic liquid enters the blankholder cylinder when the blankholder slide moves toward the work and at least one cushion cylinder at the end which permits movement away from the work, a second liquid system connecting in a closed circuit at least one other blankholder cylinder at the end at which hydraulic liquid enters the blankholder cylinder

when the blankholder slide moves toward the work and at least one other cushion cylinder at the end which permits movement away from the work, a cushion control valve in each liquid system having a first position connecting together the blankholder and cushion cylinders in the closed circuit free from connection to any source of pressure liquid and having a second position closing off the cushion cylinders and connecting the blankholder cylinders to receive a slack fluid and fluid under pressure, means to urge the cushions downward at a rate established by the rate at which the blankholder cylinders receive hydraulic fluid when the cushion control valves are in the first position, means to shift the cushion control valves to the first position as the blankholder slide moves downward, and means to shift the cushion control valves to the second position as the cushions reach a predetermined position, whereby uniform alignment of the several cushions is maintained during lowering of the cushions and the cushions are then stopped and available for stripping functions during the subsequent opening stroke of the press or to serve as resistance cushions during the last portion of the draw operation of the press.

14. A hydraulic press according to claim 13, in which the means to urge the cushions downward includes, in addition to gravity, a secondary pressure area on each cushion cylinder, and a hydraulic system including a source of liquid under pressure and valve means connected to the secondary pressure areas.

15. A hydraulic press according to claim 13, in combination with a main cylinder and ram operatively connected to the draw slide, a hydraulic system including a source of hydraulic liquid under pressure for the main cylinder and valve means in the hydraulic system of the main cylinder in one position operatively connected to release the hydraulic pressure in the main cylinder and having a predetermined rate of release, and separate valve means in the hydraulic system of the cushion cylinders operative in one position to release the hydraulic pressure in the cushion cylinders and having a predetermined rate of release more rapid than the rate of release of the valve means for the main cylinder, and means for simultaneously initiating action to accomplish release of the pressure by the valve means for the main cylinder and by the valve means for the cushion cylinders.

16. A hydraulic press according to claim 13, in combination with a hydraulic system including a source of liquid under pressure, valve means for closing same to the cushions at the ends of the draw stroke, and means for opening said valve means to perform a supplementary upward draw action.

17. In a double acting hydraulic press, a draw slide, a blankholder slide in one phase following the motion of the draw slide, a plurality of blankholder cylinders and rams operatively connected to the blankholder slide, a hydraulic system including a source of liquid under pressure and a source of slack liquid for the blankholder cylinders, a plurality of cushions, a plurality of cushion cylinders and rams operatively connected to the cushions, relief valve means for the respective cushions, a first liquid system connecting in a closed circuit at least one blankholder cylinder at the end at which hydraulic liquid is expelled from the blankholder cylinders when the blankholder slide is moved away from the work and at least one cushion cylinder at the end which causes movement toward the work, a second liquid system connecting in a closed circuit at least one other blankholder cylinder at the end at which hydraulic liquid is expelled from the blankholder cylinders when the blankholder slide is moved away from the work and at least one other cushion cylinder at the end which causes movement toward the work, a cushion control valve in each liquid system having a first position connecting together the blankholder and cushion cylinders in the closed circuit free from any connection to any source of pressure liquid and having a second position closing off the cushion cylinders and

connecting the blankholder cylinders to discharge slack fluid, means to shift the cushion control valves to the first position as the blankholder slide moves upward, and means to shift the cushion control valves to the second position as the cushions reach a predetermined position, whereby uniform alignment of the several cushions is maintained during lifting of the cushions and while the cushions are available for stripping functions.

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