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J. VERNON ET AL

2,587,076

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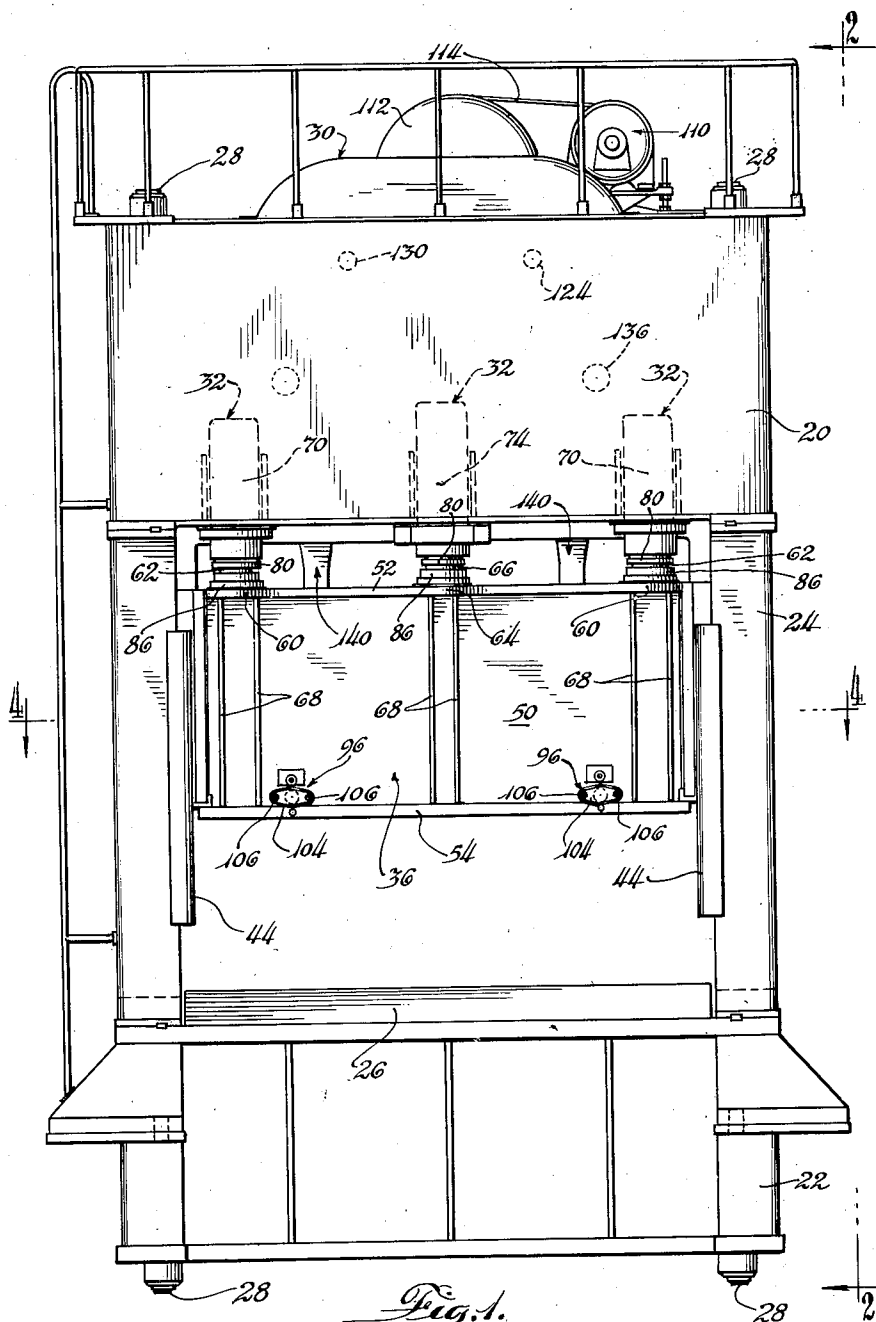


Fig. 1.

Inventors:

John Vernon

Nick Kassner

By Hinkle, Horton, Ahlberg, Hansmann & Wupper
Attorneys.

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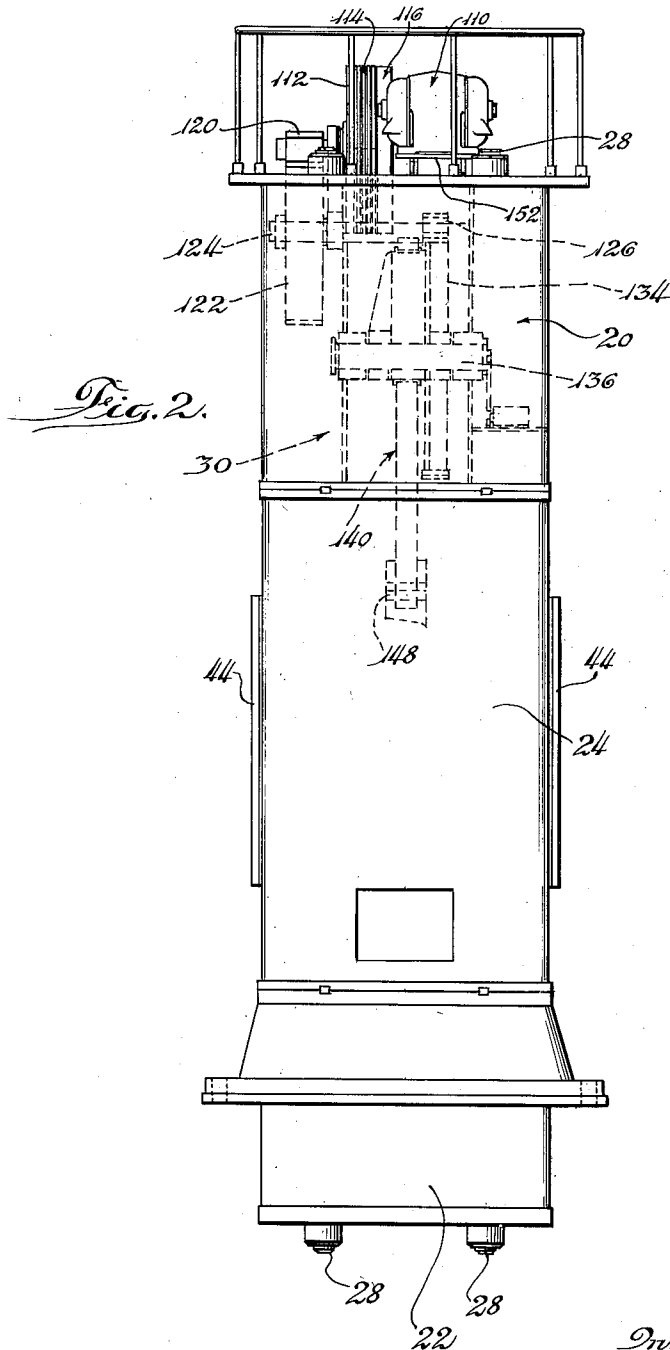
J. VERNON ET AL

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Inventors:
John Vernon
Nick Lassnel
By *Hinkle, Horton, Ahlberg, Hansmann & Myrper*
Attorneys.

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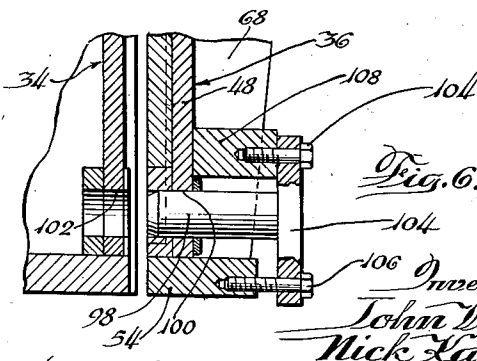
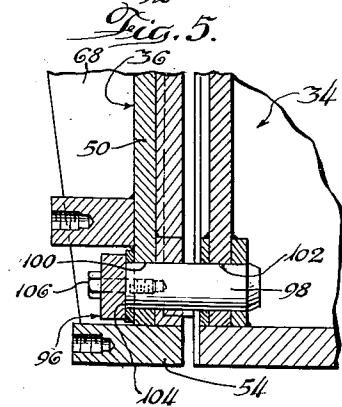
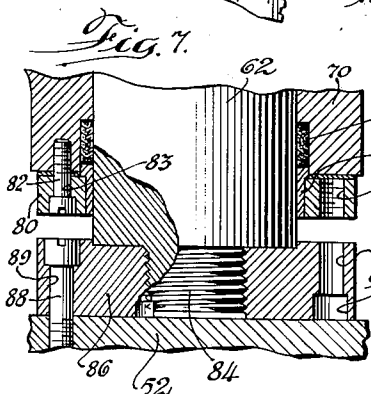
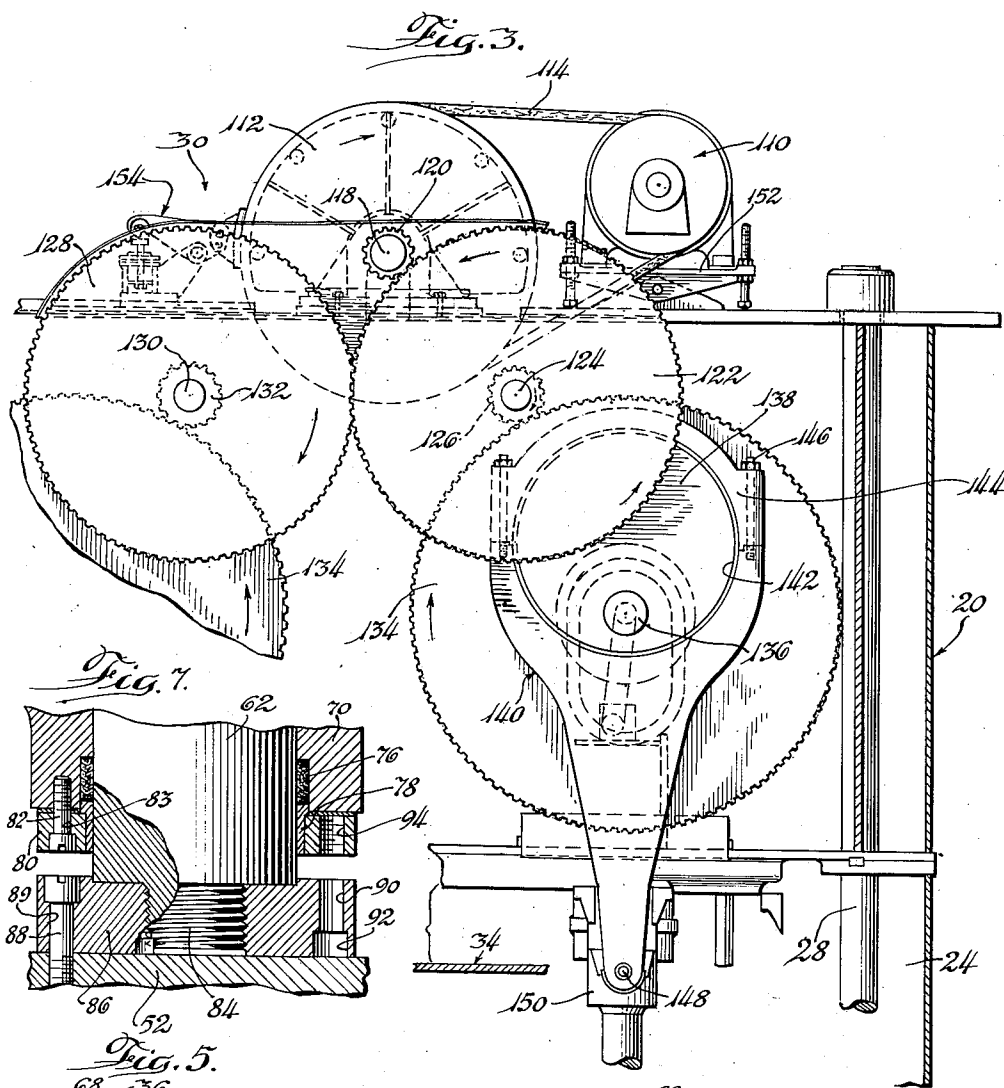
J. VERNON ET AL

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Inventors:
John Vernon
Nick Kassnel

By Hinkle, Horton, Ohlberg, Hansmann & Kupper
Attorneys.

Feb. 26, 1952

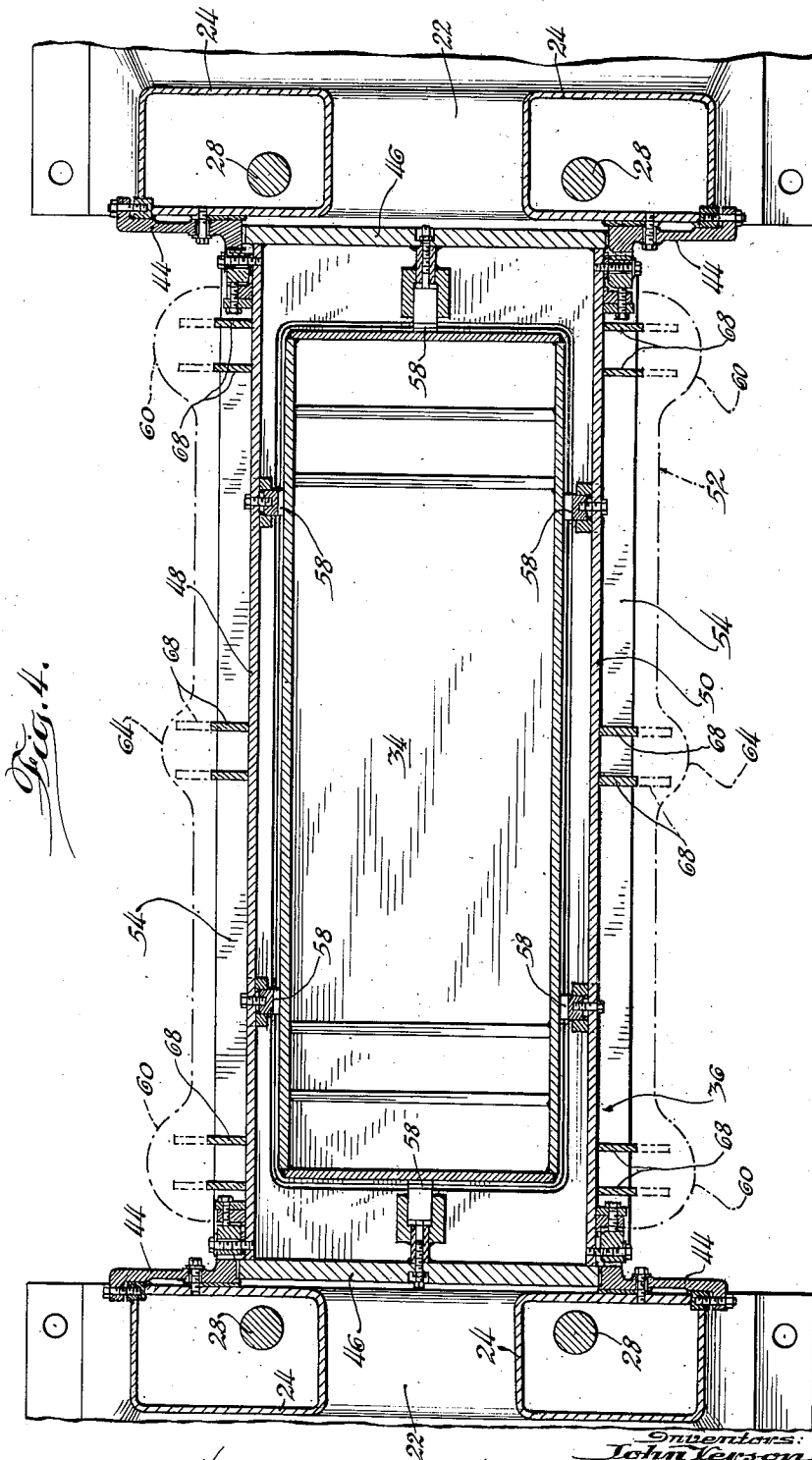
J. VERNON ET AL.

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Inventors:
John Verson
Nick Lassmel
By Hinkle, Horton, Dillberg, Hansmann & Kipper Attorneys

Feb. 26, 1952

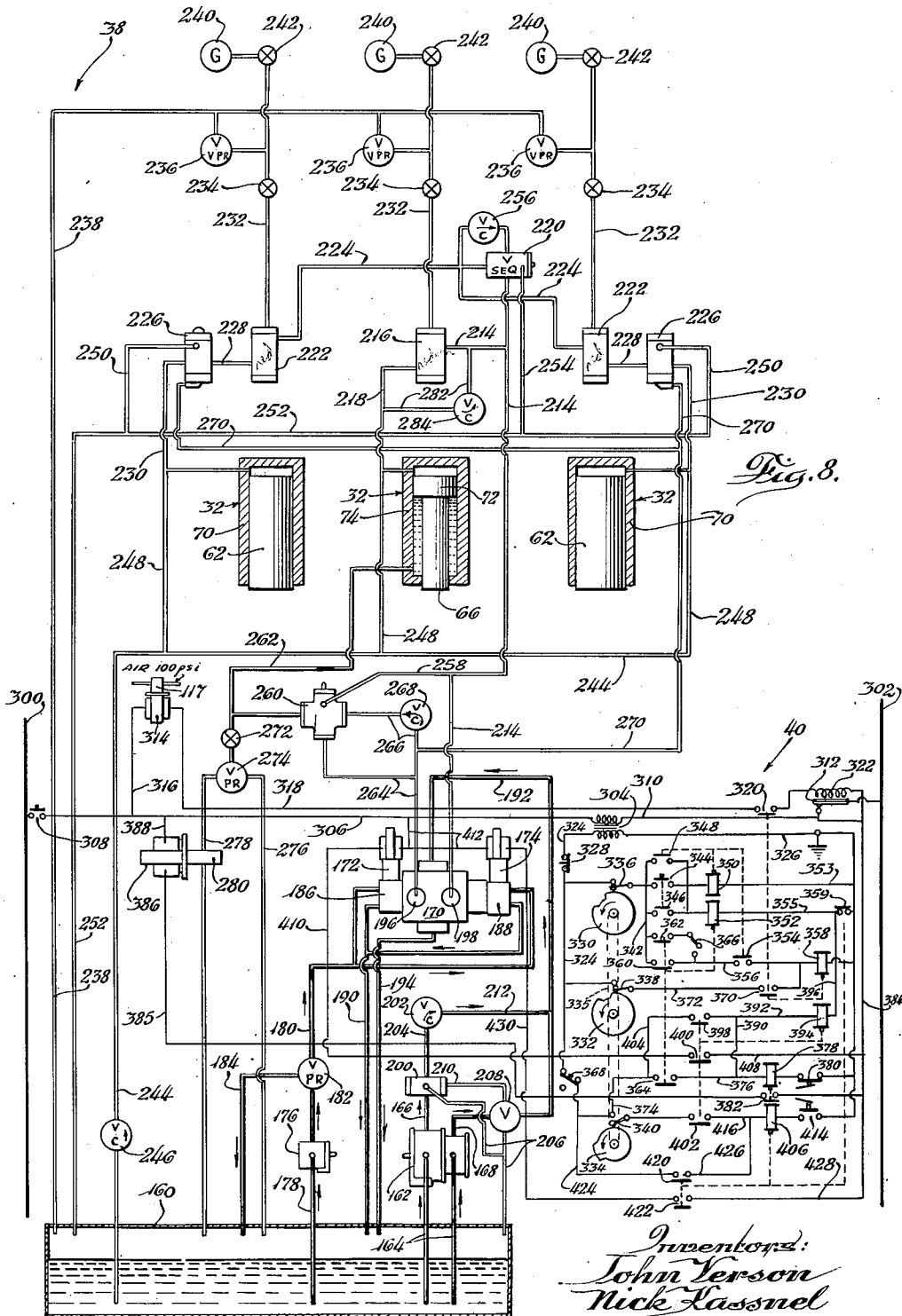
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Inventors:
John Vernon
Nick Lassnel

By Hinkle, Horton, Oltberg, Harmsmann & Whisler Attorneys.

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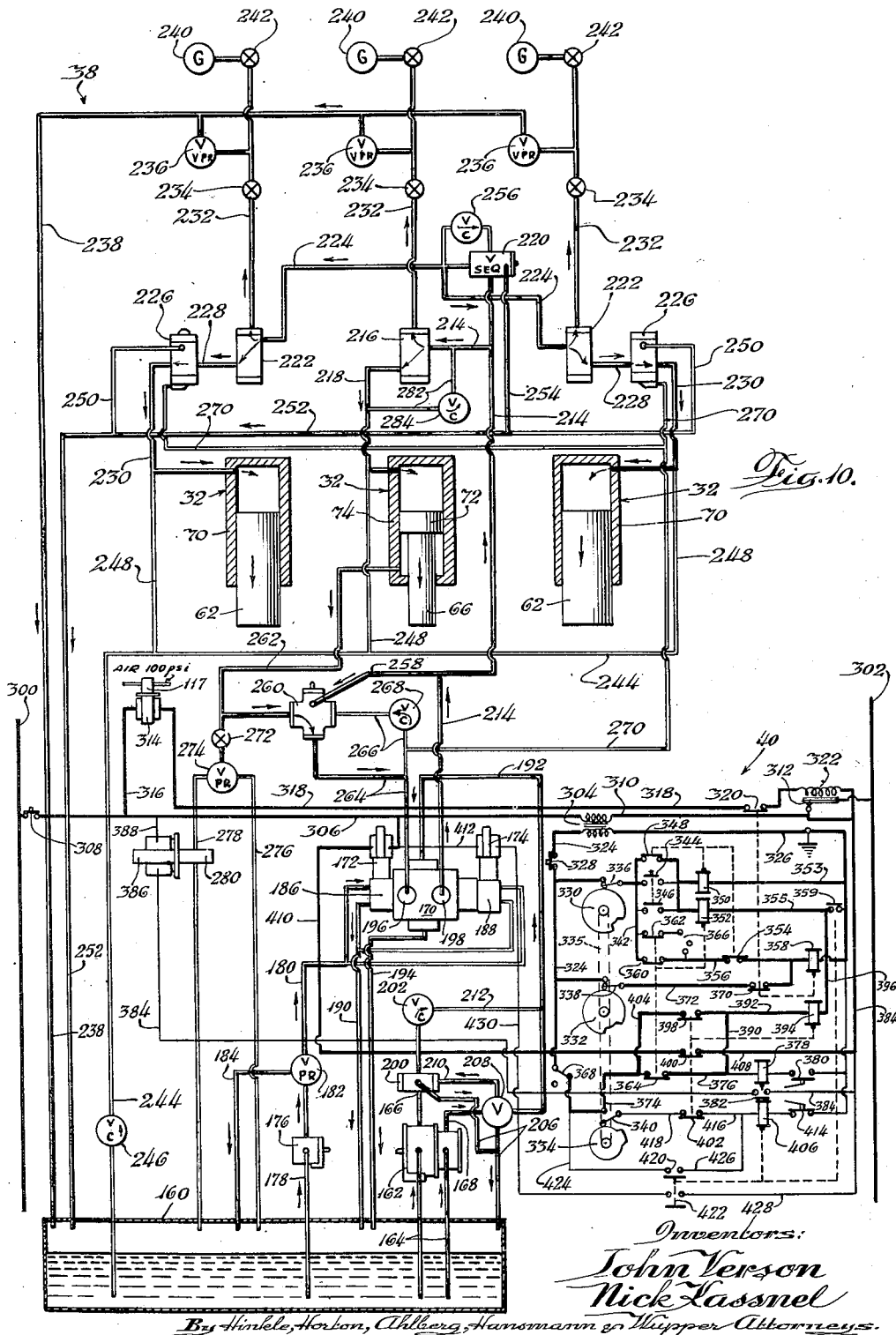
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UNITED STATES PATENT OFFICE

2,587,076

PUNCH PRESS

John Verson and Nick Kassnel, Chicago, Ill., assignors to Verson Allsteel Press Company, Chicago, Ill., a corporation of Delaware

Application July 15, 1948, Serial No. 38,916

9 Claims. (Cl. 113—46)

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The present invention relates to presses for drawing and forming sheet metal, and in particular to a novel convertible press that may be operated as single acting or double acting.

It has been difficult to obtain versatility in the design of metal working presses due to their large size, engineering problems encountered and the complexity of their operating and controlling mechanisms. These difficulties are enhanced in combination presses, that is, presses wherein the drawing or blanking is performed mechanically and the work holding is performed hydraulically. And even further difficulties are encountered when it is desired to embody mechanical drawing with hydraulic blank holding in a convertible press which can be operated as a single action press and also as a double action press.

It is, therefore, the principal object of the present invention to provide a novel combination mechanical and hydraulic metal working press which can be operated either single acting or double acting.

Another object is to provide an improved combination single action and double action press which is operated fully mechanically when single acting.

Another object is to provide a novel combination single action and double action press which is mechanically and hydraulically actuated when operated double acting.

A further object is to provide an improved combination single and double action press which provides complete control over the timing of the blank holding cycle.

Still another object is to provide an improved single and double action press wherein the timing of the blank holding cycle is accomplished from the work cycle.

Another object is to provide an improved combination single and double action press which may readily be changed to double acting from single acting and to single acting from double acting.

Another object is to provide a novel single and double acting press which when operated single acting has a work slide which is composed of the blank holder slide and the work slide of the double action press.

Another object is to provide a novel interlock between the work and blank holder slides of a press so that these two slides may, if desired, be reciprocated in unison.

Another object is to provide a novel combination single and double acting press which when operated single acting utilizes only the main or

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work slide with the blank holder slide locked in its inoperative position.

And another object is to provide a novel combination single and double action press which when operated single acting may use either a work slide composed of the usual work slide locked to the blank holder slide or only the work slide with the blank holder slide locked in its inoperative position.

And a further object is to provide a novel convertible single and double action press wherein the independent mechanism for reciprocating the blank holder slide is rendered inoperative when the press is operated single acting.

And still another object is to provide a novel convertible single and double action press having a hydraulic system for effecting the blank holding operation when the press is operated double acting and incorporating means whereby the hydraulic pistons are disconnected from the blank holder slide and are locked in their cylinders when the press is operated single acting.

Other objects and advantages will become apparent from the following description taken in conjunction with the accompanying drawings wherein:

Fig. 1 is a front elevational view of a press embodying the present invention;

Fig. 2 is a side elevational view of the press and may be considered as being taken along the line 2—2 of Fig. 1 looking in the direction of the arrows;

Fig. 3 is an enlarged elevational view of the mechanical drive for the work slide or main platen;

Fig. 4 is an enlarged cross-sectional plan view showing constructional details of the work and blank holder slides and may be considered as being taken substantially along the line 4—4 of Fig. 1, looking in the direction of the arrows;

Fig. 5 is a detailed sectional view of the interlock between the work slide and the blank holder slide, illustrating the "locked" position;

Fig. 6 is a detailed sectional view of the interlock between the work slide and the blank holder slide illustrating the "unlocked" position;

Fig. 7 is a detailed view showing a typical connection between a blank holder slide piston and the blank holder and illustrating the means for locking the blank holder slide piston to the crown of the press when the press is operated as single acting;

Fig. 8 is a diagrammatic view of a representative portion of the hydraulic control circuit and a typical electrical circuit illustrating the circuit components in top rest position;

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Fig. 9 is a diagrammatic view similar to Fig. 8, illustrating the circuit components immediately after the "start" button has been pressed and the blank holder slide is in the rapid advance stage of its cycle;

Fig. 10 is a diagrammatic view similar to Fig. 8 illustrating the circuit components when the press has developed pressing speed and is in the drawing or forming portion of the press cycle; and

Fig. 11 is a diagrammatic view similar to Fig. 8 illustrating the circuit components after the press has reversed itself and the work and blank holder slides are being restored to the rest position.

General organization

Referring primarily to Figs. 1 and 2, the press is shown as comprising a crown 20 and a bed 22 interconnected by end columns 24; a bolster plate 26 is supported upon the press bed 22. The crown and bed are tied together by the conventional tie rods 28 by means of which the press frame is prestressed. A mechanical drive mechanism 30 is mounted in the crown 20 as are the blank holding cylinder-piston combinations 32 of which there are six in the embodiment of the press shown in this patent application. The mechanical drive 30 is suitably secured to a work slide or main platen 34 and the cylinder-piston combinations 32 may likewise be suitably and removably secured to a blank holder slide 36.

The blank holder slide is actuated when the press is operated as double acting by a hydraulic circuit 38 illustrated diagrammatically in Figs. 8 to 11. The hydraulic circuit includes solenoid operated elements which are controlled from an electrical circuit 40 similarly diagrammatically illustrated in Figs. 8 to 11. These figures, for simplicity of illustration, show a hydraulic circuit having only three cylinders, but it is understood that any number of cylinders may be employed. Likewise, the electrical circuit is merely typical of any suitable electrical circuit that may be used in conjunction with the particular hydraulic circuit.

Blank holder slide

Referring particularly to Figs. 1 and 4, it will be observed that the blank holder slide 36 is guided on gibs 44 adjustably bolted to the columns 24. The blank holder slide 36 comprises a pair of end wall forming members 46, a rear wall 48, front wall 50, and top and bottom plates 52 and 54, respectively. The blank holder slide is hollow and is formed with openings in the top and bottom plates through which the work slide 34 may move relative to the blank holder slide (Fig. 4). The work slide 34 is slidable on suitable adjustable gibs 56 carried by the blank holder slide 36. These gibs 56 are sufficiently long to permit the work slide 34 to be guided thereby when the press is operated single acting with the blank holder slide 36 stationary.

The top plate 52 of the blank holder slide 36 is formed at the corners as indicated by the dash-dot lines in Fig. 4 with arcuate projections 60 to accommodate blank holder pistons 62. At the front and rear the top plate 52 is formed with smaller arcuate projections 64 to form places in which to secure blank holder piston rods 66. Since the top plate 52 carries all of the load transmitted from the blank holder piston-cylinder combinations 32 to the blank holder slide, it is additionally braced by suitable plates 68 which may be welded to the outer faces of the

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blank holder slide walls 48 and 50 and to the under side of the top plate 52.

A typical connection between a blank holder piston and the blank holder slide 36 is illustrated in detail in Fig. 7. Inasmuch as this connection is substantially the same whether it is for one of the blank holder pistons 62 or for a blank holder connecting rod 66 only one such connection will be described.

When the press is operated single acting with the blank holder slide 36 locked to the work slide 34 for movement therewith, it is essential that the mechanical drive not be hampered by the fluid which otherwise would be trapped in the cylinders 70 and 74. Such trapped fluid would impose a nonproductive load on the work slide with the blank holder slide interlocked with the work slide. The nonproductive load can be removed from the work slide by disconnecting the pistons 62 and the connecting rods 66 from the blank holder slide 36, but then these pistons and piston rods must be secured out of the path of the reciprocating blank holder slide which then is a part of the work slide.

The structure for holding the pistons and connecting rods out of the path of the reciprocating blank holder slide is shown in detail in Fig. 7, which is taken with reference to one of the pistons 62 and cylinders 70. At the lower end of the cylinder 70 is a packing gland 76 held against displacement by a retainer ring 78. The retainer ring 78 is secured in position by an annulus 80 which is bolted to the lower open end of the cylinder 70 by means of a plurality of machine screws 82 extending through holes 83.

The lower end of the piston 62 is formed with a reduced portion having a threaded stem 84 which is adapted to be threaded into an annulus 86. The annulus 86 is removably secured by means of machine screws 88, extending through suitable holes 89, to the upper plate 52 of the blank holder slide 36. The annulus 86 is provided with a second set of holes 90 having enlarged openings 92 to accommodate the heads of the screws which are arranged so as to coincide with tapped openings 94 in the annulus 80. There are six of each of the holes 83, 94 and 89, 90; and these holes are arranged alternately in the two annuli 80 and 86.

When it is desired to operate the press as single acting, the screws 88 are removed from the upper wall 52 of the blank holder slide and the annulus 86 is moved upwardly against the lower face of the annulus 80. The screws 88 are inserted through the openings 90 and into the tapped openings 94 in the annulus 80 and by drawing the screws 88 up tight the annulus 86 will be drawn against the annulus 80 and the piston 62 locked within the cylinder 70. The piston is thus prevented from slipping downwardly into the path of the reciprocating blank holder slide 36.

At other times when the press is operated single acting the blank holder slide may be held in its upper or rest position by the fluid trapped below the piston heads 72 in the cylinders 74. In these circumstances it is not necessary to lock the pistons 62 to the press crown as they do not interfere with the mechanical reciprocation of the main slide 34 which is guided by the gibs 56 in the stationary hollow blank holder slide 36.

Interlock between the slides

Under certain circumstances when it is desired to operate the press as single acting, the blank

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holder slide 36 may be locked to the main or work slide 34. An interlock 96 is shown in its locked and unlocked positions, respectively, in Figs. 5 and 6. The interlock comprises a pin 98 which extends through openings 100 and 102, respectively, in adjacent walls of the blank holder slide 36 and work slide 34. In the locked position the pin 98 is secured by means of a generally diamond shaped head piece 104 and bolts 106 to the wall 50 of the blank holder slide 36, and the pin 98 extends through the aligned openings 100 and 102 insuring that when the work slide 34 is reciprocated the blank holder slide is similarly reciprocated.

In unlocked position the bolts 106 are withdrawn from the tapped openings in the wall 50, permitting the withdrawal of the pin 98 from the opening 102. After the pin 98 has been withdrawn so that it no longer extends into the opening 102 it is turned through 90° so that the diamond shaped plate 104 has its long axis extending vertically and the bolt holes adjacent the more acute ends of the plate 104 coincide with tapped openings in bottom plate 54 of the blank holder and a block 108 which is welded to the wall 50 of the blank holder slide. The block 108 is of such size that when the inner face of the plate 104 bears against the block's outer face, the inner end of the pin 98 is free of the work slide 34. The pin 98 is secured in the unlocked position by screwing the bolts 104 into tapped openings in the lower wall 54 and block 108.

Mechanical drive

The mechanical drive 30 is most clearly shown in Figs. 3 and 2, and includes an electric motor indicated generally by the reference character 110. The motor 110 drives a fly wheel 112 by means of a multiple belt pulley 114. The fly wheel 112 has associated therewith a suitable air operated combination brake and clutch 116 which is controlled by a solenoid operated air valve 117 (Figs. 8 to 11). The fly wheel and combination brake and clutch are mounted upon a shaft 118 which has a spur gear 120 secured to its outer end, the spur gear 120 intermeshing with an intermediate large gear 122 mounted upon and keyed to a stub shaft 124; the stub shaft has secured to it for rotation therewith a spur gear 126. The intermediate gear 122 meshes with a similarly sized second intermediate gear 128 which is mounted for rotation with a shaft 130 which has secured to it a spur gear 132 similar to the spur gear 126. The spur gears 132 and 126 drive a pair of bull gears 134 in opposite rotational directions as indicated by the arrows in Fig. 3.

One of the bull gears 134 is shown in detail and is mounted upon a shaft 136. An eccentric 138 is formed on or secured to one face of the bull gear 134 and drives a connecting rod 140. The connecting rod 140 includes the conventional split bearing 142, and part 144 is secured in position by means of the bolt and nut combination 146. The lower end of the connecting rod 140 is pivotally secured by means of the pin 148 to an adjustable thrust bearing mechanism 150 in the work slide 34. This bearing mechanism is well known in the press art and need not be described in detail as it forms no part of the present invention.

The motor 110 is mounted on a suitable support 152 at the top of the crown of the press, and the shafts 124, 130 and 136 are journaled in the conventional manner in the crown of the press. A suitable and conventional fly wheel

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brake 154 is provided for coaction with the fly wheel 112 to brake the action of the fly wheel 112 when it is desired to bring the wheel to a stop after a press run and sooner than it would stop by expending its stored up energy.

Hydraulic circuits

The control circuits will be described with particular reference to Figs. 8 to 11 wherein the component parts of the press and the control circuit are diagrammatically illustrated at different stages of the press cycle when the press is being operated as double acting. These illustrations are diagrammatic and the parts may not be properly proportioned as to size relative one to the other. In these figures, those parts of the hydraulic circuit and the electrical circuit which are operative during different stages of the cycle are indicated in heavier lines than the inoperative parts of the circuit. This will become apparent as the description of these parts progresses.

Fluid for the hydraulic circuit is obtained from a tank 160 which is located in the crown of the press. Fluid is circulated from the tank 160 by means of a hydraulic pump 162 having its inlets connected to the tank by inlet pipes 164 and having its outlets connected to conduits 166 and 168.

The hydraulic circuit is primarily controlled by a spring centered, solenoid controlled, pilot operated four-way valve 170. This valve shown is of the type manufactured by Vickers, Inc., of Detroit, Michigan, and is illustrated in U. S. Pat. No. 2,307,544. A pilot pump 176 supplies fluid for operation of the valve 170 and has its inlet connected by means of a pipe 178 to the tank 160 and has its outlet connected by means of a pipe 180 to the valve 170. A variable pressure relief valve 182 having a spill conduit 184 is inserted in the conduit 180 between the pump 176 and valve 170. Solenoids 172 and 174 control pilot valves 186 and 188, respectively, which in turn control the flow of fluid from the pump 176 to operate the four-way valve 170. A return conduit 190 is connected to the outlets from the pilot valves 186 and 188 and leads to the tank 160. The valve 170 has four ports, one port being connected to conduit 192 through which fluid under pressure from the double pump 166 enters the four-way valve 170. A second port is connected by a conduit 194 to the tank 160 and returns fluid to the tank 160 either while the press is at rest position, during which time no fluid under pressure is furnished to the cylinders or while the press is being run through the work phase of the cycle. The functions of and connections to the other two ports 196 and 198 will be explained in detail hereinafter.

Conduit 166 is connected to an unloading valve 200 which in turn is connected to a check valve 202 by a conduit 204 and to the tank by conduit 206. It likewise is connected to a relief valve 208 by conduit 210. The unloading valve is set at 900 p. s. i. The pressure relief valve is also connected to the conduit 206 which returns to the tank 160. The check valve 202 and pressure relief valve 208 are connected to the conduit 192, the former by a conduit 212.

During the work portion of the cycle fluid flows from the four-way valve 170 through the port 198 into a conduit 214 which is connected to a pressure reducing valve 216 which is in turn connected through a conduit 218 to a port at the upper end of the cylinder 74 and above

the piston 72. The conduit 214 also is connected to a variable sequence valve 220 which is connected to a pair of pressure reducing valves 222 by a branched conduit 224. Each pressure reducing valve 222 has its outlet connected to an unloading valve 226 by a conduit 228, and the unloading valve 226 is connected by a conduit 230 to the upper end of the cylinder 70. The pressure reducing valves 216 and 222 are connected by conduits 232 containing shut-off valves 234 and variable pressure relief valves 326 to a return conduit 238 which leads to the tank 160. Also connected to the pressure reducing valves 216 and 222 are pressure indicating gauges 240 which are protected by means of shut-off valves 242.

Cylinders 70 and 74 are directly connected to the tank 160 by means of a main conduit 244 containing a variable setting flow regulating check valve 246 and by branch conduits 248. The branch conduits 248 are connected to the conduits 218 and 230 at or just ahead of the inlet port to the cylinders 70 and 74.

The unloading valves 226 are connected by means of conduits 250 to a return conduit 252 leading to the tank 160. The variable sequence valve 220 is connected to spill excess fluid to the conduit 252 through a conduit 254. For a reason which will be apparent hereinafter, the conduit 224 connecting the sequence valve 220 with the reducing valve 222 is connected through a check valve 256 back to the sequence valve 220 for ridding the hydraulic circuit of excess fluid.

The conduit 214 is connected by a conduit 258 to a pressure operated unloading valve 260. The unloading valve has its inlet connected by means of a conduit 262 to a port at the lower end of the cylinder 74 and regulates the back pressure against the piston 72 during such times as the press is being driven through the work portion of its cycle. The outlet from the unloading valve 260 is connected by means of a conduit 264 to the port 196 of the four-way valve 170. This port 196 is also connected by means of a conduit 266 containing check valve 268 to a second inlet to the unloading valve 260, the conduit 266 being connected to the conduit 264 between the port 196 and the unloading valve 260. The conduit 266 is also connected by means of a conduit 270 with the unloading valves 226 which are thus connected to a port 196 of the main valve 170.

Conduit 262 is connected through a flow regulating and shut-off valve 272 to a pressure relief valve 274, one outlet from which is connected directly to the tank 160 by a conduit 276, the other outlet being connected to the tank 160 by a conduit 278 containing a solenoid operated valve 280 which when opened vents the valve 274 to allow the latter to open.

The reducing valve 216 is bypassed by a conduit 282 connected to the conduits 214 and 218 and containing a check valve 284.

The specific constructions of the unloading valve 260, the pressure reducing valve 216, the variable sequence valve 220, the pressure reducing valves 222, the unloading valve 226 and the unloading valve 260 are not part of the present invention and these valves may be of a type manufactured by Vickers, Inc., Detroit, Michigan. Specifically the unloading valve 260 may be of a type illustrated in U. S. Patent No. 2,200,824; the pressure reducing valves 216 and 222 may be of a type illustrated in U. S. Patent No. Re. 21,529, and the valves 220, 226 and 260 may be of the type illustrated in U. S. Patent No. 2,104,780 (Fig. 2).

These last three named patents are all owned by Vickers, Incorporated, as assignee of the inventors thereof.

The complete operation and organization of this hydraulic system will be appreciated when the sequential operation thereof is described hereinafter.

Electrical circuit

The various solenoids which have been referred to in discussing the organization of the hydraulic control system are in turn operated by the electrical circuit 40 which has heretofore been referred to only generally. A typical circuit is shown in Figs. 8 to 11 and is of the type wherein the control relays and switches are operated at a low voltage and the current for operating the solenoids in the control circuit is of a higher voltage.

The current for the electric circuit is obtained from the line 300, 302 which may be a source of 440 volt 60 cycle current. The line 300 is connected to the primary of a step down transformer 304 by a conductor 306 containing a master switch 308 which preferably is of the knife type. Closing of the switch 308 conditions the electrical circuit for operation. The other end of the primary of the transformer 304 is connected by a conductor 310 to one terminal of a normally closed thermostatic overload switch 312 which is in turn connected to the line 302. In some installations it may be desirable to combine the switches 308 and 312 into one master control and overload responsive switch.

Solenoid 314 controlling the air valve 117 for the combination air operated clutch and brake 115 is connected by conductor 316 to the conductor 306 and by conductor 318 to one terminal of a normally open switch 320. The other terminal of the normally open switch 320 is connected to a heater coil 322 arranged opposite the thermostatic switch 312. The heater coil 322 is connected through the thermostatic switch 312 to the line 302.

The secondary of the transformer 304 is connected to conductors 324 and 326. The conductor 324 contains a manually operable emergency disconnect switch 328.

The switches in the electrical circuit are under the master control of three cams 330, 332, and 334 which operate, respectively, switches 336, 338 and 340. The cams are mounted on a camshaft 335 and make one complete revolution for every complete cycle of the press; the cams are thus synchronized to the operation of the main slide 34. The switches 336 and 338 are closed at the start of a press cycle while the switch 340 is open. The fixed contacts of the switches 336, 338 are directly connected to the conductor 324. Switch 336 is connected by a conductor 342 to a pair of manually operable "start" switches 344 and 346. Arranged in parallel with the switches 344 and 346 is a holding circuit switch 348. The switches 344, 346 and 348 are connected to relays 350 and 352; the relay 350 is connected by conductor 353 to the conductor 326, and the relay 352 is connected by conductor 355 containing the normally closed switch 359 to the conductor 326.

Closing the "start" switches 344 and 346 energizes the relays 350 and 352. Energization of the relay 350 closes the switch 348 and a switch 354 which is in series via the conductor 356 with a relay 358 and a time delay switch 360. The switch 360 is of the type including a time delay closing device of the dashpot type and made by the Cutler-Hammer Company of Milwaukee, Wisconsin.

Energization of the relay 352 moves the switch 360 toward closed position, but actual closing of this switch does not take place until after a predetermined time interval has passed. The relay 352 also actuates switches 362 and 364 to closed position. Switch 362 is parallel with the switch 360 through a manually operable switch 366.

Switch 366 and switch 368 in the conductor 324 are shown in Figs. 8 to 11 in the position in which they are set when the press is operated as a double acting press. They are moved to their alternate position when the press is to be operated as single acting.

With the circuit as shown in Figs. 8 to 11, it will be observed that the relay 358 is not energized until after the switch 360 closes, even though the switch 354 is closed immediately upon energization of the relay 350. When, however, the circuit to the relay 358 is closed, the latter closes switch 320, energizing the circuit to the solenoid 314, and also closes the switch 370 in the conductor 372. This conductor 372 including switches 338 and 370 connects relay 358 to conductor 324 through a circuit in parallel with the previously described circuit and is, therefore, a holding circuit for the relay 358.

Closing the switch 364 which is connected by conductor 374 to the conductor 324 and by a conductor 376 to relay 378 energizes this relay through a normally closed slow-down position limit switch 380. Energization of the solenoid 378 moves switch 382 to the closed position. One terminal of switch 382 is connected to conductor 384 which is in turn connected to the line 302 through the bimetal thermostatic switch 312. The other terminal of the switch 382 is connected by a conductor 385 to solenoid 386 the opposite end of which is connected by conductor 388 to the conductor 306. The circuit which energizes the solenoid 386 is line 300, switch 308, conductor 306, conductor 388, solenoid 386, conductor 385, switch 382, conductor 384, bimetal switch 312, and line 302.

When energized the solenoid 386 opens the venting valve 280 so that this valve vents the valve 274 to allow the free flow of fluid through the valve 274 and conduit 276 to the tank 160. The circuit is thus in the energized position which is shown in Fig. 9 wherein the blank holder slide is advancing rapidly toward the bed of the press under the influence of gravity.

The conductor 376 is connected by a conductor 390 to a conductor 392 leading to relay 394 which is in turn connected by a conductor 396 with the switch 359. Thus when the switch 364 is closed, the relay 394 is energized through the circuit from the conductor 324 through conductor 374, switch 364, conductors 376, 390, 392, relay 394, conductor 396, switch 359, conductor 326 and secondary of the transformer 304. Upon energization the relay 394 closes the three switches 398, 400 and 402. The switch 398 is in a holding circuit to the relay 394 and is in parallel with the switch 364 having one terminal connected to the conductor 374 by a conductor 404 and having its other terminal connected to the conductor 392.

Closing of the switch 402 conditions the circuit to relay 406, the function of which will be described hereinafter.

Switch 400 is connected by a conductor 408 to the conductor 384 and by conductor 410 to the solenoid 172 which is connected by conductor 412 to the conductor 306. The solenoid 172 is energized through the following circuit: line 300, switch 308, conductor 306, conductor 412, solenoid 172, conductor 410, switch 400, conductor 408, conductor 384, bimetal switch 312 and line 302.

172, conductor 410, switch 400, conductor 408, conductor 384, bimetal switch 312 and line 302.

The solenoid 172 controls the operation of the pilot valve 186 to allow fluid under pressure from the pump 176 to shift the valve 170 to connect the inlet conduit 192 with the port 193 which is connected to the conduit 214 whereby fluid is supplied to the upper ends of the cylinders 70 and 74.

When the blankholder slide starts its downward movement, top position limit switch 414 closes. One terminal of the limit switch 414 is connected to the conductor 326, and the other terminal is connected directly to the relay 406. The relay 406 is also connected by a conductor 416 to one terminal of the switch 402 which has its other terminal connected by conductor 418 to the cam-operated switch 340. The cam-operated switch 340, which is open during most of the press cycle, is connected to the conductor 324. Closing of the switch 402 by the relay 394 and the closing of the top position limit switch by the movement of the blank holder slide away from its uppermost position conditions the circuit through the normally open switch 340 for energization upon closing of this switch later in the press cycle.

As the blank holder slide moves toward and just before encountering the work, it trips the slow-down position limit switch 380 to open it, thus breaking the circuit to the relay 378 to open the switch 382. Opening of the switch 382 deenergizes the circuit to the previously energized solenoid 386, and the valve 280 is closed thereby shutting off the free flow of fluid to the tank 160.

After the venting valve 280 has been closed any further flow of fluid from the cylinder 74 is through the unloading valve 260 and a back pressure is built against the blank holder slide which is moved downwardly by the fluid under pressure which it receives from the double pump 162 through the conduit 214. The arrows in Fig. 10 show the direction in which the fluid is flowing and also the parts of the hydraulic and electric circuit which are energized during the "down pressing" portion of the press cycle.

When the pressing operation has been completed, the properly timed cam 334 closes the switch 340 to energize the circuit to the relay 406. Energization of the relay 406 closes switches 420 and 422 and opens switch 359. The switch 420 has one terminal connected to a conductor 424 which is connected to the switch 368 and thus to conductor 324, and has its other terminal connected by a conductor 426 to the conductor 416. The switch 420 is thus in the holding circuit which is in parallel with the switches 340 and 402 and even though these switches may open subsequently, the holding circuit will maintain the relay 406 in energized condition. The switch 422 is connected by conductor 428 to the conductor 384 and by a conductor 430 to the solenoid 174. The other end of the solenoid 174 is connected to the conductor 412 which connects it to the conductor 306. Closing the switch 422, therefore, energizes the solenoid 174 through the following circuit: line 300, switch 308, conductor 306, conductor 412, solenoid 174, conductor 430, switch 422, conductor 428, conductor 384, thermostatic bimetal switch 312 and line 302.

Simultaneously with the closing of the switches 420 and 422, the relay 406 opens the switch 359 to break the circuit to the relays 352 and 394.

Breaking the circuit to the relay 352 opens the switches 360, 362 and 364. However, the relay 358, in series with switch 360, is continued energized through its holding circuit. Breaking the circuit to the relay 394 opens switches 398, 400 and 402. Since the switch 420 is in parallel with switch 402, the circuit to the relay 406 remains complete. Opening the switch 398 breaks the holding circuit to the relay 394, and opening the switch 400 breaks the circuit to the solenoid 172.

Since the solenoid 172 is deenergized and solenoid 174 is energized, the pilot valve 188 is actuated to connect the hydraulic circuit through the valve 170 as shown in Fig. 11 wherein the inlet from the conduit 192 is connected to the port 196 and fluid is pumped through the conduits 264, 266 and 262 to the lower inlet of cylinder 74 to move the blank holder slide 36 toward the uppermost position.

The circuit conditions shown in Fig. 11 continue until the blank holder slide is restored to its uppermost position, when the top position limit switch 414 is tripped open to break the circuit to the relay 406. Previously, however, cams 330 and 332 had sequentially opened their switches 336 and 338, respectively, to break the circuit to the relays 358 and 350 thereby to condition the circuit for another operating cycle.

Operation of press—Single acting

When the press is to be operated as single acting with the work and blank holder slides interlocked, the blank holder slide 36 is disconnected from the pistons 62 and connecting rods 66 as has previously been described, and the pistons 62 and connecting rods 66 are locked against the lower ends of the cylinders 70 and 74. The blank holder slide 36 is then mechanically connected to the work slide 34 by means of the interlocks 96 of which there are four.

In the electrical circuit the switches 366 and 368 are moved to their positions opposite from those shown in Figs. 8 to 11. Switch 366, therefore, short circuits the time delay switch 360 through the switch 362, and switch 368 is opened and renders inoperative that part of the circuit containing the position limit switches 380 and 414, cam operated switch 340 and relays 394, 378 and 406.

Inasmuch as none of the hydraulic circuit has to be used during the operation of the press as single acting, none of the solenoids 172, 174 or 386 are energized. However, the solenoid 314 must be energized, as it controls the air valve 117 controlling the supply of air to the air operated combination clutch and brake 116.

The master switch 308 is closed to condition the control circuit for operation, and then the "start" switches 344 and 346 are closed to energize the relays 350 and 352. Energization of the relay 350 closes the switch 348 to the holding circuit for the relays 350 and 352 and also closes the switch 354 in series with the relay 358. The relay 352 closes the switches 360, 362 and 364. Inasmuch as switch 360 is short circuited by the switch 362 through the switch 366, there is no time delay and the relay 358 is energized immediately. The relay 358 closes the switches 370 and 320. Closing of the switch 320 completes the circuit to the solenoid 314 and air under pressure is supplied immediately to the clutch 116 to cause it to engage the flywheel 112. Since the switch 364 is in the inoperative part of the circuit whether it is closed or not is immaterial.

As the press cycle nears its end the cam 330 opens the switch 336 to break the circuit to the

switches 348 and 362. This deenergizes the relays 350 and 352, which in turn open the switch 348 in the holding circuit, and switches 354, 362, 360 and 364. However, the circuit to the relay 358 remains complete through the holding circuit containing the switches 338 and 370, and this circuit is not broken until immediately prior to the end of the press cycle, when the cam 332 opens the switch 338. This breaks the circuit to the relay 358 to open the switches 370 and 320. It will be noted that the operation of the switches 336 and 338 is arranged so that the switch 336 will close before the end of the press cycle, and the switch 338 is closed immediately upon the termination of a press cycle.

When it is desired to operate the press single acting without interlocking the slides as under the conditions just described, the switches 366 and 368 are moved to the single acting position. The hydraulic circuit is rendered inoperative except to maintain the blank holder slide 36 in its upper or "rest" position. Also the adjustable gibs 44 might be tightened against the blank holder slide 36 to brake the slide against any tendency to move as the work slide 34 is reciprocated. The pistons 62 and 66-72 remain connected to the slide 36, and the interlock connection is not made. Operation of the press is initiated by pressing the button to close the "start" switches 344 and 346. The operation of the press continues as described in the immediately preceding paragraphs—with the work slide 34 reciprocating on the gibs 58 in the blank holder slide 36.

It is within the skill of those versed in this art to arrange this circuit so that the press will run continuously without the necessity of pressing the start button each time.

Operation of press—Double acting

When it is desired to operate the press as double acting, the blank holder slide 36 must be connected to the pistons 62 and connecting rods 66, and then the interlock between the blank holder slide 36 and the main slide or work platen 34 is disconnected by withdrawing the pin 98 from the hole 102 in the wall of the blank holder slide 34. The pin in its withdrawn position is rotated 90° from the position shown in Fig. 1, and then fastened to the blank holder slide 36 by means of the screws 104 (Fig. 6). When these operations have been completed (assuming that they were necessary from a previous single acting operation), the blank holder slide 36 will be independent of the work slide 34 and the blank holder slide will be held in its uppermost or rest position by the hydraulic circuit which is in the condition shown in Fig. 8.

In the electrical circuits the switches 366 and 368 are set in the positions shown in Figs. 8 to 11.

Fig. 8 illustrates the hydraulic circuit in the rest position of the press. A column of hydraulic fluid is trapped on the under side of the piston 72 and is prevented from escaping by the closed valves 274 and 260. Even though the motor or motors operating the pumps 162 and 176 are running, these pumps are doing no work, as the fluid from the pump 162 is circulated through the conduits 168 and 212 to the conduit 192 through the four-way valve 170 to the return conduit 194. Pump 176 circulates fluid through the variable pressure relief valve 182 and the pilot valves 186 and 188 and the return conduit 190. This circulation of fluid is shown by the arrows in Fig. 8.

When it is desired to operate the press, the master control switch 308 is closed and the but-

ton or buttons controlling the "start" switches 344 and 346 are pressed, manually closing these switches. The switch 308 energizes the circuit between the lines 300, 302, through the primary of the transformer 304. Closing the switches 344 and 346 energizes the circuit through the secondary of the transformer to the relays 350 and 352. The relay 350 closes the switches 348 and 354. Switch 348, in parallel with the switches 344 and 346, energizes a holding circuit to the two relays 350 and 352, preventing their deenergization upon release and opening of the switches 344 and 346. Closing of the switch 354 conditions the circuit to the relay 358 which is not energized immediately because there is a time delay mechanism incorporated in the switch 360.

The relay 352 immediately closes switches 362 and 364 and slowly closes switch 360 through the previously mentioned time delay mechanism. Closing of the switch 364, however, completes the circuit through the relay 378 to close the switch 382 which is in series with the solenoid 386 controlling operation of the venting valve 280.

When the solenoid 386 is energized the valve 280 is opened and a small amount of fluid is allowed to pass through the conduit 278 to the tank 160 (Fig. 9). The opening of valve 280 vents the pressure relief valve 274 which opens and fluid flows from the cylinder 74 to the tank 160 through the conduit 276. The speed with which this fluid is allowed to flow from the lower part of the cylinder 74 is regulated by the adjustable metering valve 272 in series with the valve 274. The press is in the "free fall" or "rapid advance" stage of the cycle wherein the blank holder slide is moving rapidly toward the work and is exhausting hydraulic fluid from beneath the piston 72 through the conduit 262 leading to the valve 274 via the pressure resistance regulator valve 272. Fluid is supplied to the upper ends of the cylinders 70 and 74 through the conduit 244 including the check valve 246 and the branch conduits 248.

Simultaneously with the energization of the relay 378, the circuit to the relay 394 was closed. Energization of the relay 394 closes the switches 398, 400 and 402. Switch 398 is in a holding circuit which is in parallel with the switch 364 and prevents the deenergization of the relay 394 even though the circuit to the relay 378 be broken. Switch 402 is in a circuit to the relay 406 and closes merely to condition this circuit for future energization. The switch 400 is in series in the circuit containing the solenoid 172 controlling the flow of fluid to the pilot valve 186, and closing of this switch 400 energizes the circuit to the solenoid 172. The solenoid 172 operates the pilot valve 186 so that fluid is supplied to the main four-way valve 170 to shift it so as to connect the conduit 192 with the conduit 214 through the port 198. When the circuit is in this condition the fluid is supplied from the pump 162 through the conduits indicated by the arrows to the conduit 214 which is connected to the sequence valve 220 and to the pressure reducing valve 216. Fluid flows from the pressure reducing valve 216 through the conduit 218 to the upper end of the cylinder 74 above the piston 72. Thus fluid is flowing in the circuit which subsequently will supply fluid for the blank holding pressure, and the circuit is conditioned for the blank holding operation while the blank holder slide is in a "free fall" toward the press bed.

Inasmuch as the initial movement of the blank holder slide is somewhat slower than the move-

ment of the mechanically driven work platen toward the press, the switch 360 of the time-delay character is provided in the electrical circuit 40. After a predetermined interval of time has elapsed following the circuit energization just described, the switch 360 will close to energize the circuit to the relay 358 which closes the switches 370 and 320. Closing of the switch 370 energizes the holding circuit to the relay 358 through the switch 338, which circuit is in parallel with the switches 336, 360 and 354. Closing the switch 320 energizes the circuit to the solenoid 314 operating the air valve 117 which controls the supply of air to the press clutch 116. When the clutch 116 is engaged the mechanical drive for the work slide is rendered operative to send the work slide 34 through its work cycle which movement is not interrupted until the cycle has been completed.

Fig. 10 illustrates the hydraulic and electrical circuits during the forming or work producing portion of the press cycle. Just prior to the commencement of this portion of the cycle the blank holder slide 36 had tripped the slow-down limit switch 380 to break the circuit to the solenoid 378. This opened the switch 382 thereby deenergizing the solenoid 386 and closing the valve 280. When the valve 280 has been closed, flow of fluid through the conduit 276 will be stopped because valve 274 closes and the fluid is returned to the tank 160 through the circuit which will be described immediately hereinafter.

By the time the work producing stage of the press cycle has been reached the pressure of the fluid from the pump 162 through the conduit 192, main valve 170 and the conduit 214 has increased considerably so that a substantial pressure is built up in the cylinder 74 above the piston 72. This increased pressure likewise has tripped the sequence valve 220 so that fluid flows through the conduit 224, the pressure reducing valves 222 and the unloading valves 226 to the cylinders 70 so as to supply blank holding pressure to the pistons 62. Fluid under pressure continues to supply pressure to the piston 72. The blank holding pressure holds the work against the die member which rests upon the press bed. Excess fluid is returned to the tank from the sequence valve 220 through the conduits 254 and 252. Since the valves 216 and 222 are pressure reducing valves, excess fluid from these valves must be disposed of and is exhausted through the conduits 232, pressure relief valves 236 and return conduit 238.

A reactance pressure of about 100 p. s. i. against the blank holder slide is obtained by the unloading valve 260 through which the fluid from the lower end of the cylinder 74 flows during this portion of the press cycle. The unloading valve is actuated to connect the conduit 262 with the conduit 264 leading to the port 196 of the main valve 170 by the pressure in the conduit 214 as transmitted to the valve 260 through the conduit 258. The port 196 is connected through the valve 170 with the drain conduit 194 leading to the tank 160. The fluid thus flows from the bottom of the cylinder 74 through the conduit 262, unloading valve 260, conduit 264, port 196, valve 170 and drain conduit 194.

Since the work slide 34 is crank driven it is mechanically reversed in its direction of movement after the eccentric 138 has been rotated 180° from the position shown in Fig. 3. The blank holder slide 36 preferably continues the blank holding operation for an interval after termination of the forming operation to allow

the work slide to strip its die from the work. Proper timing of this added holding operation is obtained by timing the cam 334 relative to the work slide cycle since the camshaft 335 is driven in synchronism with the work slide 34.

Referring to Fig. 11, there are shown the circuits in operative condition to restore the blank holder slide 33 to the normal or rest position. This part of the press cycle is under the influence of the timed cam 334 which on further counterclockwise rotation closes the switch 340 to engage the circuit to the relay 406. Energization of the relay 406 closes the switches 420 and 422. The switch 420 is in parallel with the switches 340 and 416 and closes the holding circuit for the relay 406. Opening the switch 359 breaks the circuit to the relay 394 to open the switches 393, 430 and 402. Opening the switch 400 breaks the circuit to the solenoid 172, which permits release of holding pressure from the pilot valve 186 and the centering of the spool in the four-way valve 170. It is noted, however, that the energization of relay 406 closes the switch 422 in circuit to the solenoid 174. The solenoid 174 then moves the pilot valve 188 so as to connect the operating fluid from the pump 176 to shift the valve 170 so as to connect the conduit 192 through the valve 170 with the port 196 and to connect the port 198 through the valve 170 with drain conduit 194. The hydraulic fluid from the pump 162 is thus used to restore the blank holder slide 33 to its uppermost position. The fluid flows from the pump 162 to the conduit 192 through the valve 170, port 196, conduit 264, check valve 268 in the conduit 266, unloading valve 260, conduit 262 to the inlet at the lower end of the cylinder 74 and below the piston 72. Forcing of fluid under pressure through this circuit moves the piston 72 upwardly, and since the piston rod 63 is connected to the blank holder slide 33 as are the pistons 62, the three or six pistons, as the case may be, are moved upwardly and evacuate the fluid from the upper ends of all the cylinders 70 and 74.

The fluid is forced from the upper end of the cylinder 74 through the conduit 218, conduit 282, check valve 284, conduit 214, port 198, valve 170 and drain conduit 194. The fluid is forced from the cylinders 70 through the conduits 230, unloading valves 226, conductors 250 and drain conduit 252 which returns it to the tank 160. This latter circuit is conditioned by fluid under pressure in conduit 270 actuating the unloading valves to interconnect the conduits 230 and 250. While the work slide 34 and the blank holder slide 33 are being restored to their uppermost positions, the timing cams 330, 332 and 334 continue their counterclockwise rotation. The timing cam 334 first opens the switch 340 so as to condition the electrical circuit for another cycle of operation. Then the timing cam 330 opens the switch 335 which deenergizes the holding circuit, including switch 348, for the relay 350. Deenergization of the relay 350 opens the switches 348 and 354 likewise to condition the electrical circuit for a second or successive cycle of operation. At approximately the same time, and timed to coincide with the return of the work slide to its rest position, the cam 332 opens the switch 338 to deenergize the relay 358. This opens the switches 370 and 320, thereby breaking the holding circuit to the relay 358 and breaking the circuit to the solenoid 314 thereby to close the valve controlling the supply of air under pressure to the air operated clutch 116.

When the blank holder slide 36 reaches its

uppermost position it trips the top position limit switch 414 which opens the circuit to the relay 405, thereby opening the switches 420 and 422 and closing the switch 359. Closing the switch 359, however, does not energize either the relay 352 or the relay 358 inasmuch as the direct circuits to these relays have already been broken and conditioned for successive operation. Opening of the switch 420 breaks the holding circuit to the relay 406, maintaining it in deenergized condition when the top position limit switch 414 closes upon a successive operation of the press. Opening the switch 422 breaks the circuit to the solenoid 174. Since the valve 170 is of the self-centering type, its valve spool is centered and the conduit 192 is connected directly through the valve 170 to the conduit 194 and the fluid which is circulated from the pump 162 merely flows through the valve 170 without the use of any substantial pressure.

From the foregoing description it has been demonstrated that the objectives claimed for the present invention have been met. It is within the skill of those well versed in this art to make modifications and variations in this invention without departing from the spirit and scope thereof.

What is claimed as new and desired to be secured by United States Letters Patent is:

1. A convertible single and double acting press comprising a work slide, means for reciprocating said work slide, a blank holder slide, hydraulic means separate from said work slide reciprocating means for reciprocating said blank holder slide, said hydraulic means including a cylinder, a piston reciprocable in said cylinder, means removably connecting said piston to said blank holder slide when the press is operated double acting, said last named means being adapted to secure said piston to said cylinder when the press is operated single acting, and means for controllably supplying fluid under pressure to said cylinder to reciprocate said blank holder slide, manually removable means to interlock said blank holder slide with said work slide so that they may move in unison when the press is operated single acting, and manually operable selector means for rendering said fluid supplying means operative or inoperative during such time as the press is operated double acting or single acting, respectively.

2. A convertible single and double acting press comprising a work slide, means for reciprocating said work slide, a blank holder slide, hydraulic means for reciprocating said blank holder slide, said hydraulic means including a cylinder, a piston reciprocable in said cylinder, means removably connecting said piston to said blank holder slide when the press is operated double acting, a source of fluid under pressure, and controllable means connecting said source of fluid under pressure to said cylinder, and electrical means having means synchronized with the reciprocation of said work slide for actuating said controllable means, said electrical means including manually operable selector switch means for rendering a portion of said electrical means and all of said controllable means inoperative during such time as the press is operated single acting.

3. A convertible single and double acting press comprising a work slide, means for reciprocating said work slide, a blank holder slide, hydraulic means separate from said work slide reciprocating means for reciprocating said blank holder slide, means for removably connecting a part of said

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hydraulic means with said blank holder slide when the press is operated double acting and for removably connecting said same part to a fixed part of the press when the press is operated single acting, common electrical control means for said work slide reciprocating means and said hydraulic means so that said blank holder slide is reciprocated in synchronism with said work slide, said electrical control means including manually operable selector switch means for rendering a part of said electrical control means and said hydraulic means operative or inoperative during such time as the press is operated double acting or single acting, respectively, and removable means to interlock said work slide and said blank holder slide so that both said slides may be reciprocated in unison when the press is operated single acting.

4. A convertible single and double acting press comprising a work slide, means for reciprocating said work slide, a blank holder slide, a cylinder-piston combination having a fixed part and a movable part, means for removably securing said movable part to said blank holder slide when the press is operated double acting and for removably securing said movable part to said fixed part when the press is operated single acting, a source of fluid under pressure including a fluid tank, valve means controllably connecting said source of fluid with said cylinder-piston combination when the press is operated double acting, a conduit including a second valve means connecting said cylinder-piston combination with said tank, and electric circuit means for actuating both said valve means and for controlling the operation of said work slide reciprocating means, said electric circuit means including means timed to the movement of the blank holder slide toward the work to actuate said second valve means to closed position to slow down said movement and to enable a holding pressure to be built up in said cylinder-piston combination and including means synchronized with the reciprocation of the work slide to actuate said first valve means to release the blank holding pressure and to enable said source of fluid under pressure to restore said blank holder to the start position, said electric circuit means including manually operable selector switch means for rendering both said valve means inoperative when the press is operated single acting.

5. A convertible single and double acting metal working press comprising a work slide, means for reciprocating said work slide, a blank holder slide, a cylinder-piston combination having a fixed part and a movable part, means for removably securing said movable part to said blank holder slide when the press is operated double acting and for removably securing said movable part to said fixed part when the press is operated single acting, a source of fluid under pressure including a fluid tank, valve means controllably connecting said source of fluid under pressure with said cylinder-piston combination to reciprocate said blank holder slide under pressure and to supply fluid under pressure for a blank holding operation, a conduit containing a second valve means connecting said cylinder-piston combination directly to said tank, other conduit means connecting another part of said cylinder piston combination directly to said tank, electric circuit means for actuating both said valve means and for controlling the operation of said work slide reciprocating means, said electric circuit means containing means timed to the movement of said blank holder slide toward the work to actuate said second valve means to closed posi-

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tion to slow down said movement and to enable a holding pressure to be built up in said cylinder-piston combination and including means synchronized with the reciprocation of the work slide to actuate said first valve means to release the blank holding pressure and to enable said source of fluid under pressure to restore said blank holder to the start position, said other conduit means conveying fluid to and from said cylinder-piston combination during non-holding portion of the blank holder cycle, said other conduit means including means preventing inadvertent release of the holding pressure, and said electric circuit means including manually operable selector switch means for rendering both said valve means inoperative when the press is operated single acting.

6. A metal working press comprising a work slide, means for reciprocating said work slide, a blank holder slide, hydraulic means for reciprocating said blank holder slide, said hydraulic means comprising a source of fluid, a fixed cylinder, a piston reciprocable in said cylinder and secured to said blank holder slide, means for transferring fluid under pressure from said fluid source to one end of said cylinder to urge said piston and said blank holder slide toward the work under pressure, main valve means associated with said transferring means for controlling the flow of fluid to said cylinder, conduit means connecting said end of said cylinder with said fluid source, a valve in said conduit to prevent fluid flow from said cylinder to said fluid source, second conduit means connecting the other end of said cylinder with said fluid source, controllable valve means in said second conduit means, third conduit means connecting said second end of said cylinder with said fluid source through said main valve means, an unloading valve in said third conduit means, means timed with the movement of the blank holder slide to actuate said controllable valve means to stop fluid flow through said second conduit means, and means timed with the work cycle of the press to control said main valve means whereby said hydraulic means reciprocates said blank holder slide and applies a holding pressure thereto.

7. In a convertible single and double acting press the combination of a reciprocable work slide, a reciprocable blank holder slide, said blank holder slide having an opening extending vertically therethrough through which said work slide is reciprocable, alignable openings in adjacent walls of said slides, a pin having a shank adapted to extend through said openings when aligned to interlock said slides for reciprocation in unison, said pin having an elongated head with at least one aperture therethrough, a block secured to and standing out from the outer face of said blank holder slide wall adjacent said wall opening therein, and means for securing said pin head in a first radial position to said block so that said shank projects into the wall opening in only said blank holder slide and for securing said pin head in a second radial position directly to the wall of said blank holder slide so that said shank projects through said blank holder slide wall opening and into said work slide wall opening.

8. In a convertible single and double acting press, the combination of a reciprocable work slide, a reciprocable blank holder slide, and means for reciprocating said blank holder slide, said means including a hydraulic cylinder and a piston reciprocable therein, a mounting annulus secured to and carried by said piston outside of

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said cylinder, means removably securing said annulus to said blank holder slide when the press is operated double acting, said annulus being adapted to be secured to said cylinder thereby to prevent reciprocation of said piston in said cylinder when the press is operated single acting, manually operable means for rendering said hydraulic means inoperative when the press is operated single acting, and removable means to interlock said work slide and said blank holder slide so that both slides may be reciprocated in unison.

9. In a convertible single and double acting press, the combination of a reciprocable work slide, a reciprocable blank holder slide, hydraulic means for reciprocating said blank holder slide, said hydraulic means including a hydraulic cylinder and a piston reciprocable therein, means removably securing said piston to said blank holder slide, said last named means being adapted to secure said piston to said hydraulic cylinder, manually operable means for rendering said hydraulic means inoperative when the press is operated single acting, and removable means to

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interlock said work slide and said blank holder slide so that both slides may be reciprocated in unison.

JOHN VERNON.
NICK KASSNEL.

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