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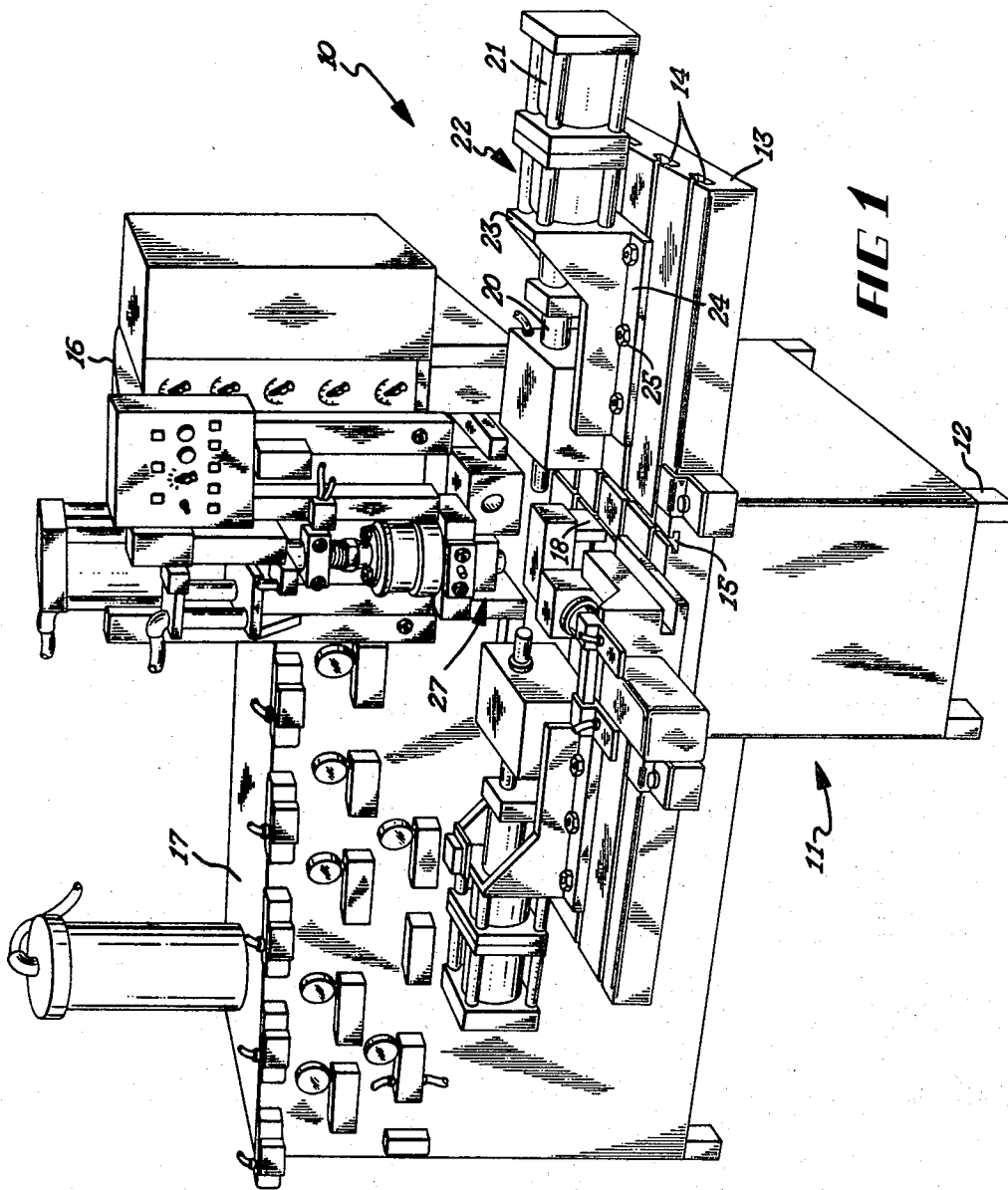
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3,417,584

MATERIAL WORKING PROCESS AND APPARATUS

Filed April 13, 1966

3 Sheets-Sheet 1



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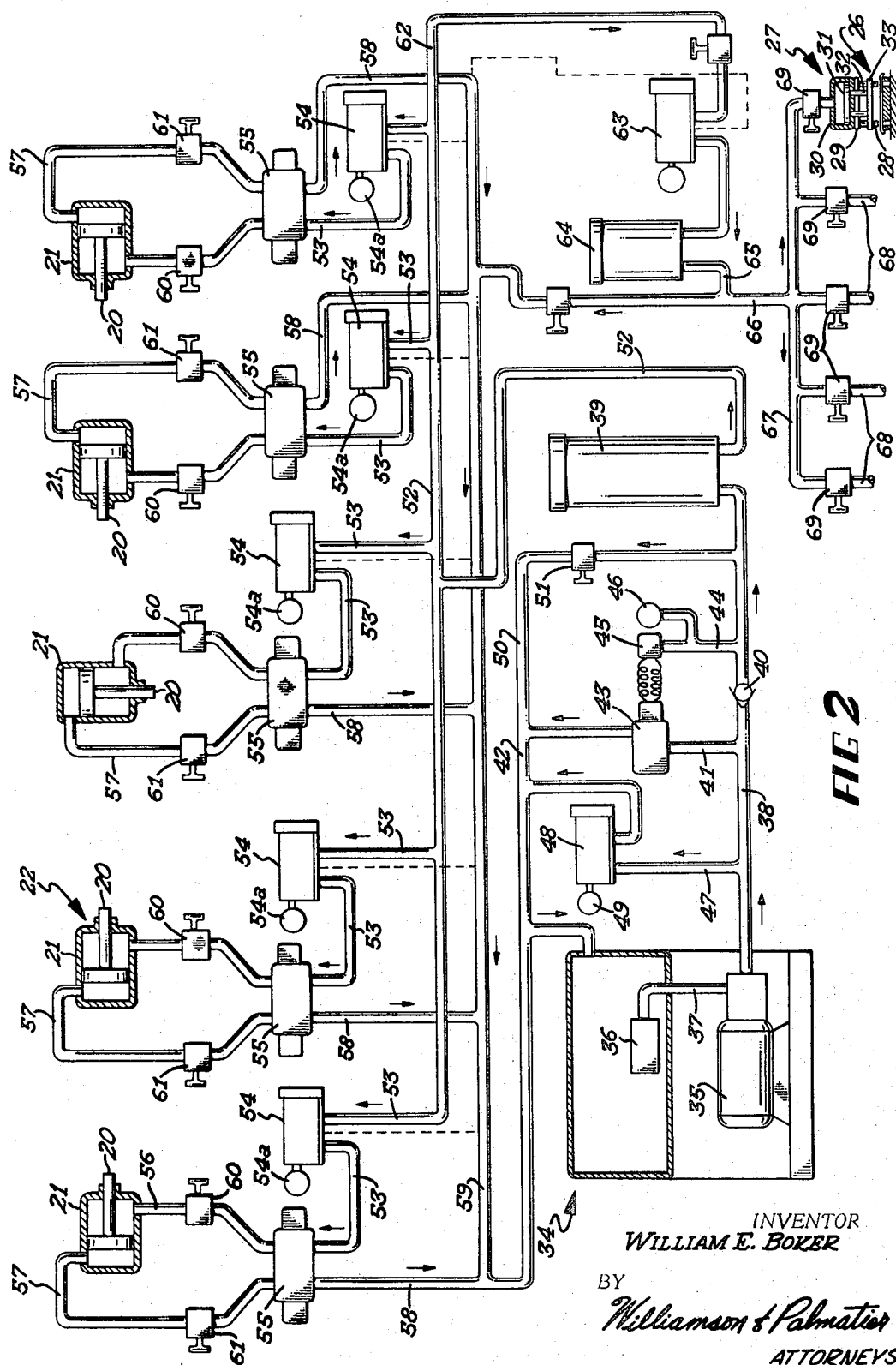
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3 Sheets-Sheet 3

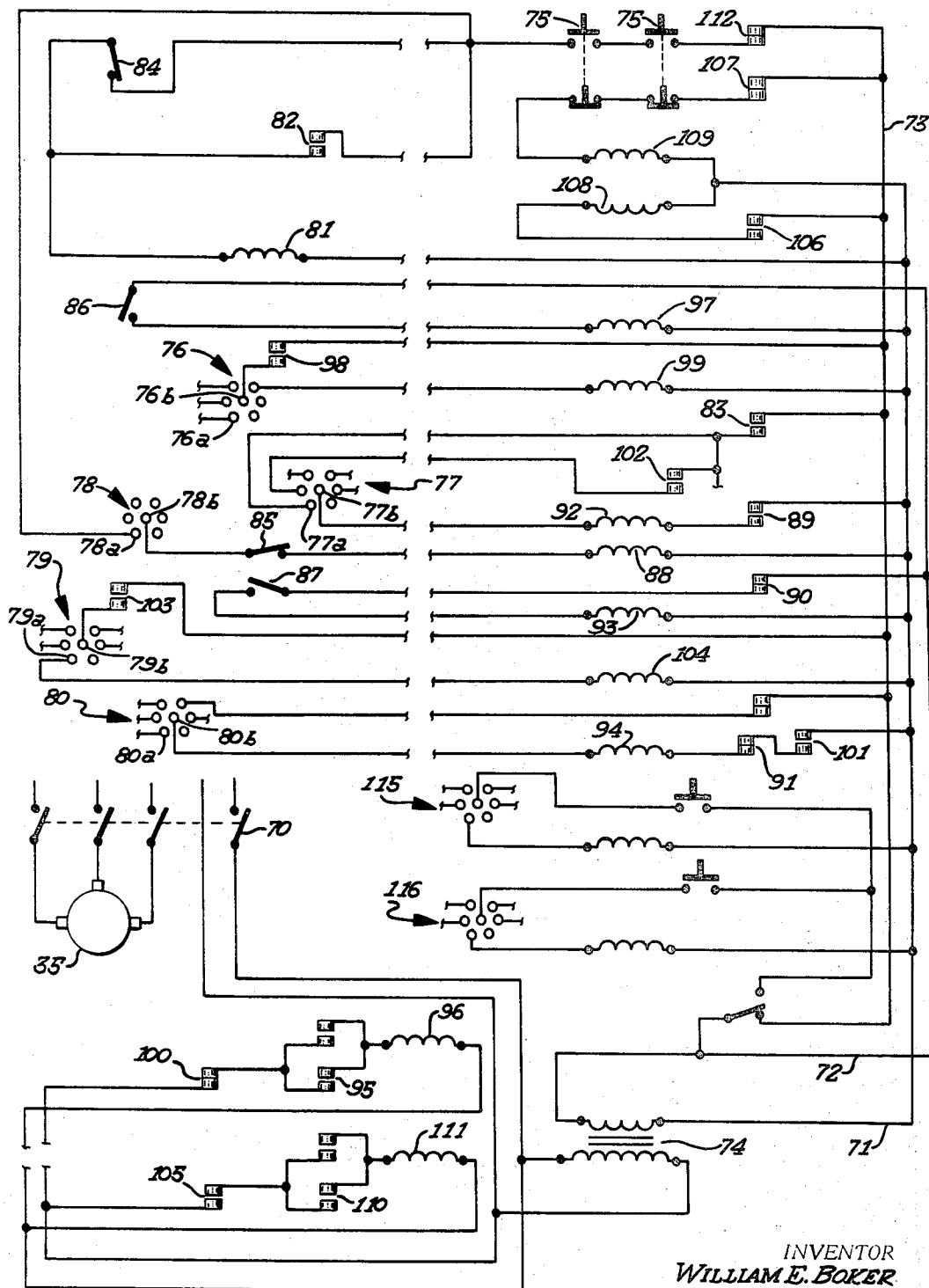


FIG 3

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MATERIAL WORKING PROCESS AND APPARATUS

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ABSTRACT OF THE DISCLOSURE

Apparatus for forming, shaping, and/or piercing an article of work, including a support having a die mounted on the support for supporting the work thereon. A plurality of piston and cylinder units, each having work-engaging mechanisms thereon and cooperating with the die for engaging and forming the work. An electrical system being presettable to program the sequence of operation of each piston and cylinder unit so that the units may operate simultaneously or in a preselected sequence.

In conventional material working processes and apparatus such as a punch press, the set-up time required in adjusting the press for a particular operation is quite extensive since the set-up operation involves trial and error in the adjustment of the cam operated rams. The same problems apply when the press is used in a shaping operation especially when a plurality of rams are used to act upon the work. In conventional presses, even though the rams used therein may be adjusted with respect to the work and work supporting die, this adjustment is limited because of the specific manner in which the conventional presses are constructed. In most conventional material working press systems, no provision is made for adjusting the velocity of the rams, nor is there any provision for making a tonnage adjustment of pressure over a wide range.

It is therefore a general object of this invention to provide a novel process and apparatus for a material working operation such as a work piercing or work shaping operation, in which a plurality of work engaging media may be quickly and easily set up for a piercing or shaping operation with a minimum of effort and in a minimum of time. The present apparatus may be used in a piercing or shaping operation and the work engaging media is advanced and retracted with respect to the work supporting die by means of fluid pressure rams, the latter being controlled by electrical circuitry. The rams along with the work engaging tools may be readily removed from the press and may be readily adjusted through a wide range of positions with respect to the work supporting die. The control circuitry of the system which controls electrically operated valves may be quickly and readily programmed to permit simultaneous operation of all or any selected group of fluid pressure rams or may be preconditioned for a complete sequential operation. In the present system, a constant pressure is exerted by the ram throughout the entire stroke although the velocity of the ram may be adjusted through a relatively wide range of adjustment.

These and other objects and advantages of the invention will more fully appear from the following description made in connection with the accompanying drawings, wherein like character references refer to the same or similar parts throughout the several views, and in which:

FIG. 1 is a perspective view of the apparatus;

FIG. 2 is a diagrammatic illustration of the fluid pressure system utilized in the present process and apparatus; and

FIG. 3 is a partial diagrammatic electrical schematic

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illustrating the circuitry used for operating one specific ram of the present system.

Referring now to the drawing and more specifically to FIG. 1 one embodiment of the apparatus of the present invention is there shown and is designated generally by the reference numeral 10. The apparatus 10 includes a support structure 11 comprised of a plurality of legs 12 and including a work supporting table structure 13 which is horizontally oriented. It will be noted that the table support structure 13 is of generally rectangular configuration and has a plurality of spaced apart longitudinally extending T slots 14 therein and a plurality of transversely extending spaced apart substantially parallel T slots 15 thereon. The support structure 11 also includes a vertical support member 16 which projects upwardly beyond the table support structure 13. A component support housing 17 is secured to the vertical support member 16 and projects laterally therefrom. It will be noted that the component support housing 17 is spaced from the table support structure 13 and provides a support for a plurality of components of the fluid pressure and electrical systems.

The work forming die 18 may be of any type and may be of the kind used in a piercing operation and provided with a plurality of apertures to support the work thereon. The work is acted upon by a plurality of work engaging media which may be in the form of piercing tools or pins or alternatively may be in the form of shaping tools. Reference is now made to FIG. 2 wherein one of the work engaging medium is diagrammatically illustrated as a pair of punches 28.

Each work engaging medium is carried by the end of a piston rod 20 that is affixed to a piston movable in a hydraulic cylinder 21, each cylinder and piston comprising a hydraulic ram unit 22 which is removably mounted upon the table support structure 13 as best seen in FIG. 1. To this end it will be seen that each ram unit 22 is provided with a mounting adaptor assembly 23 having outturned transverse flanges 24 that are suitably apertured for receiving the mounting nut and bolt assemblies 25. It is pointed out that the nut and bolt assemblies 25 extend into the longitudinal or transverse T slots of the table support structure 13 to permit adjustable mounting of the hydraulic ram units 22 with respect to the die 18.

The work engaging medium carried by each of the hydraulic ram units 22 may be a piercing mechanism 26 which is mounted upon a stripper mechanism carried by piston rod 20 of each hydraulic ram 22. It will be seen that each piercing mechanism may include punches 28 mounted on a suitable mounting plate 29 to permit penetration of the work by the pins as the associated piston rod 20 is advanced. The stripper mechanism 27 includes a small cylinder 30 carried by the end of the piston rod 20 and upon which the mounting plate 29 of each piercing mechanism is mounted. A piston 31 is mounted within the cylinder 30 of each stripper mechanism and piston 31 has a small rod 32 secured thereto and projecting outwardly therefrom. The rod 32 also projects through an aperture in plate 29 and has a stripper plate 33 secured thereto. It will be seen that the piercing pins also project through the stripper plate 33 which is normally urged outwardly by the piston 31. However, as the piston rod 20 of the associated ram unit 22 is advanced, the stripper plate 33 will engage the work initially and will yield inwardly thereby allowing the piercing pins 28 to pierce the work. Thus the action of the stripper plate 33 is a yieldable resilient action with respect to the pins and the work W.

Referring now to FIG. 2 it will be seen that a diagrammatic illustration of the fluid pressure system to operate the ram units is there shown. As pointed out above, the fluid pressure rams 22 are operated by hy-

hydraulic fluid which is supplied to the various conduits from a reservoir 34, the hydraulic liquid being removed therefrom by a pump 35. A suitable filter 36 may be provided to assure that the hydraulic fluid passed through the pump 35 will have all foreign material removed therefrom. A conduit 37 interconnects the filter 36 in communicating relation with respect to the pump 35.

Hydraulic fluid pressure is pumped through a main outlet conduit 38 to an accumulator 39 which is adapted to contain a predetermined amount of hydraulic liquid and a predetermined amount of a pressure applying inert gas such as nitrogen. A one way valve 40 is interposed in the conduit 38 and which prevents back flow through the line 38 into the pump 35. Although it is desirable to maintain a predetermined pressure in the system, it has also been found undesirable to provide the pump unit with means to automatically deenergize the electric motor thereof in response to pressure changes. Therefore, in order to permit the pump unit to operate continuously, but prevent overloading of the same by excessive pressures, the conduit 41 has one end thereof interconnected in communicating relation with the conduit 38 and has the other end thereof connected in communicating relation to a conduit 42 which in turn is interconnected in communicating relation with the reservoir 34. An electrically operated solenoid valve 43 is interposed in flow controlling relation with respect to conduit 41 and this valve is normally closed but opens when the actuating solenoid is energized. Another conduit 44 is interconnected in communicating relation with the conduit 38 and is provided with a pressure responsive switch 45 which is connected in controlling relation with respect to the solenoid valve 43. A pressure gauge 46 may be connected to the conduit 44 to permit visual inspection of the pressure in the supply conduit 38. The switch 45 is normally open but may be set to close in response to a predetermined pressure and when this pressure is reached, the switch 45 will close and energize the solenoid 43 so that the hydraulic fluid will then be circulated from the pump through conduit 38, conduit 41, conduit 42 and back into the accumulator rather than being forced through the entire system.

In order to prevent the occurrence of pressures that exceed safe limits in the system, a conduit 47 has one end thereof connected in communicating relation with the conduit 38 and has the other end thereof connected in communicating relation with the return conduit 42. A pressure relief valve 48 is interposed in flow controlled relation with respect to the conduit 47, and valve 48 is normally closed but opens in response to the development of a predetermined pressure in the conduit 47 to permit fluid to be quickly returned to the reservoir 34. A suitable conduit 50 is also interposed between conduit 38 and conduit 42, conduit 50 being provided with a valve 51 to control the flow of liquid through conduit 50. Hydraulic fluid leaves the accumulator 39 through a conduit 52, and conduit 52 branches and is connected in communicating relation to a plurality of inlet conduits 53 which are in turn connected to each of the hydraulic ram units 22. Each inlet conduit 53 has a pressure reducer mechanism 54 interposed in flow controlling relation therewith so that the pressure to the associated hydraulic ram unit may be selectively adjusted. It will be noted that conduit 53 is connected in communicating relation with a four way electrically controlled solenoid type valve mechanism 55, the latter also being connected in communicating relation by means of a conduit 56 with the associated hydraulic ram unit 22. Each ram unit 22 also has the cylinder 21 thereof connected in communicating relation with the solenoid valve mechanism 55 associated therewith by a conduit 57.

Each solenoid valve mechanism 55 is also interconnected in communicating relation with a common return conduit 59 by means of a conduit 58. Each solenoid valve mechanism 55 is of the four way type so that conduit 53

may be selectively intercommunicated with conduit 56 or 57 and also permitting conduit 58 to be intercommunicated selectively with conduits 56 and 57. Each solenoid valve may also be disposed in a neutral condition wherein conduits 53, 56, 57 and 58 are not arranged in communicating relation with respect to each other. In this condition, no hydraulic fluid passes through the solenoid valve mechanism.

It will be seen that when conduit 53 is intercommunicated with conduit 57, the piston rod 20 of the associated hydraulic ram unit will be advanced, and conversely when conduit 53 is intercommunicated with conduit 56, the associated piston rod 20 will be retracted. In the embodiment shown, each conduit 56 has a manually operable valve mechanism 60 interposed in flow controlling relation therewith while each conduit 57 also has a valve mechanism 61 interposed in flow controlling relation therewith. This arrangement permits the volume of hydraulic fluid to each ram unit to be variously and selectively adjusted. It will also be noted that each pressure reducer 54 is provided with a suitable gauge 54a to permit visual reading of the fluid pressure to each ram unit.

It will be seen that conduit 52 is interconnected in communicating relation to a branch conduit 62 that is also connected in communicating relation to an accumulator 64 adapted to contain a predetermined amount of hydraulic fluid and inert gas such as nitrogen and the like. A pressure reducer mechanism 63 is interposed in flow controlling relation with respect to the conduit 62 and serves to reduce the fluid pressure to the accumulator 64. The accumulator 64 is interconnected to a return conduit 66 by means of an outlet conduit 65. It will be noted that the return conduit 66 is interconnected to a common conduit 67 which in turn is intercommunicated to the cylinders 30 of each stripper mechanism 27 by means of a conduit 68. In the embodiment shown, suitable manually operable valves 69 may be interposed in flow controlling relation with respect to the branch conduit 68 so that the volume of hydraulic fluid supplied to the stripper mechanisms may be variously adjusted.

Electrical control circuitry is provided for permitting programming of the order and manner of operation of the work engaging media with respect to the work and reference is now made to FIG. 3 which illustrates the circuitry utilized in the operation of a single hydraulic ram unit. It will be seen that when the control circuitry for the system is energized by closing switch 70, the pump unit 35 will also be energized since the pump control switches and the switch 70 are mechanically linked together. Power is supplied to main power lines 71, 72, and 73 through a transformer 74. Since the apparatus of the present system includes various moving parts, it is desirable to include as a safety feature a pair of palm switches 75 which are normally open, and both of which must be closed in order to close the circuit to operate the work engaging media. To this end, it is pointed out that the switches 75 must be held in closed condition until piston rods 20 of those hydraulic ram units that have been selected for operation are fully advanced or the piston rods will automatically retract when the palm switches are released or opened.

Although several hydraulic ram units are illustrated in FIG. 1, the control circuitry for only one of the hydraulic ram units is illustrated in FIG. 3. The particular means for programming the hydraulic ram units through a cycle of operation comprises a plurality of gang type wafer switches and these switches may be adjusted to arrange the sequence of operation of those hydraulic ram units that are selected for performing the piercing or shaping function. Thus several hydraulic ram units may be programmed to operate simultaneously, or alternatively may be adjusted so that some of the ram units operate simultaneously and sequentially with respect to other ram units.

Although the circuitry for controlling only one hydraulic ram unit will be described in this operating cycle,

it is pointed out that the present system includes circuitry which may be present or programmed for controlling operation of other hydraulic units in a predetermined order. Wafers 76, 77, 78, 79 and 80 will be simultaneously adjusted so that the respective contacts 76a, 77a, 78a, 79a and 80a will be closed with respect to the associated contacts 76b, 77b, 78b, 79b, and 80b respectively. Adjustment or presetting of this gang type wafer switch, simultaneously arranges the various wafers of the switch in the pre-selected condition.

Thereafter when the palm switches 75 are closed, power supply to the locking relay coil 81 thus causing relay contacts 82 to be closed thus locking the locking relay 81 while relay contacts 83 are closed. It is pointed out that at the beginning of the cycle, the piston rod 20 of the hydraulic ram unit will be in the retracted position, and microswitches 84 and 85 will be in the closed condition while microswitches 86 and 87 will be in the open condition. Each hydraulic ram and cylinder unit is provided with four such microswitches which are mechanically actuated upon extension and retraction of the associated piston rod. Since microswitch 85 is in the closed condition, power will be supplied to relay 88 which causes relay contacts 89 to close while relay contacts 90 and 91 will be opened. When contacts 83 and 89 are closed, relay coil 92 will have power applied thereto. However, since contacts 90 are in the open condition, the circuit to relay coil 93 is also opened. Similarly, since contacts 91 are open the circuit to relay coil 94 also is opened.

When relay coil 92 is closed, contacts 95 are closed thus supplying power to solenoid 96 of the solenoid valve mechanism 55 for the associated hydraulic ram unit 22. It is pointed out that each of the solenoid valve mechanisms 55 includes a pair of solenoids for controlling the valve, one of which when energized allows hydraulic liquid to be passed through the associated supply line or conduit 53 into conduit 57 to extend the piston rod 22 associated therewith. In the present embodiment, the solenoid 96 for each solenoid valve mechanism is that solenoid which when energized intercommunicates conduit 53 with conduit 57 to permit extension or advancement of the piston rod.

As the piston rod 20 reaches the end of its stroke, the particular work engaging tool carried thereby will cooperate with the die to permit a piercing action of the work to take place or alternatively a shaping action to be produced. When the end of the stroke of the piston rod is reached, limit switch 86 will be closed and limit switch 85 will be opened. As limit switch 86 is closed, power is supplied through the relay 97 while the power to relay 88 is opened. When relay 97 is energized, the relay contacts 98 will be closed thus applying power to relay 99 and opening normally closed contacts 100 to deenergize solenoid 96. When this occurs, the piston rod 20 is immediately stopped in its advanced direction. Since limit switch 85 is opened, the circuit to relay 88 is interrupted which causes relay contacts 89 to open. When relay contacts 89 are open, relay contacts 90 and 91 will simultaneously close thus energizing relay coil 93. Relay coil 94 however is not energized even though relay contacts 91 are in the closed position since relay contacts 101 will be in the open condition.

When relay coil 99 is energized, relay contacts 102 will be closed. Ordinarily, the next hydraulic ram unit which would be sequenced for operation would have the piston rod thereof advanced at this time but since only one hydraulic ram unit is conditioned for operation, the circuit through wafer 77 is inoperative. When relay coil 92 is deenergized, relay contacts 95 will be opened but this produces no change in the circuit to solenoid 96 since the contacts 100 are in the open condition. When power is supplied to relay coil 93, relay contacts 103 will be closed which supplies power through the wafer 79 to relay 104. Simultaneously as relay coil 93 is energized, contacts 105 will be closed, the latter being in the retract circuit for the

associated hydraulic unit. As relay coil 104 is energized, relay contacts 101 and 106 will be closed and relay contacts 107 will be opened. When relay contacts 106 are closed, power is supplied to the relay coil 108 and opening of contacts 107 interrupts the circuit to relay coil 109.

When power is supplied to relay 94, contacts 110 will be closed thus energizing solenoid 111 of the solenoid valve mechanism 55 so that conduit 53 is intercommunicated with conduit 56 to initiate retraction of the piston rod. The latching relays 108 and 109 open latching relay contacts 112 so that the circuit to relay coil 81 is opened.

When relay coil 81 is deenergized, relay contacts 82 and 83 are simultaneously opened. This merely conditions the respective circuits associated with the relay contacts since relay contacts 112 are already in the open condition as are relay contacts 89. As the piston rod reaches the end of its retracted stroke, microswitch 86 is open whereas microswitch 87 is closed. When microswitch 86 opens, relay coil 97 is deenergized and although microswitch 85 is closed, the circuit thereto remains inoperative since the relay contacts 112 are in the open condition. When relay 97 is deenergized, relay contacts 98 are open which interrupts the power to relay 99 while relay contacts 100 close. Closing of the relay contacts 100, however, also merely conditions a circuit to solenoid 96 since relay contacts 95 are in the open condition.

In the event that other of the hydraulic ram units were programmed to operate in sequence with respect to the ram unit described in operation, the retracting circuit for the second unit will be phased in at this time. Therefore, when power is open to relay 99, relay contacts 102 will be open but since only one cylinder is in operation, the circuit through wafer 77 is opened and inoperative.

In the event that two or more of the units were programmed to operate simultaneously, each of the controlling gang type wafers would be adjusted so that the circuit would pass through those contacts of the other wafers of each wafer switch corresponding to contacts 76a, 77a, 78a, 79a and 80a. Alternatively, if the ram units are arranged to operate in a consecutive sequence with respect to each other, the control wafer switch of each cylinder is adjusted to the next advanced operating set of contacts with respect to another of the hydraulic ram units. With this particular arrangement, the control circuitry for one of the hydraulic ram units will be operable to advance the piston rod thereof completely through its forward stroke prior to the circuitry for advancing the piston rod of the next unit to be operated being energized. Therefore in a sequential operation, each piston rod is first completely advanced by its control circuitry in the selected sequence, and similarly the piston rods are sequentially retracted in the opposite order in which they were advanced. It will be recognized that a selected number of the hydraulic units may be arranged to operate simultaneously but sequentially with respect to other of the ram units. Thus it will be seen that the present system may be programmed to operate in a wide variety of ranges upon the work. This is extremely important, when for example, one or more of the hydraulic ram units have work engaging media or tools that perform a piercing operation and which may be operated simultaneously with respect to each other but sequentially to other units that perform other types of piercing or shaping operations. Other control circuitry 115 and 116 are provided to permit an initial set-up action to be performed wherein each hydraulic unit may be advanced a very small distance at a time to facilitate positioning of the die, the work and the tools on the ram units. This arrangement also allows a precision deliberate advancement of a piston rod and tool carried thereby to be performed which is highly desirable in a draw operation with respect to a cylindrical or tubular shaped work piece.

The entire order and manner of operation of the process and apparatus described, may be readily changed by merely adjusting each of the control wafer switches that control the circuitry for the hydraulic ram units. Thus

the programming of the entire system may be readily changed at will which is not possible with conventional punch presses and similar systems. It is pointed out that any particular ram unit may be immediately phased out of operation by moving the control wafer switch thereof to the open condition. With the present type of programming system, an operator may quickly set-up the apparatus for the desired operation on the work in a fraction of the time ordinarily experienced with conventional systems. It will be seen that by using hydraulic and electrical systems to control operation of the present apparatus and process, the tonnage pressure exerted by the work engaging media may be adjusted to a relatively wide range which also is a desirable feature since the work acted upon will vary with respect to its physical properties, structural dimensions and the like. It will further be noted that the present system also permits wide adjustment of the velocity of the work engaging media carried by the ram units, a condition which is not possible with a conventional system.

The various hydraulic units may also be readily removed and repositioned.

Thus it will be seen that we have provided a novel process and apparatus for engaging an article of work to be engaged by work engaging media to perform a piercing or shaping operation on the work in a more efficient manner than any heretofore known comparable system.

It will, of course, be understood that various changes may be made in the form, details, arrangement and proportion of the various parts without departing from the scope of my invention.

What I claim is:

1. Apparatus for forming and shaping an article of work, said apparatus comprising:

a support, a die detachably mounted on said support for supporting the work thereon, a plurality of fluid pressure double-acting cylinder and piston units each comprising a cylinder having a piston movable therein, a piston rod secured to said piston for retraction and extension relative to said cylinder, means detachably mounting each of said cylinders on said support to permit ready removal thereof from the support, each piston rod having a work engaging mechanism thereon for engaging the work when the piston rod is advanced, said work engaging mechanism cooperating with said die for engaging and forming the work, a plurality of conduits interconnected with a source of fluid on the pressure, each cylinder having a pair of said conduits connected in communicating relation therewith, a plurality of similar electrically controlled valve mechanisms each interposed in flow-controlling relation with respect to a pair of said conduits, each valve mechanism being operable to selectively intercommunicate one of its associated conduits with the associated cylinder and thereby control extension and retraction of the piston rod for the associated cylinder, each valve mechanism being selectively adjustable to a neutral position whereby each associated pair of conduits is closed with respect to the associated cylinder, electrical circuitry comprising a plurality of inter-connected electrical circuits and each including one of said electrically controlled valve mechanisms, each circuit including a plurality of substantially identical multiple position switches, each being inter-

posed in circuit controlling relation with respect to one of said electrically controlled valve mechanisms, each multiple position switch being shiftable between an open position wherein the circuit to the associated electrically controlled valve is open and a plurality of closed positions wherein the circuit to the associated electrically controlled valve is closed, the closed position of each multiple position switch determining the sequence of operation of the associated piston and cylinder unit with respect to other piston and cylinder units whereby when any of said multiple position switches are preset to the same closed positions, the associated piston and cylinder units will extend and retract simultaneously with respect to each other, and when any of said multiple position switches are preset in different closed positions, the associated piston and cylinder units will extend and retract sequentially with respect to each other, a pair of normally open manually operable control switches in said circuitry and arranged in series, said control switches being operable to energize said circuits through a complete cycle only when held in a closed position until the piston rods of said units have been completely extended.

2. The apparatus as defined in claim 1 wherein said actuating units comprise hydraulic fluid pressure units, said support having a plurality of elongate slots therein and each cylinder having attachment elements thereon releasably engaging selected of said slots to permit relative adjustment of the position of each unit with respect to the die.

3. The apparatus as defined in claim 1 wherein said work engaging mechanism for each actuating unit includes a piercing element.

4. The apparatus as defined in claim 3 wherein each of said work engaging mechanisms includes a housing having a hollow interior and connected to a source of fluid under pressure, a piston positioned within said housing and being movable therein in response to fluid pressure, a piercing pin affixed to said housing and projecting outwardly therefrom, a perforated plate positioned exteriorly of said housing and being connected to said piston for movement with the latter, said piercing pin extending through said perforated plate and serving to pierce the work when the piston rod of the associated pressure unit is advanced, said perforated plate being normally urged outwardly and engaging the work during said piercing operation and being yieldably held thereagainst whereby when said piston rod of the fluid pressure unit is retracted, said perforated plate serving to facilitate retraction of the piercing pin from the work.

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