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PIERCING UNIT HYDRAULIC CONTROL
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This invention relates to piercing unit hydraulic controls of the type generally disclosed in my prior Patents No. 3,089,375, issued May 14, 1969, for Hydraulically Actuated Piercing Unit, and No. 3,016,707, issued Jan. 16, 1962, for Hydraulic System for Fabricating Dies. The invention of the instant application is an improvement over that disclosed in my prior copending application Ser. No. 91,362, now Patent No. 3,147,657, filed Feb. 24, 1961, for Hydraulically Actuated Piercing Unit, of which the present application is a continuation-in-part, such copending application in turn being a continuation-in-part of the applications upon which Patent No. 3,089,375 is based.

The present invention has reference to certain new and useful improvements in hydraulic piercing systems where- by the tool of the piercing unit may be hydraulically and rapidly actuated in both directions and wherein the pressure applied in moving such tool in one direction is independent of that applied for moving it in the other direction. The present invention also provides a system which is very flexible whereby it may be readily adapted to meet a wide variety of conditions.

A principal object of the invention is to provide a new and improved piercing unit hydraulic control. Other and further objects of the invention will be apparent from the following description and claims and may be understood by reference to the accompanying drawings, of which there are three sheets, which by way of illustration show preferred embodiments of the invention and what is now considered to be the best mode of applying the principles thereof. Other embodiments of the invention may be used without departing from the scope of the present invention as set forth in the appended claims.

In the drawings:
FIGURE 1 is a schematic view of a piercing unit hydraulic control system embodying the invention, with certain parts shown in section; FIGURE 2 is an enlarged sectional view of the piercing unit per se; and FIGURE 3 is a view similar to FIGURE 1 of a modified system.

As illustrated in FIGURE 1, the system in general comprises a piercing unit 10, a valve 12, a tank of hydraulic fluid 14, and a booster unit 16 interconnected in a hydraulic circuit for supplying hydraulic fluid under pressure to the piercing unit for advancing the tool thereof. The system of FIGURE 1 further includes another valve 20, a tank of hydraulic fluid 22, and a booster unit 24 which are interconnected in the hydraulic circuit for supplying hydraulic fluid under pressure to the piercing unit for retracting the tool thereof. The tanks should be mounted at an elevation above the piercing units and the boosters. The piercing unit 10 preferably comprises the construction illustrated in FIGURE 2. A cycling valve 26 is associated with the booster 16 for regulating the supply of compressed air thereto for energizing the booster 16, and a similar cycling valve 28 is associated with the booster 24, the cycling valves 26 and 28 being arranged to be alternately actuated for effecting the feed and retraction of the tool of the piercing unit.

As illustrated in FIGURE 2, the piercing unit comprises a cylinder 40 provided at one end with a guide 42, the bore 43 of which forms a sliding support for the enlarged head 44 of a tool holder indicated generally at 46. The guide 42 is removably fixed to one end of the cylinder 40 and a cap 48 is removably fixed to the guide 42. The tool holder 46 includes a shank 50 which projects into the bore 52 of the cylinder where it is secured to a piston 54 by bolt 56. The other end of the cylinder 40 is closed by a cap 58 to which the hydraulic fluid pressure line 60 is connected. The line 60 communicates with a passage 62 in the cap 58 which communicates with the cylinder bore 50 on one side of the piston 54, the latter being shown in its retracted position. The joint between the cap 58 and the cylinder 40 is gasketed by a seal, such as an O-ring 64, and the piston 54 is provided with sealing rings 66 and 68.

A shaft seal cage 70 is secured within the cylinder bore 52 adjacent the guide 42 and is provided with an annular sealing ring 72 for cooperation with the cylinder bore 52 and an annular seal 74 for sealing engagement with the shank 50 of the tool holder 46. The cage 70 is suitably anchored in the position illustrated and along with the guide 42 serves to slidably support the tool holder 46. A stop collar 76 is seated within the bore 52 adjacent the cage 70 and is provided with an aperture for accommodating the shank 50 of the tool holder. A coil spring 78 is confined between the collar 76 and a washer 80 which abuts the forward face of the piston 54 and serves to bias the piston 54 and the tool holder 46 axially thereto to their retracted position.

A hydraulic fluid pressure line 82 is connected to the cylinder 40 and communicates with a passage 84 whereby hydraulic fluid under pressure may be supplied to the cylinder bore 52 to react on the piston 54 for returning it to its retracted position. A washer 86 is confined by and between the cap 48 and the guide 42 and includes an integral key 88 which projects into a longitudinally extending groove 90 in the enlarged portion 44 so as to prevent rotation thereof. When the bolts 92 which clamp the cap 48 to the guide 42 are loose, the tool holder 46 may be rotated about its axis so as to properly orient the tool 94 with the work, this adjustment being accomplished by using a hand tool on the projecting end of the tool or punch 94 so as to rotate the tool holder 46 to the desired position. Thereafter the bolts 92 are tightened so as to lock the tool holder and the tool 94 carried thereby against rotation. The tool holder 46 includes a socket 100 in which the shank of the tool 94 is seated and retained by a setscrew 102 which is threadedly positioned in a tapped hole in the tool holder 46 whereby the tool 94 may be secured in the socket 100 and removed therefrom. A stripping nose 104 is slidably secured on the end of the tool holder 46 and biased to its extended position by a spring 106 which is confined between the tool holder 46 and the inside end of the nose 104. The tool securing end of the piercing unit construction is disclosed and can be had by my prior application Ser. No. 294,427, filed July 11, 1962.

The length of the stroke of the tool 94 is determined by the distance between the piston 54 and the collar 76, and where different travel is required a cage 70 or collar 76 of different axial length than the one illustrated may be employed. The collar 76 is packed in grease 70 thus forms a stop for limiting the feed stroke of the tool 94 under the hydraulic fluid pressure applied to the back face of the piston by fluid introduced into the cylinder 52 through the port 62. The spring 78 and hydraulic fluid under tank pressure supplied to the cylinder bore 50 through the fluid control 82 retracts the tool 94 for retracting it and the tool 94 with a force considerably in excess of the tank pressure normally applied through line 60 so that the tool 94 is normally retracted.
The tank 14 is supplied with hydraulic fluid under pressure, say for example 20-40 lbs. per square inch (preferably about one-half the air pressure supplied to tank 22), through the air pressure line 110, and the pressure in the tank is maintained and regulated by the valve 112. The tank contains a quantity of hydraulic fluid under such pressure which is supplied to the booster 16 and to the cylinder bore 52 of the hydraulic cylinder of the feed stroke of the tool 94. The tank 14 is connected by hydraulic fluid pressure line 116 to a passage 118 in the valve 12. The passage 120 communicating at one end with the passage 118 communicates with a passage 122 past a check valve 124, the check valve serving to permit hydraulic fluid flow from the passage 120 into the passage 122, but not in the reverse direction. The passage 126 in the valve 12 interconnects the passage 122 and a hydraulic fluid pressure line 128 which leads to the hydraulic fluid cylinder (not shown in detail) of the booster 16. The booster 16 may be of the construction disclosed in my prior application Ser. No. 91,362 and includes, in addition to the hydraulic cylinder, an air cylinder of larger size which when energized is effective to energize the hydraulic cylinder so as to discharge hydraulic fluid from the booster 16 at a pressure many times that prevailing in the tank 14. The air cylinder of the booster 16 may have a diameter ten times that of the hydraulic cylinder, with the result that when the booster 16 is energized, the hydraulic fluid discharged from the hydraulic fluid cylinder will be discharged under a pressure ten times that of the air pressure applied to the air cylinder of the booster, and if such air pressure is 100 lbs. per square inch, the booster will discharge hydraulic fluid under a pressure of 1000 lbs. per square inch.

The hydraulic cylinder of the booster is charged with hydraulic fluid from the tank 14 when the booster is deenergized, the pressure on the hydraulic fluid in the tank serving to recharge the hydraulic cylinder of the booster and to retract the air piston thereof. The supply of air under pressure to the booster 16 is controlled by the cycling valve 26 which is adapted when actuated to open the air pressure line 118, thus permitting the application of air pressure to the air cylinder of the booster 16 for energizing the booster. When the cycling valve 26 returns to its normal position, it shuts off the air supply to the booster 16 and vents the air under pressure previously supplied thereto so as to deenergize the booster 16. Upon the deenergization of the booster 16 the hydraulic fluid under said pressure will flow from the tank 14 to the hydraulic cylinder of the booster for recharging the same.

The passage 118 in the valve 12 communicates through a normally open valve 130 with passage 134 which is in open communication with the oil line 60 leading to the cylinder bore of the piece unit 10 so that oil under tank pressure is supplied to the cylinder bore 52 through the passage 62, but the tank pressure on such oil is inadequate to move the piston 54 against the resistance of the spring 78 and the hydraulic pressure supplied through line 82. The valve 130 comprises a sleeve 136 seated in valve chamber 138 and a piston type valve 140 which is slidable within the sleeve 136 and biased to the position illustrated by spring 142. The valve chamber 138 intersects the passage 118 and also a passage 144 which communicates with one end of the passage 134.

The sleeve 136 is provided with ports which are in line with the passage 118 whereby in the position of the valve 130 as shown, oil is free to flow through such ports into the interior of the sleeve 136 and thence into the passage 134. The sleeve 136 is also provided with ports 146 in line with the passage 144, but such ports are normally closed by the piston valve 140 which is actuated on the end of the chamber 138 and around a shoulder provided by a port 150 which communicates with the passage 122.

When the booster 16 is energized, the hydraulic fluid discharged thereby reacts on the piston valve member 140 to shift the same so as to uncover ports 146 whereby the hydraulic fluid discharged by the booster is supplied through passages 144, 132, 134 and line 60 to the cylinder bore 52 of the piece unit 10 for effecting the feed stroke of the piece unit. The shifting of the piston valve member 140 in response to the discharge of hydraulic fluid from the booster closes the ports in the sleeve 136 which communicate with the passage 118 and thereby shuts off the normally open communication between the tank 14 and the cylinder bore 52 of the piece unit 10 and prevents transmission to the tank of the pressure generated by energization of the booster.

After the feed stroke of the tool 94 has been completed, the cycling valve 26 closes, which deenergizes the booster 16, and the cycling valve 28 is then actuated to energize the booster 24 as so as to effect the rapid retraction or return stroke of the tool 94 of the piece unit. The cycling valve 28 preferably is actuated in response to the completion of the feed stroke of the tool 94; that is, a sensing device responsive to the completion of the feed stroke of the tool 94 may be employed to actuate (i.e., open) the cycling valve 28 so as to energize the booster 24 as soon as the feed stroke of the tool 94 is completed thereby having the booster 24 effect rapid retraction and stripping stroke of the tool 94. The cycling valve 28 is the same type as the cycling valve 26, the booster 24 is of the same construction as the booster 16, the tank 22 is of the same construction as the tank 14, and the valve 20 is of the same construction as the valve 12; and the tank 22, valve 29, and booster 24 are hooked up in a hydraulic circuit in the same way as the corresponding elements 12, 14 and 16 and will function in the same way. However, the pressure maintained in the tank 22 preferably is higher and adjusted independently of the pressure in the tank 14, and the booster 24 may be larger or smaller than the booster 16 so that the pressure available on the feed stroke of the tool 94 may be greater or less than the pressure available for retracting the tool 94. When spring 78 is adequate to effect the retraction of tool 94 against the hydraulic pressure supplied from tank 14, tank pressure on both of the circuits may be the same and a common pressure tank may be employed, although for efficient retraction and stripping and other reasons I prefer to use a pressure in tank 22 sufficiently high to overcome the difference in effective area on opposite sides of piston 54.

The check valve 28 and 26 prevents the boosters 16 and 24 from being fed with pressure above tank pressure when the boosters 16 and 24 are normally open or inactive so that the boosters 16 and 24 are normally deenergized so that the system will normally be in the position as illustrated in FIGURE 1. The cycling valve 26 may be actuated in any suitable way, such as for example in response to a sensing device responsive to positioning of the blank in operative relation with respect to the tool 94. The feed of the work blank may be manual or mechanized, and with the arrangement illustrated the tool 94 may be rapidly actuated and power moved in both directions so as to make it possible to achieve rapid piercing of successive blanks. In fact, the tool 94 may be reciprocated with such rapidity that the recharging of the hydraulic cylinders of the boosters 16 and 24 is expedited by the hydraulic fluid displaced from the cylinder bore 52 of the piece unit 10 through passages 118 and 120 due to the fact that spring 142 opposes valve 130 as soon as booster 16 is deenergized. It will be evident that oil under tank pressure may be supplied for use by the hydraulic cylinders of the booster units 16 and 24 and the cylinder bore 52 of the piece unit 10 so as to make up for any leakage around the piston 54 and the pistons of the booster units 16 and 24.

If hydraulic pressure return of the tool 94 is not desired, the means for trip points on the tool 94 and may be removed or the circuit which includes the valve 20, booster 24, and tank 22 otherwise disabled.
whereby the spring 78 will be effective to retract the tool holder 46 and the tool 94 carried thereby. The spring 78 is not required where hydraulic fluid pressure in tank 22 is adequate to retract the piston 54, but the spring does serve to locate the stop collar 76 adjacent the seal cage 77. The cylinder 52 is differentially on opposite sides of piston 54, and where hydraulic retraction pressures are adequate the spring 78 can be a very light spring. However, when the spring 78 alone is used for retraction, a much heavier spring is required.

In the modification of FIGURE 3, the pierce unit 10 and the hydraulic system for effecting the retraction thereof, including the ram 24 and the first hydraulic tank 22 are substantially the same as in FIGURE 1. However, the system for effecting the feed stroke of the tool is actuated differently but operates in the same way as the system which includes the valve 12, the booster 16, and the pressure tank 14 of FIGURE 1. The pressure tank 214 for the feed part of the system in FIGURE 3 may be the same as in FIGURE 1. The valve 212 includes all of the mechanism of the valve 12 plus a pressure relief valve which is indicated at 215, and instead of using air pressure operated booster such as 16 to supply the pressure required for effecting the feed stroke, such pressure is supplied by a booster cylinder 216 and piston 217 actuated by the ram 218 of a press, as shown in FIG. 1 of my Patent No. 3,089,375. The cylinder 216 is supplied with hydraulic fluid pressure from the tank 214 through the fluid pressure line 228 which is connected to the valve 212, and the tank pressure normally biases the piston 217 to its upper position. However, when the closing of the press ram, the piston 217 is moved so as to displace hydraulic fluid from the cylinder 216 which is supplied through the line 228 to the valve 212 and thence to the pierce unit 210 in a manner similar to that described in connection with the valve 12. For convenience, the parts of the valve 212 which correspond to the valve 12 are indicated by the same reference characters.

When the press ram 218 reaches the bottom of its stroke, the oil flow to the cylinder of the pierce unit stops and the spring 142 of the balance valve moves the valve piston to open the ports in sleeve 136 which communicate with passage 118. This allows free flow of oil from the pierce unit to the tank and prevents a hydraulic lock between the pierce unit and the cylinder 216, allowing fast return of the piston 54 and the tool 94 for stripping.

Since the ram-actuated piston and cylinder 217, 216 are capable of developing tremendous pressure in the system, a pressure relief valve 215 is included in the valve 212 so as to dissipate excess pressure in the event that the feed stroke of the pierce unit is completed before the ram 218 reaches the bottom of its stroke. The pressure relief valve essentially is of the construction illustrated in my patent Reissue 25,027. The pressure relief valve 215 essentially provides a pressure relief by-pass between passage 122 on the high pressure side of the system and passage 118 on the low pressure side when the valve 130 is closed so as to prevent the generation of dangerous pressures on the high pressure side of the system. The pressure relief valve of course may be adjusted so as to set the bleed-off pressure at any desirable pressure, and such pressure will then be the maximum pressure that can develop on the high pressure side of the system.

While I have illustrated and described preferred embodiments of my invention, it is understood that these are for the purpose of illustration and that the invention may be practiced in many other ways and that the scope of the invention is limited only by the scope of the appended claims.

I claim:

1. A hydraulically actuated pierce unit comprising a hydraulic cylinder having a piston reciprocable therein and a piercing tool connected to said piston so as to move therewith, a first hydraulic circuit connected to said cylinder on one side of said piston for supplying hydraulic fluid under pressure thereto for moving said piston in one direction, a second hydraulic circuit connected to said cylinder on the other side of said piston for supplying hydraulic fluid under pressure thereto for moving said piston in the opposite direction, each of said circuits including a tank of hydraulic fluid under pressure thereto, a pressure relief valve connected in fluid flow and a pressure relief valve connected in fluid flow and pressure transmitting relation to each other and to said cylinder so that said cylinder and said booster are supplied with hydraulic fluid under tank pressure, and a value in the hydraulic connection between said cylinder and said tank which is operable upon energization of said booster to prevent the transmission to said tank of pressure generated by the energization of said booster, said valve including a spring biased valve member normally positioned to provide fluid flow from said cylinder to said tank upon energization of said booster, the pressure in the tank of the circuit for effecting the retraction stroke of said tool being substantially higher than the pressure in the other tank so that said tool is normally retracted when said boosters are deenergized.

2. Apparatus according to claim 1 wherein the fluid flow and pressure transmitting connections of each of said circuits comprises a one-way fluid flow connection therethrough.

3. A hydraulically actuated pierce unit comprising a hydraulic cylinder having a piston reciprocable therein and a piercing tool connected to said piston so as to move therewith, a first hydraulic circuit connected to said cylinder on one side of said piston for supplying hydraulic fluid under pressure thereto for moving said piston in one direction, a second hydraulic circuit connected to said cylinder on the other side of said piston for supplying hydraulic fluid under pressure thereto for moving said piston in the opposite direction, each of said circuits including a tank of hydraulic fluid under pressure thereto, a pressure relief valve connected in fluid flow and pressure transmitting relation to each other and to said cylinder so that said cylinder and said booster are supplied with hydraulic fluid under tank pressure, and a value in the hydraulic connection between said cylinder and said tank which is operable upon energization of said booster to prevent the transmission to said tank of pressure generated by the energization of said booster, said valve including a spring biased valve member normally positioned to provide fluid flow from said cylinder to said tank upon energization of said booster, the pressure in the tank of the circuit for effecting the retraction stroke of said tool being substantially higher than the pressure in the other tank so that said tool is normally retracted when said boosters are deenergized.

4. Apparatus according to claim 3 wherein said boosters are energized alternately.

5. A hydraulically actuated pierce unit comprising a hydraulic cylinder having a piston reciprocable therein and a piercing tool connected to said piston so as to move therewith, a first hydraulic circuit connected to said cylinder on one side of said piston for supplying hydraulic fluid under pressure thereto for moving said piston in one direction, a second hydraulic circuit connected to said cylinder on the other side of said piston for supplying hydraulic fluid under pressure thereto for moving said piston in the opposite direction, each of said circuits including a tank of hydraulic fluid under pressure thereto, and a pressure relief valve connected in fluid flow and pressure transmitting relation to each other and to said cylinder so that said cylinder and said booster are supplied with hydraulic fluid under tank pressure, and a normally open valve in the hydraulic connection between said cylinder and said tank which is operable upon energization of said booster to shut off the fluid flow connection between said cylinder and said tank, said valve including a spring biased
valve member normally positioned to provide fluid flow from said cylinder to the tank when said booster is de-
energized.

6. Apparatus according to claim 5 wherein said pierce unit includes a spring biasing said piston to its retracted position whereby said piercing tool may be retracted by said spring when the hydraulic circuit operable for re-
tracting said tool is ineffective.

No references cited.

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