

Nov. 26, 1963

H. R. GOFF ETAL

3,111,869

PORTABLE PUNCH RIVETER

Filed Dec. 4, 1961

5 Sheets-Sheet 1

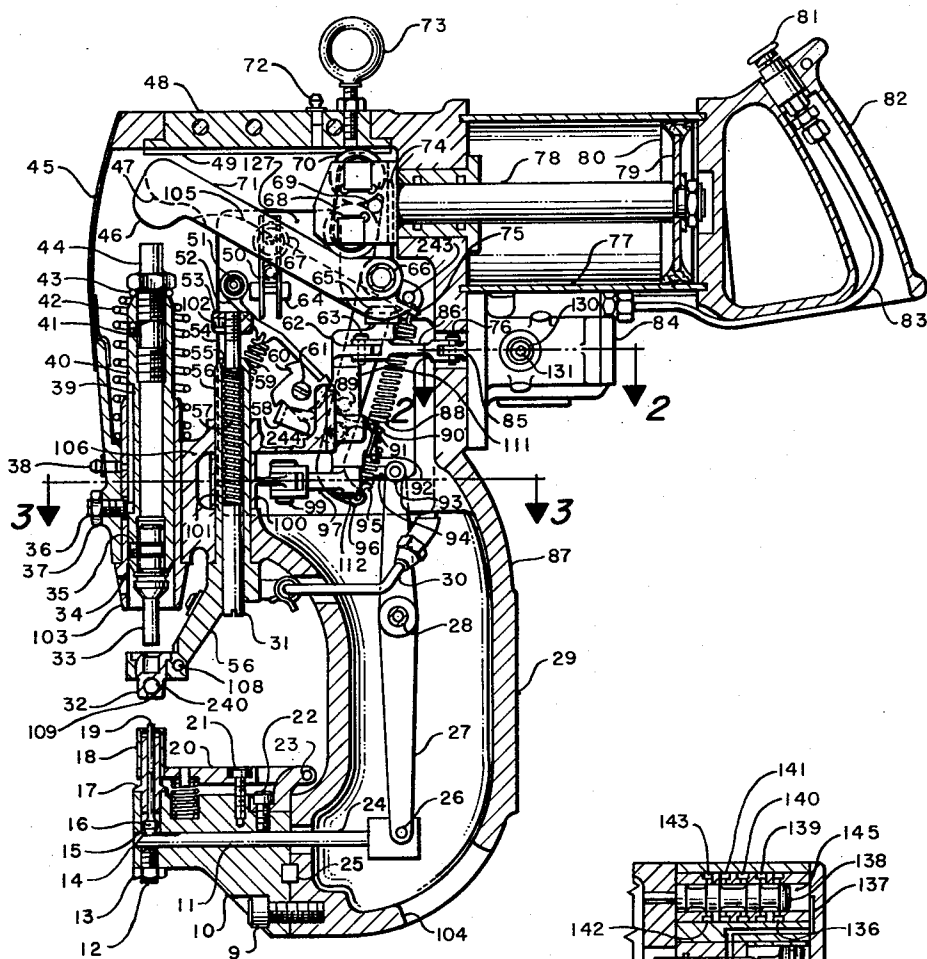


FIG. 1

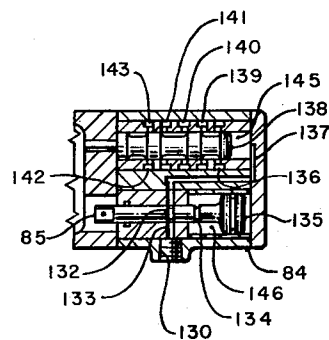


FIG. 2

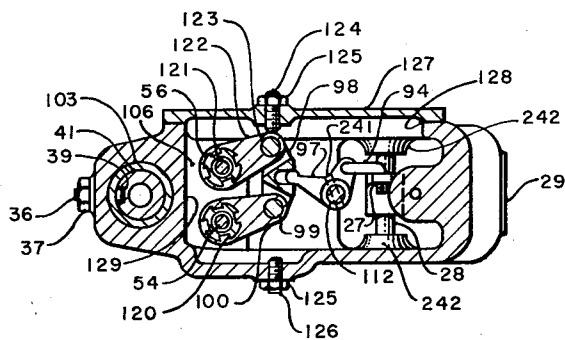


FIG. 3

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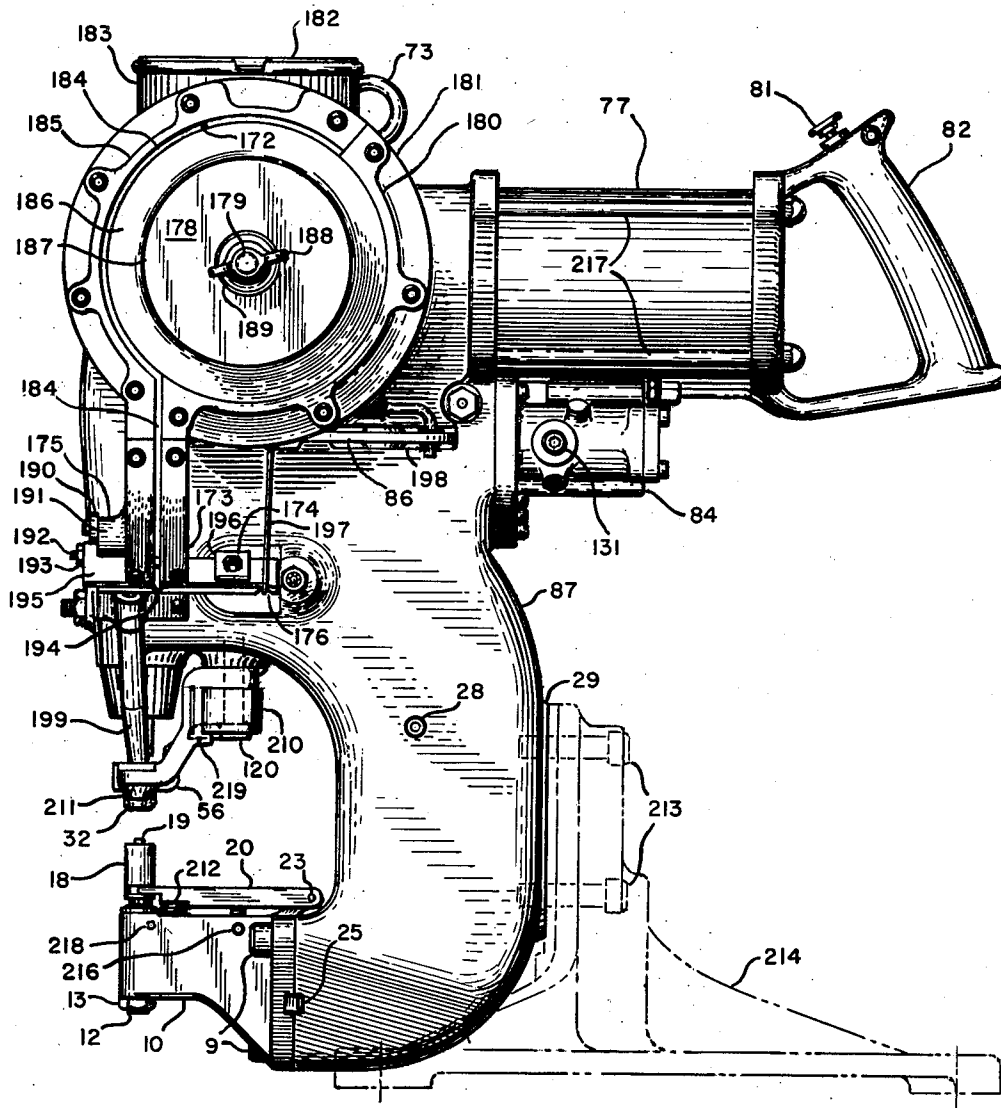


FIG. 4

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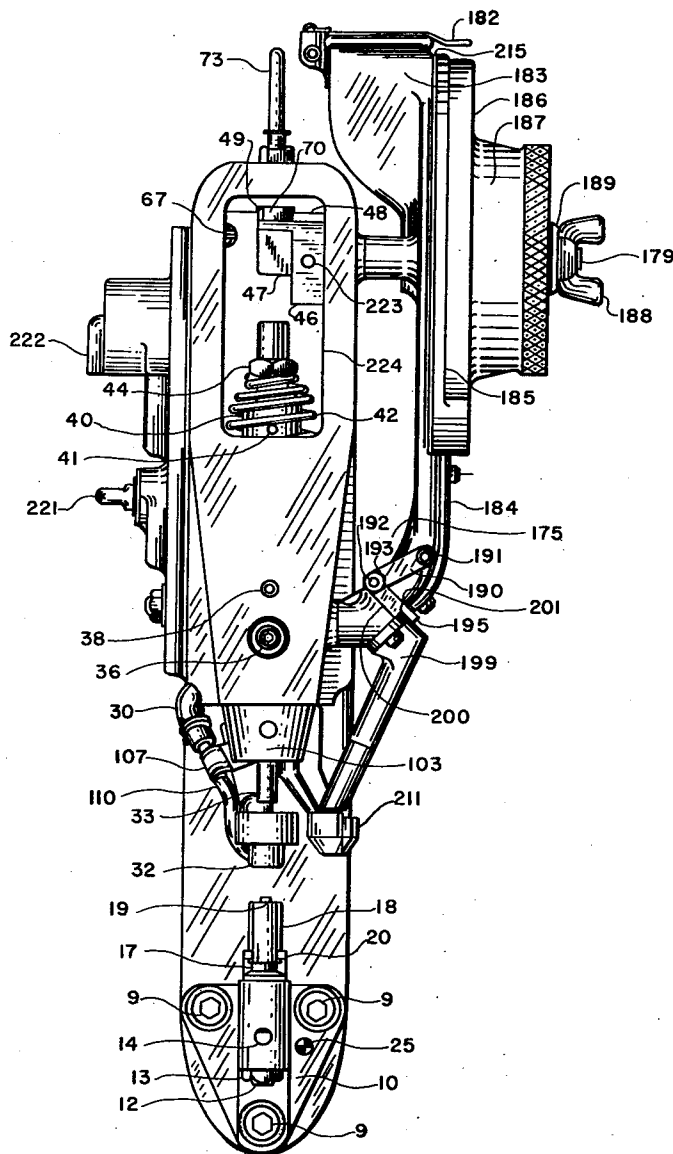
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3,111,869

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Filed Dec. 4, 1961

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INVENTOR.

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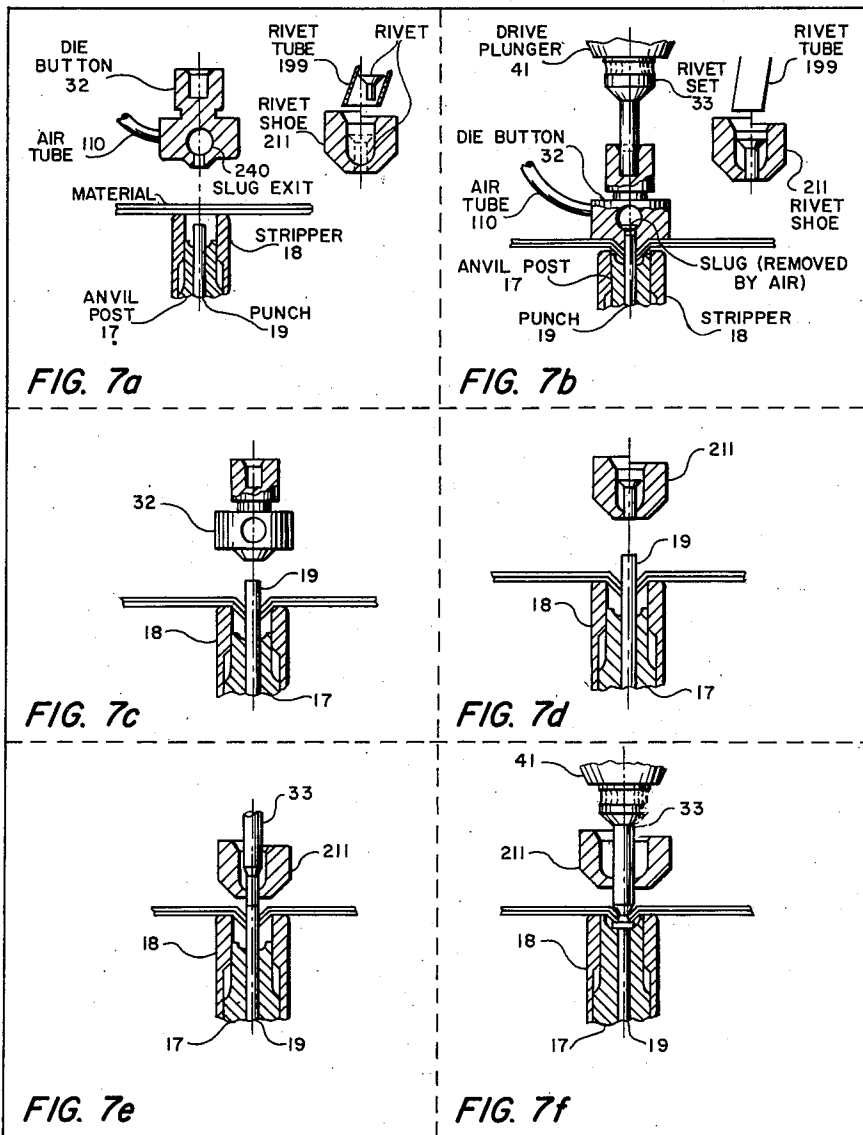
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3,111,869

Filed Dec. 4, 1961

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3,111,869

PORTABLE PUNCH RIVETER

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Filed Dec. 4, 1961, Ser. No. 156,872
5 Claims. (Cl. 78—46)

This invention relates to riveting machines and more particularly to a portable squeeze punch riveter of the type that automatically punches a hole in parts to be fastened, places the rivet in the hole, and heads or flares over the rivet to secure the parts together.

In fastening large or massive sheet assemblies such as airfoil structures in the aircraft industry where the configuration or weight of the components precludes moving the parts to be joined under a stationary riveting machine, it is the practice to perform the fastening operations by means of portable tooling at the final assembly site. This is generally accomplished by means of a portable power driven drilling tool which first drills the rivet holes in the parts to be joined, then the rivets are manually inserted into the rivet holes, then one operator "bucks" the rivets by holding a bucking bar against the rivet head on one side of the assembly while another operator operates a power driven riveter on the other side of the assembly to flare over the rivet shank and secure the parts together. These operations are tedious, time consuming and require relatively skilled operators and the exercise of great care to secure a satisfactory riveted joint. In an attempt to reduce the time and skill required for the operation, portable combination drilling and riveting machines have been developed. These machines are an improvement over the separate operation type of assembly, but the drilling still requires an appreciable period of time, drill chips become lodged between the parts to be joined, and they contaminate the surrounding area.

It is accordingly a broad object of the present invention to provide an improved light weight machine for automatically forming holes in the parts to be joined, for inserting rivets in the holes formed and for bucking and heading the rivets without moving the material during the cycle.

It is a further object to provide an improved light weight punch riveting machine.

It is a still further object to provide a fully portable punch riveter for punching holes, or punching and dimpling holes for flush type rivets, and automatically feeding and heading the rivets in one continuous operation.

It is an additional object to provide a fully automatic self-contained portable punch riveter that requires only a source of compressed air for control and power during the automatic cycling.

It is a feature of this invention that it may be operated automatically in a single cycle performing the punching and riveting operation by actuating the control valve once or semi-automatically in two cycles requiring actuation of the control valve before both the punching operation and the riveting operation.

It is a further feature of this invention that in addition to being fully portable it can be very simply adapted for bench mounting or for use with an overhead balance reel attachment as a means of reducing operator fatigue, increasing production and decreasing maintenance costs by eliminating accidental dropping or rough handling.

These and additional objects and features are accomplished in the present invention by a self-contained pneumatically operated automatic machine in which the drive plunger supplies both the punching and riveting stroke to the workpiece supported on the cylindrical stripper

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surrounding the anvil within which is the punch which arises with forward motion of the punch lift. The pneumatic power system consists of a drive cylinder and piston which in the forward position depresses either of two camming surfaces, depending upon the position of a shift piston, against a drive plunger to furnish the punch stroke or the rivet heading stroke. The pneumatic control system employs a control valve, a shift valve and some miscellaneous valves.

The control valve controls the direction of flow of compressed air into the drive cylinder and correspondingly the direction of motion of the drive piston and drive plunger. The shift valve piston drives a mechanical linkage which in one shift piston position moves the punch camming surface over the drive plunger, releases a rivet to the rivet shoe, indexes a die shaft holding a die button under the rivet set which is attached to the bottom of the drive plunger, and moves the punch lift forward to extend the punch up above the anvil post. Upon opening the start valve, the control valve directs compressed air against the drive piston to bring down the drive plunger and attached rivet set forcing the die button against the workpiece and down over the punch thereby perforating the workpiece. When the drive piston reaches its full forward extension, it actuates the control valve to pass compressed air in the reverse direction to the drive cylinder and initiate the up stroke. This in turn trips another valve which causes the shift valve piston to shift to the rivet position in which the attached linkage moves the rivet shoe shaft holding the rivet shoe and rivet under the rivet set, and withdraws the punch lift from under the lower end of the punch which because of friction remains in the hole to keep the workpiece fixed. If the selector valve is in the automatic position, when the rivet camming surface moves over the drive plunger in response to the linkage motion, it trips another valve which actuates the control valve again to direct air against the drive piston and bring down the rivet set for the second time thereby forcing the rivet through the punched hole in the workpiece, driving out the punch and heading the rivet against the punch face. As discussed above, when the drive piston is fully extended, it actuates the control valve to initiate the upstroke again and the spring actuated stripper forces the riveted workpiece away from the anvil to complete the automatic cycle. If the selector valve is in the semi-automatic position, the start valve must be manually opened a second time after completing the punching operation to start the riveting stroke.

The following description and drawings will give a fuller appreciation of these and other features of this invention in which:

FIG. 1 is a sectional view of the portable punch riveter of this invention in an upright position.

FIG. 2 is a sectional view of the master control valve of the present invention taken along the cutting plane line 2—2 of FIG. 1.

FIG. 3 is a sectional view of the shifting linkage of the present invention taken along the cutting line 3—3 of FIG. 1.

FIG. 4 is a side elevation of the portable punch riveter in the same position as is shown in FIG. 1.

FIG. 5 is a front elevation of the portable punch riveter of the present invention.

FIG. 6 is a pneumatic schematic representation of the internal air channelling and controls operating the portable punch riveter.

FIGS. 7a, 7b, 7c, 7d, 7e and 7f are successive sequential diagrams showing the punching, dimpling and riveting operations of the portable punch riveter of the present invention on the work piece.

The portable punch riveter shown in various views and

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sections in FIGS. 1, 2, 3, 4 and 5 comprises seven main assemblies: the housing, a pneumatic power system, a pneumatic control system, a mechanical drive system, a mechanical shift linkage, a rivet feeding system and the anvil assembly.

The housing 87, in the present embodiment, is shown as a hollow casting suitably apertured to provide access holes and space for connections between parts that extend on either side of the casting wall. FIG. 3 shows a horizontal section along cutting plane line 3—3 through the center of housing 87 and illustrates that the housing typically consists of a shell of uniform thickness with suitable increases in thickness to furnish the necessary bearing strengths for stressed members and with mounting bosses such as 106, to furnish supports for the component parts. Master control bracket 111 which has an axial hole through its length as shown by shaft 112 protruding from its lower end is fastened to mounting boss 106 in a vertical position by screws not shown. Access holes 224 in FIG. 5, 104 in FIG. 1 and 128 in FIG. 3 provide for convenient inspection and adjustment of movable parts. Cover 45 of FIG. 1 covers access hole 224 and cover 127 of FIG. 3 covers access hole 128 when the riveting machine is in operation. Drive plunger bushing 103 is pressed into position in front boss 129.

Housing 87 has a vertical finished boss 29 to which may be fastened as shown in FIG. 4 by suitable fastenings 213, a mounting bracket 214 which in turn may be securely fastened to a solid bench or stand, so that the punch riveter may also be used in a stationary position where it is more convenient to handle the work piece than the riveting machine.

Eyebolt 73 is threaded into roller track plate 48 at the top of housing 87 and provides means for fastening a balance reel attachment ring to the punch riveter and to an overhead support, thus reducing the effective weight of the riveter in the hands of an operator. The overhead support may be movable such as in the manner of a wheel on a monorail, so that the balance reel and riveter can roll along parallel to a long work piece, and the operator is not limited to one station but can apply rivets all along the length of a work piece so long as the overhead monorail is properly located.

Anvil 10 of the anvil assembly is accurately aligned with respect to housing 87 by dowel 25 and fastened to the housing with three screws 9. Anvil post 17 is press fitted into anvil 10 and locked into place with set screw 218. Within the anvil post, punch 19 and punch adaptor 16 are free to slide up and down. When the beveled end 14 of punch lift 24 comes forward in guide hole 15 underneath the lower convex surface of punch adaptor 16 during the punching stroke, it elevates the punch to a level with or slightly below the top of stripper 18 which fits around the circumference of anvil post 17. On the riveting stroke, punch lift 24 is withdrawn so that its beveled end 14 moves out from under punch adaptor 16. Punch 19 is adjusted by means of adjusting screw 12 and locknut 13 at the bottom end of anvil 10 when punch lift 24 is withdrawn. Stripper 18 is held in place by stripper arm 20 which fits into recesses in the stripper and is mounted on pivoted joint 23 fastened to anvil 10 by means of screw 22. The stripper 18 acts mainly as a buffer during the punching stroke due to the force exerted on stripper arm 20 by compression spring 212. Stripper adjusting screw 21 adjusts the stripper 18 for proper height against the force exerted by spring 212. Set screw 216 locks adjusting screw 21 in place when the proper stripper height has been obtained.

In the pneumatic power assembly, drive cylinder 77 is fastened at one end to housing 87 by four tie rods 217. Handle 82 is formed integral with the opposite end of drive cylinder 77 and incorporates a normally closed thumb operated pneumatic control valve 81 which in the open position exhausts compressed air line 83 to the atmosphere. Air line 83 in this embodiment is formed of

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copper tubing. Gasket 80 seals the cylinder air on either side of piston 79 from leakage around the piston edge. Piston rod 78 is attached to and moves with piston 79. As described later and shown schematically in FIG. 6, there is an opening or port at either end of drive cylinder 77 to let air into or exhaust air out of the drive cylinder. Piston 79 and piston rod 78 move in the direction of decreasing pressure within cylinder 77. Also as described later and shown schematically in FIG. 6, there is an aperture through piston rod 78 which in the most forward position of travel of the piston rod connects together two air lines that are in all other positions of the piston rod 78 interrupted by the piston rod.

The mechanical drive system furnishes the downward force required for the punching and riveting operations. Drive plunger 40 is slidably mounted within drive plunger bushing 103. Half-dog set screw 36 is threaded through housing 87 so that the half-dog point fits within keyway 39 in drive plunger 40 and prevents the drive plunger from rotating in its vertical travel. Jam nut 37 locks set screw 36 in place. Grease fitting 38 is pressed into housing 87 for lubricating the bearing surface between drive plunger 40 and drive plunger bushing 103. Plunger adjusting screw 44 is screwed into the threaded top end of the central hole in drive plunger 40 and compresses plunger return spring 42 on its top coil 43 until the proper stroke is obtained. When this adjustment is made, plunger adjusting screw 44 is locked into position with set screw 41. Rivet set 33 is lightly press fitted into the bottom end of the central axial hole in drive plunger 40 and locked into place with set screw 35. Clearance hole 34 in housing 87 allows access to set screw 35.

Attached to the forward end of piston rod 78 are two rollers 70 and 68. Upper roller 70 is constrained by roller track 49 in roller track plate 48 so that forward and backward motion of piston rod 78 and attached parts is in a straight line. Pin 69 which serves as a stop for shift valve lever 74 to be described hereafter is also attached to the forward end of piston rod 78.

Plunger drive cam 71 is pivotally and slidably mounted on cam pin 66 so that it is free to slide back and forth in a plane perpendicular to the plane of the paper of FIG. 1, as well as being free to pivot about cam pin 66 in the plane of the paper of FIG. 1. Plunger drive cam 71 has an axial spline 105 running along the bottom and two camming surfaces 46 and 47 at its forward under end. The top of plunger drive cam 71 is flat to provide a path for bottom roller 68. The back end of plunger drive cam 71 is constrained by the tension of cam spring 88 which fits into hole 75 in the cam and at the other end is fastened to groove 92 in master control bracket 111 to be described hereafter.

The disposition of the components of this mechanical drive system is such that as piston rod 78 moves forward, lower roller 68 depresses plunger drive cam 71 so that the camming surface 46 or 47 previously indexed into drive position by the action of the mechanical shift linkage to be described later contacts plunger adjusting screw 44 and forces drive plunger 40 down against the force of the drive plunger return spring 42 to perform the punching or riveting operation. At the end of each stroke, the plunger is returned to its idle position by return spring 42. As lower roller 68 returns to its idle position the back end of cam 71 is pulled down by the action of cam spring 88.

The rivet feeding system comprises hopper assembly 178, the rivet selector mechanism and the rivet tube 199 which are illustrated in FIGS. 4 and 5. Spring loaded cover 182 may be raised for introducing rivets into rivet hopper 183. Rivet drum 187 is rotatably mounted on shouldered hopper drum shaft 179 with washer 189 and wingnut 188 and spaced from rivet hopper 183 by hopper face plate 215 of suitable bearing material and by the shoulder on hopper drum shaft 179 to allow suitable clearance between the under surface of the rivet drum flange

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186 and the bearing face plate. Rivet drum 187 which has the configuration of a flanged cup as shown in FIG. 5 is hollow on the underside of the cup shaped portion to increase the rivet holding capacity of the machine. The undersurface of the flanged portion of rivet drum 187 bears against hopper face plate 215 and contains spaced radial slots of a suitable dimension for the shanks of the rivet size employed. As the rivet drum 187 is manually rotated clockwise by the operator, the shanks of some rivets in the drum fall into the bottom slots in the rivet drum flange. As the drum continues to rotate, the rivets in the outer periphery of the slots are carried upward and fall into rivet track 184 and gravity carries them down to the rivet selector mechanism. The edge of rivet guide 172 facing rivet track 184 is shaped to guide rivets climbing up the rivet track back into the rivet drum and prevent jamming. Side flange 180 also mounted to rivet hopper 183 contains the rivets within the drum slots on the other side of the drum. The rivet track on the hopper assembly is formed by the space between side flange 185 and rivet drum 187 which accommodates the rivet shanks and a recess between side flange 185 and hopper face plate 215 to accommodate the rivet heads. There is a similar space between the under surface of the flanged portion of rivet drum 187 and bearing face plate 215 for the rivet heads. Side flange 185 is also fastened to rivet hopper 183.

The rivet selector 195 shown in FIGS. 4 and 5 is translationally mounted on the flat surface of mounting boss 200. Rivet selector 195 has a T slot 194 cut into it, so that when the T slot leg is properly aligned with the rivet track 184, the rivet head falls into the horizontal part of the T slot and the rivet shank falls into the leg of the T slot. When this occurs and rivet selector 195 is then moved toward the front of the riveting machine to the point that the leg of T slot 194 is aligned with the central hole in rivet tube 199, the rivet falls by gravity, shank first down the rivet tube. Since the T slot 194 only holds one rivet, it provides a means of feeding one rivet at a time into rivet tube 199. Two adjustments are provided on rivet selector 195 to limit the travel and secure the proper alignment. Rivet selector stop 196 may be adjusted on rivet selector 195 by cap screw 174 to bear against bracket 173 and limit rivet selector travel toward the front of the riveting machine, and adjusting screw 192 can be adjusted with jam nut 193 to bear against mounting boss 175 on housing 87 and thereby limit rivet selector travel toward the rear of the riveting machine. The travel limits are set of course so that the T slot 194 is aligned in turn with rivet track 184 and the center hole of rivet tube 199. Rivet selector 195 is notched 201 to fit behind rivet tube 199 as shown in FIG. 5 so that it does not fall out of position.

The translating motion of rivet selector 195 is obtained through corresponding motion of drive spring 197 which fits into slot 176 in the rivet selector. Drive spring 197 is fastened by a screw not shown to feed link 86 which translates due to the action of the mechanical shift linkage to be described hereafter. Drive spring 197 is flexible to take up any differential in travel between feed link 86 and rivet selector 195.

In making some adjustments on the riveter requiring shifting of the mechanical shift linkage, it may be desirable to prevent rivets from entering the rivet tube. Selector stop pawl 190 which hangs as a pendulum from screw 191 can be positioned as shown in FIG. 5 to hold rivet selector 195 stationary and prevent it from picking up rivets. Rivet selector drive spring 197 then takes up the motion of feed link 86.

The mechanical shift linkage motion is initiated by translation of shift piston rod 85. In the position of shift piston rod 85 shown in FIG. 1, the machine is indexed for the punching stroke.

Rivet shoe shaft 120 and die shaft 56 are rotatably mounted in mounting bosses 106. Controlled vertical

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motion of both shafts is accomplished by adjusting the tension of the return springs 57 located inside the shafts. The construction is the same for both shafts which have external axial splines and internal bores to a depth 55 from the lower end. Extending through the shafts are tension screws 54 and 121 which are threaded at their top ends into mounting boss 53 and locked into place with set screws 102. Wound around tension screws 54 and 121 within the bores of rivet shoe shaft 56 and die shaft 120 are return springs 57. Threaded around the bottom ends of tension screws 54 and 121 are return spring stop nuts 31 which are clearance fits within the bores of rivet shoe shaft 56 and die shaft 120. Both the tension screws 54 and 121 as well as the stop nuts 31 have screw driver slots at their lower ends for adjustment. By adjusting stop nuts 31 on their respective tension screws 54 and 121, the compression of return springs 57 can be adjusted to control the motion of rivet shoe shaft 120 and die shaft 56.

Inserted in the bottom of die shaft 56 which is of one piece construction is die button 32 held in place by a set screw 108. Die button 32 contains slug ejection hole 240 directly above the die hole 109.

At the bottom end of rivet shoe shaft 120 is a tongue 219. Rivet shoe 211 which is in two pieces split along a vertical plane is clamped over the tongue 219 to rivet shoe shaft 120 by expansion spring 210 which squeezes each half of rivet shoe 211 to the shaft. The tongue 219 on rivet shoe shaft 120 prevents rotation of rivet shoe 211.

Telescoped over the splined periphery of rivet shoe shaft 120 and die shaft 56 are upper shift arms 100 and 122 respectively with the keys of the shift arms fitting into the splines of the shafts. The opposite ends of shift arms 100 and 122 are joined together by means of shift link 98 and pins 99 and 123 respectively.

Master shift arm 97 is pinned to the lower end of shaft 112, through master control bracket 111, with pin 241. Shift lever 62 is pinned to the top end of shaft 112. The hubs of master shift arm 97 and shift lever 62 on opposite ends of master control bracket 111 keep shaft 112 in position. Rotatably mounted at the top of shift lever 62 and to the cover 127 side of the axis of shaft 112 is cam-shift roller 65 which fits into spline 105 at the bottom of plunger drive cam 71.

Shift arm 27 is rotatably pivoted about shift arm pin 28 which is mounted to bosses 242 on the sides of housing 87. Shift arm 27 is fastened at its bottom end to punch lift 24 with pin 26. Shift arm rod 94 connects the top end of shift arm 27 to master shift arm 97.

Feed link 85 is fastened at one end to shift piston rod 85 with pin 76 and at the other end to shift lever 62 with pin 63.

The disposition of these components of the mechanical shift linkage is such that in the forward position of shift piston rod 85, shaft 112 rotates clockwise to create the condition shown in FIG. 3. In this position, die button 32 is indexed under rivet set 33, punch lift 24 is pushed forward under punch adaptor 16 because the bottom half of shift arm 27 moves forward with clockwise rotation of master shift arm 97, and plunger drive cam 71 is pulled away from cover 127 on cam pin 66 by cam shift roller 65, so that the plunger drive cam is in its closest position to shaft 112 which is the center of rotation of the mechanical shift linkage. This puts camming surface 47, the punching surface, over drive plunger 40. Since feed link 86 moves forward with forward motion of shift piston rod 85, it moves rivet selector drive spring 197 shown in FIG. 4 and rivet selector 195 to its foremost position which indexes the leg of T slot 194 over the central hole in rivet tube 199 and a rivet drops into rivet shoe 211. When die button 32 is under drive plunger 40 and rivet set 33, the disposition of the linkage is such that rivet shoe 211 is under rivet tube 199.

When shift piston rod 85 is in its rearward position, shaft 112 rotates counter clockwise to create the opposite

condition to that shown in FIG. 3. In that position, rivet shoe 211 is indexed under rivet set 33, punch lift 24 is pulled backwards out from under adaptor 16 as the bottom half of shift arm 27 moves backwards with counter clockwise rotation of master shift arm 97, and plunger drive cam 71 is pushed on cam pin 66 by cam shift roller 65 so that the plunger drive cam is in its furthest position from shaft 112, the center of rotation of the mechanical shift linkage, and closest to cover 127. This puts camming surface 46, the riveting surface over drive plunger 40. There are two bosses 64 on cover 127, and pivotally fastened to the bosses so as to move toward and away from cover 127 is spring loaded return valve trip lever 50. Also mounted to cover 127 is normally closed pneumatic return valve 67. The spring loading of trip lever 50 pushes the trip lever in a direction away from return valve 67. When plunger drive cam 71 moves toward cover 127, it pushes return valve trip lever 50 against return valve 67 to open the valve and cause the subsequent results described hereafter in the description of the pneumatic control system. On the subsequent shift position to the one just described when shift piston rod 85 comes forward again and plunger drive cam 71 is moved away from cover 127, the spring loading pushes return valve trip lever 50 away from return valve 67 which thereupon resumes its normally closed position.

The shift piston rod 85 shifts position each time shift valve ratchet wheel 60, which is fastened to the armature of shift valve 61 that is in turn mounted to cover 127, rotates through 90 degrees as described hereafter under the pneumatic control system and illustrated schematically in FIG. 6. FIG. 6 shows that ratchet wheel 60 through its attachment to the shift valve armature connects the compressed air supply to a first side of shift piston 135 and exhausts the air from the second side at one position and then upon rotating 90 degrees reverses this and connects the compressed air to the second side and exhausts air from the first side and so on for successive 90 degree rotations.

Shift valve lever 74 pivots about cam pin 66 and is constrained to move with plunger drive cam 71 by means of a pin in the shift valve lever which fits into hole 243 in the drive cam. Shift valve lever 74 has a second pin 89 which serves as a stop for clockwise rotation of shift pawl 58, and a bearing hole 90. Shift pawl 58 is rotationally mounted on a pin which fits into bearing hole 90 in shift valve lever 74. The forward end of shift pawl 58 as shown in FIG. 1 is continuously impressed against ratchet wheel 60 because of the tension of shift pawl spring 95 which connects the back end 91 of the shift pawl to the bottom end 96 of shift valve lever 74 through suitable holes in the respective ends. During the forward stroke of drive piston rod 78 and corresponding depression of plunger drive cam 71, shift valve lever 74 rotates counter clockwise and shift pawl 58 through its shaft mounting in bearing hole 90 is pulled to the right still pressing against ratchet wheel 60 until the forward end of the shift pawl slips past ratchet tooth 244. Ratchet wheel 60 is prevented from rotating counter clockwise by the restraining force of stop pawl 52 which is rotatingly mounted to pin 51 affixed to cover 127. The restraining force is the tensile force exerted by stop pawl spring 59 also connected to a pin on cover 127. On the return stroke of drive piston rod 78, pin 69 in the drive piston rod as well as the pin fitting in hole 243 in plunger drive cam 71 cause shift valve lever 74 to rotate clockwise. This in turn pushes shift pawl 58 to the left in FIG. 1 against ratchet tooth 244 and causes ratchet wheel 60 to rotate clockwise through 90 degrees and reverse the connections of the ports of shift valve 61. During this stroke of shift pawl 58, it is prevented from rotating clockwise by pin 89 and from rotating counter clockwise by ratchet tooth 244 and the restraining force exerted by stop pawl 52.

The pneumatic control system governs the operation of the portable punch riveter of the present invention. The

master control valve 84 is mounted to housing 87 as shown in FIG. 1. The mechanical details are shown in some detail in cross section in FIG. 2 and all of the functional details are shown schematically with the rest of the pneumatic control system in FIG. 6.

The control valve is composed of control cylinder 145 in which control plunger 138 is free to move in the direction of decreasing pressure. The control valve contains ports 136, 137, 139, 140, 141, 142 and 143 as well as five other unnumbered ports shown in FIG. 2 which are not used in the present embodiment. The periphery of control plunger 138 has four diametral sections which are free to slide within control cylinder 145 but are large enough to block air flow around the edges of the four diameters and therefore can be used to block off the flow of air from any of the ports when suitably positioned. Between the large diameters of control plunger 138 are three reduced diametral sections which allow the flow of air around their edges and thus may be used to conduct air from one port to another when properly positioned. From each end of control plunger 138 to the central reduced diametral section runs an internal aperture through which air may pass from the center to both ends of control plunger 138.

The shift valve is composed of shift cylinder 146 in which shift piston 135 and shift piston rod 85 are free to move in the direction of decreasing pressure. The shift cylinder contains ports 151 and 152, and the shift piston periphery contains two reduced diametral sections 132 and 134 which line up at the respective limits in either direction of piston travel with ports 133 and 144. Shift piston 135 is gasketed to prevent leakage of air around its edges. Port 144 of the shift valve is connected to port 137 of the control valve. Thumb operated control valve 81 and foot operated control valve 153 may be connected to connection 130.

Control plunger 138 channels the flow of exhaust and compressed air, into and out of, drive cylinder 77 to accomplish a complete cycle of drive piston 79, that is one forward stroke and the return stroke, say the punch and return stroke or punch cycle. At the end of the punch return stroke, the shift valve actuates shift piston 135 to index the mechanical shift linkage and place rivet shoe 211 under rivet set 33 in preparation for the riveting cycle. If, after completion of the punch cycle, the selector valve 222 is positioned to "Off," the semi-automatic condition, operation halts. If however, selector valve 222 is positioned to "Auto," the automatic condition, the mechanical shift linkage, in preparing the machine for the rivet cycle, causes plunger drive cam 71 to strike return valve 67, repeating the cycle of drive piston 79. Selector valve 222 is a two position manually operated pneumatic valve which either connects or interrupts the passage of air between two air lines.

FIG. 6 shows schematically the punch riveter of the present invention in idle position with selector valve 222 in the "Off," semi-automatic position. The outline of the punch riveter is shown in phantom merely to indicate connections between the various operating components which are located generally according to their relative positions with respect to the riveter as an aid to understanding the following description. The mechanical details of the air lines shown in FIG. 6 are not completely illustrated in the mechanical drawings of FIGS. 1 through 5 as the details are not essential to a proper understanding of the invention.

For the sequence of airflow that follows, it will be assumed that selector valve 222 is in the "Auto" or automatic position.

Compressed air centers control cylinder 145 through inlet port 140. Momentarily depressing either the thumb operated control 81 or the foot operated control 153 allows compressed air to bleed from port 137 into the atmosphere. As port 142 and line 159 are closed to the atmosphere this bleeding results in the control plunger

138 moving to its extreme right in FIG. 6, the drive position, closing port 136, closing the air inlet port 140 to port 141, opening the air inlet port 140 to port 139 and opening port 141 to port 143 which exhausts to the atmosphere. Line pressure air at port 140 flows out of port 139 into port 163 moving drive piston 79 and attached piston rod 78 to the left, toward its forward or drive position. Exhaust air from drive cylinder 77 is forced out of port 162 to port 141. Since port 141 is now open to port 143, the air is exhausted into the atmosphere. When the drive piston 79 reaches its extreme left position, port 161 in piston rod 78 opens line 159 and port 142 to port 160. Port 160 allows the air to exhaust into the atmosphere, and since port 137 is no longer open to the atmosphere, control plunger 138 is caused to move to its extreme left, the position it has in FIG. 6. Here the air inlet port 140 is closed to port 139 and open to ports 141, 162 and 142. Compressed air at 162 forces drive piston 79 to the right. Exhaust air on the other side of drive piston 79 is forced out through port 163 to port 139 and thus to port 136. Port 136 leads to air line 30 and slug removal tube 110 where the blast of air ejects the punched slug from slug exit hole 240.

The full return of drive piston 79 causes ratchet wheel 60 to rotate 90 degrees as explained heretofore and shift valve 61 allows compressed air from air line 154 to pass through an opening in the shift valve to line 155 instead of to line 156. Air line 155 leads to port 152 at the left end of shift cylinder 146, where the compressed air forces shift piston 135 and shift piston rod 85 to the extreme right, actuating the mechanical shift mechanism to move rivet camming surface 46 over drive plunger 40 into its rivet position. At the same time, rotation of shift valve 61 also allows air at port 151 to exhaust into the atmosphere through line 156 and the shift valve. In moving toward the cover 127 side of housing 87, plunger drive cam 71 strikes return valve 67 causing the air at port 137 of control cylinder 145 to exhaust through line 164 and selector valve 122 into the atmosphere. Operation of return valve 67 serves the same function as operating either thumb operated control valve 81 or foot operated control valve 153, thereby repeating the cycling of drive piston 79.

On the second return of drive piston 79 after completing the riveting stroke, ratchet wheel 60 is again rotated through 90 degrees and shift valve 61 allows compressed air from air line 154 to pass into line 156 and port 151 in the shift cylinder 146. The rotation of shift valve 61 also allows the air at port 152 to exhaust into the atmosphere through line 155 and shift valve 61. This causes shift piston 135 to move to its extreme left, actuating the mechanical shift linkage and preparing the machine for the punching cycle again. It should be noted that drive piston 79 cannot recycle until either aperture 132 or 134 in the shift piston rod 85 is aligned with lines 133 and 144. This safety feature requires all shifting to be accomplished prior to the cycling of drive piston 79. If drive piston 79 jams before completing its cycle, it can be returned to idle by actuating poppet valve 158 which exhausts line 159 and its connections to the atmosphere.

The punching, dimpling and riveting operations of the portable punch riveter are shown in sequence in FIGS. 7a, 7b, 7c, 7d, 7e and 7f with the work piece placed in position on stripper 18. When shift piston rod 85 moves to the left, it actuates the mechanical shift linkage to index die button 32 under rivet set 33, to move rivet selector 195 forward to drop a rivet through rivet tube 199 into rivet shoe 211, to move punch camming surface 47 over drive plunger 40, and to move punch lift 24 forward under the punch adaptor 16 and punch 19. Stripper 18 is up over anvil post 17 due to the force exerted by spring 212. This condition is shown in FIG. 7a.

When drive plunger 40 comes down, rivet set 33, attached to the drive plunger, enters a recess at the top of die button 32, thus assuring perfect alignment with the punch 19. The continued downward motion of rivet set 33 causes downward motion of die button 32, workpiece and stripper 18, exposing the punch 19 to the workpiece. As drive plunger 40 completes its total length of travel, die button 32 forces the workpiece over punch 19 and punches the hole or punches and dimples the hole for countersunk rivet heads and forces stripper 18 down on anvil post 17. At the same time the air blast exhausted from the drive cylinder 77 during the return stroke of drive piston 79 and directed to slug exit hole 240 through air tube 110 blows out the slug of pierced material. This condition is shown in FIGURE 7b.

FIG. 7c shows that once the hole is punched and rivet set 33 withdrawn, punch 19 remains in the work because of friction and prevents shifting of the material. Since the die button 32 has gone up when rivet set 33 was removed, spring 212 pushes stripper 18 to the up position carrying the material and punch 19 with it.

Return action of drive piston 79 rotates shift valve 61 through 90 degrees. In this position compressed air is directed through line 155 and port 152 to move shift piston rod 85 backwards. This motion of shift piston rod 85 operates the mechanical shift linkage to index rivet shoe 211 under rivet set 33, to withdraw punch lift 24 from under punch adaptor 16, to move rivet camming surface 46 over drive plunger 40, and to move rivet selector 195 backward to pick up another rivet in T slot 194. This condition is illustrated in FIG. 7d.

With the shifting completed, drive plunger 40, with attached rivet set 33 forces rivet shoe shaft 120 downward to its stop position. When the stop position of rivet shoe 211 is reached, continued downward motion of rivet set 33 spreads the rivet shoe halves apart allowing the rivet to contact punch 19 and drive it out of the work. This condition is illustrated in FIG. 7e.

Once the punch 19 is out of the work, the punch falls free where it drops flush with the upper face of anvil post 17. While the rivet is being forced into the hole, the work is kept from moving downward by the force of spring 212 against stripper 18. Continued pressure from rivet set 33 seats the rivet in the hole, lowers stripper 18 on anvil post 17 and exposes the anvil post face to the rivet shank. The remainder of the stroke of drive piston 79 causes the shank to be upset, forming a rivet head. This condition is illustrated in FIG. 7f.

When drive piston 79 reaches the end of its forward stroke, it returns to idle in the same manner as described for the drive piston's return during the punching stroke. At this point the shift piston rod 85 and mechanical shift linkage are again actuated, causing rivet shoe 211 to be moved out from under the rivet set 33, die button 32 to be indexed under rivet set 33, punch camming surface 47 to be positioned over drive plunger 40 and rivet selector 195 to be moved forward to drop another rivet through rivet tube 199 into rivet shoe 211. The machine is then ready for the next punch cycle.

The illustrated embodiment of the present invention uses a pneumatic control valve to actuate the drive piston 79 and a pneumatic shift valve to actuate the mechanical shift linkage for automatic operation. However, ports 162 and 163 on either side of the drive piston can just as well be connected to the pressure or exhaust line by manual switching, or a spring return means can be added to the drive piston and manual switching used to connect the pressure and exhaust line to port 163 on the driving side of piston 79 alone. Similarly, the mechanical shift linkage can be operated manually by any suitable means that will apply sufficient force to shift the apparatus. Thus where automatic operation is not required, the control valve and shift valve may be eliminated.

It should be understood that a preferred embodiment

of the present invention has been described using specific terms and examples but using them in a generic and descriptive sense and not for purposes of limitation, as the scope of the invention is set forth in the following claims.

What is claimed is:

1. An automatic punching and riveting machine comprising:

- (a) a housing having a vertical work axis,
- (b) a rivet set and return spring means mounted to the housing for movement along the work axis,
- (c) punching means mounted to the housing under the rivet set for movement along the work axis,
- (d) means advancing transversely to the punching means mounted to the housing for lifting the punching means toward the rivet set and retracting to allow retraction of the punching means,
- (e) die means,
- (f) rivet shoe means,
- (g) means for inserting rivets into the rivet shoe means,
- (h) camming means having a punching cam and a riveting cam and mounted to the housing for rotation toward the rivet set about an axis transverse to the work axis and for translation along said transverse axis to align said punching cam and riveting cam with said rivet set,
- (i) shift linkage means for indexing the die means into the work axis, actuating the rivet inserting means, advancing the punch lifting means under the punching means, and translating the camming means along the transverse axis to align the punching cam with the rivet set in a first position, and for indexing the rivet shoe means into the work axis, de-actuating the rivet inserting means, withdrawing the punch lifting means, and aligning the riveting cam with the rivet set in a second position,
- (j) fluid pressure actuated driving piston means mounted to the housing for transverse motion to the work axis for depressing the camming means and driving the rivet set onto the die toward the punching means with forward motion and for returning said camming means with return motion, and
- (k) fluid pressure control means for the shift linkage means and the driving piston means.

2. A punching and riveting machine according to claim 1 in which the control means includes:

(a) control valve means connected to sources of high pressure and low pressure fluid and to the fluid pressure actuated driving piston means and having a first position for causing said driving piston means forward motion and a second position for causing said driving piston means return motion, said control valve means taking said second position responsive to the extreme forward position of said driving piston means motion,

(b) shift cylinder valve means for shifting the linkage means alternately between said linkage means first and second positions responsive to each return stroke of the driving piston means, and

(c) means for setting the first position of the control valve means.

3. A punching and riveting machine according to claim 2 further including means for performing both the punching and riveting cycles separately and automatically, said means comprising:

(a) a normally closed return valve opening to low fluid pressure responsive to the shifting of the shift linkage means into its second position,

(b) a selector valve connecting the control valve means to the return valve for producing the first position of said control valve means responsive to said selector valve automatic position but breaking said connection responsive to said selector valve other position.

4. A punching and riveting machine according to claim 2 in which the shift cylinder valve means includes a piston structure connected to the linkage means which interrupts the flow of fluid actuating the driving piston, until the shift linkage means has completed its shifting.

5. A punching and riveting machine according to claim 2 in which a blast of fluid exhausted by the driving piston means return motion is directed against the die means in the second position of the control valve means.

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