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Novak et al.

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[45] **Sept. 16, 1975**

[54] **FASTENER DRIVING TOOL**

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[73] Assignee: **Duo-Fast Corporation**, Franklin Park, Ill.

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[52] **U.S. Cl.** **227/120**; 227/130

[51] **Int. Cl.**[2] **B25C 5/10**; B25C 5/16

[58] **Field of Search** 227/7, 120, 130; 91/356

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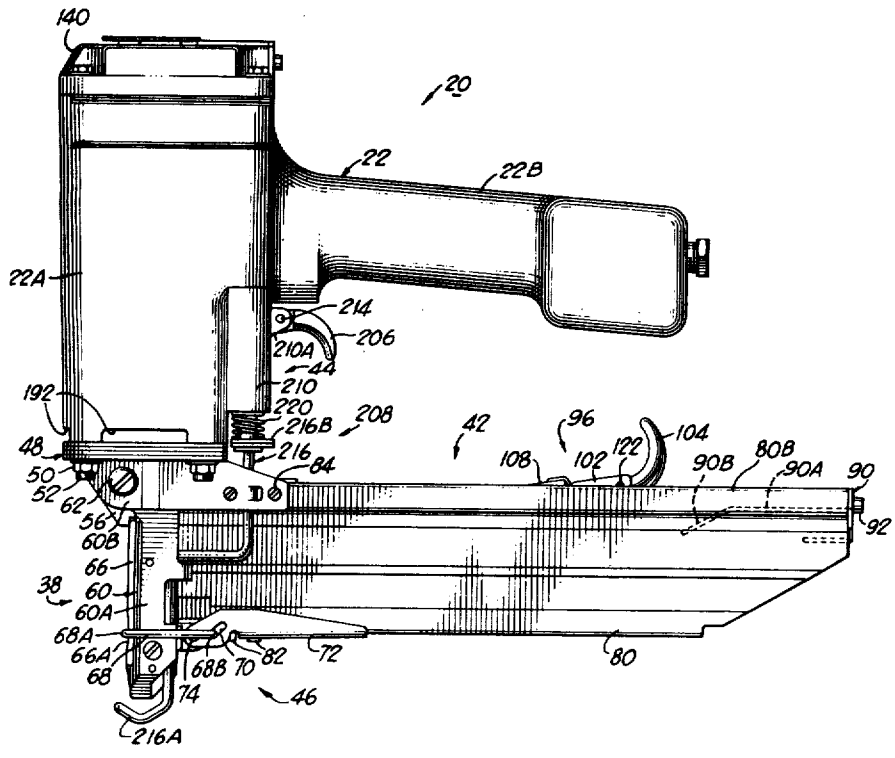
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Attorney, Agent, or Firm—Mason, Kolehmainen, Rathburn & Wyss

[57] **ABSTRACT**

A pneumatic stapler includes a housing in which is mounted for limited sliding movement a drive cylinder containing a piston coupled to a driver blade. A nosepiece structure on the housing contains a drive track slidably receiving the blade and supporting an annular or cylindrical member aligned with the lower end of the cylinder and carrying a valve seat. A main valve engages the top of the cylinder and forces the cylinder downwardly to seat on the valve seat in the normal condition of the tool. When the main valve moves upwardly, it closes an upper cylinder exhaust valve, and the cylinder follows through its limited travel to move out of engagement with the valve seat and exhausts the lower end of the drive cylinder. Further upward movement of the main valve admits compressed air to move the drive piston downwardly through a power stroke. A cycle valve receiving air from the cylinder at the end of the power stroke controls the main valve to move downwardly and not only seat the cylinder lower end on the valve seat, but also exhaust the upper end of the cylinder interior. A return valve senses this condition and supplies compressed air through the nosepiece within the annular member to return the drive piston and to supply compressed air to the cycle valve to prevent a premature opening of the main valve. The completion of the return stroke of the piston releases the return valve. A magazine includes a biased staple strip pusher with a pair of rigid legs pivoting in the planes of the staple legs to facilitate loading the staple strips.

16 Claims, 13 Drawing Figures



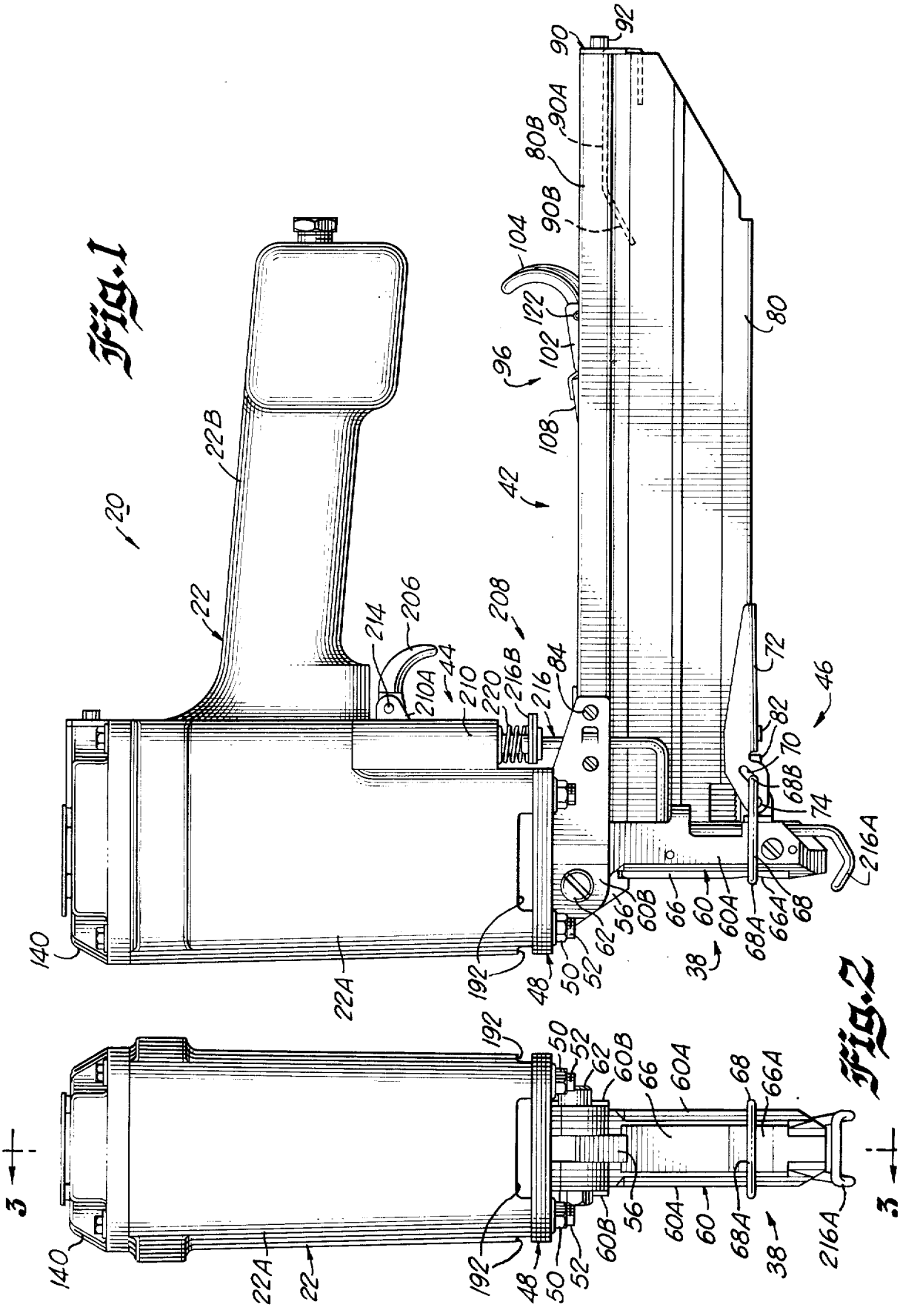

20
22
22B
22A
140
192
48
50
52
62
56
608
66
604
38
684
664
68
216A
74
688
70
82
72
46
42
44
210
220
216B
216
84
214
206
208
104
122
102
96
108
90
92
904
808
908
80
3
3

FIG. 1

FIG. 2

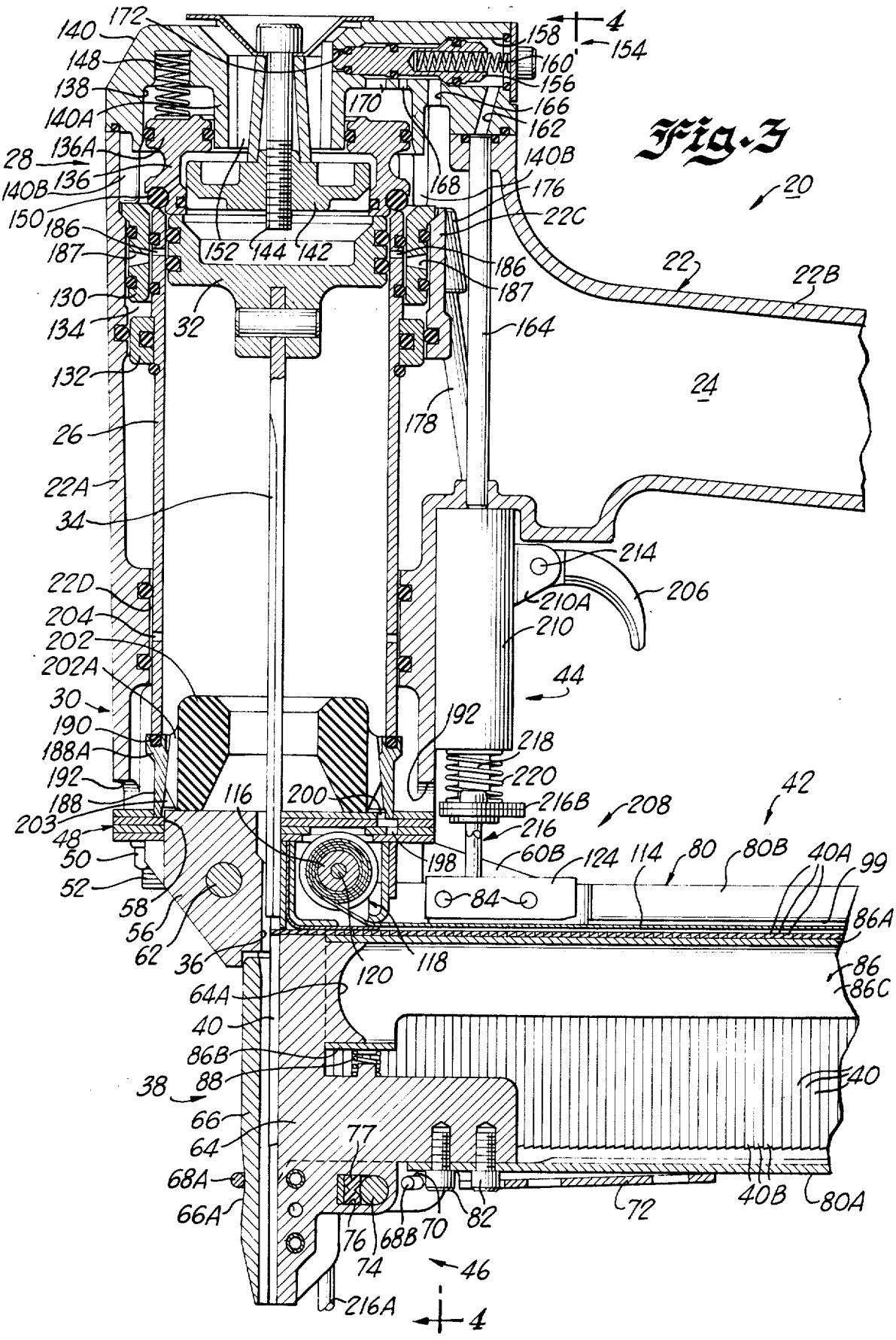

140
172
148
138
140A
136A
28
136
140B
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186
187
130
134
132
26
22A
34
22D
204
202
202A
30
190
188A
192
188
203
48
50
52
58
56
62
36
64A
40
86B
38
88
66
64
68A
66A
152
144
142
32
158
4
154
160
156
170
166
162
140B
168
176
22C
186
187
164
178
22
22B
24
214
206
210A
210
44
192
218
220
216B
208
216
42
116
200
198
60B
124
114
80
80B
40A
99
84
86A
86
86C
120
118
40
40B
80A
72
77
76
68B
70
82
74
46
216A
4

Fig. 3

20

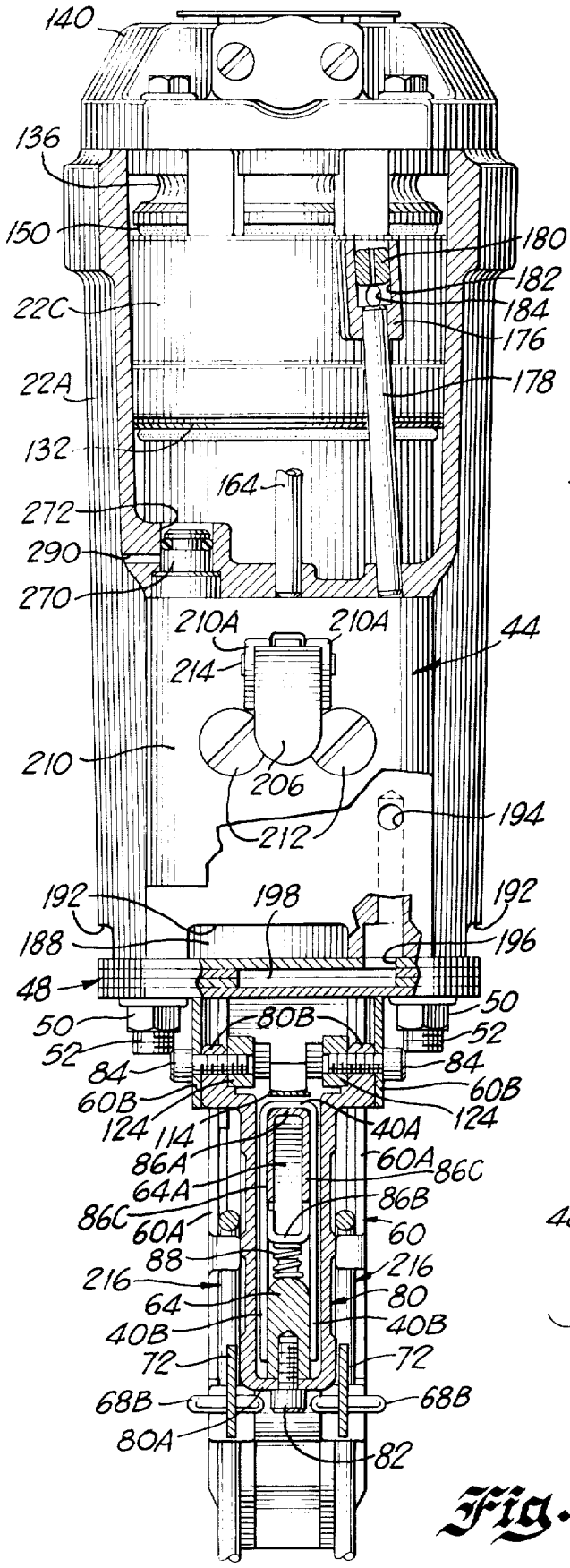

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136
150
22C
22A
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210A
210A
214
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212
44
164
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182
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176
178
194
192
198
192
188
196
48
50
52
80B
50
52
84
84
60B
60B
124
124
114
40A
86A
60A
86C
64A
86C
60A
86B
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88
216
216
64
80
40B
40B
72
72
68B
68B
80A
82

Fig. 4

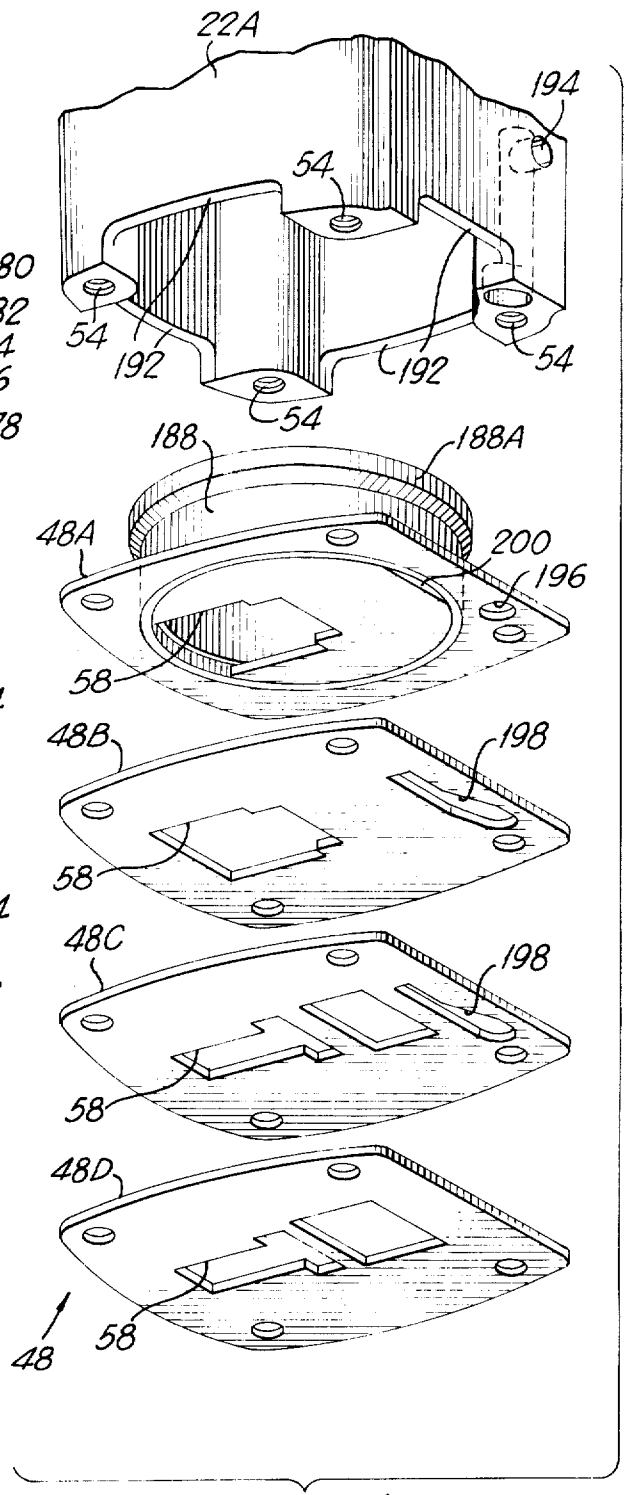

22A
194
54
54
192
192
54
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188
188A
48A
200
196
58
48B
198
58
48C
198
58
48D
58
48

Fig. 5

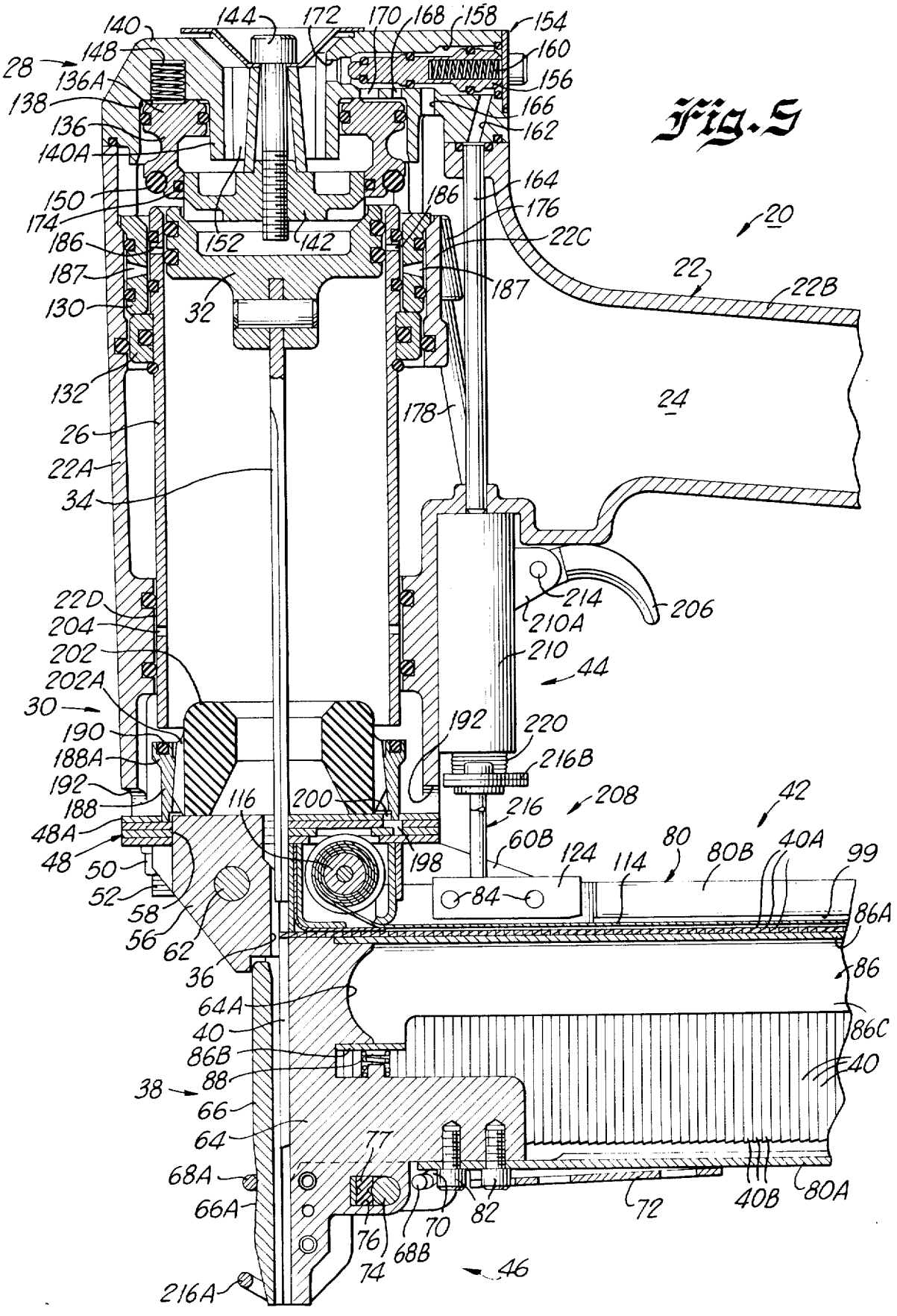
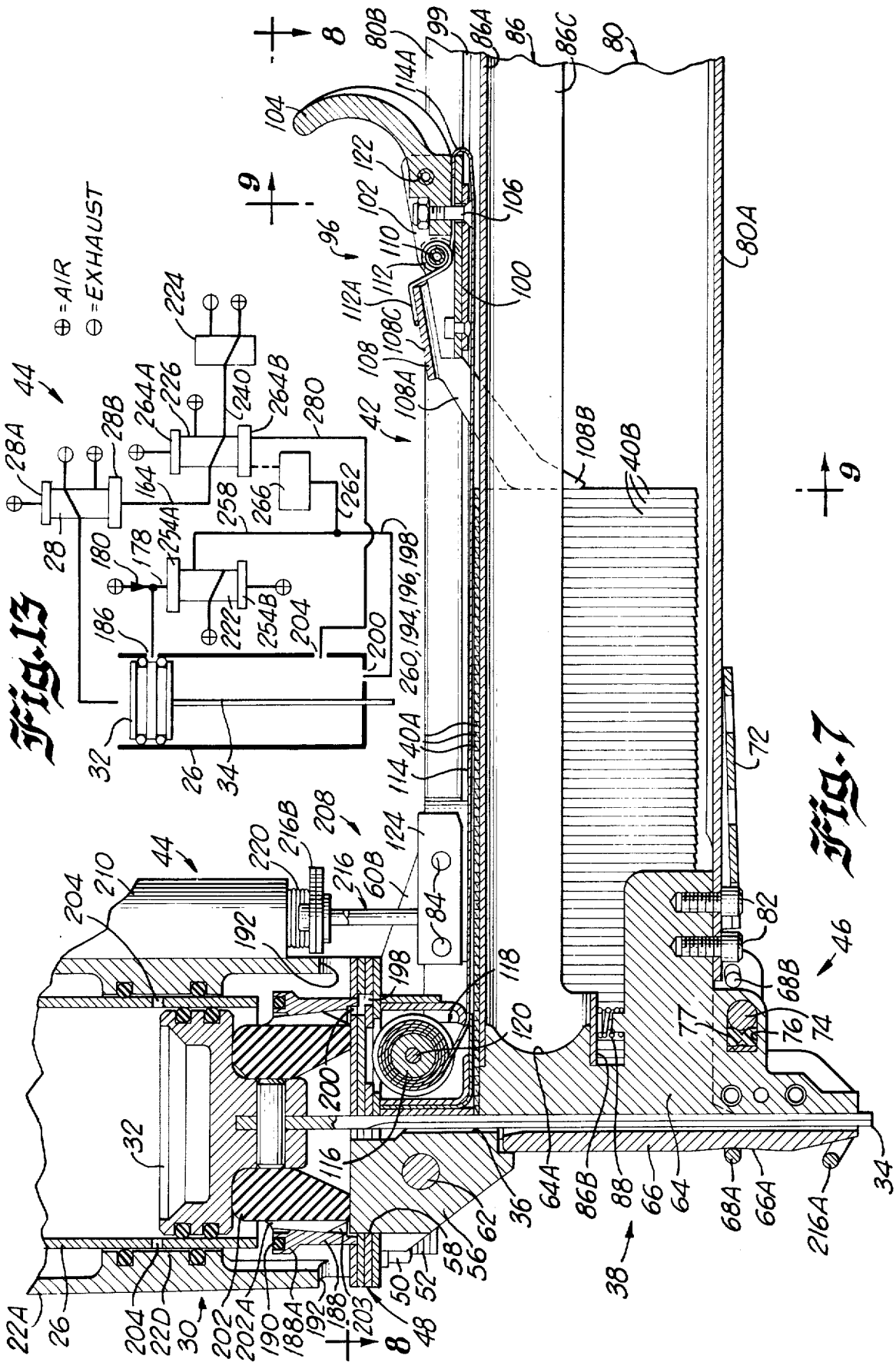

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136A
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166
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162
140A
164
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186
176
174
152
142
22C
186
20
187
187
22
130
32
22B
132
24
178
26
22A
34
22D
214
206
204
210A
202
210
44
202A
30
192
220
190
216B
188A
208
42
192
116
200
216
188
48A
60B
124
114
80
80B
40A
99
48
50
198
84
52
58
86A
56
62
86
36
64A
86C
40
86B
40
38
88
66
64
77
68A
66A
72
40B
80A
82
70
76
68B
74
46
216A

Fig. 5


⊕=AIR
⊖=EXHAUST
Fig. 13
Fig. 7

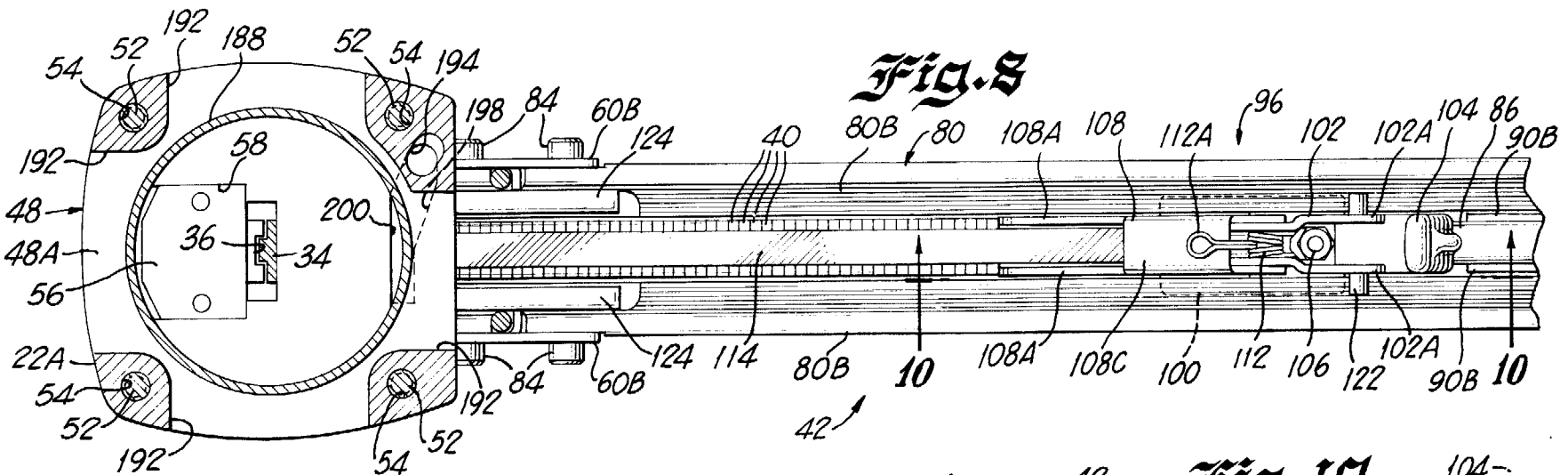


Fig. 8

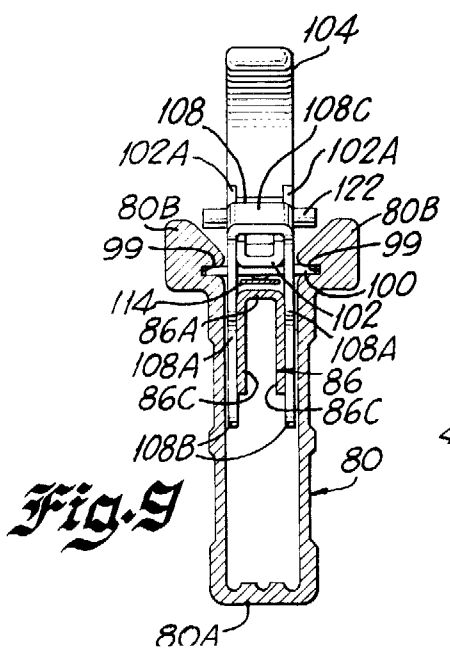


Fig. 9

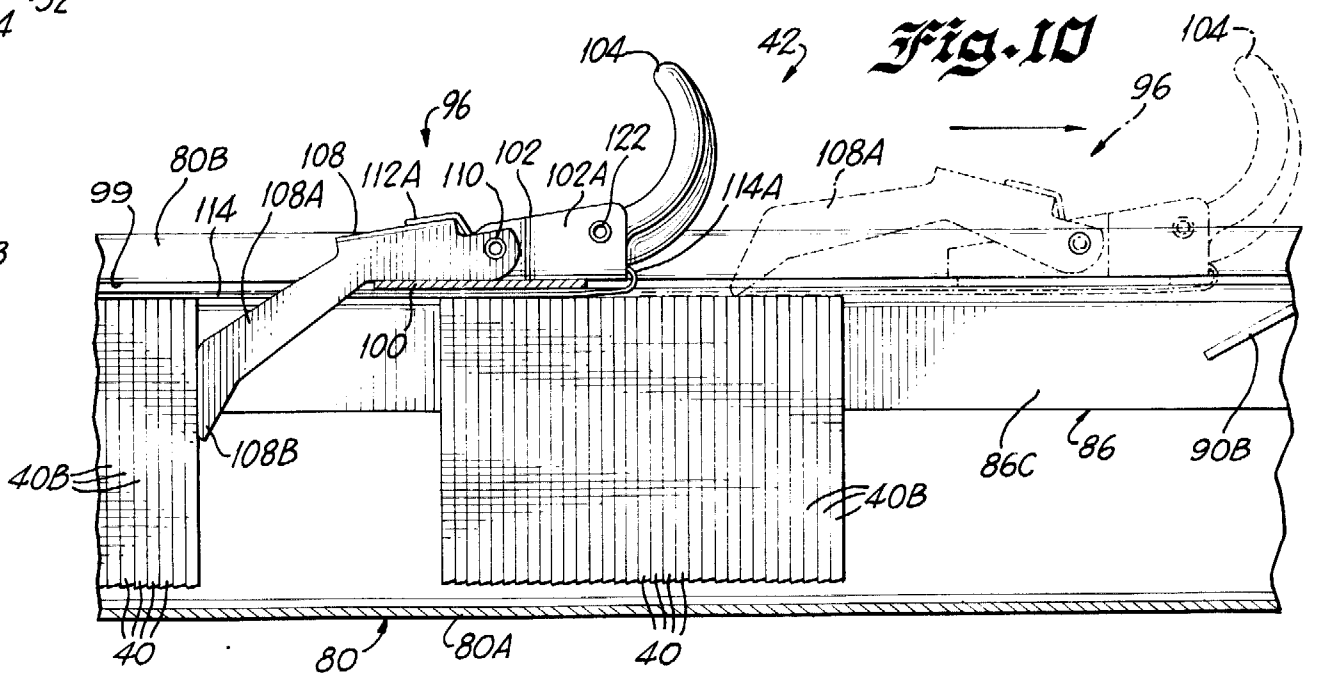


Fig. 10

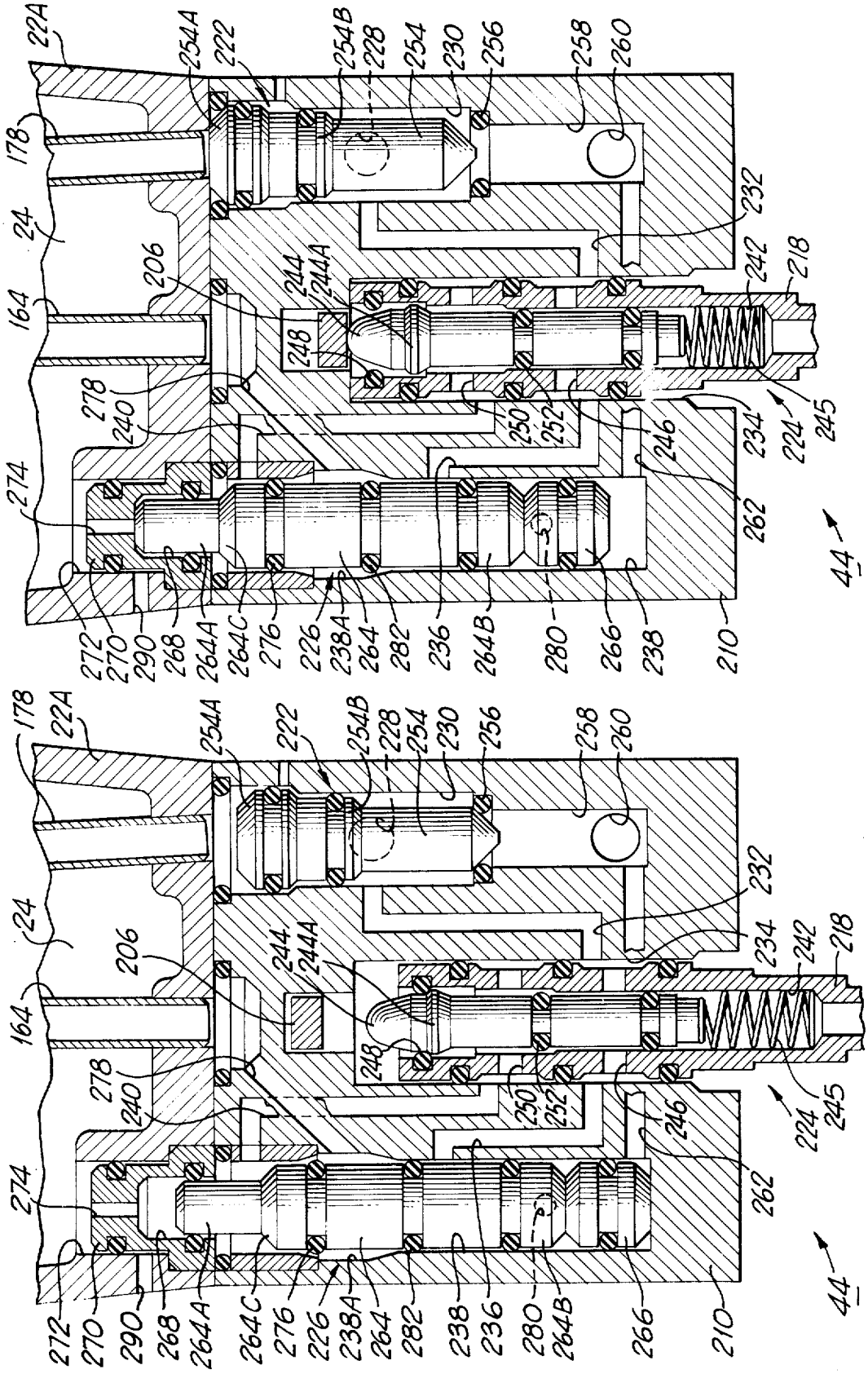

22A
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244A
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264A
264C
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238A
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264B
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FIG. 12

178
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254A
222
254B
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244A
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224
245
274
262
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270
290
268
264A
264C
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226
238A
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280
264B
266
210

FIG. 11

FASTENER DRIVING TOOL

This invention relates to a fastener driving tool and, more particularly, to a fastener driving tool including new and improved fastener driving and feeding means.

There is a growing tendency to extend the applications in which power driven fasteners, such as staples and nails, are used. This extension frequently involves driving fasteners of larger sizes with the result that the power required of the driving tools must be increased. However, this increase in driving power must be obtained within the limits imposed by the pressures and quantities of compressed air available in most manufacturing and fabricating locations and by weight that can be conveniently manipulated by an operator. In general, this requires the design of more efficient tools, tools that are more efficient in the utilization of power available from existing compressed air sources, and tools that are more efficient in the quantity of air consumed. Included in any consideration of the efficiency of use by the operator are the ease of replenishing the supply of fasteners and, in the case of multifire tools, the assurance by the operator that a fastener will be driven in each successive power stroke of the tool.

Accordingly, one object of the present invention is to provide a new and improved fastener driving tool.

A further object is to provide a fastener driving tool including a new and improved drive system.

A further object is to provide a fastener driving tool including a new and improved piston drive and return system.

A further object is to provide a fastener driving tool including a shiftable cylinder for venting the lower end of the cylinder prior to the power stroke of a drive piston and new and improved means for effecting the return of the drive piston.

A further object is to provide a fastener driving tool using a cycle valve for effecting an automatic sequence of power and return strokes and a controlled source of pressurized fluid for insuring that each return stroke is completed before the initiation of the following power stroke.

A further object is to provide a fastener driving tool including a new and improved magazine for feeding fasteners to a drive track.

In accordance with these and many other objects, an embodiment of the present invention includes a pneumatic fastener or staple driving or applying tool having a housing containing a drive cylinder mounted for limited vertical reciprocation. A main valve movable into and out of engagement with the upper end of the cylinder normally holds the lower end of the cylinder seated on a cylindrical member upstanding from the housing at its lower end to close off communication between the cylinder and the atmosphere. When the main valve is elevated, the cylinder moves with the main valve through its limited travel so that the upper cylinder exhaust valve is first closed and the lower end of the cylinder moves out of engagement with the valve seat defined by the cylindrical member, thereby connecting the lower interior of the cylinder to the atmosphere. The main valve then moves out of engagement with the top of the cylinder to admit compressed air for driving a piston slidably mounted in the cylinder and a connected driver blade through a power stroke.

A cycle valve assembly senses the arrival of the piston at the end of its power stroke and controls a cycle valve in the control valve assembly to effect reclosure of the main valve. Closure of the main valve moves the cylinder downwardly so that its lower end seats on the cylindrical valve seat and closes off communication between the atmosphere and the lower interior of the cylinder. This movement of the main valve also vents the upper interior of the cylinder which is detected by a return valve assembly. The return valve assembly supplies compressed air to the lower interior of the cylinder beneath the piston through a system of passageways extending to a point inside of the cylindrical lower valve. This compressed air elevates the piston to its normal position and also provides a supplemental signal or bias for retaining the cycle valve in its prior position. When the drive piston returns to its normal position, this condition is sensed by the return valve, and the supply of pressurized fluid below the piston is terminated to terminate one cycle of operation of the tool. When the pressurized fluid beneath the drive piston and the cycle valve leaks to the atmosphere, the cycle valve returns to its alternate state, and an additional cycle of operation of the tool is initiated.

A magazine assembly is provided for feeding successive staples into the drive track in the nosepiece structure beneath the driver blade. This magazine assembly includes a resiliently biased pusher having a pair of rigid arms pivotally mounted in the planes of the staple legs. When staple strips are inserted into the magazine behind the pusher, rearward movement of the pusher pivots the legs upwardly to a position clearing their crowns from which they are returned to a position engaging the legs of the last staple in the strip by a resilient bias.

Many other objects and advantages of the present invention will become apparent from considering the following detailed description in conjunction with the drawings in which:

FIG. 1 is a side elevational view of a pneumatically operated fastener driving tool embodying the present invention;

FIG. 2 is an end elevational view of the tool shown in FIG. 1;

FIG. 3 is an enlarged fragmentary sectional view taken along line 3—3 in FIG. 2;

FIG. 4 is a sectional view taken along line 4—4 in FIG. 3;

FIG. 5 is a fragmentary sectional view similar to FIG. 3 illustrating the tool after the opening of a main valve assembly but prior to the initiation of a power stroke of the tool;

FIG. 6 is an exploded perspective view of a structure for closing the lower end of a drive cylinder in the tool;

FIG. 7 is a fragmentary sectional view illustrating the tool at the end of a power stroke and portions of the magazine assembly;

FIG. 8 is a sectional view taken along line 8—8 in FIG. 7;

FIG. 9 is a sectional view taken along line 9—9 in FIG. 7;

FIG. 10 is an enlarged fragmentary sectional view taken in the direction of line 10—10 in FIG. 8;

FIG. 11 is a sectional view of a control valve assembly for the tool shown in a normal state;

FIG. 12 is a sectional view similar to FIG. 11 illustrating the control valve assembly at the conclusion of a power stroke of the tool; and

FIG. 13 is a schematic diagram illustrating the control functions performed by the control valve assembly shown in FIGS. 11 and 12.

Referring now more specifically to FIGS. 1–3 of the drawings, therein is illustrated a fastener driving tool which is indicated generally as 20 and which embodies the present invention. The tool 20 includes a housing shown generally as 22 including a vertically extending forward head portion 22A and a rearwardly extending hollow handle portion 22B. The cavity defined by the head portion 22A and the hollow handle portion 22B provide a reservoir 24 of pressurized fluid or compressed air for operating the tool 20. Slidably mounted within the head portion 22A for limited movement is a drive cylinder 26 normally engaged at its upper end by a main valve assembly indicated generally as 28 for selectively connecting the upper interior of the cylinder 26 to the atmosphere or to the pressurized fluid in the reservoir 24. A lower cylinder exhaust valve assembly indicated generally as 30 selectively connects the lower interior of the cylinder 26 to the atmosphere prior to and during the power stroke to improve the efficiency of drive of the tool 20. A piston 32 slidably mounted within the cylinder 26 is secured to the upper end of a fastener driving blade or element 34, the lower end of which is slidably received within a drive track 36 formed in a nosepiece assembly indicated generally as 38. On each power stroke of the piston 32, the driver blade 34 engages and drives a staple 40 supplied to the drive track 36 by a magazine assembly indicated generally as 42. The power and return strokes of the piston 32 are controlled by a control valve assembly indicated generally as 44.

Nosepiece Assembly 38 and Magazine 42

The magazine assembly 42 is secured at its forward end to and supported by the nosepiece assembly 38 and feeds successive staples 40 from a strip thereof into the drive track 36 defined by the nosepiece assembly 38. This assembly also includes a quick release assembly indicated generally as 46 (FIG. 1) for obtaining access to the drive track 36.

The nosepiece assembly 38 is carried out on a laminated plate assembly indicated generally as 48 which closes the lower open end of the head portion 22A of the housing and which is secured thereto by a plurality of nuts 50 threaded on inserts 52, the upper ends of which are threaded within tapped openings 54 (FIG. 6) at the lower end of the head portion 22A. A nose insert 56 (FIGS. 1–3 and 10) is disposed within aligned openings 58 (FIG. 6) in the plate assembly 48 and welded thereto. The rear wall of the nose insert 56 provides the front wall of the upper portion of the drive track 36.

The nosepiece assembly 38 further includes a multiplate or welded, laminated, and generally T-shaped structure 60 including depending side walls 60A and spaced transverse cross members 60B which are secured to and are on opposite sides of the nose insert 56 by suitable fasteners 62, such as a bolt carrying a nut. A shear block 64 (FIG. 3) is secured between depending leg portions 60A of the structure 60 and defines a substantial portion of the back wall of the drive track 36 as well as defining a generally U-shaped opening through which the staples 40 pass into the drive track 36.

A substantial portion of the front wall of the drive track 36 is defined by the assembly 46. This assembly includes a removable front plate 66 fitting within the recess defined between the spaced depending legs 60A of the structure 60 with longitudinally extending flanged edges overlying the front walls of the legs 60A. The rear wall surface of the plate 66 is recessed in accordance with the desired configuration of the drive track 36.

To provide means for detachably mounting the front plate 66 on the nosepiece assembly 38, there is provided a generally U-shaped bail 68 (FIGS. 1 and 2), a bight portion 68A of which passes around the front wall of the nosepiece structure 38 to be received within an indentation 66A in the front wall of the plate 66. The free ends of the rearwardly extending legs 68B of the bail 68 are slidably received within two angled and elongated slots 70 formed in a lever 72. The lever 72 is pivotally mounted on a rearwardly extending portion of the shear block 64 by a pivot pin 74 which passes through an elongated opening 76 in the lower rearwardly disposed portion of the shear block 64 adjacent a resilient body 77 (FIGS. 3 and 5). The bail 68 and the lever 72 provide an over-center linkage for clamping the front plate 66 in its desired position. When the plate 66 is to be removed, the lever 72 is pivoted about the pivot pin 74 in a clockwise direction (FIG. 1) to displace the bail 68 sufficiently to permit the plate 66 to be removed. When the plate 66 has been reassembled following, for example, the removal of a jammed staple from the drive track 36, the bight portion 68A of the bail 68 is placed in the recess 66A, and the lever 72 is pivoted in a counterclockwise direction to the position shown in FIG. 1.

The magazine assembly 42 comprises a generally U-shaped magazine housing indicated generally as 80 which is open at its top and closed at its bottom by a bottom wall 80A (FIG. 4) to define a narrow recess approximately the size of a strip of staples 40. At its forward end, the lower wall 80A of the housing 80 is secured, as by a plurality of machine screws 82, to a rearwardly extending portion of the shear block 64 (FIGS. 3 and 4). At its upper end, the magazine is secured to and within the outer lamina of the cross pieces 60B of the nosepiece structure 60 by a plurality of machine screws 84 (FIG. 4).

To provide means for slidably supporting a strip of staples 40 within the cavity in the housing 80, there is provided a staple rail 86 which is generally U-shaped in configuration and mounted within the housing 80 so that a wall 86A defining the bight portion of the rail 86 faces upwardly to provide a support for the crown portions 40A of the staples 40 (FIGS. 3 and 4). At its forward end indicated as 86B (FIG. 3), the rail 86 is closed to encircle a rearwardly extending portion 64A of the shear block 64. A compression spring 88 biases the lower wall of the closed portion 86B of the rail 86 against the adjacent structure 64A to retain the rail 86 in position. This interfitting resiliently biased connection of the front end of the rail 86 to the shear block 64 aids in controlling manufacturing tolerances and prevents wear which might result in eccentric or misaligned positioning of the rail 86 relative to the shear block 64 and the structures defining the drive track 36. The rear end of the rail 86 is secured to the housing 80 in any suitable manner such as by a member 90 which is secured to the housing 88 by machine screws 92 (FIG. 1) and which interfits with the rear end of the rail 86.

Strips of staples **40** can be inserted into the magazine **42** to be supported on the rail **86** through the open top of the housing **80.** A plate-like extension **90A** on the member **90** (FIGS. **1** and **8**) extends forwardly between the housing side walls and includes two downwardly inclined legs **90B** (FIGS. **1, 8,** and **10**) straddling the U-shaped rail **86** and disposed immediately adjacent depending opposite side walls **86C** of the rail. The pointed ends at the lower end of the legs **40B** of the staples **40** in a strip can be placed in engagement with the downwardly inclined legs **90B** to guide a strip into the magazine **42** to a position in which the legs **40B** of the staples in the strip are disposed immediately adjacent and extending generally parallel to the rail side walls **86C** with the crown portions **40A** of the staples resting on the upper wall **86A** of the rail **86.**

To provide means for resiliently biasing or feeding a strip of staples **40** toward the drive track **36** in the nosepiece assembly **38,** there is provided a pusher assembly indicated generally as **96.** The pusher assembly **96** is movably mounted on the housing **80** within a pair of aligned and opposed grooves **99** (FIG. **9**) formed in enlarged upper end portions **80B** of the side walls of the housing **80.** The grooves or slots **99** slidably receive the side edges of a supporting plate **100** to mount this plate in a position spaced above the wall **86A** of the staple supporting rail **86.** A generally U-shaped bracket **102** having a pair of spaced upstanding side walls **102A** is mounted on the upper surface of the plate **100** with the lower end portion of a handle **104** for the pusher assembly **96** disposed between the walls **102A.** The handle **104** and the bracket **102** are secured to the plate **100** by a suitable fastener **106.** To provide means for engaging the staples **40,** the pusher assembly **96** includes a generally U-shaped pusher member **108** pivoted at one end to the side walls **102A** of the bracket **102** by a pivot pin **110.** The opposite end of the member **108** is provided with two downwardly inclined legs **108A** having staple leg engaging portions **108B** generally disposed parallel to and in immediate proximity to the side walls **86C** of the staple rail **86.** To provide means for resiliently biasing the staple legs **108A** to the position shown in FIG. **10,** a torsion spring **112** is provided having a cylindrical center portion which is mounted on the pivot pin **110** between the side walls **102A** with the outer free ends bearing against the plate **100.** An end portion **112A** of the torsion spring **112** bears against a bight portion **108C** to pivot the pusher element **108** in a counterclockwise direction about the pivot pin **110** to the normal position shown in FIG. **10.** This position is determined by engagement of the pusher **108** with the top surface of the plate **100.**

To provide means for biasing the pusher assembly **96** toward the nosepiece assembly **38,** there is provided a constant force spring **114,** one end portion **114A** of which is hooked or clamped between the bight of the bracket **102** and the lower wall of the handle **104** to secure the constant force spring **114** to the pusher assembly **96.** The other end of the constant force spring **114** (FIG. **3**) is coiled about a spool **116** (FIG. **3**) rotatably mounted within an enclosure indicated generally as **118** by a shaft or a pin **120.** The constant force spring **114** tends to return to the coiled position whenever it is extended by moving the pusher assembly **96** to the right. This tendency to return to a coiled position provides a resilient bias forcing the pusher assembly **96** to the left as shown in the drawings, and thus forcing the staple leg engaging portions **108B** on the pusher legs **108A** into engagement with the leg **40B** of the last staple **40** in the strip. The withdrawn portion of the constant force spring **114** extending between the spool **116** and the pusher assembly **96** is narrower than the upper opening in the magazine housing **80** and is spaced above to overlie the crowns **40A** of the staples **40** in a strip disposed within the magazine assembly **42.** The spring **114** passes between the pusher legs **108A.**

Assuming that a partially consumed strip of staples **40** is disposed within the magazine assembly **42** and an additional strip of staples **40** is placed on the rail **86** disposed to the right of the pusher assembly **96** (FIG. **10**), the handle **104** is grasped by the operator, and the pusher assembly **46** is moved to the right. As the pusher assembly **96** moves to the right, the inclined right-hand edges **108B** of the two pusher legs **108A** engage the first staple **40** in the strip to be added, and the pusher element **108** may either be pivoted in a clockwise direction about the pivot pin **110** to the position shown in dot and dash outline in FIG. **10** or engage the first staple **40** in the strip and move the strip rearwardly until the last staple engages legs **90B** whereupon the pusher element **108** is pivoted in the manner described. When the lower ends of the pusher legs **108A** clear the last staple **40** in the strip to be added, the torsion spring **112** pivots the pusher element **108** in a counterclockwise direction about the pivot pin **110** so that the staple leg engaging portions **108B** of the pusher legs **108A** and slide down legs **90B** and engage the legs **40B** of the last staple **40** in the strip to be added. If the handle **104** is released, the extended constant force spring **114** biases the pusher assembly **96** to the left (FIG. **10**) to move the first staple **40** in the strip to be added into engagement with the last staple **40** in the strip previously disposed in the magazine assembly **42,** and the pusher assembly **96** thereafter advances successive staples **40** into the drive track **36** as they are driven.

To provide means for limiting movement of the pusher assembly **96** to the left so that the pusher legs **108A** cannot enter the drive track **36,** a drive or roll pin **122** extends through the side walls **102A** and the lower portion of the handle **104** (FIG. **8**) so that the ends of the pin **122** extend substantially beyond the side walls **102A.** When the pusher assembly **96** reaches the position at which the staple engaging portions **108B** on the pusher legs **108A** are disposed immediately adjacent the entrance to the drive track **36,** the projecting ends of the pin **122** engage the end surfaces of a pair of plates **124** which are mounted within relieved portions along the inner surface of the side walls of the housing **80** and secured therein by the machine screws **84.** The engagement of the ends of the pin **122** with the plates **124** provides a positive stop for limiting movement of the pusher assembly **96** to the left, as shown in the drawings.

If the pusher **96** is pulled to an extreme right-hand position (FIGS. **8** and **10**), the inclined right-hand edges of the pusher legs **108A** come into contact with the downwardly inclined legs **90B.** This cams the pusher element **108** in a clockwise direction against the bias of the torsion spring **112** to permit the pusher **108** to be manually grasped. The pusher assembly **96** can then be permitted to move to the left with the pusher element **108** elevated. In this way, by tipping the magazine **46,** strips of staples **40** can be removed from the rail **86** within the magazine housing **80.**

Drive System

The drive system for controlling the reciprocation of the piston **32** within the slidably mounted cylinder **26** includes the main valve assembly **28** which selectively connects the upper interior of the cylinder **26** to the atmosphere or to the compressed air in the reservoir **24** as well as controlling the shifting movement of the cylinder **26** to open and close the exhaust valve assembly **30.** The exhaust valve assembly **30** opens the lower interior of the cylinder **26** prior to and during a power stroke of the piston **32** and seals the lower interior of the cylinder **26** during a return stroke to permit the piston **32** to be pneumatically returned to its normal position.

To provide for slidably mounting the cylinder **26** within the head portion **22A,** this head portion **22A** includes an annular or cylindrical portion **22C** (FIGS. **3–5**) formed integral with the housing **22** within which is mounted a sleeve **130** sealed by the illustrated O-rings. The cylinder **26** is slidably mounted within the cylindrical sleeve **130,** and a similar cylindrical portion **22D** formed in the housing **22.** To provide means for limiting the movement of the cylinder **26,** the cylinder carries an annular ring **132** sealed by the illustrated O-rings and bearing against a shoulder on the cylinder **26.** A space **134** between the ring **132** and the sleeve **130** is continuously vented to the atmosphere. Upward movement of the cylinder **26** relative to the housing **22** is limited by engagement of the ring **132** with the lower surface of the sleeve **130** (FIG. **5**). The exposed lower surface of the ring **132** provides a continuous upwardly directed pneumatic bias tending to shift the cylinder **26** to the elevated position shown in FIG. **5.** The selective movement of the cylinder between the upper position shown in FIG. **5** and the lower position shown in FIG. **3** is controlled by the main valve assembly **28.**

More specifically, the main valve assembly **28** includes an annular main valve member **136,** an upper annular piston portion **136A** of which is slidably mounted within an annular chamber **138** formed in a closure cap **140** and surrounding a central hollow post **140A** on the closure cap **140.** A plurality of depending lugs **140B** on the cap bear against the upper end of the sleeve **130** to mechanically hold the sleeve **130** in position. A circular exhaust valve member **142** secured to the cap by a fastener **144** is disposed within a central opening in the annular valve **136.** A plurality of compression springs **148** interposed between the cap **140** and the upper surface of the main valve element **136** together with the pressurized fluid normally supplied to the chamber **138** above the piston portion **136A** normally hold the main valve element **136** in the position shown in FIG. **3** in which a resilient valve element **150** engages the upper end of the cylinder **26** to hold this cylinder in the position shown in FIG. **3.** The resilient valve element **150** closes off communication between the upper interior of the cylinder **26** and the compressed air contained in the surrounding reservoir **24.** In this position, the interior surfaces of the annular valve **136** are spaced from the exhaust valve member **142** so that the upper interior of the cylinder **26** is connected to the atmosphere through a plurality of passageways **152** in the closure cap **140.**

To provide means for controlling the shifting movement of the annular main valve element **136,** there is provided a dump valve assembly indicated generally as **154.** The dump valve assembly **154** includes a plural diameter valve element **156** carrying the illustrated sealing O-rings and slidably disposed within a cylinder **158** formed in the cap **140.** A compression spring **160** continuously biases the valve element to the left-hand position shown in FIG. **3.** The bias provided by the spring **160** is supplemented by pressurized fluid supplied to the right-hand end of the cylinder **158** over a passageway **162** in the closure cap **140** which is placed in communication with the control valve assembly **44** by a conduit **164** (FIGS. **3–5**). In the normal condition of the tool, pressurized fluid is supplied to the conduit or duct **164** by the control valve assembly **44.** This pressurized fluid in the right-hand end of the cylinder **158** coupled with the resilient bias of the spring **160** forces the valve piston **156** to the position shown in FIG. **3.** In this position, the pressurized fluid from the reservoir **24** passes from a passageway **166** in the closure cap into the chamber **138** through a passageway **168.**

When the main valve assembly **28** is to be operated, the conduit **164** is connected to the atmosphere by the control valve assembly **44,** and the pressurized fluid supplied through the passageway **166** acts on the enlarged right-hand portion of the valve piston **156** to shift this valve piston against the bias of the compression spring **160** to the position shown in FIG. **5.** In this position, the passageway **168** is cut off from communication with the passage **166,** and pressurized fluid from the reservoir **24** can no longer be supplied to the chamber **138.** Further, the passageway **168** and an additional passageway **170** are connected to the atmosphere through the passageways **152** by means of a port **172** that is now opened by the displacement of the valve piston **156.**

When the dump valve assembly moves to the position shown in FIG. **5,** pressurized fluid in the chamber **138** above the piston portion **136A** on the annular main valve **136** is exhausted to the atmosphere through the passageways **168** and **170,** the port **172,** and the passageways **152.** The pressurized fluid in the reservoir acts on the lower effective surfaces of the main valve **136** to move this valve upwardly toward the position shown in FIG. **5** against the resilient bias of the compression springs **148.** During the first portion of this movement, the cylinder **26,** because of the continuous upwardly directed bias applied to the ring **132,** moves with the main valve **136,** and the resilient element **150** remains seated on the upper end of the cylinder **26.** When the upper surface of the ring **132** bears against the lower surface of the sleeve **130,** the cylinder **26** can no longer move upwardly. During further movement of the main valve element **136,** an O-ring **174** carried on the inner surface of the annular main valve element **136** seats on the outer periphery of the exhaust valve member **142** to close off communication between the upper interior of the cylinder **26** and the exhaust passageways **152** in the cap. Further upward movement of the main valve **136** moves the resilient element **150** completely out of engagement with the now stationary cylinder **26** so as to connect the upper interior of the cylinder **26** to the reservoir **24** of pressurized fluid. This initiates a power stroke of the piston **32** and the connected driver blade **34.**

When the main valve assembly **28** is to be closed, the control valve assembly **44** again supplies pressurized fluid over the conduit **164** and the passageway **162** to

the right-hand end of the cylinder **158.** This pneumatic bias coupled with the bias of the compression spring **160** shifts the valve piston **156** from the position shown in FIG. **5** to the position shown in FIG. **3.** In this position, the port **172** is closed, and the passageways **166** and **168** are placed in communication so that pressurized fluid again flows into the chamber **138** above the piston portion **136A** of the main valve element **136.** This pneumatic bias coupled with the resilient bias provided by the compression springs **148** initiates downward movement of the main valve element **136** from the position shown in FIG. **5** to the position shown in FIG. **3.** During the initial movement, the resilient O-ring **150** seats on the upper end of the cylinder **26** so that the upper interior of the cylinder **26** is cut off from communication with the pressurized fluid in the reservoir **24.** During subsequent movement, the O-ring **174** is moved downwardly enough to place the cylinder **26** in communication with the exhaust passageways **152** to exhaust the upper end of the cylinder. Continuing downward movement of the annular main valve **136** moves the cylinder **26** downwardly from the position shown in FIG. **5** to the position shown in FIG. **3.** In this position, the piston **32** and the driver blade **34** can be moved through a return stroke to restore the drive system to its normal condition.

Associated with the sliding cylinder **26** and the main valve assembly **28** is an assembly for providing the control valve assembly **44** with signals representing the position of the piston **32.** More specifically, the cylindrical portion **22C** of the housing is provided with a hollow projection **176** (FIGS. **3–5**) communicating with the control valve assembly **44** over a duct or conduit **178.** A plug **180** (FIG. **4**) with a restricted orifice therethrough places a chamber **182** in communication with the pressurized fluid in the reservoir **24.** The chamber **182** is placed in communication with the exterior of the sleeve **130** (FIGS. **3** and **5**) through an opening or port **184** (FIG. **4**). The outer surface of the sleeve **130** (FIGS. **3** and **5**) is, in turn, placed in communication with a port or passageway **186** through the upper end of the cylinder **26** by means of a passageway **187** through the sleeve **130.** These passageways are sealed by the illustrated O-rings.

When the piston **32** occupies the normal position shown in FIG. **3,** the two illustrated O-rings on the piston **32** seal the passageways **186** and **187** so that the chamber **182** (FIG. **4**) and thus the conduit **178** extending to the control valve assembly **44** becomes pressurized to the pressure of the compressed air in the reservoir **24.** This signal indicates that the piston **32** is in its normal home position. Alternatively, when the piston **32** is displaced from its normal position through a power stroke and the main valve assembly **28** has again been closed at the termination of this power stroke, the upper interior of the cylinder **26** is placed at atmospheric pressure in the manner described above. At this time, the passageways **186** and **187** and the port **184** vent the chamber **182** and the duct **178** to the atmosphere because these passageways exhaust pressurized air faster than it can be supplied through the restricted orifice in the plug **180.** Thus, when the main valve assembly **28** is closed and the piston **32** is not in a normal home position, the conduit **178** provides an exhaust signal to the control valve assembly **44.** When the piston **32** is returned to its normal position, the port **186** is again sealed, and the restricted orifice in the plug **180** (FIG. **4**) again pressurizes the chamber **182** and the conduit **178** to advise the control valve assembly **44** that the piston **32** has been returned to its normal home position.

To provide the exhaust valve assembly **30** for selectively sealing or opening to the atmosphere the lower interior of the cylinder **26,** there is provided an annular or cylindrical member **188** (FIGS. **3, 5,** and **6**) whose lower end is welded or otherwise permanently secured to an uppermost plate **48A** in the four laminated plates **48A-48D** in the plate assembly **48.** The annular member **188** includes an enlarged upper end portion **188A** having a recess in which is disposed a resilient O-ring **190** providing an exhaust valve seal. The element **190** is aligned with the lower end of the cylinder **26.**

In the normal condition of the tool **20** (FIG. **3**), the engagement of the upper end of the cylinder **26** by the main valve **136** or the resilient element **150** thereon seats the lower end of the cylinder **26** on the resilient element **190** to close off communication between the lower interior of the cylinder **26** and the atmosphere through, for example, a plurality of spaced ports or openings **192** (FIGS. **3, 5,** and **6**). When, however, the main valve assembly **28** is opened (FIG. **5**), the cylinder **26** is moved upwardly in the manner described above, and the lower end of the cylinder **26** is spaced from the resilient element **190.** This places the lower interior of the cylinder **26** beneath the piston **32** in communication with the atmosphere through the openings **192.** The entire lower end of the cylinder **26** is vented through the large area openings **192,** and thus no back pressure is encountered by the piston **32** during its driving stroke. This substantially improves the efficiency of the drive system for the tool **20.**

Associated with the exhaust valve assembly **30** is a unique fluid conveying means controlled by the control valve assembly for supplying pressurized fluid to the lower interior of the cylinder **26** to move the piston **32** through a return stroke. More specifically, this pressurized fluid is supplied by the control valve assembly **44** to a passageway **194** (FIGS. **4, 6,** and **8**), which passageway extends through a depending portion of the head portion **22A** of the housing **22** immediately adjacent one of the tapped openings **54** used to secure the plate assembly **48** to the head portion **22A.** This passageway **194** is aligned with an opening **196** in the uppermost plate **48A,** and the port or passageway **196** is, in turn, aligned with a pair of elongated passageways **198** in the plates **48B** and **48C** at the right-hand end thereof. The elongated slots **198** extend through the plates **48B** and **48C** to a point underlying an opening **200** (FIGS. **6** and **8**) in the uppermost plate **48A.** The opening **200** extends through the plate **48A** to discharge air within the annular member **188.**

A resilient or elastomeric bumper or cushion **202** is disposed within and held in position by the annular member **188** in a position to cushion or terminate the power stroke of the piston **32.** The bumper **202** includes a plurality of radially extending, tapered ribs **202A** terminating above the plate **48A** so that pressurized fluid supplied through the opening **200** can be dispersed around the periphery of the bumper **202** through a passage **203** and then pass downwardly through the passageways defined by the ribs **202A** to be applied to the lower surface of the piston **32** when this piston is in its lower position (FIG. **7**). The pressurized return air supplied through the opening **200,** in passing

through the passageways defined by the ribs **202A**, cools the bumper **202** to prevent deterioration and overheating thereof. By thus supplying piston return air over the system of passageways **194** and **196** and **198** and **200**, and then dispersing this air around the exterior surface of the bumper **202**, the piston return air not only is supplied directly beneath the piston **32** without passing through the side walls of the cylinder **26**, but is also used to effect cooling of the bumper **202**. Further, the use of the laminated plate assembly **48** facilitates the formation of the passageways in a construction of welded or brazed individual plates which are capable of absorbing the impact shocks arising from terminating the power stroke of the piston **32**.

Associated with the exhaust valve assembly **30** is an improved arrangement for supplying a signal to the control valve assembly **44** indicating that the piston **32** has completed its power stroke. This arrangement is best illustrated in FIG. **7** of the drawings. More specifically, when the piston **32** reaches the end of its power stroke, as determined by engagement with the bumper **202**, pressurized fluid from above the piston **32** flows out of the cylinder through a plurality of spaced ports **204** to an area in the interface between the cylinder **26** and the portion **22D** of the head **22A** of the housing. A passageway through the portion **22D** of the head **22A** supplies this pressurized signal to the control valve assembly **44**. In the past, there has been a tendency for this end of power stroke signal of pressurized fluid to become dissipated when the interior of the cylinder **26** above the piston **32** is exhausted by closing the main valve to start the return stroke of the piston **32**.

However, in the present arrangement, as soon as the signal supplied through the ports **204** controls the control valve assembly **44** to effect the closing of the main valve, the cylinder **26** is moved downwardly from the position shown in FIG. **7** to the position shown in FIG. **3** in which the lower end of the cylinder **26** seats on the exhaust valve seat **190**. When this happens, the ports **204** are moved to a position bounded on opposite sides by the two O-rings carried on the piston **32**. The pressurized signal supplied through the ports **204** is thus sealed off from communication with either the upper or lower interior of the cylinder **26**. Further, when compressed air is supplied through the opening **200** beneath the piston **32** to start the return stroke of the piston **32**, this pressurized fluid also passes through the ports **204** to supplement the cycle valve bias previously supplied from the pressurized fluid above the piston **32** which may now have been exhausted to the atmosphere by the closure of the main valve assembly **28**.

Control Valve Assembly 44

The control valve assembly **44** is controlled by a manually actuated trigger **206** and a conventional workpiece engaging assembly indicated generally as **208** to operate the fastener driving tool **20** through one or a number of automatically effected cycles of power and return strokes of the piston **32**. The mechanical construction of the control valve assembly **44** can be of any suitable type and can, for example, be of the general nature disclosed and described in U.S. Pat. No. **3,685,396**. In general, the control valve assembly is carried in a housing **210** as an integral subassembly which can be secured to a wall of the head portion **22A** of the housing **22** by suitable fasteners, such as machine bolts or screws **212** (FIG. **4**). The passages in the valve housing **210** communicating with the various control components of the assembly **44** are coupled to ports terminating related passageways formed in the housing **22**. The valve housing **210** is provided with a pair of spaced supporting lugs **210A** between which the trigger **206** is pivotally mounted on a pivot pin **214** (FIGS. **1** and **4**).

The workpiece engaging assembly or means **208** which is actuated when the tool **20** is placed adjacent a workpiece can be of any suitable well known construction, such as that shown in U.S. Pat. No. **3,615,049**. In general, the assembly **208** includes a linkage **216** mounted on the housing **22** and the nosepiece assembly **38** and resiliently biased to a position in which a workpiece engaging portion **216A** of the mechanism projects downwardly below the lower end of the nosepiece assembly **38**. An upper portion **216B** is coupled by a lost motion arrangement to the lower end of a safety valve stem **218** (FIG. **3**) forming a part of the control valve assembly **44**. When the tool **20** is placed adjacent a workpiece, the lower end portion **216A** engages the workpiece and moves the mechanism **216** upwardly. After the lost motion has been taken up, the portion **216B** of the linkage **216** moves the safety valve stem **218** upwardly from a normal position shown in FIG. **11** to an actuated position shown in FIG. **12**. When the tool **20** is moved away from the workpiece, resilient biasing means **220** (FIG. **1**) moves the linkage **216** downwardly so that after the lost motion is taken up, a portion **216B** moves the valve stem **218** downwardly from the actuated position shown in FIG. **12** to the normal position shown in FIG. **11**.

Referring now more specifically to the valving arrangement included in the control valve assembly **44**, the assembly **44** is shown in normal position in FIG. **11** and in an operated position in FIG. **12**. The control valve assembly includes a return air valve assembly indicated generally as **222**, a combined manual-safety valve assembly indicated generally as **224**, and a cycle valve assembly indicated generally as **226**. To provide a master source of pressurized fluid or compressed air for use by the control valve assembly **44**, there is provided a port or passageway **228** extending from the reservoir **24** through a wall of the housing **22** and the back wall of the housing **210** to the control valve assembly **44** to open into a valve cylinder **230** forming a part of the return valve assembly **222**. A passageway **232** forwards this pressurized fluid to a valve cylinder **234** forming a part of the manual valve assembly **224**. A further passageway **236** forwards this pressurized air to a valve cylinder **238** forming a part of the cycle valve assembly **226**.

The manual-trigger valve assembly **224** is actuated by the trigger **206** and the workpiece engaging assembly **208** to selectively connect a passageway **240** coupled to the cycle valve assembly **226** to a source of pressurized fluid when the control valve assembly **44** is in its normal position and to connect the passageway **240** to the atmosphere when the assembly **224** has been properly actuated by the trigger **206** and the workpiece engaging assembly **208**. The manual valve assembly **224** includes the safety valve stem **218** having therein a valve chamber **242** open at its upper end to the atmosphere. Slidably disposed within the valve chamber or cylinder **242** is a valve element or stem **244** with an enlarged upper end portion **244A**. A compression spring **245** interposed between the lower end of the valve stem

244 and the lower wall of the valve chamber 242 normally biases the valve stem 244 to the position shown in FIG. 11. The pressurized fluid admitted to the interior of the chamber 242 through a plurality of passageways 246 from the valve cylinder 234 and the passageway 232 also acts on the enlarged portion 244A to aid the bias of the spring 245 and normally seat this enlarged portion 244A on an exhaust valve O-ring 248. The spring bias insures that the tool 20 will not fire when first coupled to pressurized air. This pressurized fluid also passes outwardly from the chamber 242 through a plurality of ports or passageways 250 and the portion of the valve chamber 234 bounded by the illustrated O-rings to be conveyed over the passageway 240 to the cycle valve assembly 226.

When the valve stem 218 is moved upwardly to its actuated position determined by engagement of the upper stem 218 with a shoulder formed in the valve cylinder 234 (FIG. 12) and when the trigger 206 is pivoted in a counterclockwise direction about the pivot pin 214 to the position shown in FIG. 5, the indicated portion of the trigger 206 moves downwardly into engagement with the upper end of the valve stem 244 and shifts this valve stem to the position shown in FIG. 12. In this position, an O-ring 252 seats on the inner wall of the valve chamber 242 to close off communication between the ports or passageways 246 and 250 to terminate the supply of pressurized fluid to the passageway 240. At the same time, the enlarged upper end portion 244A of the valve element 244 moves out of engagement with the O-ring 248 to connect the passageway 240 to the atmosphere. The valve means 244 cannot be moved to the position shown in FIG. 12 unless both the safety valve stem 218 is elevated to the position shown and the trigger 206 is depressed to the position shown. Thus, the manual-safety valve assembly 224 cannot be operated to connect the passageway 240 to the atmosphere unless both the trigger 206 and the workpiece engaging assembly 208 are actuated. The release of these elements restores the manual valve assembly 224 to its normal position shown in FIG. 11 so that pressurized fluid is reapplied to the passageway 240 and its communication with the atmosphere is interrupted.

The return air valve assembly 222 is controlled by the pressure in the upper interior of the drive cylinder 26 to selectively supply return air to the lower end of the cylinder 26 at the end of a power stroke and to terminate this supply of return air when the piston 32 is restored to its normal position. In addition, the return air valve assembly 222 supplies a supplemental source of pressurized air for preventing premature operation of the cycle valve assembly 226. The return air valve assembly 222 includes a valve piston 254 slidably mounted in the valve chamber 230 and having an upper greater area piston portion 254A and a lower smaller area piston portion 254B providing a bias oppositely directed to that provided by the piston portion 254A. The pressurized fluid normally supplied through the conveying means 178 in the manner described above acts on the piston portion 254A to provide a greater magnitude downwardly directed bias acting on the valve piston 254 than is provided by the pressurized fluid supplied by the passageway 228 to the valve chamber 230 which provides an upwardly directed bias acting on the piston portion 254B. Thus, the valve piston 254 normally occupies the position shown in FIG. 11 in which its lower end seats on a resilient O-ring 256.

When the drive piston 32 reaches the end of its power stroke and the main valve assembly 28 is closed to exhaust the upper interior of the cylinder 26, the conduit 178 is placed at atmospheric pressure, and the bias is removed from the large piston portion 254A on the valve piston 254. At this time the pressurized fluid supplied to the lower end of the valve cylinder 230 by the passageway 228 acts on the small area piston portion 254B to move the valve piston 254 upwardly to the position shown in FIG. 12. At this time, the lower end of the valve piston 254 moves out of engagement with the valve seat 256, and pressurized fluid from the passageway 228 and the valve cylinder 230 enters a passageway 258 to be forwarded through a port 260 to the passageway 194 (FIGS. 4 and 8) to be supplied in turn through the opening 200 to the lower end of the cylinder 26. In addition, pressurized fluid from the passageway 258 is forwarded over another passageway 262 to be supplied to the lower end of the valve chamber 238 for the cycle valve assembly 226. The pressurized fluid supplied by the passageway 262 is used to avoid a premature change in the state of the cycle valve 226.

When the drive piston 32 has been restored to its normal position in the manner described above, the conduit 178 is again pressurized, and the greater bias applied by the large piston portion 254A returns the valve piston 254 to the normal position shown in FIG. 11 so that the supply of pressurized fluid to the passageway 258 is terminated. The pressurized fluid trapped in the passageways 258, 260, and 262 is discharged to the atmosphere over the connection through the opening 200 to the lower end of the interior of the cylinder 26. From the closed cylinder, trapped fluid can leak to the atmosphere through clearances along the driver blade 34.

The cycle valve assembly 226 illustrated in FIGS. 11 and 12 is one that automatically and successively cycles the main valve assembly 28 between open and closed conditions after the manual valve assembly 224 has been operated to produce a sequence of power and return strokes of the piston 32 and the driver blade 34. To accomplish this, the control valve assembly 226 includes a valve piston 264 movable to a position causing opening of the main valve 28 by a continuous bias and movable to an alternate position closing the main valve assembly 28 in accordance with the high pressure signal received through the ports 204 (FIG. 7) and 280 (FIG. 11) when the piston 32 has reached the end of its power stroke. A control piston 266 slidably mounted within the valve cylinder 238 for the cycle valve assembly 226 also forms a part of this assembly and is controlled by the return air valve assembly 222 to prevent premature return of the valve piston 264 to its setting effecting opening of the main valve 28.

More specifically, the cycle valve piston 264 which is slidably mounted within the valve cylinder 238 includes a small area piston portion 264A slidably mounted within a reduced diameter cylinder 268 formed in a plug 270 that is carried within an opening 272 in the housing 22B immediately above and in alignment with the valve chamber 238 in the valve housing 210. The chamber 268 is continuously supplied with pressurized fluid from the reservoir 24 through a restricted orifice 274 formed in the plug 270. This pressurized fluid acts on the small diameter portion 264A

to continuously bias the cycle valve piston **264** to the normal position shown in FIG. **11.**

In this position, pressurized fluid normally supplied by the manual valve assembly **224** over the passageway **240** passes around an O-ring **276** in an enlarged portion **238A** of the valve chamber to be forwarded over a passageway **278** to one end of the conduit **164.** As described above, the conduit **164** extends to the dump valve assembly **154** (FIG. 3) in the closure cap **140** for the tool **20** and holds the main valve assembly **28** in a position closing the open upper end of the cylinder **26.** When the manual-safety valve assembly **224** is operated in the manner described above to connect the passageway **240** to the atmosphere, the conduit **164** and the passageway **278** are also connected to the atmosphere to effect opening of the main valve assembly **28** in the manner described above. In this operation, the lower exhaust valve assembly **30** opens first, the exhaust passageways **152** are then closed, and finally compressed air is admitted to the top of the cylinder **26.**

When the piston **32** reaches the end of its power stroke (FIG. 7), pressurized fluid is supplied through the ports **204.** This pressurized fluid is conveyed through a passageway **280** extending through the portion **22D** of the head portion **22A** and the back wall of the housing **210** for the valve assembly **44** to supply this fluid below a large area piston portion **264B** on the cycle valve piston **264.** This fluid is supplied above the upper surface of the control piston **266.** The pressurized fluid supplied through the passageway **280** provides a greater upwardly directed bias than the pressurized fluid acting on the small area piston portion **264A.** Thus, the cycle valve piston **264** is moved upwardly from the position shown in FIG. **11** to the position shown in FIG. **12.** When the piston **264** moves to the position shown in FIG. **12,** the O-ring **276** closes off communication between the passageways **240** and **278** so that the conduit **164** is no longer connected to the atmosphere. In addition, an O-ring **282** moves into the enlarged portion **232A** of the valve cylinder **238** and places the passageway **278** in communication with the pressurized fluid supplied to the valve chamber **238** by the passageway **236.** When the conduit **164** is again pressurized, the main valve assembly **28** is closed to terminate the supply of pressurized fluid above the piston **32** and then to connect the upper interior of the cylinder **26** to the atmosphere. Further, when the main valve assembly **28** is closed, the cylinder **26** is then moved downwardly to close the lower end exhaust valve assembly **30** (FIG. 3). In this position, the O-rings on the piston **32** seal the ports **204** so that the pressurized fluid applied to the piston portion **264B** cannot be dissipated. This aids in holding the cycle valve piston **264** in the elevated position shown in FIG. **12.**

When the pressure within the upper interior of the cylinder **26** becomes sufficiently dissipated, the return air valve assembly **222** is opened, as shown in FIG. **12,** and pressurized fluid is applied over the passageways **258** and **262** to the extreme lower end of the cycle valve cylinder **238.** This pressurized fluid, in being supplied directly from the reservoir **24** without appreciable throttling, is of greater pressure than that trapped above this control piston and supplied through the signal passageway **280.** Accordingly, the control piston **266** moves upwardly to the position shown in FIG. **12.** The piston **266** may not physically engage the large piston portion **264B** of the cycle valve piston **264** under certain conditions where the pressure supplied by the port **280** is great enough. In any event, the control piston **266** provides an additional bias urging the piston **264** upwardly to the position shown in FIG. **12** against the bias applied to the small area piston portion **264A** with the result that the cycle valve piston **264** cannot be prematurely restored to its alternate setting shown in FIG. **11.**

The opening of the return air valve assembly **222** also supplies pressurized fluid in the manner described above to the lower interior of the cylinder **26** so that the piston **32** is elevated toward its normal position. As the piston **32** clears the ports **204** (FIG. 7), the signal air supplied to the large piston portion **264B** begins to dissipate over the passageway **280** due to expansion of air within the lower interior of the cylinder **26.** However, the pressure of this air is supplemented by that supplied by the return valve assembly **222** so that a substantial bias remains applied to the large piston portion **264B.** In addition, the control piston **266** provides a continuing bias acting on the large piston portion **264B** to prevent any movement of the cycle valve piston **264** at this time.

When the piston **32** is returned to its normal home position, the conduit **178** is pressurized, and the return valve assembly **222** is moved to the closed position shown in FIG. **11.** This terminates the supply of return air beneath the piston **32** and beneath the control piston **266.** The air acting on the piston **266** becomes dissipated primarily by leakage around the driver blade **34,** and the bias resulting from the pressurized fluid within the chamber **268** acting on the small piston portion **264A** is now effective to move the cycle valve piston **264** to the normal position shown in FIG. **11** along with the control piston **266.** When the cycle valve piston **264** reaches the position shown in FIG. **11,** the O-ring **282** closes off communication between the passageway **278** and the fluid pressure supplying passageway **236.** The O-ring **276** in moving into the enlarged portion **238A** connects the passageway **278** to the exhaust passageway **240** so that the main valve **28** is again opened. This initiates another cycle of operation of the drive system for the tool **20.** This operation continues, providing successive cycles of alternate power and return strokes until such time as the manualsafety valve assembly **224** is released.

The cycle valve assembly **226** can also easily be modified to provide single cycle rather than autofire operation. The only change that is required is to replace the plug **270** with another plug of identical configuration except that the passageway **274** instead of extending axially within the opening **272** to place the chamber **268** in communication with the reservoir **24** extends laterally through the plug **270** to communicate with a passageway **290** leading to the atmosphere. This, in effect, removes the autofire bias applied to the small area piston portion **264A.** With this modification, a small area piston portion **264C** is effective when the passageway **240** is pressurized to hold the piston **264** for the cycle valve assembly **226** in the normal position shown in FIG. **11.** However, when the valve piston **264** is shifted to its elevated position shown in FIG. **12** in precisely the manner described above, the piston portion **264C** is connected to the atmosphere over the passageway **240,** and no bias exists for returning the piston **264** to the normal position shown in FIG. **11** until such time

as the manual-safety trigger assembly **224** is released to repressurize the passageway **240.** With this modification, the cycle valve assembly **226** operates the tool **20** through a single power and return stroke, and further power strokes cannot be initiated until the manual-safety valve assembly **224** is released.

Referring now more specifically to FIG. **13** of the drawings, therein is illustrated a schematic diagram of the control valve assembly **44** for effecting autofire operation of the tool **20.** The main valve assembly **28,** in its schematic form shown in FIG.. **13,** includes the dump valve assembly **154.** A small effective area piston portion **28A** shown in FIG. **13** represents the lower area of the main valve element **136** tending to open this valve. A large effective area piston portion shown as **28B** in FIG. **13** represents the upper effective area of the piston portion **136A** as well as the bias applied by the compression springs **148.** Since the bias provided by the large area piston portion **28B** overcomes the bias provided by the piston portion **28A,** the main valve **28** in its normal position connects the upper interior of the cylinder **26** to the atmosphere. The large area piston portion **28B** is normally connected to pressurized fluid over the passageways **164, 240,** the cycle valve **226,** and the manual-safety valve assembly **224.**

When the tool **20** is to be operated, and both the trigger **206** and the workpiece engaging assembly **208** are operated, the manual-safety valve assembly **224** is operated to its alternate setting, and the lines **164** and **240** connect the large piston portion **28B** on the main valve assembly **28** to the atmosphere. The continuous bias applied to the small area piston portion **28A** shifts the main valve assembly **28** to its open position so that the lower exhaust valve assembly **30** is first opened, the exhaust passages **152** are next closed, and finally pressurized fluid is applied to the upper interior of the cylinder **26.** This moves the piston **32** and the driver blade **34** through a power stroke to drive a staple **40** supplied to the drive track **36.** At the end of the power stroke of the piston **32,** pressurized fluid collected through the ports **204** is supplied over the passageway **280** to pressurize the large piston portion **264B** of the cycle valve assembly **226.**

The force applied by the large area piston portion **264B** overcomes the continuous bias applied to the small area piston portion **264A,** and the cycle valve **226** shifts to its alternate setting so that even though the line **240** remains at atmospheric pressure, the passageway **164** is again pressurized, and the large area piston portion **28B** shifts the main valve assembly to its normal setting shown in FIG. **13.** Incident to this, the exhaust valve assembly **30** for the lower interior of the cylinder **26** is closed.

When the upper interior of the cylinder **26** approaches atmospheric pressure, the port **186** exhausts the passageway or conduit **178** faster than pressurized fluid can be supplied through the restricted orifice in the plug **180,** and the large area piston portion **254A** of the return air valve assembly **222** becomes substantially depressurized. At this time, the continuous pneumatic bias applied to the small area piston portion **254B** is effective to operate the return air valve assembly **222** to its alternate setting. When this happens, the line **258** is pressurized to supply fluid pressure over the passageway **262** to the control piston **266.** The control piston mechanically biases the cycle valve assembly **226** toward its alternate setting to supplement the pneumatic bias applied by the large piston portion **264B.**

The pressurized fluid supplied to the passageway **258** is also supplied to the opening **200** below the piston **32** in the cylinder **26** over a system of passageways and ports including the components **194, 196, 198,** and **200.** This pressurized fluid moves the piston **32** upwardly through a return stroke toward its normal position. As the piston **32** clears the ports **204,** pressurized fluid from the opening **200** also passes out of the cylinder **26** through the ports **204** to be applied over the passageway **280** to supplement the bias applied to the large area piston portion **264B** on the cycle valve **226.** When the piston **32** reaches its normal home position, the ports **186** are sealed from communication with the atmosphere by the O-rings carried on the piston.

The orifice in the plug **180** then begins to pressurize the passageway **178.** When this becomes sufficiently pressurized, the bias applied to the large piston portion **254A** on the air return valve **222** shifts this valve to the normal position shown in FIG. **13** against the continuous bias applied to the small area piston portion **254B.** When this happens, the passageway **258** and the passageways connected thereto tend toward atmospheric pressure along with the passageway **280,** by, for example, leakage of air from the bottom of the cylinder **26** along the sides of the driver blade **34.** When this pressure drop becomes great enough, the continuous bias applied to the small area piston portion **264A** of the cycle valve assembly **226** shifts this cycle valve back to its normal position shown in FIG. **13** and restores the control piston **266** to its normal position.

With the cycle valve **226** in its normal position, the passageway or conduit **164** is again connected to atmosphere over the passageway **240** and the operated valve assembly **224.** This opens the main valve assembly **28** in the manner described above. This cyclic operation continues until such time as the manual-safety valve assembly **224** is released. At this time, the control components of the control valve assembly **44** are restored to the normal position shown in FIG. **13.**

Although the present invention has been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this invention.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. A tool for driving fasteners into a workpiece comprising

a powered fastener driving assembly including a driver element actuated by a drive piston slidable within a drive cylinder,

a fluid controlled main valve means opened to supply pressurized fluid to and closed to exhaust fluid from the cylinder to move the piston through power and return strokes,

a cycle valve coupled to the main valve means and operable to alternate positions to open and close the main valve means, said cycle valve being biased to a position to close the main valve means, said cycle valve also including valve piston means,

passage means coupling the valve piston means to the drive cylinder to receive pressurized fluid for biasing the cycle valve to a position to close the main valve means,

return valve means responsive to the exhaust of the drive cylinder above the drive piston for supplying pressurized fluid into the drive cylinder below the drive piston to move the drive piston through a return stroke, the pressurized fluid below the drive piston being supplied to the valve piston means to bias the cycle valve to a position to close the main valve means,

and means responsive to the completion of the return stroke of the drive piston for controlling the return valve means to terminate the supply of pressurized fluid to the drive cylinder below the piston means and thus to the valve piston means.

2. A tool as set forth in claim 1 including

a bias piston movable into engagement with the valve piston means,

and means coupling the bias piston to the return valve means to receive pressurized fluid from the return valve means.

3. A tool as set forth in claim 1 including

a valve seat adjacent the lower end of the drive cylinder communicating with the atmosphere,

and means movably mounting the drive cylinder for movement into engagement with the valve seat when the main valve means is closed and out of engagement with the valve seat when the main valve means is opened to exhaust the drive cylinder below the piston.

4. A tool as set forth in claim 3 including

port means in the cylinder forming a part of said passage means, said port means being opened to pressurized fluid in the drive cylinder above the drive piston when the cylinder is out of said engagement with the valve seat and the drive piston is at the end of its power stroke, said port means being closed by said drive piston when the drive cylinder engages said valve seat and the drive piston is at the end of its power stroke.

5. A tool for driving fasteners into a workpiece comprising

a housing,

a cylinder slidably mounted in the housing and slidably receiving a piston movable through power and return strokes,

a fastener driving blade actuated by the piston,

a main valve means opened to supply a pressurized fluid to the top of the cylinder and closed to exhaust fluid from the top of the cylinder, said main valve means including means engaging the cylinder to move the cylinder down when the main valve means is closed and permitting upward movement of the cylinder when the main valve means is opened,

a nosepiece structure on the housing adjacent the lower end of the cylinder and having a drive track through which the fastener driving blade extends,

a cylindrical valve seat engaged by the lower end of the cylinder when the main valve means is closed and spaced below the lower end of the cylinder when the cylinder moves upwardly as the main valve means is opened, the space between the valve seat and the lower end of the cylinder exhausting the lower interior of the cylinder,

a fluid actuated cycle valve means coupled to the main valve means and automatically operable through a sequence of two spaced positions to open and close the main valve means, said cycle valve means including means responsive to pressurized fluid from the lower end of the cylinder to effect closure of the main valve means,

a fluid controlled return valve means responsive to the closure of the main valve means for supplying pressurized fluid to the cycle valve means to hold the main valve means closed and to the lower end of the cylinder below the piston to move the piston through a return stroke, said fluid controlled return valve means being released to terminate the supply of pressurized fluid when the piston completes its return stroke,

and control means for initiating movement of the cycle valve means to start a power stroke of the piston.

6. A tool as set forth in claim 5 in which

the cylindrical valve seat is fixedly secured to and projects upwardly from the nosepiece structure,

and the return valve means is carried on the housing and includes passage means through the housing and nosepiece structure terminating in a discharge port disposed within the cylindrical valve seat.

7. A tool for driving fasteners into a workpiece comprising

a housing defining a chamber,

a cylinder slidably mounted within the chamber for limited movement,

a fluid actuated main valve assembly movable into and out of engagement with the top portion of the cylinder, said cylinder being fluid biased toward the main valve assembly and movable over a limited travel with the main valve assembly before separation of the top portion of the cylinder and the main valve assembly,

a piston slidable within the cylinder,

a fastener driving blade actuated by the piston,

a nosepiece structure on the housing adjacent the lower end of the cylinder and defining a drive track slidably receiving the fastener driving blade,

an annular member fixedly secured to the nosepiece structure encircling the fastener driving blade and aligned with the lower portion of the cylinder,

a resilient sealing element carried on the annular member adapted to be engaged by the lower portion of the cylinder when the main valve means is moved into engagement with the top of the cylinder to move the cylinder down into seating engagement with the sealing element, said sealing element being spaced from the lower portion of the cylinder when the main valve assembly is moved upwardly out of engagement with the cylinder to permit limited upward movement of the cylinder away from the sealing element,

a fluid passage passing through the housing and the nosepiece structure and having a port in the nosepiece structure within the annular member,

and fluid control means coupled to the main valve assembly and to the fluid passage to move the main valve assembly into and out of engagement with the top portion of the cylinder and to supply fluid to the fluid passage.

8. A tool for driving fasteners comprising

a tool housing with a nosepiece structure including a drive track,

power actuated fastener driving means on the tool housing including a driver element movable in said drive track,

a magazine housing with an open top coupled to the nosepiece structure and having a fastener supporting structure disposed below said open top for supporting and feeding a series of fasteners into the drive track,

a pusher carriage mounted on said housing for movement toward and away from the drive track along an elongated path,

a rigid fastener engaging pusher element for engaging fasteners on said fastener supporting structure,

pivot structure coupling the pusher carriage and the pusher element to mount the rigid pusher element for pivotal movement into and out of the open top of the magazine about an axis extending transverse to the direction of the elongated path of movement of the pusher carriage,

and resilient means coupled to the pusher carriage to resiliently bias the pusher carriage for movement toward the drive track.

9. The tool set forth in claim **8** in which

the resilient means includes an extensible elongated flat spring means coupled between the tool housing and the pusher carriage and disposed at the open end of the magazine housing overlying the fasteners on the fastener supporting structure.

10. The tool set forth in claim **9** for use with U-shaped fasteners with spaced legs in which

a pair of rigid pusher elements are pivotally mounted on the pusher carriage and spaced from each other in the direction of said axis to engage the spaced legs of the U-shaped fasteners,

and the flat spring means includes a portion disposed between the spaced pair of pusher legs.

11. In a fastener driving tool having a reciprocable driver for driving generally U-shaped fasteners successively supplied to a drive track,

a magazine housing communicating at one end with the drive track and having an open top,

a support disposed within the housing for supporting a strip of U-shaped fasteners,

a carriage slidably mounted on the housing adjacent its open end for movement toward and away from the drive track,

flat spring means connected between the tool and the carriage and overlying the portion of the strip and the support that is disposed between the carriage and the drive track, said flat spring means biasing the carriage toward the drive track,

pusher means with at least one rigid pusher arm pivotally mounted on the carriage for movement into and out of the open top of the housing and adapted to engage the U-shaped fasteners when disposed within the magazine housing, the flat spring means being provided with a clearance to permit the pusher arm to move past the flat spring in moving into and out of the open end of the magazine housing,

and biasing means normally biasing the pusher arm into the open top of the magazine housing to a position for engaging a U-shaped fastener.

12. The tool set forth in claim **11** in which

the pusher means includes a pair of rigid pusher arms connected for joint movement and normally disposed within the magazine housing on opposite sides of the support,

said pair of pusher arms being spaced a given distance apart, and the flat spring means having a width less than said given distance in the portion of the length of the flat spring means adjacent the pusher arm so as to permit the pair of pusher arms to move into and out of the open top of the magazine housing.

13. A tool for driving fasteners comprising

a housing having a cylinder means closed at its lower end by a lower wall structure,

a power actuated drive means in the housing including a coupled piston and driver blade movable within the cylinder means,

valve means for selectively connecting the cylinder means to pressurized fluid to move the piston and driver blade through a power stroke,

a bumper on said lower wall structure and cooperating with the cylinder means and the lower wall structure to provide a peripheral passage around the bumper adjacent the lower wall structure communicating with a plurality of upwardly extending passages spaced circumferentially around the outer surface of the bumper,

and means for supplying pressurized fluid to the peripheral passage to be conveyed over said peripheral and upwardly extending passages to the interior of the cylinder means to move said piston and driver blade through a return stroke,

said means including a source of pressurized fluid and control means responsive to said drive stroke for interconnecting said source with said peripheral and upwardly extending passages.

14. A tool for driving fasteners into a workpiece comprising

a housing,

a powered fastener driving assembly in said housing including a driver element actuated by a drive piston slidable within a movable drive cylinder,

fluid controlled main valve means opened to supply pressurized fluid to and closed to exhaust fluid from the cylinder to move the piston through power and return strokes,

said main valve means including passageways exhausting said main valve means, and valve means movable to open and close said passageways,

said drive cylinder being movable with said passageway valve means, and

control means for controlling the main valve assembly, said control means actuating said valve means to close said passageways prior to supplying pressurized fluid to said cylinder to drive said piston and opening said passageways prior to the return stroke of said piston.

15. The tool set forth in claim **14** further comprising

a lower wall structure closing said cylinder at its lower end,

means for exhausting the portion of said housing beneath said drive piston, and said control means controlling the movement of said cylinder from its closed position with said lower wall structure to an open position communicating said cylinder with said exhaust means.

16. The tool set forth in claim **14** further comprising

a bumper on said lower wall structure cooperating with said cylinder and said lower wall structure to provide a peripheral passage around the bumper adjacent the lower wall structure communicating with a plurality of upwardly extending passages

spaced circumferentially around the outer surface of the bumper,

means for supplying pressurized fluid to the peripheral passage to be conveyed over said peripheral and upwardly extending passages to the interior of the cylinder means to move said piston and drive blade through a return stroke, and

said means including a source of pressurized fluid and control means responsive to said drive stroke for interconnecting said source with said peripheral and upwardly extending passages.

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