

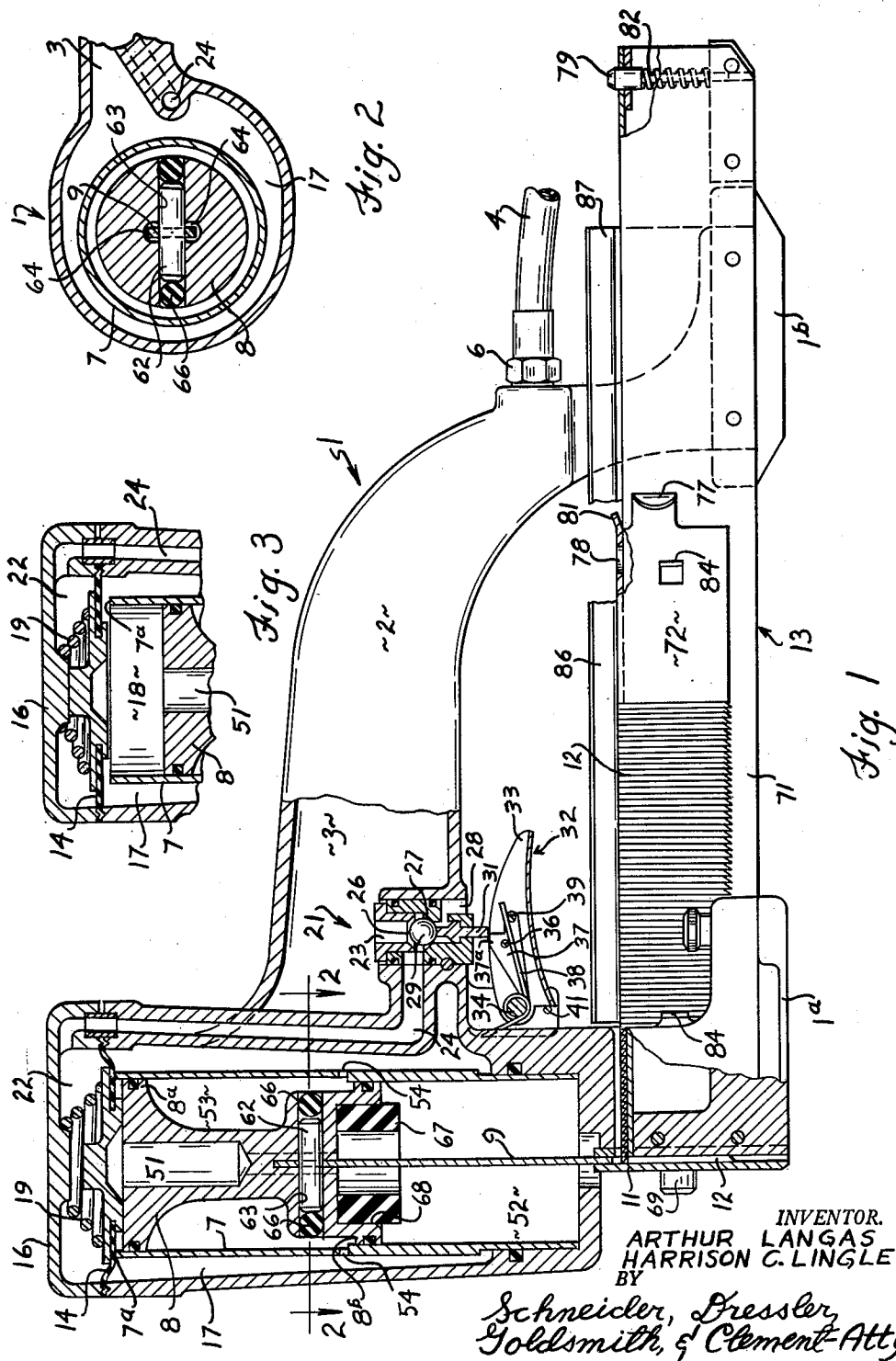
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A. LANGAS ET AL
FASTENER DRIVING TOOL

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3 Sheets-Sheet 1



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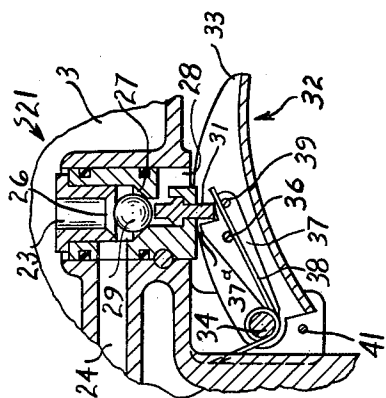


Fig. 4

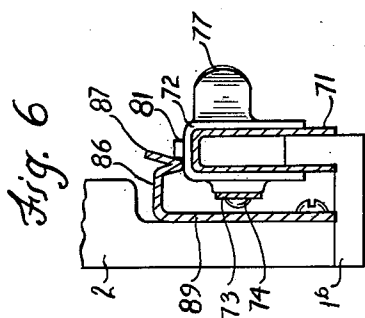


Fig. 6

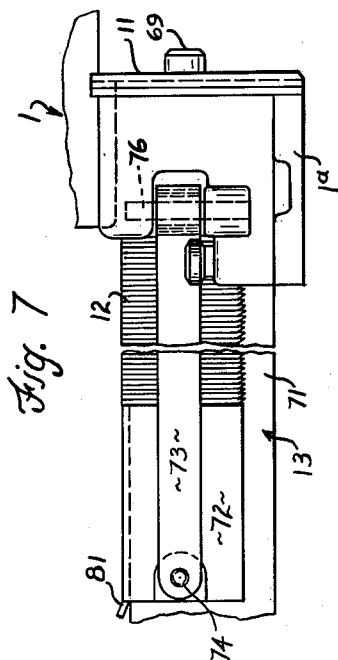


Fig. 7

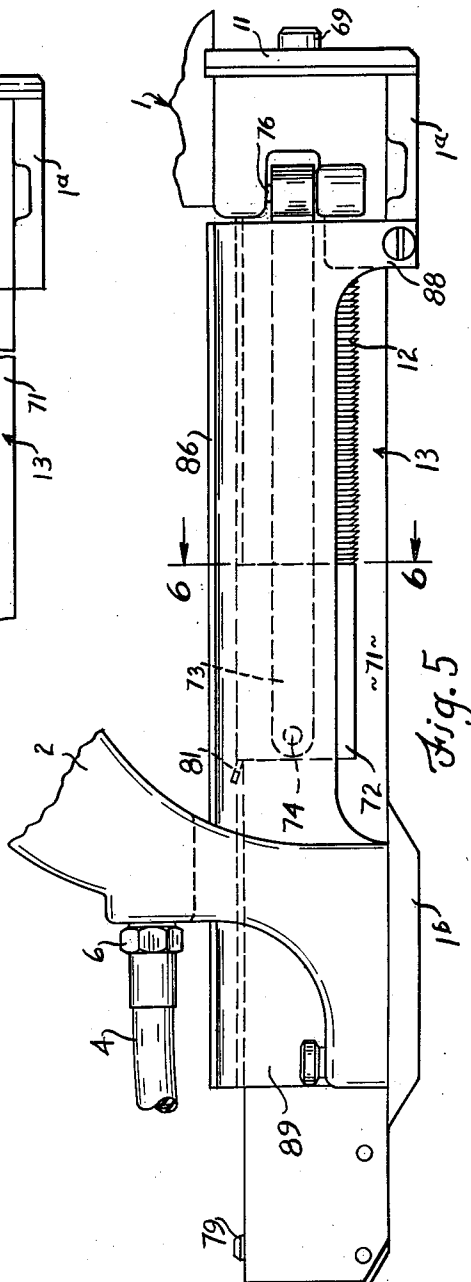


Fig. 5

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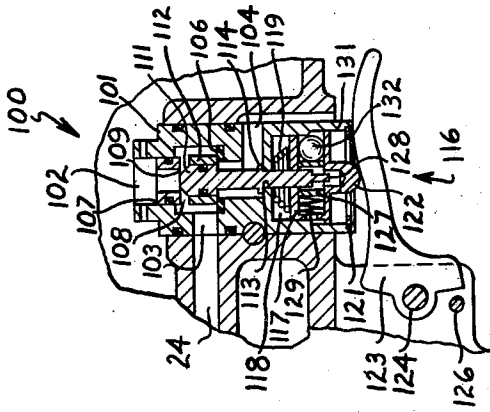


Fig. 9

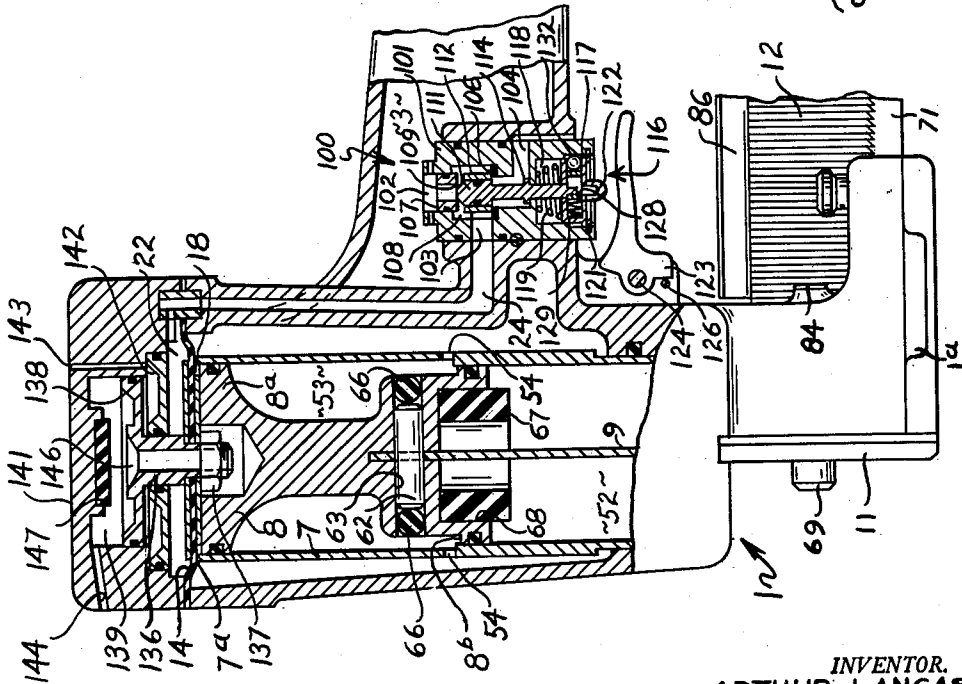


Fig. 8

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FASTENER DRIVING TOOL

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12 Claims. (Cl. 91—417)

This invention relates to a fastener driving tool and particularly to a pneumatically operated stapler for driving heavy-duty staples.

Pneumatically operated fastening tools are used in a number of industries, including those of furniture, luggage, and construction. These tools have been used to drive such fasteners as staples, tacks, and T-nails through readily pierceable materials. The tool in the instant application can likewise be adapted for driving various types of fasteners but for ease of description the present application will be directed to pneumatically operate staplers.

Pneumatic staplers on the market today are generally operated by a trigger actuated valve that functions to regulate the movement of a second valve that controls the flow of air under line pressure to a stapler driving member. In each of these staplers, as long as the trigger is held in a valve actuating position, high-pressure air will be continuously biasing the staple driving member in the driving direction. When the trigger is released, air from the driving side of the piston, which is at line pressure, is exhausted to atmosphere to allow the piston to be returned to its starting position. With this type of stapler, the operator must remove his finger from the trigger after each staple is driven to allow the piston or other power actuator to be returned to its starting position before another staple can be driven. This greatly reduces the operating speed of the stapler. Also, this method of controlling the operation of a stapler requires the use of large quantities of air under line pressure and is subject to the obvious disadvantage that due to inadvertence or lack of operator skill, the pilot valve may be held in an intermediate position with the attendant loss of substantial quantities of air which further adds to the operating cost of the fastener driving tool.

In addition to the above, pneumatic staplers presently on the market are relatively complex assemblies that employ a large number of parts. These parts are subject to wear and necessitate the keeping of a large inventory to maintain the tools in working order. This results in a relatively expensive tool, which expense has proved a deterrent to the wider use of pneumatic stapling devices.

Furthermore, the magazines presently used with staplers of all types are relatively complicated structures made of a large number of parts. Such magazines are generally enclosed with the result that any foreign matter that enters the magazine tends to clog it up and makes necessary at least a partial disassembly of the magazine to return it to working operation. Removal or repositioning of some parts is also required to determine the size and amount of the staples left in the magazine.

It is the purpose of the present invention to provide a pneumatically operated stapler which, while made up of a minimum of parts, is durable and highly efficient in operation. The stapler includes a piston and associated driver which, upon the application of air to the driving side of the piston, quickly and positively drives a staple into position. The flow of high-pressure air to the piston is controlled by a diaphragm valve which eliminates the sliding, sticking, and wearing problems found when using a sliding type assembly such as a piston valve.

The position of the diaphragm valve is determined by a pilot valve that regulates the flow of high-pressure fluid to and from the side of the diaphragm valve opposite the

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driving piston. The pilot valve is operated in the prescribed manner by a trigger assembly which when moved in one direction by the operator positions the pilot valve to vent the high-pressure air acting on the side of the diaphragm opposite the driving piston. With the pilot valve in this position, the high-pressure air continuously acting on the other side of the diaphragm raises the diaphragm. When the diaphragm raises, air stored in the storage chamber expands into the cylinder to drive the piston in a staple driving direction. Upon further movement of the trigger assembly, almost instantaneously with the driving action of the piston, the trigger assembly becomes disengaged from the pilot valve to allow the pilot valve to return to its starting position. When the pilot valve has returned to its starting position, high-pressure air is again introduced above the diaphragm valve and the diaphragm valve is moved to the closed position which cuts off the flow of air to the chamber above the piston. After the diaphragm is closed and the piston driven, the air under pressure trapped between the diaphragm and piston is vented to atmosphere. After the air above the piston is vented, the piston is returned to its raised position by high-pressure air acting against the underside of the piston. Thus, the stapler will be operated and returned to its starting position without having to release the trigger.

The introduction of air into the cylinder imparts a sharp, explosive driving action to the piston after which the piston immediately returns to its starting position. The piston in the stapler is driven by the expansion of air stored in the storage chamber and not by air entering through the air hose at the time of driving. In order to obtain maximum economy of air, the diaphragm valve is only open for the instant required to fully drive the piston and closes before the cylinder chamber above the piston builds up to the pressure of the air being introduced into the stapler. This method of operation results in the driving of the largest quantity of staples in the shortest possible time while using a minimum amount of high-pressure air.

The present invention also provides for a magazine that is simple in construction. The magazine is designed so that the staples located therein are visible at all times and are readily accessible without being encumbered by slidable covers, or the like. The disclosed design which essentially consists of a rail that supports a row of staples that are resiliently held against relative displacement prevents the accumulation of foreign material that would tend to clog the stapler. The arrangement enables the operator to determine quickly the number and size of staples currently in the magazine. Such an arrangement also greatly reduces the time required to load the magazine.

Two illustrative embodiments of the invention are described in detail in the following specification taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a cross-sectional view of the stapler and associated magazine;

FIGURE 2 is a view taken along lines 2—2 of FIGURE 1;

FIGURE 3 is a view showing the diaphragm valve in the open position;

FIGURE 4 is an enlarged view showing the trigger-operated pilot valve;

FIGURE 5 is a side view of the lower portion of the stapler housing and magazine;

FIGURE 6 is a view taken along lines 6—6 of FIGURE 5;

FIGURE 7 is a side view of the staple magazine;

FIGURE 8 is a cross-sectional view of a modified form of fastening tool; and

FIGURE 9 is an enlarged view of the trigger operated valve shown in FIGURE 8.

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Referring first to FIGURE 1, there is illustrated a stapler housing 1 having a body portion 2 which also serves as a handle by which the operator may grasp and manipulate the stapler. The handle portion is cored to provide a storage chamber 3 into which air under pressure from any suitable source is introduced through a hose 4 and hose nipple 6 connected to one end of the storage chamber 3. In the other end of the housing 1 is a cylinder 7 in which a driving piston 8 is slidably disposed. Secured to piston 8 is a staple driver 9. The driver 9 extends through a driver and staple guide 11 where it engage a staple 12 to drive it into position. The staple 12 is the end staple of an adhered row of staples located in a magazine 13 secured to the staple housing 1. The housing 1 and staple magazine 13 are supported by leg portions 1a, 1b of the housing 1.

The flow of compressed air between the storage chamber 3 and the interior of cylinder 7 above piston 8 is controlled by a diaphragm valve assembly 14 that seats against the upper edge 7a of the cylinder 7. The diaphragm assembly 14 is clamped between the cap 16 and main portion of the housing 1 and serves to block off the flow of compressed air between the annular chamber 17 surrounding cylinder 7 and the chamber 18 within the cylinder immediately above piston 8 (see FIGURE 3). As shown in FIGURE 2, the annular chamber 17 is in constant communication with the storage chamber 3. The diaphragm assembly 14 is resiliently biased against the upper edge surface 7a of the cylinder 7 by a spring 19 located between the cap 16 and the diaphragm assembly 14. The high-pressure air introduced into chamber 18 acts on piston 8 to move it and driver 9 with a sharp, quick driving action against the staple 12.

The movement of the diaphragm assembly 14 relative to the cylinder edge seating surface 7a is controlled by a pilot valve 21. The pilot valve regulates the pressure of the air in the chamber 22 formed between the diaphragm assembly 14 and the cap 16. This is accomplished by controlling the flow of air between the storage chamber 3 and chamber 22, and between chamber 22 and atmosphere.

When the pilot valve 21 is in the position shown in FIGURE 1, high-pressure air is directed to chamber 22 from storage chamber 3 through pilot valve inlet 23 and passage 24 to assist in maintaining diaphragm 14 against cylinder 7 to prevent the entry of high-pressure air into chamber 18.

The pilot valve 21 consists of an upper valve seat portion 26 located intermediate valve inlet 23 and conduit 24, and a lower valve seat 27 located between conduit 24 and exhaust port 28. The flow between storage chamber 3 and conduit 24, and between conduit 24 and exhaust port 28 is controlled by ball 29. As shown in FIGURE 1, the ball 29 normally seats against lower valve seat 27 to permit high-pressure air to flow from storage chamber 3 to chamber 22. This high-pressure air acts on the upper surface of diaphragm assembly 14, which is much larger than the portion of the undersurface of diaphragm assembly 14 that is exposed to the high-pressure air in chamber 3, to block the flow of air between storage chamber 3 and chamber 18.

The movement of ball 29 is controlled by valve plunger 31, the position of which is determined by a trigger mechanism 32. The trigger mechanism 32 includes a trigger 33 that is pivotally mounted relative to the stapler housing 1 by a pivot pin 34. Pivotaly mounted to the trigger 33 by a pin 36 is a pawl 37 which has an abutment portion 37a that is adapted to engage the underside of valve plunger 31 to move it upwardly when trigger 33 is moved in a counterclockwise direction. The pawl 37 and trigger 33 are biased in the clockwise direction by a torsion spring 38. One end of the spring 38 is wrapped around pin 34 and the other end extends outwardly between pin 36 and a pin 39 that only extends through the pawl 37. The clockwise movement of trigger 33 is limited by stop 41.

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During the counterclockwise movement of the trigger 33 by the operator, the abutment portion 37a of pawl 37 engages valve plunger 31 to move it upwardly to unseat ball 29 from seat 27 to open conduit 24 to exhaust port 28. Continued upward movement of plunger 31 by pawl 37 moves ball 29 into engagement with seat 26 to block the flow of compressed air between storage chamber 3 and conduit 24. With ball 29 in this position, the compressed air in chamber 22 is vented to atmosphere which unbalances the pressures acting on the opposite sides of the diaphragm assembly to permit the high-pressure air in annular chamber 17 to raise diaphragm assembly 14 from cylinder 7 to admit air under pressure to chamber 18 above piston 8. The admission of air to chamber 18 acts on the upper surface of piston 8 to drive it instantaneously in a staple driving direction.

Further clockwise movement of trigger 33 moves pawl abutment 37a out of engagement with plunger 31 so that almost immediately after ball 29 has been raised to vent conduit 24 and chamber 22 to atmosphere, valve plunger 31 is moved to the position shown in FIGURE 4 to permit ball 29 to be resealed on seat 27 to close off exhaust port 28. When ball 29 is resealed on seat 27, conduit 24 is again opened to storage chamber 3 to admit compressed air to chamber 22. The high-pressure air acting on the upper surface of diaphragm assembly 14 along with the spring 19 overbalances the forces acting on the underside of diaphragm assembly 14 to bias it against cylinder edge surface 7a. The resetting of the pilot valve takes place almost instantaneously with the driving action of the piston with the result that the piston is driven by the full power of the expansion of the air in the storage chamber but without the waste of air that would occur if the pressure in the cylinder were allowed to rise to equal line pressure. The air trapped in chamber 18 is vented and the piston 8 is returned to its starting position by means which will be described in detail hereinafter.

When the operator removes his finger from the trigger, the torsion spring 38 acts against pin 39 to rotate pawl 37 counterclockwise about pin 36 to return trigger 33 and pawl 37 to the position shown in FIGURE 1. The mechanism is then in position to drive another staple.

As previously mentioned, the introduction of air under pressure against the upper surface of piston 8 drives the piston in the staple driving direction. After the staple has been driven, the diaphragm assembly 14 closes off cylinder 7 and traps air in chamber 18 which must be vented to permit piston 8 to be returned to its raised or driving position to drive another staple. In the embodiment illustrated in FIGURES 1 through 4, the air trapped in chamber 18 is exhausted through a longitudinally extending exhaust port 51 in piston 8 that connects the chamber 18 with the opening 52 in housing 1. It is important to note that the piston 8 is driven so instantaneously when the diaphragm valve 14 opens that no substantial loss in drive results from either a pressure buildup under the piston, or from a loss of air, due to this arrangement of ports and openings.

After the piston has been driven, means must be provided to return the piston to its upper position to drive another staple. To this end, a chamber 53 is formed between piston lands 8a, 8b and cylinder 7. This chamber 53 is in communication with the storage chamber 3 through openings 54 in the walls of cylinder 7. The piston land 8a is larger than piston land 8b and thus the air under pressure introduced to chamber 53 drives piston 8 upwardly to return the piston to the driving position after diaphragm valve 14 is closed and chamber 18 is vented to atmosphere.

The driver 9 is connected to the piston 8 by a pin 62 extending through aligned passages 63, 64 in piston 8 and driver 9, respectively. The lower portion of the driver 9 extends through the staple and driver guide 11 that is secured to the staple housing 1 by bolt 69. The

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leakage of air through piston passages 63, 64 is prevented by rubber balls 66.

When the piston is driven, the shock of the piston against the housing wall at the base of the cylinder is cushioned by an annular resilient compressible shock absorbing bumper 67. The bumper 67 is frictionally engaged in the recess 68 in piston 8 and extends below the bottom of the piston.

The rapid downward movement of the piston and associated driver brings the driver 9 into engagement with the staple 12 located in the staple guide 11. The staples 12 are formed in an adhered array and are located on a rail 71 which forms the main element of the stapler magazine 13. The staples are resiliently biased toward guide 11 by a follower 72 which extends over the rail 71 and is in engagement with the other end of the adhered strip of staples as seen in FIGURES 1, 5, and 7. The follower 72 is spring-pressed into engagement with the row of staples by a negator spring 73. One end of the spring 73 is secured to the follower 72 by a pin 74, and the drum portion of the spring is secured to the front frame leg 1a by a pin 76 (see FIGURE 7).

The follower 72 has a tab 77 whereby it can be readily grasped and moved longitudinally to permit reloading of the magazine 13. The follower 72 has an opening 78 for receiving a spring-loaded latch 79 to hold the follower 72 in the retracted position. A tab portion 81 extends upwardly from the follower 72 to direct it over the latch 79 that is resiliently biased upwardly by spring 82. The forward movement of the follower is limited by cooperating stop members 83, 84 secured to the front leg 1a and follower 72, respectively.

The staples are retained in place against vertical movement relative to the rail 71 by a staple retaining member 86 shaped as shown in FIGURES 5 and 6. The staple retaining member 86 is essentially a longitudinally extending spring clip that includes a downwardly extending portion 87 that acts on the top of the row of staples to prevent the staples from climbing over each other and from falling away from the rail 71 when the stapler is turned over. The stapler retainer 86 is just located on one side of the row of staples and thus the magazine is open to eliminate pockets where foreign matter could collect. It is also apparent that with such an arrangement the operator can quickly ascertain the size and quantity of staples left in the magazine. Furthermore, he can quickly load the magazine by latching the follower 72 and slightly bending the portion 87 of staple retainer 86 away from rail 71. The staple retaining member 86 has depending leg portions 88, 89 that are secured by bolts to the front and rear frame legs 1a, 1b of the staple housing 1.

A second embodiment of a fastener tool embodying the present invention is illustrated in FIGURES 8 and 9. This version differs from the embodiment disclosed in FIGURES 1 through 7 in the trigger operated pilot valve assembly and the structural arrangement for venting the compressed air confined in chamber 18 between the closed diaphragm valve 14 and piston 8 after the piston and driver have been driven and the diaphragm valve 14 has returned to its closed position against cylinder rim 7a.

Briefly, the pilot valve 100 in the modified version controls the flow of air between the storage chamber 3 and chamber 22, and chamber 22 and atmosphere in the same manner as pilot valve 21 in the embodiment shown in FIGURES 1 and 4. The other area of difference between the two staplers is that in the second embodiment the air confined in chamber 18 is vented out through the cap of the fastening tool instead of through the driving piston. The leakage of air between the chamber 18 and driving piston 8 during the driving action of the piston 8 is prevented by a valve that is closed to block the flow of air.

As shown in FIGURES 8 and 9, the pilot valve 100

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includes a valve housing 101 having an inlet port 102, an outlet port 103 in communication with passage 24, and an exhaust port 104. Located intermediate the outlet port 103 and exhaust port 104 is a valve seat 106.

Slidably disposed in the valve housing 101 is a sleeve 107 that communicates with the inlet port 102 of the valve housing and includes an outlet port 108 which communicates with port 103 and passage 24. The sleeve also defines a valve seat 109 between valve inlet 102 and sleeve outlet 108 which when engaged by a valve member 111 block the flow of air between ports 102 and 103. The lower portion 112 of sleeve 107 is adapted to seat against the valve seat 106 of the valve housing 101 to control the flow of air between passage 24 and exhaust port 104.

The elongated valve member 111 is slidably disposed in the sleeve 107 and as previously mentioned is adapted to control the flow of air between the storage chamber 3 and passage 24. When valve member 111 is moved upwardly by a trigger operated assembly, which will be discussed in detail hereinafter, it first contacts the sleeve seat 109 to close off the flow of air between valve ports 102 and 103. Upon further upward movement, the valve member 112 raises the sleeve 107 away from the valve seat 106 to allow the air in chamber 22 to exhaust to atmosphere out through passage 24, housing port 103, and exhaust port 104.

The valve member 111 extends downwardly through an opening 113 in the valve housing 101 to where it can be engaged by the trigger operated valve positioner assembly. The downward movement of valve member 112 is limited by a shoulder portion 114 which engages valve housing 101.

The trigger operated valve positioner assembly 116 is designed to do the following in sequence without removing the finger from the trigger, (1) raise the valve member 111 to close off the flow of air between the storage chamber 3 and chamber 22, (2) raise the valve sleeve 107 to exhaust the air from chamber 22, and (3) release the valve member 111 to allow sleeve 107 to reseat against valve seat 106 to close off the exhaust port 104 from chamber 22 and reopen passage 24 and chamber 22 to storage chamber 3. To these ends, the trigger operated assembly 116 includes a plunger 117 that is located in a recess 118 formed in the underside of valve housing 101. The plunger 117 is spring biased downwardly by a spring 119 and is retained in place in the valve housing by a snap ring 121. Depending from the plunger 117 is a button 122, which is adapted to be engaged by a trigger 123 which is pivotally mounted to the housing 1 by a pivot pin 124. A pin 126 limits clockwise movement of trigger 123.

There is located within the plunger 117 a collar 127 which, in the position shown in FIGURE 8, surrounds the reduced end portion 128 of valve member 111 and is in engagement therewith so that upward movement of plunger 117 will raise the valve member 111. The collar 127 is resiliently maintained in this position by a spring 129 located between the collar 127 and the plunger 117. Located between the collar 127 and a cam surface 131 formed in the lower wall of the recess is a ball 132. The cam face 131 is so designed that when the plunger 117 is moved upwardly a predetermined amount, the cam face will move the ball 132 to the left to move the collar 127 out of engagement with the reduced end portion of the valve member 111. This repositioning of collar 127 allows the valve member 111 to move down to permit the sleeve 107 to reseat against valve seat 106 and reopen communication between storage chamber 3 and passage 24. It can be appreciated that with the aforementioned structure, pilot valve 100 will operate in a manner equivalent to that of pilot valve 21 in the fastener tool illustrated in FIGURE 1.

After the staple has been driven by the introduction of compressed air to chamber 18, the chamber is closed

off by diaphragm 14 and the air confined therein must be vented to permit the driving piston to be returned to its upper or driving position to drive another staple. In the embodiment disclosed in FIGURE 1, the air was bled through the piston to an outlet at the bottom of the valve housing. While this is satisfactory, another arrangement such as that to be described could be employed.

In the tool disclosed in FIGURE 8, a hollow stem 136 is connected to diaphragm 14 by nut 137. The stem 136 depends from a piston 138 that is slidably disposed in a chamber 139 defined by cap 141. The top of chamber 22 and underside of piston 138 is separated by a cover plate 142. The space between piston 138 and plate 142 is open to atmosphere through vent 143. The hollow stem 136 communicates with the chamber 139 which is open to atmosphere through an exhaust port 144 in cap 141. Thus, when the diaphragm 14 is closed against seat 7a, chamber 18 is opened to atmosphere through stem 136, chamber 139, and exhaust port 144.

To prevent the loss of air during the driving action of the piston 8, the piston 138 is formed with a valve head portion 146 which seats against a valve seat 147 secured to cap 141 to close off the hollow stem 136 and chamber 18 from the exhaust port 144. The valve seat 147 is in the form of a resilient pad which is secured to the upper wall of the cap 141. After the diaphragm 14 is opened and the pilot valve positioned to direct air into chamber 22, the combined area exposed to the high-pressure air from storage chamber 3 acting on the upper side of the diaphragm 14 and stem 136 is larger than that acting on the underside of diaphragm 14 with the result that diaphragm 14 is moved to the closed position without requiring a spring such as that used with the modification of FIGURE 1. When the diaphragm starts to close against the cylinder 7, the entire upper surface of piston 138 is exposed to the air under pressure flowing from chamber 18 to increase the speed at which diaphragm 14 moves to close off the open end of cylinder 7 and minimize the quantity of air that flows into chamber 18.

The operation of the stapler shown in FIGURES 1 to 7 is as follows:

Prior to the time a staple is driven, high-pressure air admitted to storage chamber 3 through hose 4 flows into chamber 17 against the underside of diaphragm 14 and through conduits 23 and 24 to chamber 22 located above diaphragm assembly 14. The high-pressure air in chamber 22 combined with spring 19 maintains diaphragm valve 14 closed against the top of cylinder 7. At the same time, piston 8 is biased and held in an upwardly direction by the compressed air introduced into chamber 53 from storage chamber 3 through openings 54.

When a staple is to be driven into position, the trigger 33 is moved counterclockwise by the operator to move pawl 37 into engagement with valve plunger 31 and plunger 31 against ball 29 to move ball 29 away from seat 27 and against valve seat 26. The ball 29 against seat 26 closes off chamber 22 from chamber 3 and brings chamber 22 into communication with exhaust port 28 to vent the air from chamber 22. When this occurs, the high-pressure air in chamber 17 acting on the underside of diaphragm 14 moves diaphragm assembly 14 upwardly against spring 19 to allow compressed air to enter chamber 18 and drive piston 8 and driver 9 in a staple driving direction. Immediately after ball 29 is moved upwardly to close off conduit 23, pawl 37a continues to move counterclockwise out of engagement with valve plunger 31 which allows ball 29 to reseat and again open chamber 22 to the high-pressure air in storage chamber 3. The compressed air in chamber 22 along with spring 19 offsets the forces acting on the underside of the diaphragm 14 to close it against the top of cylinder 7. The pilot valve 21 is closed almost instantaneously with the driving action of the piston with the result that high-pressure air from storage chamber 3 is cut off after the driving of the piston 8 and before air pressure in the cylinder and stor-

age chambers builds back up to air line pressure. After the piston is driven, the air trapped in chamber 18 above piston 8 bleeds out through exhaust ports 57 and housing opening 52 to atmosphere. The air under pressure in the chamber 53 then raises piston 8 back to its starting position. It remains to note that when the operator releases his finger from the trigger 33, the trigger 33 and associated pawl 37 are moved back to their starting position by the torsion spring 38.

Referring now to the modified form of stapler shown in FIGURES 8 and 9, when the stapler is in the driving position, diaphragm valve 14 is closed by the high-pressure air in chamber 22. Chamber 18 has been vented through hollow stem 136 and exhaust port 144. When a staple is to be driven, trigger 123 is moved counterclockwise to engage button 122 and move plunger 117 upwardly to the position shown in FIGURE 9. Upward movement of the plunger 117 cycles the pilot valve 100 through various positions as outlined below. During the initial upward movement of plunger 117, plunger 117 engages valve stem 111 to move it into contact with sleeve seat 109 to close off the flow of compressed air to conduit 24 and chamber 22. Further upward movement of valve stem 111 raises sleeve 107 away from valve seat 106 to vent chamber 22 to atmosphere and unbalance diaphragm 14 to allow the compressed air acting on the underside of diaphragm 14 to open chamber 18 and piston 8 to the high-pressure air in storage chamber 3. The expansion of the air in the stapler housing drives piston 8 and associated driver 9 with a snap action against the staple 12 in staple guide 11 to drive the staple into position.

Further upward movement of plunger 117, almost simultaneous with the driving action, brings ball 132 into contact with the upper portion of cam surface 131 which biases ball 132 to the position shown in FIGURE 9. When ball 132 is moved to this position it moves collar 127 out of engagement with valve stem 111 to allow valve stem 111 to move downwardly away from sleeve seat 109. The ports in sleeve 107 are then open to interconnect storage chamber 3 and chamber 22. At the same time the lower portion 112 of sleeve 107 closes off exhaust port 104. The force of the compressed air in chamber 22 acting on diaphragm 14 along with the force of the air acting downwardly on hollow valve stem 136 acts against the forces acting on the underside of diaphragm 14 to seat diaphragm 14 against cylinder edge 7a and close off chamber 18. The air confined in chamber 18 is vented out through hollow stem 136, chamber 139, and port 144. After chamber 18 is vented, the compressed air continuously acting on the differential piston areas 8a, 8b raises piston 8 and driver 9 to its starting or driving position to drive another staple.

The staples 12 are placed in the magazine 13 by bending the staple retainer 86 backwardly and dropping them over the top of rail 71. The staple retainer 86 prevents the staples from climbing over each other and from falling away from the rail when the stapler is turned over. The end staple of an adhered row of staples is then positioned in staple guide 11 by the resiliently biased follower 72. When the staples are used up, the follower may be moved rearwardly into engagement with latch 72 to permit reloading of the magazine.

While the invention has been directed to a stapler, it is apparent that the driving tool disclosed herein can be used for driving other types of fasteners, such as tacks, brads, nails, or T-nails. Furthermore, it is noted that the particular magazine assembly disclosed is not limited to use with a pneumatically operated fastening tool.

From the foregoing, it will be observed that numerous variations and modifications may be affected without departing from the true spirit and scope of the novel concepts of the invention. For example, a pneumatically operated reset mechanism could be used in place of the mechanical trigger assembly herein disclosed for automatically closing the diaphragm valve almost immediately

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after the stapler has been actuated. Also, a spring could be used for returning the piston after it has been driven in place of the air return system herein disclosed.

It is intended to cover by the appended claims all such modifications and embodiments that fall within the true spirit and scope of the invention.

We claim:

1. A fastener driving tool comprising a housing adapted to receive fluid under pressure, a cylinder in said housing, a piston slidably disposed in said cylinder, driver means secured to one side of said piston, first valve means for controlling the flow of fluid under pressure to the other side of said piston, second valve means for controlling the operation of said first valve means, and means for sequentially positioning said second valve means to effect in one continuous motion first opening and then closing movement of said first valve means.

2. A fastener driving tool comprising a housing, means for supplying compressed air to said housing, a cylinder in said housing, a piston slidably disposed in said cylinder, an elongated driver secured to one side of said piston, diaphragm means for controlling the flow of compressed air to the other side of said piston, valve means for controlling the operation of said diaphragm means, and trigger operated means for sequentially positioning said valve means to effect in one continuous movement first opening and then closing movement of said diaphragm means.

3. A stapling device including a housing adapted to receive compressed air, a cylinder in said housing provided with an open end for exposure to the compressed air in the housing, a piston slidably disposed in said cylinder between driving and driven positions and normally biased toward said open end, a staple driver secured to one side of said piston, diaphragm valve means for controlling the flow of compressed air to the other side of said piston, second valve means for controlling the operation of said diaphragm valve means, means for sequentially positioning said second valve means to effect first opening movement of the diaphragm valve means to admit compressed air to the open end of the cylinder to drive the piston to the driven position and then closing movement of said diaphragm valve means to cut off the supply of compressed air to the cylinder, and means for venting the fluid trapped between the diaphragm valve means and piston after the piston has been driven and the diaphragm valve means closed.

4. A pneumatically operated fastener driving tool including a housing adapted to contain compressed air; a cylinder in said housing; a piston slidable in said cylinder; a fastener driver secured to one side of the piston; diaphragm means controlling the flow of compressed air to the other side of the piston, said diaphragm means having one side exposed to the compressed air in said housing; valve means for directing and controlling the flow of compressed air to the other side of said diaphragm means comprising a first valve seat controlling the flow of compressed air to said other side of said diaphragm, a second valve seat for controlling the flow between said other side of the diaphragm and atmosphere; and valve element means for (1) closing off the first valve seat to block the flow of compressed air to the other side of said diaphragm, (2) opening the second valve seat to exhaust the compressed air from the other side of said diaphragm and (3) for closing the second valve seat and opening the first valve seat to admit compressed air to the other side of said diaphragm; whereby the diaphragm means will be opened to admit air to drive the piston and thereafter closed to cut off the flow of air to the piston.

5. A pneumatic stapler including a housing adapted to contain compressed air; a cylinder in said housing; a piston slidable in said cylinder between driving and driven positions; a staple driver secured to one side of the piston; diaphragm means controlling the flow of air to the other side of the piston having one side exposed to the air in said housing; valve means for directing and controlling

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the flow of air to the other side of said diaphragm means comprising a first valve seat controlling the flow of air to said other side of said diaphragm, and a second valve seat for controlling the flow of air between said other side of the diaphragm and atmosphere; and sequentially operated valve element means for (1) closing off the first valve seat to shut off the flow of air to the other side of said diaphragm, (2) opening said second valve seat to exhaust the air from the other side of said diaphragm and (3) closing said second valve seat and opening said first valve seat to admit compressed air to said other side of said diaphragm; whereby the diaphragm means will first be opened to admit air to drive the piston and then closed almost immediately thereafter to shut off the flow of air to the piston; and means for venting the compressed air confined between the diaphragm means and piston when the diaphragm is closed, said piston defining a differential area exposed to the compressed air in the housing for returning the piston to the driving position after the compressed air confined between the closed diaphragm and piston has been vented.

6. A pneumatically operated fastener driving tool comprising a cylinder provided with an open end for exposure to air under pressure in the tool, a piston reciprocally disposed in said cylinder and normally biased toward the open end thereof and having a driving member connected thereto, means for supplying air under pressure to drive the piston, diaphragm means for controlling the flow of air into the open end of the cylinder and responsive on one side thereof to the air under pressure in the tool, means for controlling the movement of the diaphragm between open and closed positions comprising valve means, trigger operated means for controlling the position of said valve means, said trigger operated means being continuously movable in one direction to move said valve means to effect first opening of said diaphragm means to admit air to drive the piston and driving member and then to release the valve means to effect closing movement of said diaphragm means, and means for venting the air under pressure confined between the piston and diaphragm means, and whereby the piston may be returned to the driving position after a fastener has been driven.

7. A pneumatically operated fastener driving tool including a housing, a cylinder provided with an open end for exposure to air under pressure in said housing, a piston slidable in said cylinder and being normally biased into the driving position, a fastener driver secured to one side of said piston, diaphragm means extending across the open end of said cylinder and engageable therewith for controlling the flow of compressed air to the other side of said piston and having the periphery of the side of said diaphragm facing said piston exposed to the compressed air in said housing, means for directing and controlling the flow of compressed air to the other side of said diaphragm means, whereby the diaphragm means will be opened to admit air to drive the piston and thereafter closed to cut off the flow of air to the piston, and means for venting the air confined between the diaphragm means and piston when the diaphragm is closed including a port defined by the piston and extending therethrough.

8. A pneumatic stapler including a housing adapted to contain compressed air, a cylinder provided with an open end for exposure to air under pressure in said housing, a piston slidable in said cylinder and normally biased into the driving position, a staple driver secured to one side of the piston, diaphragm means extending across the open end of said cylinder and engageable therewith controlling the flow of air to the other side of the piston and having the periphery of the side of said diaphragm facing said piston exposed to the air in said housing, means for directing and controlling the flow of air to the other side of said diaphragm means, whereby the diaphragm means will be first opened to admit air to drive the piston and then closed to shut off the flow of air to the piston, and means for controlling the flow of air from a chamber defined

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between the diaphragm means, piston, and cylinder including a hollow valve stem secured to the diaphragm and extending away from said cylinder and connecting said chamber to atmosphere, and a valve seat disposed adjacent the end of said valve stem remote from said cylinder and adapted to be engaged by the valve stem when the diaphragm is raised to close off said chamber to prevent the leakage of air from said chamber during the driving operation.

9. A pneumatic stapler including a housing adapted to contain compressed air; a cylinder in said housing; a piston slidable in said cylinder between driving and driven positions; a staple driver secured to one side of the piston; diaphragm means controlling the flow of air to the other side of the piston and having one side continuously exposed to the air in said housing; valve means for directing and controlling the flow of air to the other side of said diaphragm means comprising a first valve seat controlling the flow of air between the housing and the other side of said diaphragm, and a second valve seat for controlling the flow of air between the other side of the diaphragm and atmosphere, and valve element means for controlling the operation of said first and second valve seats including a trigger and plunger assembly which during continuous movement thereof engages the first valve seat to shut off the flow of air to the other side of the diaphragm, opens the second valve seat to exhaust the air from the other side of the diaphragm and then closes the second valve seat and opens the first valve seat to admit compressed air to said other side of said diaphragm, whereby the diaphragm means will be first opened to admit air to drive the piston and then closed to shut off the flow of air to the piston; and means for venting the compressed air confined in a chamber defined between the diaphragm means, cylinder, and piston when the diaphragm is closed including a hollow valve stem portion secured to the diaphragm and adapted to vent said chamber, a valve seat disposed adjacent the valve stem and adapted to be engaged by the valve stem when the diaphragm is raised to prevent the leakage of air from said chamber during the driving operation, said piston defining a differential area exposed to the compressed air in said housing for returning the piston to the driving position after the air confined in said chamber has been vented.

10. A pneumatic fastening tool including a housing adapted to contain compressed air, a cylinder in said housing having an open end exposed to the compressed air in the housing, a piston slidable in said cylinder and normally biased toward the open end thereof, a driving member secured to one side of the piston, diaphragm means controlling the flow of air to the other side of the piston and having one side exposed to the air in said housing, means for directing and controlling the flow of air to the other side of said diaphragm means to effect opening and closing thereof relative to the open end of the cylinder, a pressure responsive member connected to said diaphragm means and disposed in a first chamber vented to atmosphere, means defining a passageway interconnecting the first chamber with a second chamber formed between the diaphragm, cylinder and piston, valve means for closing off the flow of air through said passageway when the diaphragm is raised to admit air to the open end of the cylinder, said pressure responsive member defining a first area exposed to the pressure of air in the second chamber when said valve means is closed to effect movement of the diaphragm means in the closing direction and an enlarged area surrounding said first area which enlarged area is exposed to the air under pressure from said second chamber after the valve means is opened to rapidly move the diaphragm to the closed position.

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11. A pneumatic fastening tool including a housing adapted to contain compressed air, a first cylinder in said housing having an open end exposed to the compressed air in the housing, a piston slidable in said cylinder and normally biased toward the open end thereof, a staple driver secured to one side of the piston, diaphragm means controlling the flow of air to the other side of the piston and having one side exposed to the air in said housing, means for directing and controlling flow of air to said diaphragm means whereby the diaphragm means will be opened to admit air to drive the piston and closed to shut off the flow of air to the first cylinder, a second cylinder in said housing exposed to atmosphere, a piston disposed in said cylinder, hollow stem means interconnecting the piston in the second cylinder with a chamber formed between the diaphragm, first cylinder and piston to vent the fluid in said chamber to atmosphere, valve means for closing off the flow of air through said stem portion when the diaphragm is raised to admit air to the open end of the first cylinder, the piston in said second cylinder defining a first area exposed to the pressure of air in said chamber when said valve means is closed to effect movement of the diaphragm means in the closing direction and an enlarged area surrounding said first area which enlarged area is exposed to the air under pressure in said chamber after the valve means is opened to rapidly move the diaphragm to the closed position.

12. A pneumatic fastening tool including a housing adapted to contain compressed air, a first cylinder in said housing having an open end exposed to the compressed air in the housing, a first piston slidable in said cylinder, said first piston defining a differential area exposed to the air in the housing whereby the piston is normally biased toward the open end thereof, a staple driver secured to one side of the first piston, diaphragm means controlling the flow of air to the other side of the first piston and having one side exposed to the air in said housing, means for directing and controlling flow of air to said diaphragm means whereby the diaphragm means will be opened to admit air to drive the first piston and closed to shut off the flow of air to the first cylinder, a second cylinder in said housing, a second piston disposed in said second cylinder, a vented cap closing said second cylinder and defining therewith a first chamber exposed to atmosphere, hollow stem means interconnecting the first chamber with a second chamber formed between the diaphragm, first cylinder and first piston to vent the fluid in said second chamber to atmosphere, valve means for closing off the flow of air through said stem portion when the diaphragm is raised to admit air to the open end of the first cylinder, the piston in said second cylinder defining a first area exposed to the pressure of air in said second chamber when said valve means is closed to effect movement of the diaphragm means in the closing direction and an enlarged area surrounding said first area which enlarged area is exposed to the air under pressure in said second chamber after the valve means is opened to rapidly move the diaphragm to the closed position.

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