A fastener driving tool includes a cylinder slidably receiving a piston for operating a driver to drive fasteners successively supplied beneath the driver. A main valve selectively supplies compressed air to and exhausts air from above the top of the cylinder to control movement of the piston between normal and displaced positions. The piston is returned by air supplied from a return air space communicating with the bottom of the cylinder when the top of the cylinder is exhausted. Since this return air leaks to the atmosphere as or after the piston is returned, the uppermost part only of the cylinder is provided with different diameter portions cooperating with two spaced sealing means on the piston which trap or are supplied with compressed air to provide an upwardly directed pneumatic bias for releasably holding the piston in its normal position, this bias being removed as soon as the piston moves downwardly into the uniform diameter portion of the cylinder. The piston biasing air is derived directly from the reservoir air or from a valve carried on the piston.

20 Claims, 8 Drawing Figures
3,638,534

FASTENER DRIVING TOOL WITH IMPROVED PNEUMATIC PISTON RETAINING MEANS

This invention relates to a pneumatic fastener driving tool using a brief pulse of pressurized fluid to restore a piston to a normal position, and more particularly, to such a tool having new and improved means for releasably retaining the piston in its normal position.

Many fastener driving tools use pneumatic piston return systems to obtain such advantages as the reduction of tool height and the removal of the need for a return spring. In some of these systems, the piston and cylinder have different diameters so that the entire stroke of the piston with the result that the piston must always be driven through its power stroke in opposition to the return bias or else the volume bound by the different diameter portions must be great enough to supply adequate air for returning the drive system to a normal position. Such prior arrangements using two separate cylinder portions of different diameters are shown, for example, in U.S. Pat. Nos. 3,040,709; 3,043,272; and 3,208,533. One such arrangement using a cylinder continuously tapered from top to bottom is shown in U.S. Pat. No. 3,229,589.

In another type of air return system, such as shown in U.S. Pat. Nos. 2,979,725; 3,173,340; and 3,190,187, single-diameter cylinder and pistons are used, and valve arrangements are provided for supplying air below the piston to return the piston to normal position. In a variation of these arrangements, part of the air swept by the piston on its drive stroke is trapped or stored during the drive stroke, and this air with some added air is used for return. Examples of this type of system are shown in U.S. Pat. Nos. Re. 26,262; 3,353,453; and 3,363,517. These types of tools either require the provision of air beneath the piston to hold it in normal position between strokes or else require some mechanical means or means independent of air pressure for holding the piston in its normal position. Some tools use the normal friction between the piston O-ring and the cylinder wall. This friction may not be adequate if the tool is subjected to sharp blows. Other tools use mechanical latches such as magnets or spring-biased members which add parts to the tool and thus increase its cost.

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

Another object is to provide a fastener driving tool with new and improved pneumatic means for releasably holding a piston in its normal position between strokes.

A further object is to provide a pneumatic means for releasably holding in a normal position a piston which has been returned to this normal position by a brief impulse of pressurized fluid, which pneumatic holding means do not retard movement of the piston through its power or driving stroke.

Another object is to provide a pneumatic means for releasably holding a piston in normal position, which holding means does not require additional parts or space.

A further object is to provide a pneumatic means for releasably holding in a normal position a piston returned to its normal position by a brief impulse of pressurized fluid, which holding means uses the same valve arrangement used to supply at least a part of the pressurized piston return fluid.

In accordance with these and many other objects, an embodiment of the invention comprises a pneumatic fastener driving tool having a cylinder in which is slidably mounted a piston for actuating a fastener driving blade or driver. A main valve assembly selectively connects the upper end of the cylinder to the atmosphere or to a reservoir or source of pressurized fluid such as compressed air for driving the piston from a normal position at the upper end of the cylinder to a displaced position at the lower end of the cylinder during which a fastener such as a staple or nail supplied below the driver is driven. When the upper end of the cylinder is connected to the atmosphere by the main valve assembly, a brief impulse of pressurized fluid supplied to the lower end of the cylinder below the piston, as from a return air storage chamber or by a valve, returns the piston from its displaced position to a normal position, the return air being dissipated to the atmosphere as and after the piston is returned to its normal position.

In accordance with the present invention, novel pneumatic means are provided for retaining the piston and a connected driver blade in their normal positions in the interval between successive operating cycles or strokes of the fastener driving tool. This pneumatic retaining means includes a two-diameter portion formed in the upper end of the cylinder in the area occupied by the piston in its normal position. The remaining internal surface of the cylinder is of a uniform diameter. The piston includes a pair of O-rings which in the normal position of the piston seal against the two-diameter portion. Pressurized fluid or compressed air is selectively supplied to an air-receiving space between the two sealing means and is retained therein between cycles of operation of the tool. This pressurized fluid acting on the different diameter portions of the cylinder and the sealing means carried on the piston produce an upwardly directed pneumatic bias releasably retaining the piston in its normal position. When compressed air is supplied to the upper end of the cylinder to drive the piston downwardly, the sealing means on the piston both engage the uniform diameter portion of the piston, thereby removing the differential areas and removing the bias so that the drive stroke of the piston takes place without requiring the piston to operate against a return bias. A pressurized fluid can be supplied between the O-rings either directly from the reservoir air or selectively under the control of valve means carried on the piston which may be provided to supply the impulse of compressed air for returning the piston to its normal position. Thus, the releasable pneumatic piston holding means of the present invention does not require additional parts over and above those normally encountered in tools of this type, does not provide a return bias operating against the piston during its power stroke, and affords a positive pneumatic bias supplying adequate force to maintain the piston in its normal position between driving strokes, even when the tool is subjected to sharp blows.

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

FIG. 1 is a fragmentary sectional view of a fastener driving tool embodying the improved pneumatic holding means of the present invention;
FIG. 2 is a sectional view of another embodiment of the pneumatic holding means used in the tool shown in FIG. 1;
FIG. 3 is a fragmentary sectional view of another embodiment of a pneumatic holding means useful with the tool shown in FIG. 1;
FIG. 4 is a fragmentary sectional view of a pneumatic fastener driving tool embodying another form of a pneumatic piston holding means;
FIG. 5 is a fragmentary sectional view of another piston-cylinder arrangement embodying the novel pneumatic holding means of the present invention, which holding means is illustrated in conjunction with a tool of the type shown in FIG. 4; and
FIGS. 6, 7 and 8 are fragmentary sectional views of further piston-cylinder modifications embodying the novel pneumatic holding means.

Referring now more specifically to FIG. 1 of the drawings, therein is illustrated a fastener driving tool which is indicated generally as 10 and which embodies the present invention. The tool 10 includes a housing 12 having a forward and generally vertically extending head portion 12A and a rearwardly extending hollow handle portion 12B forming a reservoir 14 to which a pressurized fluid, such as compressed air is supplied in any suitable manner, as by a flexible air line. The head portion 12A of the housing includes a cavity 16 in which is mounted a cylinder 18 having its lower end in communication with the cavity 16 and an upper open end in continuous
communication with a passageway 20 formed in the housing. A control valve assembly which is manually controlled and which is indicated generally as 22 normally connects the passageway 20 to the atmosphere through a passageway 24 formed in the hollow handle portion 12B, and this control valve assembly 22 is operable to a position in which it connects the passageway 20 to the reservoir 14. The fluid admitted to the passageway 20 enters the upper end of the cylinder 18 and drives a piston 26 which is slidably mounted within the cylinder 18 and which is secured to the upper end of a fastener driving blade 28 downwardly so that the lower end of the blade engages and drives a fastener supplied to a drive track in a nosepiece assembly 30 by a magazine assembly indicated generally as 32. Before the piston 26 can move downwardly through a power stroke from its normal position shown in solid line in FIG. 1 to its displaced position shown in dashed outline, a pneumatic bias afforded by a releasable pneumatic holding means indicated generally as 34 must be overcome. As the piston 26 moves downwardly toward its displaced position shown in dashed outline in FIG. 1, a portion thereof disposed beneath the piston is discharged to the atmosphere through the structures defining the drive track in the nosepiece structure 30 in the lower end of the head portion 12A, and a portion of the air is forced into an air return reservoir or space 36 formed in the cavity 16 between the walls of the head portion 12A and the cylinder 18. A valve assembly on the piston 26 supplies additional compressed air from above the piston 26 to the air return reservoir 36 when the piston 26 is in its displaced position. When the valve assembly 22 releases to interrupt the connection between the passage 20 and the compressed air reservoir 14 and to connect the passage 20 to the atmosphere through the exhaust passage 24, the upper end of the cylinder 18 is exhausted, and the compressed air stored in the reservoir 36 enters the lower end of the piston 18 and provides a momentary impulse of pressurized fluid for restoring the piston 26 and the connected driver blade 28 to the normal position illustrated in FIG. 1. When the piston 26 reaches the illustrated position, the pneumatic holding means 34 is rendered effective to pneumatically bias the piston to retain this position until the next operating cycle of the tool 10. The general mechanical construction of the housing 12 and the magazine assembly 32 can be of any type well known in the art, such as the construction shown in U.S. Pat. No. 3,215,324. In general, the head portion 12A of the housing 12 includes a structure defining a circular opening in which a flange portion 18A of the cylinder 18 is received within the inner face of the head portion 12A and the outer wall of the flange portion 18A being sealed by an O-ring 44. An upper opening in the head portion 12A is closed by a closure cap 46 removably secured to the housing 12. A centrally disposed opening 48 in the upper surface of the piston 26 carries a resilient or elastic bumper 50 which engages the lower wall of the closure cap 46 to provide a resilient stop for arresting return movement of the piston 26 in its normal position. Another cylindrical or annular resilient or elastic bumper 52 is disposed in the lower end of the cavity 16 adjacent the lower end of the cylinder 18 to provide a means for arresting downward movement of the piston 26 at the end of its power stroke. The lower end of the interior of the cylinder 18 is placed in communication with the air return space 36 through two axially spaced sets of ports 54 and 56. The piston 26 carries a pair of axially spaced, expansible, and compressible sealing means or O-rings 58 and 60 which individually or conjointly not only seal the interface between the cylinder 18 and the piston 26, but also form part of the pneumatic holding means 34 and control the admission of pressurized fluid or compressed air to the air return space or reservoir 36. The O-ring 60 is mounted in a peripherally extending groove on the piston 26, and the O-ring 58 is mounted in a peripherally extending groove in which one or a plurality of slots or recessed portions 62 are provided. The O-ring 58 cooperates with the groove in which it is disposed and the slots 62 in the manner described in detail in U.S. Pat. No. 3,040,709 to provide a one-way check valve which permits pressurized fluid to flow from above the O-ring 58 to the area disposed between the O-rings 58 and 60 and to prevent the flow of pressurized fluid from this space to the area above the O-ring 58. As indicated above, the control valve assembly 22 controls the reciprocation of the piston 26 within the cylinder 18 by selectively connecting the upper end of this cylinder or the passageway 20 to either the pressurized fluid reservoir 14 or the passageway 24 extending to the atmosphere. The construction of the valve 22 is illustrated and described in detail in U.S. Pat. No. 3,173,340. In general, the valve assembly 22 includes a pilot valve assembly indicated generally as 66 which is actuated by manual operation of a trigger 68 to control movement of a main valve assembly 70 between normal and actuated positions, the valve assembly 22 being shown in a normal position in FIG. 1. The valve assembly 70 includes a resilient sealing element or O-ring 72 which is selectively moved into and out of engagement with a valve seat 74 forming a tapered throat to selectively place the passageway 20 into and out of communication with the exhaust passageway 24. The valve assembly 70 also includes another resilient sealing or valve element 76 which is selectively moved into and out of engagement with structure defining a port 78 to place the passageway 20 in and out of communication with the pressurized fluid reservoir 14. When the tool 10 is to be operated, the trigger 68 is actuated to control the pilot valve assembly 66 so that the main valve assembly 70 moves downwardly from the position illustrated in FIG. 1 so that the resilient valve 72 seats on the valve seat 74, and the valve element 76 moves out of engagement to open the port 78. The valve element 72 closes communication between the passageway 20 and the exhaust passageway 24, and the opening of the port 78 supplies pressurized fluid from the reservoir 14 through the passageway 20 to the upper end of the cylinder 18. The compressed air supplied to the upper surface of the piston 26 at the open upper end of the cylinder 18 overcomes the holding force provided by the assembly 34 and drives the piston 26 downwardly through a power stroke from its illustrated normal position to the displaced position illustrated in dashed outline. During this movement, the O-rings 58 and 60 seal the interface between the cylinder 18 and the piston 26 so that the pressurized fluid supplied to the top of the cylinder 18 is effective to drive the piston 26 downwardly and actuate the blade 28 and to drive the drive track in the nosepiece structure 30 by the magazine assembly 32. During this downward movement, a portion of the air beneath the piston 26 is discharged to the atmosphere, and a portion of this air is supplied through the ports 54 and 56 to the air return space or reservoir 36. When the piston 26 reaches its displaced position, further downward movement of the piston is arrested by engagement with the bumper 52. At this time, compressed air within the cylinder 18 above the piston 26 acts on the upper O-ring 58 to move this O-ring somewhat downwardly within the groove within which it is mounted so that air passing through the interface between the cylinder 18 and the piston 26 and the O-ring 58 passes through the slots or recesses 62 and through the upper ports 56 to be accumulated within the return air space 36. A portion of this air is also disposed in an air receiving space defined by the area of the interface between the axially spaced O-rings 58 and 60. The piston 26 remains in its displaced position until the control valve assembly 22 is released. At this time, the release of the trigger 68 releases the pilot valve assembly 66 to return to its normal position so that the main valve assembly 70 returns to the normal position illustrated in FIG. 1. This closes the port 78 and moves the valve element 72 out of engagement with the valve seat 74 so that pressurized fluid or compressed air within the cylinder 18 above the piston 26 is discharged to the atmosphere through
the passageway 24. This produces a pressure differential across the O-ring 58 so that it moves to an upper position closing off communication through the slots or recesses 62 between the area sealed by the O-rings 58 and 60 and the portion of the cylinder 18 disposed above the O-ring 58. At this time, compressed air in the reservoir 36 enters the lower end of the cylinder 18 through the ports 54 and moves the piston 26 upwardly until such time as the bumper 50 engages the lower surface of the closure cap 46, in which position the piston 26 occupies its normal position. As the piston 26 moves into this normal position, the pneumatic holding means 34 are rendered effective.

More specifically and in order to provide the pneumatic holding means 34, the inner surface of the upper end of the cylinder 18 is provided with a greater diameter portion 18B, the diameter of which is greater than the uniform diameter of the remaining portion of the interior surfaces of the cylinder 18. The greater diameter portion 18B occupies an axial length no greater than the spacing between the O-rings 58 and 60. As the piston 26 was moved upwardly from its displaced position toward the normal position shown in Fig. 1, the lower O-ring 60 sealed off the port 56 so that pressurized fluid is trapped between the O-rings 58 and 60. This pressurized fluid is carried upwardly with the piston 26 as it moves to its normal position. When the piston 26 reaches its normal position, the O-ring 60 expands outwardly to maintain its sealing engagement with the inner surface of the cylinder 18 and thereby produces an arrangement of differential areas exposed to the pressurized fluid trapped between the O-rings 58 and 60. More specifically, as the upper O-ring 58 expands into the greater diameter portion 18B of the cylinder 18, the piston 26 is provided with a greater diameter upper portion which contains the compressed air trapped between the O-rings 58 and 60 acts on to provide an upwardly directed component of force urging the bumper 50 on the piston 26 against the stop surface provided by the lower wall of the closure cap 46. This force dependent on the compressed air trapped between the O-rings 58 and 60 provides a continuous upwardly directed bias positively holding the piston 26 in its normal position as the return air leaks to the atmosphere from the cylinder 18 below the piston.

The advantages of the pneumatic holding means 34 are many. In the first place, any blows applied to the tool 10 which tend to move the piston 26 downwardly thereby cause the compression of the volume of pressurized fluid in the area in which is in communication with a plurality of radially spaced and radially extending passageways 80 which open into the openings 48 in which the resilient bumper 74 is seated. The lower end of the bumper 74 is provided with a plurality of passageways 74A which place the passageways 80 in communication with the pressurized fluid supplied by the passageway 20 through an axially extending opening 74B in the bumper 74. A circular or annular resilient O-ring or valve element 82 is seated in the groove 78 and normally seals the outer ends of the radial passages 80.

Referring now more specifically to Fig. 2 of the drawings, therein is illustrated a pneumatic fastener driving tool which is indicated generally as 70 and which embodies the present invention. The tool 70 is, in most respects, identical to the tool 10 except for a modification in the construction of a piston 72 and a return bumper 74 carried thereon. This similarity or identity of parts is indicated by the use of identical reference numbers. The modifications provide a pneumatic holding means indicated generally as 76 for the piston 72 which is similar in operation and construction to the pneumatic holding means 34 provided for the tool 10.

More specifically, the piston 72 is of generally the same configuration as the piston 26 and is secured at its lower end to the upper end of the driver blade 28, the piston 72 being slidably mounted within the cylinder 18. However, the piston 72 is provided with two similar grooves or recesses for receiving the two O-rings 58 and 60 so that the O-ring 58 no longer provides the additional function of providing a check valve construction.

To provide the check valve for both supplying entrapped air for use in the pneumatic holding means 76 and for supplying pressurized fluid to the return air space 36 through the ports 56, the piston 72 is provided with a peripherally extending recessed area 78, the inner portion of which is in communication with a plurality of radially spaced and radially extending passageways 80 which open into the opening 48 in which the resilient bumper 74 is seated. The lower end of the bumper 74 is provided with a plurality of passageways 74A which place the passageways 80 in communication with the pressurized fluid supplied by the passageway 20 through an axially extending opening 74B in the bumper 74. A circular or annular resilient O-ring or valve element 82 is seated in the groove 78 and normally seals the outer ends of the radial passages 80.

Accordingly, when the control valve assembly 22 is actuated to supply compressed air to the passageway 20, the pneumatic holding force provided by the assembly 76 is overcome, and the piston 72 is driven downwardly to its displaced position determined by engagement of the lower surface of the piston 72 with the resilient bumper 52. At this time, compressed air passes through the passageways or openings 74B, 74A and 80 to unseat the circular valve element 82. Thus, pressurized fluid is supplied through the port 56 to the return air space 36 and the area in which is in communication with the O-rings 58 and 60 defined thereby. When the passageway 20 is connected to the atmosphere, pressurized fluid in the reservoir return space 36 is supplied to the lower end of the cylinder 18 beneath the piston 72 through the ports 54, and the piston 72 is returned to the normal position illustrated in Fig. 2. Further, when the upper end of the cylinder 18 is connected to the atmosphere, the O-ring 82 seals the radial passageways 80 so that when the O-ring 60 passes the ports 56, a body of pressurized fluid is trapped between the O-rings 58 and 60.

When the piston 72 reaches its upper or normal position defined by engagement of the bumper 74 with the closure cap 46, the O-ring 58 expands out to sealingly engage with the greater diameter portion 18B of the cylinder, and the pressurized fluid trapped between the O-rings 58 and 60 expands in the area of volume therebetween and acts on the effective greater diameter upper portion of the piston 72 afforded by the expanded O-ring 58. This provides a continuous upwardly directed bias holding the bumper 74 against the closure cap 46 to pneumatically bias and retain the piston 72 in its normal position. As with the pneumatic holding means 34, the means 76 does not offer any resistance to downward movement of the piston 72 after the O-ring 58 clears the greater diameter portion 18B of the cylinder 18 and requires no additional parts while affording a positive holding force for retaining the piston 72 in its normal position.

Fig. 3 of the drawings illustrates a tool indicated generally as 90 which embodies the present invention and which is identical to the tool 10 except for the construction of a
cylinder 92. The identity of the parts is designated by the use of identical reference numbers for corresponding parts. The modified cylinder 92 cooperates with the piston 26 to provide a holding means indicated generally as 94 which is identical in function and operation to the holding means 34.

More specifically, the cylinder 92 is identical to the cylinder 18 except that the upper end of the cylinder 18 is provided with an outwardly flared or tapered upper end portion 92B. The tapered wall section 92B is engaged by the piston 26 in the normal position shown in FIG. 3, and thus affords different diameter portions on the piston 26 and the cylinder 92 which result in a net upwardly directed pneumatic bias acting on the piston 26 to retain it in its normal position. The advantage of the tapered wall 92B in place of the stepped wall of the cylinder 18 where the greater diameter portion 18B is formed arises from the fact that there may be somewhat less wear on the upper O-ring 58 with the tapered wall 92B. This is true because as the piston 26 moves downwardly, the O-ring 58 is compressed by a gradual camming rather than an abrupt camming action, as with the cylinder 18. The tapered wall can also be used at the upper end of the cylinder 18 in the tool 70 illustrated in FIG. 2.

FIG. 4 of the drawings illustrates a pneumatic fastener driving system generally as 100 and which embodies the present invention. The tool 100 is similar in operation to the tools 10, 70, and 90 insofar as a piston 102 is reciprocated within a cylinder 104 between normal and displaced positions to actuate a drive blade 106 connected to the piston 102 so as to drive a fastener supplied to a drive track in a nosepiece structure 108 from a magazine 110. The tool 100 differs, however, from the tools 10, 70, and 90 in the respect that pressurized fluid or compressed air from a reservoir 112 formed in a hollow handle portion 114A of a housing 114 is continuously present in an area surrounding the upper end of the cylinder 104, as contrasted with the tools described above in which pressurized fluid is supplied to a position in proximity to the upper input of the cylinder through a valve and reservoir located somewhat remote from the cylinder 104. This modification in the driving system or the control for the driving system for the piston 102 in the tool 100 makes possible the provision of another modified form of the pneumatic piston holding means which is indicated generally as 116.

The drive system for and the construction of the tool 100 is illustrated and described in detail in the preceding application of Richard H. Doyle, Ser. No. 602,728, filed Dec. 19, 1966. Only slight modifications have been made in the piston 102 and the cylinder 104 to make possible the provision of the improved pneumatic holding means 116 in the tool 100.

As set forth in detail in the above-identified and copending Doyle application, compressed air from the reservoir 112 in the normal condition of the tool 100 passes by a ball valve 117 and over a series of passageways 118 to be applied to the greater area upper surface of a combined main valve-exhaust valve assembly indicated generally as 120, the compressed air supplied by the passageway system 118 being disposed in a chamber 122. This pneumatically biases a resilient diaphragm 124 in the assembly 120 against the open upper end of the cylinder 104 so as to seal off communication between the compressed air surrounding the open upper end of the cylinder 104 and the interior thereof.

When the tool 100 is to be operated, a trigger 126 is depressed so that an actuating element 128 secured to the ball valve 117 moves upwardly to move this ball valve upwardly. This disconnects the passageway system 118 from the reservoir 112 and connects it to the atmosphere through an opening which is normally sealed by engagement of the ball valve 117 with an O-ring 130. This disconnects the air from the chamber 122 to the atmosphere and permits the pressurized fluid acting on the lower surface of the diaphragm 124 to move the main valve assembly 120 upwardly. In moving upwardly, the upper surface of an exhaust valve stem 132 moves into seating engagement with a resilient exhaust valve element 134 to close off communication through an axial passage 136 in the stem 132 between the upper interior of the cylinder 104 and the atmosphere. The upward movement of the valve assembly 120 and of the diaphragm 124 admits pressurized fluid from the reservoir 112 to the top of the interior of the cylinder 104 so that the piston 102 moves downwardly through a power stroke which is terminated by engagement of the piston 102 with a resilient bumper 138. The interface between the piston 102 and the cylinder 104 is sealed by two axially spaced resilient or O-rings 140 and 142.

When the piston 102 reaches its displaced or lower position, compressed air from within the cylinder 104 above the piston 102 passes through the passageway 144 in the piston to unseat a resilient valve element or O-ring 146 so that this compressed air passes through a plurality of peripherally spaced ports 148 in the lower end of the cylinder 104 to be collected together and disposed of in passageway 142.

When the trigger 126 is released, pressurized fluid in the reservoir 112 biases the ball valve 117 downwardly into engagement with the O-ring 130 to close off the connection between the passageway system 118 and the atmosphere. At the same time, compressed air from the reservoir 112 enters the passageway 118 and flows into the chamber 122. The pressurized fluid in the chamber 122 when combined with the downwardly directed force of a compression spring 152 moves the valve assembly 120 downwardly so that the diaphragm 124 seats on the upper end of the cylinder 104 to close off communication between the pressurized fluid and the interior of the upper end of the cylinder 104. At the same time, the upper end of the valve stem 132 moves downwardly out of engagement with the exhaust valve element 134 so that the interior of the cylinder 104 above the piston 102 is connected to the atmosphere through the passageway 136. At this time, the valve element 146 seals the radial passageways 144, and the compressed air in the air return space 140 enters the lower end of the interior of the cylinder 104 through the ports or passageways 148. This compressed air moves the piston 102 upwardly to its normal position illustrated in FIG. 4. This position is determined by engagement of the upper surface of the piston 102 with the lower surface of the diaphragm 124 in the main valve assembly 120.

The pneumatic holding means 116 retains the piston 102 in this normal position until the next cycle of operation of the tool 100. It is necessary to provide this pneumatic holding means because the compressed air supplied from the reservoir 150 becomes dissipated by leakage to the atmosphere between operations of the tool, such leaking occurring, for instance, along the drive blade 106 and at other places. The pneumatic holding means 116 includes a greater diameter portion 104A formed in the upper end of the cylinder 104 in only the part thereof occupied by the piston 102 in its normal position, the remaining interior surface of the cylinder 104 being of substantially uniform diameter somewhat less in value than the greater diameter portion 104A. The greater diameter portion 104A is so located that as the piston engages the stop provided by the diaphragm 124, the lower O-ring 142 remains in sealing engagement with the uniform lesser diameter portion of the interior surface of the cylinder 104, and the upper O-ring 140 expands into sealing engagement with the greater diameter portion thereby defining a dual diameter piston and cylinder relationship. The upper end of the cylinder 104 is provided with a port or passage 154 extending between the pressurized fluid in the reservoir 112 and the portion of the interior of the cylinder 104 disposed between the O-rings 140 and 142. Accordingly, when the piston 102 reaches the normal position illustrated in FIG. 4, the pressurized fluid is supplied between the O-rings 140 and 142 and acts on the effective differential diameters of the piston 102 to provide a continuous upwardly directed pneumatic bias holding the upper surface of the piston 102 against the stop afforded by the diaphragm 124.
Thus, the pneumatic piston retaining or holding means 116 included in the tool 100 also provides means for pneumatically retaining in its normal position the piston 102 while permitting this piston 102 to be driven downwardly free of the effects of the bias. In the holding means 116, the pressurized fluid acting on the differential diameters of the piston 102 is supplied directly from the reservoir 112 in the normal position of the piston 102, and no means are required on the piston 102 for entrapping this fluid, as in the constructions illustrated in FIGS. 1, 2, and 3. If desired, the greater diameter portion 104A of the cylinder 104 can be formed with a tapered surface comparable to the tapered surface 923 provided on the upper end of the cylinder 92 in the tool 90 illustrated in FIG. 3 of the drawings.

FIG. 5 of the drawings illustrates a tool 160 which in its general construction is identical to the tool 100 in including a pneumatic holding means 116. To illustrate the identity of parts, identical reference numbers have been applied to the same parts in FIGS. 4 and 5.

The tool 160 differs from the tool 100 in the manner of supplying pressurized fluid to the air return space 150. More specifically, the radial passageways 144 and the O-ring 146 have been removed from the piston 102 in the tool 160, and the cylinder 104 has been provided with a plurality of spaced ports 162 adjacent its lower end, which ports 162 are normally closed by a resilient element or O-ring 164.

When the piston 102 is driven to its displaced position engaging the bumper 138, the upper end of the piston 102 clears the ports 162, and the pressurized fluid in the upper end of the cylinder 104 displaces the O-ring 164 to permit the pressurized fluid to be accumulated within the chamber 150. This fluid returns the piston 102 to its normal condition when the upper end of the cylinder 104 is connected to the atmosphere in the manner described above. This connection of the upper end of the interior of the cylinder 102 to the atmosphere permits the O-ring 164 to seat and again close the ports 162. When the piston 102 is returned to its normal position, pressurized fluid supplied from the reservoir 112 through the ports 154 to the area bounded by the O-rings 140 and 142 again affects the resilient bias of the piston 102 to its normal position determined by engagement with the lower surface of the diaphragm 124.

FIG. 6 of the drawings illustrates a pneumatic holding means indicated generally as 170 which embodies the present invention and which is useful, for instance, in a tool such as that illustrated in FIG. 5. The pneumatic holding means 170 includes a cylinder 172 having a greater diameter portion 172A at its upper end in the area normally occupied by a piston 174 when this piston is in its illustrated normal position. The piston 174 is coupled, for example, to a driver blade (not shown).

The holding means 170 includes a pair of resilient and expandable sealing means or O-rings 176 and 178. The O-ring 176 is carried in a recess or groove adjacent the top of the piston 174 and is adapted to seal the interface between the piston 174 and the cylinder 172 as the piston 174 moves through its drive or power and return strokes. The sealing means or O-ring 178, however, is disposed within a recess or groove 172B on the inner surface of the cylinder 172 and seals the interface between the piston 174 and the cylinder 172 only when the piston 174 is in its normal position illustrated in FIG. 6. Thus, during the power stroke the interface between the cylinder 172 and the piston 174 is sealed only by the sealing means 176.

When the piston 174 is returned to its normal position illustrated in FIG. 6, the upper O-ring 176 expands outwardly in a radial direction to engage the wall surface of the greater diameter portion 172A of the cylinder 172 and to provide an upper seal. At the same time, the lower portion of the piston 174 moves into a sealing engagement with the O-ring 178 carried on the cylinder 172 to define a lower seal. Compressed air supplied through a port or opening 180 enters the area bounded by the two sealing means 176 and 178 and provides an upwardly directed pneumatic bias acting on the greater diameter effective structure of the piston 174 to bias this piston upwardly against a suitable stop structure (not shown). Thus, the piston 174 is pneumatically retained in its normal position by the assembly 170 with only a single sealing means 176 carried on the piston 174.

FIG. 7 illustrates a pneumatic holding means which is indicated generally as 190. The assembly or holding means 190 includes a cylinder 192 in which is slidably mounted a piston 194. The piston 194 carries a pair of expandable or resilient sealing means or O-rings 196 and 198. The upper end of the cylinder 192 is provided with an undercut portion 192A against which the upper sealing means 196 seals when the piston 194 is in its normal position.

The holding means 190 can be used, for example, in a tool such as the tool 10 by providing structure so that the upper sealing means 190 operates as a one-way check valve, such as the O-ring 58, in addition to its normal sealing function. In this application, the area between the O-rings 196 and 198 is supplied with pressurized fluid under the control of the check valve action afforded by the O-ring 196. Thus, when the piston 194 is returned to its normal position illustrated in FIG. 7, the sealing engagement of the O-ring 196 with the greater diameter portion of the cylinder 192 provided by the undercut portion 192A results in an upwardly directed pneumatic biasing force which holds the piston 194 against a stop (not shown) in its normal position.

On the other hand, if the holding means 190 is to be used in a tool such as that illustrated in FIG. 5, the O-rings 196 and 198 provide seals for the interface between the piston 194 and the cylinder 192 and do not provide the function of supplying pressurized fluid for either the pneumatic holding means or the piston return system. In this application, a port or passage 200 communicating with pressurized fluid is provided in the cylinder 192 communicating with the undercut portion 192A. The passage 200 supplies pressurized fluid which acts on the effective greater diameter upper structure on the piston 194 to bias the piston to its normal position.

The pneumatic holding means can also be constructed using a cylinder of a given diameter which is uniform along its length except for a portion of lesser diameter in the area engaged by the lower O-ring or sealing means when the piston is in its normal position to provide the differential piston and cylinder diameters.

FIG. 8 of the drawings illustrates a further embodiment 210 of the pneumatic holding means which is useful, for example, in the tool 10. The construction of a tool incorporating the holding means 210 is the same as that of the tool 10 except for the arrangement of the piston sealing means. Accordingly, like reference numbers are used in FIGS. 1 and 8 to designate identical parts.

It has been determined in operating the tool 10 that, on occasion, insufficient compressed air or pressurized fluid is trapped between the sealing means 58 and 60 to effect as positive a holding force as would be desired. It has been further determined that the fluid available for holding can be increased by using the lower O-ring 60 as a one-way check valve. Accordingly, the piston 26 is provided with slots or recesses 62A in the groove for the O-ring 60 so that this O-ring provides a check valve similar to the O-ring 58. The check valve provided by the O-ring 60 will not pass fluid from above this O-ring to below this O-ring but will pass air from below this O-ring to above this O-ring.

In operating the tool 10 with the holding means 210, the pressurized fluid admitted to the cylinder 18 drives the piston 26 downwardly and supplies compressed air to the reservoir 36 through the opening 56 in the manner described above. The air passing the check valve afforded by the O-ring 58 does not pass the O-ring 60 because this O-ring closes the slots 62A during the power stroke.

During the return stroke, the O-ring 58 seals the slot 62 when the top of the cylinder 18 is vented to the atmosphere. Pressurized fluid from the reservoir 36 enters the lower end of
the cylinder 18 through the opening 54 to move the piston 26 upwardly. Part of the air also passes back to the area between the O-rings 58 and 60 through the opening 56, which area is sealed when the O-ring 60 passes beyond the opening 56. If insufficient air is trapped between the O-rings 58 and 60, the air in the cylinder 18 below the O-ring 60 unseats the O-ring to momentarily open the slots 62A so that compressed air from below the O-ring 60 passes into and is trapped in the fluid receiving space between the O-rings 58 and 60. The O-rings 60 closes the slots 62A when the pressure below this O-ring drops as by leakage to the atmosphere. This supplemental holding air assures positive retention of the piston 26 in its normal position.

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

1. In a fastener driving tool of the type using an impulse of pressurized fluid for returning a piston from a displaced position to a normal position in which the piston is to be retained, said piston having a single effective diameter during its movement between said displaced and normal positions, said single effective diameter being located at an upper portion of said piston,

a cylinder in which the piston is slidably mounted, said cylinder having a first end portion occupied by the piston in its normal position and a second end portion occupied by the piston in its displaced position, said cylinder having at its type using an impulse of a pressurized fluid for returning a piston from a displaced position to a normal position in which the piston is to be releasably retained, said piston having a single effective diameter during its movement between said displaced and normal positions, said single effective diameter being located at an upper portion of said piston,

a cylinder in which the piston is slidably mounted, said cylinder having a first end portion occupied by the piston in its normal position and a second end portion occupied by the piston in its displaced position, said cylinder having at its first end portion spaced from an intermediate portion of the cylinder through which the piston moves in moving to the displaced position an inner wall surface with greater and lesser diameter portions, the remaining inner surface of the cylinder in said intermediate portion being of a substantially uniform diameter generally corresponding to said single diameter, said cylinder having port means at said second end portion,

a pair of spaced sealing means on the piston slidably engaging the inner wall surface of the cylinder and defining a fluid-receiving space therebetween, at least one of the sealing means being expansible and compressible, an air return space communicating with the interior of the cylinder at the second end portion through the port means,

first stop means for arresting return movement of the piston in said displaced position with the piston adjacent the port means,

return means for providing pressurized fluid to said air return space which passes through said port means to provide said impulse of pressurized fluid to return the piston to its first end portion and spaced from an intermediate portion of the cylinder through which the piston moves in moving to the displaced position an inner wall surface with greater and lesser diameter portions, the remaining inner surface of the cylinder in said intermediate portion being of a substantially uniform diameter generally corresponding to said single diameter,

a pair of spaced sealing means on the piston slidably engaging the inner wall surface of the cylinder and defining a fluid-receiving space therebetween, at least one of the sealing means being expansible and compressible, piston return means for supplying an impulse of pressurized fluid for returning the piston from the displaced position to the normal position,

stop means on the tool for arresting return movement of the piston in the normal position with the pair of spaced sealing means engaging the different diameter portions of the inner wall surface of the cylinder, and air-supplying means for supplying pressurized fluid to said space between the pair of sealing means which is effective by virtue of the different diameter portions of the inner wall surface of the cylinder and the corresponding different effective diameters of the sealing means to provide a fluid bias urging the piston toward the stop means which releasably retains the piston at the first end of the cylinder in its normal position.

2. The fastener driving tool set forth in claim 1 in which the cylinder has a step formed in the inner wall surface to provide the greater and lesser diameter portions.

3. The fastener driving tool set forth in claim 1 in which the cylinder has a tapered inner wall surface providing the greater and lesser diameter portions.

4. The fastener driving tool set forth in claim 1 in which the air-supplying means includes valve means carried on the piston.

5. The fastener driving tool set forth in claim 4 in which the valve means includes the sealing means disposed adjacent the greater diameter portion of the inner wall surface of the cylinder when the piston is in its normal position.

6. The fastener driving tool set forth in claim 1 in which the air-supplying means includes a fluid pressure supplying passage passing through the cylinder and opening into the cylinder at said first end portion.

7. The fastener driving tool set forth in claim 1 in which the air-supplying means includes a unidirectional valve communicating with said space at one end and the interior of the cylinder above the piston at the other end.

8. In a fastener driving tool of the normal position, second stop means on the tool for arresting return movement of the piston in the normal position with the pair of spaced sealing means engaging the different diameter portions of the inner wall surface of the cylinder, and air-supplying means for supplying pressurized fluid to said space between the pair of sealing means which is effective by virtue of the different diameter portions of the inner wall surface of the cylinder and the corresponding different effective diameters of the sealing means to provide a fluid bias urging the piston toward the stop means which releasably retains the piston at the first end of the cylinder in its normal position, the pressurized fluid from said air return space being exhausted to the atmosphere when the piston is returned to its normal position.

9. The fastener driving tool set forth in claim 8 in which the return means includes means controlled by the piston for supplying air to the air return space when the piston is in its displaced position.

10. The fastener driving tool set forth in claim 8 in which the return means includes a valve carried on the piston for supplying pressurized fluid to the air return space.

11. The fastener driving tool set forth in claim 8 in which a valve carried on the piston forms a part of both the return means and the air-supplying means for supplying pressurized fluid to both the air return space and the fluid receiving space.

12. A fastener driving tool as set forth in claim 8 in which the air-supplying means includes a passage through the first end portion of the cylinder communicating with the fluid receiving space.

13. A fastener driving tool as set forth in claim 8 in which a fluid pressure reservoir continually supplied with pressurized fluid is disposed adjacent the first end portion of the cylinder, and the fluid-supplying means includes a passage through the first end portion of the cylinder between the reservoir and the fluid receiving space.
14. In a fastener driving tool of the type in which a piston is reciprocated between a normal position in which the piston is to be releasably retained and a displaced position, said piston having a single effective diameter during its movement between said normal and displaced positions, a cylinder in which the piston is slidably mounted, said cylinder having a first end portion occupied by the piston in its normal position and a second end portion occupied by the piston in its displaced position, said cylinder having only at its first end portion and spaced from an intermediate portion of the cylinder through which the piston moves in moving to the displaced position a pair of its inner wall surface with greater and lesser diameter portions, stop means on the tool for arresting return movement of the piston in the normal position, a pair of spaced sealing means sealing the piston-cylinder interface when the piston is in said normal position and defining a fluid-receiving space therebetween, the pair of sealing means being so spaced as to provide seals at the different diameter portions of the inner wall surface of the cylinder, at least one of the sealing means being carried on the piston and being expandable to different diameters to slidably engage the inner wall of the cylinder during the reciprocating movement of the piston, and air-supplying means for supplying pressurized fluid to the space between the pair of sealing means which is effective by virtue of the effective diameters of the piston to provide a fluid bias urging the piston toward the stop means which releasably retains the piston at the first end portion of the cylinder in its normal position.

15. The fastener driving tool set forth in claim 14 in which the other sealing means is carried on the cylinder at its first end portion to engage the piston only when the piston is in its normal position.

16. The fastener driving tool set forth in claim 14 in which the cylinder has a substantially uniform diameter equal to said lesser diameter, and the greater diameter portion at said first end portion of the cylinder is formed by an undercut portion spaced slightly below the end of the cylinder.

17. The fastener driving tool set forth in claim 14 in which the air-supplying means includes a passage extending through the wall of the cylinder and supplied with pressurized fluid.

18. In a fastener driving tool of the type in which a piston is reciprocated between a normal position in which the piston is to be releasably retained and a displaced position, said piston having a single effective diameter during its movement between said normal and displaced positions, a cylinder in which the piston is slidably mounted, said cylinder having a first end portion occupied by the piston in its normal position and a second end portion occupied by the piston in its displaced position, said cylinder having at its first end portion and spaced from an intermediate portion of the cylinder through which the piston moves in moving to the displaced position a part of its inner wall surface with greater and lesser diameter portions, stop means on the tool for arresting return movement of the piston in the normal position, a pair of spaced sealing means sealing the piston-cylinder interface when the piston is in said normal position and defining a fluid-receiving space therebetween, the pair of sealing means being so spaced as to provide seals at the different diameter portions of the inner wall surface of the cylinder, at least one of the sealing means being carried on the piston and being movable between a first diameter only when the piston is in said normal position and a second different and constant diameter to slidably engage the inner wall of the cylinder during the reciprocating movement of the piston through said intermediate portion of the cylinder, first means for supplying pressurized return fluid below the piston to move the piston from its displaced position to its normal position, and second means for supplying a part of said pressurized return fluid to the space between the pair of sealing means which is effective by virtue of the different effective diameters of the piston to provide a fluid bias urging the piston toward the stop means which releasably retains the piston at the first end portion of the cylinder in its normal position.

19. The fastener driving tool set forth in claim 18 in which both of the sealing means are carried on the piston, and the sealing means that engages the lesser diameter portion of the cylinder provides a check valve forming a part of said first means for supplying pressurized return fluid to said fluid-receiving space.

20. The fastener driving tool set forth in claim 19 in which the sealing means engaging the greater diameter portion of the cylinder provides a check valve forming a part of said first means for supplying pressurized return fluid below the piston.

* * * * *
In place of Column 11, lines 16-72 and Column 12, lines 1-12, insert the following claim:

--1. In a fastener driving tool of the type using an impulse of pressurized fluid for returning a piston from a displaced position to a normal position in which the piston is to be retained, said piston having a single effective diameter during its movement between said displaced and normal positions, said single effective diameter being located at an upper portion of said piston,
a cylinder in which the piston is slidably mounted, said cylinder having a first end portion occupied by the piston in its normal position and a second end portion occupied by the piston in its displaced position, said cylinder having at its first end portion and spaced from an intermediate portion of the cylinder through which the piston moves in moving to the displaced position an inner wall surface with greater and lesser diameter portions, the remaining inner surface of the cylinder in said intermediate portion being of a substantially uniform diameter generally corresponding to said single diameter,
a pair of spaced sealing means on the piston slidably engaging the inner wall surface of the cylinder and defining a fluid receiving space therebetween, at least one of the sealing means being expansible and compressible, piston return means for supplying an impulse of pressurized fluid for returning the piston from the displaced position to the normal position,
stop means on the tool for arresting return movement of the piston in the normal position with the pair of
It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

spaced sealing means engaging the different diameter portions of the inner wall surface of the cylinder, and air supplying means for supplying pressurized fluid to said space between the pair of sealing means which is effective by virtue of the different diameter portions of the inner wall surface of the cylinder and the corresponding different effective diameters of the sealing means to provide a fluid bias urging the piston toward the stop means which releasably retains the piston at the first end of the cylinder in its normal position.

In place of Column 12, lines 35-49, insert the following claim:

8. In a fastener driving tool of the type using an impulse of a pressurized fluid for returning a piston from a displaced position to a normal position in which the piston is to be releasably retained, said piston having a single effective diameter during its movement between said displaced and normal positions, said single effective diameter being located at an upper portion of said piston, a cylinder in which the piston is slidably mounted, said cylinder having a first end portion occupied by the piston in its normal position and a second end portion occupied by the piston in its displaced position, said cylinder having at its first end portion and spaced from an intermediate portion of the cylinder through which the piston moves in moving to the displaced position an inner wall surface with greater and lesser diameter portions, the remaining inner surface of the cylinder in said intermediate
It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

A portion being of a substantially uniform diameter generally corresponding to said single diameter, said cylinder having port means at said second end portion,

a pair of spaced sealing means on the piston slidably engaging the inner wall surface of the cylinder and defining a fluid receiving space therebetween, at least one of the sealing means being expandable and compressible,

an air return space communicating with the interior of the cylinder at the second end portion through the port means,

first stop means for arresting movement of the piston in said displaced position with the piston adjacent the port means,

return means for providing pressurized fluid to said air return space which passes through said port means to provide said impulse of pressurized fluid to return the piston to its normal position,

second stop means on the tool for arresting return movement of the piston in the normal position with the pair of spaced sealing means engaging the different diameter portions of the inner wall surface of the cylinder,

and air supplying means for supplying pressurized fluid to said space between the pair of sealing means which is effective by virtue of the different diameter portions of the inner wall surface of the cylinder and the corresponding different effective diameters of the sealing means to provide a fluid bias urging the piston toward the stop means which releasably retains the piston at the first end of the cylinder in its normal position, the pressurized fluid from said air return space being exhausted to the atmosphere when the piston is returned to its normal position.--

Signed and sealed this 11th day of July 1972.

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCALK
Commissioner of Patents