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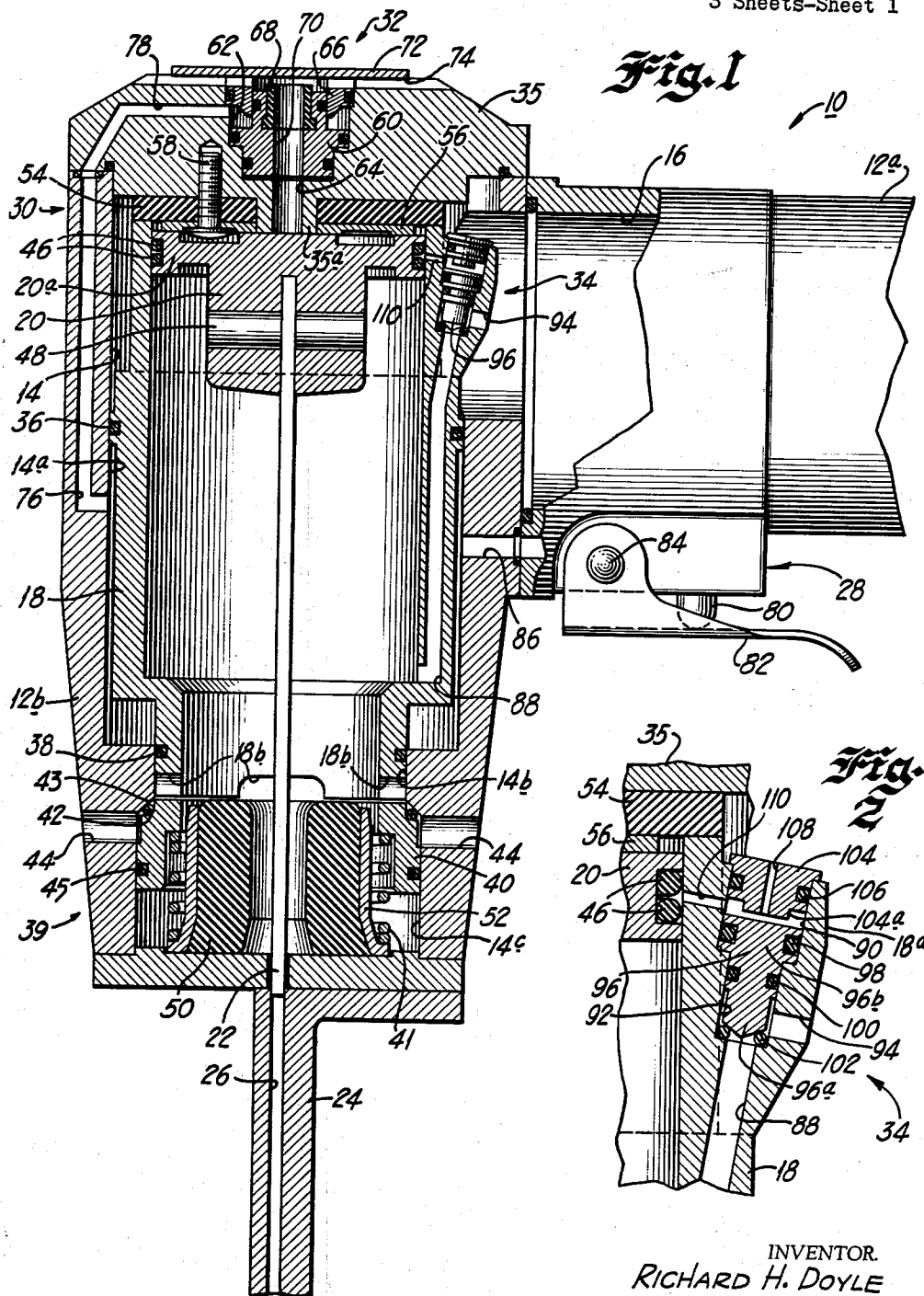
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3,190,187

FASTENER DRIVING APPARATUS

Filed Dec. 21, 1962

3 Sheets-Sheet 1



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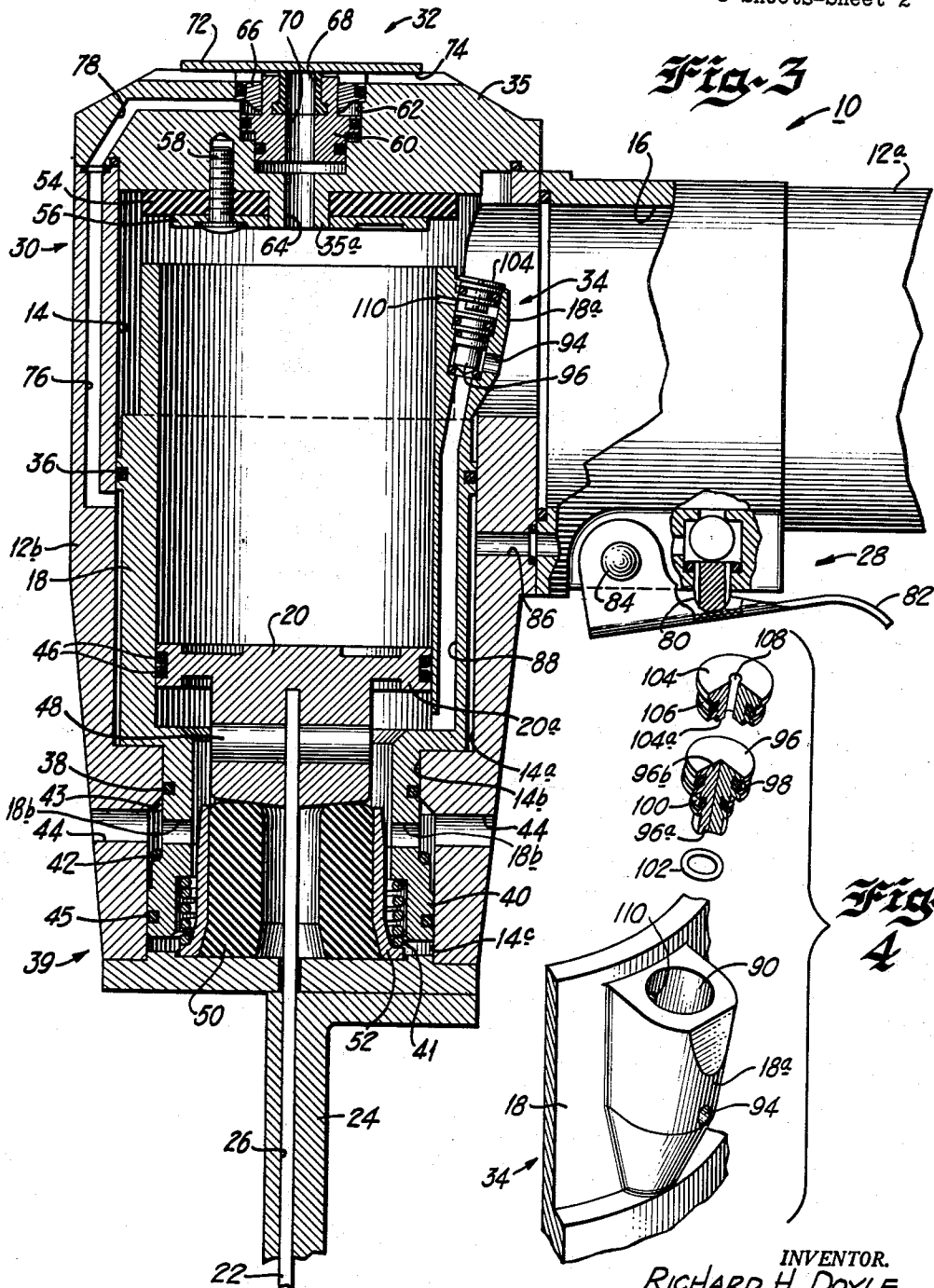
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3 Sheets-Sheet 2



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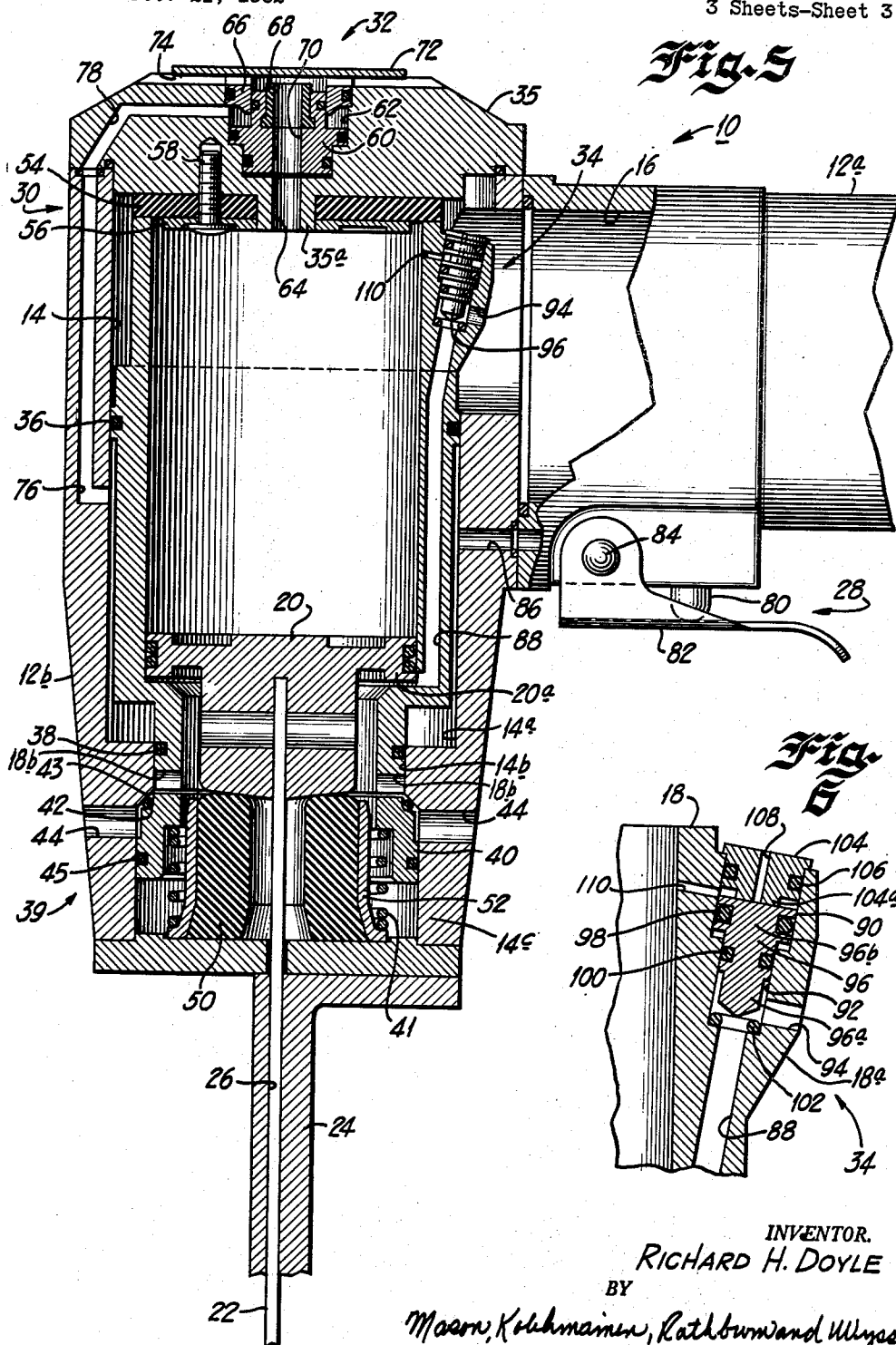
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FASTENER DRIVING APPARATUS

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3 Sheets-Sheet 3



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3,190,187

FASTENER DRIVING APPARATUS

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18 Claims. (Cl. 91-403)

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

The use of a compression spring to return the piston in a pneumatic fastener driving tool to its normal at the end of a power stroke has largely been supplanted by pneumatic piston return means. These piston pneumatic return systems, which can avoid the failures of prior tools due to the fatigue of the return spring and also permit a reduction in the height or size of the tool, commonly use such techniques as continuously supply the pressure fluid to a differential piston or selectively applying compressed air below the piston following the termination of the power stroke. Some of these types of return systems suffer from the disadvantage that they reduce the drive power of the tool, and others of the system consume an excessive amount of the pressurized fluid or require somewhat complicated valve arrangements for controlling the flow of the piston return fluid.

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

Another object is to provide a fastener driving apparatus including new and improved means for pneumatically returning a piston.

Another object is to provide a pneumatic piston return system including means for selectively supplying a pressurized fluid that returns a piston in dependence on the pressure within the cylinder.

Another object is to provide a pneumatic return system in which a valve is pneumatically operated in dependence on the position of the drive piston to control the flow of a pressurized fluid to the cylinder.

Another object is to provide a fastener driving tool of the type including a movable cylinder in which a fluid operated valve carried on the cylinder controls the application of a pressurized fluid to the cylinder for returning the piston.

A further object is to provide a fastener driving tool in which the connection of the interior of one end of the cylinder to the atmosphere at the end of a drive stroke of a piston controls a piston return means to supply pressurized fluid to another portion of the cylinder to return the piston.

A further object is to provide a fastener driving tool including new and improved means for selectively discharging fluid from the interior of the cylinder.

Another object is to provide a fastener driving tool including both a cylinder movable into and out of engagement with a fixed position main valve means and a piston actuated valve for selectively connecting the interior of the cylinder to the atmosphere.

In accordance with these and many other objects, an embodiment of the invention comprises a fastener driving tool having a housing defining a reservoir continuously supplied with compressed air in which is slidably mounted a cylinder. A main valve means carried on the housing immediately above an open end of the cylinder is selectively engaged by moving the cylinder relative to the housing to control the admission of fluid from the reservoir into the interior of the cylinder to drive a fastener driving means including a piston slidably mounted within the cylinder. The upper end of the interior of the cyl-

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inder is selectively placed in communication with the atmosphere through an exhaust system including a passageway formed in the housing, a part of which is an axial passage formed in a piston slidably mounted on the housing. In the normal condition of the tool, compressed air is supplied to the lower surface of the cylinder to hold it in engagement with the main valve means, and the compressed air is also applied to the piston structure forming a part of the exhaust valve system to displace this valve to a condition in which the interior of the upper end of the cylinder is connected to the atmosphere.

When the tool is to be operated, the lower surface of the cylinder and the piston means in the exhaust valve assembly are connected to the atmosphere so that the cylinder moves downwardly away from the main valve to supply compressed air to the cylinder to drive the piston downwardly in a power stroke. The compressed air, when admitted to the cylinder, also acts on the piston structure in the exhaust valve to move this piston against a transversely extending valve surface to close off the exhaust for the cylinder. When the control valve assembly is released to readmit compressed air to the lower surface of the cylinder and to the piston means in the exhaust valve assembly, the cylinder is shifted upwardly to engage the main valve and the piston is shifted out of engagement with the valve surface in the exhaust valve assembly to place the upper end of the interior of the cylinder at atmospheric pressure.

To provide means for pneumatically returning the piston to its normal condition, the cylinder structure is provided with a passageway connecting the lower end of the cylinder below the piston means with the fluid provided in the reservoir. Communication through this passageway is controlled by a pneumatically actuated piston return valve including a piston slidably mounted in a chamber formed on the cylinder structure. This chamber is continuously supplied with compressed air from the reservoir through a bleeder port, and this chamber is also placed in communication with the upper end of the interior of the cylinder through a passageway terminating in a port on the inner wall of the cylinder adjacent its upper end. When the cylinder is in its normal position, the compressed air supplied by the bleeder port acts on the pneumatically actuated control valve to close off communication between the reservoir and the lower end of the cylinder. Similarly, when the cylinder is moved downwardly out of engagement with the main valve, the compressed air admitted to the upper end of the cylinder supplements the fluid pressure provided through the bleeder port to maintain the piston return control valve in a closed condition.

When the cylinder has been returned to a position engaging the main valve and the exhaust valve assembly has been opened to connect the interior of the cylinder to the atmosphere, the piston means remains adjacent the lower end of the cylinder in the position occupied at the end of the power stroke. However, the chamber in the control valve assembly is connected directly to the atmosphere through the exhaust valve assembly, and the compressed air in the fluid reservoir acts on the piston return control valve to shift this valve to its open condition. This opens the passageway in the cylinder so compressed air from the reservoir is supplied below the piston to pneumatically return it to a position adjacent the upper end of the cylinder. At this time, one or a pair of resilient O-rings carried on the piston seal the port or passageway extending to the chamber in the piston return control valve so that the fluid supplied through the bleeder port builds up in the chamber and is effective to close the piston return control valve. This terminates the application of compressed air from the reservoir to the portion of the cylinder disposed below the piston means. The light

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frictional engagement of the inner walls of the cylinder by the sealing O-ring generally will prevent the piston from dropping from its normal position. However, if the piston does drop, the chamber in the piston return control valve is again vented to the atmosphere, and this valve is momentarily opened to supply air for returning the piston.

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

FIG. 1 is a sectional view of a pneumatically actuated fastener driving tool which embodies the present invention and which is shown in normal position;

FIG. 2 is an enlarged sectional view of a piston return control valve carried on a cylinder structure included in the tool that illustrates the control valve in its normal condition;

FIG. 3 is a sectional view similar to FIG. 1 showing the fastener driving tool in an operated condition at the termination of a power stroke;

FIG. 4 is an exploded perspective view of the piston return control valve shown in FIG. 2;

FIG. 5 is a sectional view similar to FIGS. 1 and 3 illustrating the tool in its condition after a power stroke and prior to the return of the piston to its normal condition; and

FIG. 6 is an enlarged sectional view similar to FIG. 2 illustrating the piston return control valve in an operated condition.

Referring now more specifically to FIG. 1 of the drawings, therein is illustrated a fastener driving tool indicated generally as 10 which embodies the present invention and which is of the same general type as those shown and described in United States Patent Nos. 2,944,522; 2,979,725; and 3,043,272. The tool 10 includes a housing 12 comprising a rearwardly extending hollow handle portion 12a and a generally vertical head or forward portion 12b. The cavity in the hollow handle portion 12a and a chamber 14 formed in the head portion 12b provide a reservoir 16 that is continuously supplied with a pressurized fluid, such as compressed air. A cylinder 18 movably mounted in the chamber 14 slidably receives a piston 20 to the lower end of which is secured a driver blade 22. A nosepiece structure 24 is secured to the lower end of the forward portion 12b of the housing 12 and defines a drive track 26 to which suitable fasteners to be driven, such as staples, are supplied by a conventional magazine assembly (not shown). Compressed air from the reservoir 16 is normally supplied by a manually actuated control valve assembly 28 to hold the open upper end of the cylinder 18 seated in engagement with a main valve assembly 30 secured in a fixed position on the housing 12. The compressed air supplied by the control valve assembly 28 is also forwarded to an exhaust valve assembly, indicated generally as 32, to hold this valve assembly in a position in which the interior of the upper end of the cylinder 18 is connected to the atmosphere.

When the tool 10 is to be operated, the manually actuated valve assembly 28 is operated to connect a portion of the chamber 14 to the atmosphere so that the cylinder 18 is moved downwardly away from the main valve assembly 30 by the compressed air in the reservoir 16 to permit the compressed air to enter the cylinder 18 and drive the piston 20 and driver blade 22 downwardly to engage and set a fastener supplied to the drive track 26. The control valve 28 also connects the exhaust valve assembly 32 to the atmosphere so that it is operated to a closed position by the compressed air admitted to the cylinder 18 thereby preventing the loss of fluid pressure in the reservoir 16. The piston 20 remains in its position at the lower end of the cylinder 18 at the end of the power stroke until the control valve assembly 28 is released to again supply compressed air to a portion of the chamber 14 and to the exhaust valve assembly 32. At this time,

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the cylinder 18 is moved upwardly to engage the main valve assembly 30 so as to close off communication between the interior of the cylinder 18 and the reservoir 16, and the compressed air supplied to the exhaust valve assembly 32 operates this assembly to its open condition so that the fluid trapped in the upper end of the interior of the cylinder 18 above the piston 20 is discharged to the atmosphere.

To control the return of the piston 20, a piston return control valve assembly 34 responsive to the pressure within the upper end of the cylinder 18 is now operated to an open condition to supply compressed air from the reservoir 16 to the cylinder 18 below the piston 20. This compressed air returns the piston 20 to its normal position adjacent the upper end of the cylinder 18. The control valve 34 is automatically operated to a closed condition by the return of the piston 20 to prevent the supply of any additional compressed air from the reservoir 16 to the lower end of the cylinder 18. Therefore, the pneumatically actuated fastener driving tool 10 embodying the present invention includes means for selectively supplying compressed air for returning the piston 20 to its normal condition only when communication between the reservoir 16 and the interior of the cylinder 18 has been terminated and the cylinder has been connected to the atmosphere under the control of the improved exhaust valve assembly 32.

Referring now more specifically to the construction of the housing 12, this housing can be formed in any of the manners well known in the art and comprises either an integral or multiple part structure. In the illustrated construction, the top of the head portion 12b and the upper end of the chamber 14 is provided with an opening closed by a removable cover 35 on which the main valve assembly 30 and the exhaust valve assembly 32 are mounted. The chamber 14 is provided with a larger diameter portion 14a and a smaller diameter portion 14b for slidably receiving the cylinder 18. An upper portion of the cylinder 18 is provided with an upper of first piston portion slidably mounted in the larger diameter portion 14a and sealed by an O-ring 36. A second or smaller diameter portion at the lower end of the cylinder 18 is slidably mounted in the smaller diameter portion 14b of the chamber and is sealed by an O-ring 38.

To provide means for selectively connecting the lower end of the interior of the cylinder 18 to the atmosphere, a lower cylinder exhaust valve assembly 39 is provided. The assembly 39 includes a generally cylindrical valve member 40 slidably mounted in an enlarged portion 14c of the smaller diameter portion 14b of the chamber 14. A compression spring 41 normally urges the element 40 upwardly to seat a resilient, circular valve element 42 carried on the upper end of the member 40 on an inclined valve surface 43 on the housing to close communication between the lower end of the interior of the cylinder 18 and a plurality of exhaust ports 44 in the head portion 12b of the housing 12. A resilient O-ring 45 carried on the valve member 40 seals the interface between the wall of the enlarged portion 14c and the outer surface of the member 40. The spring 41 also biases the cylinder 18 to its normal position when air is not supplied to the tool 10 to insure that this tool does not fire inadvertently when air is connected to it.

In the normal position of the tool 10, the resilient valve element 42 is held against the valve seat 43 by the spring 41 to close the lower end of the cylinder 18, and the lower end of the cylinder, which is provided with a plurality of notches or recesses 18a, is spaced slightly above the upper end of the valve member 40. When the cylinder 18 is moved downwardly to open its top, its lower end engages the valve member 40 and moves it downwardly against the action of the spring 41 to move the resilient valve element 42 out of engagement with the seat 43. This places the lower interior of the cylinder 18 in communication with the atmosphere through the

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recesses 18a and the ports 44 at least as soon as the top of the cylinder 18 is opened to the compressed air in the reservoir 16. When the cylinder 18 is restored to its normal position at the end of a cycle of operation, the spring 41 biases the valve element 42 into engagement with the seat 43 to close the lower interior of the cylinder 18. Since the valve assembly 39 includes the resilient elements 42 and 45 for sealing the lower interior of the cylinder 18, the loss of air sometimes encountered in prior tools sealed by metal-to-metal interfaces is avoided. Further, the element 42 provides a tight seal without requiring the elongated metal-to-metal seal previously used and permits the connection to the atmosphere to be opened with less downward movement of the cylinder 18 with the result that the lower end of this cylinder is connected to the atmosphere at least as soon as compressed air is admitted to the top of the cylinder 18. In some prior tools, the exhaust for the lower end of the tool was not opened until after the top had been opened with a resultant decrease in the power available for driving the blade 22.

The piston 20 includes an upper flanged portion 20a having a recess in which are disposed two resilient O-rings 46. A lower depending portion of the piston 20 is secured to the upper end of the driver blade 22 by a pin 48. The downward movement of the piston 20 is arrested by a resilient buffer assembly comprising an annular body 50 of resilient material encircled by a metal sleeve 52 biased against the bottom wall of the chamber 40 by the spring 41. The body 50 includes an axial opening through which the driver blade 22 extends.

The main valve assembly 30 which is secured in a fixed position on the closure cap 35 comprises a circular sheet 54 of resilient material having an outer diameter approximately equal to the outer diameter of the upper portion of the cylinder 18. The center of the sheet 54 is provided with an opening for receiving a depending cylindrical portion 35a on the closure cap 35 which also extends through a central opening in a rigid retaining plate 56 having an outer diameter slightly less than the inner diameter of the upper portion of the cylinder 18. The resilient valve element 54 and the plate 56 are secured to the closure 35 by one or more machine screws 58.

The exhaust valve assembly 32 which is controlled by the control valve assembly 28 includes a piston 60 slidably mounted in a chamber or cylinder 62 in the closure cap 35 which communicates with an exhaust passage 64 that passes through the depending portion 35a on the closure cap 35 to the interior of the cylinder 18. The lower end of the piston 60 is slidably mounted in a reduced diameter portion of the chamber 62, and the upper end of the piston 60 is slidably mounted within a centrally disposed opening in an annular guide member 66 that is disposed within the upper end of the chamber 62. A resilient sleeve 68 is mounted in an enlarged upper end of an exhaust passage 70 passing through the piston 60 and includes an upper end portion projecting above the upper surface of the piston 60 adapted to be moved into and out of engagement with a transverse wall element or valve seat 72 secured to the closure cap 35.

In the normal condition of the tool 10, the exhaust valve 32 is in an open condition connecting the upper interior of the cylinder 18 with the atmosphere through the passageways 64 and 70 and a plurality of transverse passageways 74 formed by the plate 72 and the closure cap 35. The exhaust valve assembly 32 is normally held in this open condition by compressed air supplied to the chamber 62 through a passageway 76 in the forward portion 12b of the housing and a passageway 78 in the closure cap 35. This compressed air acts on the upper effective area of the piston 60 disposed within the chamber 62 to force the piston downwardly against a stop formed by the shoulder in the wall of the chamber 62.

As indicated above, the manually actuated control valve

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28 controls the selective operation of the exhaust valve assembly 32 and the movement of the cylinder 18 into and out of engagement with the main valve assembly 30. The valve assembly 28, which can be of the type disclosed and described in detail in the above-identified patents, includes a valve operator stem 80 that is biased into engagement with a trigger 82 pivotally mounted on the housing 12 by a shaft or a pivot pin 84. In the normal or released condition of the control valve assembly 28, compressed air from the reservoir 16 is supplied through a passageway 86 to the part of the larger diameter portion 14a of the chamber 14 that is disposed between the sealing O-rings 36 and 38. Since the lower effective area on the cylinder 18 is greater than the upper effective area on the cylinder 18 exposed to the pressurized fluid in the reservoir 16, an upwardly directed component of force is applied to the cylinder 18 to normally force its upper edge into engagement with the resilient valve element 54. This normally closes off communication between the upper end of the interior of the cylinder 18 and the pressurized fluid in the reservoir 16. The compressed air supplied to the lower end of the greater diameter portion 14a of the chamber 14 is also supplied through the passageways 76 and 78 to act on the upper area of the piston 60 disposed within the chamber 62 to hold the exhaust valve assembly 32 in its normal condition in which the upper end of the interior of the cylinder 18 is vented to the atmosphere through the passageways 64, 70, and 74.

When the control valve assembly 28 is actuated by pivoting the trigger element 82 in a counter-clockwise direction about the pivot pin 84, the valve assembly 28 closes off communication between the passageway 86 and the pressurized fluid in the reservoir 16 and connects the passageway 86 to the atmosphere so that the compressed air in the chamber 62 and the portion of the chamber 14 disposed between the O-rings 36 and 38 is exhausted to the atmosphere. The compressed air acting on the upper effective surfaces of the cylinder 18 exposed to the pressurized fluid within the reservoir 16 now produces a downwardly directed component of force that shifts the cylinder 18 downwardly from the normal position illustrated in FIG. 1 to the displaced position illustrated in FIG. 3. In moving downwardly, the cylinder 18 moves the valve member 40 downwardly to move the valve element 42 out of engagement with the seat 43 to connect the lower interior of the cylinder 18 to the atmosphere. This permits the air trapped below the piston 20 to be discharged to the atmosphere during the power stroke of the fastener driving means. As the upper end of the cylinder 18 moves out of engagement with the resilient valve element 54, the pressurized fluid or compressed air in the reservoir 16 flows into the open upper end of the cylinder 18 and drives the piston 20 and the connected driver blade 22 downwardly to engage and drive a fastener or staple supplied to the drive track 26. At the lower end of the power stroke illustrated in FIG. 3 of the drawings, the lower end of the reduced diameter portion of the piston 20 engages the upper edge of the resilient bumper or buffer element 50 to resiliently cushion the termination of the power stroke.

When the upper end of the cylinder 18 moves out of engagement with the resilient valve element 54 in the main valve assembly 30, compressed air is admitted to the lower end of the passageway 64. Since the compressed air in the chamber 62 acting on the upper effective surface of the piston 60 has been discharged to the atmosphere by the actuation of the control valve assembly 28, and since the area of the passageways 64 and 70 is small relative to the volume of compressed air now supplied to the cylinder 18, this compressed air is effective through the passageway 64 to act on the reduced diameter lower effective surface of the piston 60 to move this piston upwardly to the position illustrated in FIG. 3 in which the upper end of the resilient sleeve 68 is held in sealing engagement with the transversely extending valve seat 72.

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This closes communication between the passageway 70 and the passageways 74 to close the exhaust valve assembly 32 and prevent the loss of compressed air from the reservoir 16. The fastener driving tool 10 remains in the condition shown in FIG. 3 of the drawings with the exhaust valve assembly 32 in a closed condition and with the cylinder 18 and the piston 20 moved downwardly to their displaced positions until the control valve assembly 28 is released.

At this time, the passageway 86 is closed off from communication with the atmosphere and is again connected to the pressurized fluid in the reservoir 16. This fluid flows into the portion 14a of the chamber 14 bonded by the O-rings 36 and 38 and, because of the greater effective lower surface on the cylinder 18, moves this cylinder upwardly so that its upper edge again engages the resilient valve element 54 in the main valve assembly 30 to close off communication between the reservoir 16 and the interior of the cylinder 18 (FIG. 5). When the cylinder 18 moves upwardly, the valve member 40 is moved upwardly by the spring 41 to seat the valve element 42 on the surface 43 to close off communication between the atmosphere and the lower end of the interior of the cylinder 18. The compressed air supplied to the chamber portion 14a also flows through the passageways 76 and 78 into the chamber 62. This compressed air acts on the greater upper effective area of the piston 60 to move this piston downwardly from the position shown in FIG. 3 to the position shown in FIG. 5. When the piston 60 moves to this position, the upper end of the resilient sleeve 68 moves out of engagement with the element 72 so that the upper end of the interior of the cylinder 18 is again placed in communication with the atmosphere through the passageways 64, 70, and 74 to exhaust the pressurized fluid trapped in the upper end of the cylinder 18 when this cylinder was moved into engagement with the main valve assembly 30. The reduction in the pressure in the upper end of the cylinder 18 automatically controls the operation of the piston return valve assembly 34 to supply compressed air to the lower end of the interior of the cylinder 18 to return the piston 20 to its normal position.

The piston return valve assembly 34 is mounted on the cylinder 18 and, more specifically, is mounted on a projecting portion 18a (FIGS. 2, 4 and 6) adjacent the upper end of the cylinder 18 to control communication between the reservoir 16 and the lower end of the interior of the cylinder 18 through a passageway 88 formed in the wall of the cylinder 18. The piston return valve assembly 34 includes a pair of aligned and cylindrical chambers 90 and 92 formed in the projecting portion 18a. The lower end of the chamber 92 is placed in communication with the reservoir 16 through a port or passageway 94. A member 96 includes a conical or tapered valve portion 96a disposed in the chamber 92 and a piston portion 96b slidably mounted in the chambers 90 and 92. A pair of O-rings 98 and 100 seal the interfaces between the member 96 and the chambers 90 and 92 in two spaced positions. The lower end of the valve portion 96a is adapted to be moved into and out of engagement with a resilient O-ring or valve element 102 to selectively control communication between the port 94 and the passageway 88. The upper end of the chamber 90 is closed by a plug 104 which is received within the upper end of the chamber 90 and carries a sealing O-ring 106. A bleeder passage 108 in the plug 104 continuously supplies pressurized fluid from the reservoir 16 to the chamber 90 in the area disposed between the lower or inner end of the plug 104 and the upper surface of the piston portion 96b. A passageway 110 in the wall of the cylinder 18 also places this portion of the chamber 90 in communication with the upper end of the interior of the cylinder 18.

In the normal condition of the tool 10, the passageway 110 is closed off from communication with the interior of the cylinder 18 by the O-rings 46 which, when the piston 20 is disposed in its normal position adjacent the

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main valve assembly 30, are disposed on opposite sides of the port terminating the passageway 110. The bleeder passageway 108 continuously supplies pressurized fluid from the reservoir 16 to the chamber 90 which acts on the upper surface of the piston portion 96b to force the member 96 downwardly to the position shown in FIGS. 1 and 2 in which the valve portion 96a seats against the resilient valve element 102 to prevent communication between the port 94 and the passageway 88. The compressed air acting on the upper surface of the piston portion 96b holds the valve assembly 34 in a closed condition even though the compressed air from the reservoir 16 acts on the lower surfaces of this piston portion because the upper surfaces of the piston portion have a greater effective area than the lower surfaces.

When the control valve assembly 28 is actuated to operate the tool 10 to the position illustrated in FIG. 3 of the drawings, the cylinder 18 is moved downwardly out of engagement with the main valve assembly 30, and the piston 20 is driven through a power stroke. When the piston 20 moves downwardly, the O-rings 46 move away from the port terminating the passage 110 so that the chamber 90 is also supplied with pressurized fluid from the upper end of the cylinder 18 through the passageway 110. This provides an additional source of pressurized fluid for maintaining the valve portion 96a of the member 96 in engagement with the valve element 102.

When the control valve 28 is released and the cylinder 18 moves upwardly into engagement with the main valve assembly 30, the exhaust valve assembly 32 is also actuated to its normal or open position shown in FIGS. 1 and 5 so that the interior of the cylinder 18 disposed above the piston 20 is connected to the atmosphere. Since the passage 110 is in communication with the interior of the upper end of the cylinder 18, the pressurized fluid supplied through the bleeder passage 108 is exhausted to the atmosphere, and the portion of the chamber 90 disposed between the piston portion 96b and the plug 104 is placed substantially at atmospheric pressure. In one tool 10 constructed in accordance with the present invention, the diameter of the larger passageway 110 is twice that of the smaller passageway 108. The compressed air supplied through the port 94 acts on the lower effective surface of the piston portion 96b below the sealing O-ring 100 to provide an upwardly directed force that moves the member 96 until the upper surface of the piston portion 96b engages a bossed portion 104a on the plug 104. This moves the valve portion 96a out of engagement with the sealing O-ring 102, and the compressed air continuously supplied to the passage or port 94 from the reservoir 16 flows through the passageway 88 to the interior of the cylinder 18 below the piston 20 as illustrated in FIGS. 5 and 6 of the drawings.

Since the interconnection between the atmosphere and lower end of the interior of the cylinder 18 has previously been closed by moving the cylinder 18 upwardly to the position illustrated in FIG. 5, the compressed air supplied by the passageway 88 acts on the lower surface of the piston 20 to move the piston upwardly to the position shown in FIG. 1 of the drawings. When the piston 20 is restored to its normal position, the O-rings 46 are again disposed on opposite sides of the port terminating the passage 110 so that the connection between the atmosphere and the chamber 90 provided by the open exhaust valve assembly 32 is terminated. Thus, the pressurized fluid supplied through the bleeder passage 108 from the reservoir 16 accumulates within the chamber 90. Since the upper effective area of the piston portion 96b of the member 96 is greater than the lower effective surface thereof, the compressed air in the chamber 90 provides a downwardly directed force that shifts the member 96 until the valve portion 96a again engages the valve element 102 to close communication between the port 94 and the passageway 88. Thus, the supply of pressurized fluid to the lower end of the cylinder 18 is terminated as

soon as the piston 20 is restored to its normal condition.

The piston return valve assembly 34 is now restored to the normal condition illustrated in FIGS. 1-3 of the drawings. In the event that the compressed air trapped in the lower end of the cylinder 18 becomes dissipated by leakage prior to the initiation of the next cycle of operation of the tool 10, the piston 20 usually will not drop below its normal position because the light frictional engagement of the inner wall of the cylinder 18 by the O-rings 46 retains the piston 20 in its retracted or normal position. In the event that the piston 20 does drop, the O-rings 46 again open the passageway 110 so that the chamber 90 is vented to the atmosphere through the open exhaust valve assembly 32. This operates the valve assembly 34 to supply compressed air below the piston 20 for returning it to its normal position. The piston 20 causes the reclosure of the valve assembly 34 as soon as the piston is returned to its normal position.

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

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

1. A fastener driving apparatus comprising a housing supplied with a pressurized fluid and including a cylinder, fastener driving means including piston means slidably mounted in the cylinder, control means for alternately connecting the upper end of the cylinder means to the atmosphere and to the fluid to drive the piston means, and means responsive to the pressure in the upper end of the cylinder and controlled by the connection of the upper end of the cylinder to the atmosphere for selectively supplying fluid to the cylinder below the top of the piston means when the upper end of the cylinder disposed above the piston means is placed at atmospheric pressure.

2. A fastener driving apparatus comprising a housing supplied with a pressurized fluid and including a cylinder, fastener driving means including piston means slidably mounted in the cylinder, control means for alternately connecting the upper end of the cylinder means to the atmosphere and to the fluid to drive the piston means, valve means for supplying fluid to the cylinder means below the piston means, and pressure responsive means communicating with the upper end of the cylinder for selectively operating the valve means to supply pressurized fluid below the piston means when the pressure within the upper end of the cylinder means approaches atmospheric pressure.

3. A fastener driving apparatus comprising a housing including a reservoir continuously supplied with a pressurized fluid and cylinder means having an open end exposed to the fluid, fastener driving means including piston means slidably mounted in the cylinder means, main valve means normally closing the open end of the cylinder means, means for producing a separation between the main valve means and the end of the cylinder means to admit fluid to the cylinder for driving the piston means, exhaust means for discharging pressurized fluid from the cylinder means above the piston means, and piston return means controlled by the pressure within the cylinder means above the piston means for selectively supplying fluid to the cylinder means below the top of the piston means to return the piston means to a position adjacent the open end of the cylinder means when the exhaust means discharges the pressurized fluid from the cylinder means above the piston means.

4. A fastener driving apparatus comprising a housing including a reservoir continuously supplied with a pressurized fluid and cylinder means having an open end exposed to the fluid, fastener driving means including piston means slidably mounted in the cylinder means, main valve means normally closing the open end of the cylinder

means, means for producing a separation between the main valve means and the end of the cylinder means to admit fluid to the cylinder for driving the piston means, and a pressure responsive valve means for controlling the flow of pressurized fluid between the reservoir and a point in the cylinder disposed below the top of the piston means, said pressure responsive valve means being controlled by the pressure in the cylinder means above the piston means and communicating with the cylinder means adjacent the open end for selectively supplying fluid from the reservoir to the cylinder means below the top of the piston means when the pressure in the cylinder means above the piston means approaches atmospheric pressure.

5. A fastener driving apparatus comprising a housing including a reservoir continuously supplied with a pressurized fluid and cylinder means having an open end exposed to the fluid, fastener driving means including piston means slidably mounted in the cylinder means, main valve means normally closing the open end of the cylinder means, means for producing a separation between the main valve means and the end of the cylinder means to admit fluid to the cylinder for driving the piston means, exhaust means for connecting the portion of the cylinder means above the piston means to the atmosphere when the open end of the cylinder means is closed by the main valve means, return means for supplying fluid to the cylinder means below the top of the piston means to return the piston means to a position adjacent the end of the cylinder means, and means controlled by the pressure within the cylinder above the piston means and responsive to the connection of the cylinder means above the piston means to the atmosphere by the exhaust means for selectively operating the return means to supply fluid to the cylinder means below the piston means.

6. A fastener driving apparatus comprising a housing including a reservoir continuously supplied with a pressurized fluid and cylinder means having an open end exposed to the fluid, fastener driving means including piston means slidably mounted in the cylinder means, main valve means normally closing the open end of the cylinder means, means for producing a separation between the main valve means and the end of the cylinder means to admit fluid to the cylinder for driving the piston means, exhaust means for connecting the portion of the cylinder means above the piston means to the atmosphere when the open end of the cylinder means is closed by the main valve means, control valve means for supplying fluid from the reservoir to the cylinder means below the top of the piston means, and pressure responsive means for operating the control valve means and communicating with the cylinder means above the piston means.

7. A fastener driving apparatus comprising a housing supplied with a pressurized fluid and including a cylinder, fastener driving means including piston means slidably mounted in the cylinder, control means for alternately connecting the upper end of the cylinder means to the atmosphere and to the fluid to drive the piston means, valve means for supplying fluid to the cylinder means below the piston means, control piston means for moving the valve means between opened and closed positions, means for applying fluid to the control piston means, and means including a passage communicating with the upper end of the cylinder means for connecting the control piston means to the atmosphere.

8. A fastener driving apparatus comprising a housing including a reservoir continuously supplied with a pressurized fluid and cylinder means having an open end exposed to the fluid, fastener driving means including piston means slidably mounted in the cylinder means, main valve means normally closing the open end of the cylinder means, means for moving the main valve means and cylinder means into and out of engagement to selectively admit the fluid to the end of the cylinder means, exhaust means for connecting the portion of the cylinder means above the

piston means to the atmosphere when the main valve means closes the end of the cylinder means, and control means responsive to closing the cylinder end and connecting the closed cylinder to the atmosphere for supplying fluid to the cylinder means below the top of the piston means.

9. A driving device comprising a housing including a reservoir of pressurized fluid, a cylinder movably mounted on the housing and having an end exposed to the fluid in the reservoir, driving means including a piston slidably mounted in the cylinder, main valve means, control means for moving the cylinder into and out of engagement with the main valve means to open and close the cylinder, and control valve means carried on the cylinder and selectively operable to supply fluid to the cylinder below the piston.

10. The driving device set forth in claim 9 including means responsive to movement of the cylinder for selectively connecting the portion of the cylinder below the piston to the atmosphere.

11. A driving device comprising a housing including a reservoir of pressurized fluid, a cylinder movably mounted on the housing and having an end exposed to the fluid in the reservoir, driving means including a piston slidably mounted in the cylinder, main valve means, control means for moving the cylinder into and out of engagement with the main valve means to open and close the cylinder, fluid conveying means on the cylinder connecting a portion of the cylinder below the end to the reservoir, control valve means carried on the cylinder for controlling the flow of fluid through the fluid conveying means, and means for selectively operating the control valve means.

12. A fastener driving apparatus comprising a housing including a cylinder, fastener driving means including a piston slidably mounted in the cylinder, control means for selectively supplying a pressurized fluid to the cylinder to drive the piston through a single power stroke from a normal position to a displaced position, said control means also including means for connecting the cylinder to the atmosphere to permit the piston to be returned from the displaced position to the normal position, piston return means including a control valve for supplying fluid to the cylinder to return the piston to its normal position, and fluid responsive means for controlling the operation of the control valve and including a port in the wall of the cylinder adjacent the normal position of the piston, the port being located in the wall of the cylinder to be closed by the piston when the piston is disposed in the normal position to close the control valve, the port being uncovered when the piston is moved to the displaced position to connect the fluid responsive means to the atmosphere to open the control valve to supply fluid to the cylinder to return the piston to the normal position.

13. A fastener driving apparatus comprising a housing including a reservoir supplied with a pressurized fluid, main valve means secured to the housing in a fixed position therein, a cylinder slidably mounted on the housing and having an open end exposed to the fluid in the reservoir, fastener driving means including a piston slidably mounted in the cylinder, control means for moving the cylinder into and out of engagement with the main valve means to selectively admit fluid to the cylinder, exhaust means including an opening communicating with the cylinder below the main valve means, said opening including a cylindrical portion, piston means slidably mounted in the cylindrical portion of the opening and movable be-

tween positions in which the opening is opened and closed, and means for connecting the cylindrical portion to the fluid and the atmosphere to move the piston means to selectively open and close the exhaust means.

14. A fastener driving apparatus comprising a housing including a reservoir continuously supplied with a pressurized fluid and a cylinder having an end exposed to the fluid; fastener driving means including piston means slidably mounted in the cylinder; main valve means normally closing the open end of the cylinder; control means for separating the cylinder and main valve means to admit fluid for driving the piston means; fluid conveying means on the housing extending between the atmosphere and the cylinder at a point below the piston means; and an exhaust valve arrangement for selectively opening and closing the fluid conveying means; said exhaust valve arrangement including a valve seat carried on the housing, a movable valve member movable into and out of abutting engagement with the valve seat to open and close the exhaust valve arrangement, and resilient sealing means interposed between the valve seat and the valve member.

15. The fastener driving apparatus set forth in claim 14 in which said cylinder is movably mounted in the housing and in which the valve member includes means engaged by the cylinder to move the valve member to a position opening the exhaust valve arrangement.

16. A fastener driving apparatus comprising a housing having both a cylinder and a reservoir supplied with a pressurized fluid, fastener driving means including drive piston means slidably mounted in the cylinder, control means for alternately connecting the upper end of the cylinder means to the atmosphere and to the fluid in the reservoir to drive the piston means, valve means for supplying fluid to the cylinder means below the drive piston means, control piston means for moving the valve means between opened and closed positions, means for continuously applying fluid to the control piston means from the reservoir, and means including a passage communicating with the upper end of the cylinder means for selectively connecting the control piston means to the atmosphere to control the operation of the valve means.

17. The apparatus set forth in claim 16 in which the passage includes a port selectively opened and closed by the drive piston means.

18. The fastener driving apparatus set forth in claim 12 in which the fluid responsive means includes a slidably mounted control piston normally biased to a position closing the control valve by the fluid and in which the connection of the port to the atmosphere exhausts the fluid acting on the control piston through the port to permit the control piston to open the control valve and admit fluid to the cylinder for returning the piston to the normal position.

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