April 2, 1968 R. F. NOVAK ET AL 3,375,758

FASTENER DRIVING TOOL

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FIG. 1

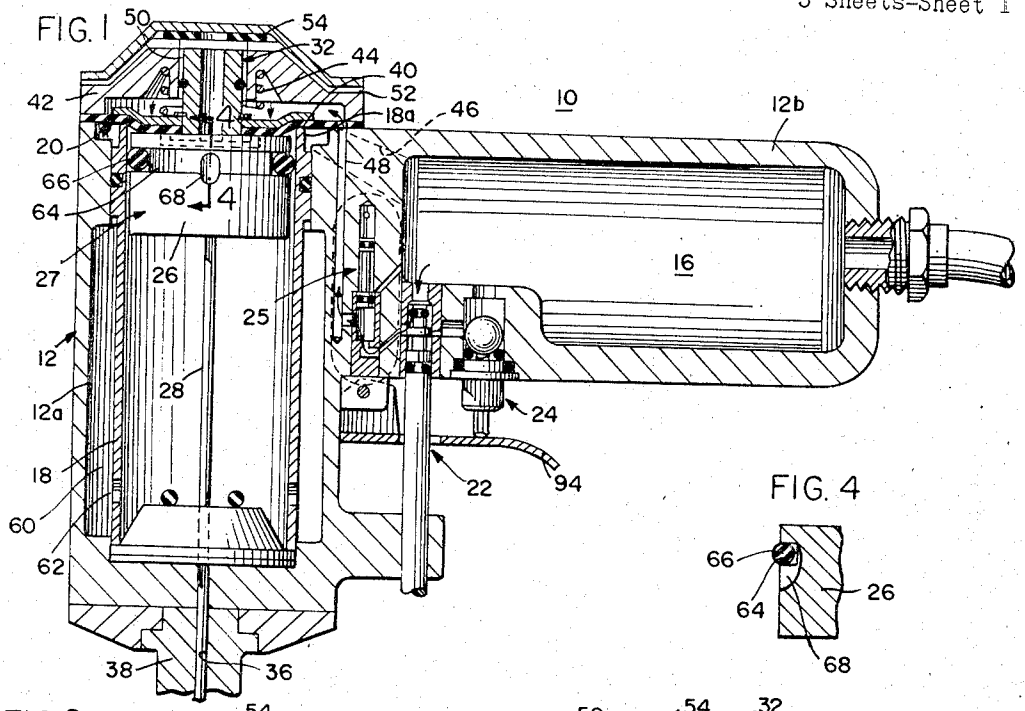



FIG. 4




FIG. 2

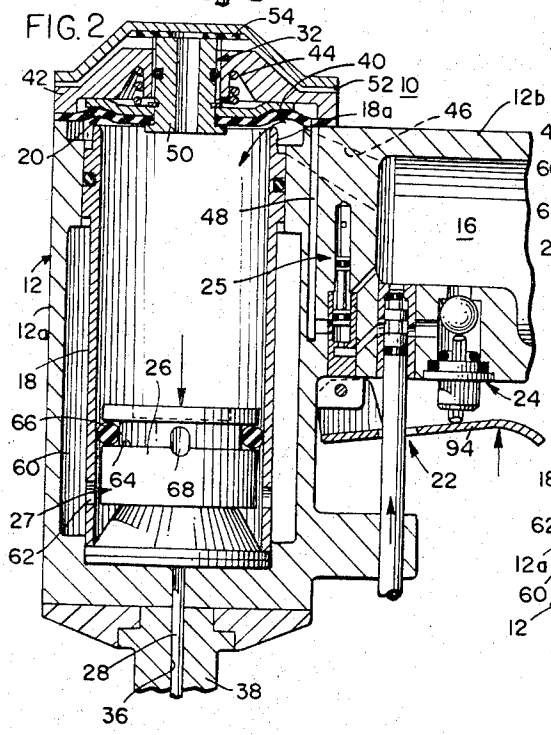
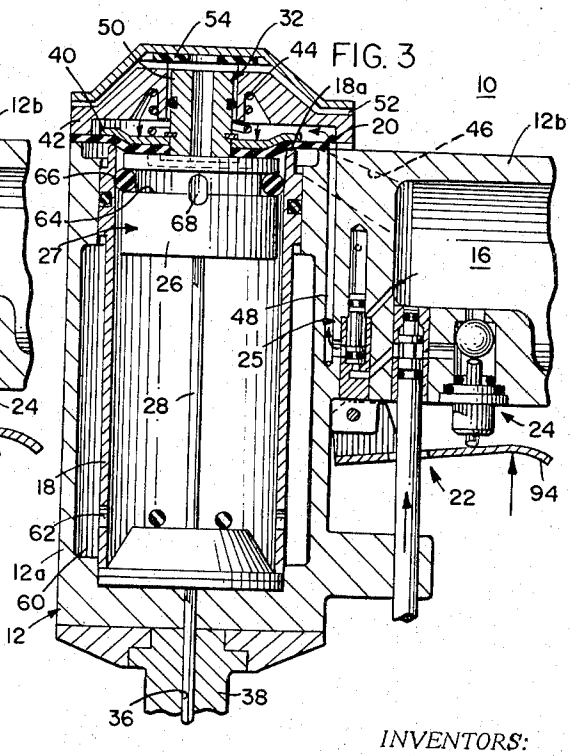



FIG. 3




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FIG. 7

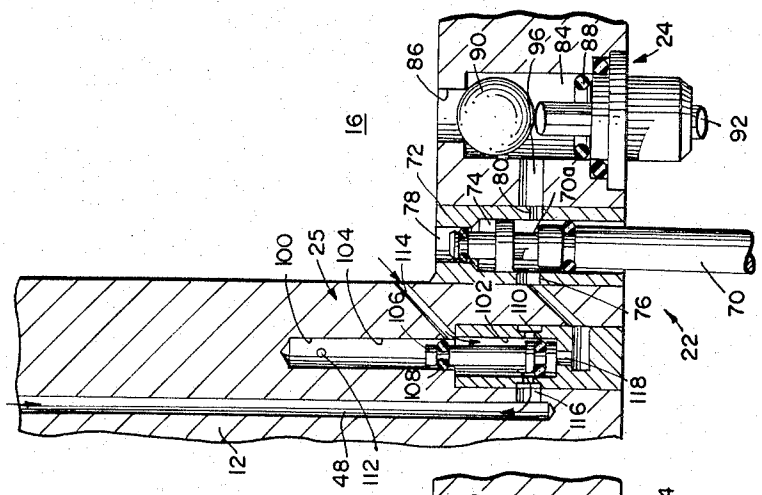



FIG. 6

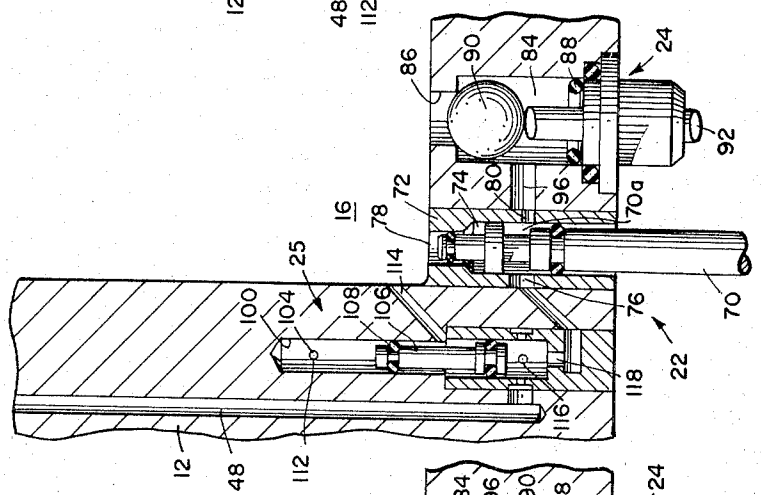
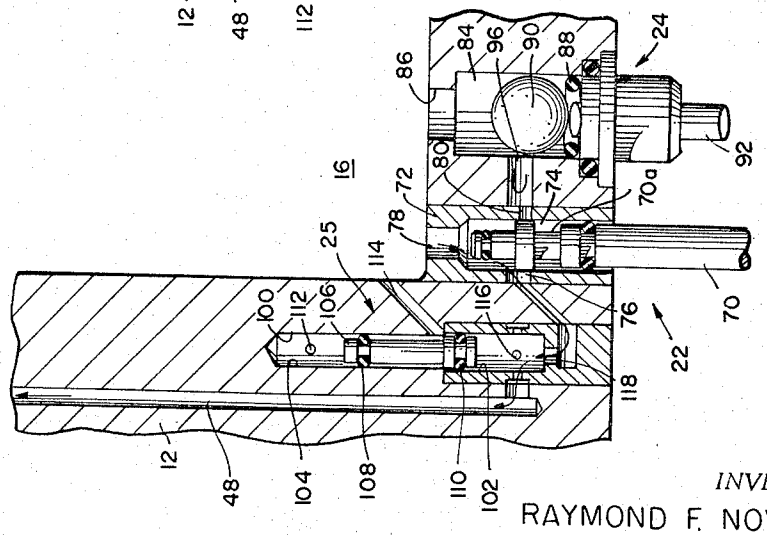



FIG. 5



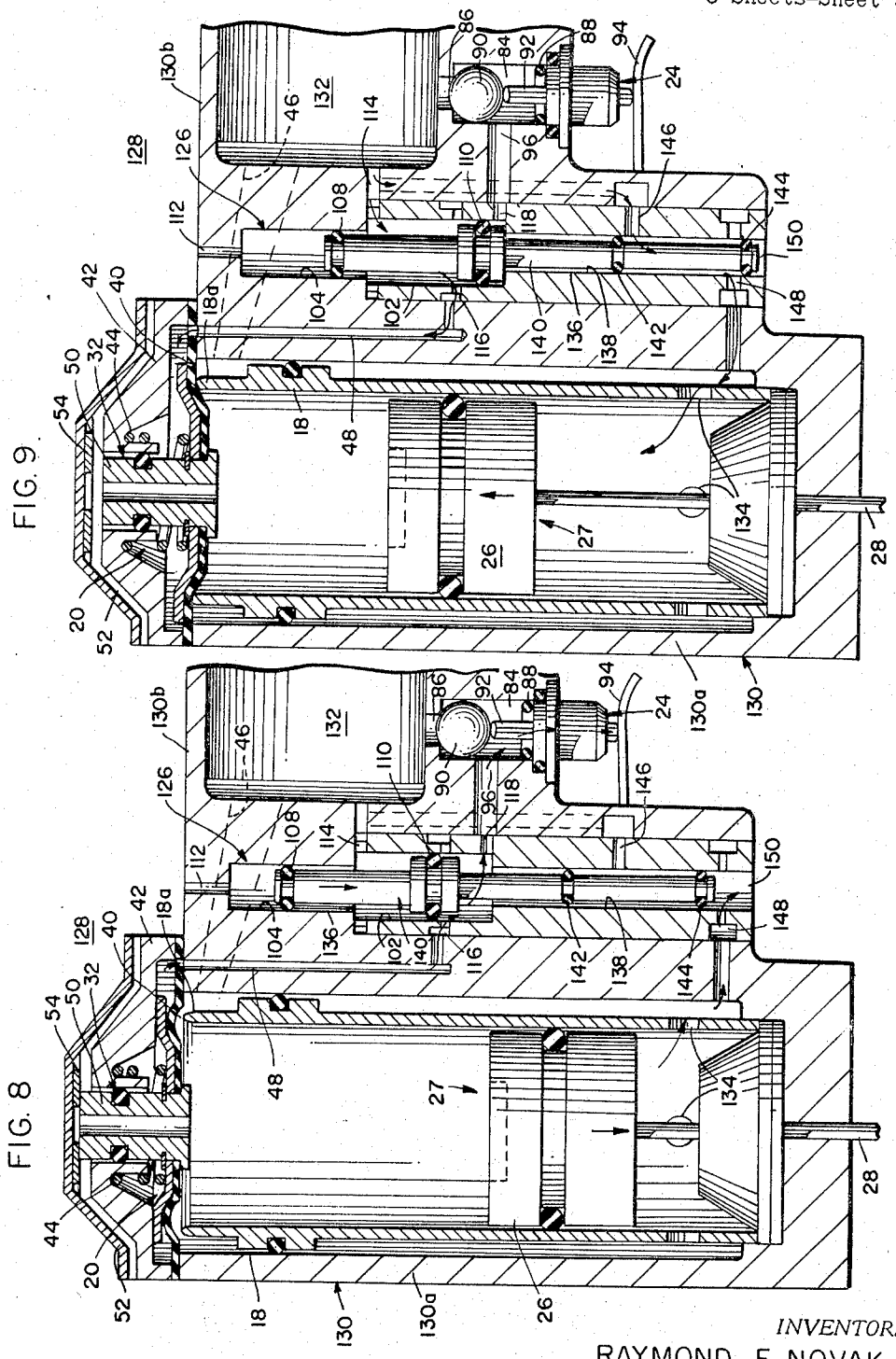

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3,375,758

# FASTENER DRIVING TOOL

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7 Claims. (Cl. 91—356)

## ABSTRACT OF THE DISCLOSURE

A pneumatically operated fastener driving tool is provided with suitable control mechanism to provide for single-cycle operation. The improved control mechanism may be applied to a known type of tool wherein a drive or power piston is slideably mounted in the cylinder of the tool. A control valve is provided which is actuated by depression of a trigger or other manual actuator to control the movement of the drive piston through a drive stroke, and thereafter automatically and sequentially to return the drive piston through a return stroke. The control valve is connected between the main valve controlling the flow of fluid to the cylinder, and receives a signal when the drive piston is at the end of its drive stroke to recondition the cylinder for the return stroke of the piston.

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

Commercial pneumatic fastener driving tools on the market today are generally of the type operated by a trigger actuated pilot valve that functions when the trigger is depressed to move the drive piston and connected fastener driving blade through a power or drive stroke of a fastener driving operation by admission of pressurized fluid into the cylinder of the tool. The drive piston will generally remain at the end of its power stroke until the fluid pressure in the cylinder is released, as by exhausting the cylinder to the atmosphere, at which time the piston return means is effective to return the piston to its normal or static position. Moreover pneumatic fastener driving tools are known wherein the drive piston and driving blade move both down and up automatically upon depression of the trigger, before the trigger is released. For example, one such tool is described and claimed in a copending application of Howard B. Ramspeck, Ser. No. 457,767, filed May 21, 1965, which application is assigned to the same assignee as the present invention. This snap-action or automatic single cycle piston and driving blade operation is desirable in many applications such as upholstery stapling to prevent fraying of the material by the driving blade while the tool is moved along the workpiece.

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

Another object of the present invention is to provide a fastener driving apparatus including new and improved single-cycle control means for automatically and sequentially returning the drive piston and driver blade after completion of the fastener driving operation.

Yet another object of the present invention is to provide a new and improved pneumatically actuated fastener driving tool.

Yet a further object of the present invention is the provision of a new and improved control valve for a fastener driving tool which is effective to cycle the drive piston and driver blade through the power and return strokes automatically upon depression of the trigger.



Yet a further object of the present invention is to provide a fastener driving apparatus having a new and improved control valve which automatically and sequentially effects connection of the main cylinder first to a fluid reservoir and then to the atmosphere without the necessity of releasing the trigger.

In accordance with these and many other objects, there is provided a new and improved single-cycle control valve for a pneumatically operated fastener driving tool. The improved control valve may be applied to a known type of tool provided with a housing having a cavity defining a fluid reservoir, and having a main cylinder in the housing. A drive or power piston is slideably mounted in the cylinder and is actuated in its drive stroke by the communication of one end of the main cylinder with the fluid reservoir and is thereafter automatically driven through a return stroke by the automatic and sequential exhausting of the one end of the main cylinder. The return stroke may be under the control of compressed fluid in a return reservoir, or fluid may be directed to the underside of the piston from the fluid reservoir to effect return of the drive piston. In a known type of fastener driving tool, the pressurized fluid is admitted into the one end of the cylinder through a main valve which may be a diaphragm-type poppet valve of the type described in detail in Patent No. 3,208,353 granted Sept. 28, 1965 to O. A. Wandel. A trigger pilot valve is provided for controlling the poppet valve.

In accordance with the present invention, the new and improved control valve is connected between the main valve and the trigger pilot valve to control the snap-acting motion of the fastener driving tool. The new and improved single-cycle control valve includes a valve body defining a valve cylinder having stepped diameters to provide at least a large diameter cylinder contiguously connected to a small diameter cylinder. A valve element is slideable in the cylinder and includes a small piston in the small diameter cylinder and a large piston in the large diameter cylinder. A first port in the end of the small cylinder beyond the stroke of the small piston is vented to the atmosphere. A second port communicating with the valve cylinder adjacent the step therein between the stroke of the large and small pistons is connected to the fluid reservoir. A third port, which may be in the form of a plurality of radial ports, is provided in the large diameter cylinder intermediate the stroke of the large piston and is connected to the poppet valve. Yet a fourth port extends from the end of the large cylinder beyond the stroke of the large piston connected to the trigger pilot valve.

When the fastener driving tool is static, or at rest, pressurized fluid from the fluid reservoir passes through the trigger pilot valve, through the control valve, and to the main valve to maintain the main valve closed. However once the trigger pilot valve is depressed, the fluid from above the main valve is exhausted through the control valve and the trigger pilot valve to the atmosphere, thereby initiating the driving stroke of the drive piston. The differential pressure acting on the valve element will move the valve element, at a rate dependent on the relative size of the large and small cylinders, so as to drive the large piston past the ports connected to the main valve and thereby connecting the fluid reservoir with the main valve to close the main valve and to return the drive piston through its return stroke. Release of the trigger will return the valve element of the control valve to its static or at rest position so that the pressurized fluid from the fluid reservoir then passes through the trigger pilot valve, control valve and to the main valve to maintain the main valve in its closed position.

In accordance with another feature of the present invention, the control valve is readily adapted to a fastener

driving tool of the type wherein pressurized fluid from the fluid reservoir is directly connected to the underside of the piston to initiate the return stroke of the piston. To this end, the single-cycle control valve described above additionally includes an additional stepped diameter portion defining an exhaust cylinder contiguous with the large diameter cylinder on the side thereof remote from the small diameter cylinder. The valve element includes a portion extending into the exhaust cylinder with spaced third and fourth pistons thereon slideably received within the exhaust cylinder. Port means are provided in the exhaust cylinder between the strokes of the pistons connected directly to the fluid reservoir. Additional port means communicating with the lower side of the drive piston are provided in the exhaust cylinder intermediate the stroke of the fourth piston. Additional means at the end of the exhaust cylinder connect the exhaust cylinder to atmosphere.

This latter embodiment of the single-cycle control valve, in addition to functioning as described above, further vents the underneath of the drive piston to the atmosphere during the driving stroke, and thereafter automatically and sequentially connects the fluid reservoir to the underside of the drive piston to return the drive piston to its static or at rest position.

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

FIG. 1 is a fragmentary cross sectional view of a fastener driving tool incorporating the improved single-cycle control valve according to the present invention and illustrated with the drive piston and driver blade in its static or at rest position;

FIG. 2 is a fragmentary cross sectional view of the fastener driving tool of FIG. 1, illustrated with the drive piston and driver blade completing the drive stroke;

FIG. 3 is a fragmentary cross sectional view of the fastener driving tool of FIG. 1, illustrated with the drive piston and driver blade completing its return stroke prior to the release of the trigger pilot valve;

FIG. 4 is a cross sectional detail view taken along line 4—4 of FIG. 1;

FIG. 5 is a fragmentary cross sectional view of the control valve mechanism of the fastener driving tool of FIG. 1, drawn to a larger scale, and illustrated in a static or at rest position;

FIG. 6 is a fragmentary cross sectional view of the control mechanism of FIG. 5, illustrated during the driving stroke;

FIG. 7 is a fragmentary cross sectional view of the control mechanism of FIG. 5, illustrated during the return stroke of the drive piston and driver blade prior to the release of the trigger pilot valve;

FIG. 8 is a fragmentary cross sectional view of a modified fastener driving tool incorporating an improved single-cycle control valve according to the present invention having an additional feature and illustrated with the drive piston and driver blade during the driving stroke thereof; and

FIG. 9 is a fragmentary cross sectional view of the fastener driving tool of FIG. 8, illustrated with the drive piston and driver blade in its return stroke prior to the release of the trigger pilot valve.

Referring now to the drawings, there is fragmentarily illustrated a fastener driving tool, generally illustrated as **10**, which embodies the present invention. The tool **10** may be of known construction and, as illustrated, comprises a housing **12** including a generally vertically extending head or forward portion **12***a* and a rearwardly extending hollow handle portion **12***b* defining a fluid reservoir **16**. Pressurized fluid, such as compressed air, is supplied to the fluid reservoir **16** of the tool by a suitable flexible line. The drive system for the tool **10** includes a main or power cylinder **18** mounted within the head portion **12***a* and having an open upper end **18***a* that is adapted to be selectively connected to the reservoir **16**. The open upper end of the cylinder **18** is normally in engagement with a diaphragm-type main or cylinder valve assembly **20**, here shown of the poppet type, under the control of a safety or touch-trip valve assembly **22**, a trigger pilot valve assembly **24**, both of known design, and a snap-acting or single-cycle control valve assembly **25** according to the present invention. A fastener driving assembly **27** includes a power or drive piston **26** slideably mounted within the cylinder **18** having connected thereto a depending driver blade member **28**. The driving blade assembly **27** is normally biased to a position with the piston **26** adjacent the main valve **20**. An exhaust valve assembly indicated generally as **32** is provided for controlling the selective connection of the upper end of the cylinder **18** to the atmosphere.

When the tool **10** is to be operated, the safety valve assembly **22** and the trigger pilot valve assembly **24** are closed so that compressed fluid from the reservoir **16** enters the upper end of the cylinder **18** and drives the fastener driving assembly **27** downwardly to engage and set a fastener or nail supplied to a drive track **36** in a nosepiece or nosepiece structure **38**. The flow of compressed fluid into the upper end of the cylinder **18** is controlled by the main valve assembly **20**, which includes a diaphragm **40**, the periphery of which is clamped between a cap **42** and the head portion **12***a* of the housing **12** and which seats against the upper edge **18***a* of the cylinder **18**. The diaphragm **40** is resiliently biased against the upper edge surface **18***a* by a spring **44** located between the cap **42** and the diaphragm **40**. The cylinder side of the diaphragm **40** is continuously in communication with the fluid reservoir **16** through a suitable passageway **46** so that pressurized fluid continuously acts against the cylinder side of the diaphragm **40** tending to displace the diaphragm **40** from the edge **18***a* of the cylinder **18**. However pressurized fluid is also introduced to the opposite sides of the diaphragm **40** through a passageway **48** when the fastener driving tool **10** is in a static or at rest position. The differential pressure acting on the diaphragm **40** is effective to maintain the diaphragm **40** in a closed position, as illustrated in FIG. 1. However, if the pressurized fluid above the diaphragm **40** is discharged, the pressurized fluid acting through passageway **46** is effective to unseat the diaphragm **40** from the edge **18***a* of the cylinder **18** to dump pressurized fluid into the top of the main cylinder **18** and to drive the drive piston **26** through a drive stroke.

When the fastener driving tool is at rest, or during the return stroke of the drive piston, the upper open end of the cylinder **18** is exhausted to the atmosphere through the exhaust valve assembly **32**. In the illustrated embodiment the exhaust valve assembly comprises a hollow valve stem **50** secured to the diaphragm and connecting the upper end of the cylinder **18** to atmosphere through a suitable exhaust passageway **52**. However when the drive piston is operated through a fired or drive stroke, it is necessary for the upper end of the cylinder **18** to be closed, and to this end there is provided a valve seat **54** disposed adjacent the end of the valve stem **50** remote from the cylinder **18** and adapted to be engaged by the valve stem **50** when the diaphragm **40** is raised at the initiation of a drive stroke, thereby closing off the upper end of the cylinder **18** to the atmosphere.

To provide for the return drive of the fastener driving assembly **27**, there is provided an air return chamber **60** communicating with the lower end of the cylinder **18** through a plurality of ports **62**. Moreover the drive piston **26** is provided with suitable one way valve means to provide pressurized fluid to the air return chamber **60** during the driving stroke thereof. To this end, the piston **26** is provided with a suitable groove **64** in its side wall containing a suitable sealing means such as the O-ring **66**. A suitable recess **68**, best illustrated in FIG. 4, defines a

fluid bypass around the O-ring **66** as the piston moves through its drive stroke. More specifically, when the pressure above the piston **26** is greater than the pressure in the cylinder **18** below the piston **26**, the O-ring **66** will be driven against the bottom of the groove **64**, permitting a blowby or bypass of pressurized fluid through the recess **68**. This bypass of pressurized fluid will pass through the port **62** into the air return chamber **60** to provide pressurized fluid for the return of the piston **26** to its static position. Once the main valve assembly **20** has closed to cut off the pressurized fluid from above the piston **26** and to exhaust the cylinder **18** above the piston **26** to the atmosphere through the exahuast valve assembly **32**, the O-ring **66** will be driven against the top edge of the groove **64** to provide a positive seal. At that time the pressurized fluid in the air return chamber **60** will return the piston **26** to its static position. Subsequent thereto, there is sufficient leakage around the driver blade **28** so that the pressurized fluid below the piston **26** will leak to atmosphere thereby preparing the tool **10** for the next fastener driving operation.

Referring now to FIGS. 5, 6, and 7, there is illustrated the improved single cycle control valve assembly **25** shown in conjunction with the safety valve assembly **22** and the trigger pilot assembly **24**. It will be understood, of course, that the control valve assembly **25** is equally applicable to a fastener driving tool which is not provided with the safety valve assembly **22**. However, referring to the illustrated embodiment, it will be understood that the safety valve assembly **22** includes a valve stem **70** having a notched or recessed diameter portion **70***a* adjacent its upper end which is slidably received within a sleeve **72** to define a valve chamber **74** closed at its ends. A first port **76** is provided in the valve chamber **74** in communication with the safety valve assembly **22** and which is normally in communication with the reservoir **16** through a reservoir port **78**. When the tool **10** is moved into engagement with the workpiece, the valve stem **70** is moved upwardly so that the upper end of the stem **70** closes off the reservoir port **78** and thereby closes off direct communication between the reservoir port **78** and the port **76**. The same movement of the valve stem **70**, however, places the port **76** in communication with a pilot valve port **80**.

The trigger pilot valve assembly **24** is of known design and includes a valve chamber **84** having opposed valve ports **86** and **88** defining valve seats alternately engageable by a valve element here illustrated as a ball valve **90**. The valve port **86** communicates between the valve chamber **84** and the reservoir **16**, while the valve port **88** exhausts the valve chamber **84** to the atmosphere when the ball valve **90** is unseated therefrom. To actuate the ball valve **90**, there is provided a suitable rod actuator **92** operated by a suitable trigger **94** (FIGS. 1, 2, and 3) so that when the fastener driving tool is at rest, the ball valve **90** is seated against the valve port **88**, and when the trigger **94** is depressed, the ball valve **90** closes the valve port **86**. Additionally the pilot valve port **80** on the safety valve assembly **22** communicates with the valve chamber **84** intermediate its length through a port **96**. It will be understood that in the operation of the trigger pilot valve when the trigger **94** is released the port **96** is in communication with the reservoir **16** through the valve port **86**; but when the trigger **94** is depressed unseating the ball from the valve port **88** and closing the valve port **86**, the port **96** is exhausted to the atmosphere.

Referring now to the improved control valve in accordance with the present invention, the valve **25** includes a valve cylinder **100** having a stepped portion to provide a large diameter cylinder **102** and a small diameter cylinder **104**. Slidably positioned within the valve cylinder **100** is a valve element **106**. A first O-ring **108** on the valve element **106** defines a small piston slideably received within the small diameter cylinder **104** and a second O-ring **110** on the portion of the valve element **106** slideably received within the large diameter cylinder **102** defines a large piston. A first port **112** near the end of the small diameter cylinder **104** beyond the stroke of the small piston **108** defines a vent port venting the small diameter cylinder **104** to the atmosphere. A second port **114** communicates between the reservoir **16** and the portion of the valve cylinder **100** adjacent the step therein so as to open between the strokes of the pistons **108** and **110**. A third port here shown as a plurality of radial ports **116** in the valve cylinder **100** positioned intermediate the stroke of the large piston **110** connects with the passageway **48**. Yet an additional port **118** beyond the travel of the large piston **110** communicates with the port **76** in the safety valve assembly **22** to provide a connection between the safety valve assembly **22** and the control valve assembly **25**.



From the above brief description of the invention the operation thereof is believed clear. However, briefly, it will be understood that the single cycle control valve **25** is operated in series with the main valve **20**. Fluidized pressure to control the main valve **20** passes through the control valve **25**; likewise air bled from the main valve **20** also bleeds the air from under the large diameter piston **110** of the control valve **25**. More specifically, referring to FIGS. 1 and 5, it will be understood that when the fastener driving tool **10** is static or at rest, and the valve stem **70** is not in engagement with the workpiece, pressurized fluid will be directed above the diaphragm **40** of the main valve assembly **20** to hold the main valve assembly closed by passing through the port **78** into the valve chamber **74**, through the port **76** and into the large diameter cylinder **102** of the control valve **25**, then passing through the ports **116** and the passageway **48** to the main valve assembly **20**. Engagement of the valve stem **70** with the workpiece changes the source of pressurized fluid from the port **78** through the valve port **86** of the trigger pilot valve, but does not affect the pressure loading on the main valve assembly **20**.

To fire the tool **10**, the trigger **94** is depressed so that the reservoir **16** is shut off, and the pressurized fluid above the main valve assembly **20** is exhausted to atmosphere first through the passageway **48** and the ports **116**, then through the ports **118** and the port **76** into the safety valve assembly, then through the port **80** of the safety valve assembly and the port **96** of the trigger pilot valve assembly to be exhausted through the valve port **88**. This exhaust of air from above the main valve assembly **20** is effective to cause the diaphragm **40** to snap upwardly, dumping the air from the reservoir **16** into the upper end of the cylinder **18** above the piston **26** and driving the piston **26** through a power stroke. Simultaneously with the driving of the piston **26**, the valve element **106** in the control valve **25** is driven downwardly, at a rate dependent on the differential diameters between the large and small pistons **110** and **108**, as indicated in FIGS. 2 and 6. At the same time it will be understood that pressurized fluid which bypasses around the O-ring **66** of the piston **26** through the recess **68** will build up into a pressurized fluid in the air return chamber **60** so as to provide a return force for the piston **26**.

To provide a snap action return of the piston **26** and driver blade **28** sequentially upon its reaching the bottom of its drive stroke, the valve element **106** of the control valve assembly **25** will reach the bottom of its stroke where the piston **110** passes over the port **116** thereby closing off further exhaust of pressurized fluid from above the main valve assembly **20**, as indicated in FIGS. 3 and 7, and connecting the top of the main valve assembly in communication with the reservoir **16** through the passageway **48**, port **116**, valve cylinder **100**, and the second port **114**. This will close the diaphragm **40** against the upper edge **18***a* of the power cylinder and simultaneously will exhaust the upper end of the cylinder **18** to the atmosphere through the exhaust valve assembly **32**, causing the pressurized fluid in the air return chamber **60** to return the piston **26** to its static or at rest position.

As soon as the trigger **94** is released, the ball valve **90** will reseat itself against the valve port **88** and the pressurized fluid against the top of the diaphragm **40** is maintained either through the port **78** when the valve stem **70** is not depressed, or through the valve port **86** and the trigger pilot valve **24** when the valve stem **70** is depressed by engagement with a workpiece.

As previously indicated, the safety valve assembly **25** may be adapted to various types of poppet valves and return mechanisms. Moreover the control valve **25** may be used with or without the safety valve **22**. The embodiment of the invention illustrated in FIGS. 8 and 9 illustrates a modified form of snap-acting control valve **126** applied to a modified form of fastener driving tool **128** having a different type of piston return arrangement. Since the fastener driving tool **128** in many respects is similar to the fastener driving tool **10** heretofore described, similar parts of both fastener driving tools will be represented by the same reference numerals.

Referring now to the embodiment of FIGS. 8 and 9, there is illustrated a fastener driving tool **128** including a housing **130**. The housing **130** is provided with a forward vertical head portion **130***a* and a rearward or handle portion **130***b* defining a fluid reservoir **132**. As heretofore described, the head portion **130***a* contains the main cylinder **18** having its upper end closed by the main valve assembly **20**. The conventional trigger pilot valve assembly **24** is provided for initiating the power stroke of the tool **128**. As heretofore described, the fastener driving assembly **27**, including the drive piston **26** and the driver blade **28** are slideably mounted within the power cylinder **18**. The exhaust valve assembly **32** provides for controlling the exhaust of the upper end of the cylinder **18** to the atmosphere.

The main valve assembly **20** controls the power stroke of the fastener driving assembly **27** in like manner as heretofore described. More specifically the main valve assembly **20** includes the diaphragm **40** having its peripheral edges clamped between the cap **42** and the edge of the head portion **130***a* of the housing **130**. Moreover the diaphragm **40** closes against the upper edge **18***a* of the cylinder **18** when the tool **128** is in the static position. The diaphragm **40** is urged to the closed position by the spring **44**. The passageway **46** connects the underside of the diaphragm **40** with the fluid reservoir **132**. An additional passageway **48** connects the upper side of the diaphragm **40** with the control valve **126** according to the present invention. Moreover it is understood that the exhaust valve assembly **32** includes the hollow valve stem **50** which communicates with the atmosphere through an exhaust passageway **52** in the cap **42** of the tool **128**. As heretofore described the hollow valve stem **50** is seatable against the valve seat **54** when the diaphragm **40** is raised off the edge **18***a* of the cylinder **18** to close the exhause valve assembly **32**.

To provide for the return force of the fastener driving assembly **27**, and to exhaust the air from below the drive piston **26** during the driving stroke, the lower end of the main cylinder **18** is provided with a plurality of ports **134** communicating with the control valve **126**. During the driving stroke of the fastener driving assembly **27**, fluid from below the drive piston **26** is exhausted to atmosphere through the exhaust ports **134** and control valve **126**. Upon completion of the stroke of both fastener driving assembly **27** and control valve assembly **126** the exhaust ports **134** admit pressurized fluid from the reservoir **132** to provide for the return stroke of the drive piston **26**.

Referring now to the control valve assembly **126** according to the present invention, the control valve assembly **126** is similar to the control valve assembly **25** heretofore described, but with an additional chamber and elongated stem to provide for exhaust and control of pressurized fluid below the drive piston **26**. Accordingly, there is provided a valve cylinder **136** having the large diameter cylinder **102** and the small diameter cylinder **104** as heretofore described, and additionally provided with an additional stepped diameter portion defining a small exhaust cylinder **138** contiguous with the large diameter cylinder **102** and, in the illustrated embodiment, on the side thereof remote from the small diameter cylinder **104**. As the control element of the control valve assembly **126**, there is provided a modified valve element **140**, similar in some respects to the valve element **106** in that it is provided with an O-ring **108** defining a small piston slideably received within the small diameter cylinder **104**, and is further provided with the O-ring **110** defining the large piston slideably received within the large diameter cylinder **102**. Additionally the valve element **140** has a portion extending into the exhaust cylinder and provided with a pair of spaced O-rings **142** and **144** each defining a piston slideably received within the exhaust cylinder **138**. In like manner as heretofore described in connection with the embodiment of FIGS. 1 through 7, the control valve assembly **128** is provided with the fiirst or vent port **112** adjacent the closed end of its small cylinder **102**, beyond the stroke of the small piston **108** and is provided with an additional port **114** communicating directly with the fluid reservoir **132** and intermediate the length of the strokes of the pistons **108** and **110**, and additionally the third port **116** connects the passageway **48** with the large diameter cylinder **102** intermediate the length of the stroke of the piston **110**, while the fourth port **118** connects the end of the large diameter cylinder **102** to the valve chamber **84** in the trigger pilot valve assembly **24**. In addition to the ports heretofore described, the exhaust cylinder **138** contains a fifth port **146** in communication with the fluid reservoir **132** and extending from the side wall of the exhaust cylinder **138** intermediate the strokes of the respective pistons **142** and **144**. Additionally a sixth port **148** communicates with the lower end of the power cylinder **18** through the exhaust ports **134** therein and extends through the side wall of the exhaust cylinder **138** intermediate the length of the stroke of the end piston **144**. The lower end of the exhaust cylinder **138** defines an additional port **150** exhausted to the atmosphere.

For controlling the operation of the tool **128**, there is provided the trigger pilot valve assembly **24** in like manner as that heretofore described in the embodiment of FIGS. 1 through 7 and including the valve chamber **84** defining a valve port **86** in communication with the fluid reservoir **132** and an additional valve port **88** exhausting to atmosphere. A ball valve is alternately seatable against the valve ports **86** and **88** in response to movement by an actuator **92** upon depression or release of the trigger **94**. The additional port **96** extends from the valve chamber **84** intermediate the movement of the ball valve **90** and communicates with the end of the large diameter cylinder **102** through the port **118**.

In view of the above detailed description of the improved fastener driving tool **128**, its operation is believed clear. However, briefly, it will be understood that the operation of the fastener drivng tool **128** is similar to that of the fastener drivng tool **10** described in the embodiments of FIGS. 1 through 7, except for the method of piston return and the exhaust of the cylinder **18***a* below the piston **26** during the power or drivng stroke. Accordingly, only this aspect of the fastener driving tool **128** is herein further described. As is herein apparent, driving of the piston **26** through its power or drive stroke is effective to exhaust the fluid from below the piston **26** through the exhaust ports **134** in the cylinder **18**, through the port **148** into the exhaust cylinder **138** of the control valve assembly **126** and to atmosphere through the port **150** thereof. However, as the piston **26** reaches the lower end of its stroke, the piston **144** passes over the opening of the ports **148** in the exhaust cylinder **138**, thereby closing the exhaust ports **148** from communication with the atmosphere and connecting the exhaust

ports **148** to the fluid reservoir **132** through the ports **146**. Pressurized fluid will now enter through the ports **146**, pass through the body of the exhaust cylinder **138** and into the port **148** to be directed through the exhaust ports **134** in the lower end of the power cylinder **18** to return the piston **26** upwardly to its static or at rest position.

Advantageously the embodiment of FIGS. 8 and 9 eliminates the air return chamber of the drive system thereby permitting for a small and more compact tool. Moreover there is a slight increase in the drive power by eliminating the air cushion which necessarily builds up under the drive piston during the drive stroke. The rapid return of the driver blade permits movement of the gun across fabric or other work surface without the danger of having the driver catch and snag the material. Moreover there may be provided a greater driver blade protrusion in the fired position, allowing for a fastener to be driven flush into a workpiece without applying pressure to the gun and with a very minimum of recoil.

Although the present invention has been described by reference to several embodiments thereof, it will be apparent that numerous other modifications and embodiments may be devised by those skilled in the art and it is intended by the appended claims to cover all modifications and embodiments which will fall within the true spirit and scope of the present invention.

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

**1.** A pneumatically operated fastener driving tool comprising a housing having a cavity defining a fluid reservoir, a cylinder in said housing, a piston slideably mounted in said cylinder, diaphragm valve engaging one end of said cylinder for controlling the admission of fluid to and the exhaustion of fluid from said one end of the cylinder, control valve means connected to said diaphragm valve automatically operable upon initiation through a single-cycle for controlling the position of said diaphragm valve means to automatically and sequentially cycle said diaphragm valve first to open to connect said one end of the cylinder to the reservoir and thereafter to automatically exhaust said one end of the cylinder, and pilot valve means for initiating the operation of said cycle of said control valve means.

**2.** A pneumatically operated fastener driving tool comprising a housing having a cavity defining a fluid reservoir, a main cylinder in said housing, and a drive piston in said cylinder, cylinder valve means for controlling the admission and exhaust to said one end of said cylinder, single-cycle control valve means connected to said cylinder valve means automatically controlling the position of said cylinder valve means to sequentially cycle said cylinder valve means first to open to connect said one end of said main cylinder to the said reservoir and thereafter to exhaust said one end of said main cylinder, said control valve including a valve body defining a valve cylinder having stepped diameters to provide a large diameter cylinder contiguously connected to a small diameter cylinder, a valve element slideable in said valve cylinder and including first means defining small piston means in said small diameter cylinder and second means defining large piston means in said large diameter cylinder, first port means in the end of said small cylinder remote from said large cylinder and vented to the atmosphere, second port means adjacent the stepped portion of said control valve intermediate the strokes of said pistons communicating with said fluid reservoir, third port means in said large diameter cylinder intermediate the stroke of said large piston means communicating with said cylinder valve means, and fourth port means in the end of said large cylinder remote from said small cylinder, and pilot valve means connected to the last mentioned port means for initiating the operation of said control valve and adapted sequentially to connect said last mentioned port means first to the fluid reservoir and, upon actuation, to exhaust said last mentioned port to the atmosphere.

**3.** A pneumatically operated fastener driving tool as set forth in claim **2** above wherein said cylinder valve means includes a diaphragm means extending across said one end of said main cylinder having one side thereof engageable with said main cylinder controlling the flow of fluid into said one end and having the periphery of said one side of said diaphragm exposed to fluid from said fluid reservoir, and said cylinder valve means further including a hollow valve stem secured to said diaphragm and connecting said one end of said cylinder to the atmosphere, and a valve seat disposed adjacent the end of said valve stem remote from said cylinder adapted to be engaged by the valve stem when the diaphragm is released to close off said one end of said cylinder, and wherein said third port of said control valve means is connected to the other side of said diaphragm means so that upon exhaust of said one other of said diaphragm means, said diaphragm raises off said one end of said power cylinder to admit pressurized fluid from said reservoir into said one end of said cylinder, and subsequent admission of pressurized fluid to said other side of said diaphragm means is effective to sequentially exhaust the fluid from said one end of said cylinder to permit said power piston to return to its at rest position.

**4.** A pneumatically operated fastener driving tool as set forth in claim **2** above wherein said main cylinder includes exhaust port means adjacent its other end, and wherein said control valve additionally includes an additional stepped diameter portion defining an exhaust cylinder contiguous with said valve cylinder, and said valve element extends into said exhaust cylinder, and wherein said valve element is provided with third and fourth means defining third and fourth spaced piston means, said exhaust cylinder being provided with a fifth port means intermediate the length of the strokes of said third and fourth piston means and communicating with said fluid reservoir, and wherein said exhaust cylinder is provided with sixth port means communicating with said exhaust port means in said other end of said main cylinder and communicating with the exhaust cylinder intermediate the stroke of said fourth piston, and wherein the end of said exhaust cylinder beyond the stroke of siad fourth piston means is provided with additional port means exhausting to the atmosphere.

**5.** A pneumatically operated fastener driving tool comprising a housing having a cavity defining a fluid reservoir, a cylinder in said housing, a piston slideably mounted in said cylinder, cylinder valve means for controlling the admission of fluid to and the exhaustion of fluid from one end of the cylinder and held closed by the pressure of fluid from said reservoir acting against one surface thereof and is opened by the exhaust of fluid from said one surface, control valve means connected to said cylinder valve means automatically controlling the position of said cylinder valve means to sequentially cycle said cylinder valve means first to open to connect said one end of the cylinder to the reservoir and thereafter to exhaust said one end of the cylinder, and pilot valve means for initiating the operation of said control valve means.

**6.** A pneumatically operated fastener driving tool comprising a housing having a cavity defining a fluid reservoir, a cylinder in said housing, a piston slideably mounted in said cylinder, cylinder valve means for controlling the admission of fluid to and the exhaustion of fluid from one end of the cylinder, said cylinder valve means including diaphragm means extending across said one end of said cylinder having one side thereof engageable with said cylinder controlling the flow of fluid into said one end and having the periphery of said one side of said diaphragm exposed to fluid from said fluid reservoir and further including a hollow valve stem secured to said diaphragm and connecting said one end of said cylinder

to atmosphere, and a valve seat disposed adjacent the end of said valve stem remote from said cylinder adapted to be engaged by the valve stem when the diaphragm is raised to close off said one end of said cylinder, control valve means connected to said cylinder valve means automatically controlling the position of said cylinder valve means to sequentially cycle said cylinder valve means first to open to connect said one end of the cylinder to the reservoir and thereafter to exhaust said one end of the cylinder, and pilot valve means for initiating the operation of said control valve means, said control valve means being connected to admit pressurized fluid from said reservoir to the other side of said diaphragm means and upon actuation of said pilot valve means to automatically and sequentialy first exhaust the fluid from said other side of said diaphragm means and thereafter to connect said other side of said diaphragm means to said fluid reservoir to cycle said power piston through a driving and return stroke.

7. A pneumatically operated fastener driving tool comprising a housing having a cavity defining a fluid reservoir, a cylinder in said housing, a piston slideably mounted in said cylinder, cylinder valve means for controlling the admission of fluid to and the exhaustion of fluid from one end of the cylinder, control valve means connected to said cylinder valve means automatically controlling



the position of said cylinder valve means to sequentially cycle said cylinder valve means first to open to connect said one end of the cylinder to the reservoir and thereafter to exhaust said one end of the cylinder, and pilot valve means for initiating the operation of said control valve means, said control valve being further connected sequentially to exhaust said cylinder below said piston to the atmosphere, and thereafter automatically and sequentially to connect said lower end of said cylinder to the fluid reservoir to provide the power for the return stroke of the piston.

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