United States Patent

[11] **3,547,003**

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[45] Patented **Dec. 15, 1970**
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[54] **FASTENER DRIVING TOOL**
22 Claims, 17 Drawing Figs.

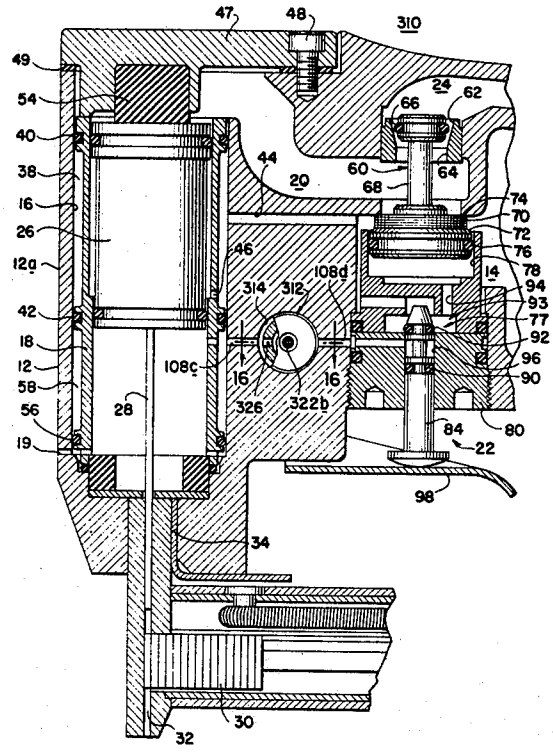
[52] **U.S. Cl.** **91/252,**
91/263, 91/300, 91/308, 91/309, 91/321
[51] **Int. Cl.** **F01l 25/06,**
F01b 7/18
[50] **Field of Search** 91/218
(Cursory), 308(Cursory), 304(Cursory),
281(Cursory), 290(Cursory), 220, 252, 300,
305(Cursory), 207(Cursory), 309(Cursory),
321(Cursory)

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Primary Examiner—Paul E. Maslousky
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ABSTRACT: There is provided a pneumatic fastener driving tool having control means providing for successive fastener driving operations upon a single depression of the tool trigger. The operating cycle is controlled by the tool piston closing a valve passageway connected sequentially to the atmosphere and to the fluid in the pneumatic return system of the tool driver. The tool is readily adaptable for multiblow operation of a single fastener by the addition of a control valve or element. Additionally a shuttle valve is provided so that the tool may selectively be fired automatically or used as a single-stroke tool.



PATENTED DEC 15 1970

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SHEET 1 OF 6

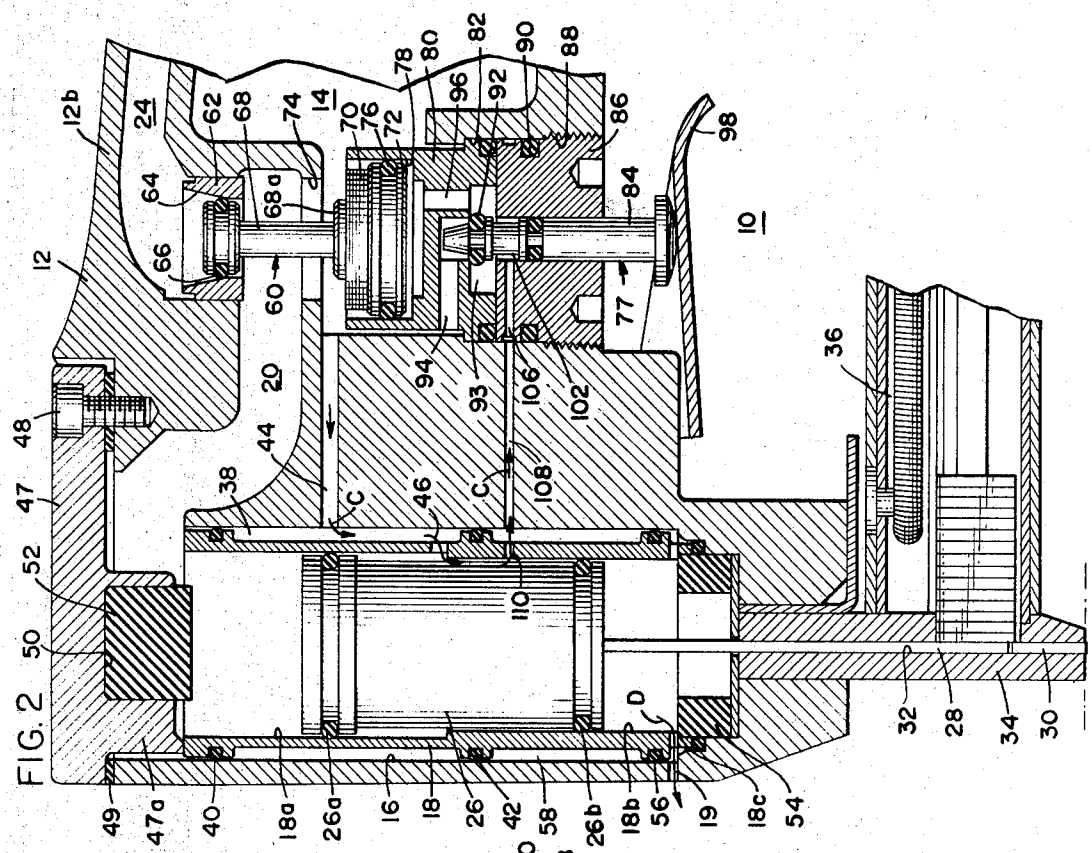


FIG. 2

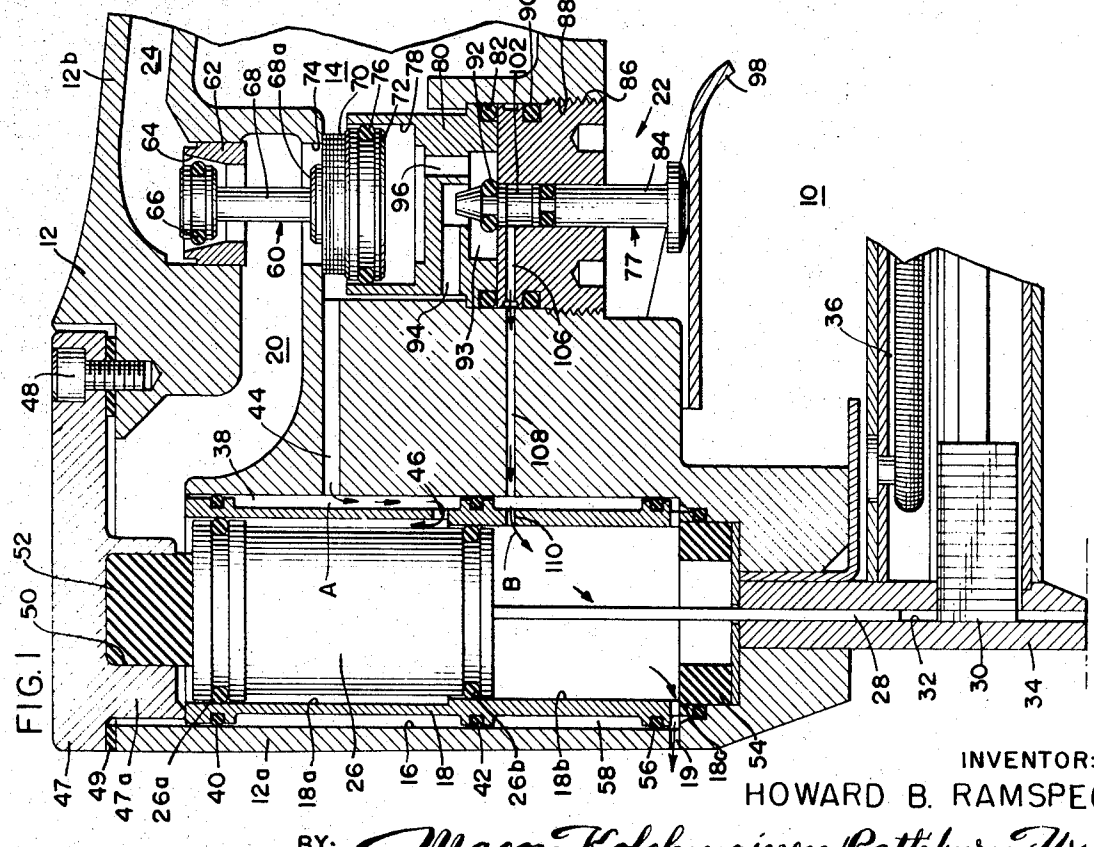


FIG. 1

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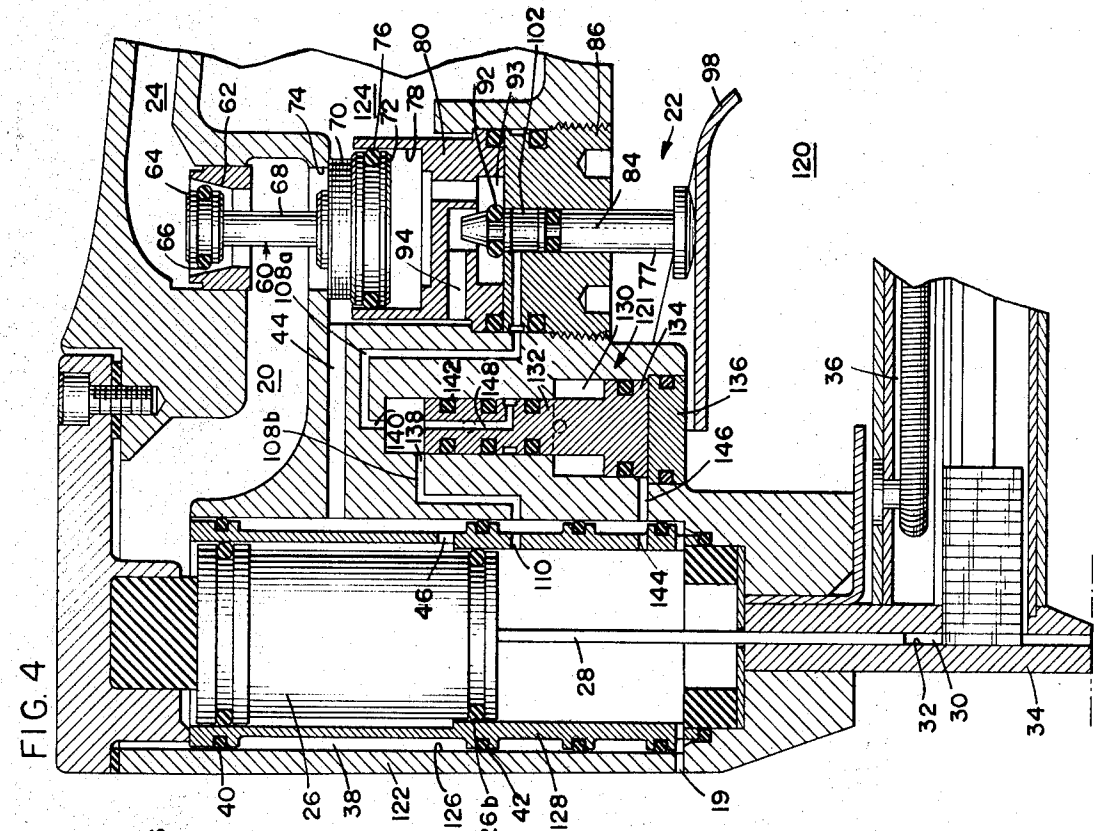


FIG. 4

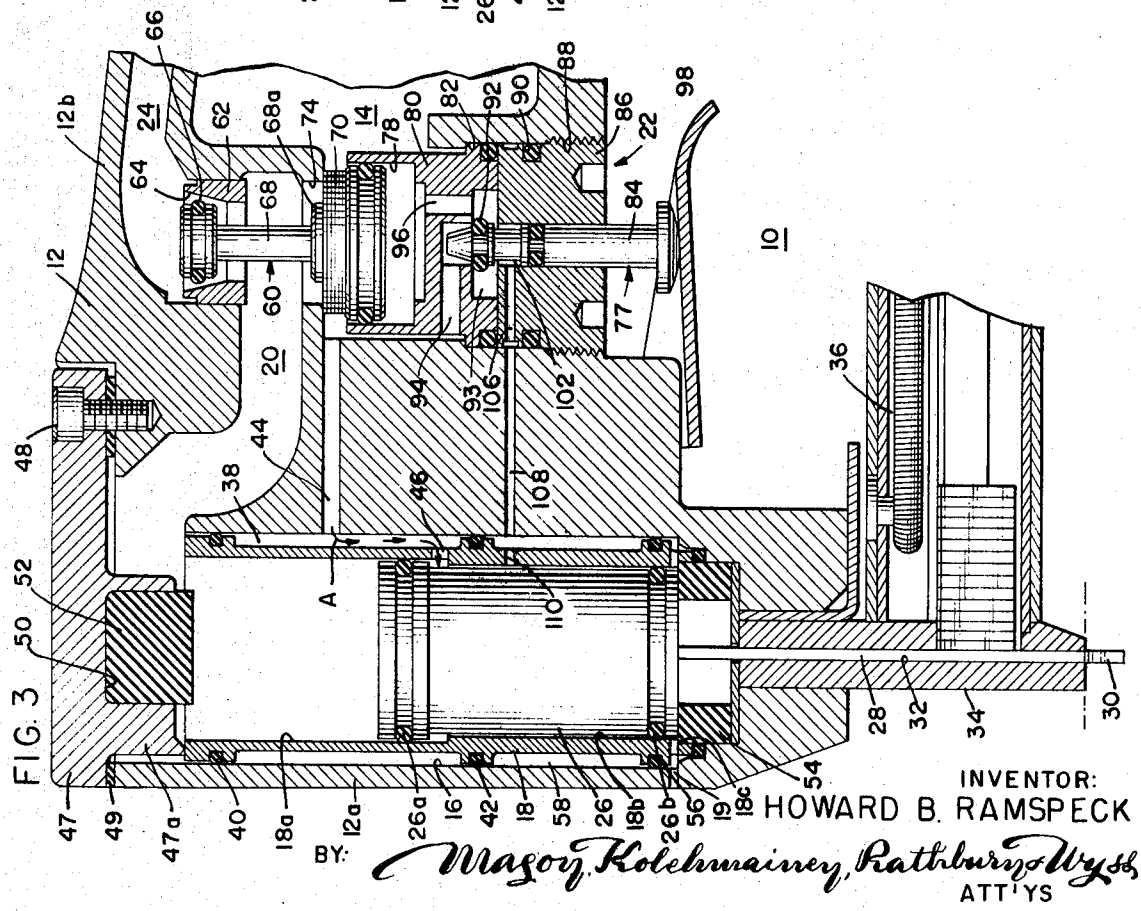


FIG. 3

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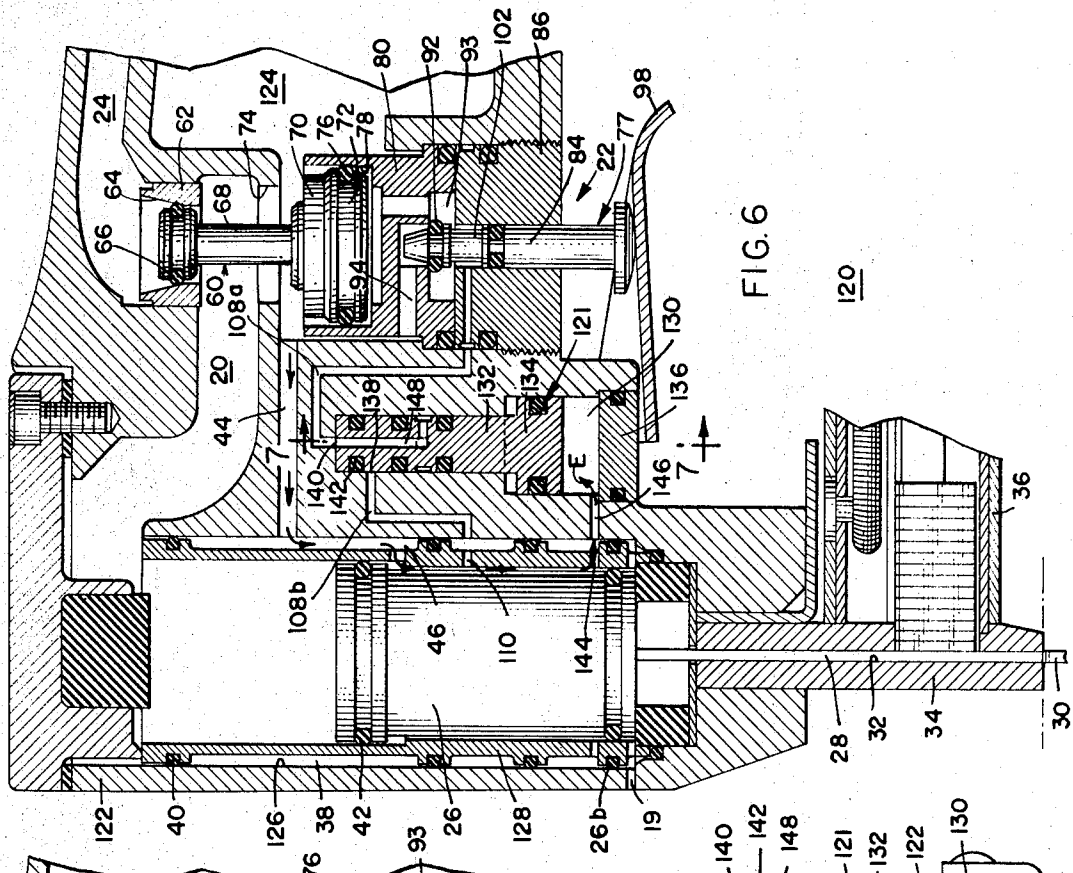


FIG. 6

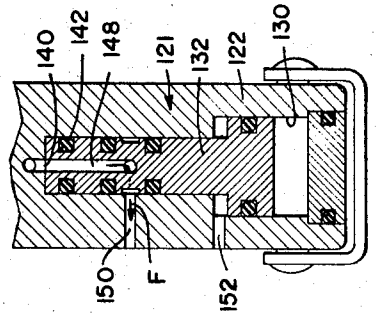


FIG. 7

FIG. 5

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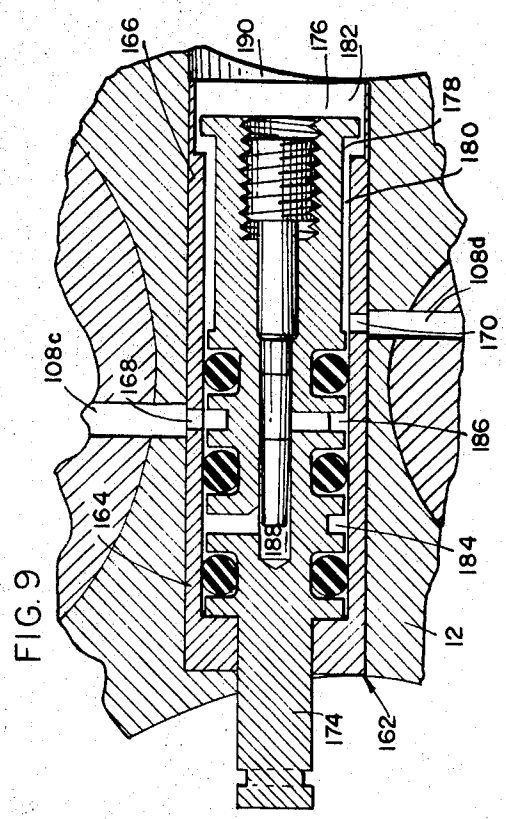


FIG. 9

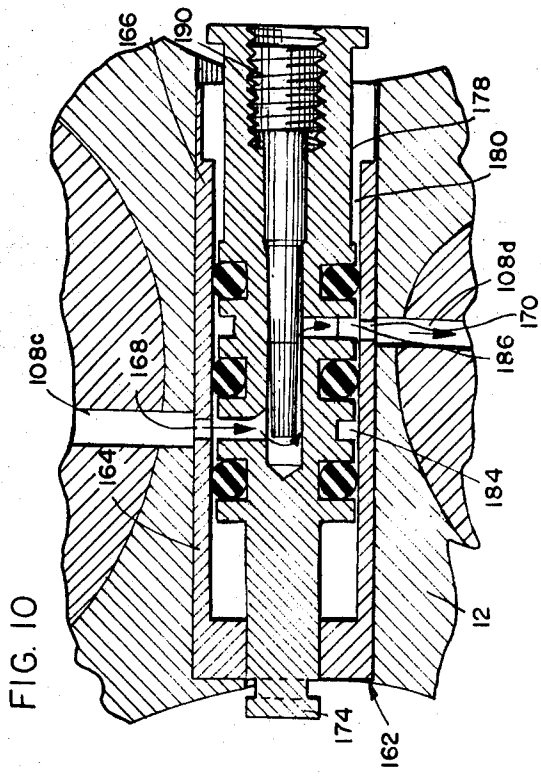


FIG. 10

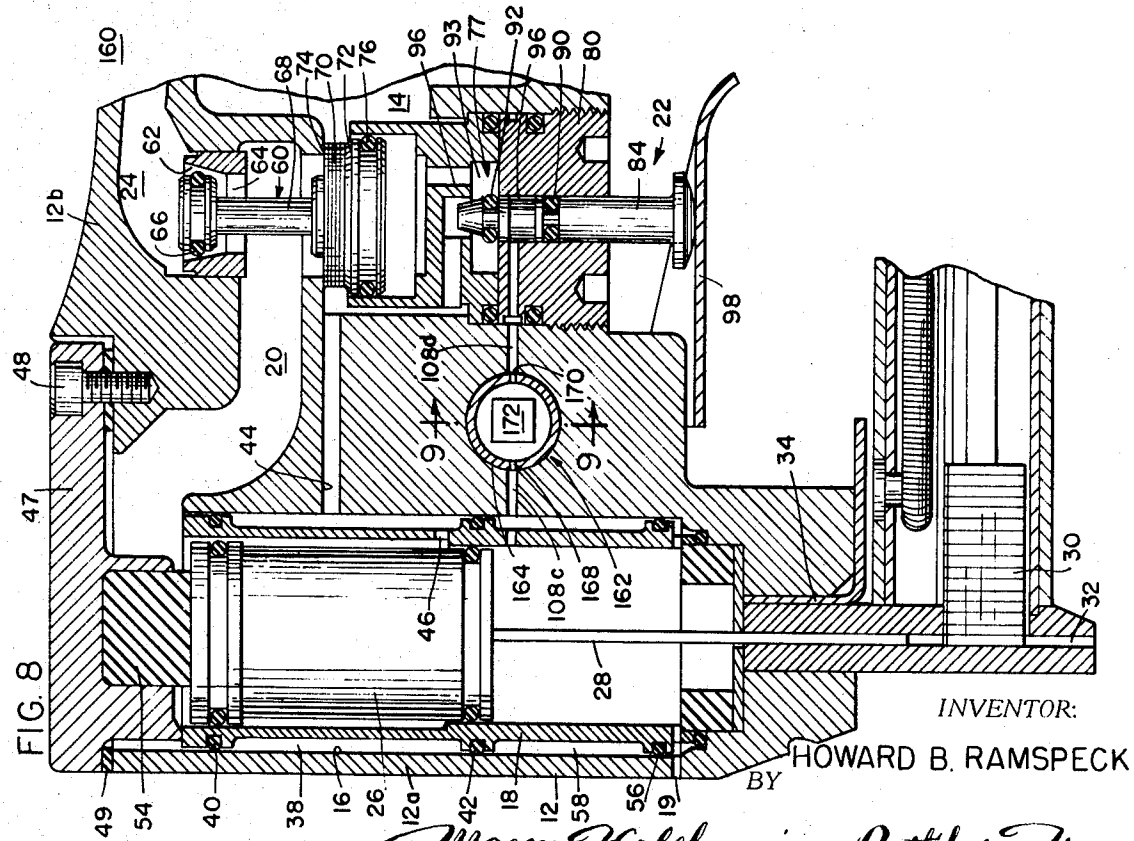


FIG. 8

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FIG. 11

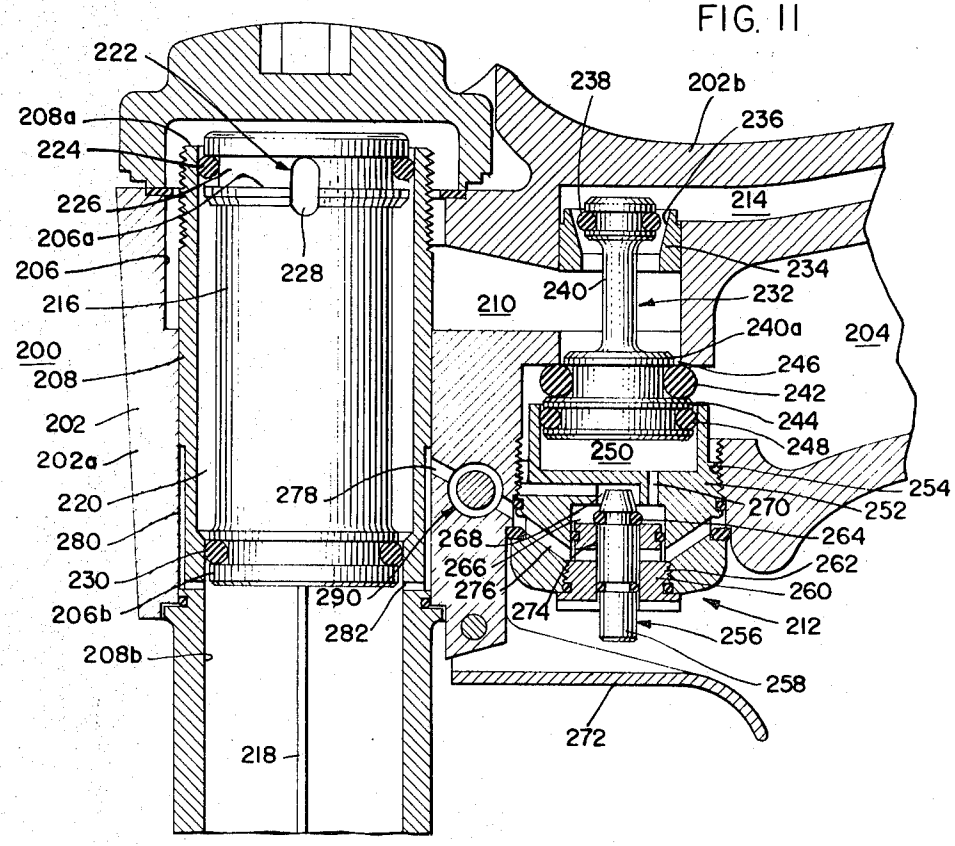


FIG. 14

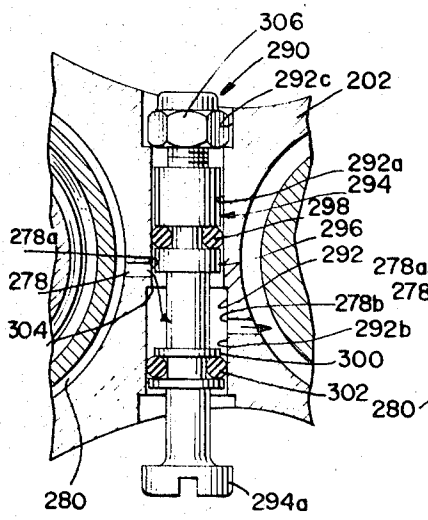


FIG. 13

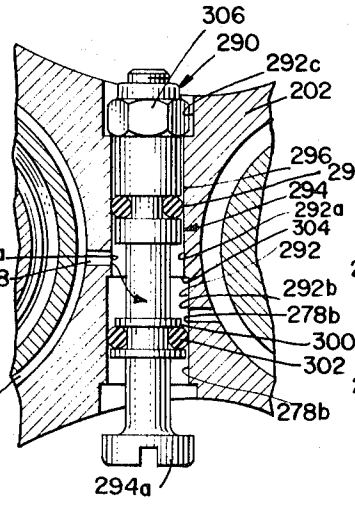
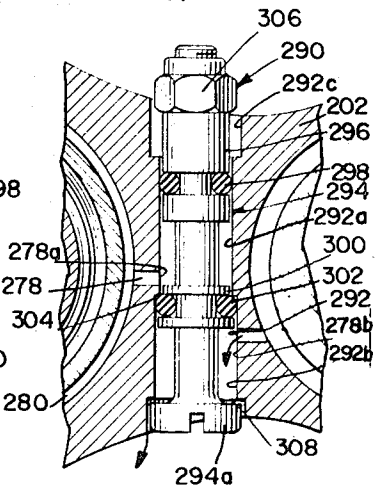


FIG. 12



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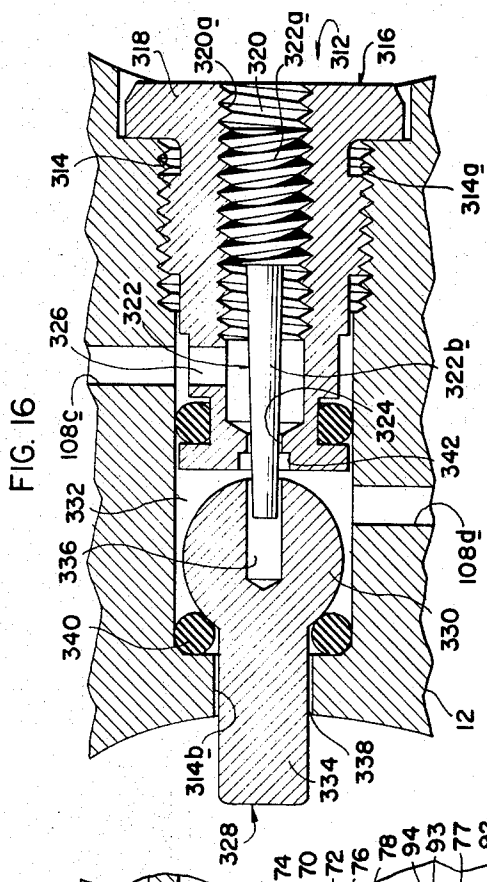


FIG. 16

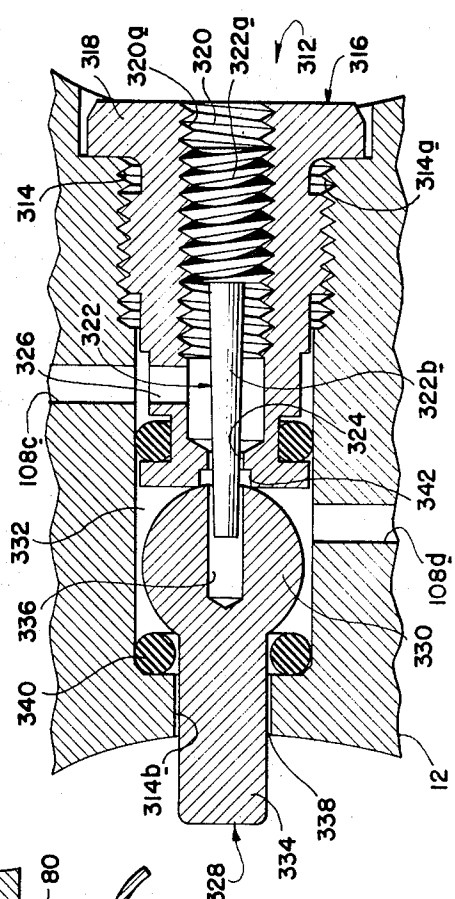


FIG. 17

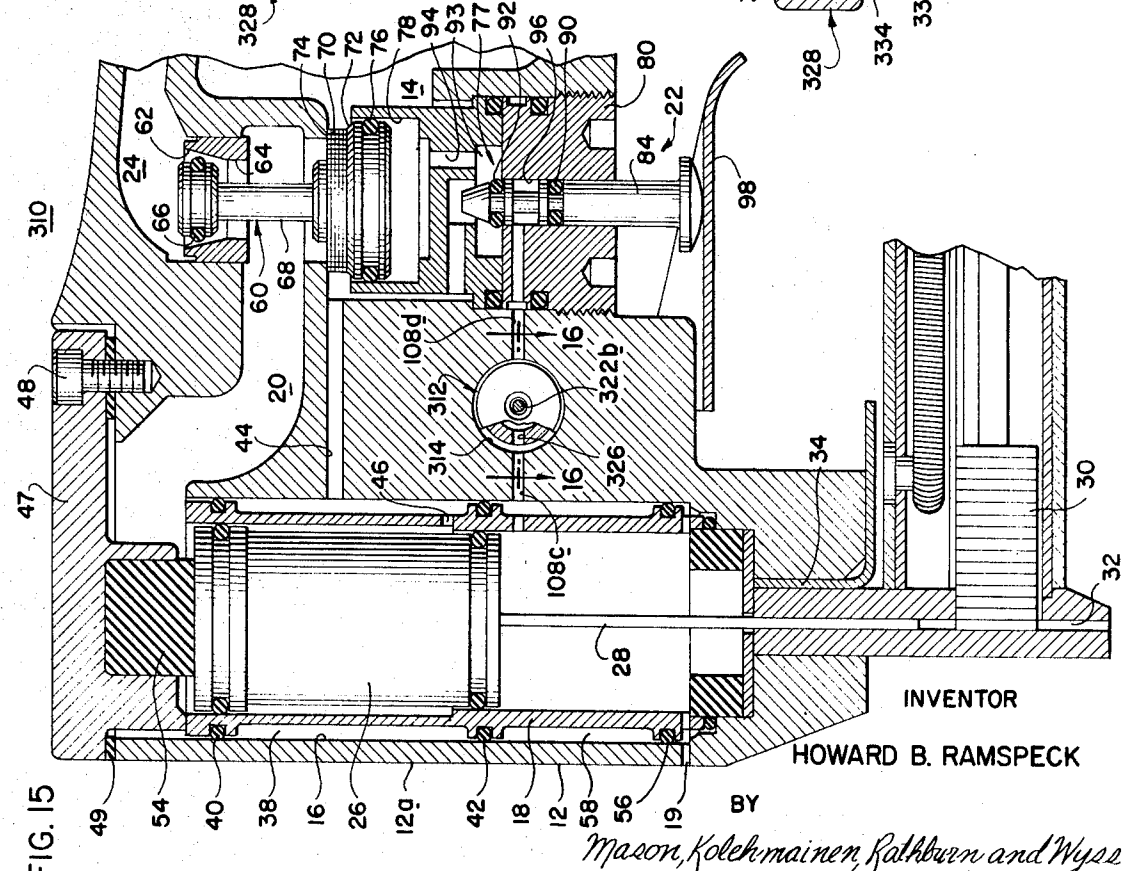


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FASTENER DRIVING TOOL

This invention relates to a fastener-driving tool, particularly to a fastener-driving tool including new and improved control means providing for successive fastener-driving operations upon a single depression of the tool trigger. A multiple-stroke fastener-driving tool similar to that shown in this application is described and claimed in a copending U.S. Pat. application of Howard B. Ramspeck, U.S. Pat. Ser. No. 708,330, filed Feb. 26, 1968, now abandoned.

Commercially available pneumatic fastener-driving tools more generally provide a single fastener-driving stroke upon each depression of the tool trigger. However more recently situations have arisen wherein it is desirable to drive a plurality of fasteners in successive fastener-driving operations at suitable short intervals upon a single depression of the tool trigger. One such automatic tool is described and claimed in the U.S. Pat. application Ser. No. 629,244 of Allen R. Obergfell filed Apr. 7, 1967, now abandoned.

Additionally situations have also arisen where it is desirable to drive larger and longer fasteners and therefore the fastener-driving tool is unable to complete the driving of the fastener in a single stroke. In these situations it would be desirable to provide a fastener-driving tool which will cycle repetitively until such time as a single fastener has been fully driven, and thereafter will return to its normal position in preparation for the next fastener driving operation.

Additionally it may be sometimes desirable to prevent repetitive cycling of the tool, so that but a single fastener will be driven by each depression of the trigger. Moreover in the automatic firing or cycling of a fastener-driving tool it may become desirable to drive one fastener, and thereafter for the tool to return automatically to the automatic or multifire position.

An object of the present invention, therefore, is to provide a new and improved pneumatically actuated fastener-driving tool of the type to continuously and repetitively operate through its working cycle for a selected interval.

An object of the present invention is to provide a new and improved pneumatically actuated fastener-driving tool of the type to continuously and repetitively operate through its working cycle so long as the trigger thereof is depressed.

Another object of the present invention is to provide a new and improved pneumatically actuated fastener-driving tool of the type to continuously and repetitively cycle during the driving of a single fastener, and to stop cycling upon completion of the driving of the fastener.

Yet another object of the present invention is to provide a new and improved pneumatically actuated fastener-driving tool which may be selectively set to automatically cycle so long as the trigger thereof is depressed, or selectively set to complete a single stroke upon each depression of the trigger.

Another object of the present invention is to provide a new and improved pneumatically actuated fastener-driving tool which may be selectively set to complete a single stroke of operation upon depression of the trigger and which will thereafter automatically return to the automatic or multifire position.

Further objects and advantages of the present invention will become apparent as the following description proceeds and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

In accordance with these and many other objects, an embodiment of the invention comprises a pneumatically operated fastener-driving tool or apparatus having a housing defining a cylinder and a fluid reservoir for compressed medium. The cylinder has an open upper end, and the lower end of the cylinder exhausts to the atmosphere. A passageway in the housing communicating with the open upper end of the cylinder includes a first port opening to the atmosphere and a second port communicating with the reservoir. A manually-controlled valve normally connects the passageway to the atmosphere through one port and is operable to a position in which the connection to the atmosphere is closed and the passageway is connected to the reservoir through the other port to supply compressed air to the cylinder. This air drives a piston which is slideably mounted in the cylinder and which is connected to a fastener-driving blade downwardly from a normal position adjacent its open upper end to a lower position. During this power stroke of the piston, the air disposed in the cylinder below the piston is discharged. One such control valve for a fastener-driving tool is more fully described in U.S. Pat. No. 3,173,340 granted on Mar. 16, 1965 to Richard H. Doyle et al.

In accordance with the present invention, the fastener-driving tool is provided with a pneumatic piston return means for returning the piston to the upper end of the cylinder. A port in the wall of the cylinder intermediate the stroke of the piston is controlled or closed by movement of the piston or piston ring past the port so as to alternately connect the return air chamber to the control valve, and exhaust the control valve to atmosphere, thereby to cycle the control valve in sequence with the stroke of the piston.

In accordance with another feature of the present invention, the fastener-driving tool is adapted for a multiblow cycling arrangement whereby the fastener-driving tool will repetitively cycle until such time as a fastener is fully driven, and then the cycling of the tool piston will automatically terminate.

In accordance with yet another feature of the present invention, a shuttle valve is provided for altering the operation of the tool from an automatic-fire tool to a single-fire tool, and for adjusting the time rate of recycling of the tool. In one embodiment the shuttle valve will return to an automatic-fire position automatically after completion of a single-fire operation.

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 fragmentary sectional view of a fastener-driving tool according to the present invention illustrated in its normal position;

FIG. 2 is a fragmentary sectional view of the fastener-driving tool of FIG. 1, illustrated with the piston moving through its power stroke;

FIG. 3 is a fragmentary sectional view of the fastener-driving tool of FIG. 1, illustrated with the drive piston at the end of its power stroke;

FIG. 4 is a fragmentary sectional view of a fastener-driving tool according to another embodiment of the present invention wherein the tool will repetitively cycle to drive a single fastener until such time as the fastener is fully driven;

FIG. 5 is a fragmentary sectional view of the fastener-driving tool of FIG. 4 shown with the piston thereof moving through its power stroke;

FIG. 6 is a fragmentary sectional view of the fastener-driving tool of FIG. 4, illustrated with the fastener fully driven;

FIG. 7 is a fragmentary sectional view illustrating the multiblow valve in the fastener-driving tool of FIG. 4, taken along line 7–7 of FIG. 6;

FIG. 8 is a fragmentary sectional view of a fastener-driving tool according to yet another embodiment of the present invention illustrating a shuttle valve providing for selective setting of the fastener-driving tool between an automatic-fire position and a single-stroke position;

FIG. 9 is a cross-sectional view of the fastener-driving tool of FIG. 8, illustrating the shuttle valve in the single-fire position;

FIG. 10 is a cross-sectional view of the fastener-driving tool of FIG. 9, illustrating the shuttle valve in the autofire position;

FIG. 11 is a fragmentary sectional view of yet another fastener-driving tool according to the present invention illustrating a modified form of shuttle valve which will automatically return to the multifire or autofire position after a single-fire operation;

FIG. 12 is a cross-sectional view of the fastener-driving tool of FIG. 11, illustrating the shuttle valve of FIG. 11 in the single-fire position;

FIG. 13 is a cross-sectional view of the shuttle valve of FIG. 12, illustrated in the autofire position;

FIG. 14 is a cross-sectional view of the shuttle valve of FIG. 12, illustrated with a restricted speed adjustment;

FIG. 15 is a fragmentary sectional view of yet another fastener-driving tool according to the present invention illustrating a modified form of shuttle valve which will automatically return to the autofire position after a single-fire operation;

FIG. 16 is cross-sectional view of the modified shuttle valve taken along line 16–16 of FIG. 15, illustrated in the autofire position; and

FIG. 17 is a cross-sectional view of the shuttle valve of FIG. 15, illustrated in the single-fire position.

Referring now to the drawings, specifically to the embodiment of FIGS. 1, 2 and 3, there is illustrated a fastener-driving tool generally as 10 which embodies the present invention. The tool 10 includes a housing 12 having a forward and generally vertically extending head portion 12*a* and a rearwardly extending hollow handle portion 12*b* forming a reservoir 14 to which is supplied pressurized fluid, such as compressed air, in any suitable manner as by a flexible air line. The head portion 12*a* of the housing 12 includes the cavity 16 in which is mounted a differential-diameter cylinder 18 having its lower end in communication with the atmosphere through suitable ports 19, and an open upper end 18*a* in continuous communication with a passageway 20 formed in the housing.

A manually-actuated control valve assembly indicated generally as 22 normally connects the passageway 20 to the atmosphere through a passageway 24 formed in the hollow handle portion 12*b* and is operable to a position in which it connects the passageway 20 to the fluid in the reservoir 14. The fluid admitted to the passageway 20 enters the open upper end of the cylinder 18 and drives a differential-diameter piston or piston assembly 26 which is slideably mounted within the cylinder 18 and to which is secured the upper end of a fastener-driving blade 28. The lower end of the driver blade 28 is adapted to engage and drive a fastener 30 through a drive track 32 in a nosepiece assembly 34 by a magazine assembly indicated generally as 36.

During the downward movement of the piston assembly 26, the air disposed within the cylinder 18 below the piston 26 is discharged to the atmosphere through the lower end of the cylinder 18 through the ports 19.

To provide for the pneumatic return of the piston chamber 38 formed between upper and intermediate O-rings 40 and 42 between the cylinder 18 and the cavity 16, continuously in communication with the reservoir 14 through a passageway 44. The return air chamber 38 communicates with the cylinder 18 through a return air port 46. Since the cylinder 18 and the piston 26 are of the differential-diameter type, with a large cylinder portion 18*a* and a small cylinder portion 18*b* receiving a large piston element 26*a* defined by an O-ring and a small piston element 26*b* also defined by an O-ring, the return air port 46 continuously opening between the piston elements 26*a* and 26*b* provides for the exertion of a greater upward force on the piston 26 than the downward force, and the differential force will continuously bias the piston 26 upwardly. However the upward bias of the piston 26 is small enough to become negligible compared to the driving force of the piston during its drive stroke. The piston 26 has substantial length so that the port 46 is always between the piston elements 26*a* and 26*b* throughout the stroke of the piston. Thus when the piston 26 is to be pneumatically returned to its normal position, the control valve assembly 22 operates so that the passageway 20 is again connected to the atmosphere through the passageway 24 and the compressed air in the return air chamber 38 acting on the differential diameters of the piston 26 will drive the piston 26 upwardly to its normal position as indicated in FIG. 1.

The mechanical construction of the housing 12 and the magazine assembly 36 is disclosed in detail in U.S. Pat. No. 3,215,324 granted May 2, 1965 to Thomas H. Dorney and assigned to the assignee of the present invention. However, in general, the head portion 12*a* of the housing 12 is closed by a closure cap 47 secured to the housing 12 by a plurality of machine screws 48 with a resilient sealing gasket 49 interposed therebetween. An opening 50 in a depending portion 47*a* on the closure cap 47 carries a block or bumper 52 of resilient material that engages the upper end of the piston 26, and an annular resilient bumper 54 is disposed in the lower end of the cavity 16 to cushion the termination of the power stroke of the piston 26. The bumper 54 is held in position at the bottom of the cylinder 18 by engagement with a shouldered portion 18*c* formed on the cylinder 18. The lower end of the interior of the cylinder 18 is placed in communication with the atmosphere through the ports 19 extending through the housing 12. The interface between the outer wall of the cylinder 18 and the inner wall of the cavity 16 is sealed by an additional O-ring 56 which further defines, along with the O-ring 46, a delay chamber 58.

The connection of the open upper end of the cylinder 18 to either the atmosphere or the fluid reservoir 14 is controlled by a pneumatically controlled main valve portion 60 of the manually actuated control valve assembly 22. The valve portion 60 includes an exhaust valve seat 62 carried on the housing 12 having downwardly and inwardly tapered openings 64 through which the passageway 20 is normally placed in communication with the exhaust passageway 24. The openings 64 can be closed by a resilient O-ring 66 defining a valve element carried on the upper end of a valve stem 68. A resilient valve element 70 defining a control valve is also carried on the valve stem 68 disposed between a shouldered portion 68*a* on the valve stem 68 and a piston 72 that is secured to the lower end of the stem 68. The resilient valve element 70 normally closes a port or passageway 74 interposed between the reservoir 14 and the passageway 20. The piston 72 carries and O-ring 76 and is slideably mounted within a valve cylinder 78 formed in a valve body 80 received within an opening 82 in the housing 12.

A trigger or pilot valve portion 77 is included in the control valve assembly 22 to control the operation thereof and to permit the assembly 22 to be operated with a minimum manually applied force. This trigger valve portion 77 includes an operating pin 84 that is slideably mounted within an axial bore formed in a valve body member 86 that is threadedly received within an opening 88 in the housing 12. An O-ring 90 seals the interface between the valve body member 86 and the opening 88. The upper end of the operating pin 84 is tapered and carries an O-ring 92 that operates as a valve element to control communication between the reservoir 14 and a valve chamber 93 through a passageway 94. In the normal condition or released state of the control valve assembly 22, compressed air flows from the reservoir 14 through the passageway 94 to deflect or bias the O-ring 92 downwardly to permit the compressed air to build up within the upper end of the valve chamber 93. This compressed air flows through a passageway 96 in the valve body 80 to enter the lower end of the cylinder 78. This compressed air, which is at the same pressure as the fluid within the reservoir 14, operates on the greater area lower surface of the piston 72 and overcomes the force of the compressed air in the reservoir 14 acting on the upper effective surface of the piston 72 to provide an upwardly directed force that holds the resilient valve element 70 in engagement with the housing 12 to close the port 74 and holds the valve element 66 spaced from the valve seat 62 so that the passageway 20 normally communicates with the atmosphere through the opening or port 64 and exhaust passageway 24.

When the tool 10 is to be operated, a trigger or actuating element 98 pivotably mounted on the housing 12 is pivoted in a counterclockwise direction to engage the lower end of the operating pin 84. This moves the pin 84 upwardly so that the O-ring 92 engages the adjacent portion of the valve body 80 to seal the passageway 94. At the same time the O-ring is moved away from the member 86 so that the upper end of an annular passageway or groove 102 is uncovered. The passageway 102 connects with a passageway 106 in the valve body member 86

and further communicates through a passageway **108** with the delay chamber **58** defined between the cylinder **18** and cavity **16**. The delay chamber **58** communicates with the cylinder **18** through a port or valve opening **110** in the wall of the cylinder **18** located below the piston **26** intermediate the travel of the piston element **26***b* so that the piston portion **26***b* passes across the port **110** during the stroke of the piston **26**. Thus the compressed air within the lower portion of the cylinder **78** is discharged to atmosphere around the annular groove **102**, passageways **106** and **108**, delay chamber **58**, port **110**, and through the exhaust ports **19** from the lower end of the cylinder **18**. When the compressed air is discharged from within the lower end of the cylinder **78**, the compressed air acting on the effective upper surface of the piston **72** moves this piston and the connected valve stem **68** downwardly. In moving downwardly, the O-ring **66** moves into engagement with the tapered wall of the valve seat **62** to close the exhaust port or opening **64**. This also moves the upper surface of the resilient valve element **70** out of engagement with the housing **12** to open the port or passageway **74**. The passageway **20** and the upper end of the cylinder **18** are now placed in direct communication with the fluid in the reservoir **14** so that the piston **26** and the connected driver blade **28** are driven downwardly to engage and drive the fastener **30** supplied through the drive track **32** by the magazine assembly **36**. Compressed fluid also enters the cylinder **18** between the differential portions thereof through the passageway **44**, return air chamber **38**, and return air port **46**. However the net upward bias of this compressed air is negligible compared to the driving force on the piston **26** due to the air in the upper end of the cylinder **18**. The flow of pressurized air to the return air chamber is indicated by the arrows A, while the exhaust of air from the cylinder **78** after depression of the trigger **98** is indicated by the arrows B, FIG. **1**.

As soon as the small piston element **26***b* on the piston **26** passes over the port **110** during its driving stroke, pressurized fluid from the reservoir **14** will now enter the lower portion of the cylinder **78** through the passageway **44**, port **46**, return air chamber **38**, valve opening **110**, and passageway **108**, around the annular groove **102** and into the valve chamber **93** as indicated by the arrows C in FIG. **2**. The lower end of the cylinder **18** is, of course, vented to the atmosphere through the ports **19** as indicated by the arrows D. As soon as the pressure in the lower end of the cylinder **78** builds up sufficiently to overcome the differential force acting downwardly on the valve element **70**, the valve element **70** will be forced upwardly until it seats to close the port **74** and exhausts the upper end of the cylinder to the atmosphere as indicated in FIG. **3**. At this time the return air will build up within the return air chamber **38**, arrows A, to effect return of the piston **26** to its uppermost position.

The operation of the improved fastener-driving tool is believed clear from the above description. However, briefly, it will be understood that with the tool at rest and the trigger released, as illustrated in FIG. **1**, the pressure of the fluid in the return air chamber **38**, which is always in communication with the reservoir **14**, will maintain the piston **26** in its uppermost or normal position. As soon as the trigger **98** is depressed the fluid will exhaust from the lower end of the cylinder **78** through the passageway **96**, valve chamber **93**, around the annular groove **102**, through the passageways **106** and **108**, through the delay chamber **58**, port **110**, lower end of the cylinder **18**, and through the exhaust ports **19** as indicated by the arrows B in FIG. **1**. This will permit the fluid in reservoir **14** acting on top of the piston **72** to drive the piston **72** downwardly, seating the valve member **66** against the valve seat **62** and closing the exhaust port or opening **64**, while at the same time coSonecting the reservoir **14** to the upper end of the cylinder **18** through the port **74** and passageway **20**. Thus the piston **26** will be driven downwardly through a power stroke. As the piston **26** moves downwardly, the O-ring **26***b* closes the valve opening **110** from the lower end of the cylinder **18**, and the exhaust of air from the cylinder **78** will end and pressurized fluid from the reservoir **14** will be directed into the lower end of the cylinder **78** through the passageway **44**, the return air chamber **38**, port **46**, valve opening **110**, delay chamber **58**, passageway **108**, passageway **106**, around the annular groove **102**, valve chamber **93**, and passageway **96**. The flow of air to the cylinder **78** will be metered by the size of the port openings, by the clearance of the piston **26** with the cylinder **18**, and by the size of the delay chamber **58** so that the piston **26** will have sufficient time to complete its drive stroke substantially unhindered prior to the actuation of the piston **72**. The size of the chamber **58**, along with the restrictions in the fluid flow, will determine the rate of pressure buildup within the cylinder **78**.

As soon as the pressure in the cylinder **78** is sufficient to overcome the differential pressure acting on the piston **72**, the piston **72** will be driven upwardly from the position indicated in FIG. **2** to the position indicated in FIG. **3**. At this time the upper end of the cylinder **18** is exhausted to the atmosphere and the return air in the return air chamber **38** will drive the piston **26** back to its normal position.

After the piston **26** is returned to its normal position, and as long as the trigger **98** remains depressed, the piston **26** will immediately recycle since the movement of O-ring **26***b* past the valve opening **110** now permits exhaust of the air from the cylinder **78**, in the manner previously described, as indicated by the arrows B of FIG. **1**. Thus the fastener-driving tool **10** will continue to cycle through a drive and return stroke so long as the trigger **98** is maintained depressed.

If desired the fastener-driving tool heretofore described may readily be modified to provide for multiblow operation of a single fastener. Thus when it is desired to drive a fastener which cannot be driven with a single blow, the drive piston of the tool will continue to recycle until such time as the fastener is fully driven, and then the piston will return to its static or normal position until such time as the fastener-driving tool is again activated to drive another fastener. A tool modified for multiblow operation is illustrated in the embodiments of FIGS. **4** through **7**. As therein illustrated there is provided a fastener-driving tool **120**, similar to the fastener-driving tool **10** heretofore described but modified by the inclusion of a shutoff valve **121**. Accordingly the fastener-driving tool **120** will not be described in detail except wherein it differs from the fastener-driving tool **10**.

However, briefly, it will be understood that the fastener-driving tool **120** includes a housing **122** defining a fluid reservoir **124** and a forward cavity **126**. A cylinder **128** is mounted within the cavity **126**. As heretofore described the cylinder **128** has its lower end in communication with the cavity **126** and has an open upper end in continuous communication with the passageway **20** formed in the housing. The operation of the fastener-driving tool **120** is under the control of the manually actuated control valve assembly **22**, identical with that described in the embodiment of FIGS. **1** through **3**. The control valve **22** is operable to alternately connect the passageway **20** to the atmosphere through the passageway **24** and connect the passageway **20** to the fluid in the reservoir **124**. The fluid admitted to the passageway **20** enters the upper of the cylinder **128** and drives the piston **26** downwardly so that the lower end of the drive blade **28** engages and drives the fastener **30** supplied to the drive track **32** in the nosepiece assembly **34** by the magazine assembly indicated generally as **36**.

To provide for the return stroke of the piston **26**, the fastener-driving tool **120** is provided with the pneumatic return system including the return air chamber **38** defined between the cylinder **128**, the cavity **126**, and the O-rings **40** and **42**, which is in communication with the reservoir **124** through the passageway **44** and which communicates with the cylinder **18** through the return air port **46**. The lower end of the cylinder **128** exhausts to the atmosphere through the plurality of exhaust ports **19**.

For providing repetitive motion of the piston **26**, the control valve **22** is provided with a signal pressure from passageway means **108***a*, **108***b*, connected to the return air chamber **38**.

Pressurized fluid which is received by the control valve **22** after the lower O-ring **26***b* clears the delay port or valve opening **110** will be effective to create a return stroke of the piston **26** so long as the passageway means **108***a* and **108***b* are unobstructed.

To provide for termination or shutoff of the cycling of the tool **120** upon completion of the driving of the fastener **30**, there is provided the shutoff valve **121** positioned within a differential diameter valve chamber **130** formed within the housing **122**. The shutoff valve **121** is adapted to block or close the passageway means **108***a*, **108***b* upon complete driving of the fastener **30**. More specifically the shutoff valve **121** includes a valve element **132** slideably mounted within the valve chamber **130** and includes an enlarged lower end defining a piston **134**. The valve chamber **130** has an open end closed by a valve cap or cylinder head **136**. When the valve element **130** is in its normal or at-rest position, as illustrated in FIG. **4**, the valve element **132** is biased toward the larger or cap end of the valve chamber **130**. Moreover the passageway means **108***b* has a port **138** opening into the inner side wall of the valve chamber **130**, and the passageway means **108***a* has a port **140** opening into the inner end of the valve chamber **130**. The port **138** is closeable by the movement of the valve element **132**, and more specifically by the movement of an O-ring **142** to a position intermediate the ports **138** and **140**.

During the multiblow operation of the fastener-driving tool **120**, the passageway means **108***b* and **108***a* are in communication through the valve chamber **130**, with the valve element **132** in its lowermost position as indicated in FIGS. **1** and **2**. During this cycling of the fastener-driving tool **120**, the tool functions in like manner as the fastener-driving tool **10** described in the embodiment of FIGS. **1** through **3**.

To provide for termination of the cycling of the fastener-driving tool **120** upon completion of the driving of a single staple **30**, means are provided for shifting the valve element **132** upwardly to cause the O-ring **142** thereof to block the port **138**. More specifically there is provided signal port means **144** in the lower end of the cylinder **128** communicating through a passageway **146** with the head or large end of the valve chamber **130**. The signal port means **144** is positioned to be covered by the lower O-ring **26***b* when the piston **26** reaches the bottom or end of its driving stroke. Thus when the stroke of piston **26** is sufficiently long so that the O-ring **26***b* moves past the signal port **144**, pressurized fluid from the reservoir **124** will enter the port **144**, pass through passageway **146** and enter the lower end of the valve chamber **130** so as to move the valve element **132** upwardly. At this time the O-ring **142** on the valve element **132** will move past the port **138** preventing the return signal in passageway means **108***b* from reaching the valve chamber **93** and preventing further automatic cycling of the piston **26** through a subsequent stroke.

So long as the trigger **98** is maintained depressed, air from the cylinder **78** will continue to exhaust to atmosphere through the passageway means **108***a* and a passageway **148** formed in the valve element **132**, best illustrated in FIG. **7**, which mates with the port **140** and which exhausts to atmosphere through a passageway **150** in the tool housing **122**. A vent **152** through the differential portion of the valve chamber **130** permits free movement of the valve element **132** within the valve chamber **130**. Thus the piston **26** will not return after it has completely driven the fastener **30** until such time as the trigger **98** is released. Upon release of the trigger **98** and movement of the O-ring **92** from the seat in the passageway **94**, pressurized fluid will once again enter the cylinder **78** from the reservoir **124** and will return the valve elements **66** and **70** to their normal position as indicated in FIG. **1**, permitting return of the piston **26** to its normal position. As soon as the O-ring **26***b* clears the port **144**, pressurized fluid from below the piston **134** will exhaust to atmosphere through the cylinder **128** and the exhaust ports **19**.

Thus it will be understood that the addition of the shutoff valve **121** into the signal passageway means **108***a* and **108***b* is effective to permit multiblow firing of the piston **26** so as to completely drive a single fastener **30**, and the shutoff valve **121** is effective to end the automatic cycling of the piston **26** upon completion of the driving of the fastener **30** until such time as the trigger **98** is released and once again activated by depression thereof.

FIGS. **8**, **9** and **10** illustrate a modification of the fastener-driving tool of FIGS. **1** through **3** wherein a shuttle valve is added to the signal line **108** thereby permitting the fastener-driving tool to be set to either an autofire position or to a single-fire position, and further to provide for adjustment of the cycling rate of the tool. More specifically there is illustrated a fastener-driving tool **160**, identical with the fastener-driving tool **10** except for the addition of a shuttle valve assembly **162** in the signal passageway. The shuttle valve assembly **162** includes a valve body or valve sleeve **164** positioned within an opening **166** within the tool housing **12**. The valve body **164** is provided with ports **168** and **170** forming a part of the signal passageway, herein identified as **108***c* and **108***d* and interconnecting the delay chamber **58** with the control valve **22**. The valve assembly **162** includes a spool valve element or valve stem **172** slideably received within the valve body **164** and provided with a projection **174** extending through one end of the valve body **164**, and further including a button portion **176** at the other end thereof so that the valve element **172** may be manually shifted between its single-fire position, illustrated in FIG. **9**, to its autofire position, illustrated in FIG. **10**, by the depression of projection **174**, and may be returned to the single-fire position by depression of the button portion **176** thereof.

To provide for single-firing of the fastener-driving tool **160**, the valve element **172** is provided with an annular groove or reduced diameter portion **178** so that in the position illustrated in FIG. **9** the control valve **22** exhausts through the passageway **108***d*, the port **170**, along a passageway **180** defined by the annular groove **178** and past the open end of the valve body as defined by a passageway **182**.

To provide for autofiring of the fastener-driving tool **160** so long as the trigger **98** is depressed, movement of the valve element **172** to the position illustrated in FIG. **10** will permit flow of the necessary signal through the passageways **108***b* and **108***d* to provide for the operation in like manner as described in the embodiment of FIGS. **1** through **3**. More specifically, as therein illustrated, the valve element **172** is provided with a pair of circumferential grooves **184** and **186** interconnected by an inner bore **188** and aligned in the autofire position with the ports **168** and **170** respectively to provide for communication between the passageways **108***c* and **108***d*. The fastener-driving tool **160** will now function in an autofire condition.

To adjust the rate of cycling of the tool, the recycling of the piston **26** is dependent on the restriction within the signal passageways and the size of the delay chamber **58**. The desired restriction may be adjustably selected by the provision of a needle valve **190** which extends into the inner bore **188** of the valve element **172** and meters the rate of fluid flow between the grooves **184** and **186**.

It is understood that with the shuttle valve assembly **162** in the autofire position, the operation of the fastener-driving tool **160** is identical with that in the embodiment of FIGS. **1** through **3**, except for the adjustable metering of the rate of flow in the signal passageway which controls the selective setting of the recycling rate.

FIGS. **11** through **14** illustrate a modification of the fastener-driving tool of FIGS. **1** through **3** wherein the shuttle valve is arranged to return to the autofire position upon completion of a single-firing operation. More specifically there is illustrated a fastener-driving tool **200**, which may be identical with the fastener-driving tool **10** heretofore described, but in the illustrated embodiment is of the type having valve means around the upper piston to provide for flow of air to the air return chamber as more fully described and claimed in the U.S. Pat. No. 3,040,709 granted to O. A. Wandel on June 26, 1962. As therein more fully described, the tool **200** includes a housing **202** having a forward and generally

vertically extending head portion 202*a* and a rearwardly extending hollow handle portion 202*b* forming a reservoir 204 to which is supplied pressurized fluid, such as compressed air, in any suitable manner as by a flexible air line. The head portion 202*a* of the housing 202 includes a cavity 206 in which is mounted a differential-diameter cylinder 208 having a large cylinder portion 208*a* and a small cylinder portion 208*b*. The lower end of the cylinder 208 is in communication with the atmosphere, and the open upper end 208*a* is in continuous communication with a passageway 210 formed in the housing.

A manually actuated control valve assembly indicated generally at 212 normally connects the passageway 210 to the atmosphere through a passageway 214 formed in the hollow handle portion 202*b* and is operable to a position in which it connects the passageway 210 to the fluid in the reservoir 204. The fluid admitted to the passageway 210 enters the open upper end of the cylinder 208 and drives a differential-diameter piston 216 which is slideably mounted within the cylinder 208 and to which is secured the upper end of a fastener-driving blade 218. The piston 216 includes a large diameter element 206*a* defined by an O-ring 224 and a small diameter element 206*b* defined by an O-ring 230. The lower end of the drive blade 218 is adapted to engage and drive a fastener through a drive track in a nosepiece assembly in like manner as the embodiment of FIGS. 1, 2 and 3.

During the downward movement of the piston assembly, the air disposed within the cylinder 208 below the piston 216 is discharged to the atmosphere through the lower end of the cylinder 208.

To provide for the pneumatic return of the piston 216 to its normal position, there is provided a return air chamber 220 formed between the differential-diameter portions of the piston 216 and cylinder 218. The air return chamber 220 may be placed in communication with the reservoir 204 through suitable valve or port means 222 located in the upper portion of the piston assembly 216. The valve means 222 includes the resilient O-ring 224 mounted within an elongated groove 226 slideably engaging the inner wall of the upper portion of the cylinder 208. To provide means for selectively supplying compressed air to the air return chamber 220, the bottom wall of the groove 226 and a portion of the lower lip of this groove are recessed to provide a slot 228 which places the air return chamber 220 in communication with the annular groove 226. Thus when compressed air is supplied to the upper end of the cylinder 208, the air passing through the interface between the upper flange and the inner wall of the upper portion of the cylinder 208 enters the groove 226 and passes through the slot 228 to be accumulated in the air return chamber 220. Since the cylinder 208 and the piston 216 are of the differential-diameter type pressurized fluid in the air return chamber 220 provides for the exertion of a greater upward force on the piston 216 than the downward force, and the differential force will bias the piston 216 upwardly.

When the piston 216 is to be pneumatically returned to its normal position, the control valve assembly 212 operates so that the passageway 210 is again connected to the atmosphere through the passageway 214 and the compressed air in the air return chamber 220 acting on the upper O-ring 224 is effective to slide the O-ring 224 upwardly, to the position illustrated in FIG. 11, thereby sealing the passageway defined by the slot 228 and the differential force acting on the differential diameters of the piston 216 will drive the piston 216 upwardly to its normal position as indicated in FIG. 1.

The valve assembly 212 is identical to the valve assembly 22 described in the embodiment of FIGS. 1 through 3 and, briefly, includes a pneumatically controlled main valve portion 232 controlling the connection of the open upper end of the cylinder 208 to either the atmosphere or to the fluid reservoir 204. The valve portion 232 includes an exhaust valve seat 234 carried on the housing 202 having a downwardly and inwardly tapered opening 236 through which the passageway 210 is normally placed in communication with the exhaust passageway 214. The opening 236 can be closed by a resilient O-ring 238 defining a valve element carried on the upper end of a valve stem 240. A resilient valve element 242, here shown in the form of an O-ring, is also carried on the valve stem 240 disposed between a shouldered portion 240*a* on the lower end of the valve stem 240 and a control valve or piston 244. The resilient valve element 242 normally closes a port or passageway 246 interposed between the reservoir 204 and the passageway 210. The piston 244 carries an O-ring 248 and is slideably mounted within a control valve cylinder 250 formed in a control valve body 252 received within an opening 254 in the housing 202.

A trigger or pilot valve portion 256 is included in the valve assembly 212 to be operated with a minimum manually applied force. This trigger valve portion 256 includes an operating pin 258 that is slideably mounted within an axial bore formed in a valve body member 260 that is threadably received within an opening 262 in the valve body 252. The upper end of the operating pin 258 is tapered and carries an O-ring 264 that operates as a valve element to control communication between the reservoir 204 and a valve chamber 266 through a passageway 268. In the normal condition or released state of the control valve assembly 212, compressed air flows from the reservoir 204 through the passageway 268 to deflect or bias the O-ring 264 downwardly to permit the compressed air to build up within the upper end of the valve chamber 266. This compressed air flows through a passageway 270 in the valve body 252 to enter the lower end of the cylinder 250. This compressed air, which is at the same pressure as the fluid within the reservoir 204, operates on a greater area lower surface of the piston 244 and overcomes the force of the compressed air in the reservoir 204 acting on the upper effective surface of the piston 244 to provide an upwardly directed force that holds the resilient valve element 242 in engagement with the housing 202 to close the port 246 and holds the valve element 238 spaced from the valve seat 236 so that the passageway 210 normally communicates with the atmosphere through the opening or port 236 and exhaust passageway 214.

When the tool 200 is to be operated, a trigger or actuating element 272 pivotally mounted on the housing 202 is pivoted in a counterclockwise direction to engage the lower end of the operating pin 258. This moves the pin 258 upwardly so that the O-ring 264 engages the adjacent portion of the valve body 252 to seal the passageway 268. At the same time the O-ring 238 is moved away from the member 234 so that the upper end of an annular passageway or groove 274 is uncovered. The passageway 274 connects with a passageway 276 in the valve body 252 and further communicates through a passageway 278 with a delay chamber 280 defined between the cylinder 208 and the cavity 206. The delay chamber communicates with the cylinder 208 through a port or valve opening 282 in the wall of the cylinder 208 located below the piston 216 intermediate the travel of the lower piston element 216*b* so that the piston portion 126*b* passes across the port 282 during the stroke of the piston 216. Thus when the tool 200 is in its rest position the compressed air within the lower portion of the cylinder 250 is discharged to atmosphere around the annular groove 274, passageways 276 and 278, delay chamber 280, and port 282 to be exhausted from the lower end of the cylinder 208. If the compressed air is discharged from within the lower end of the cylinder 250, the compressed air acting on the effective upper surface of the piston 244 moves this piston and the connected valve stem 240 downwardly. In moving downwardly, the O-ring 238 moves into engagement with the tapered wall of the valve seat 234 to close the exhaust port or opening 236. This also moves the upper surface of the resilient valve element 242 out of engagement with the housing 202 to open the port or passageway 246. The passageway 210 and the upper end of the cylinder 208 are now placed in direct communication with the fluid in the reservoir 204 so that the piston 216 and the connected driver blade 218 are driven downwardly through a fastener-driving stroke. Compressed air also enters the

cylinder **208** between the differential portions thereof through the valve means **222** and into the return air chamber **220**. However the net upward bias of this return fluid is negligible compared to the driving force on the piston **216** due to the air in the upper end of the cylinder **208**.

As soon as the small piston element **216***b* on the piston **216** passes over the port **282** during its driving stroke, pressurized fluid from the reservoir **204** will enter the lower portion of the cylinder **250** through the delay chamber **280**, passageways **278** and **276**, annular groove **274**, and passageway **270**. As soon as the pressure in the lower end of the valve cylinder **250** builds up sufficiently to overcome the differential force acting downwardly on the valve element **242**, the valve element **242** will be forced upwardly until it seats to close the port **246** and exhaust the upper end of the cylinder to the atmosphere. At this time the return air builds up within the air return chamber **220** to effect return of the piston **216** to its uppermost position.

To provide for the selective single-stroke operation of the tool **200**, and to provide for speed regulation of the repetitive cycling thereof, there is provided a shuttle valve assembly **290** in the passageway **278**. The shuttle valve assembly **290** includes a valve cylinder **292** defined within the housing **202** of the tool **200**, FIGS. **12** through **14**, of a differential type, having an intermediate small diameter portion **292***a*, a larger end portion **929***b*, and additionally a counterbore **292***c* outwardly of the intermediate portion **292***a* to define a stop. A spool or valve stem **294** is mounted for reciprocal or sliding movement within the valve cylinder **292**. The valve stem **294** includes a small piston **296** containing an O-ring **298** for slideable movement within the small diameter portion **292***a* of the valve cylinder **292**, and a large piston **300** having an O-ring **302** for sliding movement within the large diameter portion **292***b* of the valve cylinder **292**. The valve stem **294** is longitudinally movable within the valve cylinder in a single-fire direction, as illustrated in FIG. **12**, until the O-ring **302** seats against a shoulder **304** formed between the intermediate and large diameter portions **292***a* and **292***b* of the valve cylinder **292**, and into an autofire position, illustrated in FIGS. **13** and **14**, until a nut **306** adjustably threaded on the end of the valve stem **294** strikes against the bottom of the counterbore **292***c*. The adjustable threading of the nut **306** onto the valve stem **294** provides for selective positioning of the stem in the autofire position longitudinally of the valve cylinder **292**.

To provide for control of the fluid flow between the delay chamber **280** and the valve means **222**, the passageway **278** has a first port **278***a* opening into the small diameter portion **292***a* of the valve cylinder **292** beyond the longitudinal movement of the O-ring **298** on the small piston **296**. However the small piston **296** may be adjusted to move longitudinally to a position partially obstructing the flow from the port **278***a* by adjusting or backing off the nut **306**, as illustrated in FIG. **14**. Moreover the passageway **278** has a continuing port **278***b* intermediate the stoke of the large piston **300** so as to be blocked from communication with the signal air received from port **278***a*, as illustrated in FIG. **12**, exhausting to the atmosphere through a passageway **308** formed between a head **294***a* of the valve stem **294** and the edge of the valve cylinder **292**. Moreover when the valve stem **294** is moved longitudinally to its autofire position, as illustrated in FIGS. **13** and **14**, the port **278***b* is placed in communication with the port **278***a*.

From the above brief description, the operation of the improved shutter valve is believed clear. However, briefly, it will be understood that the tool **200** employs a signal taken from the delay chamber **280** to control the actuation of the valve assembly **212** so long as the trigger **272** is maintained depressed. Assuming first that the shuttle valve assembly **290** is in the autofire position illustrated in FIG. **13**; the passageway **278** is unobstructed and the tool **200** will cycle in a manner identical with that described in the embodiment of FIGS. **8** through **10**. However if it is desired to reduce the cycling speed of the tool, it is merely necessary to adjust the longitudinal position of the valve stem **294** by backing off the nut **306** to the position, for example, as illustrated in FIG. **14**. In this position the edge of the small diameter piston **296** partially obstructs flow of fluid passing through the passageway **278** by partially blocking the port **278***a*. Thus the signal fluid is retarded and the tool **200** will fire at a slower rate.

If it is desired to fire the tool **200** as a single-fire tool, it is merely necessary to depress the head end of **294***a* of the valve stem **294** to the position illustrated in FIG. **12**. In this position the passageway **278** is blocked by the large diameter piston **300** and the O-ring **302** and no signal air will be received from the delay chamber **280** by the valve means **222**. Moreover the valve means **222** will exhaust to the port **278***b* and the passageway **308** to provide for single-fire cycling of the tool. Thus the operator needs merely to move the valve stem **294** to the single-fire position, drive a fastener, and release his finger from the shuttle valve. The shuttle valve assembly **290** will automatically return to the multifire position since the diameter of the large piston **300** is greater than the diameter of the small piston **296** and the differential pressure entering through the passageway **278** will be effective to move the valve stem **294** from the single-fire to the multifire position. If it is desired to drive more than one fastener on a single-fire arrangement, the valve stem **294** may be held to the single-fire position manually.

Referring now to the embodiment of FIGS. **15**, **16** and **17**, there is illustrated a modification of the fastener-driving tool having an improved shuttle valve in the signal line **108** providing improved operation of the fastener-driving tool as either an autofire or a single-fire tool. More specifically there is illustrated a fastener-driving tool **310**, identical with the fastener-driving tool **160** heretofore described, except for a modified shuttle valve assembly **312** in the signal passageway **108**. Accordingly similar parts of FIG. **15** and of FIGS. **8** through **10** are represented by the same reference numeral and are not again described in detail. The shuttle valve assembly **312** includes a valve cylinder **314** defined in the housing **12**. The valve cylinder **314** includes a threaded portion **314***a* at one end and a reduced diameter portion **314***b* at the other end.

For regulating the rate of flow in the passageway **108**, there is provided a needle valve assembly **316** including a needle valve body **318** threadedly received in the threaded portion **314***a* and provided with a longitudinal bore **320** receiving a stem member **322**. The stem member **322** has a threaded portion **322***a* threadedly received within a threaded portion **320***a* of the longitudinal bore **320** providing adjustment of the stem member **322**. Additionally the stem member **322** includes a tapered stem portion **322***b* extending through a port **324** formed by the longitudinal bore **320** to meter the rate of flow therethrough. A port **326** in the side wall of the needle valve body **318** provides communication between the passageway portion **108***c* and the metering port **324**, and in the normal or autofire position as illustrated in FIG. **16**, the metering port **324** is in communication with the passageway portion **108***d*.

Thus it will be understood that during the autofiring of the fastener-driving tool **310** so long as the trigger **98** is depressed, a signal flow will occur through the passageway **108** between the portions **108***c* and **108***d* to provide for the operation of the tool in like manner as in the embodiment of FIGS. **8** through **10**.

To adjust the rate of cycling of the tool, the recycling of the piston **26** is dependent on the restriction within the signal passageways and the rate of flow through the metering port **324**. The desired rate may be adjustably set by the adjustment of the threaded stem member **322** within the needle valve body **318**.

To provide for firing of the tool **310** as a single-fire tool, the passageway **108***c* may be selectively blocked by a single-fire valve member **328**. More specifically the single-fire valve member **328** includes a ball valve member **330** within a valve chamber **332** and integrally formed with a manually operable stem **334** extending through the reduced-diameter portion **314***b*. The ball valve member **330** is provided with an inwardly

extending recess **336** providing clearance with the stem portion **322***b* of the stem member **322** preventing interference between the stem member **322** and the valve member **328**. The stem **334** of the valve member **328** is somewhat smaller than the port **326** so that an exhaust passageway **338** is defined around the stem **334**. The exhaust passageway **338** is normally closed, in the autofire position, by the seating of the ball valve member **330** against a valve seat member **340**, here shown as an O-ring. When depressed, the ball valve member **330** will unseat from the valve seat member **340** and will move against an edge of the needle valve body **318** defining a valve seat member **342** around the metering port **324**. Thus when the ball valve member **330** is seated against the valve seat member **342**, the passageway **108***c* is blocked, and the passageway **108***d* is exhausted to the atmosphere.

In operation it will be understood that when the tool **310** is to be fired in the autofire position, the single-fire valve member **328** will be released, so that the passageway **108** is open and fluid flow can occur therethrough. However when it is desired to fire the tool **310** as a single-fire tool, the operator will depress the single-fire valve member **328**, unseating the ball valve member **330** from the valve seat member **340** and closing the metering port **324** by the seating of the ball valve member **330** against the valve seat member **342**. In this position, with the depression of the trigger **98**, the tool will fire in the manner heretofore described. A signal flow cannot take place through the passageway **108** since the passageway **108** is now obstructed by the seating of the ball valve **330** against the valve seat member **342**. Moreover the valve cylinder **78** will now be exhausted to the atmosphere through the passageway **94**, valve chamber **93**, passageway **96**, and passageway **108***d* into the valve chamber **332** of the shuttle valve assembly **312** and through the exhaust passageway **338**. Thus so long as the single-fire valve member **328** is depressed, and so long as the trigger **98** is not released, the piston **26** and associated driver blade **28** will remain at the end of its driving stroke. Of course as soon as the trigger **98** is released, fluid from the reservoir **14** will once again enter into the valve cylinder **78** and will close the valve element **70** against the port **74**, lifting the valve element **66** from the exhaust valve seat **62**. The reservoir air from above the piston **26** is shut off, and the upper open end of the cylinder **18** is exhausted to the atmosphere. The reservoir air entering the return air chamber **38** and communicating with the cylinder **18** through the return air port **46** will be effective, acting on the differential diameter elements **26***a* and **26***b*, to return the piston **26** and associated driver blade **28** to its static or at rest position as illustrated in FIG. **15**.

Advantageously a fastener-driving tool according to the present invention provides for a high speed or cycling of the fastener-driving tool so that fasteners may be rapidly driven in a continuous manner. Moreover in a particular embodiment thereof the desired rate of cycling may be varied as desired by the operator. The easy-trip pilot valve may be operated by minimum effort on the part of the operator, and the operator is subjected to a minimum fatigue since it is not necessary that he operate or depress the trigger for each cycle of operation. Moreover, in accordance with another embodiment of the present invention, the fastener-driving tool is readily adapted to drive a large fastener with a relatively small tool which in turn would be a less expensive tool, and to shut off the recycling of the tool once the fastener has been fully driven. Moreover this arrangement provides for the driving of a wide variety of fasteners with the same drive system or tool. In yet another embodiment of the present invention, the fastener-driving tool will automatically condition itself after a single-fire operation to autofire operation upon the mere release of the shuttle or single-fire valve.

I claim:

1. An automatically cycling fastener-driving tool comprising:

a housing including a cylinder and a reservoir supplied with fluid under pressure;

fastener-driving means including a piston slideably mounted in the cylinder;

valve means operable between a normal position connecting one end of the cylinder to the atmosphere to an operated position connecting the one end of the cylinder to the reservoir;

pneumatic piston return means for returning said piston to said one end of said cylinder including an air return chamber; and

means controlled by movement of said piston sequentially connecting said return air chamber to said valve means to cycle said valve means in response to the stroke of said piston and thereby provide for automatic cycling of said piston.

2. A fastener-driving tool as set forth in claim **1** wherein said last-mentioned means includes a passage means connected to said valve means having a port opening in said cylinder sequentially connected to said return air chamber by the movement of said piston.

3. A fastener-driving tool as set forth in claim **2** including shutoff means for blocking said passage means when said piston completes a full drive stroke.

4. A fastener-driving tool as set forth in claim **3** wherein said shutoff means includes a shutoff valve and passage means connecting said shutoff valve with a port opening in the other end of said cylinder to provide a signal when said piston moves past said port.

5. A fastener-driving tool as set forth in claim **4** wherein said signal is provided by the connection of said port with said return air reservoir.

6. A fastener-driving tool as set forth in claim **2** including a shuttle valve in said passage means operable to exhaust said valve means to atmosphere.

7. A fastener-driving tool as set forth in claim **2** including throttling valve means in said passageway.

8. A fastener-driving tool as set forth in claim **2** including adjustable throttling means operatively connected to delay recycling of said valve means to provide for speed control of the automatic cycling of said tool.

9. An automatically cycling fastener-driving tool comprising:

a housing including a differential-diameter cylinder and a reservoir supplied with fluid under pressure;

fastener-driving means including a differential-diameter piston slideably mounted in the cylinder;

an air return chamber being defined by the space formed between the differential-diameter portions of said cylinder and piston;

means continuously connecting said air return chamber to said reservoir;

valve means operable between a normal position connecting one end of the cylinder to the atmosphere to an operated position connecting the one end of the cylinder to the reservoir;

pneumatic piston return means including an air return chamber; and

means controlled by movement of said piston selectively connecting said return air chamber to said valve means to cycle said valve means in sequence with the stroke of said piston and thereby provide for automatic cycling of said piston and including a port in the wall of said cylinder intermediate the movement of one of said portions of said piston to connect said valve means to said air return chamber upon a predetermined movement of said piston.

10. An automatically cycling fastener-driving tool comprising:

a housing including a differential-diameter cylinder and a reservoir supplied with fluid under pressure;

fastener-driving means including a differential-diameter piston means with larger and smaller diameter pistons slideably mounted in the cylinder;

pneumatically controlled valve means operable between a normal position connecting the larger end of said cylinder to the atmosphere and an operated position connecting said larger end of the cylinder to the reservoir;

pneumatic piston return means for returning said piston means to said larger end of said cylinder including a return air chamber and first port means for connecting said return air chamber to said reservoir;

exhaust means connecting the other end of said cylinder to the atmosphere;

second port means in said cylinder intermediate the stroke of the smaller diameter piston, said second port means normally being in communication with said exhaust means and communicating with said first port means when said smaller diameter piston moves between said second port means and said exhaust means;

passage means communicating with said second port means; and

pilot valve means movable between a released position placing said pneumatically controlled valve means in communication with said reservoir and an operated position placing said pneumatically controlled valve means in communication with said passage means, whereby pressure from said return air chamber through said passage means is effective to move said pneumatically controlled valve means to said normal position.

11. A fastener-driving tool as set forth in claim **10** including a shuttle valve means connected in said passage means selectively movable between a first position permitting flow through said passage means and a second position bypassing said pneumatically controlled valve means to exhaust to selectively set said tool for automatic recycling thereof and for single firing thereof.

12. A fastener-driving tool as set forth in claim **11** wherein means are provided for throttling the fluid flow in said passage means when said shuttle valve is in said autofire position to regulate the speed of recycling of said tool.

13. A fastener-driving tool as set forth in claim **12** wherein said shuttle valve comprises a differential diameter valve cylinder defined in said housing open at both ends, and a spool valve of differential diameters slideable therein, said valve cylinder having a first port opening into the smaller diameter portion for receiving a signal flow and a second port intermediate the stroke of the smaller diameter portion of said spool valve communicating with said pilot valve.

14. A fastener-driving tool as set forth in claim **13** including means adjustably positioning said spool valve in its said autofire position to provide for throttling the flow therethrough.

15. A fastener-driving tool as set forth in claim **10** including throttling valve means for adjustably metering the rate of fluid flow in said passage means.

16. A fastener-driving tool as set forth in claim **10** including shutoff means for closing said passage means upon completion of a full drive stroke by said piston.

17. A fastener-driving tool as set forth in claim **16** wherein said shutoff means includes a shutoff valve having a valve element movable between a first position wherein said passage means is unobstructed and a second position in which said pneumatically controlled valve means is connected to exhaust thereby shutting off the automatic recycling of said piston.

18. a Fastener-driving tool as set forth in claim **17** including passage means having a shutoff port opening near said lower end of said cylinder connected to said shutoff valve to provide a signal whenever said smaller diameter piston moves past said shutoff port in its drive stroke.

19. An automatically cycling fastener-driving tool comprising:

a housing including a cylinder and a reservoir supplied with fluid under pressure;

fastener-driving means including a piston slideably mounted in the cylinder;

main valve means operable between a normal position and an operated position connecting one end of said cylinder to the reservoir to provide a power stroke for said piston;

pneumatic piston return means operatively associated with said piston;

means for exhausting said one end of said cylinder to atmosphere to provide a return stroke of said piston under the force developed by said pneumatic piston return means;

control valve means connected to control said main valve;

trigger valve means pneumatically connected to said control valve;

passage means communicating with said cylinder for supplying a control signal to said control valve; and

means sequentially connecting said pneumatic piston return means and said passage means to automatically cycle said tool.

20. An automatically cycling fastener-driving tool as set forth in claim **19** including adjustable metering means in said passage means metering the flow of fluid through said passage means to regulate the rate of recycling of said tool.

21. An automatically cycling fastener-driving tool comprising:

a housing including a cylinder and a reservoir supplied with fluid under pressure;

fastener-driving means including a piston slideably mounted in the cylinder;

valve means operable between a normal position connecting one end of the cylinder to the atmosphere to an operated position connecting the one end of the cylinder to the reservoir;

pneumatic piston return means including a return chamber;

means responsive to the pressure in said return chamber to control the movement of said valve means between said normal and said operated positions;

shuttle valve means selectively operable between an autofire position and a single-fire position; and

pneumatic means for automatically shifting said shuttle valve means to an autofire position upon completion of a single-fire operation.

22. An automatically cycling fastener-driving tool comprising:

a housing including a cylinder and a reservoir supplied with fluid under pressure;

fastener-driving means including a piston slideably mounted in the cylinder;

valve means operable between a normal position connecting one end of the cylinder to the atmosphere to an operated position connecting the one end of the cylinder to the reservoir;

shuttle valve means selectively operable between an autofire position and a single-fire position; and

means automatically shifting said shuttle valve means to an autofire position upon completion of a single-fire operation.