United States Patent

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[54] FASTENER DRIVING TOOL

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[52] **U.S. Cl.**.....**91/220,** 91/226, 91/298, 91/300, 91/308, 91/356

[51] **Int. Cl.**.....**F01b 25/04,** F01l 21/04, F01l 25/06

[58] **Field of Search**.....91/220, 300, 399, 226, 298, 91/308, 356

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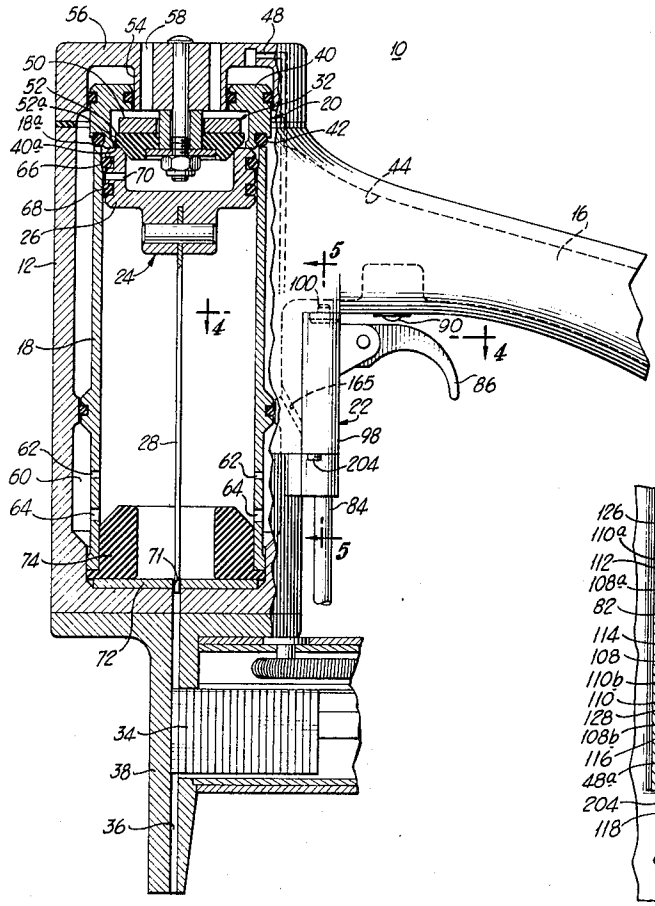
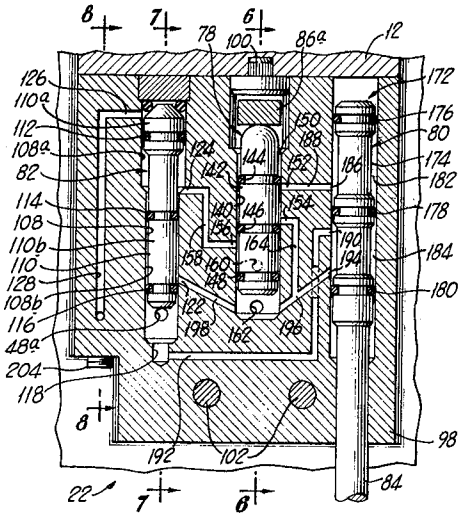
[57] **ABSTRACT**

There is provided a fastener driving tool having a control valve arrangement including a trigger valve, a cycling valve and a safety valve. The cycling valve is adapted to repetitively cycle the driving piston of the fastener driving tool through power and return strokes or to provide for single-cycling of the piston through a drive and return stroke in response to the position of the trigger. In addition there is provided an arrangement wherein the operation of the piston is arrested when the bumper cushioning the power stroke of the piston is excessively worn.

19 Claims, 12 Drawing Figures





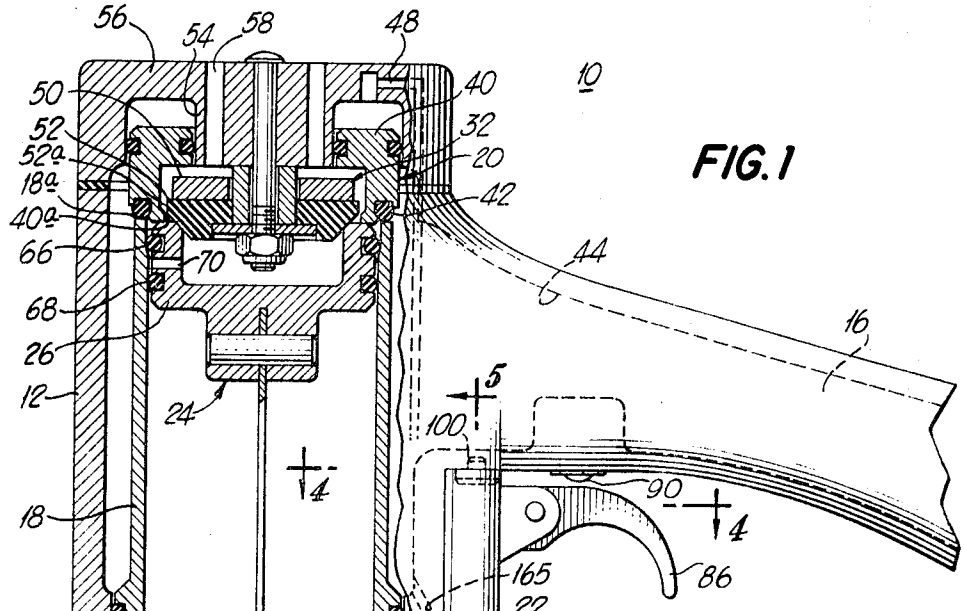


FIG. 1

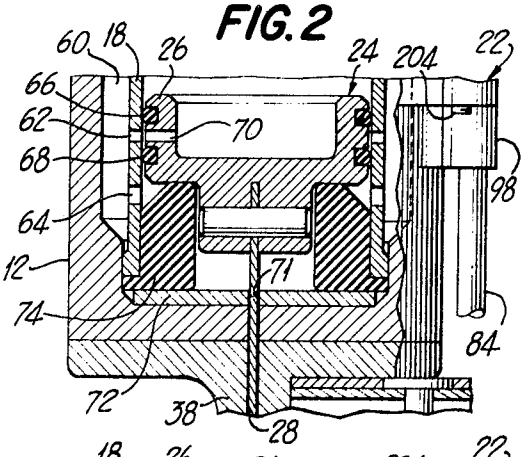


FIG. 2

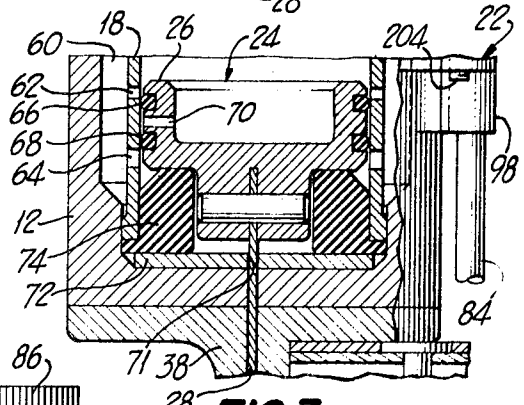


FIG. 3

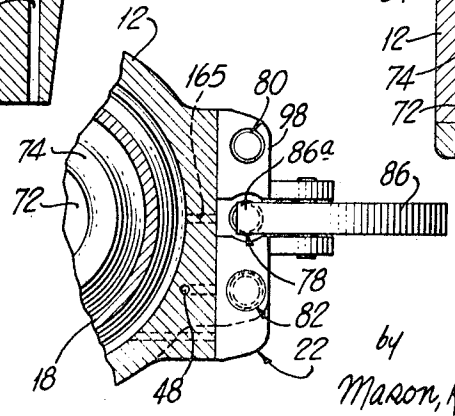


FIG. 4

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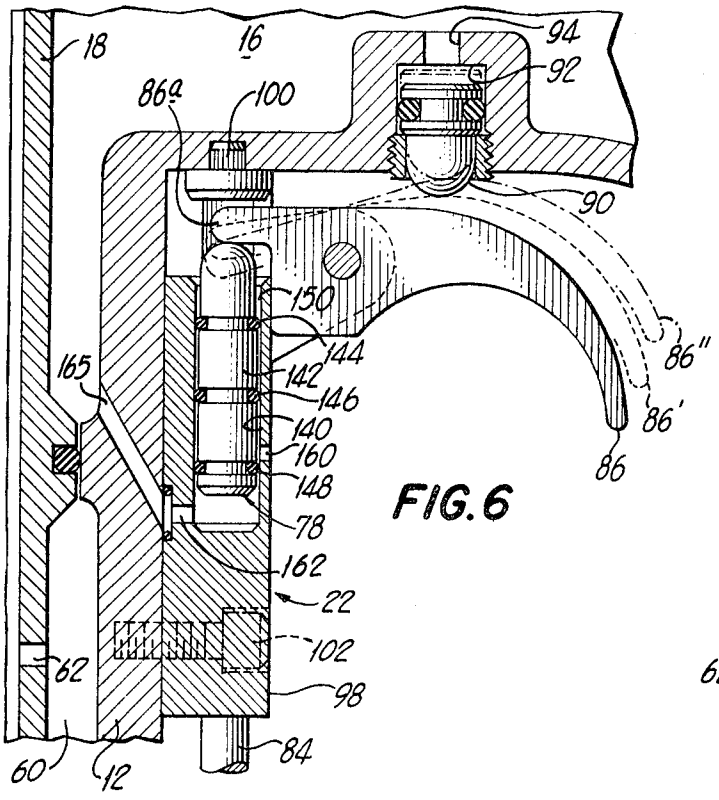
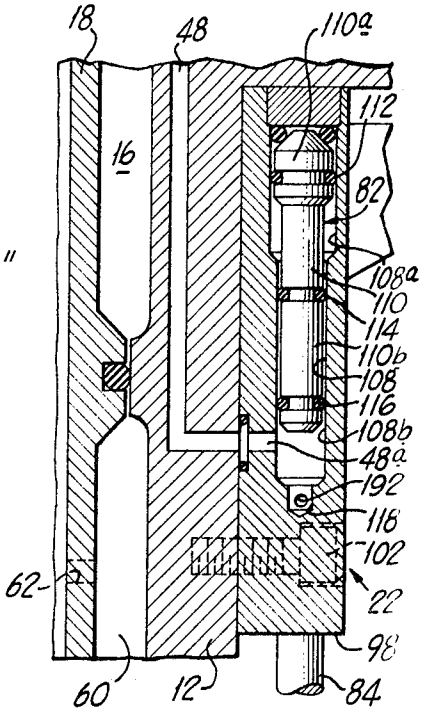


FIG. 6

FIG. 7



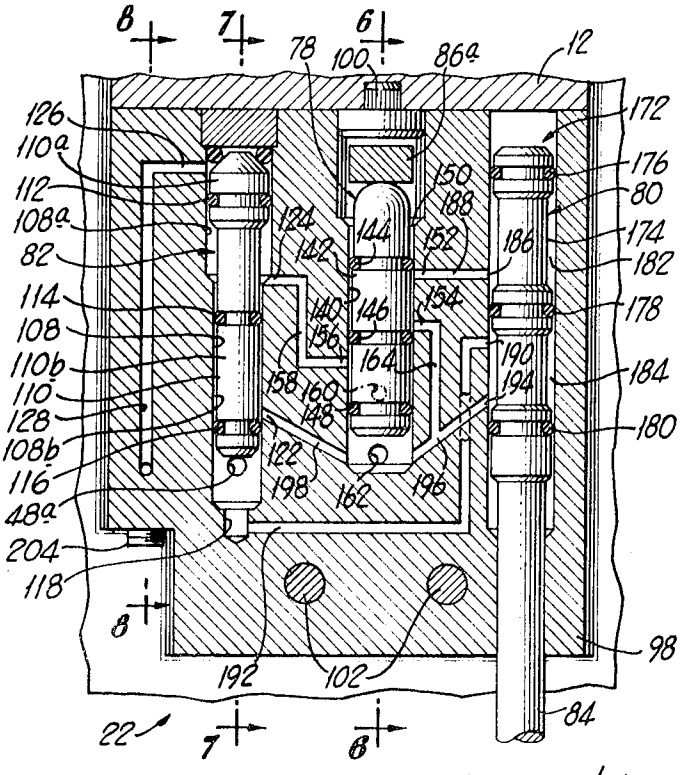


FIG. 5

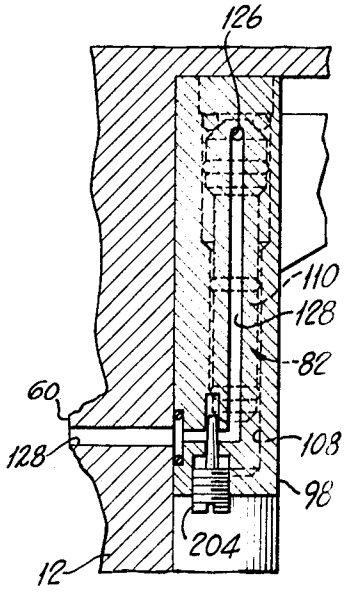


FIG. 8

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FIG. 9

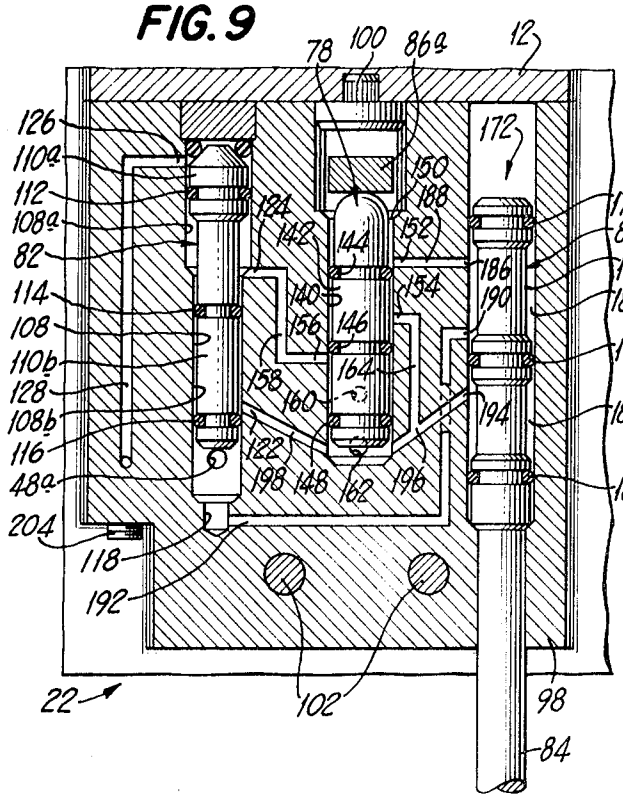
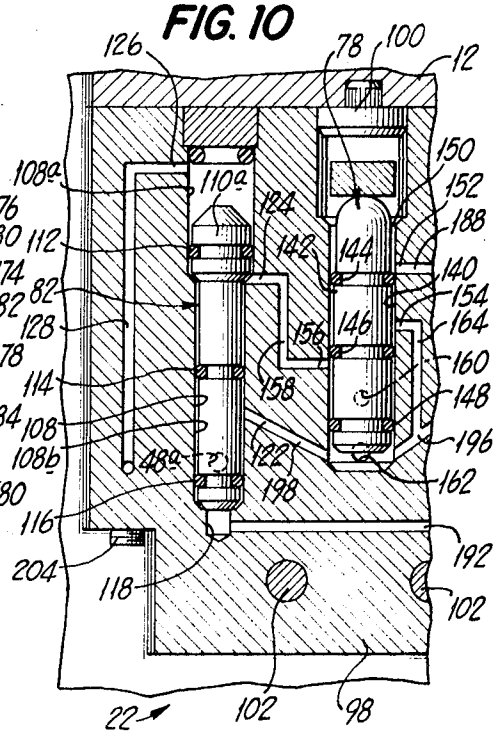


FIG. 10



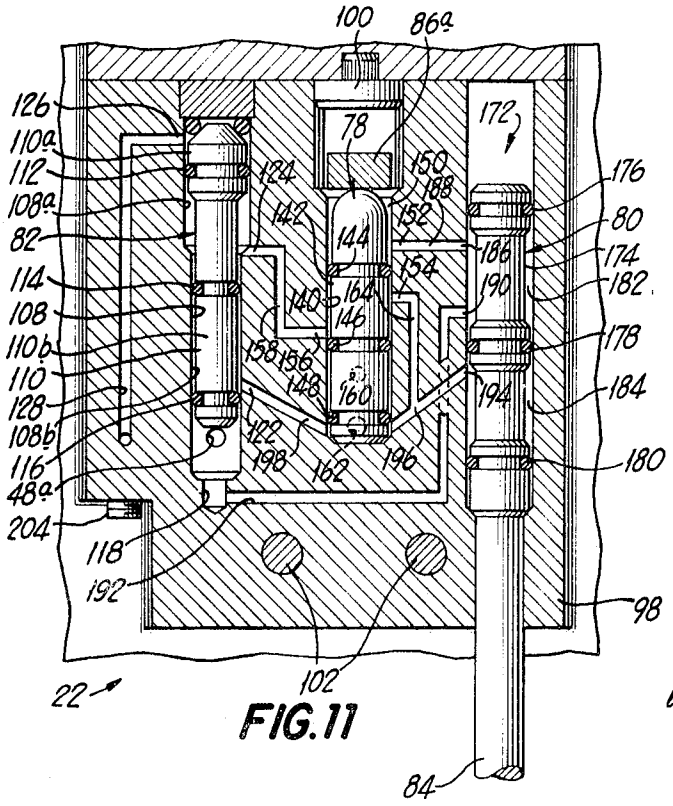


FIG. 11

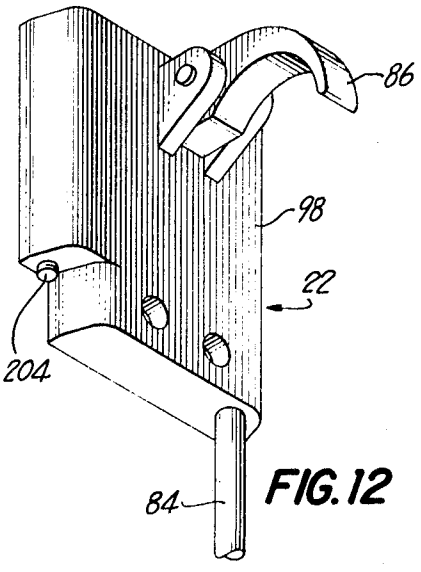


FIG. 12

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FASTENER DRIVING TOOL

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

Pneumatic fastener driving tools on the market today may be of the type that, when the trigger is depressed, the drive piston and connected fastener driving blade move through a power or drive stroke of a fastener driving operation and are returned upon completion thereof by a suitable piston return means. Such piston and driving blade are cycled through a single cycle of power and return strokes upon depression of the trigger, whether or not the trigger has been released to provide for single-cycle operation of the tool.

Fastener driving tools also are known which are provided with means for repetitively cycling the driving piston and driving blade through its cycle of power and return strokes so long as a trigger valve is maintained depressed, to provide for autofiring or multiple-firing of the tool. Means may be provided in such a multiple-fire tool to provide for single-firing thereof if desired.

Heretofore it has been known to provide means for adjusting the autofiring rate of the tool. However such autofiring adjusting means in commercially known tools has adjusted or restricted the single-firing rate of the tool. Such tools are restricted to the autofire repetitive rate which may be a handicap when a few fasteners are required to be fired at a higher rate of speed into a particular area of the workpiece.

Moreover it has been customary to provide a bumper or cushion for the drive piston at the end of its drive stroke. However when the fastener driving tool is operated in the autofire position for long periods of time, the bumper becomes hot and deteriorates rapidly.

Accordingly one object of the present invention is to provide a new and improved pneumatically actuated fastener driving tool wherein the autofire rate thereof may be adjusted without affecting the single-fire rate of the tool.

Another object of the present invention is to provide a new and improved fastener driving tool wherein the tool is rendered inoperative if the piston bumper has deteriorated beyond useful limits.

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 fastener driving tool having a new and improved control valve permitting ease of autofire selection or single-fire selection by the operator.

In accordance with the present invention there is provided a new and improved fastener driving tool of the general type including a housing having a cavity defining a fluid reservoir and a cylinder in the housing. A driving piston having a driving blade is slidably mounted in the cylinder. A main valve of known type is provided for controlling the admission of fluid to and the exhaust of fluid from one end of the cylinder so as to drive the piston through a power or drive stroke and to permit the return of the piston through a return stroke.

In accordance with the present invention there is provided an improved control valve including a safety valve, a trigger valve, and a cycling valve. The cycling valve is movable between a first position permitting control of the driving piston through a driving stroke by the trigger valve and safety valve, to a second position providing for the return of the piston upon completion of a driving stroke. To this end a signal is received by the cycling valve representative of the completion of a driving stroke. When the tool is operatively selected for autofire, a back pressure on the cycling valve prevents shifting of the cycling valve until the signal fluid builds up to an amount sufficient to overcome the back pressure. Thus throttling of the signal fluid passageway will vary the repetitive firing rate of the tool. When it is desired to fire the tool as a single-fire tool, the back pressure on the cycling valve is removed and the cycling valve will shift upon the first pressure buildup to the valve. Thus throttling or restriction of the signal fluid passageway is ineffective to alter the cycling of the tool through the single-fire cycle.

In accordance with another feature of the present invention, the driving piston is returned through its return stroke by a pressure buildup of fluid within a return air chamber. The pressure buildup in the chamber results when passages in the piston line up with passages through the cylinder wall leading into the return air chamber. However, in the event that the bumper at the end of the power stroke has deteriorated, air from the return air chamber will discharge through the same passageway into the cylinder above the piston and exhaust to the atmosphere through an exhaust valve in the cylinder preventing return cycle of piston to take place. Thus the operator will be apprised of the fact that the tool requires servicing or maintenance before it can be further operated.

For a better understanding of the present invention, reference may be had to the accompanying drawings wherein:

FIG. **1** is a fragmentary elevational view of a fastener driving tool according to the present invention illustrated in its normal or at rest position;

FIG. **2** is a fragmentary view of the improved fastener driving tool shown with the driving piston at the end of a driving stroke;

FIG. **3** is a fragmentary view of the improved fastener driving tool similar to that shown in FIG. **2** but illustrating a deteriorated cushioning bumper;

FIG. **4** is a fragmentary view of the valve arrangement taken along line **4—4** of FIG. **1**;

FIG. **5** is a cross-sectional view of the valve arrangement according to the present invention, taken along lines **5—5** of FIG. **1**;

FIG. **6** is a cross-sectional view of the trigger valve of the improved fastener driving tool taken along line **6—6** of FIG. **5**;

FIG. **7** is a cross-sectional view of the cycling valve of the improved fastener driving tool taken along line **7—7** of FIG. **5**;

FIG. **8** is a cross-sectional view of the control valve housing of FIG. **1**, illustrating the throttling mechanism, taken along line **808** of FIG. **5**;

FIG. **9** is a cross-sectional view of the control valve mechanism of the fastener driving tool of FIG. **1**, illustrated in the single-fire arrangement;

FIG. **10** is a fragmentary cross-sectional view of the control valve arrangement of FIG. **9**, illustrating the cycling valve in its position for the return of the piston through a return stroke;

FIG. **11** is a cross-sectional view of the control valve of the improved fastener driving tool illustrated in the autofire position; and

FIG. **12** is a perspective view of the control valve housing of the improved fastener driving tool.

Referring now to the drawings, particularly to FIG. **1**, there is fragmentarily illustrated a fastener driving tool, generally illustrated as **10**, which embodies the control valve assembly and bumper arrangement according to 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 and a rearwardly extending hollow handle portion having a cavity 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 of the housing **12** 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 in engagement with a main or cylinder valve assembly **20** of a known type, under the control of a control valve assembly **22** according to the present invention. A fastener driving assembly **24** slidably mounted in the cylinder **18** includes a main or drive piston **26** and has connected thereto a depending drive blade member **28**. The fastener driving assembly **24** is normally biased to a position with the piston **26** adjacent the cylinder valve assembly **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, compressed fluid from the reservoir **16** enters the upper open end **18***a* of the cylinder **18** and drives the fastener driving assembly **24** downwardly to engage and set a fastener or nail **34** supplied to a drive track **36** in a nosepiece or nosepiece structure **38**. The flow of compressed fluid in the upper end of the cylinder **18** is controlled by the main valve assembly **20**, which includes a vertically movable ring member **40** defining a valve element, and having a sealing ring **42** engageable with the upper open end **18***a* of the cylinder **18**. The cylinder side of the ring member **40** is continuously in communication with the fluid reservoir **16** through a suitable passageway **44** so that pressurized fluid continuously acts against the cylinder side of the ring member **40** tending to displace the ring member **40** from the edge **18***a* of the cylinder **18**. However pressurized fluid is also introduced to the opposite side of the ring member **40** through a passageway **48** while the fastener driving tool **10** is in a static or at rest position. The differential pressure acting on the ring member **40** is effective to maintain the ring member **40** down, in a closed position, with the sealing ring **42** against the top **18***a* of the cylinder **18**. However if the pressurized fluid above the ring member **40** is discharged, the pressurized fluid acting through the passageway **44** is effective to unseat the ring member **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 the 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 includes a disc-shaped valve member **50** having a resilient valve element **52**, one edge **52***a* of which is engageable with an inwardly projecting lip **40***a* of the ring member **40** when the ring member is displaced upwardly to provide a seal therebetween. The valve element **52** is spaced below the inner surface of a downwardly projecting boss **54** defined in a cap **56** of the tool **10**. The downwardly projecting boss has a plurality of exhaust passageways **58** providing for the exhaust of the fluid when the ring member **40** is in its downward position.

To provide for the return stroke of the fastener driving assembly **24**, there is provided a return air chamber **60** communicating with the lower end of the cylinder **18** through a plurality of fluid inlet ports **62** and a plurality of fluid outlet ports **64**. Moreover the drive piston **26** is provided with a pair of spaced O-rings **66** and **68**, and a passageway **70** that communicates from the upper surface of the piston **26** opening between the O-rings **66** and **68**. The smaller passageway **70** defines a valve or passage for the flow of return fluid from above the piston **26** into the return air chamber **60** whenever the passageway **70** is aligned with the fluid inlet ports **62**, as illustrated in FIG. **2**. Thus it will be understood that in the normal operation of the fastener driving tool **10**, the working fluid above the piston **26** will flow through the passageway **70** and fluid inlet ports **62** into the return air chamber **60**, and will thereafter flow through the fluid outlet ports **64** below the piston **26** to drive the piston **26** back through its return stroke. For efficient piston return, restricting passage **70** should be smaller than passage through ports **64**. The fluid pressure drop through port **64** should be appreciably less than that through port **70**, otherwise, fluid will escape from this port rapidly to atmosphere when the poppet is closed and the exhaust valve **52** is open. In this event the piston will not shift initially blocking passage between ports **62** to **70**, thereby allowing escape of fluid from the storage chamber **60** until it is depleted. The fluid pressure drop should be less through the port beneath the piston than above, otherwise it will not be displaced sufficiently, blocking ports **62** and **70** and allowing the full return stroke. A greater volume of fluid will exit from chamber **60** to the bottom of the driver thus shifting it upwardly and closing off flow from passage **62** to above the driver and to atmosphere. Residual return fluid below the piston **26** will be dissipated to atmosphere by bleeding through a bleed opening **71** formed between the drive blade **28** and a washer **72**.

In accordance with the customary practice, there is provided a resilient cushioning member or bumper **74** in the lower end of the cylinder **18**, defining a stop for the piston **26** when it is at the end of its drive stroke. At this time the passageway **70** will be aligned with the fluid inlet port **62** as indicated in FIG. **2**.

In the event that the bumper **74** has deteriorated, so that the piston **26** moves down the cylinder **18** further than desired, to the position illustrated in FIG. **3**, the passageway **70** will no longer align with the fluid ports **62**; the O-ring **66** of piston **26** will have cleared past the fluid ports **62**. Thus any pressurized fluid entering the return air chamber **60** as the piston **26** travels past the ports **62** will be discharged into the cylinder **18** above the piston **26** and exhausted to atmosphere through the exhaust valve assembly **32**, and the piston **26** will not return upon completion of a drive stroke. Under normal conditions, fluid will leak only momentarily through the small port **70**, until the fluid pressure beneath the piston discharging through the least resistant port **64**, raises the piston to its fully retracted position. When the piston is displaced below the larger port **64**, as caused by deterioration of the bumper, a much higher proportion of the stored fluid will escape above the piston as this flow is no longer restricted through the small passage **70**. A substantial decrease in chamber **60** fluid pressure will result, preventing the full return of the piston. The tradesmen will be required to replace the fastener driving tool and to have the tool serviced so that the bumper **74** may be replaced.

The control valve assembly **22** includes a trigger valve **78**, a safety valve **80**, and a cycling valve **82**. As is known in the art, the safety valve **80** includes an actuator rod **84** connected by linkage to move down when the nosepiece **38** of the fastener driving tool is in engagement with the workpiece, and is programmed to prevent firing or cycling of the tool when the nosepiece **38** is not in engagement with the workpiece. The trigger valve **78** includes a trigger **86** which may be depressed to a first position, illustrated in phantom as **86'** in FIG. **6**, and represented in FIGS. **9** and **10** to provide for single-fire operation of the tool **10**, and further depressible to a second position illustrated in phantom in FIG. **6** as **86''**, represented in FIG. **11** wherein there is provided autofire operation of the tool **10** so long as the trigger is held in the depressed position. Any suitable means may be provided for positioning the trigger depression into its intermediate position; however in the illustrated embodiment there is provided a pneumatic bias to the trigger **86** such that for depression of the trigger **86** to its intermediate position **86'** the trigger **86** is brought to bear against an outwardly biased piston **90** riding within a cylinder **92** communicating with the fluid reservoir **16** through a passageway **94**. In order to further depress the trigger **68** into its position **86''**, the trigger **86** must overcome the resisting bias of the piston **90**, depressing the piston **90** to the position illustrated in phantom in FIG. **6**. The cycling valve **82** is effective to control the return movement of the fastener driving assembly **24** through its return stroke and will control the return thereof through a single cycle or through multiple repetitive cycles as called for by the function of the trigger **86**.

Advantageously the control valve assembly **22** including the trigger valve **78**, safety valve **80** and cycling valve **82** is housed within one compact removable valve housing **98**, best illustrated in FIG. **12**. Passageways may be die cast into the housing **98** and the housing **98** is readily secured to the housing **12** with the upper end thereof retained by a suitable pin **100** and the lower end thereof fastened by suitable screws or bolts **102**. Advantageously the valve housing **98** may be readily removed for repair and replacement.

Referring now to the valves in the control valve assembly **22**, the cycling valve **82** includes a differential cycling valve cylinder **108** defined within the valve housing **98**, closed at both ends, and slideably receiving a cycling valve spool or element **110** of a differential diameter type. The cycling valve cylinder **108** has an upper large diameter portion **108***a* and a lower small diameter portion **108***b*. The cycling valve spool **110** has an enlarged upper portion **110***a* received within the

large diameter portion **108***a*, and a lower small diameter portion **110***b* slideably receivable within the small diameter portion **108***b*. Additionally the cycling valve spool **110** is provided with a large sealing ring **112** defining a valve piston and a pair of spaced small diameter O-rings **114** and **116** spaced apart from the O-ring **112** and carried on the small diameter portion **110***b*. A first cycling port **118** opens into the end of the small diameter portion **108***b* of the valve cylinder **108**. A second cycling port **48***a* opens into the lower end of the small diameter portion **108***b* of the valve cylinder **108** intermediate the stroke of the O-ring **116**, and connects through passageway **48** to the upper surface of the ring member **40** of the cylinder valve assembly **20**. A third cycling port **122** opens into the small diameter portion **108***b* of the valve cylinder **108** intermediate the stroke of the small diameter O-rings **114** and **116**. A fourth cycling port **124** opens into the valve cylinder **108** intermediate the large O-ring **112** and the spaced small O-ring **114** throughout their travel. A fifth cycling port **126** opens into the end of the large diameter portion **108***a* of the valve cylinder **108** and is connected by a signal passageway **128** (FIG. **8**) to a source of signal fluid, here shown as connected to the return air chamber **60**.

The trigger valve **78** includes a valve cylinder **140**, open to the atmosphere at its upper end, and slideably receiving a trigger spool valve **142**, the upper end of which is engaged by a projecting finger **86***a* of the trigger **86** to be actuated thereby. The trigger spool valve **142** contains three spaced O-rings **144**, **146** and **148**. The trigger spool valve **142** is movable from a normal position, with the tool at rest, as illustrated in FIGS. **5** and **6**, to an intermediate or single-fire position as illustrated in FIGS. **9** and **10**, to a fully depressed or autofire position as illustrated in FIG. **11**. The valve cylinder **140** is provided with an annular exhaust passageway **150** formed around the upper protruding end of the valve spool **142**. A first trigger port **152** opens into the valve cylinder **140** intermediate the normal and displaced positions of the valve O-ring **144**. A second trigger port **154** opens into the valve cylinder **140** intermediate the stroke of the trigger spool valve **142** between the valve O-rings **144** and **146**. A third trigger port **156** opens into the valve cylinder **140** intermediate the travel of the valve O-ring **146** from the single-fire position to the autofire position and is connected to the fourth port **124** of the cycling valve **82** by a passageway **158**. A fourth trigger or exhaust port **160** opens into the valve cylinder **140** intermediate the travel of the valve O-rings **146** and **148**, and exhausts to the atmosphere. A fifth trigger port **162** opens into the closed lower end of the valve cylinder **140**, and is connected to the second trigger port **154** by a passageway **164**, and to the reservoir by a passageway **165**.

Referring now to the safety valve **80**, the safety valve **80** is defined by a safety valve cylinder **172** containing a safety spool valve **174** joined to the actuating rod **84** for movement therewith. The safety spool valve **174** carries three spaced O-rings **176**, **178** and **180** defining or forming a pair of annular passageways **182** and **184** therebetween. A first safety port **186** opens into the annular passageway **182** formed by the O-rings **176** and **178**, and is connected to the first trigger port **152** by a passageway **188**. A second safety port **190** opens into the valve cylinder **172** intermediate the travel of the O-ring **178**, and is connected to the first port **118** of the cycling valve **82** by a passageway **192**. A third safety port **194** opens into the valve cylinder **172** into the annular passageway **184**, and is connected to the trigger ports **154** and **162** by a passageway **196**, and further interconnects these trigger ports with the third port of the cycling valve **82** through a passageway **198**. An adjustable needle valve **204**, FIG. **8**, restricts the fluid flow through the signal passageway **128**, thereby providing the regulation of the repetitive cycling rate of the tool **10** when in the autofire position.

From the above detailed description, the operation of the control valve assembly **22** is believed clear. However, briefly, it will be understood that the control valve assembly has three operable positions; namely a normal position, with the valve elements as illustrated in FIG. **5**; a single-fire position with the trigger and safety valve as shown in FIGS. **9** and **10**, and the cycling valve cycling between the positions also therein indicated; and an autofire position, with the safety and trigger valves in the position illustrated in FIG. **11** and the cycling valve movable between the position illustrated in FIG. **11** and the position illustrated in FIG. **10** repetitively so long as the trigger **86** is maintained in the fully depressed position.

More specifically, and referring to the normal or at rest position of the tool, in this position the upper surface of the ring member **40** is maintained at reservoir pressure through the trigger port **162**, passageway **196**, safety port **194**, annular passageway **184**, safety port **190**, passageway **192**, port **118** in the cycling valve, port **48***a*, and passageway **48** to maintain the ring member **40** down and closed against the top **18***a* of the cylinder **18**.

The tool **10** will not operate unless both the trigger valve **78** and safety valve **80** are actuated. Thus if the safety valve **80** alone is actuated, then the flow of pressurized fluid between the safety ports **190** and **194** will be blocked by the O-ring **178**, but the upper surface of the ring member **40** will not be exhausted to atmosphere and thus the tool **10** will not fire. More specifically, the upper surface of the ring member **40** remains pressurized by the fluid supplied to the port **190** over the fluid conveying system including the passages **196**, **164**, the port **154**, the clearance between the O-rings **144** and **146**, the port **152**, the passage **188**, the port **186**, and the clearance between the O-rings **176** and **178**.

When it is desired to operate the tool **10** as a single-fire tool, it is necessary that the safety valve **80** be actuated to the operative position, as illustrated in FIG. **9**, and that the trigger valve **78** be actuated to its intermediate position as also therein illustrated. In this position the upper surface of the ring valve **40** will be exhausted to atmosphere through the passageway **48**, cycling ports **48***a* and **118**, passageway **192**, safety ports **190** and **186**, passageway **188**, trigger port **152**, and through the exhaust passageway **150** thus opening the cylinder valve assembly **20** and driving the fastener driving member **24** through a fastener driving cycle. At the same time the differential portion of the cycling valve **82**, intermediate the large and small O-rings **112** and **114**, will be exhausted to atmosphere through the cycling port **124**, passageway **158**, trigger port **156**, and trigger port **190**. As soon as the drive piston **26** reaches the end of its drive stroke, the return air chamber **60** will be pressurized by the flow of pressurized fluid through the passageway **70** and fluid inlet port **62**. The pressure will instantly act on the upper large diameter portion of the cycling valve **82** through the passageway **128** and cycling port **126**. Since there is no counter bias to the cycling valve **174**, the cycling valve **82** will instantly shift from the position illustrated in FIG. **9** to the position illustrated in FIG. **10**. At this time pressurized fluid will flow from the reservoir by means of the trigger port **162**, passageway **198**, and cycling ports **122** and **48***a* through passageway **48** to the upper surface of the ring member **40** to close the ring member **40** against the open upper end **18***a* of the cylinder **18**. This permits exhaust of the upper end of the cylinder **18** and the pressurized fluid which has now built up in the return air chamber **60** will be effective to return the piston **26** to its normal or at rest position. Moreover since there is no force on the cycling valve **82** tending to return the cycling valve **82** back to its original position, it will remain in its displaced position so long as the trigger is held in the single-fire condition. Upon release of the safety and/or the trigger from the single-fire position, pressurized fluid will be admitted to the closed lower end of the cycling valve to the port **118**, in like manner as described in connection with FIG. **5**, and the cycling valve **82** will be returned to its normal position.

When it is desired to operate the tool **10** in the autofire position, it is necessary that the trigger **86** be fully depressed against the resisting bias of the piston **90**, depressing the trigger spool valve **142** to the position illustrated in FIG. **11**. Under these conditions there is provided a return bias to the

cycling valve **82**; specifically the differential portion of the cycling valve spool **110** will be connected to reservoir pressure through the port **124**, passageway **158**, trigger ports **156** and **154**, passageway **164**, and trigger port **162** which is connected to the reservoir through the passageway **165**. As soon as the piston **26** reaches the end of its driving stroke, as illustrated in FIG. **2**, fluid pressure will build up within the return air chamber **60**. This pressure will be transmitted through the signal passageway **128**, past the needle valve **204**, and into the upper closed end of the portion **108***a* of the cycling valve cylinder **108**. As soon as the pressure in this end of the valve cylinder **108** builds up to a sufficient magnitude to overcome the return bias on the differential diameter portion of the valve spool **110**, the cycling valve spool **110** will shift to its down position, as illustrated in FIG. **10**. Because the rate of pressure buildup in the valve cylinder **108** from the signal passageway **128** may be regulated by adjusting the needle valve **204**, the speed at which the cycling valve spool **110** shifts can be controlled, and thus the cycling rate of the tool is selectively controlled. As soon as the cycling valve spool **110** is shifted to its downward position, pressure will once again be applied to the upper surface of the ring valve **40** in like manner as described in connection with FIG. **10**. Specifically the reservoir fluid from the trigger port **162** will flow through passageway **198** and cycling passageways **122** and **48***a*, through passageway **48** to the upper surface of the ring member **40**. At the same time the air pressure below the piston **26**, effective to return the drive piston **26** upwardly through a return stroke, will be depleted by leakage through the bleed opening **71**. The pressure of the fluid in the closed upper end of the portion **108***a* of the cycling valve cylinder **108** will be bled off the atmosphere and the return bias pressure acting on the differential diameter portion of the cycling valve spool **110**, applied through the trigger port **162**, passageway **164**, trigger ports **154** and **156**, passageway **158**, and safety port **124**, will be effective to more or shift the cycling valve spool **110** back to its upper position, to the position illustrated in FIG. **9**. At this point the cycling valve **82** is reset to exhaust the cylinder valve assembly **20** and to repeat the cycling operation of the tool.

Although the present invention has been described by reference to only a single embodiment, it will become apparent that numerous 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 and desired to be secured by Letters Patent of The United States is:

1. A pneumatically operated fastener driving tool including a housing having a cavity defining a fluid reservoir; a cylinder in said housing; a piston slideably mounted in the cylinder; main valve means controlling admission of fluid to and the exhaustion of fluid from one end of the cylinder; pneumatic piston return means including a return air chamber, a cycling valve having a body defining a cycling valve cylinder of the differential type having a small and a large diameter portion and a spool valve element in said cylinder movable through a stroke from a first to a second position, said spool valve element having large and small diameter portions slideable in the corresponding portions of the cycling valve cylinder and having a first sealing means on the large diameter portion of the spool valve element and a pair of spaced second and third sealing means on the small diameter portion of the spool valve element, said body having means defining a first port in the end of said small diameter portion of the cycling valve cylinder, first passageway means extending from said first port, a second port intermediate the stroke of the third sealing means, second passageway means connecting said second port to said main valve means, a third port opening between the second and third sealing means, throughout their stroke, third passageway means connecting said third port to said fluid reservoir, a fourth port opening between the first sealing means and the second sealing means throughout their travel, fourth passageway means extending from said fourth port, a fifth port in the end of said large diameter portion of the cycling valve cylinder, fifth passageway means extending from said fifth port to a source of signal fluid, and control means for selectively connecting said first and fourth passageways to said reservoir and to exhaust.

2. A fastener driving tool as set forth in claim **1** wherein said control means includes a trigger valve movable between a first position exhausting said fourth port, a second position exhausting said first port to provide single-fire operation of said tool, and a third position connecting said fourth port to the reservoir to provide multiple-fire operation of said tool.

3. A fastener driving tool as set forth in claim **2** and including a safety valve in said first passageway movable between a safety position connecting said first port to said reservoir and a second position connecting said first port to said trigger valve for exhaust thereby.

4. A pneumatically operated fastener driving tool as set forth in claim **1** and including metering means in said fifth passageway regulating the repetitive firing rate of said tool without affecting the single-fire rate thereof.

5. A pneumatically operated fastener driving tool as set forth in claim **1** wherein said fifth passageway opens into said return air chamber.

6. A pneumatically operated fastener driving tool including a piston slideably mounted in a cylinder and movable through a driving and return stroke, control means including manually operable means operable from a normal position to a first operated position for selectively operating said tool through a single-fire operation, wherein said piston automatically moves through a single driving and return cycle while said manually operable means remains in said first operated position, said manually operable means being movable to a second operated position to effect a multiple-fire operation wherein said piston automatically and continuously moves through repetitive cycles of driving and return strokes, and means for adjustably regulating the repetitive cycling rate of said tool during said multiple-fire operation without altering the single firing cycling speed thereof.

7. A pneumatically operated fastener driving tool as set forth in claim **6** wherein said tool includes a cycling valve movable between a normal position controlling a power stroke and an actuated position providing the return stroke, and means selectively providing for retention of said cycling valve in said actuated position and for cycling said cycling valve in response to a cycling signal.

8. A pneumatically operated fastener driving tool comprising a driving member operable through cycles of power and return strokes, control means selectively positionable to a first position to automatically operate said driving member through a single cycle with the control means held in the first position and to a second position to automatically operate said driving member through repetitive cycles with the control means held in the second position, and means for adjustably regulating the repetitive cycling rate without altering the single cycle speed thereof.

9. A fastener driving tool as set forth in claim **8** and including a cycling valve controlling the movement of said driving member through its strokes, said cycling valve having a differential diameter portion defining first and second surfaces of different area, first passage means connecting said first surface area to a source of signal fluid, and second passage means connecting said second surface area selectively to the atmosphere and to a source of pressurized fluid in response to the selective setting of said control means to said first and second positions for single-cycle operation and multifire operation.

10. A fastener driving tool as set forth in claim **9** and including adjustable means for throttling the fluid flow in said first passage.

11. A fluid-operated fastener driving tool comprising a driving member operable through a cycle of a power stroke and a return stroke, a main valve assembly operable to apply fluid to

and to exhaust fluid from the driving member to move the driving member through its power and return strokes, a cycling valve operable between spaced positions to control the operation of the main valve assembly, and manually operable control means operable from a normal position to a single cycle position to control the main valve and the cycling valve to effect a single cycle of the driving member while the manually operable control means remains in said single cycle position, said manually operable control means being operable to a second position to control the main valve assembly and the cycling valve to automatically and continually move said driving member through successive and repeated cycles so long as the manually controlled means remains in said second position.

12. The tool set forth in claim 11 in which the manually operable control means includes means operable in one of said first and second positions for applying a bias to the cycling valve and operable in the other of said first and second positions to prevent the application of a bias to the cycling valve.

13. A fluid-actuated fastener driving tool operable through a single cycle of a power stroke and a return stroke or a number of cycles each including a power stroke and a return stroke, said tool comprising a cylinder, a piston slideable in the cylinder, fluid-actuated main valve means for alternately supplying fluid to and exhausting fluid from the cylinder to move the piston through the power stroke and a return stroke, respectively, a cycling valve operable between two spaced positions and coupled to the main valve means for selectively controlling the connection of the main valve means to fluid and the atmosphere, said cycling valve being coupled to receive fluid admitted to the cylinder by the main valve means and operable to one of its two spaced positions thereby on each tool operation to institute the return stroke of the piston, and manual control means operable from a normal position to a first position to control the cycling valve to remain in said one position until the manual control means is returned to its normal position so that the tool automatically operates through a single cycle, said manual control means also being operable from a normal position to a second position to control the cycling valve to move from said one position to the other of its positions on each return stroke so long as the manual control means is held in its second position so that the tool automatically operates through a number of cycles.

14. The tool set forth in claim 13 in which the cycling valve includes a differential piston operator and the manual control means includes a valve for selectively connecting the differential piston to the atmosphere and fluid.

15. A pneumatically operated fastener driving tool including a housing, a cylinder in said housing, a piston slidably mounted in said cylinder for movement through power and return strokes, cylinder valve means for controlling the admission and exhaust of fluid from one end of said cylinder to drive said piston through a power stroke and permit return thereof, cushioning means positioned in the other end of said cylinder in the path of said piston to stop and cushion power strokes thereof at a normal piston stopping point, an air return chamber, first port means adjacent the cushioning means for supplying air from the chamber beneath the piston to move the piston through a return stroke, means for supplying pressurized air to the chamber incident to each power stroke, and second port means spaced above the first port means and placing the chamber in communication with the cylinder, said second port means being so spaced relative to the cushioning means that when the cushioning means deteriorates a given amount, the piston moves downwardly beyond the normal piston stopping point and the second port means become opened to discharge pressurized air from the chamber into the cylinder above the piston, the second port means being of such size that the air discharged renders the air in the chamber ineffective to move the piston through a return stroke.

16. The fastener driving tool set forth in claim 15 in which the piston carries a sealing means disposed between said one end of the cylinder and the second port means when the piston is at its normal stopping point and disposed between said first and second port means when the cushioning means deteriorates said given amount.

17. The fastener driving tool set forth in claim 16 in which the means for supplying pressurized air to the chamber includes a passage through the piston and opening into the cylinder between said sealing means and said other end of the cylinder.

18. A fluid-actuated fastener driving tool operable through a single cycle of a power stroke and a return stroke or a number of cycles each including a power stroke and a return stroke, said tool comprising a cylinder, a piston slideable in the cylinder, fluid-actuated main valve means for alternately supplying fluid to and exhausting fluid from the cylinder to move the piston through the power stroke and the return stroke, respectively, a cycling valve operable between two spaced positions and coupled to the main valve means for selectively controlling the connection of the main valve means to fluid and the atmosphere, said cycling valve being coupled to receive fluid admitted to the cylinder by the main valve means and operable to one of its two spaced positions thereby on each tool operation to institute the return stroke of the piston, and manual means coupled to the cycling valve and the main valve means for selectively controlling operation of the tool through a single cycle or a number of cycles, said control means including first valve means operable between operated and released positions for selectively supplying a connection to fluid and the atmosphere to operate the tool, said manual control means also including a second valve means, said second valve means being operable to a first position to control the cycling valve to remain in said one position until the first valve means is returned to its released position so that the tool automatically operates through only a single cycle, said second valve means also being operable to a second position to control the cycling valve to move from said one position to the other of its positions on each return stroke so long as the first valve means is in its operated position so that the tool operates through a number of cycles.

19. The tool set forth in claim 18 in which the cycling valve includes a differential piston operator with two fluid surfaces, one of said surfaces receiving fluid admitted to the cylinder by the main valve means, and in which the second valve means selectively connects the other of said surfaces to the atmosphere and fluid.

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