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Ramspeck et al.

[11] **3,888,404**

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[54] **SAFETY FOR FASTENER DRIVING TOOL**

[75] Inventors: **Howard B. Ramspeck**, Chicago; **Raymond F. Novak**, Schiller Park, both of Ill.

[73] Assignee: **Duo-Fast Corporation**, Franklin Park, Ill.

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[52] **U.S. Cl.** **227/8**; 227/130
[51] **Int. Cl.** **B25c 1/04**
[58] **Field of Search** 227/7, 8, 130; 91/356

[56] **References Cited**

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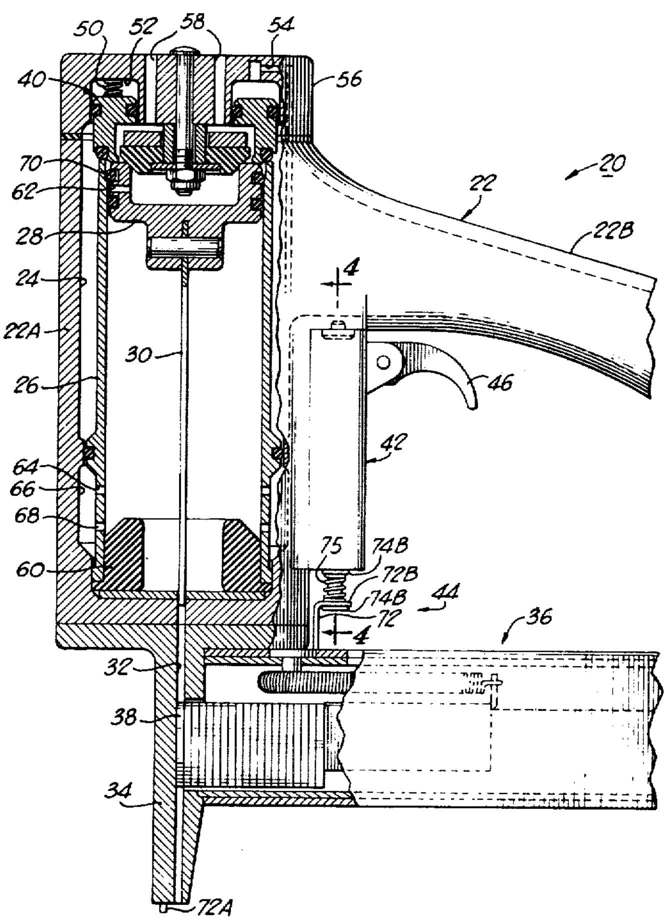
3,278,103	10/1966	Juilfs et al	227/130
3,638,532	2/1972	Novak	227/130 X
3,685,396	8/1972	Obergfell	227/130 X

Primary Examiner—Granville Y. Custer, Jr.
Attorney, Agent, or Firm—Mason, Kolehmainen, Rathburn & Wyss

[57] **ABSTRACT**

A fastener driving or applying tool includes a fluid actuated cycle valve for controlling a main valve to move through an automatic sequence of opening and closing movements to operate a piston actuated fastener driving blade through power and return strokes. In two embodiments, the degree of bias applied to the cycle valve is varied to provide a single cycle of power and return strokes (single cycle tool) or a series of such cycles (multifire tool). The tool includes a trigger or firing control and a safety control, and a fluid actuated piston prevents movement of the cycle valve unless the safety control is actuated prior to the firing control.

14 Claims, 9 Drawing Figures



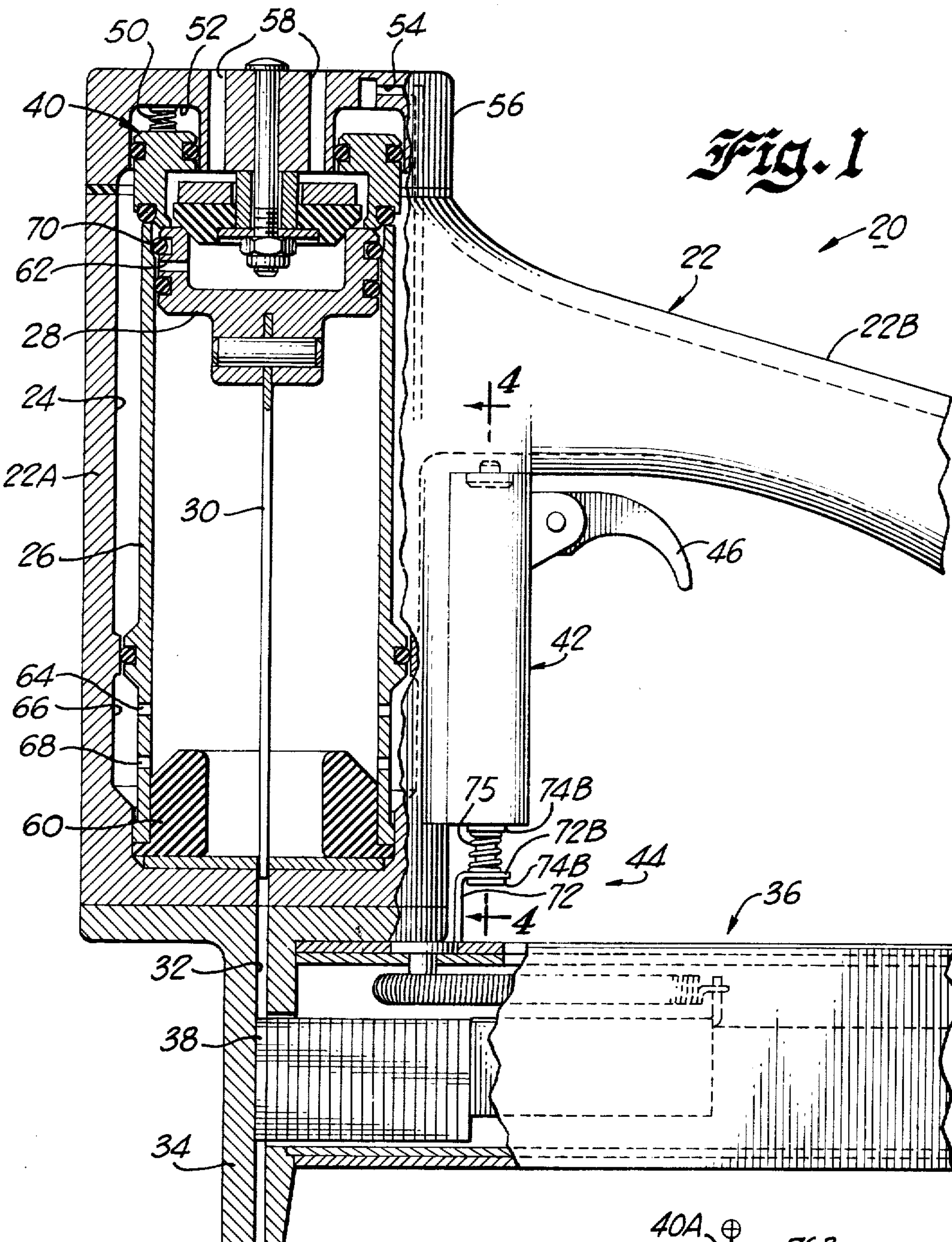


Fig. 1

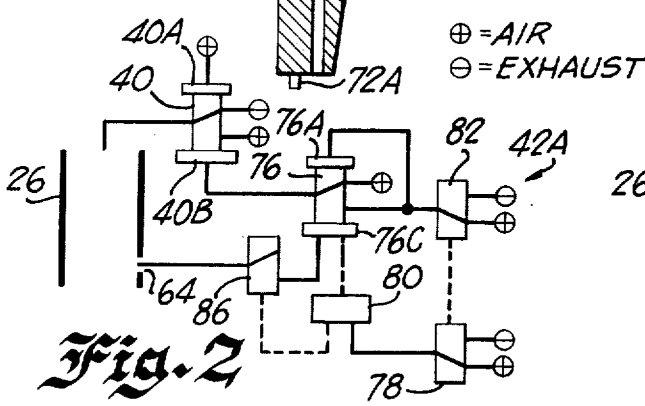


Fig. 2

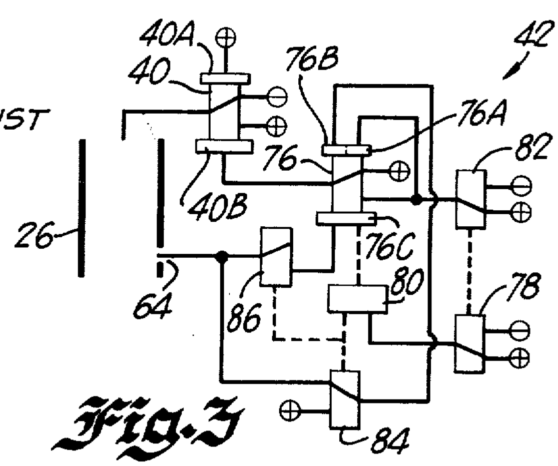


Fig. 3

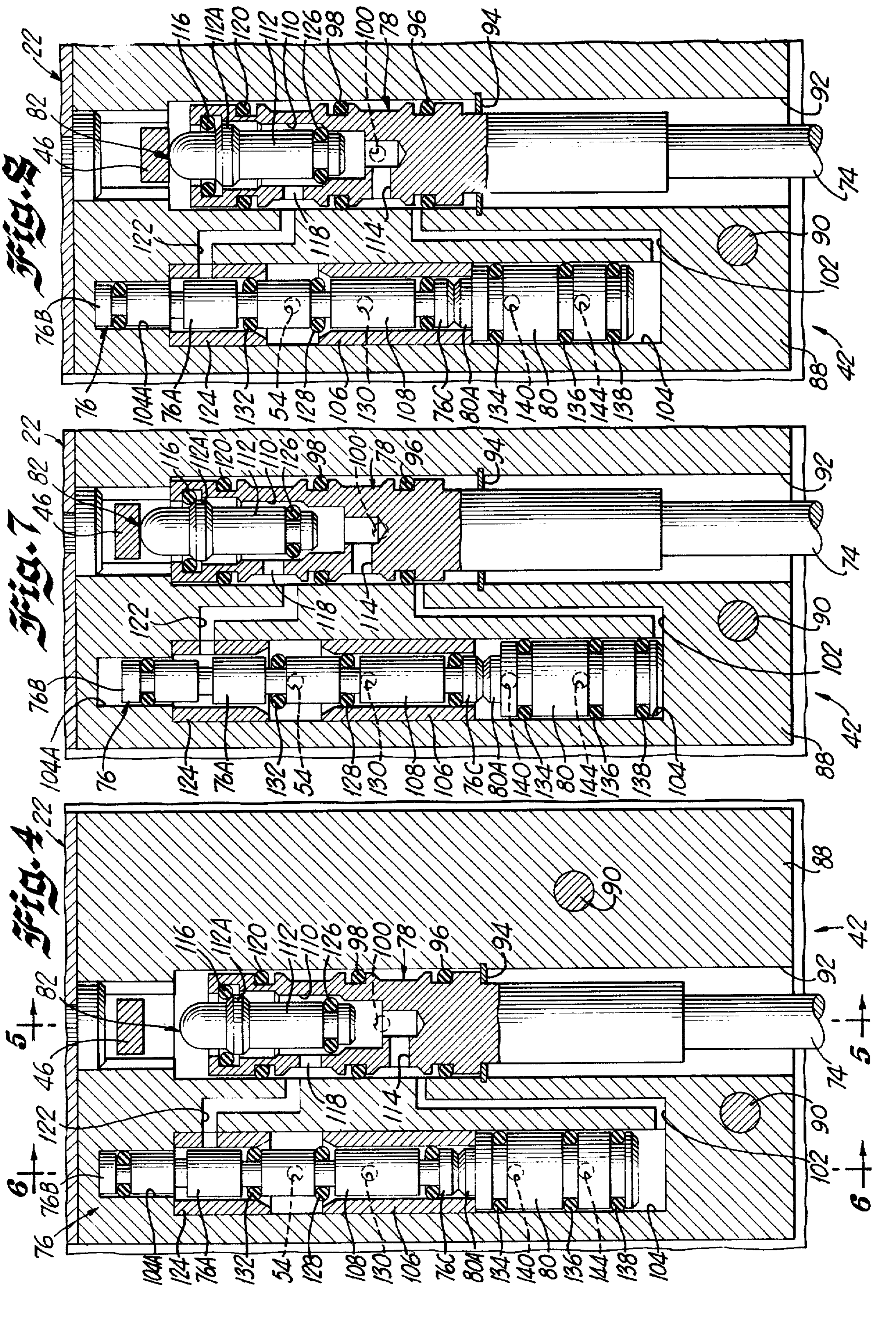


Fig. 8

Fig. 7

Fig. 4

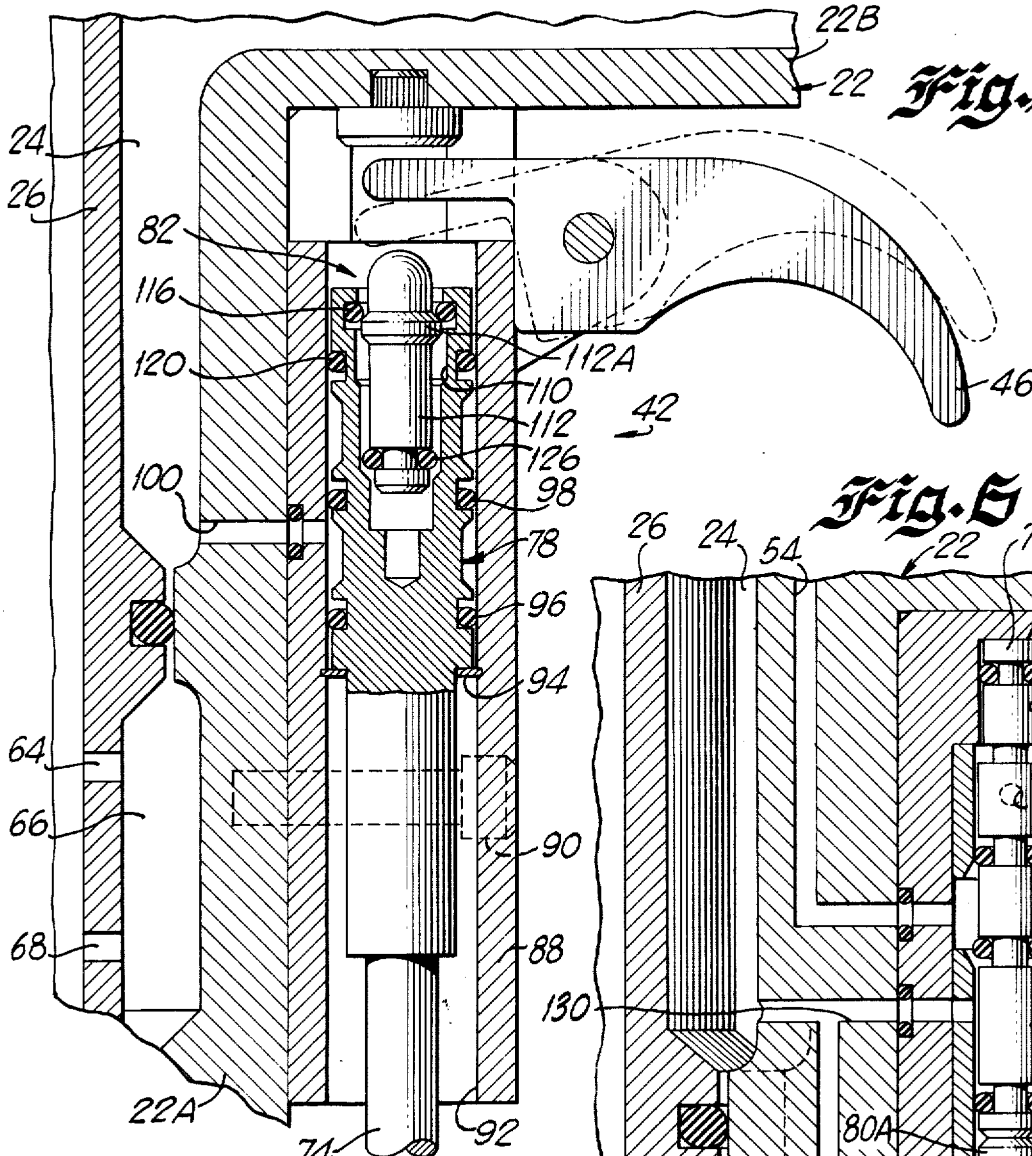
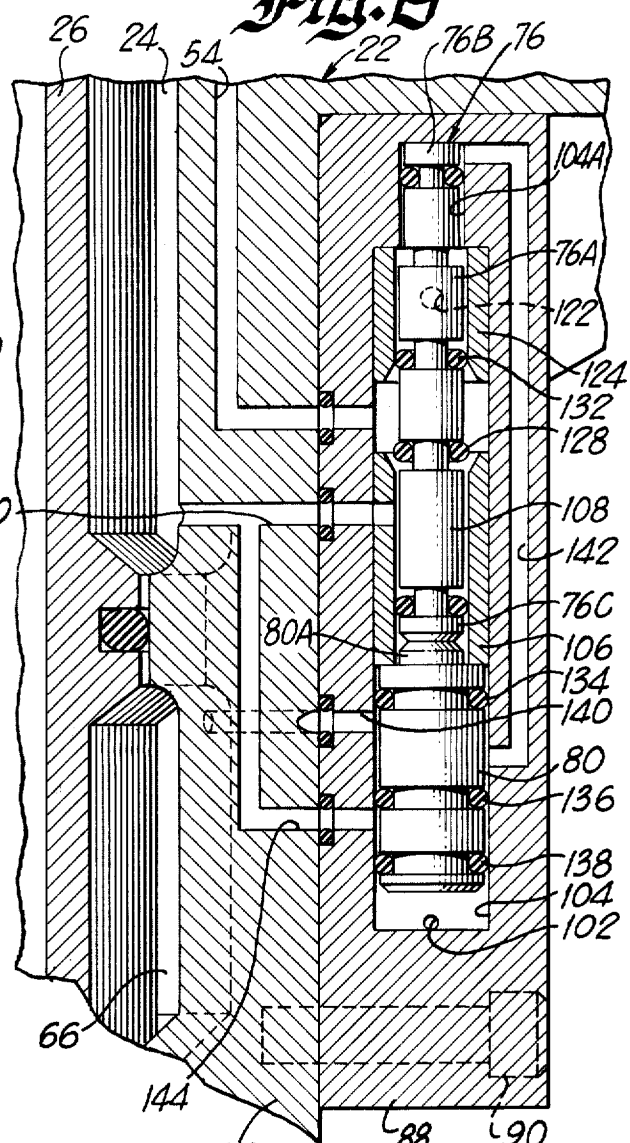


Fig. 5

Fig. 6



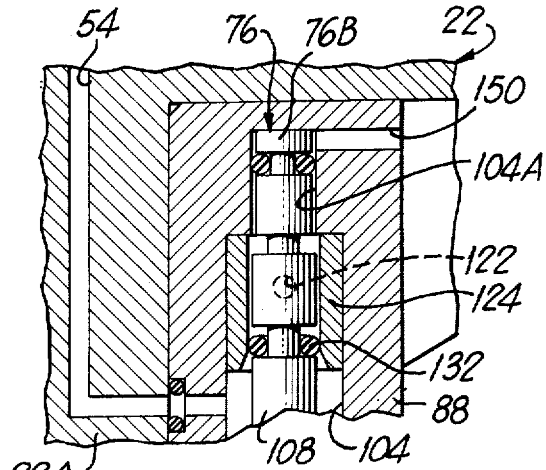


Fig. 9

SAFETY FOR FASTENER DRIVING TOOL

This invention relates to a fastener applying tool and, more particularly, to such a tool with automatic stroke sequences and a new and improved safety therefor.

A safety standard that is becoming increasingly applicable to power actuated fastener driving tools including pneumatic nailers and staplers is one requiring the tool to be disposed against the workpiece before the operation of a firing control, such as a trigger. U.S. Pat. Nos. 3,677,456 and 3,677,457 disclose two arrangements for inhibiting operation of fastener driving tools when a trigger control is operated prior to a safety control. The arrangements shown in these two patents are ones in which a main valve assembly controlling the supply of pressurized fluid to and the exhaust of fluid from the drive cylinder is opened and closed directly by the trigger control and the safety control. However, there are a number of nailers and staplers using cycle valves to provide automatic opening and closing sequences of the main valve, and it would be desirable to provide a safety-before-trigger safety control for this type of tool.

Accordingly, one object of the present invention is to provide a new and improved control for a fastener applying tool.

Another object is to provide a fastener applying tool of the type including a cycle valve which includes means for preventing operation of the tool unless a workpiece engaging safety is actuated prior to a firing control.

A further object is to provide a new and improved safety for automatic main valve sequence fastener driving tools, which safety includes a fluid actuated piston for inhibiting initiation of a sequence of operations of the main valve.

A further object is to provide a safety for a fastener driving tool using a cycle valve in which a movable fluid actuated piston mechanically blocks movement of the cycle valve when a safety control and a firing control are operated in an improper sequence.

In accordance with these and many other objects, an embodiment of the present invention comprises a fastener driving tool including a main cylinder containing a drive piston for actuating a fastener driving blade. A main valve is operable to opened and closed positions to supply pressurized fluid to and exhaust fluid from the main cylinder, respectively. The movement of the main valve to its opened and closed positions to provide power and return strokes of the fastener driving blade is controlled by a fluid actuated cycle valve having two magnitudes of fluid bias applied thereto so as to obtain either single cycle or multifire operation. A pneumatic piston disposed in a position in which it can be moved into an abutting mechanical relationship with the cycle valve is selectively controlled by a workpiece engaging safety and a firing or trigger control to mechanically block movement of the cycle valve whenever the firing control is actuated prior to the safety. In the multifire embodiment, the locking piston also includes valve means for selectively applying the bias necessary for multifire operation only after it has been determined that the safety control has been actuated prior to the trigger or firing control.

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 an elevational view in partial section illustrating the fastener driving tool embodying the present invention;

FIG. 2 is a schematic diagram of the pneumatic control circuit used in the tool shown in FIG. 1 to provide single cycle operation;

FIG. 3 is a schematic diagram illustrating the fluid controls used in the tool shown in FIG. 1 to obtain multifire operation;

FIG. 4 is an enlarged sectional view taken along line 4—4 in FIG. 1 illustrating a multifire control valve assembly shown in normal position;

FIG. 5 is a sectional view taken along line 5—5 in FIG. 4 illustrating a combined safety and trigger or firing control;

FIG. 6 is a sectional view taken along line 6—6 in FIG. 4 illustrating a cycle valve and sequence control piston included in the control valve assembly;

FIG. 7 is a fragmentary sectional view similar to FIG. 4 illustrating the control valve assembly after the operation of the safety control and prior to the operation of the firing control during a proper sequence of operation;

FIG. 8 is a fragmentary sectional view similar to FIG. 4 illustrating the control valve assembly on an improper operating sequence in which the firing control has been actuated prior to the safety control; and

FIG. 9 is a fragmentary sectional view similar to FIG. 6 illustrating a portion of a cycle valve for attaining single cycle operation in the manner shown achematically in FIG. 2 of the drawings.

Referring now more specifically to FIG. 1 of the drawings, therein is illustrated a fastener driving tool which is indicated generally as **20** and which embodies the present invention. The fastener driving tool **20** includes a housing **22** having a forward or head portion **22A** defining a chamber **24** continuously supplied with pressurized fluid such as compressed air from a reservoir defined by a hollow rearwardly extending handle portion **22B** of the housing **22.** A drive cylinder **26** disposed in the chamber **24** slidably receives a drive piston **28** to which the upper end of a fastener driving blade or element **30** is connected. The lower end of the driver blade **30** is slidably received within a drive track **32** formed in a nosepiece structure **34** forming a part of the housing **22.** A conventional magazine assembly indicated generally as **36** supplies successive staples **38** from a strip thereof to the drive track **32** below the lower end of the driver blade **30.**

A main valve assembly **40** in a normal closed condition connects the upper end of the interior of the cylinder **26** to the atmosphere and can be moved to an open position to supply pressurized fluid to the cylinder **26** to move the piston **28** and connected driver blade **30** through a power stroke. The main valve assembly **40** is automatically moved through this cycle of operation by a cycle valve in a control valve assembly indicated generally as **42.** The control valve assembly **42** is controlled by a conventional workpiece engaging mechanism indicated generally as **44** and a firing control or manual trigger **46.** The control valve assembly **42** is arranged so that the main valve **40** cannot be moved to an open position if the trigger **46** is actuated prior to operation of the safety mechanism **44** by placing the nosepiece structure **34** against a workpiece.

The construction of the tool **20** can be of any of the types well known in the art and can, for example, be constructed as shown and described in detail in U.S. Pat. No. 3,638,532. In general, the combined main and exhaust valve assembly **40** is normally held in a closed position by a plurality of compression springs **50** and pressurized air admitted to an annular chamber **52** over a passageway **54** by the control valve assembly **42**, the chamber **52** being formed in a closure cap **56** for the tool **20**. With the main valve assembly **40** in its normal position, communication between the pressurized fluid in the chamber **24** and the upper interior of the cylinder **26** is closed off, and this upper interior is connected to the atmosphere over a system of passageways including a plurality of passageways **58** formed in the closure cap **56**. When the control valve assembly **42** is actuated by the manual trigger **46** and the workpiece engaging assembly **44**, the chamber **52** is vented to the atmosphere over the passageway **54** by the control valve assembly **42**, and the main valve assembly **40** moves upwardly to close the connection to atmosphere above the upper interior of chamber **26** and to place the upper interior of the cylinder **26** in communication with the pressurized fluid in the chamber **24**. This drives the piston **28** downwardly through a power stroke during which the lower end of the fastener driving blade **30** engages a staple **38** disposed in the drive track **32** and drives this staple into a workpiece.

When the piston **28** reaches the lower end of its power or drive stroke determined by engagement with a resilient bumper **60**, pressurized fluid from the interior of the cylinder **26** flows through one or more openings **62** in the piston **28** and through one or more ports **64** to be collected within a fluid return chamber **66**. This pressurized fluid is also supplied as a control signal to the control valve assembly **42**.

When the control valve assembly **42** initiates a return stroke of the piston **28**, pressurized fluid is again supplied over the passageway **54** to the chamber **52**. This pneumatic bias coupled with the bias provided by the springs **50** moves the main valve **40** downwardly so that it again seats on the upper end of the cylinder **26** to close off communication with the pressurized fluid in the chamber **24**. In this position the main valve assembly **40** also opens the exhaust passages **58** so that the interior of the cylinder **26** above the piston **28** is connected to the atmosphere. At this time pressurized fluid enters the interior of the cylinder **26** below the piston **28** through one or a number of ports **68**. This compressed air forces the piston **28** upwardly to the normal position shown in FIG. **1**. The piston is retained in this position by an O-ring **70** on the piston which rests on a shoulder formed in the upper end of the cylinder **26**. The air below the piston **28** leaks to the atmosphere around the lower end of the driver blade **30** and through the drive track **32** so that at the conclusion of the return stroke of the piston, both the lower end of the interior of the cylinder **26** and the air return chamber **66** are placed substantially at atmospheric pressure.

The workpiece engaging assembly or means **44** which is actuated when the tool **20** is placed adjacent a workpiece can be of any suitable well known construction, such as that shown in U.S. Pat. No. 3,615,049. In general, the assembly **44** includes a linkage or mechanism **72** mounted on the housing **22** and the nosepiece structure **34** and resiliently biased to a position in which a workpiece engaging portion **72A** of the mechanism projects downwardly below the lower end of the nosepiece structure **34**. An upper portion **72B** of the mechanism **72** is coupled by a lost motion arrangement to the lower end of a safety valve stem **74** forming apart of the control valve assembly **42**. The illustrated lost motion coupling includes a pair of spaced enlargements or collars **74B** on the valve stem **74**. When the tool **20** is placed adjacent the workpiece, the lower end portion **72A** engages the workpiece and moves the mechanism **72** upwardly. The upper portion **72B**, after taking up the lost motion between the spaced collars **74B**, engages the upper collar **74B** to move the valve stem **74** upwardly. When the tool **20** is moved away from the workpiece, the resilient biasing means **75** moves the linkage **72** downwardly so that after lost motion is taken up, the portion **72B** engages the lower collar **74B** to move the valve stem **74** to the normal position shown in FIG. **1**.

Referring now more specifically to FIG. **3** of the drawings, therein is illustrated in schematic form the control valve assembly **42** for operating the tool **20** as an autofire tool in which the piston **28** will repeatedly cycle through power and return strokes within the cylinder **26** so long as the work engaging assembly **44** and the trigger **46** remain operated. The control valve assembly **42** is such that the workpiece engaging assembly **44** must be actuated to shift the safety valve stem **74** before the trigger **46** is operated in order to enable the control valve assembly **42** to produce operation of the tool **20**. As illustrated in the schematic diagram, in the normal condition of the tool **20**, the main valve assembly **40** connects the upper interior of the cylinder **26** to the atmosphere. In this normal condition, a continuous pneumatic bias applied to a piston portion **40A** tending to open the main valve **40** is overcome by the pneumatic bias applied to a greater area piston portion **40B** by a cycle valve **76**. In the physical embodiment of FIG. **1**, the piston portion **40B** includes the larger, upper area of the annular valve disposed in the chamber **52**, and the piston portion **40A** includes the smaller, lower area exposed to the fluid pressure in the chamber **24**.

In the normal condition of the tool **20**, a valve **78** controlled by the safety stem **74** normally supplies pressurized fluid to a piston **80** which is mechanically coupled to the cycle valve **76** as indicated in dashed line to hold the cycle valve **76** in the illustrated position in which pressurized fluid is supplied to the piston portion **40B** of the main valve assembly **40**. The bias applied by the piston **80** overcomes the bias applied in an opposite direction by a piston portion **76A** on the cycle valve which is normally connected to pressurized fluid through a valve assembly **82** controlled jointly by the trigger **46** and the workpiece engaging assembly **44**. A second piston portion **76B** on the cycle valve **76** providing a biasing force similarly directed to the piston portion **76A** is used to effect autofire operation. A greater area piston portion **76C** is provided for biasing the cycle valve **76** in an opposite direction. The piston portion **76B** is normally connected to the atmosphere through the ports **64** at the lower end of the cylinder **26** through a valve **84** controlled by the piston **80**. A passage to the piston portion **76C** is normally blocked at a valve **86** controlled by the piston **80**.

Assuming that the tool **20** is to be placed in operation to provide autofire operation in the correct sequence, the workpiece engaging assembly **44** is first actuated to move the valve stem **74** upwardly so that the valve **78** first shifts to its alternate position. In this position, the piston **80** is connected to the atmosphere, and the bias applied to the piston portion **76A** through the valve **82** is effective to shift the cycle valve **76** to its alternate position. This movement of the cycle valve **76** mechanically moves the piston **80** to its released position in which the state of the valves **84** and **86** controlled thereby are shifted. When the valve **84** is shifted, pressurized fluid applied to the autofire piston portion **76B** to provide the bias necessary to effect cyclic autofire operation of the cycle valve **76.** The operation of the valve **86** connects the piston portion **76C** to the port **64** to receive fluid pressure when the piston **28** reaches the end of its power stroke. The bias applied to the piston portions **76A** and **76B** holds the cycle valve **76** in its alternate position so that the piston portion **40B** on the main valve assembly **40** is connected through the cycle valve **76** to the valve **82** controlled by the safety stem **74** and the trigger **46.**

When the trigger **46** is operated after the actuation of the workpiece engaging assembly **44** in the desired sequence, the valve **82** is shifted to its alternate setting and the piston portion **40B** on the main valve assembly **40** is connected to the atmosphere. This permits the continuous bias applied to the piston portion **40A** of the main valve **40** to open the main valve assembly and supply compressed air to the upper interior of the cylinder **26** while closing off the connection to the atmosphere. This moves the piston **28** downwardly through a power stroke during which a stable **38** is driven into a workpiece.

When the piston **28** reaches the bottom of its power stroke, pressurized fluid supplied by the main valve assembly **40** enters the port **64** in the lower end of the drive cylinder **26** (FIGS. **1** and **3**) and is supplied to the piston portion **76C.** The greater area piston portion **76C** provides a biasing force greater than that supplied by the piston portion **76B,** the portion **76A** now being connected to the atmosphere through the operated valve **82.** Thus, the piston portion **76C** shifts the cycle valve **76** to the setting shown in FIG. **3** in which pressurized fluid is again applied to the piston portion **40B.** This closes the main valve by shifting the main valve assembly **40** to the position illustrated in FIG. **3.** In this position, the upper interior of the cylinder **26** is connected to the atmosphere, and the piston **28** is moved through a return stroke in the manner described above.

When the piston **28** has been returned to its normal position, the pressurized air in the lower end of the cylinder **26** leaks to the atmosphere in the manner described above, and thus pressurized fluid from the piston portion **76C** on the cycle valve **76** leaks to the atmosphere through the port **64.** When this pressure is decreased sufficiently, the bias applied to the piston portion **76B** shifts the cycle valve **76** to its alternate position so that the piston portion **40B** is again connected to the atmosphere through the cycle valve **76** and the operated valve **82.** This opens the main valve **40** by shifting the valve assembly **40** to its alternate position, and another power stroke of the piston **28** is initiated. This operation continues until such time as the trigger **46** and the workpiece engaging assembly **44** are released. When these elements are released, the valves **78** and **82** return to the position shown in FIG. **3.** When the valve **78** is released, the pneumatic bias is again applied to the piston **80,** and this piston forces the cycle valve **76** to its illustrated state in which pressurized fluid is again applied to the piston portion **40B** to hold the main valve assembly **40** in its closed state. In addition, when the piston **80** is shifted, the valve **84** is moved to its illustrated position in which the piston portion **76B** is connected to the atmosphere through the port **64.** This removes the autofire bias from the piston portion **76B** of the cycle valve **76.** When the valve **82** is released, bias is reapplied to the piston portion **76A** of the cycle valve, and pressurized fluid is applied to the connection of the valve **82** to the cycle valve **76** so that the piston portion **40B** cannot be connected to the atmosphere until such time as the valve **82** is operated.

The control valve assembly **42** is such that the autofire operation of the tool **20** described above cannot be initiated whenever the trigger **46** is actuated to shift the valve **82** to its alternate state prior to the operation of the valve **78** to its alternate state by actuation of the workpiece engaging assembly **44.** More specifically, when the valve **82** is actuated first to its alternate state, this valve connects the piston portion **76A** to the atmosphere so that the only bias applied to the cycle valve **76** tending to shift it to its alternate state is removed. Accordingly, when and if the workpiece engaging assembly **74** is thereafter operated to shift the valve **78** to its alternate state, the piston portion **80** is again connected to the atmosphere. However, since this piston portion is moved as described above through mechanical engagement with the cycle valve **76** and since no bias is now applied by either of the piston portions **76A** or **76B** to the cycle valve, the cycle valve **76** remains in the setting illustrated in FIG. **3,** and pressurized fluid remains applied to the piston portion **40B** of the main valve assembly **40** so that this valve cannot be moved to its open condition. Accordingly, the valve **82** must be released to its setting shown in FIG. **3** to reapply a bias to the piston portion **76A** followed by operation of the valve **78** by the workpiece engaging assembly **44** before autofire operation of the tool **20** can be initiated.

The mechanical construction and implementation of the valving shown in FIG. **3** is illustrated in FIGS. **4–8** of the drawings. The mechanical construction of the control valve assembly **42** can be of any suitable type and can, for example, be of the general nature disclosed and described in U.S. Pat. No. 3,685,396. In general, the control valve assembly **42** is carried in a valve housing **88** as an integral subassembly which can be secured to a wall of the head portion **22A** of the housing **22** by suitable fasteners such as machine bolts or screws **90.** Passages in the valve housing **88** communicating with the various control components are coupled to ports terminating related passageways formed in the housing **22.** A mechanical arrangement other than those described below can be devised for carrying out the control functions described above with reference to FIG. **3** of the drawings.

FIGS. **4–6** of the drawings illustrate the control valve assembly **42** in its normal position. The housing **88** includes a bore **92** (FIGS. **4** and **5**) open at its opposite end to the atmosphere and in which is slidably mounted the safety valve stem **74.** The normal position of the valve stem **74** is set by engagement of a locating washer **94** by a shoulder formed on the valve stem **74.** The valve stem **74** in cooperation with the bore **92** defines the valve **78** and also carries and forms a part of the valve **82.**

To provide the valve 78, the valve stem 74 carries a pair of spaced O-rings 96 and 98 between which terminates a passageway 100 communicating with pressurized fluid in the chamber 24 so that the area between the O-rings 96 and 98 within the bore 92 is continuously supplied with pressurized fluid. This fluid normally passes through a passageway 102 (FIG. 4) to the lower end of a second valve bore 104 in the housing 88 in which is slidably mounted the bias piston 80. The pressurized fluid supplied over the passageway 102 normally biases the piston 80 to the position shown in FIG. 4 in which it is set by engagement of the piston with a sleeve 106 disposed within the bore 104. In this position, a projection 80A engages the lower end of an elongated piston member 108 forming a part of the cycle valve 76 to hold the cycle valve 76 in the normal position illustrated in FIG. 3 of the drawings.

When the valve stem 74 is moved upwardly to effect the functional actuation of the valve 78 shown in FIG. 3, the valve stem 74 is moved to the position shown in FIG. 7 in which the lower O-ring 96 is disposed above the point in the bore 92 at which the passageway terminates. This connects the passageway 102 and thus the lower end of the bore 104 beneath the piston 80 to the atmosphere through the bore 92 inasmuch as the interface between the washer 94 and the cylindrical portion of the valve stem 74 is not sealed. In this manner, the valve 78 shown in FIG. 3 is provided by the passageway 100, the O-ring 96, and the port terminating the passageway 102 within the bore 92.

To provide the valve 82 (FIG. 3) operated by conjoint actuation of the workpiece engaging assembly 44 and the trigger 46, there is provided a recess 110 in the upper end of the valve stem 74 in which is movably mounted a valve member 112. The chamber or recess 110 is supplied with pressurized fluid at its lower end from the passageway 100 by an opening 114 (FIG. 4) passing through the valve stem 74 to the chamber or recess 110. Pressurized fluid supplied to the chamber 110 biases the valve element 112 upwardly so that an enlargement 112A thereon seats on an O-ring 116 carried on the valve stem 74, thereby sealing off communication between the chamber 110 and the atmosphere. In the normal condition of the valve 82, the pressurized fluid within the chamber 110 passes through an opening 118 in the valve stem 74 and a portion of the bore 92 sealed by a further O-ring 120 carried on the valve stem 74 and a passageway 122 to be supplied to the cycle valve 76 through an opening in a sleeve 124 disposed in the upper end of the bore 104.

To operate the valve 82 to its alternate setting from that illustrated schematically in FIG. 3, both the trigger 46 and the workpiece engaging assembly 44 must be operated. When the workpiece engaging assembly 44 is operated, the valve stem 74 is moved upwardly to the position shown in FIG. 7. If the trigger 46 is then pivoted in a counterclockwise direction (FIG. 5), the trigger 46 engages the outer end of the valve element 112 and moves it downwardly so that the enlarged portion 112A moves out of engagement with the O-ring 116. This connects the chamber 110 to the atmosphere through the open upper end of the bore 92. This movement of the valve element 112 also moves an O-ring 126 carried on its lower end into engagement with a tapered or sloping wall surface on the valve stem 74 providing a valve seat and closes off communication between the passageway 114 and the passageway 118. This terminates the supply of pressurized fluid from the passageway 110 to the passageway 122. Thus, the cycle valve 76 is connected to the atmosphere over the passageway 122 and the operated valve 82.

The cycle valve 76 (FIGS. 4 and 6) includes the piston member 108 and adjacent portions of the sleeves 106 and 124 and the bore 104. The portion of the bore 104 intermediate the sleeves 106 and 124 is connected over the passageway 54 to the chamber 52 (FIG. 1) in which is disposed the large surface piston portion 40B (FIG. 3) of the main valve assembly 40. In the normal position of the piston member 108 to which it is biased by the piston 80, an O-ring 128 on the piston member 108 is out of engagement with the upper end of the sleeve 106 so that the passageway 54 is in communication with pressurized fluid supplied by the chamber 24 through a passageway 130. The passageway 54 is held out of communication with the passageway 122 to which pressurized fluid is supplied by the valve 82 in its normal condition by an O-ring 132 which is carried on the piston 108 and which is seated on the lower end of the sleeve 124. When the cycle valve 76 is moved to the alternate position shown in FIG. 7, the O-ring 128 seats on the upper end of the sleeve 106 to close off communication between the passageways 54 and 130, and the O-ring 132 moves out of engagement at the lower end of the sleeve 124 to connect the passageway 54 to the passageway 122 controlled by the valve 82.

To relate various portions of the piston 108 to the piston portions 76A, 76B, and 76C of the cycle valve 76 referred to in the description of FIG. 3, the lower end of the piston 108 provides the piston portion 76C and is so designated. The uppermost portion of the piston 108 which is disposed within a reduced diameter portion 104A of the bore provides the piston portion 76B. The next lowest portion of the piston 108 which is of a slightly larger diameter than the piston portion 76B provides the piston portion 76A which is selectively supplied with a biasing pressure over the passageway 122.

The valves 84 and 86 (FIG. 3) that are selectively opened and closed by the piston 80 are provided by three O-rings 134, 136, and 138 carried on the piston 80 and movable within the lower end of the valve bore 104. The upper O-ring 134 normally closes off communication between the piston portion 76C on the piston 108 (FIGS. 3 and 6) and a passageway 140 (FIG. 6) extending from the bore 104 to the air return chamber 66. Thus, the passageway 140 normally does not provide communication between the piston portion 76C and the port 64 in the cylinder 26. When the piston 80 drops to its displaced position (FIG. 7), the passageway 140 is placed in communication with the piston portion 76C within the lower end of the sleeve 106. Thus, the O-ring 134 on the piston 80 provides the valve 86 shown schematically in FIG. 3.

The O-rings 134 and 136 in the normal position of the piston 80 also place the passageway 140 in communication with a passageway 142 (FIG. 6) extending at the upper end of the reduced diameter portion 104A of the valve bore 104. Accordingly, the valve bore 104A is normally placed in communication with the atmosphere over the passageways 140 and 142, the air return chamber 66, and the ports 64. The O-ring 136 normally closes off communication between the passageway 142 and a passageway 144 directly supplied with pressurized fluid from the chamber 24.

When the piston 80 is displaced to its lower position (FIG. 7), the O-ring 134 closes off communication between the passageways 140 and 142, and the O-ring 136 places the passageway 142 in communication with the passageway 144. Thus, pressurized fluid from the chamber 24 is now supplied to the piston portion 76B in the valve bore 104A to provide an autofire bias to the cycle valve 76. Thus, the O-rings 134 and 136 and the cooperating structures including the passageways 130, 144, and 142 provide the valve 84 shown schematically in FIG. 3.

When the tool 20 is to be operated in its proper sequence, this tool is placed against a workpiece so that the valve stem 74 is moved upwardly from the normal position shown in FIG. 4 to the actuated position shown in FIG. 7. As the O-ring 96 passes the termination of the passageway 102, compressed air normally holding the piston 80 in the position shown in FIG. 4 is vented to the atmosphere through the lower portion of the valve bore 92. Since compressed air is continuously supplied from the passageway 100 through the openings 114 and 118 and the passageway 122 to the piston portion 76A on the piston 108, the piston 108 moves downwardly from the position shown in FIG. 4 to the position shown in FIG. 7. In moving to this position, the O-ring 128 engages the adjacent portion of the sleeve 106 to close off communication between the passageway 54 and the pressurized fluid inlet passage 130. Since the O-ring 132 has moved out of engagement with the adjacent end of the sleeve 124, the passageway 54 extending to the main valve assembly 40 is now connected to the passageway 122 and receives pressurized fluid supplied from the passageway 100.

Further, when the piston 80 moves downwardly from the position shown in FIG. 4 to the position shown in FIG. 7, the O-ring 134 places the passageway 140 in communication with the open lower end of the sleeve 106 so that pressurized fluid subsequently accumulated in the return chamber 66 through the ports 64 can pass over the passageway 140 to the piston portion 76C. The O-ring 134 also closes off communication between the passageways 140 and 142 and places the passageway 142 in communication with pressurized fluid supplied from the passageway 144 so that an autofire bias is forwarded over the passageway 142 to the piston portion 76B on the piston 108.

Thus, following the actuation of the work engaging assembly 44 to shift the safety valve stem 74 to the position shown in FIG. 7, the components of the control valve assembly 42 are moved to the position shown in FIG. 7.

With the components in this position, actuating the trigger 46 to the position shown in dot and dash outline in FIG. 5 moves the trigger portion 46 shown in FIG. 7 downwardly against the upper end of the valve element 112 to move it down so that the O-ring 126 seats on the adjacent portion of the valve stem 74 to close off communication between the passageway 122 and the passageway 100. This removes the source of closing fluid bias for the large piston portion 40B of the main valve assembly 40. This downward movement of the valve element 112 moves the enlarged portion 112A out of engagement with the O-ring 116 so that the passageway 122 is connected to the atmosphere. This discharges the pressurized fluid from the large area piston portion 40B and permits the main valve 40 to be opened by the small area biasing portion 40A continuously supplied with fluid from the chamber 24. Accordingly, the main valve 40 is opened to initiate a power stroke of the piston 28 in the driver blade 30 in the manner described above. At the end of this power stroke, pressurized fluid from the interior of the cylinder 26 passes through the ports 64 to be accumulated within the chamber 66 and then passes over the passageway 140.

This fluid accumulates in the area in the bore 104 above the O-ring 134 on the piston 80 and acts on the piston portion 76C of the piston 108. Since the effective area of the piston portion 76C is greater than the effective area of the piston portion 76B, the pressure supplied through the passageway 140 moves the piston 108 upwardly to the normal position shown in FIG. 4. In doing so, the O-ring 132 seats on the sleeve 124 and the O-ring 128 moves out of engagement with the sleeve 106. This connects the passageway 54 to the pressurized fluid supplied through the passageway 130, and the pressurized fluid thus supplied to the passageway 54 acts on the large area piston portion 40B of the main valve assembly 40 to move this valve assembly to its closed condition. This initiates a return stroke of the piston 28 in the manner described above.

Incident to this return stroke, pressurized fluid collected in the return chamber 66 is dissipated to the atmosphere through the ports 64 and 68, and the bias applied to the piston portion 76B on the piston 108 exceeds the bias applied to the piston portion 76C thereon. This moves the piston 108 back to the position shown in FIG. 7, and pressurized fluid is exhausted from the chamber 52 (FIG. 1) in the main valve assembly 40 so that the main valve assembly 40 again opens to initiate a second cycle of operation of the tool 20. This cyclic operation continues under the control of the bias applied to the piston portions 76B and 76C so long as the trigger 46 remains depressed or actuated, and the workpiece engaging assembly 44 is operated.

Whenever these two assemblies or either one of these assemblies is released, the valve element 112 is moved upwardly by the pneumatic bias supplied through the passageway 100 so that the enlarged portion 112A seats on the O-ring 116 and the O-ring 126 moves out of engagement with the adjacent portion of the valve stem 74. This returns pressurized fluid to the passageway 122 for holding the main valve 40 closed in the manner described above. Further, when the safety mechanism 44 is released, the O-ring 96 moves below the port terminating passageway 102 (FIG. 4). At this time, pressurized fluid from the passageway 100 flows over the passageway 102 and into the lower end of the valve bore 104. This moves the piston 80 upwardly to bias and hold the piston 108 in the normal position shown in FIG. 4. In addition, the bias applied over the passageway 142 (FIG. 6) to the autofire piston portion 76B is discharged to atmosphere over the passageway 140, and the supply of biasing fluid previously available from the passageway 144 is intercepted by the O-ring 136. In addition, the O-ring 134 cuts off the piston portion 76C on the piston 108 from communication with the signal passageway 140. The tool 20 can be placed in multifire operation in the manner described above by first actuating the workpiece engaging assembly 44 followed by the actuation of the manual trigger or firing control 46.

Assuming, however, that an attempt is made to operate the tool 20 in an improper sequence, the trigger 46 is first actuated fully to the position shown in dot and dash outline in FIG. 5. This moves the trigger **46** to the position shown in section in FIG. **8.** If the tool **20** is then moved toward the workpiece, the safety valve stem **74** begins to move upwardly. However, when the valve stem **74** reaches the position shown in FIG. **8,** the prior full actuation of the trigger **46** causes the valve element **112** in the valve assembly **82** to move downwardly to the position shown in FIG. **8** at a time prior to movement of the O-ring **96** above the port terminating the passageway **102.** When the valve element **112** moves down, the O-ring **126** again interrupts the connection between the passageway **122** and the source of pressurized fluid provided by the passageway **100.** This movement of the valve element **112** also moves the enlarged portion **112A** thereon out of engagement with the O-ring **116** so that the passageway **122** is connected to the atmosphere. This discharges pressurized fluid acting on the piston portion **76A** of the piston **108** in the cycle valve **76** and removes the only bias tending to move the piston **108** downwardly as viewed in FIG. **8.**

Accordingly, if the tool **20** is thereafter placed against the workpiece so that the safety valve stem **74** becomes sufficiently elevated to move the O-ring **96** above the port terminating the passage **102,** pressurized fluid acting on the lower surface of the piston **80** within the valve chamber **104** is again discharged to the atmosphere through the open lower end of the valve bore **92.** However, the piston **80** is held in the position shown in FIG. **8** by the resilient O-rings **134, 136,** and **138** inasmuch as there are no pneumatic biases acting on either the piston **80** or the piston **108** in the cycle valve assembly **76.** Since the piston **108** remains in the position shown in FIG. **8,** the passageway **54** leading to the main valve assembly **40** remains connected to the pressurized fluid supplied through the passageway **130** because the O-ring **128** is not seated on the upper end of the sleeve **106.** The passageway **54** cannot be connected to the atmosphere because the O-ring **132** remains seated on the sleeve **124.** Thus, a cycle of operation of the tool cannot be initiated at this time.

If the manual trigger **46** is released so that the fluid pressure supplied through the passageway **100** can again restore the valve **82** including the valve element **112** to the normal position shown in FIGS. **4** and **7,** the passageway **122** is again pressurized, and the piston portion **76A** can provide a downwardly directed force shifting both the piston **80** and the piston **108** to the lower position shown in FIG. 7. This permits the initiation of multifire operation.

Accordingly, the control valve assembly **42** includes means for preventing initiation of autofire operation of the tool **20** unless this tool is first placed against the workpiece to actuate the assembly **44** followed by manual actuation of the trigger **46.** The piston **80** holds the piston **108** in the cycle valve assembly **76** in its normal position when the valve **82** controlled by the trigger **46** in the assembly **44** is operated prior to the valve **78** controlled by the workpiece engaging assembly **44.** When the trigger **46** is first operated, the bias for moving the cycle valve **76** normally applied to the piston portion **76A** is removed which means that the control piston **80** remains in its elevated position and that the valve means **84** and **86** (FIG. **3**) remain in their normal settings so that an autofire bias cannot be applied to the piston portion **76B** and so that the passage **140** supplying a fluid pressure signal to the piston portion **76C** cannot be opened.

The control valve assembly **42** can also be provided in a modified form **42A** to provide single cycle operation rather than multifire operation. In single cycle operation, the drive piston **28** moves through one power and return cycle and remains in this position even though the trigger **46** and the workpiece engaging assembly **44** remain actuated until such time as at least one of these components is released and reoperated. This modified control assembly **42A** (FIG. **2**) also insures that the tool **20** cannot be operated through even the single cycle of operation unless the workpiece engaging assembly **44** is actuated prior to the manual trigger **46.**

The only mechanical modification required in the control valve assembly **42** to provide the single cycle control valve assembly **42A** is illustrated in FIG. **9** of the drawings. More specifically, the passageway **142** normally connecting the reduced diameter portion **104A** of the valve bore for the cycle valve **76** is plugged or not provided, and the upper end of the reduced diameter portion **104A** is vented to the atmosphere through a passageway **150.** Thus, the piston portion **76B** on the piston **108** for the cycle valve assembly **76** cannot be supplied with the pneumatic bias required for multifire operation. In other respects, the single cycle control valve assembly **42A** is identical to the control valve assembly **42.**

A schematic diagram of the control valve assembly **42A** for providing single cycle operation is illustrated in FIG. **2** of the drawings. In this schematic diagram the valve **84** has been omitted as well as the piston portion **76B** inasmuch as these components perform no useful function. The valves and controlling mechanism shown schematically in FIG. **2** are realized by the same mechanical structures described above with the modifications shown in FIG. **9.**

Assuming that the tool **20** is to be operated in a proper sequence, this tool is placed against a workpiece, and the valve stem **74** moves upwardly to first actuate the valve **78.** When the valve **78** is actuated to its alternate setting, compressed air is vented from the control piston **80.** The bias supplied by the valve **82** for the piston portion **76A** moves the cycle valve **76** to its alternate setting, and in doing so forces the piston **80** downwardly within the valve bore **104** to the position shown in FIG. **7.** This actuates the valve **86** so that the piston portion **76C** is placed in communication with the ports **64** over the passageway **140** and the air return chamber **66.** When the cycle valve **76** moves to its alternate setting, the piston portion **40B** on the main valve assembly **40** is coupled to the valve **82.**

When the valve **82** is next actuated by fully depressing the trigger **46,** the piston portion **40B** is connected to the atmosphere, and the piston portion **40A** is effective to shift the main valve assembly **40** to its alternate setting so that compressed air is supplied to the upper interior of the cylinder **26.** This moves the piston **28** and the driver blade **30** through a power stroke during which a stable **38** is driven. When the piston **28** reaches the end of its power stroke, pressurized fluid from the upper interior of the cylinder **26** is forwarded through the ports **64** and the actuated valve **86** to the piston portion **76C.** This bias immediately shifts the cycle valve **76** to its normal position illustrated in FIG. **2** inasmuch as the prior actuation of the valve **82** removes all bias from the piston portion **76A**. When the cycle valve **76** returns to this setting, pressurized fluid is again applied to the piston portion **40B** of the main valve assembly **40**, and this valve assembly moves to its illustrated closed setting in which the upper interior of the cylinder **26** is connected to the atmosphere. This permits the return of the piston **28** to its normal position as described above.

The control valve assembly **42A** remains in this position with the cycle valve **76** in the position illustrated in FIG. **2** holding the main valve assembly **40** closed inasmuch as no bias is applied to the cycle valve **76** to permit its return to an operated position when the air acting on the piston portion **76C** is dissipated to the atmosphere through the ports **64** in the manner described above. The frictional engagement of the O-rings on the piston **108** (FIG. **3**) in the cycle valve assembly **76** retains the piston in the position shown in FIG. **4** in the absence of a bias. When the trigger **46** is released and the workpiece engaging assembly **44** is released, the valves **78** and **82** return to the normal settings illustrated in FIG. **2**. This restores the piston **80** to a position biasing or blocking the piston **108** of the cycle valve assembly **76** in its normal position. This movement of the piston **80** also opens the valve **86** so that the piston portion **76C** on the cycle valve **76** is no longer connected to the port **64**. The reapplication of bias from the valve **82** to the piston portion **76A** is not effective to shift the cycle valve **76** inasmuch as the bias provided thereby is less than the bias afforded by the control piston **80**.

If an attempt is made to initiate a single cycle operation of the tool **20** by first operating the trigger **46** followed by the operation of the workpiece engaging assembly **44**, the valve **82** is first operated to remove the bias from the piston portion **76A**, and the valve **78** is thereafter operated to remove the pneumatic bias from the control piston **80**. As set forth above, the resilience of the O-rings on the pistons **80** and **108** prevents movement of these pistons from the normal position shown in FIG. **4** because no pneumatic biases are effective on any of these pistons. This means that the cycle valve **76** cannot be moved from its normal position shown schematically in FIG. **2** in which it supplies a continuous connection of pressurized fluid to the large piston portion **40B** of the main valve assembly **40**. This means that the main valve assembly **40** cannot be operated from its normal and illustrated closed state in which the upper interior of the cylinder **26** is connected to the atmosphere. Accordingly, a single cycle operation of the tool **20** cannot be initiated if the workpiece engaging assembly **44** is not actuated prior to the operation of the manual trigger **46**. By releasing and reoperating the trigger **46**, a single cycle operation of the tool **20** can be initiated.

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

We claim:

1. A tool for driving fasteners into a workpiece comprising

a powered fastener driving assembly including a driver element actuated by a drive piston movable within a cylinder,

a fluid controlled main valve means opened to supply pressurized fluid to and closed to exhaust fluid from the cylinder,

a fluid controlled cycle valve coupled to the main valve means and movable to alternate positions to control opening and closing of the main valve means,

a first control means coupled to the cycle valve including a valve controlled by independently operable manual means and safety means actuated by placing the tool adjacent the workpiece for moving the cycle valve to a position effecting opening of the main valve means only when both of the manual means and the safety means are actuated,

and a second control means coupled to the cycle valve and responsive to the operation of at least one of the manual means and safety means for preventing movement of the cycle valve when the manual means is operated prior to the safety means.

2. A tool for driving fasteners into a workpiece comprising

a powered fastener driving assembly including a driver element actuated by a drive piston movable within a cylinder,

a fluid controlled main valve means opened to supply pressurized fluid to and closed to exhaust fluid from the cylinder,

a fluid controlled cycle valve coupled to the main valve means and movable to alternate positions to control opening and closing of the main valve means, said cycle valve including at least one fluid responsive surface for moving the cycle valve to one of said alternate positions,

a first control means coupled to the cycle valve including independently operable manual means and safety means actuated by placing the tool adjacent the workpiece for moving the cycle valve to a position effecting opening of the main valve means only when both of the manual means and the safety means are actuated,

and a second control means coupled to said fluid responsive surface on the cycle valve for preventing movement of the cycle valve by preventing the supply of fluid to the fluid responsive surface when the manual means is operated prior to the safety means.

3. A tool for driving fasteners into a workpiece comprising

a powered fastener driving assembly including a driver element actuated by a drive piston movable within a cylinder,

a fluid controlled main valve means opened to supply pressurized fluid to and closed to exhaust fluid from the cylinder,

a fluid controlled cycle valve coupled to the main valve means and movable to alternate positions to control opening and closing of the main valve means, said cycle valve being movable to a position effecting closing of the main valve means under the control of fluid supplied to the cylinder,

a first control means coupled to the cycle valve including independently operable manual means and safety means actuated by placing the tool adjacent the workpiece for moving the cycle valve to a position effecting opening of the main valve means only when both of the manual means and the safety means are actuated,

and a second control means coupled to the cycle valve and to the first control means for preventing movement of the cycle valve after the manual means and the safety means are operated when the manual means is operated prior to the safety means.

4. The tool set forth in claim **3** in which

the second control means includes a fluid actuated piston mechanically coupled to the cycle valve and biasing the cycle valve against movement to a position effecting opening of the main valve means.

5. A tool for driving fasteners into a workpiece comprising

a powered fastener driving assembly including a driver element actuated by a drive piston movable within a cylinder,

a fluid controlled main valve means for selectively supplying pressurized fluid to and exhausting fluid from the cylinder,

a cycle valve coupled to the main valve means and movable to alternate positions to control opening and closing of the main valve means,

a first control means coupled to the cycle valve including manual means and safety means actuated by placing the tool adjacent the workpiece for moving the cycle valve to said main valve opening control position when both of the manual means and the safety means are actuated,

a second control means coupled to the cycle valve and to the cylinder for moving the cycle valve to, said main valve closing control position,

a fluid actuated control piston coupled to the cycle valve for controlling its movement,

and means coupling the control piston to the first control means and controlling the control piston to prevent movement of the cycle valve to said opening control position when the manual means is actuated prior to the safety means.

6. The tool set forth in claim **5** including

means mounting the control piston for movement into and out of engagement with the cycle valve.

7. The tool set forth in claim **6** in which

the first control means includes means for applying a biasing force to the control piston to hold the control piston in engagement with the cycle valve to prevent movement of the cycle valve when the manual means is actuated prior to the safety means, said first control means rendering said biasing means ineffective when the safety means is actuated.

8. A tool for driving fasteners into a workpiece comprising

a powered fastener driving assembly including a driver element actuated by a drive piston movable within a cylinder through power and return strokes,

a fluid controlled main valve means that is opened to supply pressurized fluid to and that is closed to exhaust fluid from the cylinder,

a cycle valve coupled to the main valve means and movable between a first position to control opening of the main valve means and a second position to control closing of the main valve means,

a first control means coupled to the cycle valve including manual means and safety means actuated by placing the tool adjacent the workpiece for moving the cycle valve to its first position when both of the manual means and the safety means are actuated,

a second control means coupled to the cycle valve and to the cylinder for moving the cycle valve to its second position when the piston has moved through its power stroke,

a fluid actuated control piston normally preventing movement of the cycle valve to its first position,

means coupling the control piston to the first control means,

and release means in the first control means for controlling movement of the control piston to permit movement of the cycle valve to said one first position only when the safety means is actuated prior to the manual means.

9. The tool set forth in claim **8** in which

the release means includes valve means controlled by the safety means for selectively supplying an exhaust connection and pressurized fluid to the fluid actuated control piston.

10. A tool for driving fasteners into a workpiece comprising

a powered fastener driving assembly including a driver element actuated by a drive piston movable within a cylinder,

a fluid controlled main valve means for selectively supplying pressurized fluid to and exhausting fluid from the cylinder,

a cycle valve coupled to the main valve means and cyclically movable to alternate positions to control opening and closing of the main valve means,

a first control means coupled to the cycle valve including independently operable manual means and safety means actuated by placing the tool adjacent the workpiece for initiating cyclic movement of the cycle valve between its alternate positions when both of the manual means and the safety means are actuated,

and a second control means coupled to the cycle valve and the first control means for preventing cyclic movement of the cycle valve after the safety means and manual means are operated whenever the manual means is operated prior to the safety means.

11. The tool set forth in claim **10** in which

the second control means includes a fluid actuated bias valve for applying a fluid bias to the cycle valve,

and the first control means includes valve means for selectively connecting the bias valve to pressurized fluid and an exhaust.

12. A multifire tool for driving a series of fasteners into a workpiece comprising

a powered fastener driving assembly including a driver element actuated by a drive piston movable within a cylinder,

a fluid controlled main valve means for selectively supplying pressurized fluid to and exhausting fluid from the cylinder,

a fluid operated cycle valve coupled to the main valve means and movable to alternate positions to control opening and closing of the main valve means,

bias valve means for applying a fluid bias to the cycle valve means to move the cycle valve means to one of its alternate positions, means coupled to the cycle valve and to the cylinder for applying a fluid bias to the cycle valve means to move the cycle valve to the other of its alternate positions,

and control means including manual means and safety means actuated by placing the tool adjacent the workpiece for initiating movement of the cycle valve when both of the manual means and the safety means are actuated, said control means including means operating the bias valve means to apply a fluid bias to the cycle valve means only when the safety means is actuated prior to the manual means.

13. A tool for driving fasteners into a workpiece comprising

a powered fastener driving assembly including a driver element actuated by a drive piston movable within a drive cylinder,

a fluid controlled main valve means for selectively supplying pressurized fluid to and exhausting fluid from the cylinder,

a cycle valve coupled to the main valve means and movable to alternate positions to control opening and closing of the main valve means, said cycle valve including a valve cylinder and a valve piston movable therein for controlling the connection of exhaust and pressurized fluid to the main valve means,

a piston means movable within the valve cylinder between a position biasing the valve piston and a position spaced from the valve piston,

first passage means placing the valve cylinder in communication with the drive cylinder at a point located between the piston means and the valve piston for applying a fluid bias from the drive cylinder to the valve piston,

second passage means communicating with the valve cylinder at a point spaced from the valve piston to apply a fluid bias to the piston means only,

and valve means controlling the application of fluid pressure to the second passage means.

14. A tool for driving fasteners into a workpiece comprising

a powered fastener driving assembly including a driver element actuated by a drive piston movable within a cylinder,

main assembly means opened to supply pressurized fluid to and closed to exhaust fluid from the cylinder,

cycle means coupled to the main assembly means and movable to alternate positions to control opening and closing of the main assembly means,

a first control means coupled to the cycle means including means controlled by independently operable manual means and safety means actuated by placing the tool adjacent the workpiece for moving the cycle means to a position effecting opening of the main assembly means only when both of the manual means and the safety means are actuated,

and a second control means coupled to the cycle means and responsive to the operation of at least one of the manual means and safety means for preventing movement of the cycle means when the manual means is operated prior to the safety means.

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