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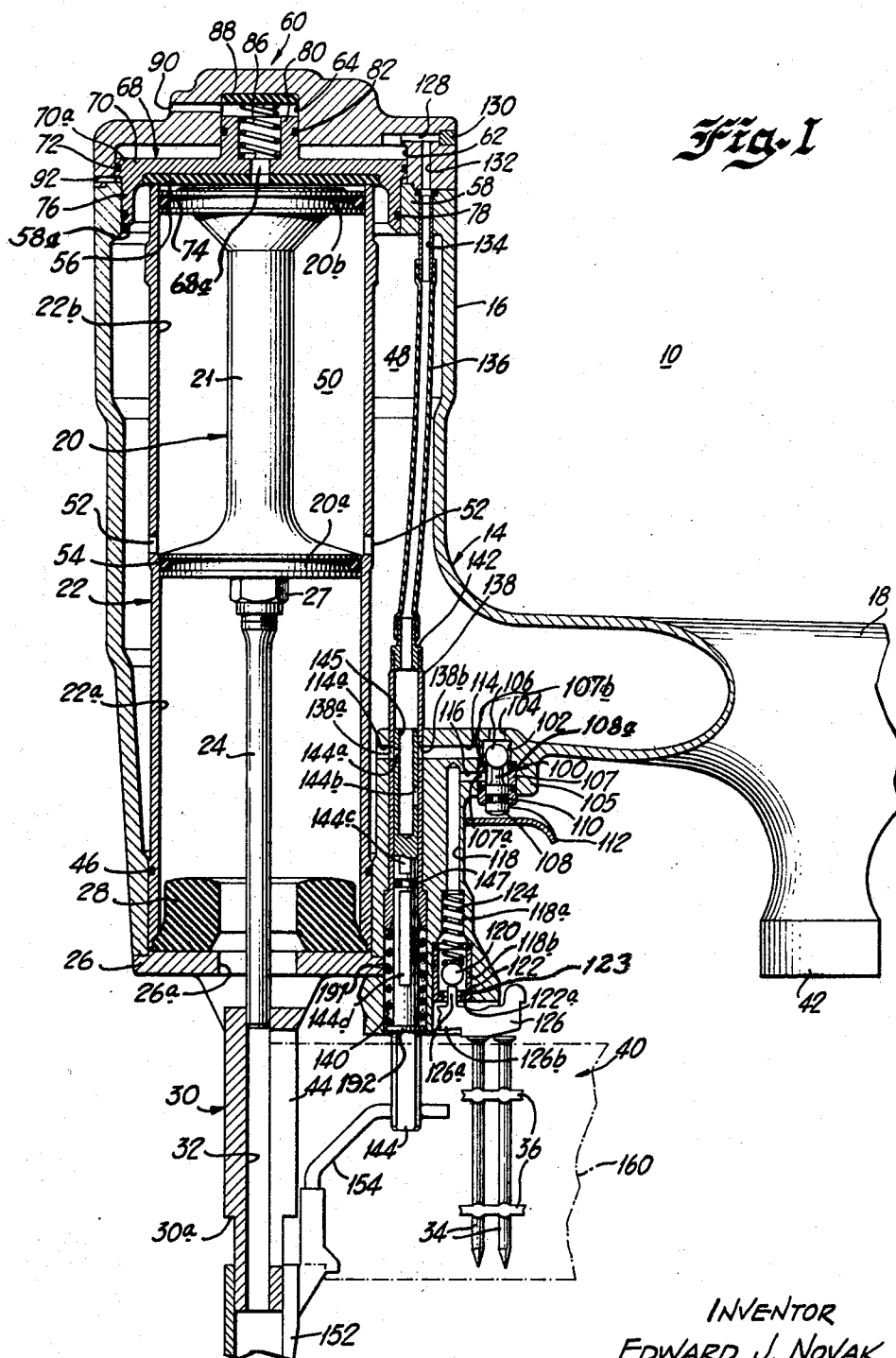
E. J. NOVAK

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FASTENER DRIVING TOOL

Filed April 21, 1967

3 Sheets-Sheet 1



INVENTOR
EDWARD J. NOVAK

64
"Mason, Kolehmainen, Rathbun and Wyse
ATTORNEYS.

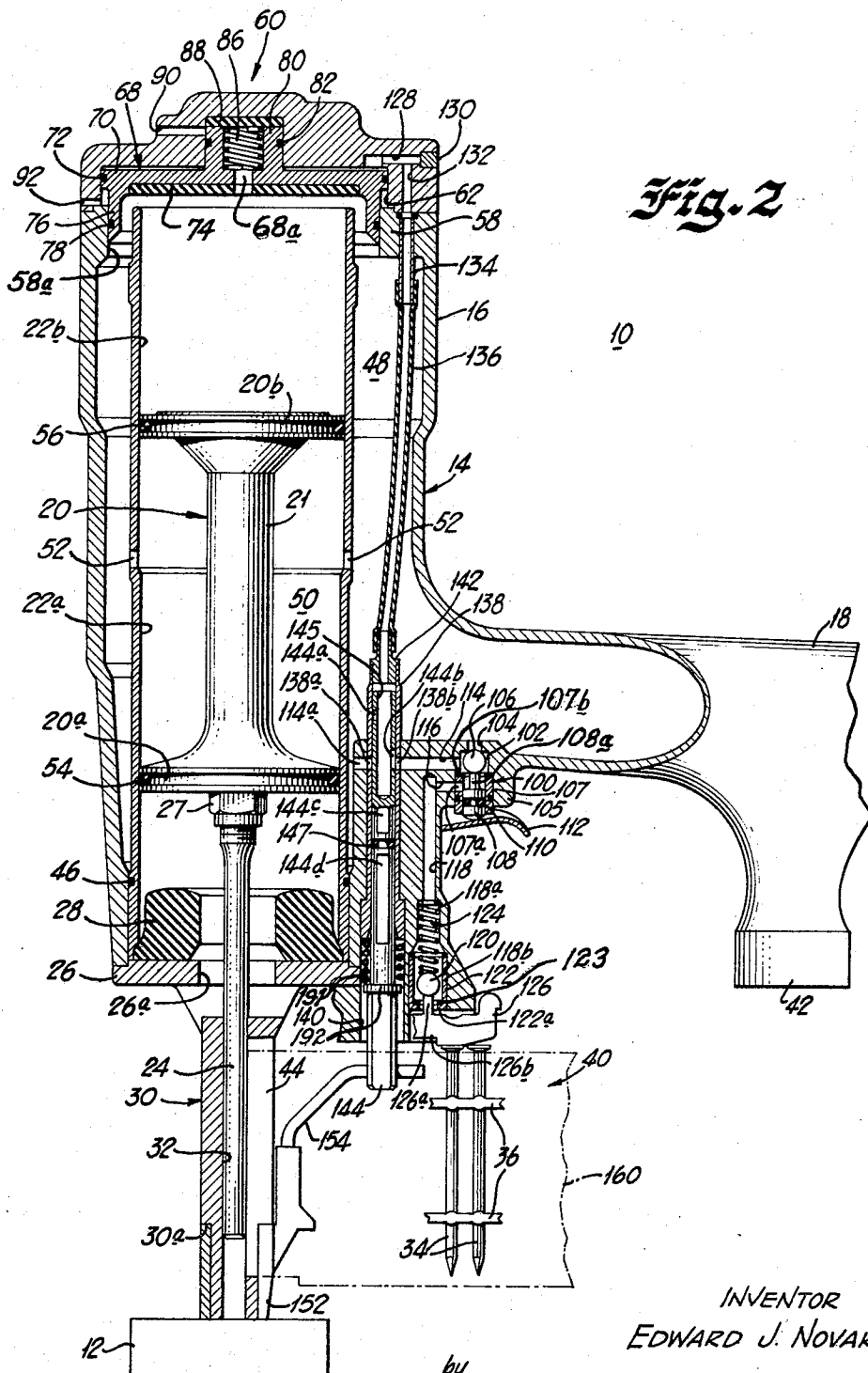
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INVENTOR
EDWARD J. NOVAK
by
Mason, Kolehmainen, Rathburn and Wyse
ATTORNEYS

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FASTENER DRIVING TOOL

Edward J. Novak, Franklin Park, Ill., assignor to Fastener Corporation, Franklin Park, Ill., a corporation of Illinois

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17 Claims

ABSTRACT OF THE DISCLOSURE

A pneumatically powered fastener driving tool including fluid operated driving means having a poppet valve means and operable to move a driver on successive power strokes in a drive track to drive fasteners positioned therein. Fluid operated feeding means is provided for advancing successive fasteners from a magazine into said drive track during each cycle of operation of said driver. Trigger valve means is in communication through passage means with said poppet valve means for initiating power strokes of said driver, and safety valve means in communication with said passage means is provided for controlling operation of said fluid operated feeding means in synchronism with said driver.

The present invention relates to new and improved fastener driving tools and, more particularly, to a new and improved fluid operated fastener driving tool employing novel means for preventing an inadvertent driving or firing stroke of the driver of the tool, and for preventing the tool from firing when the magazine is empty or nearly so of fasteners.

It is an object of the present invention to provide a new and improved fluid operated fastener driving tool for power driving fasteners, such as nails, staples, tacks, and the like, supplied from a carrier strip.

Another object of the present invention is the provision of a new and improved fastener driving tool having means for preventing a firing stroke of the tool when the supply of fasteners in the tool magazine reaches a selected minimum number.

Yet another object of the invention is the provision of a new and improved fastener driving tool having new and improved fluid operated means for initiating a power stroke of the tool.

Still another object of the invention is the provision of a new and improved fastener driving tool including a magazine assembly for supplying fasteners to be driven and having new and improved fluid operating means for feeding successive fasteners into the drive track of the tool.

A further object of the present invention is the provision of a new and improved fastener driving tool employing novel safety means for preventing a firing stroke of the driver even though the trigger mechanism is continuously maintained in a depressed condition which would otherwise initiate a firing stroke.

Another object of the invention is the provision of a new and improved fastener driving tool including a means for preventing a firing stroke of the driver regardless of the positions of both the trigger mechanism and the safety means of the tool.

The foregoing and other objects and advantages of the present invention are accomplished by the provision of a new and improved fluid operated fastener driving tool including a movable driver and a reservoir for compressed fluid in the housing of the tool. A power stroke of the driver is initiated by a fluid operated driving means comprising a valve chamber having a piston or poppet valve therein and a fluid passage is provided

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for exhausting one side of the valve chamber to move the poppet valve and thereby initiate a power stroke of the driver. Safety valve means movable in response to the position of the tool relative to a workpiece is provided to control the fluid flow through the fluid passage. The safety valve means includes a first port which is positioned to direct pressurized fluid into one side of the poppet valve chamber from the reservoir when the safety valve means is in an inoperative position.

The safety valve means additionally includes a second port which is aligned to permit the exhaust of fluid from the valve chamber through the passage when the safety valve is in an operative position and thereby permit the tool to be fired. Trigger valve means normally closing the passage to exhaust is provided to open the passage means for exhausting the fluid from the valve chamber, and thereby initiate a power stroke of the driver. The tool includes a magazine for holding a supply of fasteners, and which is fluid operated for advancing successive fasteners to be driven in synchronism with the movements of said driver. Means responsive to the presence or absence of fasteners in a selected position in the magazine are provided to close the passage from exhausting the valve chamber when the fastener supply in the magazine is low and thereby prevent initiation of a power stroke of the driver regardless of the position of the trigger valve means or the safety valve means.

For a better understanding of the invention, reference should be had to the following detailed description when taken in conjunction with the drawings, in which:

FIG. 1 is an elevational sectional view taken substantially along line 1—1 of FIG. 6, of a new and improved fastener driving tool constructed in accordance with the present invention and shown in one of its operative positions;

FIG. 2 is an elevational sectional view similar to FIG. 1 but showing the tool in another of its operative positions;

FIG. 3 is a fragmentary sectional view taken substantially along line 3—3 of FIG. 6 showing details of the magazine feeding piston and safety valve.

FIG. 4 is a fragmentary sectional view similar to FIG. 3 but showing the operative components of the magazine feeding piston and safety valve in another operative position;

FIG. 5 is another fragmentary sectional view taken substantially along line 5—5 of FIG. 6 showing a last nail valve in one of its operative positions; and

FIG. 6 is a schematic representation of the fluid passage system of the tool of FIG. 1.

Referring now, more particularly, to the drawings, therein is illustrated a new and improved fastener driving tool constructed in accordance with the present invention and referred to generally by the reference numeral 10. The tool 10 is adapted to be powered by compressed fluid supplied from a convenient source, such as an air compressor (not shown), and the tool is portable in the sense that an operator may manipulate the tool by hand into the proper position for driving fasteners into a workpiece 12 (FIG. 2).

The tool includes a housing 14 preferably formed of a lightweight metal, such as aluminum or the like to facilitate manual handling, and the housing comprises a vertically extending, hollow, forward head chamber 16 and a rearwardly extending hollow handle 18 which serve as a reservoir for containing a supply of compressed fluid supplied from the fluid source through a flexible supply line (not shown) attached to the handle. The head chamber 16 is adapted to contain and support a reciprocally movable piston member 20 which is slidable within an inner cylinder 22 and a rodlike fastener

driving element or driver 24 is secured to the lower end of the piston member by means of a nut and sleeve assembly 27. The lower end of the head chamber 16 and inner cylinder 22 is closed by a removable lower end cap or closure member 26 having a large central opening 26a to permit sliding movement of the driver 24 and to permit the ingress and egress of air in the lower end of the cylinder 22 under the piston member. The piston member moves upwardly in the cylinder 22 on a return stroke and is then driven rapidly downwardly on a power stroke, to drive a fastener into the workpiece 12. A doughnut-shaped annular cushion 28 of resilient material, such as rubber, is mounted in the lower end of the cylinder 22 to absorb the shock of the piston member 20 as it reaches the end of a power stroke.

The lower cap member 26 supports the upper end of a drive track defining member or nosepiece 30 having a longitudinal drive track 32 therein for accommodating the reciprocal movements of the driver 24 and for guiding fasteners, such as nails 34 or the like, which are fed into the drive track for driving.

In order to feed the nails 34, one at a time, into the drive track 32 and to contain a supply of the nails 34 which are fastened together by carrier strips 36 of plastic material, or the like, the tool 10 includes a magazine assembly 40 supported at its forward end by the lower cap member 26 and the nosepiece 30. The magazine assembly 40 extends rearwardly from the nosepiece generally parallel to and below the reservoir handle 18 forming an open area therebetween to permit easy gripping of the tool by the handle. The rearward end portion of the magazine assembly 40 may be supported, if desired, by means of a downwardly depending butt portion 42 formed at the rearward end of the handle 18. The nails 34 contained in the magazine assembly 40 are advanced forwardly therein into the drive track 32 through a slot or feed opening 44 in the rear face of the nosepiece 30 and are then driven into the workpiece 12 by a downward power stroke of the driver 24 which is imparted by the piston member 20.

The inner cylinder 22 is supported at its lower end by the cap member 26 and the internal wall surface of the lower end of the head chamber 16, and an O-ring seal 46 is provided to seal between the outer surface of the inner cylinder and a facing surface or bore in the lower end of the head chamber 16. The internal diameter of the head chamber 16 increases somewhat above its lower end bore and is somewhat larger than the outer diameter of the inner cylinder 22 in order to provide an annular space or air chamber 48 which surrounds the inner cylinder and is in communication with the hollow handle 18 for receiving a continual supply of compressed fluid to operate the piston member 20. The inner cylinder is open at its upper end (FIG. 2) and is formed with a lower half or section 22a having an internal diameter which is slightly smaller than the diameter of an upper half or section 22b. The piston member 20 is constructed like a spool and has a lower end flange 20a slidable in the lower cylinder section 22a, an upper end flange 20b slidable in the upper cylinder section 22b, and a rod-like central stem 21 of reduced diameter integrally connecting the upper and lower end flanges 20a and 20b. Accordingly, an annular piston chamber 50 is formed around the stem 21 within the cylinder 22 and is closed at opposite ends by the end flanges 20a and 20b of the piston chamber.

Compressed fluid is continuously supplied to the annular piston chamber 50 around the stem 21 by means of several large ports 52 in the inner cylinder 22 adjacent the junction of the upper and lower sections thereof. Sealing between the piston chamber 50 and the upper and lower ends of the inner cylinder 22 is obtained by means of a pair of O-rings 54 and 56 mounted on the piston flanges 20a and 20b, respectively. Because the upper piston flange 20b is slightly larger in diameter than

the lower flange 20a, whenever pressurized fluid is present in the annular piston chamber 50, the piston member 20 will have an upward resultant force applied thereto tending to move the piston and driver 24 upwardly on a return stroke to the upper position illustrated in FIG. 1 at the top end of the cylinder 22.

The upper end of the head chamber 16 is formed with an internal annular shoulder or flange 58 having a cylindrical bore surface 58a in concentric alignment with the longitudinal axis of the piston member 20 and slightly larger in diameter than the upper open end of the inner cylinder 22. A removable upper cap member 60 is mounted on the upper end of the head chamber 16, and the cap member is formed with a relatively large cylindrical poppet valve chamber 62 having a lower end in communication with the upper end of the head chamber 16 and slightly larger in diameter than the bore surface 58a. The cap member 60 also includes a smaller, second cylindrical valve chamber 64 in concentric alignment with and communicating with the upper end of the larger poppet chamber 62.

In order to control the flow of pressurized fluid from the annular air chamber 48 around the cylinder 22, into and out of the upper end of the cylinder above the piston member 20, a pressure-operated, slidable poppet valve member 68 is mounted for sliding movement within the valve chamber 62 in the upper cap member 60. The poppet valve member 68 comprises a circular disc or radial flange 70 having an outer peripheral edge 70a slidable against the cylindrical wall surface of the valve chamber 62 and an O-ring 72 is mounted on the disc to effect a good seal between the valve member and chamber sidewall. The underside of the valve flange 70 is recessed to accommodate a circular sealing gasket 74 which seats against the upper end of the inner cylinder 22 when the valve is closed, as shown in FIG. 1. The poppet valve member 68 also includes a downwardly depending cylindrical skirt 76, slightly smaller in diameter than the diameter of the valve chamber 62. The skirt 76 is slidable within the bore 58a in the upper end of the head chamber 16 of the tool housing and an O-ring seal 78 is mounted on the skirt to seal against the bore surface 58a as the poppet valve moves up and down.

The poppet valve member 68 also includes an upwardly extending, small diameter hollow stem 80 which is slidable within the small valve chamber 64 in the cap member 60, and an O-ring 82 is mounted on the stem 80 to seal against the cylindrical wall of the valve chamber. A central passageway 68a is formed in the valve member 68 and the gasket 74 to communicate between the upper end of the inner cylinder 22 and the upper end of the valve chamber 64. The poppet valve member 68 is normally biased downwardly to close against the upper end of the inner cylinder 22 by means of a spring 86 which is seated within the bore 68a of the hollow stem 80 and the upper end of the spring bears against a circular, disc-like sealing gasket 88 mounted in the upper end of the valve chamber 64.

When the piston member 20 moves upwardly on a return stroke to the upper position, as shown in FIG. 1, and the poppet valve member 68 is in the closed position, the air or fluid above the upper flange 20b of the piston member 20 is expelled upwardly through the central passage 68a in the valve member 68 into the upper end of the valve chamber 64. When the poppet valve 68 is closed against the upper end of the inner cylinder 22 (FIG. 1) the fluid reaching the upper end of the small valve chamber 64 is exhausted to the atmosphere through a radially extending exhaust passage 90 formed in the cap member 60. On a power stroke, when the poppet valve 68 is opened (FIG. 2) the stem 80 moves upwardly against the gasket 88 and closes the exhaust passage 90, thus preventing the loss of pressurized fluid to the atmosphere so that full fluid pressure is available to drive the piston member 20 rapidly downward on a power stroke.

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A short radial passage 92 is drilled in the cap member 60 to communicate with the interior of the poppet valve chamber 62 just below the peripheral outer edge portion 70a of the valve flange 70 to permit free movement of the poppet valve 68 between a closed and open position.

Because the diameter of the circular disc 70 is slightly larger than the diameter of the lower skirt portion 76, when fluid pressure is supplied to the upper end of the valve chamber 62 above the disc 70, the poppet valve 68 is forced downwardly to a closed position against the upper end of the cylinder 22, as shown in FIG. 1, but when the upper end valve chamber 62 is evacuated or exhausted to the atmosphere, fluid pressure within the large annular chamber 48 beneath the valve member forces the poppet valve 68 upwardly to the position of FIG. 2, and this permits pressurized fluid in the annular chamber 48 to enter the upper end of the inner cylinder 22 above the piston member 20 and drive the piston and driver 24 rapidly downward on a power or driving stroke.

During a downward power stroke of the piston 20, pressurized fluid in the piston chamber 50 also aids in moving the piston downward because the lower end of the cylinder 22 beneath the lower piston flange 20a is at atmospheric pressure, due to the large opening 26a in the lower end cap 26. The stem portion 21 of the piston member 20 is preferably constructed with a diameter considerably smaller than the diameter of the cylinder 22 (for example, about one third that of the piston flanges 20a and 20b), so that the piston chamber 50 is relatively large in volume and actually serves as a fluid reservoir in addition to the fluid reservoir in the handle 18. Accordingly, on a power stroke of the piston 20, a large resultant downward force on the piston member is supplied by the fluid pressure above the upper flange 20b, and a portion of this resultant force is supplied by the fluid within the piston chamber 50. Because the piston chamber 50 is continuously supplied with pressurized fluid through the ports 52 regardless of the position of the piston 20 in the cylinder 22, this fluid pressure is always available for a power stroke and, consequently, the size or volume of the reservoir in the handle 18 can be reduced, thereby reducing the overall size and weight of the tool 10.

In order to control the operation of the poppet valve 68, and thereby initiate power and return strokes of the piston member 20 and driver 24, the tool 10 includes a manually operated trigger valve assembly, indicated generally by the reference numeral 100. The trigger valve assembly 100 includes a cylindrical valve chamber 102 which is drilled or bored in a projection or lug 105 depending from the underside of the handle 18 of the tool housing. Communication between the upper end of the trigger valve chamber 102 and the interior of the handle 18 is provided by means of a small port 104, and a ball-type valve member 106 is mounted for movement in the valve chamber to seat alternately against the port 104 in the upper end of the chamber or against a rubber seal 107b at the upper end of a tubular sleeve 107 which is inserted into the lower end of the valve chamber 102. When the trigger valve assembly 100 is in the position shown in FIG. 1, compressed fluid from the reservoir 18 flows into the upper end of the valve chamber 102 through the port 104 and causes the ball 106 to move downwardly and seat against the upper end of the sleeve 107. In order to move the ball upwardly from its lower seated position and close the port 104, as shown in FIG. 2, a movable valve operator 108 is slidably mounted within the tubular sleeve member 107. The operator includes a short upper stem portion 108a of reduced diameter for engagement with the ball and a lower, larger, diameter body portion dimensioned to slide within the bore of the sleeve 107. An O-ring seal 110 is mounted on the lower body portion of the operator 108 to effectively seal against the internal bore of the sleeve 107. The lower end portion of the operator projects downwardly below the sleeve 107 and is rounded at its lower end for engage-

ment with a manual trigger member 112 which is pivotally mounted on the tool housing 14 beneath the handle 18. When the trigger member 112 is in a normal or non-depressed position, as shown in FIG. 1, the pressurized fluid within the handle 18 flows through the port 104 into the valve chamber 102 and forces the ball 106 downwardly into seating engagement against the upper end of the sleeve 107. Downward seating of the ball 106 in turn forces the operator 108 downwardly against the trigger 112, and this position is maintained until the user of the tool manually depresses the trigger member upwardly to unseat the ball from the upper end of the sleeve and close off the port 104 (FIG. 2) which is effective to close off direct communication between the handle 18 and trigger valve chamber 102 through the port.

Communication between the upper end of the trigger valve chamber 102 and the lower portion of the annular air chamber 48 around the inner cylinder 22 is provided by means of transversely extending, coaxially aligned passages 114 and 114a formed in the tool housing in the projecting portion 105 below the handle. In order to permit the lower end of the trigger valve chamber 102 to be exhausted or connected with the atmosphere when the ball 106 is closing the port 104, a short, transverse passage 116 is provided below the passage 114 to communicate with the lower end of the trigger valve chamber through a small port 107a formed in the sleeve 107. The opposite end of the passage 116 is in communication with the upper end of a downwardly extending exhaust passage 118 having its lower end vented to the atmosphere and formed with enlarged diameter sections 118a and 118b in the lower end thereof.

In order to control the flow of fluid through the exhaust passage 118 and communicating passage 116 between the valve chamber 102 and the atmosphere, an exhaust valve assembly including a ball member 120 is mounted in the lower enlarged section 118b for seating against an inwardly extending annular flange 122a formed at the lower end of a tubular insert or sleeve 122 which is inserted into the enlarged passage section 118b. The ball 120 is normally biased downwardly towards a seated or passage closing position against an O-ring seal 123 resting on the sleeve flange 122a by means of a compression spring 124 having its upper end bearing against a shoulder formed adjacent the upper end of the passage section 118a and the lower end of the spring bearing downwardly against the ball.

During normal operation of the tool, the ball 120 is maintained in an unseated condition upwardly away from the sleeve flange 122a to open the lower end exhaust passage 118 to the atmosphere and this is accomplished by means of an upwardly extending stem portion 126a of a valve actuating member 126 which is pivotally mounted on the magazine assembly 40, as best shown in FIG. 5. When fasteners 34 are present in the magazine 40 beneath the actuating member 126, the stem 126a extends upwardly into the sleeve 122 and forces the ball 120 upwardly away from the seat 122a to permit fluid to flow through the exhaust passage 118 to the atmosphere. The valve actuator 126 is pivotally mounted on the body of the tool or magazine and upward and downward movement of the stem 126a is controlled by the presence or absence of nails 34 directly beneath the actuator. To this end, the member 126 includes a lower edge adapted to directly engage the heads of the nails as they are advanced forwardly in the magazine assembly 40 toward the drive track 32. As best shown in FIGS. 1, 2, and 5, the heads of the successive nails engage the lower edge of the member 126 and cause its rearward end to pivot upwardly and thereby maintain the ball 120 in an upward, unseated position. The lower edge of the actuator member 126 is formed with a notched out or recessed portion 126b so that when the last nail 34 present in the magazine 40 has advanced forwardly of the recess, the actuator may then pivot in a clockwise direction allowing the compression spring 124 to seat the ball 120 against

the flange 122a and thereby close the lower end of the exhaust passage 118. The exhaust valve assembly as described is aptly termed a "last nail" valve, because when the supply of nails in the magazine reaches a selected minimum number, the ball 120 closes the exhaust passage 118 and further operation of the tool 10 is prevented until another strip of nails is inserted into the magazine 40 and moved forwardly into position to engage the valve actuator 126 until it again unseats the ball valve 120 and opens the exhaust passage 118.

The trigger valve assembly 100, previously described, directly and indirectly controls the flow of pressurized fluid from the reservoir handle 18 into the upper end of the poppet valve chamber 62 and, in conjunction with the exhaust valve assembly, controls the flow of fluid from the poppet valve chamber to the atmosphere through the passage 118 when a power stroke is initiated. Communication between the upper end of the poppet valve chamber 62, the trigger valve chamber 102 and annular chamber 48 around the cylinder 22 is provided by passages 128 and 132 in the cap member 60, a short conduit 134, a flexible conduit 136, and tubular sleeve 138 which is ported as at 138a and 138b to communicate with the passages 114a and 114, respectively. A removable threaded plug 130 is provided in the outer end of the passage 128 in the cap member 60 to facilitate cleaning of the passage, should clogging occur. The sleeve 138 is inserted upwardly into a downwardly extending passage 140 formed in the tool housing 14 generally parallel to the exhaust passage 118. The upper end of the sleeve 138 and the lower end of the flexible tube 136 are interconnected by an appropriate fitting 142, and the passage 140 in which the sleeve is mounted, directly intersects the short passages 114 and 114a and is open at its lower end. In addition, the sleeve 138 includes a third port 138e aligned with a short cross passage 174 (FIGS. 3, 4 and 6), the significance of which will be disclosed hereinafter.

In order to control the flow of fluid through the passage 114a and port 138a into the upper end of the sleeve 138 and to control fluid flow between the passage 114 and a port 138b into the upper end of the sleeve, a movable, rodlike, touch trip, safety valve member 144 is mounted for vertical sliding movement within the internal bore of the sleeve. The rod is formed with an internal bore or chamber 145 opening at its upper end to communicate with the upper end of the sleeve 138. The valve rod 144 is movable in the sleeve 138 between a lower or "safe" position (FIG. 1) an upper or "fire" position (FIG. 2) and movement of the valve rod is effected by the position of the lower end of the nosepiece 30 in relation to the workpiece 12 into which a fastener is to be driven. To this end, the nosepiece is formed with a recessed shoulder 30a adjacent its lower end and a sliding member 152 is mounted on the recessed shoulder for movement upwardly on the shoulder when the tool is positioned against a workpiece for driving a fastener. The member 152 mounted on the nosepiece is connected to the lower end of the valve rod 144 by means of a bracket 154 so as to move the latter upwardly into the "fire" position upon upward movement of the member 152 by engagement with the workpiece 12. Normally, the valve rod 144 is biased downwardly towards the "safe" position by the fluid pressure in the upper end of the sleeve 138 and a spring 191 around the lower end of the valve rod 144 between the lower end of the sleeve 138 and a flange 192 on the valve rod. The spring insures that the valve rod 144 will be in a safe position even though the tool is not connected to a source of pressurized fluid and thereby insuring that the tool will not hike accidentally when the tool is first connected to an air line or other source. The lower end of the passage 140 is enlarged to accommodate the spring 191 (FIGS. 3 and 4) and to permit the exhaust of fluid outwardly around the valve member through the open lower end of the passage, as will be explained more fully hereinafter.

The chamber or bore 145 at the upper end of the valve rod 144 is formed with a pair of ports 144a and 144b in the sidewall adapted to communicate, respectively, with the ports 138a and 138b in the sleeve 138. When the valve rod is in the lower or "safe" position, the ports 138a and 144a are aligned and the ports 138b and 144b are out of alignment. Accordingly, the upper end of the sleeve 138 is in communication with pressurized fluid from the annular chamber 48 through the short passage 114a. When the valve rod is in the upper or "fire" position, the ports 138a and 144a are out of alignment and the ports 138b and 144b are aligned. Accordingly, the upper end of the sleeve 138 is supplied with pressurized fluid through the passage 114 provided that the trigger valve ball 106 is seated in its lower position on the upper end of the sleeve 107, thereby admitting fluid into the trigger valve chamber 102 through the port 104.

From the foregoing description, it should be noted that the sliding valve rod 144 acts as safety valve mechanism when it is in a downward or "safe" position, as shown in FIG. 1, by permitting pressurized fluid from the lower end of the annular chamber 48 to flow into the upper portion of the poppet valve chamber 62 through the aligned ports 138a and 144a and passage 114a, and by closing off the port 138b in communication with the passage 114. If the trigger member 112 is depressed when the valve rod 144 is in the "safe" position, a power stroke of the piston is prevented because the upper end of the poppet valve chamber 62 is continuously pressurized through the passage 144a and cannot be exhausted via the passage 114, trigger valve chamber 102, and exhaust passage 118. When the lower end of the nosepiece 30 is brought in contact against the workpiece 12, the member 152 is moved upwardly on the shoulder 30a and causes the valve rod 144 to move upwardly into the "fire" position. When the valve member is in the "fire" position, pressurized fluid is no longer supplied to the upper end of poppet valve chamber 62 through the passage 114a and ports 138a and 144a. The ports 138b and 144b are aligned, however, to permit the exhaust of fluid from the upper end of the poppet valve chamber 62 via the passage 114, trigger valve chamber 102, and exhaust passage 118, and, consequently, a power stroke is initiated when the trigger member 112 is depressed upwardly thereby unseating the ball valve 106 from the upper end of the sleeve 107.

Referring now, more specifically, to FIGS. 3, 4, and 5 the magazine 40 of the driving tool 10 is generally similar to the magazine construction shown and illustrated in the contemporaneously filed United States patent application, Ser. No. 632,575, filed Apr. 21, 1967, and assigned to the same assignee as the present invention.

Briefly, however, the magazine assembly 40 includes a pair of spaced apart inner sidewalls 160 which support and guide the nails 34 or other fasteners in their forward movement into the drive track 32 of the tool. The nails 34 are supported by their heads which rest on and slide along the top edges of the magazine sidewalls 160, and the nails are advanced forwardly towards the drive track by means of a pusher member 162 which is mounted on the magazine for pivoting movement about pin 164 (FIG. 5). The pusher 162 is rotatable about the pin 164 in both a counterclockwise and a clockwise direction and includes an inwardly extending upper flange portion 163 having fastener engaging teeth along the inner edge thereof which engage the shanks of successive fasteners positioned in the magazine. When the pusher member is pivoted in a counterclockwise direction, the teeth on the upper flange thereof engage and advance the fasteners forwardly toward the drive track on a feeding stroke. The pusher 162 is normally biased toward a rearward position, by means of a bias spring 166 having one end connected to a stationary pin 168 and an opposite end connected to forwardly extending operating arm 162a formed on the pusher. When the pusher 162 is pivoted about its mounting pin 164 in a clockwise direction by the spring 166, the teeth

along the upper flange of the pusher move rearwardly and are cammed outwardly by engagement against the nail shanks until the forward edges of the teeth are rearwardly of the shanks of a next succeeding group of nails. The teeth then move inwardly behind the nails in preparation for the next feeding stroke of the pusher, as more fully described in the aforementioned copending application.

In order to move the pusher 162 on a forward or feeding stroke after completion of a driving stroke of the piston member 20 and driver 24, the tool 10 includes a pneumatically operated piston 178 slidably mounted in the lower end portion 172a of a passageway 172 formed in the tool housing generally parallel with the passage 140. The upper end of the passage 172 is in communication with the transverse passage 174 which is aligned with the sleeve port 138e. The piston 178 includes a downwardly extending stem 178a which is interconnected with the pusher arm 162a by means of a connector 179 and pin 180 so that as the piston moves downwardly, the pusher 162 is pivoted in a counterclockwise direction on a feeding stroke. When the piston moves upwardly, the spring 166 causes the pusher to pivot in an opposite or clockwise direction on a return stroke, thereby to engage the fasteners in preparation for advancing them during the next feeding operation of the pusher. A tubular sleeve 176 is inserted upwardly into the lower end portion 172a of the passage 172, and the piston 178 is slidable therein with its lower stem 178a projecting downwardly through an opening formed at the lower end of the sleeve by an inwardly extending annular flange 176a. An O-ring 181 is mounted on the upper portion of the piston 178 to seal against the internal surface of the sleeve 176 and a vent passage 176b is drilled in the flange 176a of the sleeve to vent the area within the sleeve below the piston head as it moves up and down. When the upper end of the passage 172 above the feeder piston 178 is filled with pressurized fluid, the piston is driven downwardly in the sleeve and the pusher 162 is moved on a feeding stroke, and when the pressure of fluid above the piston is reduced or the fluid exhausted, the piston moves upwardly because of the spring 166, and the pusher member is thereby moved on a return stroke.

In order to control the flow of pressurized fluid into and out of the upper end of the passage 172, the safety valve rod 144 is formed with a pair of recessed valve passages 144c and 144d (FIGS. 3 and 4) which are spaced apart above and below an O-ring 147 mounted on the valve rod intermediate its ends to seal against the sleeve 138. When the valve rod 144 is in an upward or "fire" position (FIG. 8) the lower passage 144d is in communication with the port 138e and, accordingly, the pressurized fluid in the upper end of the passage 172 above the piston 178 is exhausted to the atmosphere through the passage 174, port 138e, valve rod passage 144d, and around the lower end of the sleeve 138 and passage 140.

As illustrated best in FIG. 3, the upper end of the upper valve passage 144c is in communication with the lower end portion of the bore or chamber 145 in the upper end of the valve rod 144 through a port 144f. When the valve rod is returned downwardly to the "safe" position after the completion of a power stroke of the piston 20 and driver 24, pressurized fluid enters the upper end of the passage 172 and moves the piston 178 downwardly, thereby moving the pusher 162 on a forward feeding stroke advancing another nail 34 into the drive track 32. The safety valve rod 144 thus controls the feeding of nails from the magazine 40 into the drive track in addition to its function of preventing a power or driving stroke of the piston when the valve rod is in the "safe" position. Each time the valve rod 144 is cycled between the "fire" and "safe" positions, the pusher 162 is actuated to feed a new fastener 34 into the drive track 32.

Instead of utilizing compressed fluid from the bore 145 in the valve rod for operating the feeder piston 178, the port 144f on the valve member 144 may be closed and pressurized fluid direct from the chamber 48 or

handle 18 may be supplied to the safety valve passage 140 above the passage 174. Accordingly, when the safety valve rod 144 is in the "safe" position (FIG. 3) compressed fluid is supplied to the other end of the feeder piston from the passage 140 and flows via the valve passage 144c, and passages 174 and 172 into the upper end of the sleeve 176 driving the feeder piston 178 downwardly on a feeding stroke. When the safety valve rod 144 is moved to the "fire" position (FIG. 4) the O-ring 147 on the valve rod is above the passage 174, permitting the fluid in the upper end of the sleeve 176 above the piston to exhaust to the atmosphere via the passages 172 and 174 and lower valve rod passage 144d.

Referring now to the operation of the tool 10, when a source of compressed fluid is connected to the handle of the reservoir 18, the pressurized fluid flows into the annular chamber 48 around the inner cylinder 22 and into the piston chamber 50 through the ports 52 in the cylinder wall. In addition, pressurized fluid flows into the trigger valve chamber 102 through the port 104, causing the ball member 106 to move downwardly and seat against the upper end of the sleeve 107. As the ball 106 is seated in its downward seating position, the trigger member 112 is forced downwardly by the operator 108 and compressed fluid flows into the passageway 114. Pressurized fluid also flows into the passage 114a from the annular chamber 48 around the cylinder 22. Regardless of whether the safety valve rod 144 is in the "fire" or "safe" position, fluid flows into the upper end of the sleeve 138 because when the valve rod 144 is in the "safe" position, the ports 138a and 144a are aligned and fluid flows into the upper end of the sleeve through the passage 114a, or if the valve rod is in the "fire" position fluid enters the upper end of the sleeve from the passage 114 through the aligned ports 138b and 144b. Fluid from the upper end of the sleeve 138 is directed through the flexible conduit 136, conduit 134, and passages 132 and 128 into the upper end of the poppet valve chamber 62, causing the poppet valve 68 to move downwardly to close the upper end of the cylinder 22. When the poppet valve is closed, differential fluid pressure within the piston chamber 50 acting on the larger surface area of the upper piston flange 20b causes the piston member 20 and driver 24 to move upwardly on a return stroke to the position shown in FIG. 1, wherein it is ready to move on a downward power stroke. When a strip of nails 34 is loaded into the magazine 40 and is forwardly advanced to move the leading nail into the drive track 32, the tool 10 is in condition ready to drive a fastener, provided that enough nails are present to engage the member 126 to open the exhaust valve ball 120 upwardly away from the seating flange at the lower end of the exhaust passage 118. The tool cannot be fired, however, until the lower end of the nosepiece 30 is placed in contact against a workpiece 12 so that the safety valve rod 144 is moved upwardly into the "fire" position. After the valve rod is in the "fire" position, if the trigger 112 is depressed upwardly, the operator 108 forces the ball valve 106 upwardly away from the upper end of the sleeve 107 and seats it against the port 104, thus closing off direct communication through the port between the handle 18 and trigger valve chamber 102. The pressurized fluid in the upper end of the poppet valve chamber 62 can now pass through the flexible tube 136, passage 114, into the trigger valve chamber 102 and is then exhausted from the trigger valve chamber through the passage 116 and the lower open end of the exhaust passage 118. When the pressure in the upper end of the poppet valve chamber 62 is reduced sufficiently, the poppet valve member 68 moves upwardly because of the fluid pressure acting on its underside from the annular chamber 48 and the poppet valve opens the upper end of the inner cylinder 22, so that fluid from the annular chamber 48 flows into the cylinder above the piston member 20 and drives the piston and driver 24 rapidly downwardly on a power stroke.

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During the time that the safety valve rod 144 is in the "fire" position, the pressurized fluid in the upper end of the passage 172 is also exhausted to the atmosphere as previously described and the piston 178 moves upwardly, causing the pusher 162 to pivot in a clockwise direction on a return stroke. When the trigger member 112 is released, or when the lower end of the nosepiece 30 is moved away from the workpiece 12, pressurized fluid from the handle 18 or chamber 48 is again directed into the upper end of the poppet valve chamber 62, causing it to move downwardly and close the upper open end of the inner cylinder 22. When this occurs, an upward return stroke of the piston 20 is initiated. As the piston 20 is returning and the tool is moved so that the safety valve rod 144 returns to the "safe" position, pressurized fluid in the bore or chamber 145 in the upper end of the valve rod 144 flows through the port 144f, passage 144c, port 138e and passage 174 into the upper end of the passage 172, causing the piston 172 to move downwardly and thereby moving the pusher 162 to advance another nail into the drive track 32. Successive power strokes of the driver 24 can also be initiated by maintaining the trigger 112 in a depressed condition and manipulating the tool so that the lower end of the nosepiece 30 moves toward and away from the workpiece 12, thereby moving the safety valve rod 144 back and forth between "safe" and "fire" positions. In this type of operation the safety valve rod 144 in effect becomes a trigger for initiating power strokes of the driver and feeding fasteners from the magazine into the drive track. When the last nail 34 in the fastener strip which is contained in the magazine 40 is moved forwardly of the recess 126b in the lower edge of the actuator member 126, the tool 10 can no longer be fired by any means because the exhaust valve ball 120 is no longer held in an open position and seats against the annular seating flange 122a at the lower end of the exhaust passage 118. It is then necessary to reload the magazine with a new supply of nails in order to resume operation of the tool.

The tool 10 provides a new and unique pneumatically operated fastener feeding assembly for feeding nails and operates in conjunction with a safety valve system which means prevents a power stroke from being initiated unless the lower end of the nosepiece 30 is in contact against a workpiece 12. The safety valve means also serves as an alternate means of initiating successive power strokes when the trigger is maintained in a depressed condition and the tool is manipulated to contact a workpiece each time it is desired to drive a nail. In addition, when the supply of nails in the tool magazine is reduced to a selected minimum number of nails, further operation of the tool is curtailed until the magazine is reloaded and, thus, the tool cannot be fired when the magazine is empty, which may damage the driving mechanism and reduce the operating life of the tool.

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

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

1. A fastener driving tool comprising fluid operated driving means including poppet valve means and operable for moving a driver on successive power and return strokes in a drive track to drive fasteners into a workpiece, feed means for supplying fasteners, one at a time, into position in said track to be driven by said driver, first valve means in communication with said poppet valve means and operable to initiate power strokes of said driver by exhausting fluid from said poppet valve means, safety valve means in communication with said first valve means and movable between a safe and a fire position in response to the position of the drive track of said tool relative to a

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workpiece for controlling the flow of fluid between said poppet valve means and said first valve means, passage means in communication with said first valve means for exhausting fluid therefrom to the atmosphere, and second valve means for opening and closing said passage means and including an operator moved by the presence of fasteners in said feeding means to open said passage means and movable to close said passage means in response to the absence of a fastener in a selected position in said feeding means.

2. The fastener driving tool of claim 1 wherein said feed means includes fluid operated piston means operable to advance fasteners toward said drive track, said safety valve means operable to control said piston means to advance a new fastener into said drive track following the completion of a power stroke of said driver.

3. The fastener driving tool of claim 2 wherein said first valve means includes a trigger valve operable to open and close communication between said driving means and said second valve means and independent safety valve means operable to open and close communication between said driving means and said trigger valve.

4. The fastener driving tool of claim 3 wherein said safety valve means is movable from a fire to a safe position, thereby directing fluid against said piston means to advance a new fastener into said drive track.

5. The fastener driving tool of claim 4 wherein said safety valve means is movable from said safe position to said fire position, thereby exhausting fluid from said piston means.

6. A fastener driving tool comprising fluid operated driving means including poppet valve means and operable to move a driver on successive power and return strokes in a drive track to drive fasteners positioned therein, magazine means for feeding successive fasteners into said drive track, first valve means in communication with said poppet valve means operable to initiate a power stroke of said driver, said magazine means including fluid operated feeding means for advancing successive fasteners into said drive track each time said driving means is operated to drive a fastener, and second valve means in communication with said first valve means movable by fasteners in said magazine means to a first position, permitting the initiation of a power stroke, and movable to a second position in response to the absence of a fastener in a selected position in said magazine means for preventing a power stroke of said driving means.

7. The driving tool of claim 6 including an exhaust passage in communication between said first valve means and said second valve means, said second valve means blocking said passage when in said second position and opening said passage when in said first position.

8. The driving tool of claim 7 wherein said second valve means includes an operator normally engageable with a fastener in said selected position in said magazine means for maintaining said valve means in said first position and movable to said second position when no fastener is present.

9. The driving tool of claim 6 including first passage means between said poppet valve of said fluid operated driving means and said first valve means, and safety valve means responsive to the position of said tool in relation to a workpiece movable between a fire position and a safe position closing communication through said first passage means to prevent initiation of a power stroke by said first valve means.

10. The driving tool of claim 9, including an alternate passage means for supplying fluid to said fluid poppet valve of said operated driving means through a portion of said first passage means when said safety valve means is in said safe position.

11. A pneumatically powered fastener driving tool comprising a body defining a fluid reservoir, fluid operated driving means including poppet valve means and operable to move a drive on successive power strokes in a drive

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track to drive fasteners positioned therein, fluid operated feeding means for advancing successive fasteners from a magazine into said drive track during each cycle of tool operation comprising a power and return stroke of said driver, trigger valve means in communication with said reservoir operable to initiate a power stroke of said driver, passage means in communication between said poppet valve means of said fluid operated driving means and said trigger valve means, and safety valve means in communication with said passage means, said reservoir and said poppet valve means of said fluid operated feeding means, said safety valve means movable between a safe position supplying fluid from said reservoir to said poppet valve means of said driving means and exhausting fluid from said feeding means and a fire position establishing communication between said poppet valve means of said driving means and said trigger valve means through said passage means and supplying fluid to said feeding means from said reservoir.

12. The tool of claim 11 wherein said safety valve means is operable to close communication between a first portion of said passage means in communication with said poppet valve of said driving means and a second portion of said passage means in communication with said trigger valve means when in said safe position.

13. The tool of claim 11 wherein said safety valve means includes an elongated stem slidable in a safety valve passage in communication with said passage means at one end and open to the atmosphere at the other end, said feeding means including a port in communication with said safety valve passage intermediate the ends thereof, and said stem including a valve member slidable from one side of said port to the other as said safety valve means moves between said safe and fire positions.

14. The tool of claim 13 wherein said safety valve stem includes a hollow end portion in communication with a

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first portion of said passage means and longitudinally spaced wall ports in communication with said hollow end, one of said wall ports disposed to move into and out of communication with passage means leading to said reservoir on movement of said safety valve means from said safe to said fire position, the other of said wall ports disposed to move into and out of communication with a second portion of said passage means leading to said trigger valve means on movement of said safety valve means from said fire to said safe position.

15. The tool of claim 14 wherein said safety valve stem includes a third longitudinally spaced wall port in communication with said hollow end movable into and out of communication with said port of said feeding means on movement of said safety valve means from said safe to said fire position.

16. The tool of claim 15 wherein said valve member on said stem is spaced between said third wall port and the open end of said safety valve passage.

17. The tool of claim 11 including exhaust passage means in communication between said trigger valve means and the atmosphere and second valve means for opening and closing said exhaust passage in response to the presence and absence of fasteners in a selected position in said magazine.

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GRANVILLE Y. CUSTER, JR., Primary Examiner

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