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PNEUMATIC PISTON RETURN SYSTEM FOR IMPACT TOOLS

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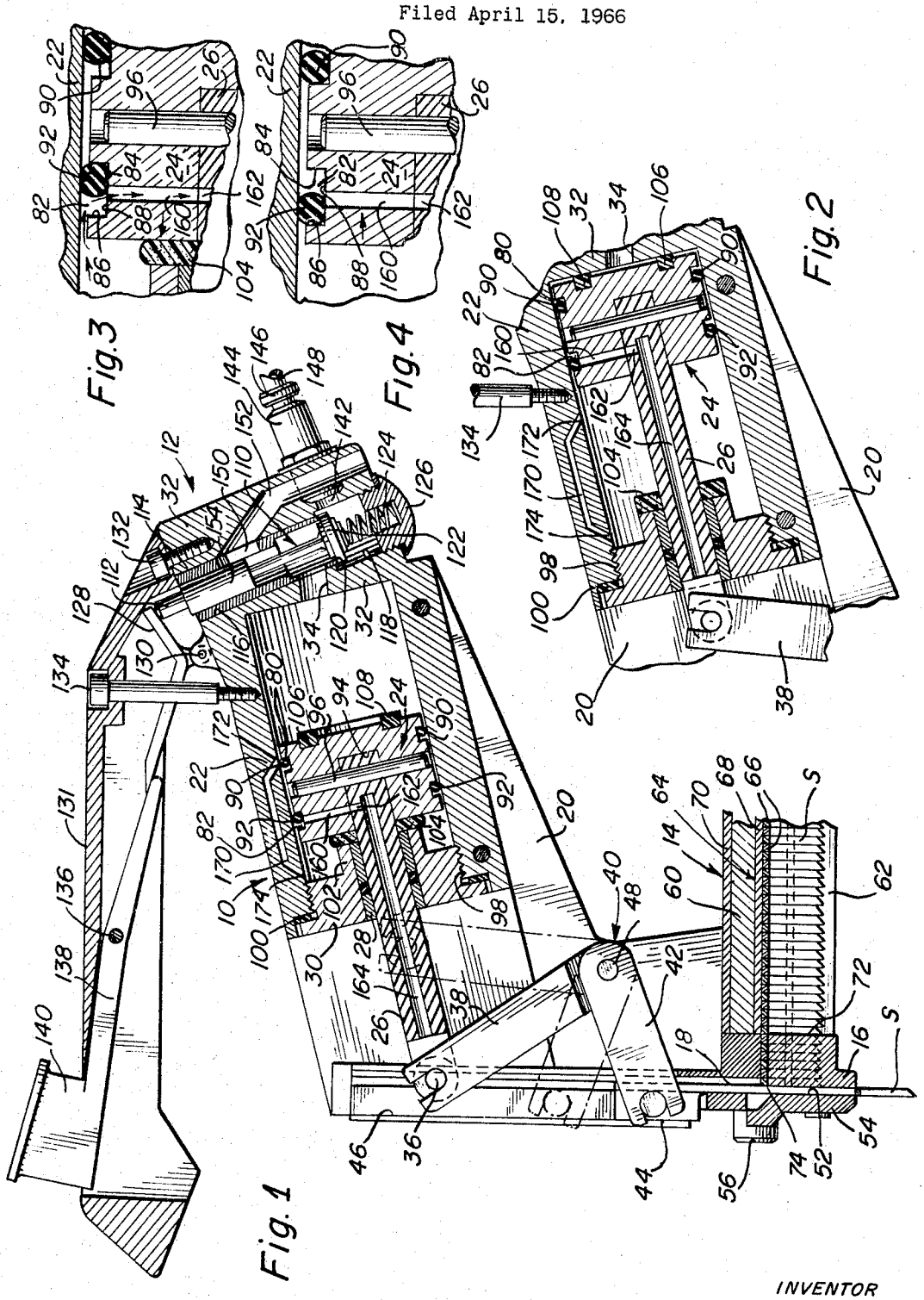

Fig. 1

Fig. 2

Fig. 3

Fig. 4

INVENTOR

ARTHUR KLAUS

BY Edward R. Lowndes

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PNEUMATIC PISTON RETURN SYSTEM FOR IMPACT TOOLS

Arthur Klaus, Frankfurt am Main, Germany, assignor to Signode Corporation, Chicago, Ill., a corporation of Delaware

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The present invention relates to impact tools of the type employing a pneumatically operable piston and cylinder assembly for powering the driver ordinarily associated with such tools. The invention has particular reference to a novel means for returning the piston of such an assembly to its retracted position after the piston has delivered its power stroke.

Insofar as piston return means are concerned, pneumatically operable piston and cylinder assemblies may, broadly, be divided into two groups. In one group the piston is returned by spring pressure and in the other group the piston is returned by air pressure. It is to this latter class of piston and cylinder assemblies that the present invention pertains.

Numerous air return systems are currently employed for returning a piston to its retracted position within a cylinder. Certain of these systems rely upon the use of live air for driving the piston in both directions. Such systems possess the obvious disadvantage that a large volume of air must be expended during each operating cycle. To obviate this limitation, certain other air return systems have been devised in which all or at least a limited portion of the air which is expelled from the cylinder during the power stroke of the piston, is collected in a fixed pressure chamber and compressed therein by the compressive action of the piston during its power stroke. After the piston has completed its power stroke, this stored and compressed air is returned to the cylinder and caused, by expansion thereof, to return the piston to its retracted position. While such systems conserve an appreciable amount of compressed air, the placement of the pressure chamber entails difficulty in cylinder design. Placement of the pressure chamber at the end of the cylinder on the driver side of the piston requires a cylinder of undue length, while placement of the pressure chamber at one side of the cylinder increases the overall bulk of the system. In either event, the use of offset pressure chambers, regardless of their location with respect to the cylinder, consumes a space which must be sufficiently large as to enclose a volume of air under pressure which, when released into the cylinder on the driver side of the piston, will maintain an effective expansion force sufficient to completely return the piston and hold it in its retracted position until the next succeeding power stroke thereof. Small porting areas for large air displacements, as well as unreliable valve mechanisms also present difficulties that have not been overcome by such air expansion piston return systems.

The present invention is designed to overcome the above-noted limitations that are attendant upon the construction and operation of conventional piston return systems of the air return type and, accordingly, the invention contemplates the provision of a novel air return system wherein that portion of the cylinder chamber which is disposed on the driver side of the piston at the time the latter is at the end of its power stroke is utilized as a pressure chamber into which live air is injected momentarily for piston return purposes. Live air for this purpose is obtained by the simple expedient of by-passing such air from the pressure side of the cylinder around the piston through the cylinder wall, the piston itself serving to uncover the bypass port by means of which such by-passing

is made possible, and to immediately thereafter cover such port as the piston commences its return stroke. This, in essence, constitutes the principal feature of the present invention and it is embodied in an operative piston and cylinder arrangement which is devoid of extraneous movable valve structures and control connections therefor, the necessary by-passing of air taking place automatically as the piston performs its working stroke.

Convenience of arrangement of parts, simplicity of construction and compactness of design are further desirable features which have been borne in mind in the production and development of the present invention.

In the accompanying single sheet of drawings forming a part of this specification, one illustrative embodiment of the invention has been shown.

In these drawings:

FIG. 1 is a fragmentary sectional view taken substantially centrally and longitudinally through a piston and cylinder assembly embodying the principles of the present invention and showing the same operatively associated with a portable air-operated stapling tool, the piston being shown in the fully advanced position which it assumes at the end of its power stroke;

FIG. 2 is a fragmentary sectional view similar to FIG. 1 showing the piston in the fully retracted position which it assumes at the commencement of its power stroke;

FIG. 3 is an enlarged fragmentary sectional view taken on a radial plane in the vicinity of an elastomeric piston- and port-sealing ring employed in connection with the present invention, showing the ring in the position which it assumes during the power stroke of the piston; and

FIG. 4 is a fragmentary sectional view similar to FIG. 3, showing the ring in the position which it assumes during the return stroke of the piston.

Referring now to the drawing in detail and in particular to FIG. 1, a piston and cylinder assembly embodying the novel piston return system of the present invention has been designated in its entirety at **10** and it is shown herein purely for exemplary purposes as being operatively associated with an otherwise conventional air-operated stapling machine **12** by means of which a series of staples S contained in a magazine **14** are successively fed to a nosepiece **16** for ejection therefrom under the impacting influence of a driver **18**, all in a manner that is well known in the art. It is to be distinctly understood however that the invention is not necessarily limited to such use and piston and cylinder assemblies constructed according to the present invention may, if desired, with or without modification as required, be employed in connection with a wide variety of impact tools for which they will be found particularly useful, as well as for other purposes too numerous to mention.

The environmental disclosure for the piston and cylinder assembly **10** is somewhat schematic and numerous details have been omitted in the interests of clarity since they bear no direct relation to the present invention. Briefly however, the stapling machine **12** involves in its general organization a framework **20** which includes the previously mentioned nosepiece **16** and which serves fixedly to support the piston and cylinder assembly **10**. The assembly **10** includes a cylinder proper **22** which may be in the form of a casting and within which there is axially reciprocable a piston **24** having a plunger **26** guided in a bushing **28** carried in a closure member cap **30** which closes one end of the cylinder. The other end of the cylinder is closed by an end wall **32** having a passage **34** therein in communication with the interior of the cylinder on the pressure side of the piston **24** and through which passage air under working pressure is adapted to be intermittently introduced to the cylinder to actuate the piston. The piston **24** establishes a pressure chamber on one side

thereof within the cylinder 22, and a piston return expansion chamber on the other side thereof as will be set forth in greater detail subsequently.

The plunger 26 projects outwardly through the closure member 30 beyond the confines of the cylinder 22 and is attached by a pin and slot connection 36 to one arm 38 of a bell crank lever 40, the other arm 42 of the lever being attached to a vertically reciprocable crosshead 44 which slides in vertically disposed guideways 46 in the framework 20. The bell crank lever is mounted for pivotal movement on a rock shaft 48 which projects across the framework 20. The crosshead 44 carries driver 18 which operates in a driver slot 52 provided in the nosepiece 16. A removable face plate 54 is held in position on the nosepiece by means of screws 56 and is capable of being removed to relieve a staple jam in the driver slot 52.

The magazine assembly 14 selected for illustration herein is of the magnetic type wherein a magnetic bar 60 holds the staples S, in cartridge form, in position within a magazine chamber 62. This latter chamber is defined by means of an inverted channel-shaped member 64 of non-magnetic material. The magnetic bar 60 overlies and rests on the member 64 so that the crown portions 66 of the individual staples S which cooperate to make up the staple cartridge are attracted to and held in sliding contract with the channel web 68. The lower portion of the channel member 64 is open for easy introduction of the staple cartridge into the magazine chamber 62. A pole plate 70 overlies the magnetic bar 60 and serves as a protective shield therefor. The magazine is provided with the usual slidable follower (not shown) by means of which the staple cartridge is yieldingly urged forwardly toward the nosepiece 16. The nosepiece is provided with a shear block 72 which projects rearwardly of the driver slot 52 and which is formed with a shearing edge 74 designed for cooperation with the driver 15 in the usual manner of staple-shearing operations.

From the above description it will be apparent that during each power stroke of the piston 24 within the cylinder 22, the plunger 26 will be projected in such a manner as to rock the bell crank lever 40 in a counterclockwise direction as viewed in FIG. 1 so as to carry the driver 18 downwardly within the driver slot 52 whereupon the lower end thereof will engage the crown portion 66 of the leading staple in the magazine chamber, and, in combination with the shear block 72, shear the same from the cartridge and carry the same downwardly through the driver slot 52 and into the work.

The arrangement of parts thus far described is more or less conventional and no claim is made herein to any novelty associated with the same, the novelty of the present invention residing rather in the nature of the piston and cylinder assembly 10 and of the novel piston return system associated therewith and which will subsequently be more fully described and claimed.

Still referring to FIG. 1, and additionally to FIGS. 2 and 3, the piston 24 is generally cylindrical and it is provided with upper and lower annular grooves 80 and 82 respectively therein each groove presenting opposed side walls 84 and 86 (see also FIG. 3) and a bottom wall 88. Respective elastormeric O-rings 90 and 92 are disposed in the two grooves 80 and 82 and the O-ring 92 is capable of limited floating movement in the groove 82 for purposes that will be made clear presently. The plunger 26 projects into a socket 94 formed in the underneath side of the piston 24 and is secured therein by a cross pin 96. The end cap 30 is threadedly received as at 98 in the lower otherwise open end of the cylinder 22 and is sealed to this end of the cylinder by a gasket 100. An annular boss 102 formed on the end cap 30 internally of the cylinder constitutes a reaction support for an annular resilient bumper pad 104. A similar annular bumper pad 106 is carried on the upper end of the piston 24 and seats within an annular groove or recess 108. The piston

24 is movable between the retracted position wherein it is shown in FIG. 2 and the advanced position wherein it is shown in FIG. 1.

Means are provided for periodically and at will admitting air under pressure to the interior of the cylinder 22 through the passage 34 to drive the piston downwardly and effect the power stroke thereof while at the same time exhausting the cylinder on the opposite side of the piston. Such admission of air to the cylinder may be accomplished by any suitable control valve mechanism, the particular mechanism disclosed herein being conventional and including a manually operable control valve 110 having a valve stem 112 which is reciprocable in a valve cage 114 fixedly disposed in a transverse bore 116 formed in the end wall 32. A counterbore 118 establishes a valve seat 120 for a valve proper 122 on an end of the valve stem 112. The valve 122 is normally maintained in its closed position on the seat 120 by means of a spring 124 which is interposed between a threaded closure cap 126 and the valve. The valve stem 114 projects outwardly of the cage 112 and cooperates with a lever 128 which is pivoted at 130 for rocking movement on the framework 20. A handle structure 131 is secured by screws 132 and 134 to the framework 20 in overlying relationship and carries a pivot pin 136 for an operating lever 138 having a conveniently accessible depressible actuating button 140. The counterbore 118 communicates through a radial passage 142 with a nipple fitting 144 of the quick-release type and which is designed for cooperation with a counterpart fitting 146 on the end of a flexible conduit 148 leading to a source of air under pressure (not shown).

From the above description it will be seen that upon depression of the actuating button 140, the levers 138 and 128 will be rocked about their respective fulcrum points and the valve 110 will be depressed against the action of the spring 124 so as to unseat the valve proper 122 and allow air under pressure to flow from the nipple fitting 144 through the passage 142, counterbore 118, valve cage 112 and passage 34 to the interior of the cylinder 22 on the pressure side of the piston to thus drive the piston downwardly and effect the working stroke thereof.

The valve cage 112 is formed with a port 150 therein in communication with an exhaust passage 152 leading to the atmosphere. When the valve stem 114 is depressed, an enlargement 154 thereon seals the port 150 but when the stem is in its normal position the port 150 is uncovered so that during the return stroke of the piston 24 the cylinder 22 is bled to the atmopshere on the working side of the piston.

The control valve and porting arrangement just described is more or less conventional, the novelty of the invention, as previously stated, residing in the air return system for the piston 24 which will now be described in detail.

As shown in all views of the drawing, the annular groove 82 in the piston 24 communicates with a radial passage 160 which in turn, communicates through a short radial passage 162 in the plunger 26 with an elongated axial exhaust passage 164 therein, the latter passage being in communication with the atmosphere. The three intercommunicating passages 160, 162 and 164, being fixed passages, travel en masse with the piston and plunger during the reciprocating movements thereof. In the lower regions of the cylinder 22 the cylinder wall is formed with a by-pass passage 170 (FIGS. 1 and 2) the effective length of which is slightly greater than the effective axial extent of the piston and this passage is so disposed that when the piston is in its fully advanced position and at the bottom of its stroke, communication will be established between the extreme lower region of the cylinder and the working chamber thereof on the upper side of the piston. The by-pass passage 170 establishes upper and lower ports 172 and 174 respectively above and be-

low the piston at the time that the latter is in its extreme advanced position and the upper port **172** cooperates with the O-ring **90** in the groove **80** while the lower port **174** cooperates with the O-ring **94** in the groove **82** in a particular manner that will be made clear presently to effect the novel piston return system of the present invention.

In the operation of the stapling machine **10**, depression of the actuating buttoon **140** will admit air to the cylinder **22** to drive the piston **24** downwardly and effect the working stroke thereof as previously described. During such downward stroke on the piston, the O-ring **92** will make frictional contact with the inner cylindrical wall of the cylinder **22** and the frictional drag exerted thereon by such wall will tend to retard its downward motion so that the same will closely hug the side wall **84** of the groove **82** and assume the deformed condition in which it is illustrated in FIG. 3, thereby uncovering the passage **160** and allowing air to be exhausted through the annulus existing between the piston and the cylinder wall and through the three exhaust passages **160**, **162** and **164**.

At such time as the piston **24** closely approaches the bottom of its power stroke, the underneath side of the piston will engage the elastomeric bumper pad **104** and compress the same axially a slight amount, the compression of the pad serving not only to soften the effect of the impact against the end closure **30** but also, to a certain degree initiating the return stroke of the piston. At such time as the piston is thus at the bottom of its stroke, the O-ring **90** which is confined within the annular groove **80** in the piston will clear the port **172** associated with the by-pass passage **170** so that the air which is under working pressure in the cylinder **22** above the piston **24** will be by-passed through the passage **170** around the piston **24** and reenter the cylinder below the piston to thus fill the space beneath the latter with air under operating pressure. This filling of the space is substantially instantaneous and the pressure thus exerted on the underneath side of the piston will augment the action of the compressed pad **104** and initiate return movement of the piston. The elastomeric O-ring **92** which, at the extreme lower position of the piston assumes a static relationship with respect to the clyinder wall, now is caused to slide on this wall as shown in FIG. 4, thus causing the ring to closely hug the wall **86** of the groove **82** so as to seal off the annulus existing between the piston and the cylinder wall so that the three exhause passages **160**, **162** and **164** are effectively sealed against the escape of air. The expansive power of the air which has been entrapped in the lower region of the cylinder is thus applied to the piston to return the same to its restricted position within the cylinder **22**. The O-ring **92** remains in its sealing relationship with respect to the side wall **86** of the groove and the cylinder wall during the entire return stroke of the piston and does not move away from the side wall **86** until it again assumes a static condition when the piston is in its fully retracted position. During such return stroke of the piston, air in the upper region of the cylinder **22** is exhausted as previously described through the passage **34**, cage **112** and passage **152** which at this time are in communication with the cylinder due to the uncovering of the port **150** by the enlargement **154** on the valve stem **114**.

It will be understood that reciprocation of the piston as set forth above will effect operation of the stapling machine as previously described to drive a staple S into the work each time the piston descends and to return the driver **50** to its uppermost position for register with a leading staple in the driver slot **52** each time the piston is returned to its retracted position.

The invention is not to be limited to the exact arrangement of parts shown in the accompanying drawings or described in this specification as various changes in the

details of construction may be resorted to without departing from the spirit of the invention. Therefore, only insofar as the invention has particularly been pointed out in the accompanying claims is the same to be limited.

Having thus described the invention, what is claimed is:

1. In a pneumatically operable device, a cylinder having a side wall and end walls defining therebetween an internal chamber, a piston slidable in said cylinder between a retracted position adjacent one end of the cylinder and an advanced position adjacent the other end thereof, a plunger movable with the piston and projecting through one of said end walls, said piston, in any position thereof, defining, in combination with said side and end walls, a pressure chamber on one side of the piston and an expansion chamber on the other side thereof, first valve means selectively operable to admit air under working pressure to said pressure chamber to drive the piston forwardly toward its advanced position and to relieve such working pressure to allow the piston to move rearwardly and return to its retracted position, by-pass means effective when said piston substantially in its fully advanced position establishing direct communication between said pressure chamber and the expansion chamber to admit air under working pressure from the former to the latter, and second valve means movable bodily with the piston and effective during forward movement of the piston from its retracted position to its advanced position for bleeding said expansion chamber to the atmosphere to thus exhaust the same, and also effective during rearward movement of the piston from its advanced position to its retracted position to disable said valve means and thus seal the expansion chamber, whereby the expansion of air admitted to the expansion chamber by said by-pass means and entrapped therein will return the piston to its retracted position, said second valve means comprising an exhaust passage extending through the piston and plunger and defining an exhaust port, and a valve element movably carried by the piston and slidingly engageable with the cylinder side wall, said valve element being movable into and out of sealing engagement with said port during movement of the piston in opposite directions respectively under the influence of its sliding contact with said cylinder side wall, said valve element being effective during movement of the piston toward its advanced position to open said port and during movement of the piston toward its retracted position to close said port.

2. In a pneumatically operable device, the combination set forth in claim **1**, wherein said by-pass means comprises a by-pass passage in the side wall of the cylinder terminating at its ends in ports on opposite sides of the piston when the latter is in its advanced position.

3. In a pneumatically operable device, the combination set forth in claim **2**, wherein said by-pass passage is disposed wholly within the confines of the side wall of the cylinder and wherein said ports are longitudinally displaced from each other a distance slightly greater than the effective longitudinal extent of the piston.

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MARTIN P. SCHWADRON, *Primary Examiner.*

P. T. COBRIN, P. E. MASLOUSKY,

Assistant Examiners.