PNEUMATIC PISTON RETURN SYSTEM AND VALVE ASSEMBLY FOR IMPACT TOOLS

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ABSTRACT

A piston return system for air cylinders in an impact tool wherein live air, when introduced into the cylinder on the pressure side of the piston, initiates the power stroke. A check valve by-passes live air around the cylinder to an expansion chamber on the opposite side of the piston where it expands when air pressure is relieved on the pressure side of the piston to return the piston to its uppermost position. The expansion air is bled to atmosphere through a passageway in the piston and through a valve carried by the piston when the piston returns to its uppermost position. A cartridge-type valve assembly is mounted in the tool to bleed air through a bore in one of the valve members to the atmosphere from the pressure side of the piston and from the expansion chamber when the piston reaches its uppermost position.

11 Claims, 3 Drawing Figures
PNEUMATIC PISTON RETURN SYSTEM AND VALVE ASSEMBLY FOR IMPACT TOOLS

This application is an improvement upon the subject matter of copending U.S. application Ser. No. 732,441, filed May 27, 1968, now U.S. Pat. No. 3,552,274.

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 is an improvement upon an improved air return and valving system 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 from the retracted position. Such systems possess the obvious disadvantages that a large volume of air must be expended during each operated cycle. To obviate this limitation, certain other air return systems have been devised in which, 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 the 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 tool. 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 for the next succeeding power stroke thereof.

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 is an improvement upon the piston return system described and claimed in a copending application Ser. No. 732,441, filed on May 27, 1968, now U.S. Pat. No. 3,552,274. The invention contemplates the provision of an improved 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 an expansion chamber into which live air is injected for piston return purposes. The live air is obtained by the expedient of boring a passageway through the piston between the piston cylinder and the body portion of the tool surrounding the piston cylinder and past a sealing ring which is of special construction and functions as a check valve for the unidirectional passage of live air into the expansion chamber. When the power stroke is completed the air in the expansion chamber is expelled to atmosphere and the return air is then bled to atmosphere directly through the piston and through an improved cartridge valve assembly.

In accordance with this invention, the piston is provided with a passageway which is in communication with the expansion chamber. This passageway is closed by an annular sealing ring which is sealable in response to the pressure of the return air when the piston returns to its uppermost position. At this time, an annular sealing ring mounted on the piston expands sufficiently to allow the return air to pass through the passageway and to be bled from above the piston. In addition to this annular ring, the piston mounts a further annular sealing ring which seals against a cylinder wall during the entire range of movement of the piston. This annular ring also serves to hold the piston in its up position after it is returned to that position for the next power stroke by the return air.

Further, in accordance with this invention, an improved valving system is provided in which a valve assembly is manufactured as a cartridge which may be inserted (and removed) as a unit from the impact tool casing. This cartridge, besides a mounting sleeve for mounting the cartridge in the casing, comprises a pair of valve members, one of which is disposed in a bore in the other. The valve member defining the bore is moveable between a pair of positions. In the first of those positions, the pressure chamber above the piston is out of communication with the source of pressure air, but is in communication with the bore of the valve member and therethrough with the air exhaust chamber which leads to the atmosphere. In the other position of that valve member, the received valve member sealingly closes the bore to prevent communication with the atmosphere and to provide communication between the pressure chamber and the source of live or pressure air.

The improved piston return and valve assembly described above is the embodiment of the present invention has been designed for use primarily in portable impact tools such as magazine fed stapling and nailing machines, and other devices which rely for their action upon the pressure stroke of a pneumatically operated driver. It is to be understood, however, that the invention is not necessarily limited to such use, and that piston and cylinder assemblies and valving assemblies constructed in accordance with the principles of the invention may be used in other environments as well.

The provision of an impact tool which is extremely simple in its construction and which therefore may be manufactured at a low cost, one which is comprised of a minimum number of parts, one which is rugged and durable and which therefore will withstand rough usage; one which is capable of ease of assembly and disassembly, and one which is well adapted to perform the service required of it, are further desirable features provided by the present invention.

Further features, objects and advantages of the present invention will become apparent from the following description and drawings of an illustrative embodiment of the invention of which:

FIG. 1 is a side elevational view, partially in section, of a pneumatic stapling tool embodying the principles of this invention;

FIG. 2 is an enlarged view of a portion of FIG. 1 illustrating the valve assembly in a piston driving position; and

FIG. 3 is a fragmentary cross-sectional view of a portion of FIG. 1.

Referring now to the drawings in detail, the piston return and valving systems of the present invention are shown, for exemplary purposes, as being operatively embodied in a portable gun-type percussion or impact tool in the form of a pneumatically operated, magazine-fed stapling tool 10. The stapling tool comprises several principal parts, including a casing comprising a cylinder-enclosing body portion 12 from which there projects sidewardly an integral lateral extension or handle portion 14, a closure head 16, a nosepiece 18, a staple magazine 20, and a valving assembly 22.

The body portion 12 is of generally tubular construction, the upper end thereof being open while the lower end is closed by means of a relatively thick bottom wall 24. The tubular body portion 12 surrounds and encloses a thin-walled sleeve-like cylinder 26 within which there is mounted for vertical reciprocation a piston 28 which carries a driver 30 for staples 5 disposed in the staple magazine 20. The upper end of the driver is secured by means of a pin 32 in a slot formed in the piston, and the lower end is guided in a slot 34 formed in the nosepiece 18. The lower rim portion of the body portion 12 is provided with an annular elastomeric bumper pad 36 designed
for engagement with the piston 28 when the latter completes its downward power stroke. An elastomeric seal 38 for the drive 30 is centered within the annular bumper pad to prevent egress of air from the lower regions of the body portion 12.

The magazine 20 may be of any conventional type. In the illustrated form of magazine, the staples S are supported in straddling relation on a guide bar 40 disposed within a magazine chamber and are urged forward in the magazine toward slot 34 by means of the usual spring-pressed follower (not shown). The forward upper edge of the bar 40 constitutes a shearing edge by means of which the leading staple S of the staple cartridge may be sheared from the cartridge each time it is engaged by the drive member 30.

The upper circular rim of the cylinder 26 terminates flush with the upper rim of the tubular body portion 12 and is provided with a thickened flange 44 which is formed with a continuous annular groove 46 therein for reception of a specially configured sealing O-ring 48 which serves as a unidirectional check valve and by means of which the cylinder 26 is sealed to the inner wall surface of the body portion 12 for a purpose to be described. The lower edge of the cylinder 26 rests on a segmental support shelf in the body portion to prevent downward axial movement with respect to the body portion 12.

Sealing ring 48 is spaced radially from the wall of body portion 12, the two walls being generally coaxial so that they define therebetween a generally annular chamber 50 which is full cylinder height. A series of ports 52, which may be in number, are provided by the shelf supporting the lower edge of cylinder 26, and establish communication between the interior of the cylinder 26 and the chamber 50.

The ports 52 are preferably equally and circumferentially spaced around the cylinder wall and are below the lowermost level to which the piston 28 moves.

The portion of the cylinder chamber below the piston constitutes a variable volume expansion chamber 54 while the annular chamber 50 constitutes an auxiliary fixed volume expansion chamber, the function of which is to increase the capacity of the chamber 54 so that a greater amount of compressed air will be available for expansion purposes for the return stroke of piston 28.

Piston 28 is generally of cylindrical design and the side wall thereof is provided with a pair of annular grooves 56, 58 in an upper region thereof, and within which there are disposed annular gaskets or sealing rings such as O-rings 60, 62, respectively. During reciprocation of the piston, sealing ring 60 functions to seal the piston 28 against the wall of cylinder 26, on the power stroke, and to prevent reverse flow of air around the piston during the return stroke of the piston under the influence of expansion air within the expansion chambers 50 and 54. The sealing rings 60, 62 are formed of a suitable elastomeric material such as rubber, either natural or synthetic, or a rubber substitute.

Sealing ring 60 is always in sealing engagement with the wall of cylinder 26. However, sealing ring 62 may be in contact with the walled cylinder 26 at all times except when the piston 28 is substantially in the position of FIG. 1, i.e., the uppermost position, at which time the return air in chambers 50 and 54 will break the seal between the O-ring 60 and air vent apertures 64 to allow return air to be vented from expansion chambers 50 and 54. Air vent apertures 64 are in communication with chambers 50 and 54 via a radial bore 66 which in turn communicates with an axial bore 68 which terminates at the end of piston 28 in a vent opening 70. It is clear that pin 32 is suitably apertured so that it will not block axial bore 68.

Preferably O-ring 62 is stretched slightly into groove 58. In that case it may not sealingly engage the wall of cylinder 26, it is stretched too tightly, however, 28, it will impede the exhausting of expansion air from chambers 50 and 54. On the other hand, if it is too loose and tightly sealed against the cylinder, on its repeated movement past the shoulder 69 of the relieved area 71 of cylinder 26, it will be gradually abraded away until it fails to satisfactorily perform its function of preventing the escape of expansion air prematurely.

It will be seen, therefore, that return air cannot and will not pass into apertures 64 from above the piston because of the sealing fit between O-ring 62 and vent apertures 64. However, when the piston returns to the position of FIG. 1, the relieved section 71 of the cylinder 26 will allow the expansion air to stretch the ring 62 sufficiently to cause it to escape through apertures 64 and upwardly to be vented from under the closure head in the manner to be described.

The closure head 16 is secured in any suitable or known manner (as for example by fastening bolts, not shown) to the upper open end of the body portion 12. A rigidified gasket member 72 is interposed between the closure head and the upper rim of the body portion in sealing relationship. The outer end of the integral hollow handle portion 14 is adapted to be connected by a suitable fitting 74 to a flexible conduit 76 leading to a source of air under pressure which is adapted to be placed in communication with a pressure chamber 80 disposed above the upper rim of the body portion 12 and below closure head 16. Pressure chamber 80 provides air to the piston 28 for its power stroke and to expansion chambers 50 and 54 through a gasket port 82. When air from the supply chamber 92 in the handle is admitted to pressure chamber 80, in the manner to be described, the air thus serves both to drive piston 28 and to fill the air return or expansion chambers 50, 54, closure head 16, and valve 48.

Sealing ring 48 is of the check valve type described and illustrated in copending application Ser. No. 732,441, filed on May 27, 1968, now U.S. Pat. No. 3,552,274, and operates in the manner described therein. The ring is provided with a series of transverse grooves 94 at its lower edge which provide air flow passages for the downward flow of air between the wall of body portion 12 and cylinder 26 from chamber 80 to fill expansion chambers 50 and 54 when driving air is admitted to pressure chamber 80. Air present in chamber 54 is compressed into air storage chamber 50 during the stroke of the piston 28. On the return or upstroke of piston 28, ring 48 sealingly engages the wall of cylinder portion 12 sufficiently to prevent the leakage of return air therepast. As such, it is seen that O-ring 48 acts as a unidirectional check valve, generally in the manner described in U.S. Pat. No. 3,552,274, and for example as O-ring 270 illustrated in FIGS. 9-11 therein.

Air for driving the piston is supplied to pressure chamber 80 (and to expansion chambers 50 and 54) from chamber 92 through the valve assembly 22 of this invention. Venting also takes place through valve assembly 22. Valve assembly is a cartridge type unit and is supported and positioned adjacent body portion 12 in a suitable stepped bore 102 formed in the casing of the stapling tool 16.

The cartridge is surrounded for part of its axial length by a generally cylindrical sleeve 104 mounting a sealing ring 106 which is seated in bore 102. Sealing ring 106 sealingly engages bore 102. Sleeve 104 defines a chondal notch 108, which is adapted to be keyed to the bore 102 to prevent axial movement, and a chondal slot 110 adjacent its base. The keying of sleeve 104 to the bore is accomplished by driving a pin, such as a roll pin 109, through a bore passing through the sidewalls of the casing and into stepped bore 102. Pin 109 rests in confronting notch segments 111 and 113 (FIG. 3). Chondal slot 110 provides communication with a vent passage 112 which opens to the atmosphere at the end remote from valve assembly 22.

A spiral valve member 114 is coaxially mounted in sleeve 104 to move from the position shown in FIG. 1 to that shown in FIG. 2. In FIG. 2, pressure chamber 80 and supply chamber 92 are in communication via pressure port 116 to drive the piston and to fill the expansion chambers 50, 54 with return air.

In the closed position of FIG. 1, pressure port 116 is shut off from communication with the pressure air by virtue of the sealing engagement between annular flange 118 and gasket 72. Flange 118 is maintained in its up position by the high pressure air acting on the lower surface 120 of the spiral valve member, and by the compression spring 121 springing upwardly against lower surface 120. The sum of these forces exceed the
The piston 52 will remain in its lowest position, after having driven a staple, and spool valve member 114 will remain in its lowest position (that of Fig. 2). Upon its release, trigger lift rod 54 will be biased downward by compression spring 170 through ball valve 140. Air will then pass below the concave upper ball valve seat 142 and will act against lower surface 120 to cause spool valve member 114 to rise to the position at which annular flange 118 is sealed against gasket 72. That will cut off communication of the pressure air with pressure chamber 80 at which time the compressed air stored in chambers 50 and 54 will expand to return piston 28 to its uppermost position. The high pressure air trapped in pressure chamber 80 at the time annular flange 118 moves into sealing engagement with gasket 72 will be vented and bled through exhaust bore 160 past conical surface 164 through a plurality of vent ports 172 into annular chamber 174 downwardly through choral notch 110 and into vent passage 112. When the piston returns to its full up position, that of Fig. 1, the return or expansion air will stretch or expand O-ring 62 sufficiently to permit the return air to be bled through axial bore 68, radial bore 66, vent apertures 64, gasket port 82 and then into exhaust bore 160, thence into the vent passage 113 in the same manner as the pressure air trapped in pressure chamber 80 passed into the vent passage 112.

It will be thus seen that the valve system of this invention provides a highly advantageous cartridge valve assembly which may be dropped as a unit into, and removed as a unit from a suitable bore provided in a stapler tool or an impact tool casing. The valve assembly comprises two valve members and a sleeve, one of the valve members defining an axial bore and being axially moveable, the other being disposed in said bore. The valve assembly serve both to supply pressure air to the driving piston for the impact or power stroke and to vent the exhaust air directly through the valve to the atmosphere. The exhaust air thus may be bled from the tool at the rearward end, rather than through the head of a common practice.

Further, a highly efficient and effective air return system for the piston is also provided. The piston is provided with a pair of annular gaskets or O-rings one of which sealingly engages the cylinder and assists in holding the piston in an up position for driving, while the other stabilizes the piston while also providing an efficient and effective means for venting the air return expansion chambers to the atmosphere through the valve assembly.

What is claimed is:

1. In a pneumatically operable impact tool comprising a casing having a generally tubular body portion, and a reciprocable piston mounted therein to be driven and returned pneumatically, said casing defining a chamber containing high pressure air, and means for supplying air to said high pressure chamber, a pressure chamber above said piston for supplying driving air to drive said piston downwardly, an expansion chamber effectively below said piston for returning said piston to an upper rest position, and an air vent passage defined by said casing for venting air to the atmosphere, an improved valve assembly mounted in said casing and comprising a first valve member and a second coaxial valve member, said valve members being relatively axially moveable, a communication port between said high pressure chamber and said pressure chamber, said first valve member being moveable from a first position in which it sealingly blocks said communication port, and a second position in which it opens said communication port, said first valve member defining a bore therein which is in constant communication with said pressure chamber in both of said positions, said second valve member being disposed in said bore, and in said first position providing communication between said bore and said air vent passage, and cooperative means on said valve members for preventing such communication except in said second position means for normally maintaining said first valve member in said first position whereby said pressure chamber is normally in communication with the atmosphere through said bore, and
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7 means for effecting the movement of said first valve member to said second position.

2. In the pneumatically operable impact tool of claim 1 in which said second valve member mounts a ball valve and said means for effecting movement includes a trigger rod for moving said ball valve from a first ball valve seat to a second ball valve seat.

3. In the pneumatically operable impact tool of claim 2 in which said high pressure air chamber is in constant communication with said ball valve through a second bore in said first valve member and the high pressure air maintains said first valve member in said first position when said ball valve is on said first ball valve seat.

4. In the pneumatically operable impact tool of claim 1 in which said cooperative means on said valve members comprises a coaxial seat and a sealing ring which are out of engagement in said first position and which are in sealing engagement to block said bore in said second position.

5. In the pneumatically operable impact tool of claim 1 in which said valve assembly includes a sleeve surrounding said first valve member, said sleeve being fixed against axial movement in said casing, said first valve member sealingly engaging said sleeve and being moveable therein, said first valve member and said sleeve defining a chamber which is in flow communication with said air vent passage and said bore in said first position.

6. In the pneumatically operable impact tool of claim 1 in which said second valve member encloses a ball valve and mounts a resiliently loaded trigger rod for moving said ball valve against said resilient load, and said second valve member defines a chamber above said ball valve which communicates with said high pressure chamber through a second bore defined by said first valve member.

7. In the pneumatically operable impact tool of claim 1 in which said means for normally maintaining said first valve member in said first position comprises spring means resiliently biasing said first valve member to said first position, said biasing means preventing driving by the tool when it is first connected to high pressure air.

8. In a pneumatically operable device for repeatedly exerting a driving work force in one direction and having a casing, a tubular body portion, a sleeve-like cylinder in said body portion and, in combination with the wall of said body portion, defining a narrow fixed volume expansion chamber, a piston sealingly slidable in said cylinder between retracted and extended positions, a variable volume expansion chamber forwardly of the piston, a closure head for the rear end of the cylinder and defining a pressure chamber rearwardly of the piston, said expansion chambers being in flow communication in all positions of the piston, valve means selectively operable to admit live air at working pressure to said pressure chamber to drive the piston forwardly to its extended position and to relieve such pressure to allow the piston to return to its retracted position under the influence of the expansion of air in said expansion chambers, and one-way check valve means automatically effective during forward movement of the piston and after the piston has assumed its full forward position for admitting live air at working pressure directly into said expansion chambers from said pressure chamber between said tubular body portion and said cylinder, said check valve means being effective to seal said expansion chambers against escape of entrapped air to said pressure chamber during substantially the entire return stroke of the piston, the improvement comprising valve means carried by said piston automatically openable by the expansion air in said expansion chambers when said piston has returned substantially to its rearwardmost retracted position for venting said expansion air through said piston to the pressure chamber and to the atmosphere.

9. In the pneumatically operable device of claim 8 in which said piston defines a passageway in constant communication with said expansion chambers and in communication with said valve means, and in which said valve means is biased to a position in which said passageway is sealingly closed thereby, said cylinder being relieved adjacent the rearwardmost position of the piston, at which position the valve means is automatically opened by the expansion air in said expansion chambers, thereby to vent said air to atmosphere.

10. In the pneumatically operable device of claim 9 in which said valve means is an annular gasket and said passageway includes at least one port sealed by said annular gasket, said annular gasket being biased to an open position automatically adjacent the relieved portion of said cylinder.

11. In the pneumatically operable device of claim 9 in which said valve means is an annular gasket mounted in an annular groove defined by said piston, said annular gasket being stretched into sealing engagement with the inner wall of said annular groove, said annular groove defining port means communicating with said passageway.

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