PNEUMATIC DRIVING TOOL WITH A FAIL-SAFE MECHANISM

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References Cited
UNITED STATES PATENTS
3,051,135 8/1962 Smith...............................91/417 A
3,147,670 8/1964 Spencer............................91/461

Abstract
A pneumatic driving tool is provided which incorporates a fail-safe mechanism for preventing damage to the tool when an abnormal operating condition occurs. The mechanism includes an elongated cylinder and a piston mounted within said cylinder for normal reciprocatory movement between longitudinally spaced first and second positions. If the piston moves to a third position which is adjacent the second position but at a greater distance from said first position, due to an abnormal wear condition, the piston will automatically remain at said third position until the abnormal wear condition is corrected.

9 Claims, 14 Drawing Figures
3,651,740

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PNEUMATIC DRIVING TOOL WITH A FAIL-SAFE MECHANISM

BACKGROUND OF THE INVENTION

The basic modus operandi of pneumatic driving tools has remained the same for years, namely a pressure-actuated linear one way motion imparts a driving blow against a fastener or the like causing the same to be expelled from the tool and driven into a predetermined air piece. The means for imparting such a driving blow is generally effected through a single or double spool type piston having a driver blade or the like affixed to the leading or fastener-contacting end thereof. The piston is reciprocally mounted within a suitable cylinder. Upon completion of the driving or firing stroke, the leading end of the piston strikes a resilient bumper which is positioned at the lower terminal of the cylinder. The bumper which is normally formed of rubber or a rubberlike material, is adapted to absorb the excess impacting force of the piston and cushion same. The return of the piston to its firing position may be accomplished by springs, trapped air, or the like.

In recent years the utility of pneumatic driving tools has expanded considerably with the result that in many instances the power capacities of the tools have been increased substantially. With the more powerful tools maintenance thereof has become more difficult and costly. One source of maintenance problems has been the rapid deterioration of the bumpers which are used in such tools. Unless frequent inspection and replacement of said bumpers are made, serious damage can result, such as breaking of the driver blade and/or the piston, scoring of the cylinder wall, or in extreme cases the housing for the cylinder becomes fractured resulting in the whole tool being replaced. In order to avoid such problems, many users replace the bumpers periodically whether they require it or not. Such a practice, however, may become costly and result in an inordinate amount of downtime for the tool.

SUMMARY OF THE INVENTION

Thus, it is an object of this invention to provide a pneumatic tool embodying a fail-safe mechanism which minimizes the maintenance of said tool and yet, markedly extends the useful life thereof.

It is a further object of this invention to provide a pneumatic tool wherein early detection of bumper deterioration can be readily effected without disassembly of the tool and thus prevent the occurrence of serious damage to the tool.

It is a further object of this invention to provide a pneumatic tool embodying a fail-safe mechanism which is simple in construction and may be readily incorporated in various types of pneumatic driving tools.

Further and additional objects will appear from the description, accompanying drawings, and appended claims.

In accordance with one embodiment of this invention a pneumatically operated device is provided which comprises an elongated cylinder, and a double spool type piston disposed therein. The piston in normal operation reciprocates within the cylinder between longitudinally spaced first and second positions. In an abnormal operational situation, however, the piston is rendered immovable and is disposed at a third position. Such an abnormal situation is frequently due to the wear or breakdown of the resilient bumper which under normal conditions engages the moving piston and absorbs or dampens its kinetic energy when the piston reaches its second position and prior to the piston returning to its first position. The third position is disposed adjacent to the second position but at a greater distance from the first position. The double spool type piston is provided with a transversely extending, air pressure responsive head which is in sliding, sealing engagement with the interior surface of the cylinder. In addition to the head, the piston includes a transversely extending air pressure responsive, annular flange which is longitudinally spaced from the head. The annular flange is adapted to be in sealing engagement with the cylinder interior surface only when the piston is reciprocating between the first and second positions. When the piston moves beyond the second position and reaches the third position, the annular flange is no longer in sealing engagement with the cylinder interior surface whereupon the piston is restrained by air pressure from returning to the first position.

DESCRIPTION

For a more complete understanding of the invention reference should be made to the drawings wherein:

FIG. 1 is a side elevational view of a pneumatically operated driving tool embodying the fail-safe mechanism.

FIG. 2 is an enlarged, fragmentary vertical sectional view of the tool of FIG. 1 and showing the piston in its firing position with respect to the cylinder.

FIGS. 3, 4, and 5 are fragmentary vertical sectional views of the fail-safe mechanism shown in FIG. 2, but with the piston thereof located respectively at the first, second, and third positions with respect to the cylinder.

FIGS. 6, 7, and 8 are similar to FIGS. 3-5, but showing a second embodiment of the fail-safe mechanism.

FIGS. 9, 10, and 11 are similar to FIGS. 3-5, but showing a third embodiment of the fail-safe mechanism assembly.

FIGS. 12, 13, and 14 are similar to FIGS. 3-5, but showing a fourth embodiment of the fail-safe mechanism.

Referring now to the drawings and more particularly to FIGS. 1 and 2, a pneumatically operated portable fastener-driving tool 20 is shown which incorporates one embodiment of the fail-safe mechanism 21.

Basically tool 20 comprises a hollow handle section 22, a housing 23 disposed at the forward end of the handle section and in which the fail-safe mechanism 21 is disposed, a magazine 24 for fasteners secured to the lower portion of the handle section, and a nose section 25 positioned beneath the housing and from which individual fasteners are rapidly expelled.

An air hose connector 27 is provided at the rear of the handle section 22 and a trigger control 28 is mounted adjacent the housing 23 for manually controlling the firing of the tool.

In FIG. 2 an enlarged vertical section of housing 23 is shown with the improved mechanism 21 located therein. The housing 23 includes a central body portion 23a, a hollow cover portion 23b removably mounted on the upper end thereof, and a bottom portion 23c removably secured to the lower end of portion 23a.

Snugly mounted within body portion 23a is an elongated cylinder 30, the upper end of which terminates at the cover portion 23b. Resiliently engaging the upper end of cylinder 30 and disposed within the cover portion is a poppet valve 31. An O-ring type seal 32 is carried by the valve 31 and is adapted to sealingly engage the upper edge of the cylinder 30 when the valve is in its closed position. The valve 31 is biased in the closed position by a coil spring 33. The upper end of the spring contacts the underside of the cover portion 23b and the lower end engages the upper side of the valve 31.

As seen in FIG. 2, valve 31 is provided with a centrally disposed upwardly extending hollow post 34 which is disposed in telescoping relation within a hollow depending post 35 formed in the hollow cover portion 23b. Posts 34 and 35 are encompassed by the spring 33. A sealing, sliding fit is maintained between the telescoping hollow posts by an O-ring seal 36 which encompasses post 34.

At the upper end of the depending hollow post 35 is affixed an annular seal pad 37 which is engaged by the upper end of post 34, when the valve 31 is moved upwardly to its fully open position with respect to the upper end of cylinder 30. When the upper end of post 34 is in contact with seal pad 37, the central bore 54a formed in post 34 is closed off.

It will be further noted in FIG. 2 that a peripheral portion 31a of valve 31 pressure is directed thereby beyond the exterior of cylinder 30 and terminates within a cavity 38. The cavity 38 surrounds the upper end portion of the cylinder and communicates with a second cavity 40 charged with high pressure air and formed in the handle section 22.
Valve 31 carries a second O-ring 41 which encompasses same and is in sliding, sealing engagement with the walls forming an annular chamber 42 within the interior of cover portion 23b. Chamber 42 communicates with one end of a passageway 43, the latter having one part thereof formed in the cover portion 23b and the remaining part formed in the housing 23. The passageway 43 interconnects cavity 40 with chamber 42. Interposed passageway 43 and cavity 40 is the trigger control 28, which includes a hollow spool 44 disposed in sliding, sealing engagement within a sleeve 45, the latter being affixed to the handle section 22. Sleeve 45 is provided with a transversely extending port 45a which effects communication between the lower end 43a of passageway 43 and the center bore 45b of the sleeve only when the spool 44 is in its normal down position as seen in FIG. 2. The upper end of the bore 45b is provided with an inwardly extending collar 45c. Disposed within the bore 45b and intermediate collar 45c and the spool 44 is a coil spring 46 which serves to bias the spool in its down position.

Spool 44 is provided with a center passage 44a, one end of which opens to the atmosphere at the lower exposed end 44a of the spool. The opposite end of passage 44a terminates at a transversely extending port 44c which is spaced from the upper end of the spool. When the spool 44 is manually moved upwardly by a trigger lever 47 which is pivoted in a clockwise direction about pin 48, the transversely extending port 44c will register with the lower end 43a of passageway 43. The spool 44 carries a pair of O-rings 50a-b disposed above and below the port 44c which sealingly and slidably engage sleeve 45 and prevent air leakage between the spool and sleeve.

In normal operation, air pressure is exerted on the upper and lower surface of poppet valve 31 and due to the fact that the area of the upper surface of the valve 31 exposed to the air pressure is greater than the area of the under surface of said valve exposed to the same pressure, the valve will remain seated on the upper end of cylinder 30. Coil spring 33 will cause the valve to remain seated when the tool is not connected to the source of compressed air. The force of spring 33 is overcome by the air pressure exerted on the under surface of valve 31, when the spool 44 is moved to its up position, because chamber 42 is then vented to the atmosphere through passageway 43, port 44c, and bore 44b.

The upper end of cylinder 30 is provided with an inwardly extending annular shoulder 30a, the underside of which is slightly chamfered, see FIG. 2. The function of the shoulder 30a will be discussed more fully hereinafter.

Mounted for reciprocatory movement within cylinder 30 is a double spool type piston 51. The upper end of the piston is provided with a transversely disposed annular head 52 the diameter of which is slightly less than the diameter of the opening delimited by shoulder 30a. Thus, when the piston 52 is in its up or firing position I as shown in FIGS. 2 and 3, the O-ring 53 will frictionally engage or become partially wedged against the chamfered surface of shoulder 30a. By reason of this frictional engagement, there is a slight delay after the poppet valve 31 has moved upwardly from the end of cylinder 30 so as to expose the top of the head to the full force of the compressed air before the piston moves downwardly with respect to the cylinder. Because of such delay, a more effective and powerful driving force is exerted on the piston by the compressed air. A further advantage resulting from the wedged relation which occurs between the periphery of the piston head and the cylinder shoulder 30a, when the piston assumes position I, is that the piston will not accidentally drop or move towards position II, and thus the possibility of the fastener feed mechanism becoming jammed is avoided.

Spaced longitudinally beneath head 52 and axially aligned therewith is an annular transversely extending flange 54. The head and flange are interconnected by a depending stem 55. The diameter of flange 54 is less than the diameter of head 52.

A peripheral groove 54a is formed in flange 54 for accommodating an O-ring 56 which is adapted to sealingly and slidably engage the interior surface of the cylinder 30. It should be noted that the lower portion of the cylinder interior is of a reduced diameter.

Adjacent the location where the diameter of the cylinder interior is reduced are provided a plurality of small ports 57 which are symmetrically arranged in a cylinder-encircling relation, see FIG. 2. The ports 57 effect communication between the cylinder interior and the portion of cavity 38 which substantially surrounds the exterior of the cylinder. When the piston 51 is in its up or firing position I, the upper surface of flange 54 will be located just beneath the row of ports 57. Thus, when cavity 38 is charged with compressed air, a portion of the compressed air becomes entrapped within the cylinder interior between head 52 and flange 54. The trapped air serves a dual purpose during normal operation of the piston 51, namely (a) it gives added force to the driving stroke, and (b) it provides a means for effecting rapid return of the piston to its firing position after it has reached the end of its firing stroke II, see FIG. 4.

To cushion the impacting force of piston 51 when it reaches position II, a bumper 59 is mounted adjacent to but spaced from the lower end of cylinder 30. The bumper is normally of ringlike configuration and formed of rubber or some synthetic resilient material. The bumper is seated within a pocket 60 formed at the lower end of the housing 23. The bumper is axially aligned with the axis of the cylinder 30 and is provided with a center opening 58c through which a driver blade or hammer rod 61 extends. The blade 61 is attached to the underside of flange 54. The lower end of the blade is slidably mounted within a stationary guide 25a which forms a part of the nose section 25.

The lower end of cylinder 30 engages a shoulder 62 formed in the interior wall of cylinder 30. As seen in FIG. 2, the lower end of the cylinder is spaced above the lower end 23c of the housing so as to form an annular chamber 63 which encompasses the upper projecting part of the bumper 58. The chamber 63 is vented to the atmosphere through ports 64 and 65. The latter ports 65 are in registered relation with the opening 58a formed in the bumper.

When the bumper 58 is operating properly, it will effect cushioning of the piston 51 at the end of its firing stroke so that the O-ring 56 carried by the flange 54 will remain in sealing engagement with the interior surface of cylinder 30 thereby preventing the compressed air entrapped between the piston head 52 and flange 54 from escaping into chamber 63 and then out through ports 64 to the atmosphere. If the bumper begins to cavitate or wear due to heat generated by repeated impact from the piston, it will no longer cushion the piston 51 when it reaches position II, but instead will permit the piston to reach an abnormal position III, see FIG. 5. When the piston has reached position III, the O-ring 56 carried by flange 54 will no longer remain in sealing, sliding engagement with the interior of cylinder 30 but will move beyond the lower end limit of the cylinder into the annular chamber 63. Once the O-ring 56 is disposed in chamber 63, the entrapped air is vented into the chamber and out through ports 64 and the O-ring resumes an expanded or uncompensated state. When the trapped air has been released, the piston will remain in position III due to the compressed air passing through ports 57 and reacting only upon the upper surface of head 52, see FIG. 5. Thus, as soon as the piston reaches position III the tool is immediately rendered inoperative whereby no damage to the piston, cylinder, or the housing is incurred. When the tool is rendered inoperative and the piston remains in its down position, the operator can readily ascertain without disassembly of the tool that the bumper has caviatured and requires replacement.

FIGS. 6-8 show a first modified tool 120 wherein the bumper 129 therefor is provided with a plurality of radially extending grooves 138b formed in the upper surface thereof which effect communication between the chamber 163 and
the center opening 158c of the bumper. Thus, with tool 120 upon the piston 151 thereof reaching position III, the compressed air entrapped between the piston head 152 and flange 154 will be vented to the atmosphere through chamber 163, grooves 158b, and opening 158a. Notwithstanding the cavitation or wear of bumper 158, the grooves 158b formed in the upper surface thereof are of sufficient depth to provide the necessary venting communication between the chamber 163 and bumper opening 158a. Aside from this difference, the structure of tools 20 and 120 may be the same.

Figs. 9-11 show a second modified tool 220 which is substantially the same as tool 120 except that a bumper 258 is provided in which the upper surface thereof is substantially dome-shaped and also is provided with one or more radially extending grooves 258a. In tool 220, the housing 223 in which the piston and bumper are located is slightly different from that of tool 120, however, in both tools the fail-safe feature embodied therein is basically the same.

The modified tool 320 shown in Figs. 12-14 differs primarily from the previously described tools in that no ports are formed in the cylinder wall through which compressed air enters the cylinder interior and becomes entrapped between the head 352 and flange 354 of the piston 351. In lieu of the cylinder wall ports, the piston stem 355 is hollow and opens at the upper surface of head 352. A transversely extending port 355a is provided which effects communication between the center bore 355b of the stem and the spacing between the head and flange. A one way valve 355c is carried by the stem and cooperates with port 355a to permit air to only flow into the spacing through port 355a.

During normal operation of the piston 351, between positions I and II, high pressure air flows through bore 355a and port 355a into and becomes trapped within the spacing between the head and flange of the piston. It is the entrapped compressed air which facilitates return of the piston to its initial or firing position I. As in the case of tool 20, tool 320 is provided with a chamber 363 into which the unentrapped compressed air is vented when the piston 351 assumes position III due to cavitation of the bumper 358. A port 364 is provided in housing 323 which in turn vents chamber 363 to the atmosphere.

As will be observed, the operation of the fail-safe mechanism in each of the tools 20, 120, 220, and 320 is substantially the same and provides the necessary protection for the various component parts of the tool while at the same time giving the operator of the tool immediate notice when an abnormal operating condition exists. With the fail-safe mechanism heretofore described, the existence of a defective bumper can be readily determined without requiring disassembly of the tool. The fail-safe mechanism reduces the downtime of the tool because replacement of the bumper is required only when cavitation of the bumper has actually occurred.

I claim:
1. A fail-safe mechanism for a pneumatic fastener-driving tool comprising an elongated cylinder; a double spool type piston mounted within said cylinder for reciprocatory movement between first and second longitudinally spaced positions and immovable when disposed at a third position adjacent said second position but spaced a greater longitudinal distance from said first position, said piston including a head having the periphery thereof in sliding, sealing engagement with the cylinder interior surface, and a flange longitudinally spaced from said head and movable therewith as a unit, said flange having the periphery thereof in sliding, sealing engagement with the cylinder interior surface only when said piston is disposed at or between said first and second positions, and being out of sealing engagement with said interior surface only when said piston is disposed at said third position, said head having a greater air pressure-responsive surface area than said flange; means for exerting a predetermined air pressure on said head to effect movement of said piston from said first position towards said second or third positions; means whereby air is entrapped between said head and said flange and the pressure of said entrapped air becomes greater than said predetermined air pressure only when said piston is disposed at said second position and during predetermined segments of travel from said second to said first positions; means for automatically releasing the entrapped compressed air from between said head and flange only when said piston is disposed at said third position; and resilient piston-engaging stop means for normally cushioning and retarding the movement of said piston when the latter has reached said second position.

2. The mechanism of claim 1 including manual control means for regulating the application of said predetermined air pressure on said piston head.

3. The mechanism of claim 1 wherein said stop means is removably mounted adjacent one end of said cylinder.

4. The mechanism of claim 1 wherein said cylinder includes a first air inlet adjacent said first position and a second air inlet disposed intermediate said first and second positions; the longitudinal distance between said second air inlet and the location of said flange, when said piston is in either said second or third position, being greater than the longitudinal distance between said flange and head.

5. The mechanism of claim 1 wherein said piston includes driver blade-attaching means disposed on the end thereof opposite said head.

6. The mechanism of claim 5 wherein said stop means is of ringlike configuration, and said driver blade-attaching means is axially aligned with respect to the center of said stop means.

7. The mechanism of claim 2 including a housing for said cylinder, said housing being provided with a handle on which said manual control means is mounted.

8. The mechanism of claim 5 including a housing for accommodating said cylinder, said housing being provided with conduit means communicating with said first and second air inlets.

9. The mechanism of claim 8 when said housing is provided with an annular chamber disposed endwise of said cylinder and adjacent said third position, said piston flange being located within said chamber only when said piston is disposed at said third position whereby the compressed air entrapped between the head and flange of said piston is vented to said annular chamber; said housing being provided with means for venting said chamber to the atmosphere.

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