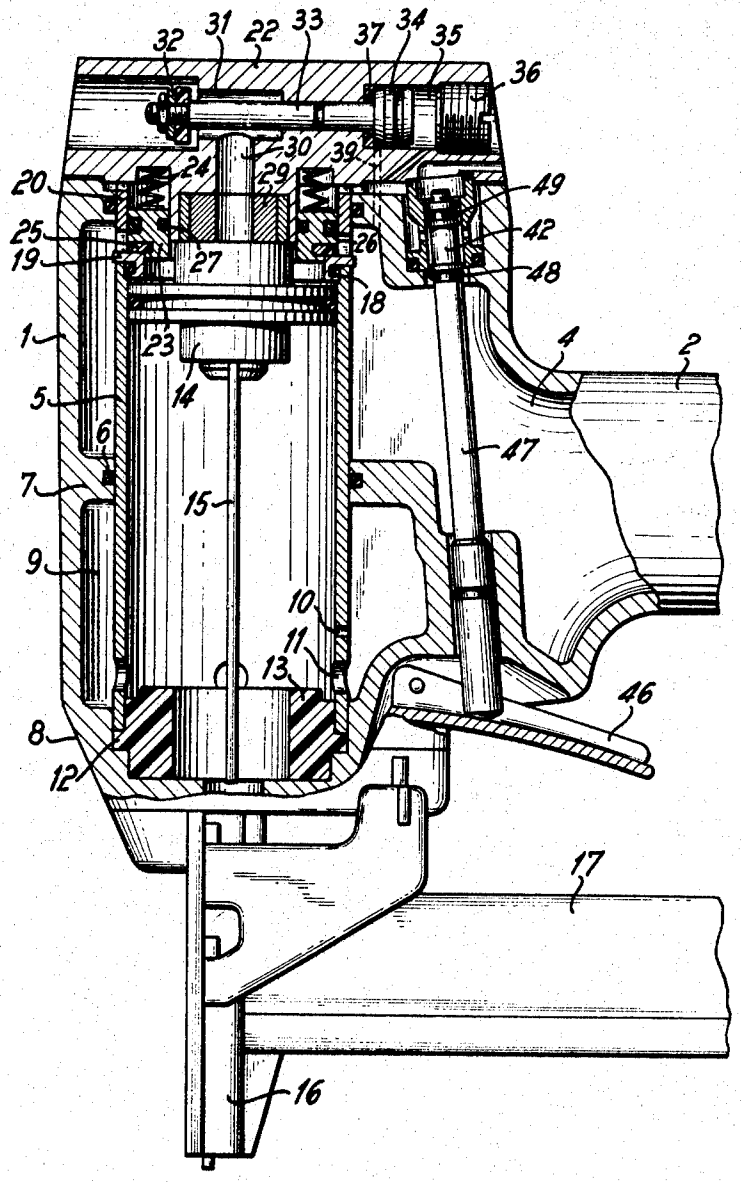
July 16, 1968 D. VOLKMANN 3,392,632

VALVE MEANS FOR AN AIR-OPERATED FASTENER DEVICE

Filed Feb. 3, 1966 4 Sheets-Sheet 1

FIG. 1



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VALVE MEANS FOR AN AIR-OPERATED FASTENER DEVICE

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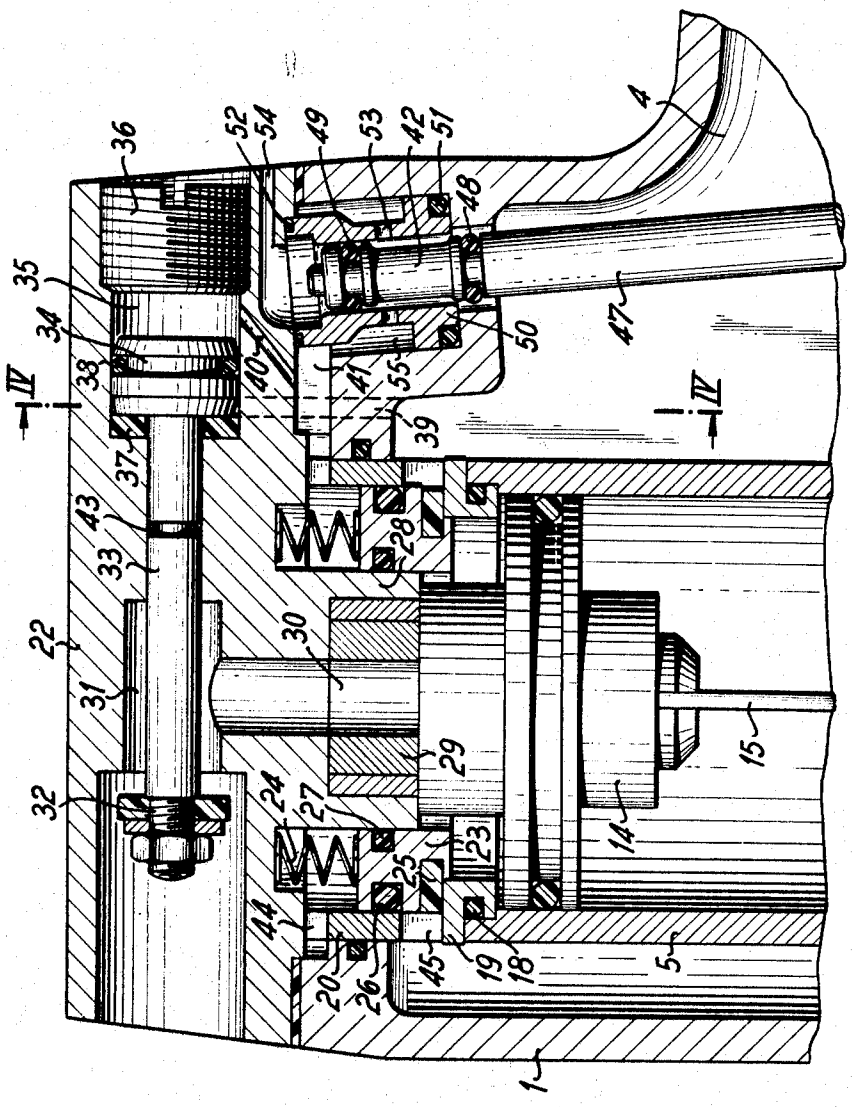


FIG. 2

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VALVE MEANS FOR AN AIR-OPERATED FASTENER DEVICE

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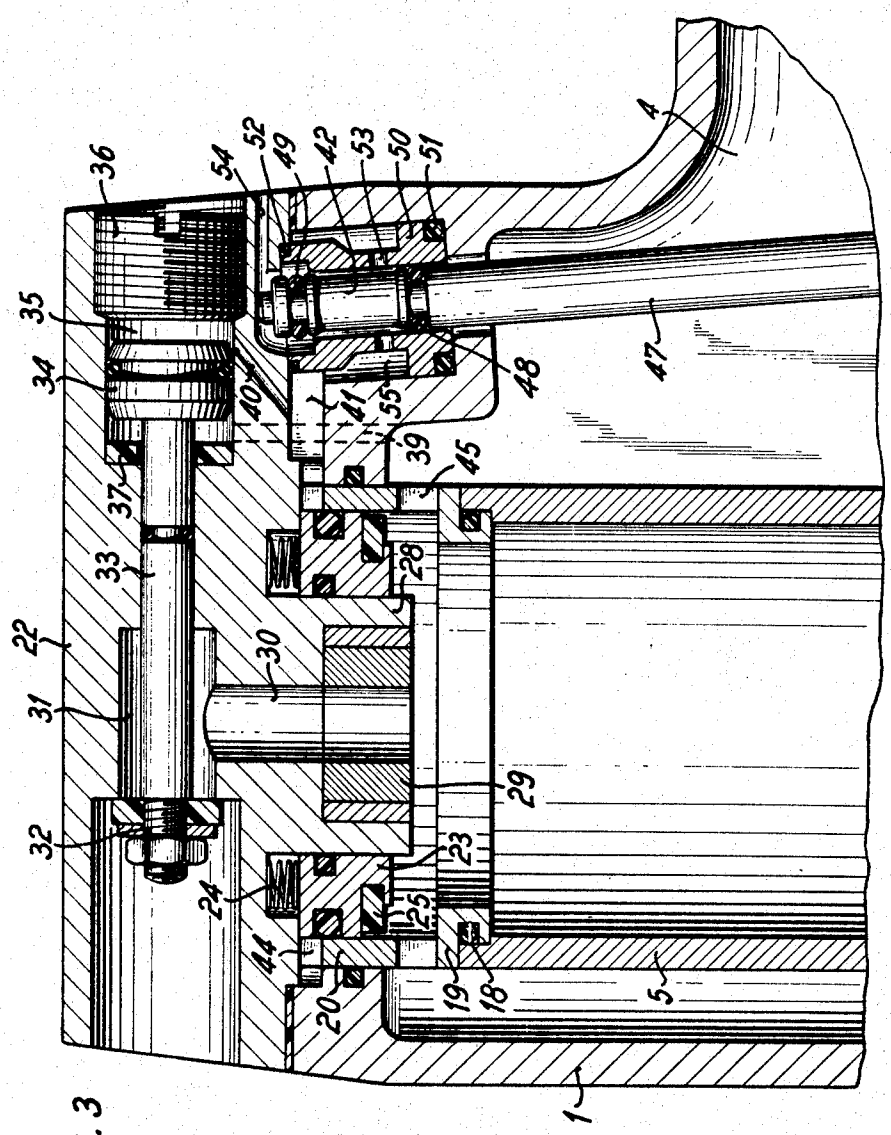


FIG. 3

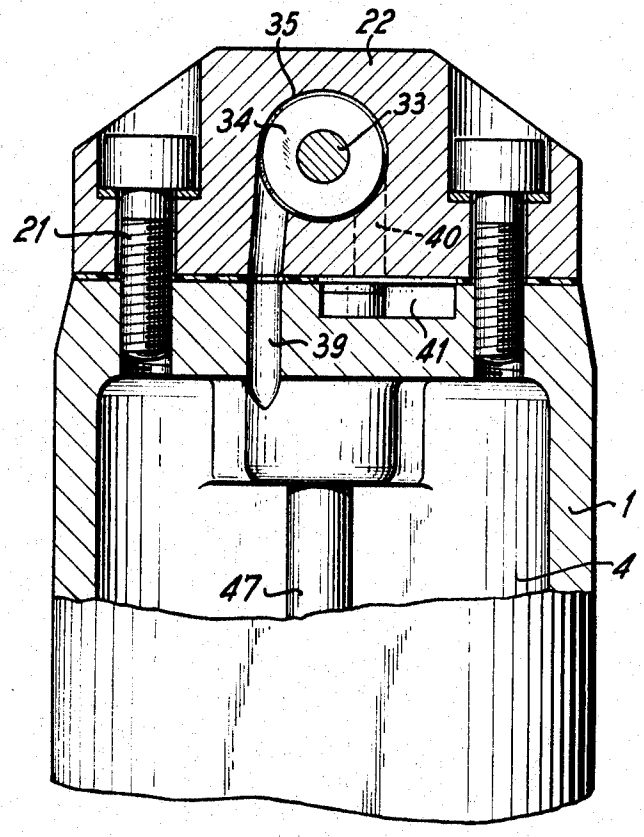
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VALVE MEANS FOR AN AIR-OPERATED FASTENER DEVICE

Filed Feb. 3, 1966 4 Sheets-Sheet 4

FIG. 4



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United States Patent Office 3,392,632
Patented July 16, 1968

3,392,632

VALVE MEANS FOR AN AIR-OPERATED FASTENER DEVICE

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Filed Feb. 3, 1966, Ser. No. 524,902
Claims priority, application Germany, Feb. 4, 1965, H 55,064
7 Claims. (Cl. 91—457)

ABSTRACT OF THE DISCLOSURE

A pneumatic fastener device having a main cylinder which is provided with a pneumatically actuated valve means, the exhaust valve of which is opened during the return stroke of the working piston and is closed at the beginning of the driving stroke of the working piston before the inlet valve is opened, so that the device is operated according to a two-cycle system. Thereby, any loss in the driving force of the compressed air on the working piston is avoided.

This invention relates to valve means for an air-operated fastener device by which fastening means, such as nails, staples, pins etc., are driven into a work piece. In this device, when in its operative position, air under pressure from a source of compressed air is admitted to a cylinder by an inlet valve, and when in its inoperative position said cylinder is exhausted. The inlet valve is by a manually actuated control valve moved into operative or inoperative position.

To provide such devices with great effective power it has to be insured that the full pressure of the operative air is instantly admitted to the driving piston reciprocable in the cylinder as the control valve is actuated.

According to methods known in the art, the cylinder is surrounded by an air chamber which is in permanent communication with the source of compressed air and against which the interior of the cylinder is sealed off by means of the inlet valve provided at its upper open end. The area of the upper face of the inlet valve is greater than of its lower face so that the air operating on the upper face of the inlet valve pushes it on its seat and closes the cylinder. When the control valve is actuated the upper face of the inlet valve is discharged from the air pressure, and the air acting on its lower face raises it from its seat to open the cylinder, which causes the compressed air to be admitted to the piston. When the inlet valve is opened the air exhaust valve must simultaneously be closed, which is open during the return travel of the piston so that the air displaced by the piston may escape. The exhaust valve is mostly constructed as a check valve which in the initial position of the device is open and only closes as the compressed air, which is introduced into the cylinder after actuating the control valve, is gaining impact on it. As long as the exhaust valve is not yet completely closed, part of the compressed air admitted to the cylinder may escape and thus cause a drop in pressure which results in equivalent loss of efficiency.

An important object of the invention is to provide valve means in which the exhaust valve is closed immediately after actuating the control valve and thus to avoid any losses of compressed air which is intended to be supplied to the opened cylinder without any pressure drop.

Another object of this invention is to provide an improved type of valve means for exhausting the air which is displaced by the driving piston during its return travel.

A further object of this invention is to provide an air operated portable fastener device in which the height of the device is less than of other comparable devices, and which device is substantially trouble free and extremely economical to operate.

According to the invention, the exhaust valve is actuated by a differential piston, the annular piston face of which is in permanent communication with the air chamber, while its opposite piston face is connected with said chamber via the control valve when in its inoperative position. The cylinder space of the differential piston actuating the exhaust valve, at its end adjacent the annular piston face, is connected to a passage, which is in continuous open communication with the air chamber, and at its other end the cylinder space is connected to a passage which is in open communication with a chamber located between the control valve and the inlet valve of the cylinder.

As soon as the control valve is moved from its initial into the operative position in that its actuating trigger is squeezed, the piston face of the differential piston actuating the exhaust valve is connected to the open air. The compressed air in the air chamber enters the cylinder space of the differential piston underneath its annular piston face and moves the piston towards the piston face which is discharged of air pressure so that the exhaust valve is instantly moved into its closed position. Thereupon, the compressed air moves the inlet valve from its inoperative into its working position and releases the open end of the cylinder for admittance of the compressed air operating the device. As the exhaust valve is closed before the operating air flows in there is not any loss in the operating air which is therefore admitted to the driving piston within the cylinder at its full pressure.

The inlet valve and the cylinder are of like cross section while the area of the differential piston actuating the exhaust valve and, along therewith, the cross section of its cylinder space, are substantially smaller. The cylinder space of the differential piston is therefore faster discharged of the compressed air than the space above the inlet valve so that also with this in view, the exhaust valve is assured to be closed before the compressed air from the air chamber is fully admitted to the driving piston being at the upper end of the cylinder. The time needed for the discharge of the compressed air from the cylinder space of the differential piston actuating the exhaust valve may be regulated by the cross section of the duct connecting the space at the face of the differential piston with the chamber between control valve and inlet valve. The larger the cross section of this duct the faster is the space vented and by this the exhaust valve is closed.

In a preferred embodiment of the invention, the exhaust valve extends across the central axis of the cylinder, which construction results in particularly short connection passageways and, together therewith, short time required for closing the exhaust valve. Besides, the overall height of the device is reduced, which is of practical importance mainly with hand tools the handling of which is considerably facilitated thereby.

Other and further important objects of the invention will become apparent by reference to the following detailed description taken in connection with the accompanying drawings, in which drawings the invention, for purposes of illustration, is shown as applied to a portable pneumatic stapler.

In the drawings:

FIG. 1 is a longitudinal section and partly side elevation of a portable air-driven stapler in its initial position;

FIG. 2 is an enlarged detailed fragmentary sectional view of FIG. 1;

FIG. 3 is a sectional view of FIG. 2 in operative position;

FIG. 4 is an enlarged sectional view taken as indicated by line IV—IV of FIG. 2.

The stapling device, which, by way of example, is designed as a portable hand tool, consists of a casing **1**, which may be made of a light metal casting or pressing and is provided with a lateral handle **2** having a conventional connection (not shown) to a suitable supply of air under pressure. The casing **1** encloses a large air chamber **4** which is in open communication with the air supply connection and surrounds the upper portion of a sleeve or main cylinder **5**. The main cylinder **5** is inserted into the casing **1** and by a resilient O-ring **6** is sealed off against an intermediate wall **7** of casing **1**. Together with a bottom portion **8**, the intermediate wall **7** encloses an air storage chamber **9**, which is through a narrow port **10** and a plurality of wider ports **11** in the wall of cylinder **5** in open communication with the interior of cylinder **5**. The lower end of cylinder sleeve **5** is supported on an annular shoulder **12** of an elastic bumper **13**, which is inserted in the bottom **8** of the casing and limits the working stroke of driving piston **14**.

The piston **14** is slidably mounted within the cylinder sleeve **5** and consists, for example, of light metal with a steel core. Firmly secured to piston **14** is a staple driver **15**, which, for instance, is made of steel sheet metal and is in the conventional manner guided in a drive track provided in a nose piece **16**, which drive track is not shown in the drawings. Secured to the nose piece **16** is a magazine **17** for handling a supply of fasteners, such as staples, which are joined together as a strip or bar.

Supported on the upper open end of main cylinder **5**, by means of a profiled ring **19**, which contains an elastic sealing ring **18**, is a sleeve or cylinder **20**, the upper end of which is adjacent to a cap or top **22**, which is by screws **21** (see FIG. 4) secured to the casing **1**.

The main cylinder **5**, loosely inserted into casing **1** by the cap **22** is rigidly clamped between the annular shoulder **12** of bumper **13** and the sleeve **20**. Therefore, if cap **22** is screwed off and sleeve **20** is pulled out, main cylinder **5** may be replaced in an easy fashion and with a minimum of time when worn out owing to rough working conditions of the device. The easy replacement of the heavily strained main cylinder **5**, which is thus enabled, avoids longer periods of break down and therefore is of importance for practical usefulness of the device.

An annular piston-like element **23** is adapted for a slight sliding movement in sleeve **20** and operates as a valve for introducing compressed air to the main cylinder **5**. The piston valve **23** is supported by the profiled ring **19** and by air and by springs **24** is pressed on its seat, which is formed by the profiled ring **19**. Piston valve **23** may be moved entirely in a pneumatic fashion without the use of any springs if it is constructed as a differential piston. The sealing surface of piston valve **23** consists of an elastic disc **25**. By a resilient O-ring **26**, piston valve **23** is also sealed off against sleeve **20**, and by a resilient O-ring **27** is sealed against a cylindrical projection **28** of cap **22**. Secured into this cylindrical projection **28** is an annular permanent magnet **29** to maintain the piston **14** in its initial upper position as shown in FIGURES 1 and 2. The magnet **29** encloses an axially extending exhaust

duct **30**, the upper angularly bent end **31** of which is closed by an exhaust valve **32**.

The valve stem **33** of exhaust valve **32** extends across the central axis of cylinder **5** and at its rear end carries an actuating piston **34** shaped as a differential piston, which has an airtight guide within a cylindrical bore **35**. The cylindrical bore **35** is closed by a screw **36** and sealed against the valve stem **33** by a resilient disc **37**. Besides, valve piston **34** is by a resilient O-ring **38** sealed against the cylindrical bore **35**. The area of the annular face of differential piston **34**, adjacent the exhaust valve **32** is substantially smaller than the area of the opposite face of the piston adjacent the end screw **36**. By a passage **39**, which is arranged in the neighbourhood of the resilient disc **37** and crosses cap **22** and casing **1** of the device (see FIG. 4), the cylindrical bore **35** permanently communicates with the air chamber **4**. The opposite end of cylindrical bore **35** adjacent screw **36**, is by a passage **40** connected with a chamber **41** located between cylinder **20** and a control valve **42**. By a resilient O-ring **43**, valve stem **33** is also sealed against the bore of cap **22**, in which it is housed. Sleeve **20** is at its upper edge provided with a plurality of ports **44** and at its lower edge with corresponding ports **45**.

The control valve **42** has a valve stem **47**, which is actuated by a trigger lever **46**, and slides within a valve box **50**, which is together wtih interposed sealing rings **51** and **52** inserted into a corresponding recess of casing **1**. Valve box **50** is provided with a port **53** and is in open communication with an exhaust duct **54**, and an annular chamber **55** enclosed between casing **1** and valve box **50** is in open communication with chamber **41**.

The valve assembly operates as follows:

In its inoperative position as shown in FIGURES 1 and 2, main piston **14** is in its uppermost position and cylinder **5** is closed by the annular piston valve **23**, which in turn is pressed on its seat **19** by springs **24** and by the compressed air acting on its upper face from within the air chamber **4**, chamber **55**, chamber **41** and ports **44**. The exhaust valve **32** is open because the full pressure of the compressed air kept in storage chamber **41** is via passage **40** admitted to the face of the differential piston **34**. As the area of this face is greater than of the opposite annular face of differential piston **34**, exhaust valve **32** is kept in its open position. Magnet **29** holds main piston **14** in its uppermost initial position.

When the trigger **46** is squeezed for carrying out a working stroke, control valve **42** is upwardly shifted into the position shown in FIG. 3 so as to interrupt supply of compressed air from air chamber **4** to chamber **41** as O-ring **48** closes the cylindrical bore of valve casing **50**. Chamber **41**, being in connection with the space above annular piston **23** through the upper ports **44** of cylinder **20**, is via annular chamber **55**, ports **53** of valve casing **50** and its annular bore in open communication with exhaust passage **54** and thus allowing the air to escape from the space above annular piston **23**.

Due to the open communication formed by passage **40** between the cylindrical space **35** and the chamber **41**, the air from the cylindrical space **35** immediately escapes to the atmosphere. The compressed air from air chamber **4** through passage **39** acts on the annular face of differential piston **34** which piston is at once shifted to the right and moves valve **32** into its closed position, in which it blocks the exhaust duct **30**, **31**. Because of the small quantity of air prevailing within the cylindrical space **35** and because of the greater volume of air in the cylindrical space within the sleeve **20** above the piston valve **23**, exhaust valve **32** is certainly closed before annular piston **23** is moved into its operative position.

The compressed air streaming in from air chamber **4** via the lower ports **45** of cylinder **20** raises annular piston **23** from its seat **19** as the air is more effective than the springs **24**.

The compressed air may therefore freely stream into main cylinder **5** and be admitted to driving piston **14**. As soon as this compressed air overcomes the arresting force of magnet **29**, driving piston **14** is pushed forward in its working direction and with its driver **15** drives a staple into the work piece.

The air displaced during the working stroke of driving piston **14** moves through ports **11** into the storage chamber **9** and is stored therein. When piston **14** has almost completed its working stroke and abuts bumper **13**, the compressed air above it flows through the narrow port **10** into the storage chamber **9** and increases the pressure of the air stored therein, which air moves through the large ports **11** to underneath the lower face of piston **14** when it has hit bumper **13** and in a known manner returns the piston **14** into its initial position.

During this return motion, the space above piston **14** is through the passages **30** and **31** connected with the outside air by means of exhaust valve **32**. As soon as piston **14** reaches the top of main cylinder **5** it is held in this position by the magnet **29**.

The instant closing of exhaust valve **32** is favored by its arrangement across the central axis of main cylinder **5** and annular piston **23** respectively, as this allows for the passages **39** and **40** to be relatively short. Besides, this across-arrangement of exhaust valve **32** reduces the construction height of the device.

The start of any working stroke thus takes place in two phases: at first exhaust valve **32** is closed after actuation of control valve **42** by trigger **46**, and secondly the annular piston **23** is opened so that no loss in compressed air by it being blown out of the then still open exhaust valve can occur before annular piston **23** is opened and effects the working stroke. In this manner, an increase in the performance of the device and a better economy of its operation are obtained as driving devices of the type referred to work for longer periods without being allowed any pauses.

Although the invention is herein shown and described as applied to a portable pneumatic stapler, it is to be understood that in its broadest aspect the invention is not to be so limited except as particularly set forth in the following claims.

I claim as my invention:

1. In an air-operated fastener device, a casing having a main cylinder, an air storage chamber adjacent said main cylinder and adapted to be connected to a source of compressed air, a piston slidable in said main cylinder, holding means adapted to maintain said piston in an initial position at one end of said main cylinder, pneumatically actuated valve means including a differential piston inlet valve arranged at said one end of said main cylinder and operable to introduce air under pressure from said air storage chamber to said main cylinder, an exhaust valve connecting said one end of said main cylinder with the atmosphere when said piston has completed its working stroke and returns to said initial position, a manual control valve for pneumatically moving said inlet and exhaust valves, an air chamber between said inlet valve and said control valve, said air chamber being exhausted to the atmosphere upon activation of said control valve, a differential piston combined with said exhaust valve, a cylindrical space containing said differential piston, the axis of said cylindrical space extending transversely of the axis of said main cylinder and said inlet valve, a first passage adjacent one face of said differential piston and communicating with said air storage chamber, a second passage adjacent the opposite face of said differential piston and communicating with said air chamber, whereby immediately after activation of said control valve said air chamber is exhausted and said exhaust valve is closed, whereupon said inlet valve is opened and air under pressure is introduced into said main cylinder to overcome said holding means and to move said piston into its driving stroke.

2. A device in accordance with claim **1**, wherein said cylindrical space of said differential piston contains a smaller quantity of air than said air chamber between said inlet valve and said control valve.

3. A device according to claim **2**, wherein the cross section of said second passage is sufficiently large so that said cylindrical space is exhausted to the atmosphere before said air chamber is exhausted to the atmosphere.

4. A device according to claim **1**, wherein said control valve has a stem extending across said air storage chamber and is guided in a valve box, said box being disposed in a cavity of said casing and being provided with air passages, said air passages in the operative position of said control valve connecting said air chamber with an exhaust port, and said air passages in the inoperative position of said control valve connecting said air chamber with said air storage chamber.

5. In an air-operated fastener driving tool having a main cylinder, a piston and driver movable in said main cylinder through a working stroke and a return stroke, means defining an air storage chamber adapted to be connected to a source of compressed air, means for supplying air under pressure from said air storage chamber to said main cylinder for moving said piston and driver through said working stroke, and exhaust passage means for venting air from said main cylinder to the atmosphere during movement of said piston and driver through said return stroke; the improvement which comprises the combination of an air inlet valve cylinder, a differential piston air inlet valve in said air inlet valve cylinder movable between open and closed positions by air under pressure from said air storage chamber for controlling the supply of air from said air storage chamber to said main cylinder, an exhaust valve for opening and closing said exhaust passage means, a differential piston cylinder containing a differential piston which is connected to said exhaust valve for moving the latter between open and closed positions, first air passage means for supplying air under pressure from said air storage chamber to said air inlet valve cylinder and to one portion of said differential piston cylinder at one face of said differential piston, second air passage means in permanent communication with said air storage chamber for supplying air under pressure from said air storage chamber to an opposite portion of said differential piston cylinder at the opposite face of said differential piston, a control valve in said first air passage means movable between operative and inoperative positions, said exhaust valve being held in open position and said air inlet valve being held in closed position by air under pressure from said air storage chamber and from said first air passage means when said control valve is in its inoperative position, said one portion of said differential piston cylinder and said air inlet valve cylinder being vented to the atmosphere through said first air passage means and said control valve when the latter is in its operative position, and said exhaust valve thereupon being movable to closed position by air under pressure from said air storage chamber and from said second air passage means and said inlet valve thereupon being movable to open position by air under pressure from said air storage chamber for admitting air under pressure to said main cylinder, the volume of said one portion of said differential piston cylinder being substantially smaller than the volume of said air inlet valve cylinder whereby said exhaust valve is fully closed before said air inlet valve is opened.

6. The tool of claim **5** further characterized in that said first air passage means includes an air chamber interposed in permanent fluid communication between said air inlet valve cylinder and said control valve and also being in permanent fluid communication with said one portion of said differential piston cylinder whereby said air inlet valve cylinder and said one portion of said differential piston cylinder are both vented through said air chamber and thence through said control valve when the latter is in its operative position.

7. The tool of claim 5 further characterized in that the axis of said differential piston cylinder is disposed transversely of the axis of said main cylinder and said air inlet valve cylinder.

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