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J. R. L. SANTOS

PNEUMATIC TOOL

Filed April 15, 1920

2 Sheets-Sheet 1

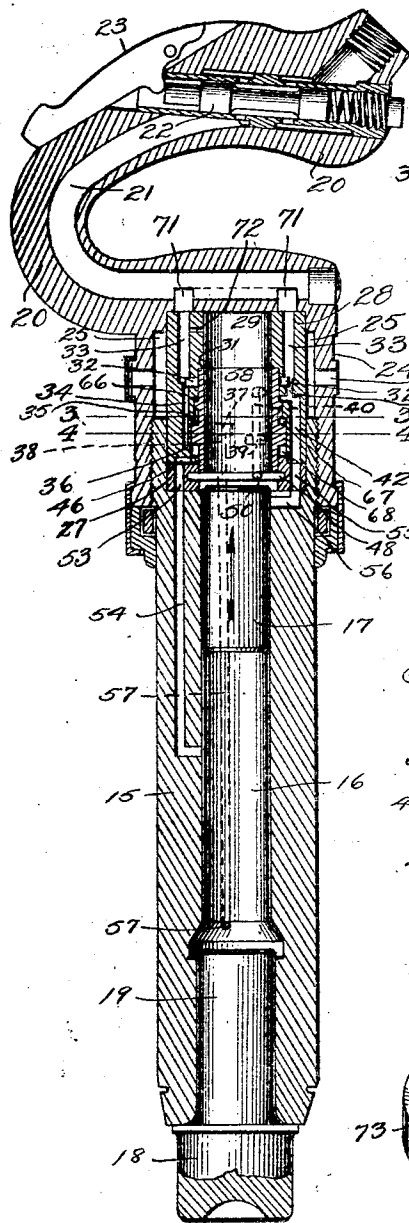


Fig. 1.

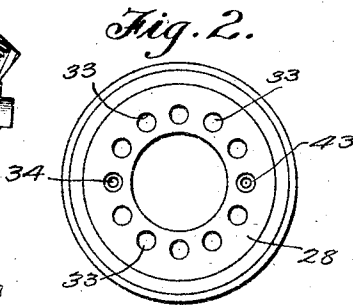


Fig. 2.

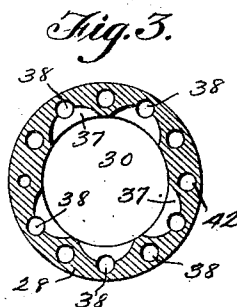


Fig. 3.

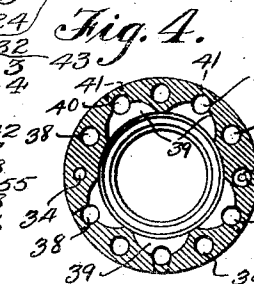


Fig. 4.

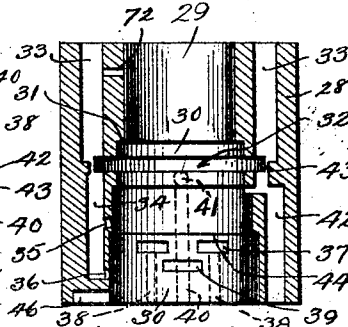


Fig. 5.

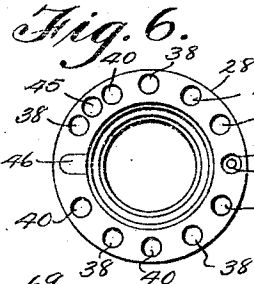


Fig. 6.

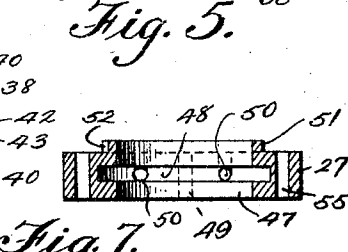


Fig. 7.

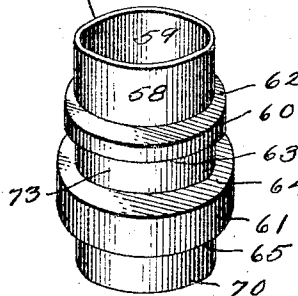


Fig. 9.

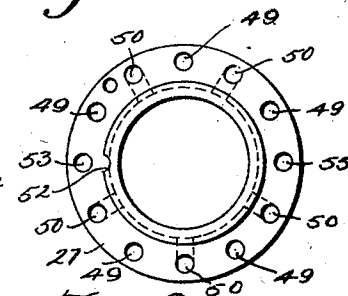


Fig. 8.

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JOHN R. L. SANTOS, OF BALTIMORE, MARYLAND, ASSIGNOR TO GEORGE OLDHAM AND SON COMPANY, OF PHILADELPHIA, PENNSYLVANIA, A CORPORATION OF PENNSYLVANIA.

PNEUMATIC TOOL.

Application filed April 15, 1920. Serial No. 374,013.

To all whom it may concern:

Be it known that JOHN R. L. SANTOS, a citizen of the United States, residing at Baltimore, in the State of Maryland, has invented certain new and useful Improvements in Pneumatic Tools, of which the following is a specification.

This invention relates to improvements in pneumatic tools and in its present form is directed to pneumatic hammers wherein a percussive plunger having a length of stroke greater than its own length, is rapidly reciprocated to deliver blows onto a working tool, such as a rivet set, chisel or similar device.

The present invention has particular reference to improved means for the operation of the valve mechanism whereby the fluid-pressure is caused to operate first on one end and then the other of the plunger to effect a rapid reciprocation of the latter.

In many of the pneumatic tools now in commercial use the valve mechanism employed to control the passage of fluid pressure alternately to the opposite sides of the plunger or piston is actuated in one direction by live air and in the opposite direction by compression that is produced by the plunger or piston on its rear or return stroke in the cylinder. An example of a structure of this kind is illustrated, described and claimed in the U. S. patent to Meissner Number 822,146 granted May 29th, 1906.

And in another type of tool the valve has one surface that is constantly subjected to fluid-pressure while another surface thereof, and of greater area, is subjected intermittently to fluid pressure to operate the valve against the action of the pressure on the first-named surface. An example of this form of tool is illustrated in U. S. Patent 879,106 of February 11th, 1908 to Keller.

My invention however differs from the structure of the Meissner patent in that my valve is actuated in both directions by live air and in neither direction by air that is compressed by the piston, and differs from the Keller structure in that my valve has no surface which is constantly acted upon by fluid-pressure to cause a shifting of said valve.

One object therefore of my invention is to provide a novel and improved construc-

tion of mechanism by means of which the fluid-pressure control valve is automatically actuated in both directions by live air intermittently applied.

Another object of my invention is to provide an improved construction of tool whereby the piston or plunger is utilized as a valve whereby the pressure-control valve is operated in both directions by live air intermittently applied.

Other objects and advantages forming a part of the invention as the result of the improved construction will be hereinafter explained and particularly pointed out in the appended claims.

The invention is illustrated in the accompanying drawings, wherein,—

Fig. 1 shows the complete tool in vertical longitudinal section.

Fig. 2 illustrates a top view of the device with the handle removed,—the illustration being on an enlarged scale.

Fig. 3 shows an enlarged cross-sectional detail through the valve box as the same would appear if cut on the line 3—3 of Fig. 1.

Fig. 4 illustrates another cross-sectional detail through the valve box as the same would appear if cut on the line 4—4 of Fig. 1 and looking upwardly toward the handle.

Fig. 5 shows a vertical sectional detail through the valve-box with the valve removed.

Fig. 6 illustrates an inverted or bottom view of the same.

Fig. 7 shows a vertical sectional detail through the ring-disk.

Fig. 8 illustrates a top or plan view of the same.

Fig. 9 shows the detached valve in perspective.

Fig. 10 illustrates in a diagrammatic way an enlarged longitudinal section through the cylinder of the tool for the purpose of more clearly disclosing the various ports and passages and the position of the valve when the plunger is making a down or operating stroke, and

Fig. 11 shows a similar view with the valve shifted and the plunger nearing a completion of its return stroke.

Referring to the drawing and particularly Fig. 1 thereof the numeral 15, designates a barrel or cylinder having a longitudinal

chamber 16, therein for the reception of a loose plunger 17, having a stroke greater than its own length.

At the lower end of the barrel a working tool 18, is loosely retained, and this tool, as is common, has a stem 19, which projects into the cylinder so that the plunger, on its forward stroke, may deliver blows thereon in rapid succession in the usual and well-known manner.

At the upper end the barrel or cylinder is provided with a handle 20, in which a fluid-pressure supply passage 21, is formed, and a throttle-valve 22 is provided at the entrance to this passage which is controlled by a lever 23, so that the operator may readily control the supply of fluid pressure to the tool.

The handle has a sleeve part 24 which is screwed onto the upper end of the barrel in such manner as to provide or form an annular chamber 25, around the interior of the sleeve, and exhaust ports 26, are provided in the sleeve which open outwardly to vent said chamber 25.

The upper end of the barrel or cylinder is provided with a vertical annular recess so as to receive a ring or disk 27 and to also receive the lower end of an annular or cylindrical valve-box 28,—the box having its lower end seated on the upper side of the disk or ring 27 and held down thereon by the clamping action of the handle on the upper end of the box.

As clearly shown in Fig. 5, of the drawing, the valve-box 28, has an upper central cylindrical chamber 29, and a lower cylindrical valve-chamber 30 which latter is of a slightly larger diameter than the said upper chamber and forms an annular shoulder 31, around the base of the upper chamber 29 which forms, in this instance, a stop for the valve on its up-stroke.

Immediately beneath the shoulder 31, the valve-box is provided with an annular groove 32, and this groove is always in open communication with a series of air-supply or intake-passages 33, which extend vertically in the wall of the valve-box and whose upper ends communicate with an annular groove 71 in the handle which latter groove is always in communication with the fluid-pressure supply passage 21, in said handle as can be seen in Fig. 1, of the drawing.

It is thus to be understood that when the throttle-valve 22 is operated to admit pressure fluid to passage 21, said pressure fluid will pass to annular groove 71 then through the vertical intake passages 33, in the valve-box 28 to the annular groove 32, on the interior of the valve-box where its further passage will be determined by means that will presently be explained.

The valve box 28, further has a longitudinal passage 34, which extends downwardly

from the annular groove 32, and the intake passage 33. This longitudinal passage 34 is provided with a lift-supply port 35, which opens into the valve-chamber 30, and is further provided at its lower end with another port 36, which also opens into said chamber both for purposes that will presently be explained.

By again referring to Fig. 5, of the drawing it will be noted that the interior of the box is provided with a plurality of lift-ports 37, which latter extend through the box-wall from the valve-chamber and are connected with lift-passages 38, that extend vertically in the wall of the valve box. These passages 38, are also clearly shown in Figs. 3-4 and 6 of the drawing.

Below the lift-ports 37, the valve-box also has a plurality of ports 39, which extend laterally from the valve-chamber and communicate with vertical passages 40 whose upper ends terminate at a lateral passage 41, which passages 40 extend entirely through the valve-box and open at the outer side of the latter, as shown by broken lines in Fig. 4 of the drawing.

It is important to note that the valve-box has also a vertical passage 42, whose upper end turns laterally and inwardly and opens on the interior of the valve-chamber and further that at the upper end of this vertical passage there is a port 43, which establishes communication between the said passage 42, and at least one of the intake passages 33. As the passages 33, are always charged with live air whenever the throttle valve 22 is open and the tool is in operation it follows that under the same conditions the passage 42 will always be supplied with a diminished amount of air through the relatively small port 43.

By reference to Fig. 6 of the drawing wherein a bottom view of the valve-box is shown, it will be seen that the lift-passages 38, the vertical passages 40 and the live-air passages 42, all extend to the bottom of the box-wall.

On the interior of the box the valve-chamber has an annular shoulder 44, which is located above the ports 37, and 39 but beneath the lift-supply port 35 and that this shoulder 44, is produced by a slight enlargement of the internal diameter of the valve-chamber all of which is for a purpose that will presently be explained.

By further reference to the bottom view of the box in Fig. 6, it will be noted that a blind hole or recess 45, to receive a dowel-pin (not shown) which is utilized to keep the several parts 15-28 and 27 in register, is provided at the lower edge of the wall, and further, that at one side a notch 46, is formed in the lower inner edge of the box wall as best illustrated in Fig. 5, all for purposes presently to be described.

Beneath the valve-box and in the bottom of the annular recess in the upper end of the cylinder, there is seated a ring or disk 27, shown in Figs. 1-7 and 8 of the drawings.

This ring has a central passage 47; an annular interior channel or groove 48 in said passage; a series of vertical lift passages 49 and a plurality of vertical exhaust passages 50 the lower ends of which latter extend inwardly and open into the channel or groove 48.

The upper side of the ring or disk is provided with an annular bead 51, which has an exterior diameter that will enable it to enter the lower end of the valve-box, when the latter is seated thereon, and at one side, this bead is vertically notched as at 52, which notch registers with the notch 46, in the lower edge of the valve-box wall.

A vertical passage 53, is provided in the ring or disk whose upper end communicates with the space formed by the notches 46-52 (which in effect form a port) and whose lower end communicates with a duct 54, that extends down in the wall of the cylinder 15, and opens into the piston-chamber 16.

The live-air passage 42 in the valve-box has its lower end communicating with a vertical passage 55, in the ring or disk and the lower end of this latter passage connects with a passage 56, in the cylinder which opens through the wall of the cylinder into the piston-chamber 16. It will therefore be seen that the entrance from the piston-chamber to the lower end of passage 56, is at a point below the annular exhaust groove 48, and that whenever that lower entrance is uncovered by the piston 17, whatever pressure fluid there may be in the piston-chamber at said passage-end will be conducted through the passages 55 and 42, as and for a purpose presently to be explained.

It is to be understood that the cylinder 15, is provided with a plurality of ducts 57 (only one of which is shown in order to avoid confusion in the drawings) which extend longitudinally in the wall thereof. The lower ends of these ducts open into the piston-chamber while the upper ends thereof connect with the passages 49, in the ring or disk 27, and also with the passages 38 in the valve-box.

By now referring to Fig. 9, of the drawing it will be noted that the valve 58, is of the cylindrical type and has a central passage 59, of a diameter substantially equal to the diameter of the piston-chamber 16, so that the piston 17, may reciprocate therethrough. On the exterior, the valve has two annular enlargements 60 and 61, the former being situated above and spaced from the latter. The enlargement 60 produces an upper annular shoulder 62 and a

lower annular shoulder 63, while the enlargement 61 has upper and lower annular shoulders 64 and 65 respectively.

By reference to Figs. 1, 9, 10 and 11, it will be noted that the annular shoulders 62 and 63 of the upper enlargement are of less area than the annular shoulders 64 and 65 on the lower enlargement of the valve whereby different pressure areas will be formed on said valve exterior.

This valve has such external dimensions as to enable it to snugly fit the valve-chamber in the valve-box 28, and when placed therein forms an upper live air chamber 66 on the upper side of shoulder 62, and an annular space 67 around the valve between the shoulders 63 and 64 and a so-called annular flip-chamber 68, beneath the shoulder 65, of the valve.

The shoulder 64, of the valve has position beneath the shoulder 44, in the valve-chamber 30.

The upper cylindric end 69, of the valve above the uppermost shoulder 62, thereon serves to open and close the annular groove 32 so as to admit or cut-off live air to or from the upper end of the piston chamber through the central valve passage 59, and when this end of the valve is in the closed position, as in Figs. 1 and 11 of the drawing, the groove 32 is cut-off and the chamber 29, in the upper end of the valve-box will be closed against the escape of fluid-pressure so as to produce a cushion for the piston on the up-stroke.

The lower cylindric end 70, of the valve below the lowermost shoulder 65, thereon also serves a useful purpose in that it controls the escape of pressure from the piston-chamber through the exhaust groove 48, opening said exhaust as the piston moves up and closing said exhaust as the piston moves down.

By reference to Figs. 1-10 and 11 of the drawing it will be noted that a small port 72 connects the cylindrical chamber 29 of the valve-box with one of the live air passages 33 so as to admit live air into the rear end of the valve-box for the purpose of starting the piston and valve forward in event they should both be in rearward position at the beginning of any operation of the tool.

It may not be amiss to here repeat that as shown in the drawings, the piston 17, has a stroke that is greater than its own length and that the invention is especially useful in tools of this class.

The operation of the device is as follows:

Presuming the valve 58 to be in the down or forward position shown in Fig. 10 of the drawing and the throttle valve 22 open so that fluid pressure can pass through passage 21 to annular groove 71 and through supply or intake passages 33, the incoming air

will pass from passages 33 to annular groove 32 then up over the end 69 of the valve into the central valve-passage 59 thus acting upon the rear end of the piston 17 and driving the latter forward in the piston-chamber 16.

During this forward stroke of the piston the air in the chamber 16, in front of the piston will be exhausted or driven out through ducts 57 to ports 39, which latter ports at this time will register with the annular space 73, around the valve between the shoulders 60 and 61, which space also registers with the lateral branch 41 of the passage 40 so as to convey the exhaust through the box-wall to the annular chamber 25 and from which chamber said exhaust escapes by port 26 to the atmosphere.

During this exhaust operation while the piston is making a forward stroke, the valve 58, is held down by live air pressure acting upon the upper shoulder 62 and upon the valve end 69.

This holding-down live air pressure is derived from supply passage 33 by passage 43 to passage 42 and, when the piston 17 has moved down far enough to uncover the lower end of passage 56, live air-pressure from the piston chamber 16, at the rear of the piston will enter said uncovered end of passage 56, and pass up through passages 55 and 42 and will act in conjunction with the pressure derived from the port 43 on the upper shoulder 62 of the valve.

When the piston has moved down far enough in the cylinder to uncover the lower end of duct 54 into the piston-chamber behind the forwardly-moving piston, live air pressure from said piston-chamber at the rear of the piston will enter said duct 54 and pass up to passage 53 and notches 46—52 to the so-called flip-chamber 68 where it will act upon the lower shoulder 65, on the exterior of the valve 58. As the area of the shoulder 65, is greater than the area of the upper shoulder 62, a force will be developed, because of the difference of these areas, that will be sufficient to push the valve 58, up,—the pressures on the opposite rim-ends of the valve being balanced and the shoulders 63 and 64 being subject or exposed to the atmosphere through the port 39.

It is thus to be noted that the valve 58, will be moved upwardly by live air-pressure as the piston is making a forward stroke, and has been completely shifted to said up or rear position by the time the piston has delivered its blow, and that said valve is held up by live air-pressure from port 36 expanding into annular chamber 68, by reason of the fact that the expanded air cannot flow outwardly through the relatively larger passage 54 as fast as it is supplied. This may be best seen in Figs. 10 and 11.

When the valve 58 has moved upwardly

or to its rear position, as shown in Fig. 11 of the drawing, the entrance of live air through annular groove 32, will be cut off by the end 69 of the valve extending up into the box-chamber 29 and live air cannot then pass over the end 69 of the valve and enter the rear end of the piston chamber 16, through the central valve passage 59.

The valve now being up or in the rear cut-off position has uncovered the annular groove 48 at its lower end 70, and by uncovering said groove has connected the latter with the piston-chamber 16 and formed a communication from the piston-chamber through the ports 50 to the passages 40 and 41 to the annular chamber 25 and ports 26 to the atmosphere so that the pressure at the rear of the piston in the piston-chamber can escape or exhaust.

At this time lift-supply port 35, has been connected with lift port 37, by the annular space 73, on the exterior of the valve so that pressure will be supplied through passages 38 and 49 to ducts 57, into the lower end of the piston-chamber 16,—the annular projection 61, on the valve having closed the exhaust ports 39.

This lifting pressure through ducts 57, will be less than the supply pressure in supply passage 21 of the handle due to the relative sizes of the ducts 57, and the passage 35.

The piston 17, now having pressure beneath its forward end and air exhausted from the cylinder on top of it, will move up, first uncovering, with its forward or bottom edge, the lower end of passage 54 thus reducing and providing a relief for the pressure on the bottom shoulder 65 of the valve. After the piston uncovers the cylinder-end of duct 54 it effects a covering of the entrance to passage 56, but at this time the central passage up through the valve, and practically a continuation of the piston-chamber, is still open to the atmosphere because groove 48, and ports 50 are uncovered.

While the cylinder-end of passage 56 is covered by the up or rear-moving piston, live air from passage 43 to the upper end of passage 42 is building up a pressure in passage 42 and in the annular chamber 66 with which said passage 42 communicates and this live air pressure acts upon the upper or rear shoulder 62, on the exterior of the valve 58, and becomes equal to the supply pressure in passages 33, at a time predetermined by the size of passage 43.

At this moment in the operation, the upper shoulder 62, of the valve is exposed to the pressure building up in annular chamber 66, while the pressures acting upon the shoulders 63, 64 and 65 are equalized, therefore when the live air-pressure in passages 56, 55, 42 and in the annular chamber 66 has built up to a greater pressure than that which is acting upon the shoulders 63—64

and 65 of the valve the latter will be pushed down or forward by such built-up live air-pressure from passage 43.

When this forward movement of the valve by live air pressure takes place the top of the piston 17, is just above the annular groove 32, where it forms compression in the chamber 29 of the valve-box and this compression serves as a cushion for the piston and returns the latter, by rebound, to a point substantially at or below the groove 32, so that live air from said groove, which is now opened, may act on the upper or rear end of the piston to repeat the operation.

It will thus be seen that the valve 58, is moved upwardly or rearwardly by live air acting on the lower or forward shoulder 65 on the valve, such live air passing from behind the piston from cylinder 16, into duct 54, and up to the flip-chamber 68, and that said valve is moved forwardly or down also by live air which latter live air acts upon the rear or upper shoulder 62 and is derived from the passages 33-43 and 42, so that both movements of the valve are effected by live air pressure.

Having described my invention, what I claim is,—

1. In a pneumatic tool having a piston with a stroke greater than its own length, a valve to control the admission and the entire exhaust of fluid pressure to and from opposite ends of the piston, said valve having a central passage into which the piston enters, said valve also being provided with differential pressure areas, and means for subjecting the said differential pressure areas to live fluid pressure directed alternately from opposite directions whereby said valve will be moved in both directions by live fluid pressure.

2. In a pneumatic tool having a piston with a stroke greater than its own length, a valve-casing, a valve in said casing and having differential areas to control the admission and the entire exhaust of fluid-pressure to and from opposite ends of the piston,—said differential areas of the valve being alternately subjected to live fluid-pressure directed from opposing sides whereby the valve may be moved in both directions by live fluid-pressure.

3. In a pneumatic tool having a cylinder with a piston therein said piston having a stroke greater than its own length, a valve-casing, a valve in said casing having differential pressure surfaces said valve controlling the admission and the entire exhaust of fluid pressure to and from opposite ends of the piston, means for subjecting one of said surfaces to the action of live fluid-pressure while a relative reduction of pressure on another of said surfaces is provided, to move the valve in one direction by live pressure, and means for subjecting said other surface

of the valve to live fluid pressure whereby to move the valve in the other direction by live fluid pressure.

4. In a pneumatic tool having a piston with a stroke greater than its own length, a differential valve to control the admission of motive fluid to and the entire exhaust of said motive fluid from the opposite ends of the piston, said valve being moved in one direction by live motive fluid intermittently acting on the larger pressure area of the valve at one stroke of the piston, and moved in the opposite direction by live motive fluid intermittently acting upon the smaller pressure area of the valve on the other stroke of the piston.

5. In a pneumatic tool having a cylinder, a piston therein with a stroke greater than its own length, a valve to control the admission and the entire exhaust of motive fluid to and from the opposite ends of the piston, said valve being located at the rear end of the cylinder and in line therewith and means for intermittently directing live motive-fluid alternately to opposing surfaces of the valve and move the same in both directions by live motive fluid.

6. In a pneumatic tool the combination with a cylinder, of a piston in said cylinder said piston having a stroke greater than its own length, a valve-chamber at one end of the cylinder and having ports and passages therein for the passage of live air-pressure to and exhaust from the cylinder, and a valve in said chamber and moved automatically in both directions by alternately built-up live air-pressure on opposing faces of the valve before the piston completes its stroke said valve alone controlling the entire exhaust from the opposite ends of the cylinder.

7. In a pneumatic tool, the combination with a cylinder having a valve-chamber at one end thereof, of a piston in said cylinder having a stroke greater than its own length; a valve in said chamber to control the inlet and the entire exhaust of air—said valve having a central passage which is open at both ends thereof whereby the piston may move into said passage on its return stroke; means for moving said valve in one direction by built-up live air as the piston is making a forward stroke and means for moving said valve in a reverse direction by built-up live air as the piston is making a return stroke.

8. In a pneumatic tool, the combination with a cylinder, of a piston in said cylinder having a stroke greater than its own length; means at the end of the cylinder for forming a valve-chamber, said means having ports and passages therein for the inlet and exhaust of fluid pressure, and having a passage that is constantly open to a live air-supply, said live-air passage having one end opening

into the cylinder and also having an opening into the valve-chamber, and a valve in said valve-chamber, said valve being moved in one direction by live air that is built up in said live air-passage while the cylinder-end of said passage is closed by the piston and being moved in a reverse direction also by live air said valve alone controlling the entire exhaust from the opposite ends of the cylinder.

9. In a pneumatic tool, the combination with a cylinder, of a piston in said cylinder having a stroke greater than its own length; a valve-bushing at one end of the cylinder and having a valve-chamber therein, said bushing having a live air passage that extends from the valve-chamber, communicates with the cylinder and is closable by the piston on the return stroke of the latter; means for feeding live air to said passage while the latter is closed by the piston, and a valve in said valve-chamber movable in one direction by the live air from said passage and movable in a reverse direction also by live air said valve alone controlling the entire exhaust from the opposite ends of the cylinder.

10. In a pneumatic tool, the combination with a cylinder, of a piston in said cylinder having a stroke greater than its own length; a valve-bushing at one end of the cylinder with a chamber therein and having a live air-passage extending from said chamber and in communication with the cylinder,—the cylinder-end of said passage being closable by the piston; a valve in said bushing-chamber having pressure surfaces of unequal areas, said valve alone controlling the entire exhaust from the opposite ends of the cylinders; means for feeding live air to said live air-passage to act on the pressure surface of the valve having the smaller area to move the valve in one direction by live air, and means for subjecting the larger pressure surface of the valve also to live air to move the valve in a reverse direction.

11. In a pneumatic tool having a cylinder with a piston therein which has a stroke greater than its own length, a valve bushing at one end of the cylinder; a valve in said bushing with opposing pressure surfaces of unequal areas, said valve controlling the entire exhaust from both ends of the piston, said cylinder and valve bushing having passages extending from the cylinder chamber to the said opposing pressure surfaces of the valve, whereby the piston will serve as a valve for said passages.

12. In a pneumatic tool having a cylinder with a piston therein that has a stroke greater than its own length, a valve bushing, a valve in said bushing and having opposing pressure surfaces of unequal areas, said bushing being provided with a passage that extends from the pressure side of one valve-surface and opens into the cylinder

and a second passage that extends from the pressure side of the other valve-surface and opens into the cylinder in a plane above the first-named passage-opening whereby the piston may control the inlet of pressure to and exhaust of pressure from the lower passage opening and may also close the upper passage-opening on its rear stroke.

13. In a pneumatic tool the combination with a cylinder, of a piston in said cylinder said piston having a stroke greater than its own length; a valve bushing at one end of the cylinder; a fluid pressure supply a valve in said bushing controlling the entire exhaust of fluid pressure from opposite ends of the piston, said valve having opposing pressure-surfaces of unequal areas; a passage which is always open to the fluid-pressure supply, said passage having an outlet adjacent one of the pressure-surfaces of the valve and another outlet into the cylinder, and a second passage from the cylinder beyond the outlet of the first-named passage, said second passage leading to and delivering fluid pressure adjacent to another of the valve pressure-surfaces whereby the latter or second passage may communicate with the cylinder at either the upper or lower sides of the piston while the first-named passage may be cut off from the cylinder by the piston to shift the valve from one position to another.

14. In a pneumatic tool the combination with a cylinder, of a piston in said cylinder said piston having a stroke greater than its own length; a valve at one end of the cylinder and having pressure surfaces of unequal area, said tool having a passage that extends from the valve-surface of the greater area to a point in the cylinder where it may be exposed either above or below the piston according to the position of the latter in the cylinder and said tool having a second passage that extends from a valve-surface of the lesser area to a point in the cylinder nearer the valve than the first named passage-opening said second passage being closable by the piston while live fluid-pressure builds up therein sufficiently to act upon the lesser area of the valve-surface and shift the valve.

15. In a pneumatic tool the combination with a cylinder, of a piston in said cylinder said piston having a stroke greater than its own length; a valve-box at one end of said cylinder and provided with exhaust passages; a valve movable in the box to open and close said exhaust passages and to control the passage of motive fluid to the opposite ends of the cylinder,—said valve having a plurality of pressure-surfaces; a passage that extends from one pressure-surface of the valve to a point in the cylinder where it may be exposed either above or below the piston according to the position of the pis-

ton in the cylinder and a second passage extending from another pressure-surface of the valve to a point in the cylinder between the first-named passage-opening and the
5 said exhaust passages said second passage being closable at the cylinder opening by the piston as the latter nears the end of its

stroke toward the valve whereby to permit live air-pressure to build up in said second passage sufficiently to shift the valve.

In testimony whereof, I affix my signature.

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JOHN R. L. SANTOS.