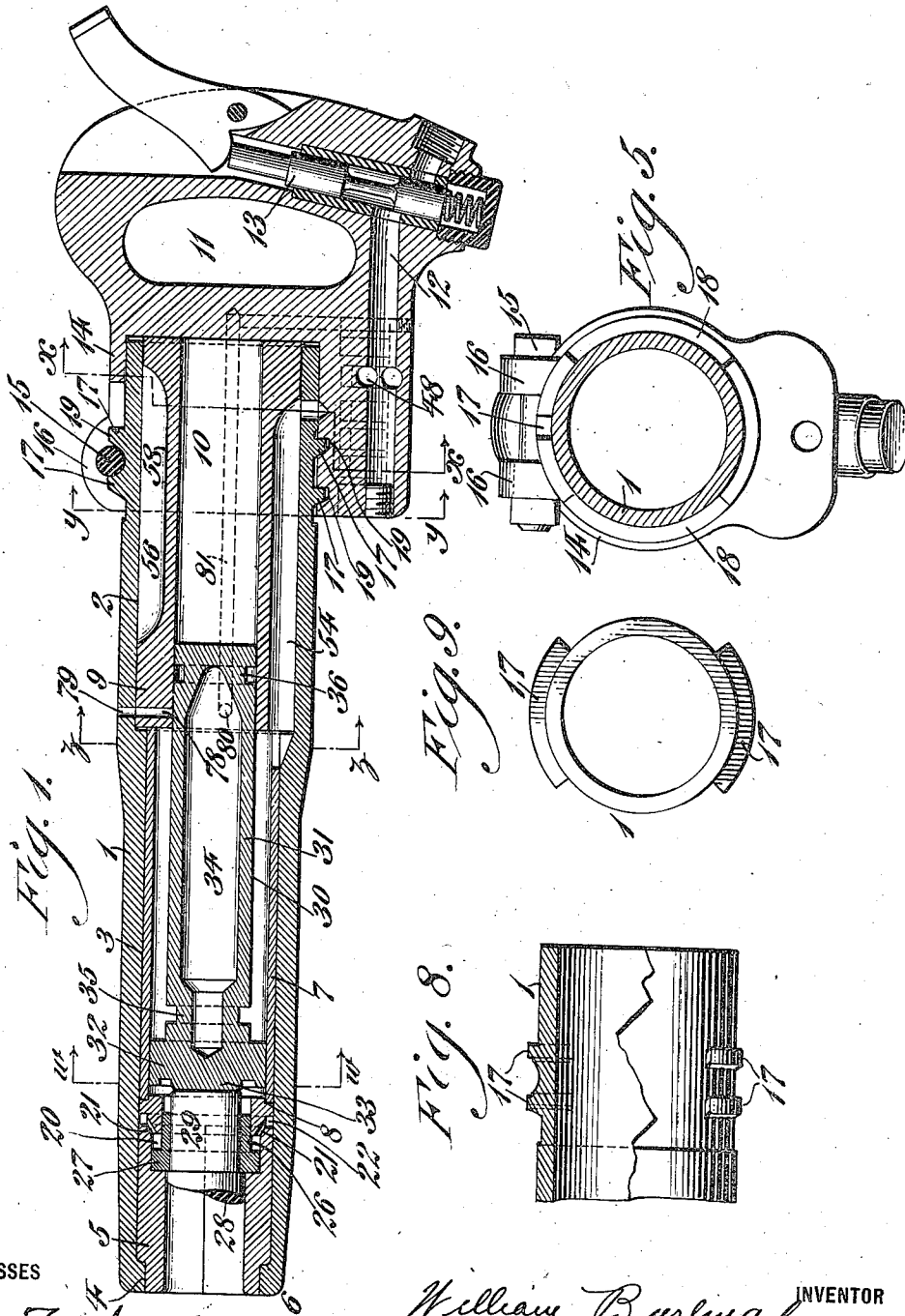


W. BURLINGHAM.
PNEUMATIC IMPACT TOOL.
APPLICATION FILED AUG. 1, 1914.

1,306,300.

Patented June 10, 1919.
4 SHEETS—SHEET 1.



WITNESSES

P. F. Nagle.
L. Douville.

William Burlingham. INVENTOR
BY Niedersheim & Spangenberg
ATTORNEYS

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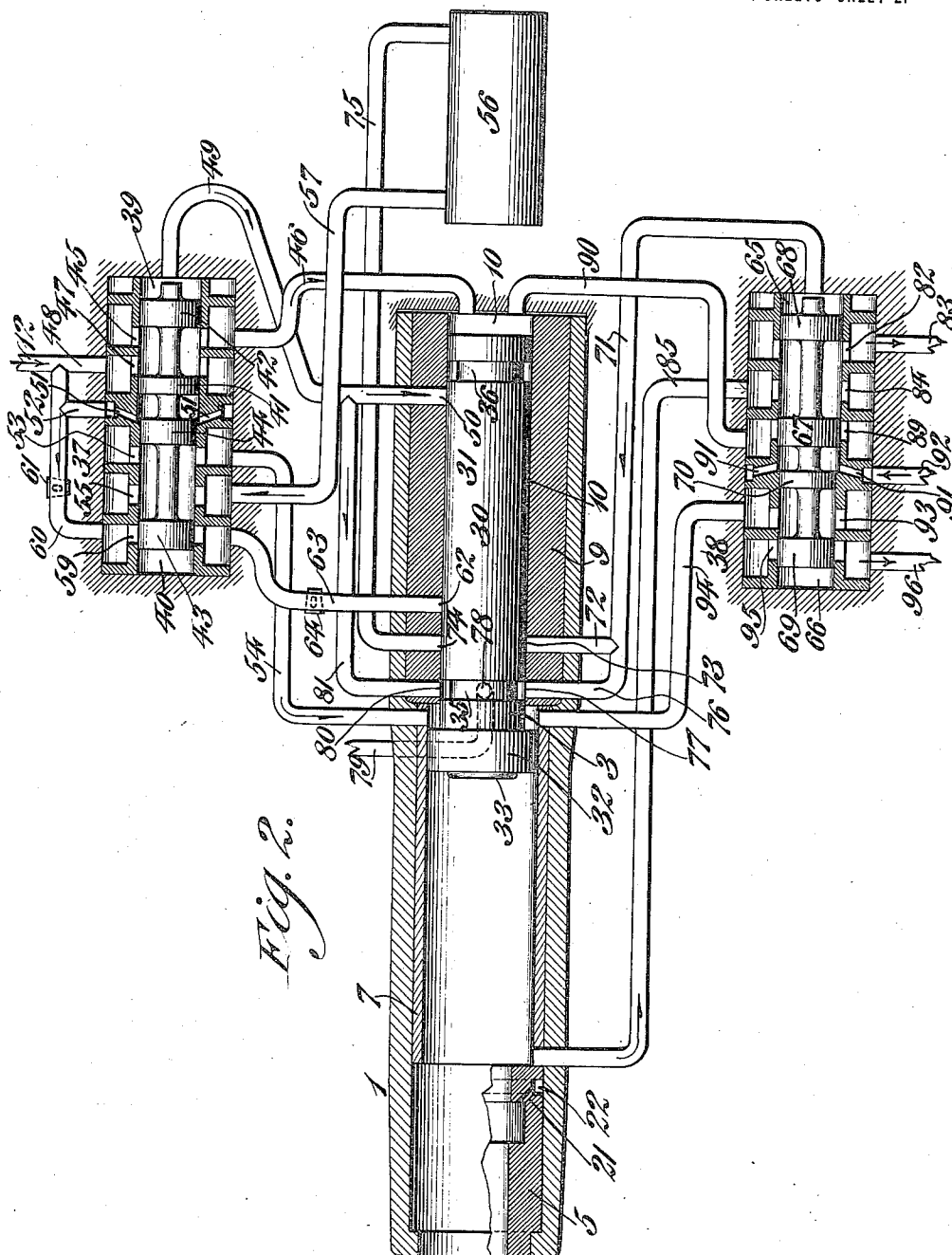


Fig. 2.

WITNESSES

L. Bouville,
P. F. Nagle.

INVENTOR

William Burlingham.
BY *Niedersheim & Gauberts.*

ATTORNEYS

1,306,300.

4 SHEETS—SHEET 3.



L. Douville,
P. F. Nagle

133
INVENTOR
BY William Burlingham.
Wiedersheim Gain Banks.

ATTORNEYS

1,306,300.

Patented June 10, 1919.
4 SHEETS—SHEET 4.

Fig. 10.

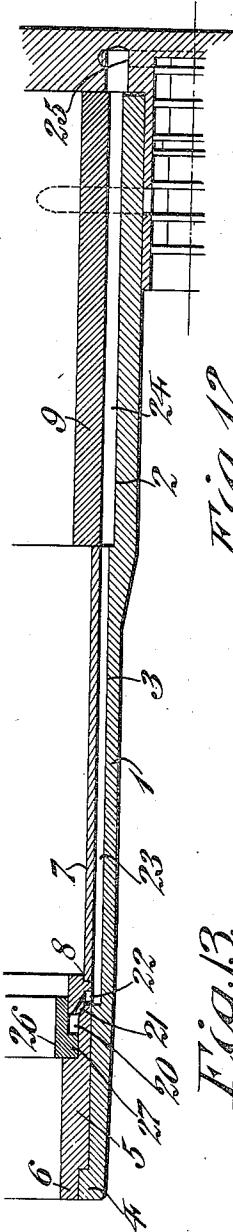


Fig. 12.

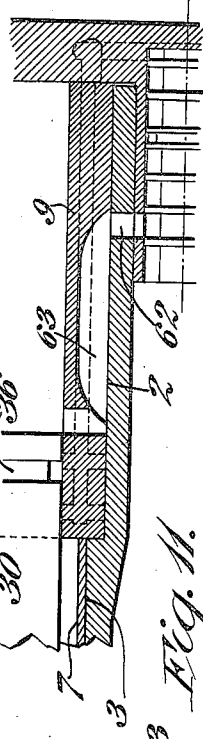
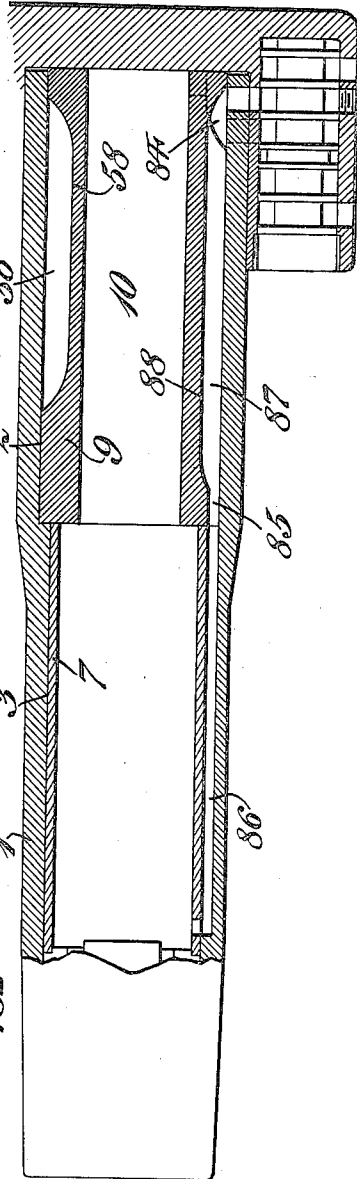


Fig. 11.



UNITED STATES PATENT OFFICE.

WILLIAM BURLINGHAM, OF NEWPORT NEWS, VIRGINIA, ASSIGNOR, BY DIRECT AND MESNE ASSIGNMENTS, TO ENGINEERING PRODUCTS CORPORATION, OF NEWPORT NEWS, VIRGINIA, A CORPORATION OF VIRGINIA.

PNEUMATIC IMPACT-TOOL.

1,306,300.

Specification of Letters Patent.

Patented June 10, 1919.

Application filed August 1, 1914. Serial No. 854,478.

To all whom it may concern:

Be it known that I, WILLIAM BURLINGHAM, a citizen of the United States, residing at Newport News, county of Warwick, State of Virginia, have invented a new and useful Pneumatic Impact-Tool, of which the following is a specification.

In large industrial plants, such as ship-yards, boiler-works, stone dressing plants and the like, where large numbers of pneumatic hammers for riveting, chipping, calking and kindred uses are constantly employed, the problem of economically furnishing, keeping up or increasing the compressed air equipment for the operation of said tools has become an important economical item in shop management, and the primary object, therefore, of my invention is to provide a novel construction of pneumatic hammer, having a novel fluid distribution system therein, whereby the cost of maintenance of the compressed air equipment is greatly reduced, and wherein the greatest possible efficiency can be attained with the greatest economy in the volume of the motive fluid consumed. Formerly, when comparatively few pneumatic implements were used in large plants, as even now in smaller establishments where but a small number of such tools are used, the question of the quantity of the cubic volume of air used was given but little consideration, as an air compressing plant supplying a sufficient amount of air under a given pressure could usually be erected at a reasonable outlay, and without occupying an excessive area. Usually, the quantity of air consumed by the pneumatic hammering tools was more or less ignored, so long as the results in power of the tools was attained.

At the present time, however, in large industrial plants, where pneumatic tools and other pneumatic appliances are extensively used, the size and initial expense of the air compressors and the space occupied by them, as well as the power and fuel required for their daily operation and the incident cost of their installation, operation and maintenance, have assumed proportions of such magnitude as to require careful attention, and have become of sufficient importance to require the careful consideration

of remedies to reduce unnecessary expense in this connection, and it is with the object of obtaining much greater efficiency from a given volume of air at a given pressure, as well as greater power, in a pneumatic impact tool for riveting, chipping or analagous uses, that my novel tool is designed.

In its broad aspects, my present invention consists in the employment of certain of the broad generic features of my Patent No. 1,123,678, granted January 5th, 1915, to which I have added in the present case, novel means for enabling the hammering piston or plunger to be operated on its downward or outward stroke by the direct action upon both its piston areas of live air, the control of the distribution system of said live air or other motive fluid being effected by a novel valve mechanism to be hereinafter referred to.

My invention further consists of a novel construction of pneumatic impact tool provided with means for adapting such tool to either operate on the compound principle, utilizing air which has acted against a small-area piston to act upon another piston, or to operate by the direct action upon both pistons of the normal pressure live air.

It further consists of such a tool in which the return or up-stroke of the piston is actuated by the differential expansion action of the air which has driven the pistons down upon the differential area pistons.

It further consists of such a tool in which the longitudinal air-distributing channels are formed by grooves in the surfaces of telescoped or interfitted cylindrical parts of the working barrel, whereby drilling of such channels and plugging of the ends of drilled holes is avoided.

It further consists of means in such a hammer for cushioning the recoil of the tool by a permanent air-cushion.

It further consists of other novel features of construction, all as will be hereinafter fully set forth.

For the purpose of illustrating my invention, I have shown in the accompanying drawings, one form thereof which is at present preferred by me, since the same will give in practice satisfactory and reliable results, although it is to be understood

that the various instrumentalities of which my invention consists can be variously arranged and organized and that my invention is not limited to the precise arrangement and organization of these instrumentalities as herein shown and described.

In said annexed drawings—

Figure 1 represents an axial or longitudinal section of a pneumatic hammer embodying my invention.

Fig. 2 represents a diagrammatical view of the hammer illustrating the arrangement and connections of the cylinders, plunger, valves and conduits of the tool, the plunger being illustrated at the extreme of its up-stroke.

Fig. 3 represents a similar diagram with the plunger at the extreme of its down-stroke.

Fig. 4 represents a transverse section on the line $x-x$ in Fig. 1.

Fig. 5 represents a transverse section on the line $y-y$ in Fig. 1, with the barrel-block removed.

Fig. 6 represents a transverse section on the line $z-z$ in Fig. 1.

Fig. 7 represents a transverse section on the line $w-w$ in Fig. 1.

Fig. 8 represents a detail view, partly in section and broken away, of the upper portion of the hammer barrel.

Fig. 9 represents an end-view of the cylinder jacket or casing.

Fig. 10 represents a section of as much of the barrel as will illustrate the channel in the same for the tool cushioning device.

Fig. 11 represents an axial section of the barrel illustrating the channel conveying air to the lower end of the plunger cylinder.

Fig. 12 represents a sectional detail view of as much of the working barrel as will illustrate the channel for conveying air from the small-diameter cylinder to the receiver.

Fig. 13 represents an axial section of the lower end of the working cylinder illustrating a form of cushioning device for the working tool.

Similar numerals of reference indicate corresponding parts in the figures.

Referring to the drawings, 1 designates a cylinder-jacket or casing, formed with a large-diameter axial bore, 2, in its upper portion, and an axial bore, 3, of smaller diameter having an inwardly projecting annular flange, 4, at its lower end. A split tool-socket, 5, having a reduced end, 6, at its end, fits in the lower end of the smaller bore of the jacket with such reduced end projecting through the flanged opening and the shoulder of such reduced end bearing against said flange 4. A lining-sleeve, 7, fits in the small diameter bore thereby forming the larger or low pressure cylinder and has its lower end bearing in an annular rabbet, 8,

in the upper end of the tool-socket, and extends the full length of said bore. A barrel-block 9, having an axial bore, 10, forming the smaller or high pressure cylinder is fitted in the large diameter bore of the cylinder-jacket and bears against the upper end of the lining-sleeve, the above socket, sleeve and block being inserted at the upper end of the jacket in the order in which they are above described. The interior axial bore of the barrel block is of a smaller diameter than that of the lining-sleeve, thereby forming the high pressure cylinder, as stated.

A handle, 11, formed with an inlet passage, 12, to which the motive fluid supply can be connected, and controlled by a throttle-valve, 13, has a longitudinally slit socket, 14, into which the upper end of the cylinder-jacket fits and which can be clamped upon said jacket by a nutted clamping bolt, 15, passing through perforated ears, 16, at the sides of the slit in the socket. The jacket has preferably two diametrically opposite pairs of threads or peripheral flanges, 17, which can enter longitudinal recesses, 18, in the socket and by turning the socket and jacket, one in its relation to the other, can engage grooves, 19, in the interior of the socket, by means of which provisions the jacket and socket are locked against longitudinal movement.

The split tool-socket is formed near the upper end of its bore with an annular recess, 20, which communicates by oblique holes, 21, with an external peripheral groove, 22, into which opens an air passage formed by a longitudinal groove, 23, in the small-diameter bore of the jacket and the lining-sleeve communicating with a longitudinal groove, 24, in the barrel-block and connected to a passage, 25, permanently communicating with the live-air supply, by means of which a constant air supply is provided to form an air-cushion in the annular recess in the tool-socket. A sleeve, 26, having an annular piston-flange, 27, is slidable in the upper end of the tool-socket with its piston-flange within the recess, and the shank, 28, of the working tool, which may be a rivet-set, a chisel, a calking-tool or any other form of tool, as required, is formed with a reduced inner end, 29, fitting in the sleeve and has its shoulder bearing against the end of the sleeve, so that the rebound of the tool will act through the flange of the sleeve against the air-cushion in the recess of the tool-socket and the recoil will thus be cushioned and absorbed.

A differential plunger, 30, preferably hollow, is reciprocable in the bores of the barrel-block and lining-sleeve, and consists of a cylindrical piston, 31, fitting to slide in the smaller diameter bore of the barrel-block, and a short piston, 32, at the lower end of said long piston and fitted to slide

in the larger diameter bore of the lining-sleeve. The lower face of the large piston has a striking projection, 33, which in the operation of the tool strikes the inner end of the tool-shank. The long differential piston 30 is preferably hollow as indicated at 34, throughout its length, which serves to decrease the weight of the plunger. Peripheral grooves, 35 and 36, are formed in the long piston near its end, to form distributing channels at the proper intervals for the motive fluid.

The handle-socket is formed with two cylindrical valve-chambers, 37 and 38, preferably parallel with the axis of the tool-barrel and preferably upon the under side of the socket and at opposite sides of the inlet-passage. As will be understood from Fig. 4, the valve-chamber 37 has a larger diameter bore, 39, and a smaller diameter bore, 40, and a spool-valve having two larger-diameter valve-disks, 41 and 42, and two smaller diameter valve-disks, 43 and 44, is movable in said valve-chamber. The larger diameter bore has a port, 45, which communicates with the upper end of the upper smaller-diameter bore of the plunger-cylinder by a passage, 46, and an inlet-port, 47, communicating with the live-air supply by a passage, 48, to have the valve-disks 41 and 42 connect said ports when the valve is in its upper position. The upper end of the valve-chamber communicates by a passage, 49, with the smaller-diameter bore of the plunger-cylinder through a port, 50, in the same and at a distance from the upper end to be uncovered by the piston when the same approaches about one-half of its down-stroke. A port, 51, at the lower end of the large-diameter valve-chamber is in constant communication with the live-air supply through a passage, 52. The small-diameter valve-chamber has a port, 53, communicating with the upper end of the larger-diameter bore of the plunger cylinder by a passage, 54, and said valve-chamber has a port, 55, adjacent said former port to be connected with the same by the space between the small-diameter valve-disks when the valve is moved upward, and connected to an air-receiver, 56, by a passage, 57. Said receiver is preferably formed between the side of the large bore in the cylinder-jacket and a longitudinal recess, 58, in the side of the barrel-block. A port, 59, is formed at the lower end of the small-diameter valve chamber and communicates with the live-air inlet by a passage, 60, controlled by a valve-plug, 61, and with a port, 62, in the small-diameter plunger-bore which will be uncovered by the small piston of the same when the latter is at the lower end of its down-stroke, by a passage, 63, controlled by a valve-plug, 64.

The valve-chamber 38 has a large-diameter

chamber, 65, and a small-diameter chamber 66, and a valve having two large-diameter pistons, 67 and 68, and two small-diameter pistons, 69 and 70, is slidable in said valve-chamber. The upper end of the valve-chamber has a passage, 71, opening from it and having a branch-passage, 72, opening through a port, 73, in the small-diameter cylinder-bore at a point near the lower end of the same to register with the upper annular groove 36 in the small-diameter piston when the latter is at the lower extreme of its stroke. A port, 74, registers with said former port and communicates with the receiver through a passage, 75. The passage from the upper end of the last-described valve-chamber also communicates through a passage, 76, and port, 77, with the lower end of the small diameter piston-bore, at a point where it will register with the lower annular groove 35 in the small-diameter piston when the latter is at the extreme of its up-stroke. A port, 78, in the bore registers with said first-mentioned port and communicates with the atmosphere through a passage, 79, and another port, 80, in the bore registers with said two ports and communicates through a branch-passage, 81, with the passage 49 from the upper end of the first described valve-chamber, so that the upper ends of the two valve-chambers can be simultaneously put in exhaust-communication with the atmosphere when the plunger arrives at the extreme of its up-stroke. A port, 82, near the upper end of the large-diameter valve-chamber communicates with the atmosphere through an exhaust-passage, 83. A port, 84, in the large-diameter valve-chamber is connected by a passage, 85, to the lower end of the large-diameter piston-bore, and the longitudinal portion of said passage is formed by a groove, 86, in the small interior bore of the jacket and the lining-sleeve, and a longitudinal groove, 87, in the large-diameter bore of the jacket and a groove, 88 in the barrel-block. A port, 89, in the large diameter valve-chamber communicates through a passage 90, with the upper end of the small-diameter piston-chamber. A port, 91, at the lower end of the large-diameter valve-chamber has permanent and direct communication with the live-air supply inlet through a passage, 92, and thus admits live-air to act permanently against the facing valve-disks at the middle of the valve. An annular port, 93, is formed in the small-diameter valve-chamber and communicates by a passage, 94, with the upper end of the large-diameter piston-chamber, and an annular port, 95, in the lower portion of the small-diameter valve-chamber has permanent communication with the atmosphere by a passage, 96.

The form of cushioning device for the

working-tool illustrated in Fig. 13 is in several respects preferable to the form formerly described and illustrated. A sleeve, 100, is secured in the lower end of the barrel, bearing against the flange 4 of the latter, and said sleeve is held in place by the lining sleeve 7 and has an enlarged recess portion, 101, in its bore, the upper end of which communicates through oblique holes, 102, with an annular groove, 103, in the sleeve which receives live motive fluid through the channel 23, in the same manner as the annular groove heretofore described. A tool-socket, 104, within which the shank 28 of the working tool fits, fits to slide in the sleeve and has an annular piston, 105, which is slidable in the enlarged recess of the sleeve, and, live-air continually being admitted through the groove and oblique holes into the recess back of the annular piston, the recoil of the rebounding tool will be largely absorbed by the air-cushion thus produced. The sleeve and tool-socket can be easily slipped from above into the cylinder and held in place by the lining sleeve and the other elements above the same.

The present form of pneumatic hammer is constructed in such a manner that it can either be operated by live-air acting against the face of the small-diameter piston and low-pressure air acting against the piston in the large-diameter piston-cylinder on the down-stroke of the plunger, or live air can be admitted to both pistons on the down-stroke, in which latter case the saving of volume of air consumed is not as great as when the hammer is used on the compound principle, but greater power of blow is attained.

When operating the hammer in the first-mentioned manner, employing the low-pressure motive fluid from the air-receiver to act downward against the large-diameter piston, the motive fluid is admitted through the inlet passage and, the valve in the first valve-chamber 37 being in its upper position, will flow between the two large-diameter valve-pistons into the upper end of the small-diameter or high-pressure cylinder through the passage 46, forcing the plunger downward to deliver its blow on the working tool. Whatever air is in the lower portion of the large diameter or low-pressure cylinder is forced out by the large piston, through the passage 85 to the port 84 in the large-diameter bore of the valve-chamber 38 or low-pressure valve-chamber, whence it exhausts through the exhaust-port 82 connected to said port 84 by the large pistons of the low-pressure valve which is also in its upper position. When the small-diameter piston in its down-stroke uncovers the port 50 in its cylinder, the live-air passes through said port and its passage to the upper end of the high-pressure valve-chamber and forces it

down to the position shown in Fig. 3, cutting off the live-air supply above the piston. The small-diameter piston, having gone down to the extreme of its down-stroke, has uncovered the port 62 and the expanding live-air passes through said port, through the passage 63 to the small-diameter bore of the high-pressure valve-chamber, where the small-diameter valve-pistons 43 and 44, being now in their down positions, connect the port 62 and passage 63 with the port 55 of the passage 57, and conduct the expanding air to the receiver 56. As the plunger is in its down-position, the upper annular distributing groove 36 of the small-diameter piston connects the passage 75 and port 74 from the receiver with the port 73 and passages 72 and 71 to the upper end of the low-pressure valve-chamber, so that the air from the receiver forces the low-pressure valve down. This causes the expanding air above the small-diameter piston to flow through the passage 90 to the large-diameter bore of the low-pressure valve-chamber, where the large pistons 67 and 68 connect the port 89 of said passage with the port 84 and passage 85, carrying the expanding air from the small-diameter piston cylinder to the lower end of the large-diameter piston cylinder where, acting against the large-diameter piston-area 32, it forces the plunger upward. While the plunger is in its down-position, the expanding air will also pass through the uncovered port 62, passage 63, ports 59 and 55 and passage 57 to the air-receiver. As the plunger ascends by the differential action of the expanding air, the air above the large diameter piston passes out through the passage 94 to the port 93 in the small-diameter bore of the low-pressure valve-chamber and, the small-diameter valve-pistons connecting said port with the exhaust port 95 and exhaust-passage 96, the air will exhaust to the atmosphere. When the plunger arrives on its up-stroke to the point where the lower annular distributing-port 35 in the small-diameter piston connects the ports 77 and 80 from the upper ends of the two-valve-chambers with the exhaust-port 78, the air above the valves in such chambers is exhausted, and the live-air which is constantly admitted through the restricted ports 51 and 91 in the valve-chambers will exert differential pressure against the larger and smaller areas of the two middle pistons of each of the valves and, the pressure against the larger pistons prevailing, will move both of said valves upward, again repeating the operation. As now the low-pressure or partly expanded air is stored in the receiver, such air passes through the passage 57, ports 55 and 53 and passage 54, which are connected by the small-diameter valve-pistons 43 and 44 in their upper positions, as in Fig. 2, into the upper end of the large-diameter

piston-cylinder, driving the plunger downward at the same time live-air acts in the upper end of the small-diameter piston-cylinder and drives the plunger down by direct pressure. The air below the large-diameter piston freely exhausts through the passage 85 and ports 84 and 82 in the upper portion of the low-pressure valve-chamber 38, to the atmosphere, admitting of the plunger delivering an unobstructed blow.

From the above it will appear that high-pressure air and low-pressure air simultaneously cooperate to augment the operative down-stroke of the plunger, that low-pressure air, only, is employed to return the plunger, and that the valves are actuated in one direction by low-pressure air and in the opposite direction by constant live-air pressure without exhaust, and that the only exhaust is of low-pressure air which has performed its functions, directly and expansively. After the high-pressure air has forced the piston down to deliver the blow, a part of the expanding air is directly employed to return the piston and a part is stored away in the receiver to be employed to act against the low-pressure piston of the plunger in the driving stroke of the latter and to actuate the valves. No air is exhausted excepting the low-pressure air which has been used in the low-pressure cylinder and in the valve-chamber, so that high efficiency is attained by using the air at its original pressure and thereupon again by compound use of the expanded low-pressure air exhausted from the high-pressure cylinder.

When it is desired to employ live-air directly to drive the plunger downward by acting on both the small and large diameter pistons, the valve plug 61 in the live-air duct 60 is opened and the plug 64 in the duct 63 is closed, so that when the live-air valve in the chamber 37 is down, live-air will pass through the passage 60, ports 59 and 55 and passage 57 to the receiver which in this case contains live-air at the working pressure. When the valve is shifted into its upper position, the live-air is directly admitted to the small-diameter plunger-piston and from the receiver to the large-diameter piston, so that the actuating stroke is made with live-air on both pistons. The operation of the tool is otherwise the same as that above described, excepting that the receiver contains live-air instead of partly expanded air.

By making the tool with grooves in the cylinder jacket and in the barrel-block and covering such grooves by the lining sleeve and by fitting the grooved barrel-block in the jacket, and thus forming the longitudinal passages, all drilling of such passages will be avoided with the expense and time

required, as the grooves and channels can be cut in less time and at less expense than the passages can be drilled. Plugging of the ends of such drilled passages with the expense and time involved is also avoided. The jacket or casing can be made from milder and less expensive metal than a solid barrel with drilled channels, and the lining-sleeve and barrel-block, only, need be of hard and wear resisting metal. In assembling the tool, the tool-socket and the recoil-absorbing sleeve is first placed in the jacket from the upper end of the latter, the lining-sleeve is then inserted, whereupon the plunger is placed with its piston in the bore of the barrel-block and said elements inserted and locked in place by the handle-socket. The plunger is thus locked within the barrel of the hammer and cannot be tampered with by the operator, as is frequently done in hammers of the constructions now in use. In the case of injury to a part of the tool or said part wearing out, such part or parts may be removed and replaced without completely removing and replacing an entire barrel, for instance, whereby considerable expense of repairs can be avoided.

As the working plunger is returned by the expanded live-air acting against differential piston-areas, the back-stroke or up-stroke of such plunger is cushioned, and shock of the tool from recoil reduced, easing the hold of the tool to the work.

By providing the constant live-air cushion for absorbing the recoil of the tool, the tool will work with a minimum of recoil, notwithstanding the great power imparted by the double action of the motive fluid acting against two pistons.

For ordinary work the hammer can be operated by partly normal-pressure live-air and partly air expanded after direct action, and a large saving of the volume of air consumed can be attained, and whenever strength of blow is of more importance than economy of air, the hammer can be converted from the compound principle to operate on the direct double action principle, by simply turning the two valve-plugs. The same tool can thus be employed for light work, such as chipping and calking and for light riveting, and be adjusted to heavy work, such as heavy riveting, whereby the cost of installation of tools in a shop or yard can be considerably reduced from the cost of installing separate light and heavy tools. Owing to the construction of the tool with the motive fluid acting upon differential area pistons, the tool can be made comparatively short in proportion to its power. In either form the live-air acting against the small-diameter plunger-piston is not exhausted, but is used to actuate the plunger in its up-stroke, and in the second disclosed

form of operating the hammer, the expanded air from the back of the large-diameter plunger-piston, only, is directly exhausted, so that economy of volume of air when the tool is operated with double direct action, is partly attained.

While my present invention is particularly adapted to smaller or medium sized pneumatic hammers which are adapted to be manually held in the hand of the user, it is obvious that the broad principles of the same may be employed in larger tools or implements or in other fluid distribution systems wherein it may or may not be desirable to employ in the same structure either the compound principle, or, in other words, live air acting against the face of the small diameter piston, and low pressure air acting against the piston in the large diameter piston cylinder on the downward or outer stroke of the plunger, or live air can be admitted to both pistons on the downward or outer stroke upon the proper manipulation or adjustment of the valve mechanism.

It will also be apparent that while I have shown my invention as applicable to that type of pneumatic hammer wherein the forward end of the barrel, cylinder jacket, casing or piston cylinder is open for the reception of the shank of the working tool, and wherein a grasping handle is employed to hold the tool up to its work, said invention is equally applicable to other types of tool and to tools wherein said grasping handle may be dispensed with, and the tool held up to its work by mechanical devices or the like.

Other modes of applying the principle of my invention may be employed for the mode herein explained. Change may therefore be made as regards the mechanism thus disclosed, provided the principles of construction set forth, respectively, in the following claims are employed.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:—

1. In a pneumatic impact tool, a cylinder, a hammering plunger therein, a valve mechanism, a receiver, means for operating said plunger and valve-mechanism by the pressure of the expanded air in said receiver, controlled means for admitting live-air to said receiver, and means for cutting out the flow of expanded air to said receiver so as to enable live-air to be admitted at will to said plunger.

2. In a pneumatic impact tool, a piston cylinder having differential piston chambers, a plunger having differential area pistons, a valve-mechanism, a receiver, means for operating said plunger and valve mechanism by the pressure of expanded air in said receiver, means for cutting off expanded air and admitting live air to said receiver, and

means for enabling live air to be simultaneously admitted at will to said pistons.

3. In a pneumatic hammer, a piston cylinder having differential piston chambers, a plunger having differential area pistons and slidable in said chambers, means for simultaneously admitting live motive fluid to said pistons, and means for controlling the passage of live air or expanded air to the large diameter piston chamber.

4. In a pneumatic hammer, a piston cylinder having differential piston chambers, said cylinder having its forward end open for the insertion of the shank of the working tool, a plunger having differential area pistons slidable in said chambers, means for simultaneously admitting live motive fluid to said pistons to impel the latter toward said working tool, and means for controlling the passage of live air or expanded air to the large diameter piston chamber.

5. In a pneumatic hammer, a piston cylinder having a large diameter and a small diameter piston chamber, a plunger having a large diameter and a small diameter piston respectively reciprocal in said piston chambers, means for admitting live motive fluid to the corresponding faces of said pistons, and means for controlling the passage of live air or expanded air to the large diameter piston chamber.

6. In a pneumatic impact tool, a piston cylinder having differential piston chambers, a receiver, a plunger having differential area pistons slidable in said chambers, connections from said receiver to said chambers, means for simultaneously admitting live motive fluid to one side of each of said pistons, and means for conveying expanding motive fluid from the small diameter piston chamber to the opposite face of the piston in the large-diameter chamber.

7. In a pneumatic hammer, riveter or chipper, a small diameter piston-cylinder, a large diameter piston-cylinder, a plunger having a small and a large diameter piston respectively reciprocal in said cylinders, means for simultaneously admitting live motive fluid into the upper ends of said cylinders, means for intermittently connecting the small-diameter piston-cylinder with the large-diameter piston-cylinder to enable the motive fluid to act differentially upon the faces of said pistons, and means for controlling the admission of live air or expanded air from said small diameter piston chamber to said large diameter piston chamber.

8. In a pneumatic impact tool, a piston-cylinder having differential piston chambers, a plunger having differential area pistons slidable in said chambers, means for simultaneously admitting live motive fluid to one side of each of said pistons, a receiver having controlled means for connecting it

to receive expanded air from the small diameter piston-chamber, and means for connecting said receiver and the large-diameter piston-chamber.

5 9. In a pneumatic impact tool, a piston-cylinder having differential piston-chambers, a plunger having differential area pistons slidable in said chambers, and means for controlling the admission of live-air or
10 expanded air from the small-diameter piston-chamber to the large-diameter piston chamber.

10 10. In a pneumatic impact tool, a piston-cylinder having differential piston-chambers, a plunger having differential area pistons slidable in said chambers, a receiver, means for controllably connecting said receiver to live motive-fluid supply or to the small-diameter piston-chamber to receive expanded motive fluid therefrom, and means for intermittently admitting motive fluid from said receiver to the large-diameter piston-chamber.

25 11. In a pneumatic hammer, riveter or chipper, a series of cylinders of different diameters, pistons of different diameters in said cylinders, means for utilizing the energy left in the expanded air after it has been used, means for controlling said means, means for admitting live motive fluid to said cylinders, means for controlling the supply of motive fluid to such admission-means, and means for controlling the admission of live air or expanded air from the small diameter piston chamber to the large
35 diameter piston chamber.

12. In a compound pneumatic impact tool, a small-diameter and a large-diameter cylinder portion, a plunger having a small-diameter and a large-diameter piston respectively reciprocable in said cylinder-portions, a receiver, a high pressure inlet controlling valve, said small-diameter cylinder-portion having a passage near its lower end connected at intervals to said receiver by said valve, means for controlling said passage, means for admitting live motive fluid to said receiver, and means for controlling such admission.

50 13. In a compound pneumatic impact tool, a plurality of working cylinder-portions of different diameters, a working plunger having pistons of different diameters reciprocable in said cylinder-portions, means for admitting motive-fluid to a small-diameter cylinder-portion, a receiver, means for admitting expanded motive-fluid from said small-diameter cylinder-portion to such receiver, means for controlling such admitting means, means for admitting live motive fluid to said receiver, means for controlling said latter means, and means for admitting motive-fluid from said receiver to a large-diameter piston.

5 14. In a pneumatic impact tool, a piston-

cylinder having differential piston-chambers, a plunger having differential area pistons slidable in said chambers, means for controllably admitting live air or expanded air from the small-diameter piston-chamber to the large-diameter piston-chamber, and controlled means for conveying expanded fluid from the small-diameter piston-chamber to the end of the large-diameter piston chamber.

15. In a pneumatic hammer, riveter or chipper, a piston-cylinder having a large-diameter and a small diameter piston-chamber, a plunger having a large-diameter and a small diameter piston respectively reciprocable in said piston-chambers, means for simultaneously admitting live motive fluid to the corresponding faces of said pistons, means for intermittently connecting the piston chambers to convey expanded fluid from the small-diameter piston-chamber to the lower end of the large-diameter piston chamber, and means for controlling the admission of live air or expanded air from the small diameter piston chamber to the large diameter piston chamber.

16. In a pneumatic impact tool, a cylindrical casing having an axial bore, a tubular member fitted in said bore and having its bore forming a piston-chamber, the fitting surface of said member being formed with a longitudinal groove closed on one side by the surface of the other member to form a longitudinal passage, and means for enabling said groove to serve as a receiver for a compound pneumatic tool.

17. In a pneumatic impact tool, a cylindrical casing having an axial bore, a tubular member fitted in said bore and having its bore forming a piston-chamber, the fitting surfaces of said member and casing respectively having longitudinal grooves and covering said grooves to form longitudinal passages, and means for enabling certain of said grooves to serve as the receiver of a compound pneumatic tool.

18. In a pneumatic impact tool, a cylindrical casing formed with axially aligned bores and with grooves in said bores, a lining-sleeve fitted in one bore to form a piston-chamber and closing the sides of the grooves in said bore to form passages, and a tubular member fitted in another bore and having an axial bore forming a piston-chamber and a recess in its exterior surface forming, together with the surrounding bore of the jacket, a receiver, and together with the grooves, passages in the assembled structure.

19. In a pneumatic impact tool, a cylindrical casing formed with axially aligned bores and longitudinal grooves in said bores, a lining sleeve in one of said bores and forming a piston-chamber, and a barrel-block fitted in a bore and having its axial bore

forming a piston-chamber and having longitudinal recesses and grooves in its side forming a receiver and passages.

20. In a pneumatic impact tool, a cylindrical casing formed with axially aligned bores and with grooves in said bores, a lining-sleeve fitted in one bore to form a piston-chamber and closing the sides of the grooves in said bore to form passages, a tubular member fitted in another bore having an axial bore forming a piston-chamber and a recess in its exterior surface forming, together with the surrounding bore of the jacket, a receiver, and together with the grooves, passages in the assembled structure, and a handle-socket secured to said casing to bear against the end of said tubular member.

21. In a pneumatic impact tool, a cylindrical casing formed with axially aligned bores and longitudinal grooves in said bores, a lining sleeve in one of said bores and forming a piston-chamber, a barrel-block fitted in a bore and having its axial bore forming a piston-chamber and having longitudinal recesses and grooves in its side forming a receiver and passages, and a handle-socket secured to said casing to bear against the end of said barrel-block.

22. In a pneumatic hammer, riveter or chipper, a piston-cylinder having differential piston-chambers, a plunger having differential area pistons slidable in said chambers, means for admitting live motive fluid to one of said piston-chambers, means for simultaneously admitting live motive fluid to the corresponding end of the other piston-chamber, means for controlling the live fluid supply to such admitting means, means for admitting expanded motive fluid from one cylinder to the other, means for controlling such admission, and means for controlling the admission of live air or expanded air from a small diameter piston chamber to a larger diameter piston chamber.

23. In a pneumatic impact tool, a working-cylinder formed with a small-diameter portion and a large-diameter portion, a hammering plunger having a small-diameter and a large-diameter piston respectively slidable in said cylinder portions, means for admitting motive fluid to said small-diameter cylinder-portion, a receiver, means for admitting expanded fluid from said small-diameter cylinder-portion to said receiver, means connected to cooperate with the motive fluid admitting means to simultaneously admit expanded fluid from said receiver back of the large-diameter piston, means for controlling such admitting means, and controlled means for admitting motive fluid to said receiver.

24. In a compound pneumatic hammer, a cylinder having a differential piston chamber forming high pressure and low pressure

cylinders, a plunger therein having high pressure and low pressure piston areas, a receiver, a high pressure inlet controlling valve mechanism, means controlled by the latter for simultaneously utilizing live motive fluid on the high pressure area of said plunger and expanded motive fluid from said receiver upon a larger area of said plunger to drive said plunger downwardly, means for controlling the expanded motive-fluid controlling means, and controlled means for admitting live motive fluid to said large area of the plunger.

25. In a compound pneumatic impact tool, a small-diameter and a large-diameter cylinder-portion, a plunger having a small diameter and a large-diameter piston respectively reciprocable in said cylinder-portions, means for intermittently admitting motive-fluid into said small-diameter cylinder-portion, a receiver, controlled means for conducting expanded fluid from said cylinder-portion to said receiver, controlled means for admitting live motive-fluid to said receiver, means connected to the motive-fluid admitting means to simultaneously admit fluid from the receiver to the large-diameter cylinder-portion back of the piston in the same, and means for connecting the opposite ends of the cylinder-portions to admit of expanded fluid differentially acting against the pistons.

26. In a pneumatic impact tool, a small-diameter and a large-diameter cylinder-portion, a plunger having a small-diameter and a large-diameter piston respectively reciprocable in said cylinder-portions, a receiver, a passage from near the lower end of said small-diameter cylinder-portion to said receiver, means for controlling said passage, means for intermittently admitting motive-fluid to the small-diameter cylinder-portion, a passage from said receiver to the upper end of the large-diameter cylinder-portion, controlled means for admitting live motive fluid to said receiver, and means cooperating with such motive fluid admitting means and controlling admission of fluid from said receiver through said passage to said cylinder-portion.

27. In a pneumatic impact tool, a small-diameter and a large-diameter cylinder-portion, a plunger having a small-diameter and a large-diameter piston respectively reciprocable in said cylinder-portions, means for intermittently admitting motive fluid into said small-diameter cylinder-portion, a receiver, a passage from near the end of said small-diameter cylinder-portion to said receiver, controlled means for opening and closing such passage, controlled means for admitting live motive fluid into said receiver, a passage connecting said receiver and the upper end of the large-diameter cylinder-portion, means for controlling said pas-

sage, an exhaust-passage from said upper end of said cylinder-portion, means for controlling said exhaust-passage, a passage connecting opposite ends of the cylinder-portions, and means for controlling such passage.

28. In a pneumatic hammer, a cylinder having its forward end open for the shank of the working tool and provided with a differential piston chamber, whereby high pressure and low pressure cylinders are formed, a receiver adapted to receive the exhaust from the high pressure cylinder and retain it for use when required in the low pressure cylinder, controlled means for opening and closing admittance of such exhaust, controlled means for admitting live motive fluid to said receiver, a high pressure inlet controlling valve, and a low pressure exhaust controlling valve.

29. In a pneumatic hammer, a handle portion having an extension thereon and provided with a high pressure piston chamber, a cylinder member detachably secured to said extension and provided with a low pressure piston chamber, a high pressure inlet controlling and a low pressure exhaust controlling valve in said extension, a receiver also carried by said extension, controlled means for connecting said receiver to the exhaust of the high-pressure piston chamber or the live motive-fluid supply, and a differential piston in said piston chambers controlled by said valves.

30. In a pneumatic hammer, a cylinder member open at its forward end to receive the shank of the working tool and bored to form a low pressure cylinder, a handle member having an extension thereon with a bore therein of less diameter forming the high pressure cylinder, whereby a differential piston chamber is formed, means for coupling said cylinder member and handle member together, a differential hammering plunger having piston areas of different diameters reciprocating in said low pressure cylinder and said high pressure cylinder respectively, a high pressure inlet controlling valve contained in the extension of said handle member, a low pressure exhaust controlling valve also contained in said extension, a receiver also contained in said extension, controlled means for admitting exhausted motive fluid from the small diameter cylinder or live motive fluid into said receiver, and ports and passages common to said valves, receiver and the differential piston chamber.

31. In a pneumatic hammer, a cylinder having its forward end open for the shank of the working tool and provided with a differential piston chamber, whereby high pressure and low pressure cylinders are formed, a receiver adapted to receive the exhaust from the high pressure cylinder and retain it for use when required in a low pressure

cylinder, controlled means for opening and closing admittance of such exhaust, controlled means for admitting live motive fluid to said receiver, a high pressure inlet controlling valve, a low pressure exhaust controlling valve, ports and passages common to said valves, receiver and piston chamber, and means for causing live air pressure to constantly act upon a portion of each of said valves to shift the same.

32. A pneumatic hammer, comprising a piston-cylinder having differential piston-chambers, a plunger having differential-area pistons and slidable in said chambers, means for simultaneously admitting live motive fluid behind said pistons, means for individually controlling admission of live motive fluid behind the large-diameter piston, means for admitting expanded motive fluid from the small diameter cylinder to the large-diameter piston cylinder behind the piston in the same, and means for individually controlling such expanded fluid.

33. In a pneumatic impact tool, a piston cylinder having differential piston chambers, a plunger therein having differential area pistons, and means for controlling the admission of live air or expanded air from the small diameter piston chamber to the large diameter piston chamber, said piston cylinder having its forward end open for the reception of the shank of the working tool.

34. In a pneumatic impact tool, a piston cylinder having its forward end open for the reception of the shank of the working tool and provided with differential piston chambers, a plunger therein having differential area pistons, means for controlling the admission of live air or expanded air from the small diameter piston chamber to the large diameter piston chamber, and a grasping handle secured to the rear end of said cylinder.

35. In a pneumatic impact tool, a piston cylinder having differential piston chambers, a plunger therein having differential area pistons, a receiver, and means for controlling the passage of live air or expanded air from said receiver to the large diameter piston chamber.

36. In a pneumatic impact tool, a piston cylinder having differential piston chambers, a plunger therein having differential area pistons, a receiver in said piston cylinder, and means for controlling the passage of live air or expanded air from said receiver to the large diameter piston chamber.

37. In a pneumatic impact tool, a piston cylinder having its forward end open for the reception of the shank of the working tool and provided with differential piston chambers, a plunger thereon having differential area pistons, a receiver located within said piston cylinder, and means for control-

ling the passage of live air or expanded air from said receiver to the large diameter piston chamber.

38. In a pneumatic impact tool, a piston 5 cylinder having differential piston chambers, a plunger in said cylinder having differential pistons, means for enabling either live motive fluid or expanded motive fluid to be simultaneously admitted to one side of 10 said pistons, and means for controlling the exhaust from said pistons.

39. In a pneumatic impact tool, a piston cylinder, a plunger in said cylinder having 15 differential pistons, valve controlled means for enabling live motive fluid to be simultaneously admitted to one side or both of said pistons, and other valve controlled connections for enabling live motive fluid and 20 expanded low pressure fluid to be admitted at will to said side of said pistons.

40. In a pneumatic impact tool, a piston cylinder having differential piston chambers, a plunger in said cylinder having differential 25 pistons, a receiver, and means for enabling either live motive fluid or expanded motive fluid to be admitted through the medium of said receiver to one side of said pistons to drive said plunger outwardly.

41. In a pneumatic impact tool, a piston 30 cylinder having its forward end open to receive the shank of the working tool, differential area pistons, a receiver in said cylinder, and means for controlling the admission of live air or expanded air from said receiver 35 to the low pressure piston chamber.

42. In a pneumatic impact tool, a piston cylinder having its forward end open to receive the shank of the working tool, high 40 pressure and low pressure chambers in said cylinder, a plunger therein having pistons of different areas, controlling means for permitting the admission of live air or expanded air from said receiver to the low pressure piston, and a grasping handle 45 attached to said cylinder and having a manually controlled pressure supply duct therein.

43. In a pneumatic impact tool, a piston cylinder, high and low pressure chambers 50 therein, a plunger having pistons of different areas, a receiver formed in the body of said cylinder, and controlling means for permitting the admission of live air or expanded air from said receiver to said low pressure chamber.

44. In a pneumatic impact tool, a cylinder, a piston therein, a valve mechanism, a receiver formed in said cylinder, and means 55 for operating said piston and valve mechanism by the medium of the pressure of the motive fluid passing through said receiver. 60

45. In a pneumatic impact tool, a piston cylinder having differential piston chambers, a plunger having differential area pistons 65 slidable in said chambers, a receiver, and means for controllably connecting said re-

ceiver to live fluid supply or connecting it to the small diameter piston chamber to receive expanded motive fluid therefrom.

46. In a pneumatic tool, the combination of a piston cylinder, a plunger therein having 70 small and large diameter pistons, a valve mechanism therefor, a receiver, means for enabling live motive fluid to enter said receiver and act directly upon both said small and large diameter pistons to augment 75 the striking blow of said plunger, and means for enabling the used motive fluid to exhaust to the atmosphere.

47. In a pneumatic tool, the combination of a piston cylinder, a plunger therein having 80 small and large diameter pistons, a valve mechanism therefor, a receiver, and means for enabling said receiver to be filled with either live motive fluid or expanded motive fluid at will. 85

48. In a pneumatic tool, the combination of a piston cylinder, a plunger therein having 90 small and large diameter pistons, a valve mechanism therefor, a receiver, means for enabling said receiver to be filled with either live motive fluid or expanded motive fluid at will, in combination with means for effecting the exhaust of the expanded motive 95 fluid.

49. In a pneumatic impact tool, a cylinder, 95 a hammering plunger therein, a valve mechanism, a receiver, and means for operating said plunger by motive fluid through a passage or chamber which is uninterruptedly in communication with the receiver and forming 100 a part thereof.

50. In combination with a pneumatic impact tool, a receiver, and means for cushioning the recoil of the hammering plunger by 105 live motive fluid from a passage or chamber which is constantly in communication with the receiver and forming a part thereof.

51. In combination with a pneumatic impact tool, a receiver, a valve mechanism, and means for cushioning the recoil of the 110 hammering plunger by live motive fluid supplied from the passage or chamber which is uninterruptedly in communication with the receiver and forming a part thereof.

52. In a pneumatic impact tool, a plunger 115 therein, a valve mechanism, a receiver and means for admitting live or expanded air or both to the receiver, and means for operating said plunger by motive fluid passing 120 through said receiver.

53. In a pneumatic impact tool, a plunger therein, a valve mechanism, a receiver, and means for admitting live or expanded air or both to the receiver, and means for operating said valve mechanism in one direction 125 by motive fluid passing through said receiver.

54. In a pneumatic impact tool, a plunger therein, a valve mechanism, a receiver, means for operating said plunger by motive 130

fluid passing through said receiver, and means for operating said valve mechanism in one direction by motive fluid which does not pass through the receiver.

5 55. A combination of a pneumatic impact tool, a receiver, a valve mechanism and means for cushioning the recoil of the inserted tool by live motive fluid supplied from a passage or chamber which is constantly in communication and forms a part of the receiver.

10 56. A pneumatic impact tool, a plunger therein, a valve mechanism, a receiver and means for admitting live air to the receiver and means for operating said valve by live motive fluid from a passage or chamber which is uninterruptedly in communication with the receiver and forms a part thereof.

15 57. In a pneumatic impact tool, a plunger therein, a valve mechanism, a receiver, and means for operating the said valve and plunger by live motive fluid from a chamber or passage in constant communication with the receiver and forming a part thereof.

20 58. In a pneumatic impact tool, a receiver, and means for absorbing the recoil of the inserted tool by pneumatic pressure supplied through a passage or chamber in uninterrupted communication with the receiver and forming a part thereof.

25 59. In a pneumatic impact tool, a receiver, and means for absorbing the recoil of the inserted tool by a constant pneumatic pressure supplied through a passage or chamber in uninterrupted communication with the receiver and forming a part thereof.

30 60. In combination with a pneumatic impact tool, a receiver and passage or chambers connected therewith and forming a part thereof, and a pneumatic shock absorber co-acting therewith between the inserted tool and the barrel.

35 61. In a pneumatic impact tool, a cylinder, a plunger therein, a valve mechanism, a receiver which is constantly in communication with live motive fluid, and means for operating said plunger and valve mechanism by a medium of the pressure of the

motive fluid supplied from a passage or chamber in uninterrupted communication with the receiver and forming a part thereof.

62. In a pneumatic impact tool, a cylinder, a valve mechanism, a receiver and chambers or passages in constant communication therewith and forming a part thereof, through which live motive fluid passes, and a plunger with two or more diameters to receive the working fluid pressure on its striking stroke.

63. In a pneumatic impact tool, a cylinder, a plunger, a valve mechanism, a receiver and chambers and passages connected therewith and a part thereof, through which the motive fluid passes for operation of the various reciprocatory parts.

64. In a pneumatic impact tool, a cylinder, a plunger, a valve mechanism, a receiver and passages and chambers connected therewith and a part thereof from which is derived pneumatic pressure to form an air cushion for preventing the contact of the end of the plunger on its recoil stroke with the end of the cylinder.

65. In combination with a pneumatic tool, a receiver and means for admitting live or expanded air thereto at will.

66. In a pneumatic impact tool, the combination of a cylinder, a plunger, a valve mechanism, a receiver, and means for introducing into the receiver live or expanded air at will.

67. In a pneumatic impact tool, the combination of a cylinder, a plunger therein, a receiver, and means for enabling live or expanded motive fluid to enter therein at will.

68. In a pneumatic impact tool, the combination of a cylinder, a plunger, a valve mechanism therefor, a receiver, and means for enabling live motive fluid to enter therein.

WILLIAM BURLINGHAM.

Witnesses:

H. S. FAIRBANKS,
C. D. McVAY.