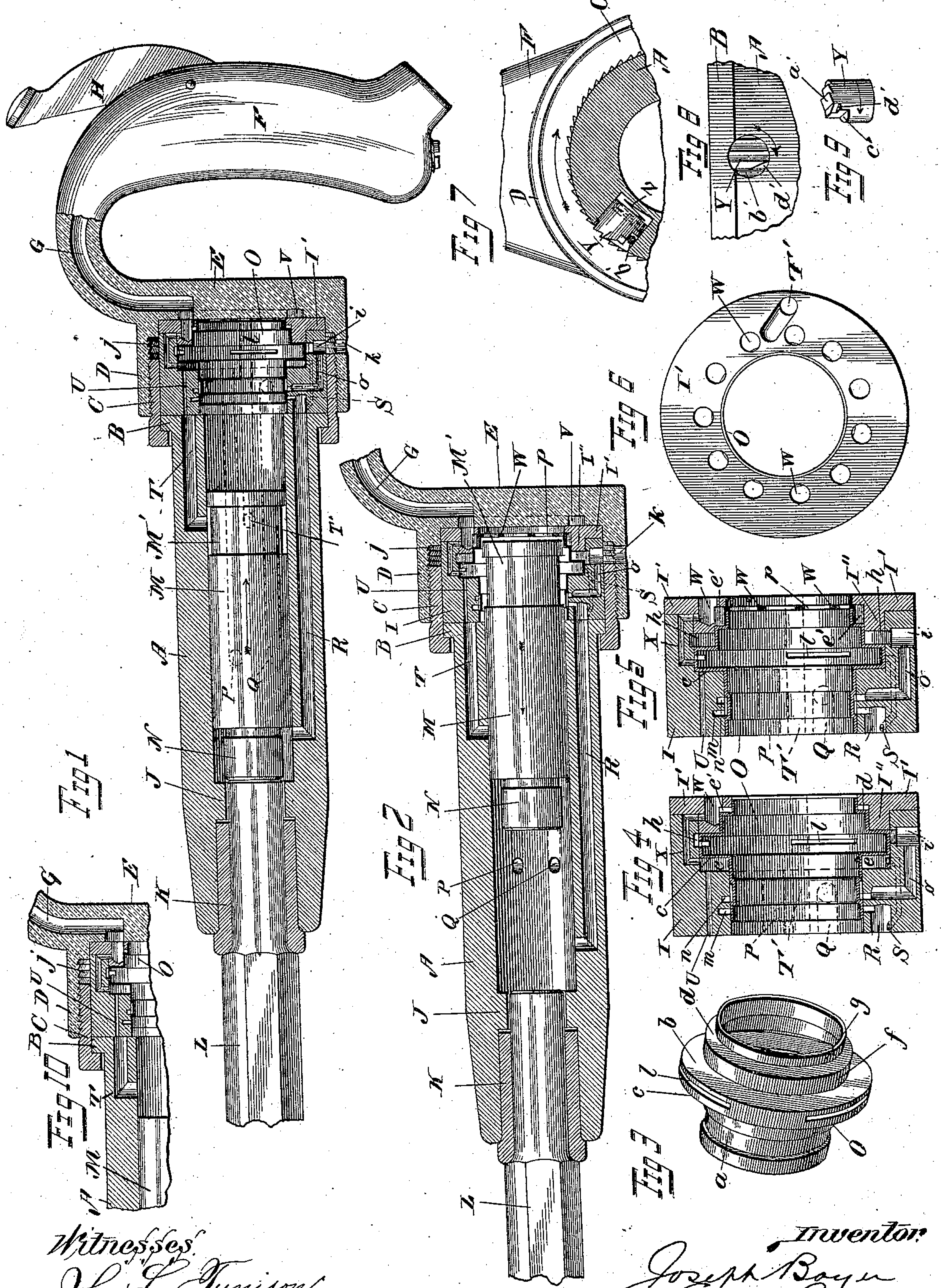
(No Model.)

J. BOYER.

PNEUMATIC HAMMER.

No. 575,589. Patented Jan. 19, 1897.



Witnesses.
John L. Tunison.
W. Donahue.

Inventor
Joseph Boyer
By Edward Rector his Atty.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

JOSEPH BOYER, OF ST. LOUIS, MISSOURI.

PNEUMATIC HAMMER.

SPECIFICATION forming part of Letters Patent No. 575,589, dated January 19, 1897.

Application filed September 4, 1896. Serial No. 604,825. (No model.)

To all whom it may concern:

Be it known that I, JOSEPH BOYER, a citizen of the United States, residing at the city of St. Louis, in the State of Missouri, have invented a certain new and useful Improvement in Pneumatic Hammers, of which the following is a description, reference being had to the accompanying drawings, forming part of this specification.

My present invention relates to machines of the general nature of those heretofore patented to me by Letters Patent of the United States No. 277,448, dated May 15, 1883, No. 537,629, dated April 16, 1895, and No. 549,102, dated November 5, 1895.

The first and principal feature of my present invention relates to the valve mechanism by which the movements of the piston are controlled. It is highly desirable for purposes of convenience in handling the tool when at work that the bodies of tools of this character shall be made as short as can be done consistently with the length of stroke which it is necessary to give the piston in order that the latter may act with sufficient power upon the chisel or other working tool employed with the hammer. Inasmuch as the force of the blows delivered by the piston at any given pressure of motive-fluid depends mainly upon its weight and length of stroke, it is desirable that it shall be heavy and that it shall have as long a stroke as possible; but it is also desirable that the body of the tool shall not be of excessive diameter, and weight must therefore be added to the piston by increasing its length rather than its diameter. Under these conditions, therefore, it follows that increased power in the tool is to be attained chiefly by increasing the length of the piston-chamber to accommodate long strokes of a long piston, and a piston-chamber of maximum length consistent with the length of the tool as a whole is therefore essential to improvement along these lines.

It is the principal object of the novel valve mechanism constituting the first feature of my present invention to accommodate a piston-chamber of increased length without increasing the length of the tool as a whole, and to thereby permit a greater length of stroke of the piston in a tool of given length, and consequently increase the power of action of tools of this character. In the tools shown and described in the last two of my aforesaid patents and in many other tools of this character which have been patented and some of which are in practical use the valve has been arranged in a separate chamber immediately in rear of the piston-chamber, between the latter and the handle or head of the tool, with the result that this interposition of the valve in a separate chamber at the rear end of the piston-chamber and in line with the latter has necessarily diminished the possible length of the piston-chamber by the amount of space occupied by the valve-chamber and valve, and has consequently diminished to that extent the possible length to be given the stroke of the piston in any tool of given length. In the novel valve mechanism of my present tool the valve consists of a cylindrical shell arranged within the piston-chamber itself and of a sufficient internal diameter to surround the piston and permit it to pass entirely through the valve. This valve is preferably located in the rear end of the piston-chamber, so that the piston passes through and is surrounded by the valve at the end of its rearward stroke, as illustrated in the drawings and hereinafter described; but this particular location of the valve is not essential to the broader scope of my invention, as will be apparent from the description thereof hereinafter given and from the terms of my respective claims. It results from this construction and arrangement of the valve that the space occupied by it does not diminish the length of the piston-chamber at all, since the piston-chamber extends entirely through the valve, and it therefore follows that a tool of given length will accommodate a piston-chamber as much longer than the piston-chambers of the prior tools above referred to as the length of the space occupied by the valve-chamber and valve in such prior tools, thereby permitting greater length of stroke for the piston and correspondingly increasing the force of its blows and the power of action of the tool.

Another feature of my present invention consists in a construction whereby the inner end of the shank of the chisel or other working tool itself forms the means for closing the front end of the piston-chamber and constitutes a part of the cylinder head or abutment against which the motive fluid admitted to the front end of the piston-chamber acts in driving the piston rearward.

Another feature of the invention relates to a novel locking device for the coupling-sleeve which holds the parts of the tool together, all of which features will be hereinafter more fully explained by reference to the accompanying drawings, in which—

Figure 1 is a longitudinal section of my new tool with part of the handle left in elevation and with the piston at the forward end of its stroke and the valve in corresponding position; Fig. 2, a view corresponding to Fig. 1 with the handle of the tool broken off and with the piston near the rear end of its stroke and with the valve in corresponding position; Fig. 3, a perspective view of the valve itself; Fig. 4, a vertical section of the valve-block and valve with the valve in the position shown in Fig. 1; Fig. 5, a corresponding view with the valve in the position shown in Fig. 2; Fig. 6, an elevation of the rear face of the valve-block, (the right-hand face of the block shown in Figs. 4 and 5;) Fig. 7, a sectional detail illustrating the locking device heretofore referred to; Figs. 8 and 9, further details of the same, and Fig. 10 a sectional detail of a modification.

Of the several views, Figs. 3 to 9 correspond in size to the tool from which the drawing was made, while Figs. 1 and 2 are approximately two-thirds such size.

The same letters of reference are employed to represent corresponding parts in all the views.

The cylinder or barrel A of the tool is provided at its rear end with an annular flange B, over which fits a coupling-sleeve C, provided at its front end with an internal flange abutting against the flange B on the cylinder and externally threaded upon its rear portion to screw into the interiorly-threaded cap D, projecting from the cylinder-head or handle-base E, such head or base having the grasping-handle F of the tool formed integral with it. The supply-duct G for the motive fluid extends through the handle F and is controlled by a throttle-valve operated by a thumb-lever H, as in the last of my aforesaid patents. Located within the cap D and rear end of the coupling-sleeve C and clamped by them between the rear end of the cylinder A and the head E is the cylindrical valve-block I, hereinafter more particularly described. Suitable dowel-pins interposed between the rear end of the cylinder A and forward side of the valve-block I and between the rear side of the valve-block and the cylinder-head or handle-base E hold the cylinder, valve-block, and head E in position and prevent turning of them relatively to each other. The novel lock which coöperates with the coupling-sleeve to prevent unscrewing of the latter will be hereinafter described.

The portion of the piston-chamber within the cylinder A consists of a straight cylindrical bore, whose rear end opens at its full diameter through the rear end of the cylinder A and whose front end is partially closed by the annular shoulder or ring J left within the cylinder A. The extreme forward end of the cylinder A is in the present instance bored out to the same diameter as the piston-chamber, and has driven into it, so as to be held in fixed position therein, a chisel sleeve or bushing K. The rounded rear end of the shank of the chisel or other working tool L extends through the sleeve or bushing K, and in the presence instance through the ring J to a point about flush with the rear face of the latter.

The piston M consists of a solid cylindrical piece of steel fitting the bore within the cylinder A, and in the present instance provided with a circumferential groove M′ near its rear end, and also having formed upon its front end (for a purpose hereinafter explained) a short projecting stem N, which contacts with the rear end of the shank of the tool L when the piston reaches the forward end of its stroke.

The valve O, Fig. 3, consists of a very thin steel shell, which is circular in cross-section at all points in its length, but of irregular shape in longitudinal section, and the passage through which is at its smallest diameter somewhat larger than the piston M. Near its left-hand or forward end the valve O is provided upon its exterior with a circumferential groove *a*, while immediately at the right or rear of its middle line it is formed into an outwardly-projecting hollow flange or ring *b*, whose left-hand or forward face forms an annular pressure area *c*, against which the motive fluid acts to move the valve rearward or to the right in the manner hereinafter explained. Near its right-hand or rear end the valve is formed with an annular shoulder or pressure area *d*, against which the motive fluid acts to force the valve forward, as hereinafter explained.

The valve O fits within the valve-block I, which latter is composed of two parts, a main portion or body I and a flanged ring or disk I′, fitting against the rear face of the block I. The left-hand or forward half of the block I is bored out to a given diameter corresponding to the external diameter of the left-hand or forward half of the valve O, while the right-hand rear half of the block I is bored out to a larger diameter, corresponding to the external diameter of the projecting ring *b* of the valve. A circular flange or ring I″, projecting from the left-hand forward face of the ring I′, enters and snugly fits within the rear end of this larger bore of the block I, leaving a space between the forward side of said flange and the annular shoulder at the forward end of the larger bore of the block I, within which space the projecting ring *b* of the valve fits and travels back and forth as the valve is moved in one direction or the other. The surface f of the valve between the ring b and the pressure area d, Fig. 3, snugly fits within the flange I″ of the ring I′, Figs. 3 and 4, while the surface g at the rear end of the valve snugly fits within the circular opening in the ring I′ when the valve is in right-hand rearward position, as in Figs. 1 and 4. When the valve is in rearward position, Figs. 1 and 4, there is an annular space or chamber e between the pressure area c of the valve and the front wall or shoulder of the larger bore of the valve-block, while there is an annular chamber or space e' between the pressure area d of the valve and the front side of the inner edge of the ring I′. The former may be called, for convenience of description, the "space or chamber in front of the valve" and the latter the "space in rear of the same." When the motive fluid is admitted to the space e', it will act upon the area d of the valve and will force the latter forward if there is no motive fluid in the space e acting upon the larger area d of the valve. When the motive fluid is admitted to the space e, the pressure against the front of the valve will overcome that against its rear and force the valve rearward.

The larger bore of the block I is provided about midway of its length with an internal circumferential groove h, which communicates by a series of radial ports i with an annular open space j around the valve-block immediately in rear of the right-hand rear end of the coupling-sleeve C, Figs. 1 and 2, and this space j opens to the outer atmosphere through a series of holes k in the lower side of the threaded cap D, which screws over the coupling-sleeve C. The groove h is therefore an exhaust-passage constantly open to the atmosphere. The ring b is provided with a series of slots l, which when the valve is in right-hand rear position register with the groove h, and thereby place the interior of the valve in communication with the exhaust. When the valve is moved forward, (to the left,) the slots l are carried away from the groove h and the communication between the interior of the valve and the exhaust cut off.

The smaller bore of the valve-block I is provided with two internal circumferential grooves m n for a purpose hereinafter explained, the groove m being considerably deeper than the groove n. When the valve is in forward left-hand position, these two grooves are put into communication with each other by the circumferential groove a upon the exterior of the valve. The rear groove n communicates by a passage o with the exhaust-port i, so that said groove n is always open to the exhaust, and when it is placed in communication with the groove m by the groove a of the valve the groove m will then likewise be open to the exhaust. For the purpose of furnishing freer communication between the groove n and the exhaust there are preferably several passages o, connecting said groove with different ports i.

A passage opening into the piston-chamber at P, Figs. 1 and 2, leads rearward through the wall of the cylinder and through the wall of the valve-block I and opens into the annular space e in front of the pressure area c of the valve, Figs. 1, 4, and 5. A second passage opening into the piston-chamber at Q leads rearward through the wall of the cylinder and wall of the valve-block I and opens by a radial port into the groove n in the valve-block, as indicated by the dotted lines in Figs. 4 and 5. Inasmuch as the groove n is constantly open to the exhaust it will be seen that the passage Q constantly communicates with the exhaust and will open the front end of the piston-chamber to the exhaust whenever the front end of said passage is uncovered by the piston, as in Fig. 2. The provision of a separate passage Q leading back to the exhaust at the rear end of the tool is not essential, since there might be instead simply a radial exhaust-port extending through the wall of the cylinder at the point now occupied by the front end of either the passage Q or the passage P, and the passage Q be thus dispensed with. It is preferable, however, to carry the exhaust back to the rear of the tool, and hence the provision of the passage Q in the present instance. A third passage R opens into the piston-chamber near the front end of the latter, and leads thence rearward through the wall of the cylinder and into the wall of the valve-block I and communicates with the groove m in the valve-block. The rear end of this passage R also communicates by a small passage S with the space e in front of the pressure area c of the valve, as indicated by the dotted lines in Figs. 1, 2, 3, and 4.

A passage T, opening into the piston-chamber at a point in front of the rear end of the piston when the latter is in forward position, Fig. 1, leads thence rearward through the wall of the cylinder and communicates with a small passage U, extending through the wall of the valve-block I and also opening into the space e in front of the valve.

The supply-inlet G, which extends through the handle F of the tool, opens at its forward end into a circular groove V, formed in the forward face of the head E. Communicating at its rear end with this groove V is a passage T′, extending forward through the valve-block I I′ and the wall of the cylinder A and opening into the piston-chamber at about the same point in its length as the passage T. (See dotted lines in Figs. 1, 4, and 5 and full lines in Fig. 6, in which latter the front end of the passage is shown.) Inasmuch as the groove V in the head E is constantly filled with the motive fluid from the inlet G, the passage T′ will likewise be constantly filled with it, and when the piston M is in forward position its groove M′ will put the forward end of the passage T′ into communication with the passage T, as in Fig. 1, and the motive fluid be thereby admitted through the passages T U to the space e in front of the valve, as hereinafter explained.

Registering with the groove V in the head E is a circular row of holes W, bored into the flanged ring I′ of the valve-block, Fig. 6, in such position that their inner sides cut through the inner surface of the flange I″ of said ring, Figs. 1, 2, 4, and 5, and thereby furnish communication between the groove V in the circular head E and the space e' at the rear of the annular shoulder or pressure area d of the valve, with the result that the motive fluid admitted through the inlet G in the handle to the annular groove V in the head E may pass through the holes W and constantly act upon the pressure area d of the valve and tend to force the latter forward.

One or more of the holes W communicates by a passage X with the larger bore of the valve-block I, said passage opening into the space e in front of the valve when the latter is in rearward position, as in Figs. 1 and 4, and being closed by the ring b of the valve when the latter is in forward position, as in Figs. 2 and 5. The capacity of the passage X is greater than that of the passage S, (or preferably, to the same end, there are several small passages X connecting the space e in front of the valve with different ones of the holes W instead of a single large passage,) so that motive fluid may be admitted to the space e by the passage or passages X faster than it can escape through the passage S, for a purpose hereinafter explained.

Under the construction and arrangement above described the operation of the tool is as follows, starting with the piston and valve in the position shown in Figs. 1 and 4: In such position of the parts the motive fluid admitted through the inlet G to the annular groove V in the cylinder-head E will pass through the holes W into the space e' and act upon the pressure area d of the valve and tend to force the latter forward; but the motive fluid in the space e in front of the pressure area c of the valve, (admitted thereto in the manner hereinafter explained,) acting upon such larger area, will serve to hold the valve in rearward position against the pressure exerted on the area d. From the annular space e in front of the valve the motive fluid will pass through the passage S into the passage R and through the latter to the front end of the piston-chamber, where it will act upon the front end of the piston and drive the latter rearward, the rear end of the piston-chamber being at such time open to the exhaust through the slots l in the valve and the exhaust-groove h in the valve-block I, the groove h, as before explained, being constantly open to the outer air through the holes i, annular space j, and holes k. When the piston has moved rearward far enough to uncover the front end of the exhaust-passage Q, the motive fluid in the front end of the piston-chamber will escape through such passage and the groove n and its connections, heretofore explained, to the outer air. The front end of the passage P will be uncovered at the same time as the passage Q, and the motive fluid in the space e in front of the valve will escape through the passage P into the piston-chamber, and thence through the exhaust-passage Q and its connections to the outer air. The exhaust-passage P, leading from the space in front of the valve, being much larger than the passage (or passages) X, by which the motive fluid is supplied to such space, the pressure upon the area c of the valve will be greatly diminished when the front end of the exhaust-passage P is uncovered by the piston, so that the pressure of the motive fluid in rear of the valve, which is acting constantly upon its smaller pressure area d, will force the valve forward to the position shown in Figs. 2 and 5, whereupon the projecting ring b of the valve will close the front end of the passage X and cut off the supply of motive fluid from the space in front of the valve, thereby permitting the pressure upon the smaller area d of the valve to hold the latter in forward position. When the valve is thus moved to forward position, its extreme rear end will have been carried forward beyond the circular inner edge of the ring I′ of the valve-block, leaving an annular opening p entirely around the rear end of the valve between the latter and the inner edge of the ring I′, Figs. 2 and 5, through which opening the motive fluid may pass from the holes W and annular space e' to the interior of the valve, and there acting upon the rear end of the piston drive the latter forward again. As the piston moves forward the air in front of it can escape through the exhaust-passage Q until the latter is closed by the front end of the piston, and thereafter can escape through the passage R into the groove m in the valve-chamber, which groove, when the valve is in the position it occupies while the piston is moving forward, is in communication with the exhaust-groove n through the medium of the groove a in the exterior surface of the valve, so that the air driven backward through the passage R may escape to the outer air. When the piston has moved forward far enough for its groove M′ to place the front end of the live-air passage T′ in communication with the passage T, the motive fluid from the passage T′ will pass through the passages T and U to the space in front of the pressure area c of the valve, Figs. 2 and 4, and there acting upon said area of the valve will overcome the constant pressure which is acting upon the smaller area d of the valve and force the valve rearward again. This rearward movement of the valve will open the front end of the passage X and again admit motive fluid through the latter to the space e in front of the valve, and will also open the passage S, leading from such space to the passage R and front end of the piston-chamber. It will also open the interior of the valve to the exhaust through the slots *l* and exhaust-groove *h*, so that the pressure behind the piston may escape, and will cut off the exhaust from the passage R and front end of the piston-chamber by disconnecting the grooves *m* and *n*, so that the motive fluid admitted to the front end of said chamber through the passages S and R will drive the piston rearward again. The rearward movement of the piston will carry its groove M′ away from the front ends of the passages T and T′ and close the communication between them, and the admission of motive fluid from the live-air passage T′ to the space *e* in front of the valve be thereby cut off; but the motive fluid admitted to such space through the passage (or passages) X will serve to hold the valve in rearward position, notwithstanding the escape of motive fluid through the passage S, since the latter is of sufficiently less capacity than the passage or passages X for that purpose.

It will be understood that while the passage T′ is put into communication with the passage T by the groove M′ to shift the valve before the front end of the piston strikes the shank of the tool L the momentum of the piston and the expanding pressure behind it carries it on forward into contact with the tool, and that likewise while the exhaust-passage Q is uncovered by the front end of the piston before the latter has reached its rearward limit of stroke the momentum of the piston and the expanding pressure behind it will carry it on rearward, the motive fluid admitted in rear of it by the shifting of the valve before it completes its rearward stroke serving to cushion it at the end of such stroke. The desideratum is to so adjust and time the operation of the parts that the piston shall be moved rearward as far as may possibly be done without danger of its rear end hammering against the cylinder-head in order that as long a forward stroke as possible may be obtained. The parts may be so adjusted that the piston will move at its rearward stroke to or beyond the position shown in Fig. 2 and there be cushioned by the newly-admitted motive fluid and not alowed to strike the cylinder-head E.

The live-air passage T′ and the groove M′ in the piston may be dispensed with by opening the front end of the passage T into the piston-chamber at a point slightly in rear of the rear end of the piston when the latter is in its forward position, as shown in Fig. 10, instead of having it open into the piston-chamber at the point shown in Figs. 1 and 2. Under such arrangement of the passage T (and dispensing with the passage T′ and groove M′ in the piston) when the piston approached its forward limit of stroke and its rear end uncovered the front end of the passage T the live air in rear of the piston would pass through the passages T and U to the space *e* at the front of the valve, and there acting upon its pressure area *c* force it rearward, just as does the live air admitted from the passage T′ through the passages T U in the construction illustrated in Figs. 1 and 2. The passage U is of such limited size that its capacity combined with that of the passage S is less than the capacity of the passage or passages X, so that the motive fluid would be admitted by the latter to the front side of the valve faster than it could escape through the passages U and S and serve to hold the valve in rearward position, notwithstanding the escape of motive fluid through the passages U and S. As soon as the piston began to move rearward the front end of the passage T, Fig. 10, would be closed by the piston, so that there could then be no further escape of motive fluid through the passage U. In tools of some sizes and under some conditions, however, I have found the valve to operate better when moved rearward by live air admitted to its front side directly from the source of supply, as distinguished from that admitted to it from the piston-chamber under the modification shown in Fig. 10, and I have therefore illustrated and described my preferred construction as embodying the live-air passage T′ and groove M′ in the piston, as in Figs. 1 and 2, although the arrangement explained in connection with Fig. 10 is entirely satisfactory in many tools and is clearly within the broader scope of my invention.

Under the preferred construction shown in Figs. 1 and 2 it is not essential that the passage U shall be made of such limited capacity as has been described, but under the construction in Fig. 10 it is necessary that it shall have such limited capacity or else that a check-valve be interposed in it to prevent the escape of motive fluid from the space *e* in front of the valve when the rear end of the piston-chamber is opened to the exhaust.

From the foregoing description of my new tool it will be seen that inasmuch as the rear end of the piston-chamber extends entirely through the valve-block and valve the space occupied by the latter is not provided at the expense of the piston-chamber, and that said chamber is as long as it could be made, even if the valve were arranged in a chamber at one side of and parallel to the piston-chamber instead of in line and concentric therewith. In the tool from which the drawings were made the longitudinal thickness of the valve-block is about an inch and a quarter, (as will appear from the full-sized views of said block in Figs. 4 and 5,) and in tools of the same size made in accordance with the last two of my previously-mentioned patents the valve-blocks were of approximately the same longitudinal thickness. In such prior tools the piston-chamber necessarily terminated at the forward side of the valve-block, while in my present tool it extends directly through the valve-block, so that in a tool of given length as a whole the piston-chamber under the construction of my present tool may be made more than an inch longer than under the construction employed in my prior tool, with the consequent possibility of correspondingly increasing the length of stroke of the piston and the power of action of the tool.

Inasmuch as the valve in my new tool consists of an exceedingly thin steel shell, and is consequently very light, and inasmuch as its limit of movement is very short, not exceeding an eighth of an inch in a tool of the size from which the drawings were made, Figs. 4 and 5, it follows that the momentum acquired by the valve in its rapid reciprocations is very slight and is not sufficient to so hammer the valve against the abutments at the opposite ends of its strokes as to cause damage and rapid wear of the valve.

Under the construction shown in Figs. 1 and 2 (which includes the live-air passage T' and the groove M' in the piston) the auxiliary passage X is necessary only for the purpose of supplying motive fluid to the front end of the piston-chamber through the passage S, and in event some other passage controlled by the valve for supplying the motive fluid to the front end of the piston-chamber were substituted for the passage S, as might be done, the auxiliary passage would be unnecessary. Under the construction shown in Fig. 10, however, the auxiliary passage X is necessary for the further purpose of supplying motive fluid to the larger area of the valve to hold the latter in rearward position after it has been moved thereto by the motive fluid admitted to it from the piston-chamber through the passage T U. As will be understood, the rearward movement of the valve opens the rear end of the piston-chamber to the exhaust, and the motive fluid which had been admitted to the larger area of the valve through the passage T U in Fig. 10 would escape backward through said passage and permit the pressure behind the valve to force it forward again if it were not for the provision of the auxiliary passage X for supplying motive fluid to the larger area of the valve faster than it can escape therefrom. Under the construction shown in Fig. 10 therefore the provision of the auxiliary passage X and the reduction in size of the portion U of the passage leading to the piston-chamber enable me to dispense with the check-valve which in the machines of my last two prior patents was employed in the passage leading from the piston-chamber to the larger area of the valve, and the auxiliary passage X thus serves a useful purpose in the construction shown in Fig. 10 quite independently of its function of supplying motive fluid to the passage S, leading to the front end of the piston-chamber.

From the foregoing it will be understood that while the auxiliary passage serves the purpose in the construction of Figs. 1 and 2 of supplying motive fluid to the front end of the piston-chamber, and while in the construction of Fig. 10 it serves that purpose and also the further purpose of rendering unnecessary any check-valve in the passage leading from the piston-chamber to the larger area of the valve, it nevertheless is not absolutely essential to either construction, and may be dispensed with in the former by substituting some other passage for the passage S, as heretofore explained, and in the latter by making the same substitution and by placing a check-valve in the passage between the piston-chamber and larger area of the valve, as in my prior machines. It therefore forms a novel and useful, but not absolutely essential, feature of my new valve mechanism, and may also be employed in connection with valves of other form than that herein shown and described, such, for instance, as the valve of my last-mentioned prior patents.

The purpose of the stem N, projecting from the front end of the piston M, is to provide a cushion for the piston at the end of its forward stroke and prevent its striking the shoulder J at the front end of the piston-chamber whenever the chisel or other working tool L is not in position to receive the blows of the piston and arrest the latter. At such time the stem N will enter and snugly fit the opening within the annular shoulder or ring J, and as the front end of the passage R will be closed by the front end of the piston proper at about the same time the air between the end of the passage R and the shoulder J will be trapped and serve to arrest and cushion the piston and prevent its striking the shoulder J. So long as the chisel L is in working position, however, the stem N is not necessary for this purpose, since the contact of the piston with the end of the shank of the chisel will serve to arrest the piston. If, therefore, means were provided for holding the working tool in position, as is frequently done in tools of this character, the piston need not be provided with the stem N, but its front end be left the same as its rear end, the shank of the tool L in such case being arranged to project slightly into the front end of the piston-chamber to receive the blows of the piston and the passage R being made to open into the piston-chamber near the front end of the latter. In such event the piston would be permitted a still longer stroke than in the present instance.

It will be noticed that the shank of the chisel L, by closing the opening which leads into the front end of the piston-chamber, itself forms a part of the end wall of said chamber or the abutment against which the motive fluid admitted by the passage R acts in driving the piston rearward. So far as I am aware I am the first in the art to employ the shank of the chisel or working tool for this purpose or to so construct and arrange the parts that it could be employed for this purpose. By so employing it the variety of means heretofore used for closing the front end of the piston-chamber are entirely dispensed with and the construction of the tool simplified and cheapened. I have found from experiments and practical use of tools of this character that the rebound of the piston from contact with the working tool is of itself nearly sufficient to return the piston to the rear end of the piston-chamber, so that but a small quantity of motive fluid need be admitted to the front end of the pis-chamber for this purpose and that the front end of the piston-chamber need not be air-tight in order that the motive fluid may act with sufficient force. To such an extent is this true that no great care need be exercised in having the shank of the chisel snugly fit the chisel-sleeve K or the opening within the ring J, and I have found the tool to work satisfactorily in some instances with a chisel whose shank was not round but hexagonal in shape, the round shoulder of the shank which fits against the outer end of the chisel-sleeve serving to sufficiently confine the motive fluid in the front end of the piston-chamber.

One of the chief objections to the use of tools of this character has heretofore been the shock and jar incident to their use, which caused a severe strain upon the workman using them. These shocks and jars were caused to an equal or greater extent by the rearward strokes of the piston than by the forward strokes thereof. As before stated, I have discovered that the rebound of the piston from contact with the working tool is of itself nearly sufficient to return the piston, so that in my new tool I have arranged to admit motive fluid to the front end of the piston-chamber through a very small passage S and to cut off its admission thereto and open the exhaust before the piston has nearly reached its rearward limit of stroke, with the result that the rebound of the piston from contact with the working tool is aided by a very small quantity of motive fluid admitted in front of the piston during only a portion of its rearward stroke, so that while the piston is thrown rearward quickly enough it is not moved with sufficient force to cause the objectionable jarring of the tool heretofore referred to.

The novel locking device for preventing the coupling-sleeve from unscrewing, which has been heretofore referred to, is illustrated in Figs. 7, 8, and 9, where Fig. 7 is a sectional detail in a vertical plane immediately in front of the front end of the coupling-sleeve and looking toward the rear. As there shown, it will be seen that the inner edge of the internal flange upon the front end of the coupling-sleeve is serrated to coöperate with a locking-block Y, which is seated in a radial bore in the wall of the cylinder A and is pressed upward by a coiled spring Z, placed beneath it and fitting in a recess in its under side. The upper or outer end of the locking-block Y has formed upon it one or more teeth a' to coöperate with the serrations of the coupling-sleeve, the spring Z serving to normally engage said teeth with said serrations and thereby prevent the coupling-sleeve being turned backward. The locking-block Y is held in place in the bore in which it fits by a pin b', which is driven from the rear end of the cylinder through a longitudinal hole intersecting the recess in which the block Y fits, which pin overlies a shoulder c' upon the side of the block Y and prevents the latter being forced out of place by the spring Z when the coupling-sleeve is removed and the tool taken apart. The locking-block Y is provided with a second shoulder d', located above and at an angle to the shoulder c', and when it is desired to release the coupling-sleeve from the locking device to permit it to be unscrewed and the tool taken apart it is only necessary to press the locking-block Y downward slightly against the resistance of the spring Z and then turn it in the direction of the arrows in Figs. 8 and 9 to move its shoulder d' beneath the pin b', whereupon, upon removing pressure from the block Y, the engagement of the shoulder d' with the pin b' will prevent the spring Z forcing the block upward into reëngagement with the serrations of the coupling-sleeve. When the parts of the tool are again reassembled and the coupling-sleeve screwed tightly in place, the locking-block Y can be reëngaged with the serrations of its flange by simply turning it back to normal position to disengage its shoulder d' from the pin b' and permit the spring Z to press it upward again.

In the tools of the last two of my prior patents I employed a coupling-sleeve having the inner edge of its flange serrated, as in the present instance, and a locking device located in the wall of the cylinder and coöperating with the serrations of the coupling-sleeve to prevent the latter becoming unscrewed; but the locking device above described is simpler and better than the ones heretofore employed and much more convenient in operation by reason of the ease with which it may be disengaged from the serrations of the coupling-sleeve and maintained out of engagement therewith while the sleeve is unscrewed and removed and replaced in position.

Having thus fully described my invention, I claim—

1. In a pneumatic hammer, a valve for controlling the movements of the piston, consisting of a cylindrical shell located in the piston-chamber and adapted to have the piston pass through it, and provided with opposing pressure areas against which the motive fluid acts to shift the valve in opposite directions.

2. In a pneumatic hammer, a valve for controlling the movements of the piston, consisting of a cylindrical shell located in the piston-chamber and adapted to have the piston pass through it, and provided with opposing pressure-surfaces of different areas, against the smaller of which the motive fluid constantly acts, to press the valve in one direc-

tion, and to the larger of which the motive fluid is intermittently admitted, to move the valve in the opposite direction.

3. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve located in the piston-chamber and consisting of a cylindrical shell through which the piston passes, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, and a passage controlled by the piston for intermittently admitting the motive fluid to the larger pressure area to move the valve in the opposite direction.

4. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve located in the rear end of the piston-chamber and consisting of a cylindrical shell through which the rear end of the piston passes at the end of its rearward stroke, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, and a passage controlled by the piston and opened by the latter at its forward stroke to admit motive fluid to the larger area of the valve.

5. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve located in the rear end of the piston-chamber and consisting of a cylindrical shell through which the rear end of the piston passes at the end of its rearward stroke, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve forward, and a passage controlled by the piston and opened by the latter at its forward stroke to admit motive fluid to the larger area of the valve, to move the valve rearward.

6. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve located in the rear end of the piston-chamber and consisting of a cylindrical shell through which the rear end of the piston passes at the end of its rearward stroke, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve forward, and a passage controlled by the piston and opened by the latter at its forward stroke to admit motive fluid to the larger area of the valve, to move the valve rearward, said valve when moved forward by the constantly-acting pressure against its smaller area opening an annular port around its rear end to admit the motive fluid to the rear end of the piston-chamber, and when moved in the opposite direction by the intermittent pressure admitted to its larger area opening a passage leading to the front end of the piston-chamber.

7. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve for controlling the movements of the piston, consisting of a cylindrical shell located in the piston-chamber and adapted to have the piston pass through it, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, a passage controlled by the piston and opened by the latter at its forward stroke to admit motive fluid to the larger area of the valve, and an exhaust-passage leading from said larger area of the valve and opened by the piston at its rearward stroke.

8. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve having differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, a passage controlled by the piston for intermittently admitting motive fluid to the larger area of the valve to move the latter in the opposite direction, an auxiliary passage opened by the last-mentioned movement of the valve to admit motive fluid to the larger area of the valve directly from the source of supply, and a passage leading from the larger area of the valve to one end of the piston-chamber through which the motive fluid admitted by the auxiliary passage may pass to said end of the piston-chamber and drive the piston toward the opposite end of the chamber.

9. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve having differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve forward, a passage controlled by the piston and opened by the latter at its forward stroke, to admit motive fluid to the larger area of the valve and move the latter rearward, an auxiliary passage opened by the last-mentioned movement of the valve to admit motive fluid to the larger area of the valve directly from the source of supply, and a passage leading from such larger area of the valve to the front end of the piston-chamber, through which the motive fluid supplied by the auxiliary passage may be admitted to the front end of the piston-chamber to drive the piston rearward.

10. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve having differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, a passage controlled by the piston and opened by the latter at its forward stroke, to admit motive fluid to the larger area of the valve and move the latter in the opposite direction, an auxiliary passage opened by the last-mentioned movement of the valve to admit motive fluid to the larger area of the valve directly from the source of supply, and a passage leading from such larger area of the valve to the front end of the piston-chamber, through which the motive fluid supplied by the auxiliary passage may be admitted to the front end of the piston-chamber to drive the piston rearward, the capacity of the afore-

said auxiliary passage being greater than the combined capacity of the other two passages communicating with the larger area of the valve.

11. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve having differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, a live-air passage leading directly from the source of supply to the piston-chamber, through the wall of the latter and independently of the piston and a passage leading from the piston-chamber to the larger area of the valve, the piston operating to close communication between said passages except when it approaches one end of its stroke and then place said passages in communication with each other, to thereby admit the motive fluid to the larger area of the valve.

12. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve having differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, a live-air passage leading directly from the source of supply to the piston-chamber through the wall of the latter and independently of the piston, a passage leading from the piston-chamber to the larger area of the valve, the piston operating to close communication between said passages and being provided with a circumferential groove which places said passages in communication with each other as the piston approaches its forward limit of stroke, to thereby admit the motive fluid to the larger area of the valve, and an exhaust-passage from the larger area of the valve opened by the piston at the forward end of its stroke.

13. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve having opposing pressure areas to which the motive fluid is admitted for shifting the valve in opposite directions, a passage controlled by the piston, for intermittently admitting motive fluid to one of the pressure areas of the valve, to move the latter in one direction, an auxiliary passage opened by the last-mentioned movement of the valve to admit an additional supply of motive fluid to said area of the valve, and a passage leading from said area of the valve to one end of the piston-chamber, through which motive fluid supplied by the auxiliary passage may be admitted to said end of the piston-chamber to move the piston toward the opposite end of said chamber.

14. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve located in the piston-chamber and consisting of a cylindrical shell through which the piston passes, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, a passage controlled by the piston for intermittently admitting the motive fluid to the larger pressure area of the valve, to move the latter in the opposite direction, and an auxiliary passage opened by the last-mentioned movement of the valve to admit an additional supply of motive fluid to the larger area of the valve.

15. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve for controlling the movements of the piston, consisting of a cylindrical shell located in the rear end of the piston-chamber and adapted to have the rear end of the piston pass through it at the end of its rearward stroke, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, a passage controlled by the piston and opened by the latter at its forward stroke, to admit motive fluid to the larger area of the valve and move the latter in the opposite direction, and an auxiliary passage opened by the last-mentioned movement of the valve to admit motive fluid to the larger area of the valve directly from the source of supply.

16. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve located in the piston-chamber and consisting of a cylindrical shell through which the piston passes, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, a passage controlled by the piston and opened by the latter at its forward stroke, to admit motive fluid to the larger area of the valve and move the latter in the opposite direction, an auxiliary passage opened by the last-mentioned movement of the valve to admit motive fluid to the larger area of the valve directly from the source of supply, and an exhaust-passage leading from said larger area of the valve and opened by the piston at its rearward stroke, said exhaust-passage being of larger area than the auxiliary passage by which the motive fluid is admitted to the larger area of the valve.

17. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve for controlling the movements of the piston, consisting of a cylindrical shell located in the piston-chamber and adapted to have the piston pass through it, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, a passage controlled by the piston and opened by the latter at its forward stroke, to admit motive fluid to said larger area of the valve and move the latter in the opposite direction, and an auxiliary passage opened by the last-mentioned movement of the valve to admit motive fluid to the larger area of the valve directly from the source of supply, said auxiliary passage exceeding in area the said passage controlled by the piston.

18. In a pneumatic hammer, the combination, with the piston-chamber and piston, of

a valve located in the piston-chamber and consisting of a cylindrical shell through which the piston passes, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, a passage controlled by the piston for intermittently admitting the motive fluid to the larger area of the valve to move the latter in the opposite direction, an auxiliary passage opened by the last-mentioned movement of the valve to admit motive fluid to the larger area of the valve directly from the source of supply, and a passage leading from the larger area of the valve to one end of the piston-chamber through which the motive fluid admitted by the auxiliary passage may pass to said end of the piston-chamber and drive the piston toward the opposite end of the chamber.

19. In a pneumatic hammer, the combination with the piston-chamber and piston, of a valve for controlling the movements of the piston, consisting of a cylindrical shell located in the rear end of the piston-chamber and adapted to have the rear end of the piston pass through it at the end of its rearward stroke, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, a passage controlled by the piston and opened by the latter at its forward stroke, to admit motive fluid to the larger area of the valve and move the latter in the opposite direction, an auxiliary passage opened by the last-mentioned movement of the valve to admit motive fluid to the larger area of the valve directly from the source of supply, and a passage leading from such larger area of the valve to the front end of the piston-chamber, through which the motive fluid supplied by the auxiliary passage may be admitted to the front end of the piston-chamber to drive the piston rearward.

20. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve located in the rear end of the piston-chamber and consisting of a cylindrical shell through which the rear end of the piston passes at the end of its rearward stroke, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve in one direction, a passage controlled by the piston and opened by the latter at its forward stroke, to admit motive fluid to the larger area of the valve and move the latter in the opposite direction, an auxiliary passage opened by the last-mentioned movement of the valve to admit motive fluid to the larger area of the valve directly from the source of supply, and a passage leading from such larger area of the valve to the front end of the piston-chamber, through which the motive fluid supplied by the auxiliary passage may be admitted to the front end of the piston-chamber to drive the piston rearward, such passage leading to the front end of the piston-chamber being of less capacity than the aforesaid auxiliary passage, whereby the necessary pressure against the larger area of the valve may be maintained by the motive fluid admitted through the auxiliary passage notwithstanding the escape of motive fluid through the passage leading to the front end of the piston-chamber.

21. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve located in the rear end of the piston-chamber and consisting of a cylindrical shell through which the rear end of the piston passes at the end of its rearward stroke, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve forward, a passage controlled by the piston for intermittently admitting the motive fluid to the larger area of the valve, to move the latter rearward, and an auxiliary passage opened by such rearward movement of the valve to admit an additional supply of motive fluid to the larger area of the valve.

22. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve located in the rear end of the piston-chamber and consisting of a cylindrical shell through which the rear end of the piston passes at the end of its rearward stroke, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve forward, a passage controlled by the piston and opened by the latter at its forward stroke, to admit motive fluid to the larger area of the valve, to move the valve rearward, an auxiliary passage opened by such rearward movement of the valve to admit motive fluid to the larger area of the valve directly from the source of supply, and an exhaust-passage communicating with the larger area of the valve and opened by the piston at its rearward stroke.

23. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve located in the rear end of the piston-chamber and consisting of a cylindrical shell through which the rear end of the piston passes at the end of its rearward stroke, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve forward, a passage controlled by the piston and opened by the latter at its forward stroke, to admit motive fluid to the larger area of the valve, to move the valve rearward, an auxiliary passage opened by such rearward movement of the valve to admit motive fluid to the larger area of the valve directly from the source of supply, and a passage leading from the larger area of the valve to the front end of the piston-chamber, through which the motive fluid supplied by said auxiliary passage may be admitted to the front end of said chamber to drive the piston rearward.

24. In a pneumatic hammer, the combination, with the piston-chamber and piston, of a valve located in the rear end of the piston-

chamber and consisting of a cylindrical shell through which the rear end of the piston passes at the end of its rearward stroke, and provided with differential-pressure areas against the smaller of which the motive fluid constantly acts to press the valve forward, a passage controlled by the piston and opened by the latter at its forward stroke, to admit motive fluid to such larger area of the valve, to move the valve rearward, an auxiliary passage opened by such rearward movement of the valve to admit motive fluid to the larger area of the valve directly from the source of supply, a passage leading from the larger area of the valve to the front end of the piston-chamber, through which the motive fluid supplied by said auxiliary passage is admitted to the front end of said chamber to drive the piston rearward, and an exhaust-passage leading from the larger area of the valve and opened by the rearward movement of the piston.

25. In a pneumatic hammer, the combination of a cylinder, a cylinder-head, a valve-block interposed between the cylinder and head and having a longitudinal bore forming a continuation of the piston-chamber in the cylinder, and a valve located in said valve-block and consisting of a cylindrical shell adapted to have the piston pass through it at the end of its rearward stroke, and provided with opposing pressure areas to which the motive fluid is admitted for shifting the valve in opposite directions.

26. In a pneumatic hammer, the combination of a cylinder, a cylinder-head, a valve-block interposed between the cylinder and head and having a longitudinal bore forming a continuation of the piston-chamber in the cylinder, and a valve located in said valve-block and consisting of a cylindrical shell adapted to have the piston pass through it at the end of its rearward stroke and provided with differential-pressure areas to the smaller one of which the motive fluid is constantly admitted through an inlet in the cylinder-head and to the larger one of which the motive fluid is intermittently admitted through a passage controlled by the piston.

27. In a pneumatic hammer, the combination of a cylinder, a cylinder-head, a valve-block confined between the cylinder and head and having a longitudinal bore forming a continuation of the piston-chamber in the cylinder, and a valve located in said valve-block and consisting of a cylindrical shell adapted to have the piston pass through it at the end of its rearward stroke, and provided with differential-pressure areas, to the smaller rear one of which the motive fluid is constantly admitted through a series of ports registering with a circular groove in the cylinder-head, and to the larger forward one of which the motive fluid is intermittently admitted through a passage controlled by the piston.

28. In a pneumatic hammer, the combination of a cylinder having an external annular flange at its rear end, a cylinder-head having a forwardly-projecting cylindrical cap provided with screw-threads, a threaded coupling-sleeve engaging said cap and provided at its front end with an internal annular flange engaging the external flange upon the rear end of the cylinder, a cylindrical valve-block fitting within the coupling-sleeve and cap and confined by them between the cylinder and cylinder-head, said valve-block having a longitudinal bore forming a continuation of the piston-chamber in the cylinder, and a valve located in said valve-block and consisting of a cylindrical shell adapted to have the piston pass through it at the end of its rearward stroke and provided with opposing pressure areas to which the motive fluid is admitted to shift the valve in opposite directions.

29. In a valve mechanism for controlling the movements of a piston, a valve provided with differential-pressure areas to the smaller one of which the motive fluid is constantly admitted to press the valve in one direction, and to the larger one of which the motive fluid is intermittently admitted, to move the valve in the opposite direction, and a passage leading from said larger area of the valve to one end of the piston-chamber, through which motive fluid supplied by the auxiliary passage may be admitted to said end of the piston-chamber to move the piston toward the opposite end of said chamber.

30. In a valve mechanism for controlling the movements of a piston, a valve consisting of a cylindrical shell located in the piston-chamber and adapted to have the piston pass through it, and provided with opposing pressure areas to which the motive fluid is admitted to shift the valve in opposite directions.

31. In a valve mechanism for controlling the movements of a piston, a valve consisting of a cylindrical shell located in position to have the piston pass through it and provided with differential-pressure areas to the smaller one of which the motive fluid is constantly admitted to press the valve in one direction, and to the larger one of which the motive fluid is intermittently admitted, to move the valve in the opposite direction.

32. In a valve mechanism for controlling the movements of a piston, a valve located in the piston-chamber and consisting of a cylindrical shell adapted to have the piston pass through it, and provided with differential-pressure areas to the smaller one of which the motive fluid is constantly admitted, to press the valve in one direction, and to the larger one of which the motive fluid is intermittently admitted, to move the valve in the opposite direction, and an auxiliary passage opened by the last-mentioned movement of the valve to admit an additional supply of motive fluid to the larger area of the valve.

33. In a valve mechanism for controlling the movements of a piston, a valve located in the piston-chamber and consisting of a cylin-

drical shell adapted to have the piston pass through it, and provided with differential-pressure areas to the smaller one of which the motive fluid is constantly admitted, to press the valve in one direction, and to the larger one of which the motive fluid is intermittently admitted, to move the valve in the opposite direction, an auxiliary passage opened by the last-mentioned movement of the valve to admit an additional supply of motive fluid to the larger area of the valve, and an outlet-passage from the larger area of the valve for conveying to one end of the piston-chamber motive fluid supplied by said auxiliary passage.

34. In a valve mechanism for controlling the movements of a piston, a valve located in the rear end of the piston-chamber and consisting of a cylindrical shell adapted to have the piston pass through it at the end of its rearward stroke, and provided with differential-pressure areas, to the smaller one of which the motive fluid is constantly admitted, to press the valve forward, and to the larger one of which the motive fluid is intermittently admitted through a passage controlled by the piston, to move the valve rearward, said valve when moved forward by the constantly-acting pressure against its smaller area opening an annular port around its rear end to admit the motive fluid to the rear end of the piston-chamber, and when moved in the opposite direction by the intermittent pressure admitted to its larger area opening a passage leading to the front end of the piston-chamber.

35. The herein-described valve, consisting of the cylindrical shell O having the ring *b* provided with the ports *l*, and the differential-pressure areas *c d*.

36. The herein-described valve, consisting of the cylindrical shell O having the circumferential groove *a*, the projecting ring *b* provided with the ports *l*, and the differential-pressure areas *c d*.

37. The combination of the valve-block having the internal circumferential groove *h* open to the exhaust, of the valve located in said block and consisting of the cylindrical shell O having opposing pressure areas to which the motive fluid is admitted, to shift the valve in opposite directions, and provided with the ring *b* having the ports *l* adapted to register with the exhaust-groove *h* when the valve is in one position.

38. The combination of the valve-block having the internal circumferential groove *h* open to the exhaust, of the valve located in said block and consisting of the cylindrical shell O having opposing pressure areas to which the motive fluid is admitted to shift the valve in opposite directions, and provided with the ring *b* having the ports *l* adapted to register with the exhaust-groove *h* when the valve is in one position, said valve when in its opposite position cutting off communication with the exhaust-groove *h* and opening the annular port *p* around its end to admit the motive fluid to its interior.

39. The combination, with the valve-block, of the valve located therein and consisting of the cylindrical shell O having the ring *b* provided with the ports *l*, and the differential-pressure areas *c d*, and said valve-block having the circumferential exhaust-groove *h* coöperating with the ports *l* in the valve, the inlet-passage U and exhaust-passage P communicating with the pressure area *c* of the valve, and the inlet-ports W communicating with the pressure area *d* of the valve.

40. The combination, with the valve-block, of the valve located therein and consisting of the cylindrical shell O having the ring *b* provided with the ports *l*, and the differential-pressure areas *c d*, and said valve-block having the circumferential exhaust-groove *h* coöperating with the ports *l* in the valve, the passages U and P communicating with the pressure area *c* of the valve, the inlet-ports W communicating with the pressure area *d* of the valve, and the auxiliary passage X communicating at one end with the inlet-ports W and at its other with the space *e* adjacent the pressure area *c* of the valve.

41. The combination, with the valve-block, of the valve located therein and consisting of the cylindrical shell O having the ring *b* provided with the ports *l*, and the differential-pressure areas *c d*, and said valve-block having the circumferential exhaust-groove *h* coöperating with the ports *l* in the valve, the inlet-passage U and exhaust-passage P communicating with the pressure area *c* of the valve, the inlet-ports W communicating with the pressure area *d* of the valve, the auxiliary passage X communicating at one end with the inlet-ports W and at its other with the space *e* adjacent the pressure area *c* of the valve, and the outlet-passage S leading from the space *e* to the piston-chamber.

42. The combination, with the valve-block, of the valve located therein and consisting of the cylindrical shell O having the external circumferential groove *a*, the differential-pressure areas *c d*, and the ring *b* provided with the ports *l*, and said valve-block having the circumferential grooves *m n* and passages R and *o* coöperating with the groove *a* of the valve, the circumferential exhaust-groove *h* coöperating with the ports *l* in the valve, the inlet-passage U and exhaust-passage P communicating with the larger area *c* of the valve, and inlet-ports W communicating with the smaller area *d* of the valve.

43. The herein-described valve-block, composed of the part I bored to different diameters, and the part I′ fitting against the end of the part I and provided with the projecting annular flange or ring I″ fitting the larger bore of the part I, the part I being provided in its larger bore with the circumferential

groove h communicating with the exhaust-ports i, and the part I′ being provided with the inlet-ports W.

44. The herein-described valve-block, composed of the part I bored to different diameters, and the part I′ fitting against the end of the part I and having the projecting annular flange I″ entering the larger bore of the part I, the part I being provided with the circumferential grooves m n in its smaller bore and the circumferential groove h in its larger bore, the grooves n and h communicating with exhaust-ports, the part I being also provided with the passages P U communicating with its larger bore, and with the passage R communicating with the groove m, and the part I′ being provided with the inlet-ports W.

45. The herein-described valve-block, composed of the part I bored to different diameters, and the part I′ fitting against the end of the part I and having the projecting ring I″ entering the larger bore of the part I, and having the inlet-ports W opening through said ring, the part I having the circumferential grooves m n in its smaller bore and the circumferential groove h in its larger bore, the passage R communicating with the groove m, the exhaust-port o communicating with the groove n, and the exhaust-port i communicating with the groove h, the passages U P S communicating with the larger bore of the part I, and the passage X communicating with the inlet-port W.

46. A pneumatic hammer provided at its front end with a tool-receiving bore opening into the front end of the piston-chamber and adapted to receive and be closed by the shank of the removable working tool, and having a passage for admitting the motive fluid to the front end of said piston-chamber, whereby the shank of the working tool is made to form part of the end wall of the piston-chamber against which the motive fluid acts to force the piston rearward.

47. A pneumatic hammer having a piston-chamber whose front end is partially closed by an annular shoulder surrounding an opening adapted to receive the shank of the removable working tool, and having a passage for admitting the motive fluid to the front end of said piston-chamber, whereby the shank of the tool is made to form part of the end wall of the chamber against which the motive fluid acts to force the piston rearward.

48. A pneumatic hammer having a piston-chamber whose front end is partially closed by an annular shoulder surrounding an opening adapted to receive the shank of the removable working tool, so that said tool forms part of the end wall of the piston-chamber against which the motive fluid acts to force the piston rearward, in combination with a piston provided upon its front end with a projecting stem adapted to enter and fit said tool-receiving opening when the absence of the working tool from position to receive the blows of the piston permits the latter to make an abnormal forward stroke, whereby the piston is cushioned at the ends of such strokes and not permitted to strike the end of the piston-chamber.

49. A pneumatic hammer having a piston-chamber whose front end is partially closed by the integral annular shoulder J surrounding the opening which receives the shank of the removable working tool L, and having the passage R for admitting the motive fluid to the front end of the piston-chamber where it may act upon the shoulder J and shank of the tool L to force the piston rearward.

50. A pneumatic hammer whose piston-chamber is partially closed at its front end by the integral annular shoulder J surrounding the tool-receiving opening, and whose front end is provided with a bore into which is driven the chisel-sleeve, and which is provided with the passage R for admitting motive fluid to the front end of said piston-chamber, the chisel-sleeve and the opening surrounded by the shoulder J being adapted to receive the shank of the removable working tool L, whereby the latter is made to form part of the end wall of the piston-chamber against which the motive fluid acts to drive the piston rearward.

51. A pneumatic hammer whose piston-chamber is partially closed at its front end by the annular shoulder J adapted to receive the shank of the removable working tool L, and which has the passage R for admitting motive fluid to the front end of said chamber, in combination with the piston M having the stem N adapted to enter and fit the opening surrounded by the shoulder J when the absence of the tool L from working position permits the piston to make an abnormal forward stroke, whereby the piston is cushioned at the ends of such strokes, and prevented from striking the shoulder J.

52. The combination, with the coupling-sleeve having the internal serrated flange, of a locking member seated in a recess beneath said flange and pressed outward into locking engagement with the flange by means of a spring, said locking member being adapted to be depressed out of engagement with the flange and turned in its recess, and means for holding it in such disengaged position.

53. The combination with the coupling-sleeve having the internal serrated flange, of a locking member seated in a recess beneath the flange and pressed outward into locking engagement with the flange by means of a spring, said locking member being provided with a shoulder and being adapted to be pressed inward out of engagement with the flange and turned in its recess, and means coöperating with its shoulder, when so depressed and turned, to hold the member out of engagement with the flange.

54. The combination, with the cylinder A having the annular flange B, and the coupling-sleeve C provided with the internal flange coöperating with the flange B and serrated

upon its inner edge, of the locking-block Y seated in a recess in the wall of the cylinder A and provided upon its upper or outer end with one or more teeth to coöperate with the serrations of the coupling-sleeve, the spring Z beneath said locking-block, and the pin b' coöperating with the shoulder d' of the locking-block to maintain the latter out of engagement with the serrations of the coupling-sleeve, substantially as and for the purpose described.

JOSEPH BOYER.

Witnesses:
EMIL WENGER,
FRANK SPIEKERMAN.