No. 697,793. Patented Apr. 15, 1902.

J. BOYER.

PNEUMATIC HAMMER.

(Application filed Nov. 19, 1898. Renewed Jan. 4, 1901.)

(No Model.)

Fig. 1.

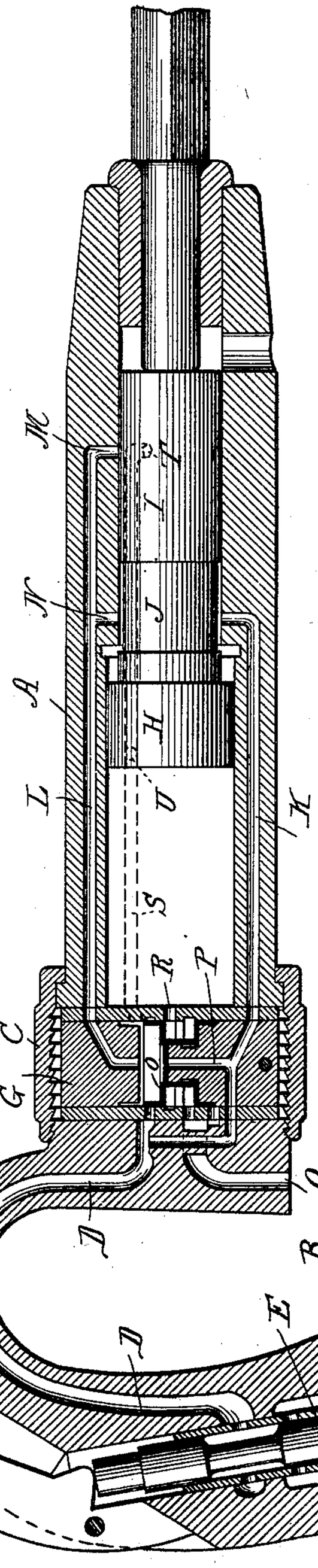
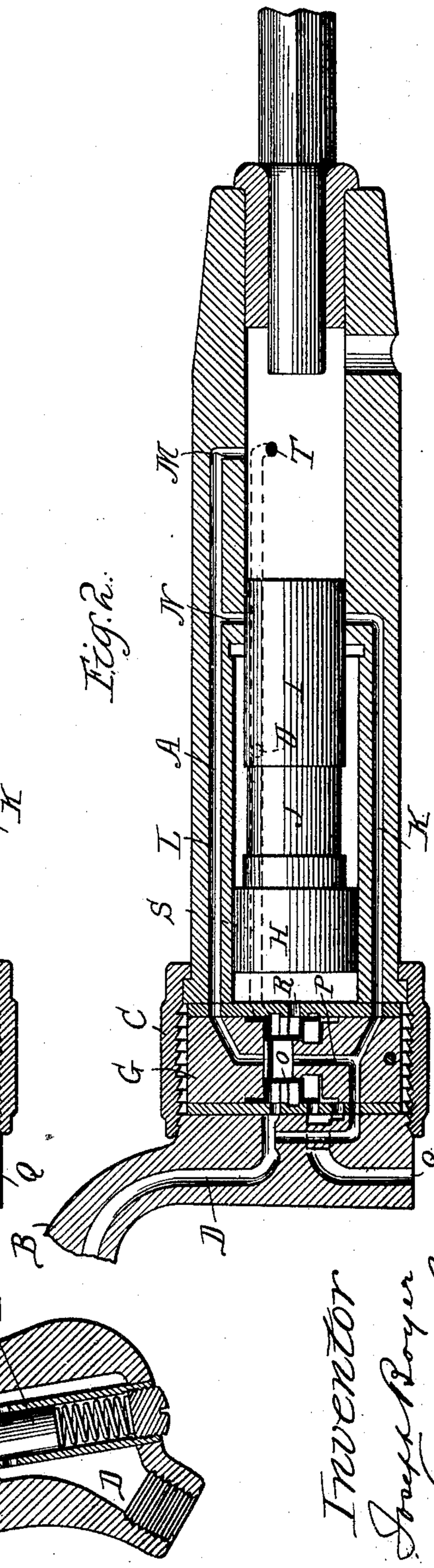


Fig. 2.



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UNITED STATES PATENT OFFICE.

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PNEUMATIC HAMMER.

SPECIFICATION forming part of Letters Patent No. 697,793, dated April 15, 1902.

Application filed November 19, 1898. Renewed January 4, 1901. Serial No. 42,121. (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 invention relates to an improvement upon or modification of the pneumatic hammer heretofore patented to me in Letters Patent of the United States No. 549,102, of November 5, 1895; and it consists in the provision of means for dispensing with the check-valve which is employed as a part of the valve mechanism of that tool, whereby the construction of the tool is simplified and cheapened and its durability increased.

The invention is not restricted in its application, however, to the exact form and style of tool shown in said prior patent, but may be employed in other pneumatic hammers of a similar character.

In the accompanying drawings, Figure 1 is a vertical longitudinal section of the complete tool, showing the piston at approximately the front end of its normal forward stroke and in contact with the shank of the chisel; and Fig. 2 is a corresponding view, with the handle broken away and showing the piston in its rearward position and the valve in opposite position from that shown in Fig. 1.

The same letters of reference are used to indicate corresponding parts in both the views.

Inasmuch as the complete tool and hammer is or may be, with the exceptions hereinafter noted, precisely the same as that heretofore patented to me, a very brief description of its general construction will suffice for an understanding of my present invention.

A represents the cylinder or barrel of the tool, and B the handle thereof, the two being secured together by a coupling-sleeve C. The motive fluid is admitted through a duct D in the handle B and its passage controlled by a throttle-valve E, adapted to be operated by a thumb-lever F. Confined between the rear end of the cylinder A and the base of the handle B, within the coupling-sleeve C, is a valve-block G, containing a valve-chamber and piston-valve, which controls the admission and exhaust of the motive fluid at the rear end of the piston-chamber. The interior of the cylinder A is bored out to form two piston-chambers of different diameters, (or a single piston-chamber whose forward portion is of less diameter than its rearward portion,) in which chamber or chambers is fitted a differential piston, consisting of a large rear end or head H and a forward prolongation or stem I, the two portions of the piston being connected by or provided with an intermediate portion J of still less diameter than the portion I, for a purpose hereinafter described. A duct K, leading forward through the wall of the cylinder A, communicates at its rear end with the main supply-duct or inlet-passage D and at its forward end opens through the wall of the cylinder A into the smaller piston-chamber a short distance in front of the rear end of the latter. Whenever motive fluid is admitted to the tool by the opening of the main throttle-valve E, this duct K will be filled with the motive fluid and remain filled so long as the throttle-valve remains open. When the piston is in its forward position, the front end of this duct K will be open, as in Fig. 1, so that motive fluid may pass from it into the small piston-chamber and thence around the reduced portion J of the piston into the front end of the large piston-chamber; but when the piston is in rearward position the front end of the duct K will be closed by the stem I of the piston, as in Fig. 2.

Located in the opposite wall of the cylinder A is a longitudinal duct L, which communicates at its rear end with the upper end of the valve-chamber and at or near its forward end opens into the small piston-chamber by two ports M and N. When the piston is in forward position, as in Fig. 1, the port M will be closed by the stem I of the piston, while the port N will be open (because of the reduced portion J of the piston-stem being opposite to it at such time) and motive fluid admitted to the piston-chamber from the duct K will pass through the port N and duct L to the upper side of the valve O. Motive fluid is constantly admitted (when the throttle-valve is open) to the under side of the valve O, in the present instance through a branch

passage P, leading from the duct K. As illustrated and described in my prior patent before referred to, and also more particularly in my still earlier patent, No. 537,629, of April 16, 1895, the valve O is a differential valve whose upper area exposed to the action of the motive fluid is considerably larger than its lower area, against which the motive fluid constantly acts, the result being that the constant pressure beneath the valve tends to force it forward, which constant pressure is overcome and the valve forced downward whenever motive fluid is admitted to the upper side of the valve.

Q is an exhaust-passage communicating at its upper forward end with the interior of the valve-chamber by a port formed in the rear wall of the latter. The lower forward end of the main inlet-passage D also communicates with the interior of the valve-chamber by a like port formed in its rear wall, while a single port R in the opposite wall of the valve-chamber furnishes communication between the interior of the valve-chamber and the rear end of the piston-chamber. When the valve is in its lower position, as in Fig. 1, the port R is in communication across the valve-chamber with the exhaust-passage Q and the port communicating with the inlet-passage D is closed by the upper end or flange of the valve. When the valve is in upper position, as in Fig. 2, the inlet-passage D is in communication across the valve-chamber with the port R and the port at the upper forward end of the exhaust-passage Q is closed by the lower end or flange of the valve.

Under the foregoing construction and arrangement of the parts the operation is as follows: With the piston in forward position, as shown in Fig. 1, motive fluid will be admitted from the duct K to the small piston-chamber and thence to the forward end of the large piston-chamber and there act upon the annular forward end of the head H of the piston to drive the latter rearward, the motive fluid at such time also passing through the port N and duct L to the upper side of the valve O and holding the latter down in what may be termed its "exhaust position," the inlet-passage D being closed and the exhaust-passage Q being in communication across the valve-chamber with the port R and rear end of the large piston-chamber. As the piston moves rearward the forward end of the duct K and the port N of the passage L will be closed by its stem I and the supply of motive fluid be thereby cut off both from the piston-chamber and from the upper end of the valve-chamber, and the latter will be opened to the exhaust by the uncovering of the port M by the front end of the piston-stem I. The motive fluid at the upper side of the valve will thereupon escape and the valve be lifted by the constant pressure beneath it, thereby closing the exhaust at the rear end of the piston-chamber and admitting motive fluid thereto from the inlet-passage D, Fig. 2. The rearward movement of the piston due both to its rebound from contact with the shank of the chisel and to the motive fluid admitted to the front end of the large piston-chamber from the duct K will be arrested by this admission of motive fluid to the rear end of the large piston-chamber, which motive fluid acting upon the full area of the rear end of the piston will drive the latter forward again to deliver the next blow to the chisel or other working tool. As the piston moves forward the front end of the passage K and the port N will be uncovered by the reduced portion J of the piston-stem and motive fluid be again admitted to the large piston-chamber in front of the piston-head and also to the upper side of the valve. The valve will thereupon be forced downward, thereby opening the exhaust from the rear end of the piston-chamber, but the piston will continue its forward movement under its own momentum and the expanding pressure behind it and strike the shank of the chisel, as in Fig. 1, whereupon it will rebound and be forced rearward again by the motive fluid admitted from the duct K, and thus continue to reciprocate back and forth, delivering a blow to the shank of the chisel at the end of each of its forward strokes.

As will be understood from the foregoing description, the piston in its forward movement opens the forward end of a duct which is constantly filled with motive fluid and permits such motive fluid to pass into the front end of the large piston-chamber, and also places said duct in communication with a passage leading to the large end of the valve, to thereby admit motive fluid to said end of the valve to overcome the constant pressure against the opposite end of the valve and move the latter to exhaust position, and as the piston moves rearward it cuts off the motive fluid from said passage leading to the larger area of the valve and opens said passage to the exhaust, and also cuts off the motive fluid from the forward end of the large piston-chamber.

In the accompanying drawings I have shown in dotted lines an additional passage S, leading forward from the upper side of the valve-chamber through the wall of the cylinder, being a passage employed in my former tool and illustrated and described in my prior patent, No. 549,102, but not essential to the operation of my present tool owing to the omission of the check-valve. This passage communicates at its rear end with the upper side of the valve-chamber and opens at its extreme forward end into the small piston-chamber at T. It also opens about midway of its length into the large piston-chamber by a port U. So far as concerns the portion of this passage which extends forward from the port I, it constitutes in the present tool an exhaust-passage for the front end of the large piston-chamber, through which the motive fluid in the front end of the large pis-

ton-chamber may escape when at the rearward movement of the piston the head H of the latter passes rearward of and uncovers the port U, and during the forward movement of the piston it permits the air in front of the piston-head to escape until the piston-head rides over and covers the port T. Inasmuch as the motive fluid can in any event act upon only a small area of the piston in moving the latter rearward, (the annular front end of the head H,) while it acts upon the full area of the piston in driving the piston forward, it is not essential to the operation of the tool that there should be any exhaust from the front end of the large piston-chamber, although I have found the provision of such exhaust advantageous in my former tool, and hence have illustrated it in my present tool. It will be manifest, however, that the presence or absence of such exhaust-passage will not affect in any manner the coöperation of piston and valve in the manner and by the means above described.

So far as concerns the portion of the passage S in rear of the port U, its sole function in the present tool is to open the upper side of the valve-chamber to the exhaust when the piston makes an extreme or abnormal forward stroke, to thereby automatically stop the reciprocations of the piston while permitting continued reciprocations of the valve, as fully explained in my former patent, No. 549,102, and this feature of the tool, while advantageous for the purpose specified, is not in any manner essential to the operation of the tool in other respects.

The passage S and ports U T may be entirely omitted and their functions retained by providing a port between the duct L and large piston-chamber at a point opposite the location of the port U in the drawings.

Having thus fully described my invention, I claim—

1. A pneumatic hammer comprising a cylinder formed at its front end to receive the shank of the working tool and having a grasping-handle secured to its rear end, a valve-chamber separate from the piston-chamber in said cylinder and located at the rear end thereof, two longitudinal passages in the cylinder-wall communicating at their rear ends with the motive-fluid supply and with the valve-chamber, respectively, a piston-controlling valve located in the valve-chamber, and a hammering-piston located in the piston-chamber and operating at its forward stroke to place the front ends of the two longitudinal passages in communication with each other and thereby admit motive fluid to the valve-chamber to shift the valve in one direction, and operating at its rearward stroke to cut off such communication and open the exhaust from the valve-chamber to permit the valve to be shifted in the opposite direction, substantially as described.

2. A pneumatic hammer comprising a cylinder formed at its front end to receive the shank of the working tool and having a grasping-handle secured to its rear end, a valve-chamber separate from the piston-chamber in said cylinder and located at the rear end thereof, two longitudinal passages in the cylinder-wall communicating at their rear ends with the motive-fluid supply and with the valve-chamber, respectively, a piston-controlling valve located in the valve-chamber, and a hammering-piston located in the piston-chamber and provided with a circumferential groove registering with the front ends of the longitudinal passages at the forward stroke of the piston, to place said passages in communication with each other and admit motive fluid to the valve-chamber to shift the valve in one direction, said piston operating at its rearward stroke to cut off such communication and open a passage from the valve-chamber to the exhaust to permit the valve to be shifted in the opposite direction, substantially as described.

3. A pneumatic hammer comprising a cylinder formed at its front end to receive the shank of the working tool and having a grasping-handle secured to its rear end, a valve-chamber separate from the piston-chamber in said cylinder and located at the rear end thereof, a differential-piston-controlling valve located in said valve-chamber and to the smaller area of which the motive fluid is constantly admitted, two longitudinal passages in the cylinder-wall communicating at their rear ends with the motive-fluid supply and with the larger area of the valve, respectively, and a hammering-piston located in the piston-chamber and operating at its forward stroke to place the front ends of the two longitudinal passages in communication with each other and thereby admit motive fluid to the larger area of the valve, to shift the valve in one direction, and operating at its rearward stroke to open an exhaust from said larger area of the valve, to permit it to be shifted in the opposite direction, substantially as described.

4. A pneumatic hammer comprising a cylinder formed at its front end to receive the shank of the working tool and having a grasping-handle secured to its rear end, a valve-chamber separate from the piston-chamber in said cylinder and located at the rear end thereof, a differential-piston-controlling valve located in said valve-chamber and to the smaller area of which the motive fluid is constantly admitted, two longitudinal passages formed in the cylinder-wall and communicating at their rear ends with the motive-fluid supply and with the larger area of the valve, respectively, and a piston located in the piston-chamber and provided with a circumferential groove adapted to register with the front ends of the two longitudinal passages at the forward stroke of the piston, to place said passages in communication with each other and admit the motive fluid to the larger area of the valve to shift the same in one di-

rection, said piston operating at its rearward stroke to open an exhaust from said larger area of the valve, to permit the valve to be shifted in the opposite direction, substantially as described.

5. A pneumatic hammer comprising a cylinder formed at its front end to receive the shank of the working tool and having a grasping-handle secured to its rear end, a valve-chamber separate from the piston-chamber in said cylinder and located at the rear end thereof, a differential-piston-controlling valve located in said valve-chamber and to the smaller area of which the motive fluid is constantly admitted, a longitudinal live-air passage formed in the cylinder-wall and communicating at its rear end with the motive-fluid supply, a second longitudinal passage formed in the cylinder-wall and communicating at its rear end with the larger area of the valve and opening at its forward end into the piston-chamber by two separate ports, and a hammering-piston located in the piston-chamber and provided with a circumferential groove adapted at the forward stroke of the piston to register with the front end of the live-air passage and with the rearmost port of the other passage, to place said passages in communication with each other and admit the motive fluid to the larger area of the valve, to shift the latter in one direction, said piston operating at its rearward stroke to cut off such communication and uncover the forward port of the passage leading to the larger area of the valve and thereby place said area of the valve in communication with the exhaust, to permit the valve to be shifted in the opposite direction, substantially as described.

6. A pneumatic hammer comprising a cylinder containing a piston-chamber and formed at its front end to receive the shank of the working tool, a separate valve-block located at the rear end of the cylinder and containing a valve-chamber separate from the piston-chamber, a grasping-handle secured to the rear end of the cylinder and serving to hold the valve-block in place, a piston-controlling valve located in the valve-chamber in said valve-block, two longitudinal passages formed in the cylinder-wall and valve-block and communicating at their rear ends with the valve-chamber and with the motive-fluid supply, respectively, and a hammering-piston located in the piston-chamber and operating at its forward stroke to place the front ends of said passages in communication with each other and thereby admit the motive fluid to the valve-chamber to shift the valve in one direction, and operating at its rearward stroke to cut off such communication and open the valve-chamber to the exhaust, to permit the valve to be shifted in the opposite direction, substantially as described.

7. A pneumatic hammer comprising a cylinder containing a piston-chamber and formed at its front end to receive the shank of the working tool, a separate valve-block located at the rear end of the cylinder and containing a valve-chamber separate from the piston-chamber, a grasping-handle secured to the rear end of the cylinder and serving to hold the valve-block in place, a piston-controlling valve located in the valve-chamber in said valve-block, two longitudinal passages formed in the cylinder-wall and valve-block and communicating at their rear ends with the valve-chamber and with the motive-fluid supply, respectively, and a hammering-piston located in the piston-chamber and provided with a circumferential groove adapted at the forward stroke of the piston to register with the front ends of said passages and place them in communication with each other, and thereby admit motiye fluid to the valve-chamber to shift the valve in one direction, said piston operating at its rearward stroke to cut off such communication and open the valve-chamber to the exhaust, to permit the valve to be shifted in the opposite direction, substantially as described.

8. A pneumatic hammer comprising a cylinder containing a piston-chamber and formed at its front end to receive the shank of the working tool, a separate valve-block located at the rear end of the cylinder and containing a valve-chamber separate from the piston-chamber, a grasping-handle secured to the rear end of the cylinder and serving to hold the valve-block in place, a differential-piston-controlling valve located in said valve-chamber and to the smaller area of which the motive fluid is constantly admitted, two longitudinal passages formed in the cylinder-wall and valve-block and communicating at their rear ends with the motive-fluid supply and with the larger area of the valve, respectively, and a hammering-piston located in the piston-chamber and operating at its forward stroke to place the front ends of the two longitudinal passages in communication with each other and thereby admit motive fluid to the larger area of the valve to shift the valve in one direction, and operating at its rearward stroke to open an exhaust from said larger area of the valve, to permit the valve to be shifted in the opposite direction, substantially as described.

9. A pneumatic hammer comprising a cylinder containing a piston-chamber and formed at its front end to receive the shank of the working tool, a separate valve-block located at the rear end of the cylinder and containing a valve-chamber separate from the piston-chamber, a grasping-handle secured to the rear end of the cylinder and serving to hold the valve-block in place, a differential-piston-controlling valve located in the valve-chamber in said valve-block and to the smaller area of which the motive fluid is constantly admitted, two longitudinal passages formed in the cylinder-wall and valve-block and communicating at their rear ends with the larger area of the valve and with the motive-fluid supply, respectively, and a hammering-piston

located in the piston-chamber and provided with a circumferential groove adapted at the forward stroke of the piston to register with the front ends of said passages and place them in communication with each other, and thereby admit motive fluid to the larger area of the valve to shift the valve in one direction, said piston operating at its rearward stroke to cut off such communication and open the valve-chamber to the exhaust, to permit the valve to be shifted in the opposite direction, substantially as described.

10. A pneumatic hammer comprising a cylinder containing a piston-chamber and formed at its front end to receive the shank of the working tool, a separate valve-block located at the rear end of the cylinder and containing a valve-chamber separate from the piston-chamber, a grasping-handle secured to the rear end of the cylinder and serving to hold the valve-block in place, a differential-piston-controlling valve located in the valve-chamber in said valve-block, a longitudinal live-air passage formed in the cylinder-wall and valve-block and communicating at its rear end with the motive-fluid supply, a second longitudinal passage also formed in the cylinder-wall and valve-block and communicating at its rear end with the larger area of the valve and opening at its forward end into the piston-chamber by two separate ports, and a hammering-piston located in the piston-chamber and provided with a circumferential groove adapted at the forward stroke of the piston to register with the front end of the live-air passage and with the rearmost port of the other passage, to place said passages in communication with each other and admit the motive fluid to the larger area of the valve, to shift the latter in one direction, said piston operating at its rearward stroke to cut off such communication and uncover the forward port of the passage leading to the larger area of the valve and thereby place said area of the valve in communication with the exhaust, to permit the valve to be shifted in the opposite direction, substantially as described.

11. A pneumatic hammer comprising a cylinder containing a differential-piston chamber and formed at its front end to receive the shank of the working tool and having a grasping-handle secured to its rear end, a valve-chamber located at the rear end of the piston-chamber, two longitudinal passages formed in the cylinder-wall and communicating at their rear ends with the motive-fluid supply and with the valve-chamber, respectively, a piston-controlling valve located in the valve-chamber, and a differential hammering-piston located in the piston-chamber and operating at its forward stroke to place the front ends of the two longitudinal passages in communication with each other and thereby admit motive fluid to the valve-chamber to shift the valve in one direction, and operating at its rearward stroke to cut off such communication and open the exhaust from the valve-chamber to permit the valve to be shifted in the opposite direction, substantially as described.

12. A pneumatic hammer comprising a cylinder containing a differential-piston chamber and formed at its front end to receive the shank of the working tool and having a grasping-handle secured to its rear end, a valve-chamber located at the rear end of the piston-chamber, two longitudinal passages formed in the cylinder-wall and communicating at their rear ends with the motive-fluid supply and with the valve-chamber, respectively, a piston-controlling valve located in the valve-chamber, and a differential hammering-piston located in the piston-chamber and provided with a circumferential groove adapted to register with the front ends of the longitudinal passages at the forward stroke of the piston, to place said passages in communication with each other and admit motive fluid to the valve-chamber to shift the valve in one direction, said piston operating at its rearward stroke to open the exhaust from the valve-chamber to permit the valve to be shifted in the opposite direction, substantially as described.

13. A pneumatic hammer comprising a cylinder containing a differential-piston chamber and formed at its front end to receive the shank of the working tool and having a grasping-handle secured to its rear end, a valve-chamber located at the rear end of said piston-chamber, a piston-controlling valve located in the valve-chamber, a longitudinal live-air passage formed in the cylinder-wall and communicating at its rear end with the motive-fluid supply, a second longitudinal passage formed in the cylinder-wall and communicating at its rear end with the valve-chamber and opening at its forward end into the smaller portion of the differential-piston chamber, and a differential hammering-piston located in the piston-chamber and provided with a circumferential groove adapted at the forward stroke of the piston to register with the front end of the live-air passage and with a port opening from the other longitudinal passage into the smaller portion of the piston-chamber, to place said passages in communication with each other and admit the motive fluid to the valve-chamber, to shift the valve in one direction, said piston operating at its rearward stroke to cut off such communication and place the passage leading to the valve-chamber in communication with the exhaust, to permit the valve to be shifted in the opposite direction, substantially as described.

14. A pneumatic hammer comprising a cylinder containing a differential-piston chamber and formed at its front end to receive the shank of the working tool and having a grasping-handle secured to its rear end, a valve-chamber located at the rear end of said piston-chamber, a differential-piston-controlling valve located in said valve-chamber and to

the smaller area of which the motive fluid is constantly admitted, two longitudinal passages formed in the cylinder-wall and communicating at their rear ends with the motive-fluid supply and with the larger area of the valve, respectively, and a differential hammering-piston located in the piston-chamber and operating at its forward stroke to place the front ends of the two longitudinal passages in communication with each other and thereby admit motive fluid to the larger area of the valve, to shift the valve in one direction, and operating at its rearward stroke to cut off such communication and open the exhaust from the larger area of the valve, to permit the valve to be shifted in the opposite direction, substantially as described.

15. A pneumatic hammer comprising a cylinder containing a differential-piston chamber and formed at its front end to receive the shank of the working tool and having a grasping-handle secured to its rear end, a valve-chamber located at the rear end of said piston-chamber, a differential-piston-controlling valve located in said valve-chamber and to the smaller area of which the motive fluid is constantly admitted, two longitudinal passages formed in the cylinder-wall and communicating at their rear ends with the motive-fluid supply and with the larger area of the valve, respectively, and a differential hammering-piston located in the piston-chamber and provided with a circumferential groove adapted at the forward stroke of the piston to register with the front ends of the two longitudinal passages, to place said passages in communication with each other and admit motive fluid to the larger area of the valve, to shift the valve in one direction, said piston operating at its rearward stroke to cut off such communication and open the exhaust from the larger area of the valve, to permit the valve to be shifted in the opposite direction, substantially as described.

16. A pneumatic hammer comprising a cylinder containing a differential-piston chamber and having its front end formed to receive the shank of the working tool and having a grasping-handle secured to its rear end, a separate valve-block located at the rear end of the cylinder and containing a valve-chamber, a piston-controlling valve located in said chamber, two longitudinal passages formed in the cylinder-wall and valve-block and communicating at their rear ends with the motive-fluid supply and with the valve-chamber, respectively, and a differential hammering-piston located in the piston-chamber and operating at its forward stroke to place the front ends of the two longitudinal passages in communication with each other and thereby admit motive fluid to the valve-chamber to shift the valve in one direction, and operating at its rearward stroke to cut off such communication and open the exhaust from the valve-chamber to permit the valve to be shifted in the opposite direction, substantially as described.

17. A pneumatic hammer comprising a cylinder containing a differential-piston chamber and having a grasping-handle secured to its rear end, a separate valve-block located at the rear end of the cylinder and containing a valve-chamber, a piston-controlling valve located in said chamber, two longitudinal passages formed in the cylinder-wall and valve-block and communicating at their rear ends with the motive-fluid supply and with the valve-chamber, respectively, and a differential hammering-piston located in the piston-chamber and provided with a circumferential groove registering at the forward stroke of the piston with the front ends of the two longitudinal passages to place them in communication with each other and thereby admit motive fluid to the valve-chamber to shift the valve in one direction, said piston operating at its rearward stroke to cut off such communication and open the exhaust from the valve-chamber to permit the valve to be shifted in the opposite direction, substantially as described.

18. A pneumatic hammer comprising a cylinder containing a differential-piston chamber and having its front end formed to receive the shank of the working tool and having a grasping-handle secured to its rear end, a separate valve-block located at the rear end of the cylinder and containing a valve-chamber, a piston-controlling valve located in said chamber, a live-air passage extending longitudinally through the cylinder-wall and valve-block and communicating at its rear end with the motive-fluid supply, a second passage extending longitudinally through the cylinder-wall and valve-block and communicating at its rear end with the valve-chamber and opening by a port into the smaller portion of the differential-piston chamber, and a differential hammering-piston located in the piston-chamber and provided with a circumferential groove passing at the forward stroke of the piston into the smaller portion of the differential-piston chamber and registering with the front end of the live-air passage and with the port of the passage leading to the valve-chamber, to place said passages in communication with each other and admit motive fluid to the valve-chamber to shift the valve in one direction, said piston operating at its rearward stroke to cut off such communication and open the passage leading to the valve-chamber to the exhaust, to permit the valve to be shifted in the opposite direction, substantially as described.

19. In a pneumatic hammer, the combination of a cylinder, a piston located therein, and a differential-piston valve located in a chamber at the rear end of the piston-chamber and controlling the inlet and exhaust of the motive fluid at the rear end of the piston-chamber, and to the smaller area of which

valve the motive fluid is constantly admitted, said cylinder being provided with two longitudinal passages communicating at their rear ends with the motive-fluid supply and with the larger area of the valve, respectively, and the piston operating at its stroke in one direction to place the two passages in communication and thereby admit motive fluid to the larger area of the valve, and operating at its stroke in the opposite direction to open the exhaust from said larger area of the valve, substantially as and for the purpose described.

20. In a pneumatic hammer, the combination of a cylinder containing a piston-chamber having a forward portion of less diameter than its rear portion, a differential piston located in said chamber, and a differential-piston valve located in a chamber at the rear end of the piston-chamber and controlling the inlet and exhaust of the motive fluid at the rear end of the piston-chamber, the motive fluid being constantly admitted to the smaller area of said valve and intermittently admitted to its larger area, and the cylinder being provided with two longitudinal passages opening at their forward ends into the smaller portion of the piston-chamber and at their rear ends communicating, respectively, with the motive-fluid supply and with the larger area of the valve, and the piston operating at its forward stroke to place the two passages in communication with each other and thereby admit motive fluid to the larger area of the valve, and operating at its rearward stroke to open the exhaust from the larger area of the valve, substantially as described.

21. In a pneumatic hammer, the combination of a cylinder containing a piston-chamber having the forward portion of less diameter than its rear portion, a differential piston located in said chamber and composed of an enlarged head fitting in the larger portion of the chamber and a reduced forwardly-projecting stem adapted to fit and travel in the smaller portion of the chamber, and provided intermediate said head and stem with a reduced portion of less diameter than said stem, and a differential valve located in a chamber at the rear end of the piston-chamber and controlling the inlet and exhaust at the rear end of the piston-chamber, to the smaller area of which valve the motive fluid is constantly admitted and to the larger area of which it is intermittently admitted, said cylinder being provided with two longitudinal passages opening at their forward ends into the smaller portion of the piston-chamber and at their rear ends communicating, respectively, with the motive-fluid supply and with the larger area of the valve, the stem of the piston controlling the ports at the forward ends of said passages and operating at the forward stroke of the piston to place them in communication with each other and at its rearward stroke to cut off communication between them and open the exhaust from the larger area of the valve, substantially as described.

22. In a pneumatic hammer, the combination of a cylinder containing a piston-chamber having a forward portion of less diameter than its rear portion, a differential piston located in said chamber, and a differential valve located in a chamber at the rear end of the piston-chamber and controlling the inlet and exhaust of the motive fluid at the rear end of the piston-chamber, to the smaller area of which valve the motive fluid is constantly admitted and to the larger area of which it is intermittently admitted, said cylinder being provided with two passages opening at their forward ends into the smaller portion of the piston-chamber and at their rear ends communicating, respectively, with the motive-fluid supply and with the larger area of the valve, and the piston operating at its forward stroke to place the former of such passages in communication with the passage leading to the larger area of the valve and with the larger portion of the piston-chamber, and operating at its rearward stroke to cut off such communication and open the larger area of the valve to the exhaust, substantially as described.

23. In a pneumatic hammer, the combination of a cylinder containing a piston-chamber having a forward portion of less diameter than its rear portion, a differential piston located in said chamber, and a differential valve located in a chamber at the rear end of the piston-chamber and controlling the inlet and exhaust at the rear end of the piston-chamber, to the smaller area of which valve the motive fluid is constantly admitted and to the larger area of which it is intermittently admitted, said cylinder being provided with two longitudinal passages opening at their forward ends into the smaller portion of the piston-chamber and at their rear ends communicating, respectively, with the motive-fluid supply and with the larger area of the valve, and also provided with an exhaust-passage opening at its forward end into the smaller portion of the piston-chamber and at its rear end into the larger portion thereof, and the piston operating at its forward stroke to close said exhaust-passage and to place the motive-fluid passage in communication both with the front end of the large piston-chamber and with the passage leading to the larger area of the valve, and operating at its rearward stroke to cut off such communication and to open both the front end of the larger piston-chamber and the larger area of the valve to the exhaust, substantially as described.

24. In a pneumatic hammer, the combination of the cylinder A containing the differential-piston chamber, the piston fitting therein and composed of the head H, stem I, and intermediate reduced portion J, the valve-chamber located at the rear end of the cylinder A

and containing the differential-piston valve O, the handle B having the inlet-passage D and exhaust-passage Q, the former of which is in constant communication with the smaller area of the valve O, and both of which are alternately placed in communication with the rear end of the piston-chamber by the movement of the valve, the cylinder A being also provided with the two longitudinal passages L and K, both opening at their forward ends into the smaller portion of the piston-chamber, and the former communicating at its rear end with the inlet-passage D and the latter communicating at its rear end with the larger area of the valve, and the front ends of said passages being placed in communication at the forward stroke of the piston by the interposition between them of the reduced portion J of the piston, the rearward stroke of the piston cutting off such communication by the interposition between them of its stem I, and opening the front end of the passage L to the exhaust, substantially as described.

25. In a pneumatic hammer, the combination of the cylinder A containing the differential-piston chamber, the piston fitting therein and composed of the head H, stem I, and intermediate reduced portion J, the valve-chamber located at the rear end of the cylinder A and containing the differential-piston valve O, the handle B having the inlet-passage D and exhaust-passage Q, the former of which is in constant communication with the smaller area of the valve O, and both of which are alternately placed in communication with the rear end of the piston-chamber by the movement of the valve, the cylinder A being also provided with the two longitudinal passages K and L, both opening at their forward ends into the smaller portion of the piston-chamber, and the former communicating at its rear end with the inlet-passage D and the latter communicating at its rear end with the larger area of the valve, said cylinder being also provided with a third longitudinal passage opening at its forward end into the smaller portion of the piston-chamber and at its rear end into the larger portion thereof, and the portions I and J of the piston serving to control the forward ends of all three of said passages, in the manner and for the purpose described.

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Witnesses:
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