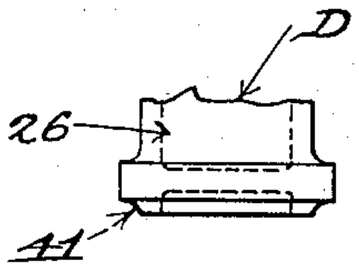
G. L. BADGER.

PNEUMATIC IMPACT TOOL.

APPLICATION FILED JAN. 6, 1906.

904,827. Patented Nov. 24, 1908.

Fig. 8.



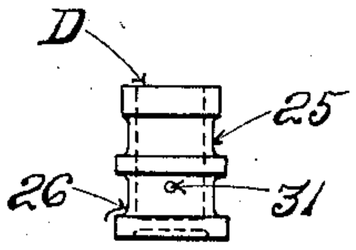
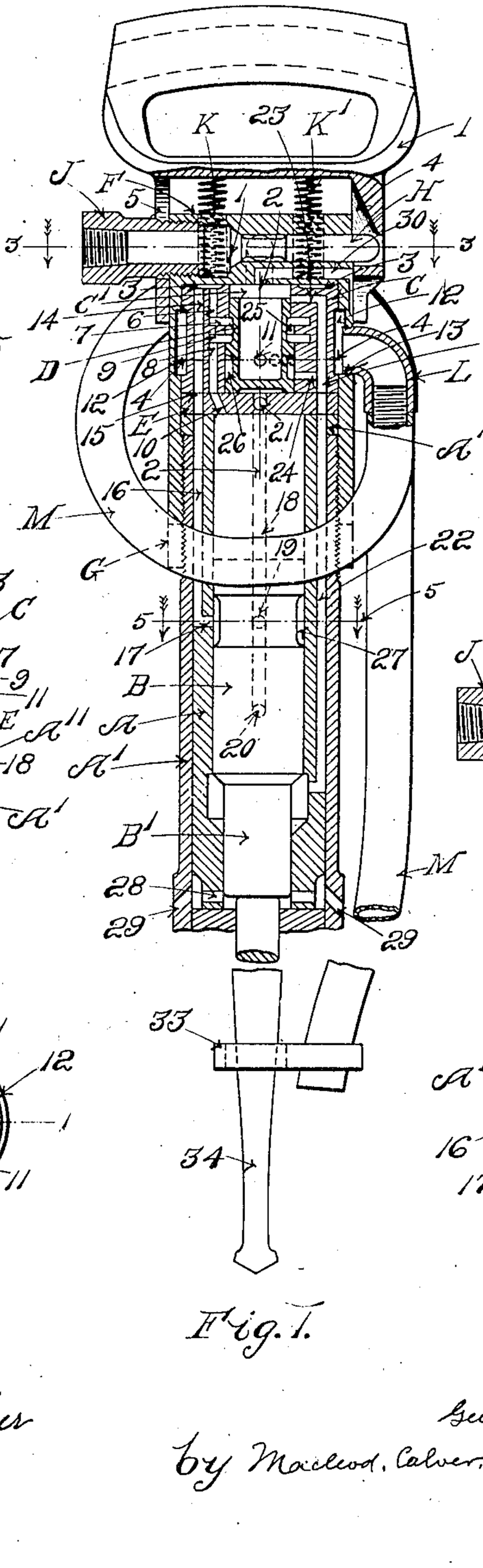


Fig. 6.



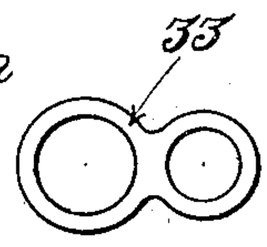


Fig. 7.

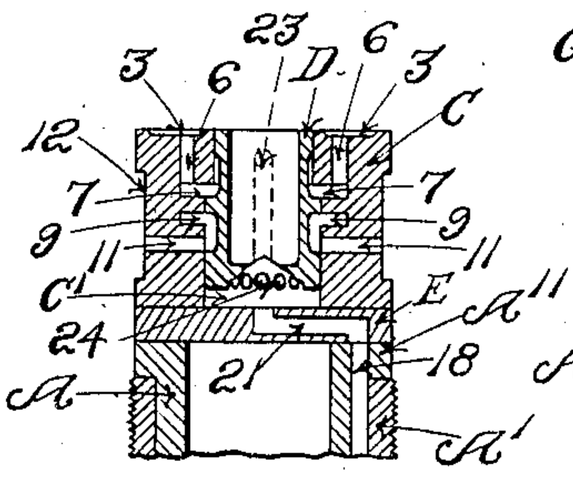


Fig. 2.

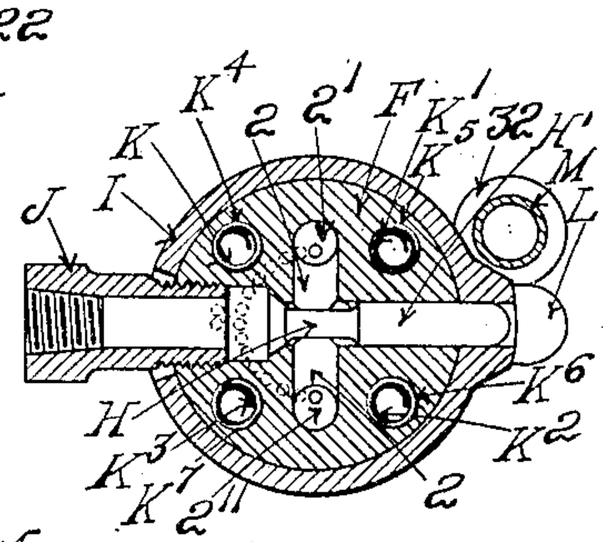


Fig. 3

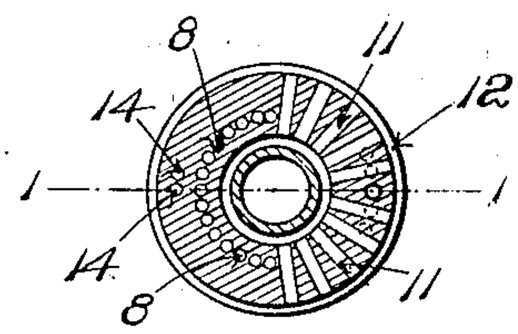


Fig. 4.

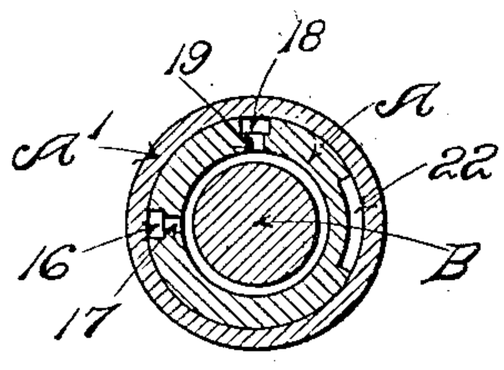


Fig. 5.

Fig. 1.

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UNITED STATES PATENT OFFICE.

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PNEUMATIC IMPACT-TOOL.

No. 904,827. Specification of Letters Patent. Patented Nov. 24, 1908.

Application filed January 6, 1906. Serial No. 294,916.

To all whom it may concern:

Be it known that I, GEORGE L. BADGER, citizen of the United States, residing at Quincy, in the county of Norfolk, State of Massachusetts, have invented a certain new and useful Improvement in Pneumatic Impact-Tools, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to improvements in pneumatic impact tools.

The principal features of the present invention relate to an improved form of valve for controlling the movements of the piston, the valve being quickly actuated, light and strong, and having a large area of port opening with a comparatively small diameter of valve and short travel or movement; and a throttle-valve for controlling the initial admission of motive fluid to the tool, which is operated by a longitudinal movement of the grasping-handle, the assembled parts requiring less than the usual length needed for the grasping-handle and throttle-valve in tools of this class.

The controlling-valve is made with bearing surfaces of different diameters and provided with two annular grooves, one of said grooves being in the small diameter of the valve and always open to fluid pressure, which acting on the groove walls of different areas always tends to press the valve in a forward direction. The other groove is in the larger diameter of the valve and is always open to the atmosphere through ports in the valve-block. The construction is such that the motive fluid which might escape from the inlet-port or groove, in the small diameter of the valve, past the large bearing surface will enter the exhaust groove in the large diameter of the valve and pass through the exhaust-ports in the valve-block, so that it cannot reach the large area or pressure surface of the valve to interfere with the proper operation of the valve.

With the construction and arrangement of grooves or ports in the valve and valve-block, the area of the larger pressure surface of the valve can be made much greater than the effective area pressing the valve forward, even with a valve of comparatively small diameter, so that when air is admitted to the larger area it moves the valve backward very quickly, thereby increasing the piston speed over that of a slower moving valve.

The diameters of the valve can be made so that the effective area for moving the valve forward will be very slight. The rush of air against the forward wall of the inlet-groove of the valve always tends to move the valve forward, and owing to the great difference of the opposing pressure areas I obtain a very quick moving valve, which as before stated may be of comparatively small diameter having grooves and port areas of large capacity. It is obvious that, other things being equal, a valve with a small diameter is much to be preferred to a valve of large diameter.

I also provide means whereby the smaller end of the valve is always open to the atmosphere. I prefer to connect the smaller end of the valve-chamber with the atmosphere by a passage in the retaining-head of the valve-block.

I prefer to make the valve in the form of a tubular shell closed at one end; it may however be made solid. The tubular construction is used simply to reduce the weight of the valve and is not essential to the broader scope of the invention.

In some instances it is desirable to provide port openings of very large area, especially the port connecting with the rear end of the pison-chamber. To accomplish this it has heretofore been necessary to use valves of comparatively large diameter provided with inlet or exhaust ports through the interior of the valve, or through the walls thereof. The latter construction greatly weakens the valve which is liable to be broken by the constant hammering action to which the valve is subjected when in operation.

I am enabled to provide the greatest possible area of valve port opening, for supplying and exhausting the motive fluid to the rear end of the piston-chamber with a given diameter and movement of the valve. When the tubular form of valve is employed I can, if desired, connect the interior of the valve by a small hole with the annular exhaust groove on the exterior of the valve, in order to prevent any accumulation of fluid pressure on the small end of the valve which might leak by the joints or bearing surfaces. In this case it will not be necessary to connect the rear end of the valve-chamber with the atmosphere exteriorly to the valve.

It is desirable in some instances that the operation of the throttle-valve be controlled

by the action of pressing the tool to the work. With this object in view I provide a grasping-handle mounted on the retaining-head and longitudinally movable thereon and adapted to engage the throttle-valve to unseat the latter when the grasping-handle is pushed forward. I arrange the throttle-valve transversely to the bore of the piston-chamber in order to shorten the length of the tool. I provide the working cylinder in the present instance with an outer jacket which is in threaded engagement at its rear end with the retaining-head. In order to prevent longitudinal displacement of the cylinder in a forward direction, due to the piston striking the forward end of the cylinder when the working-tool is not in position, I provide the cylinder at its rear end with a flange adapted to engage the rear end of the jacket. When the parts are in assembled position, the retaining-head serves to prevent rearward displacement of the cylinder.

When tools of this type are employed for drilling holes in stone, it is customary to provide a flexible hose arranged to conduct a part of the exhaust to the lower end of the working-tool to force the dust from the hole being drilled.

In practice much difficulty is experienced in properly clearing the hole on account of the varying lengths of the working-tools. In order to accomplish the result desired, the end of the hose must be at the proper distance from the stone.

The working-tool is dulled quickly, and has to be replaced by a sharp one. With the object in view of avoiding the difficulty above mentioned, I provide means whereby the hose can be quickly adjusted for varying lengths of working-tools, so that the end of the hose will be at the proper distance from the stone.

My invention further consists of novel details of construction, all as will be hereinafter more fully described and pointed out in the claims.

In the drawings,—Figure 1 is a longitudinal central section on line 1—1 of Fig. 4 of a tool embodying the invention, partly broken away, the valve being in its forward position. Fig. 2 is a longitudinal central section of the valve-block and upper portion of the cylinder on line 2—2 of Fig. 1, showing a portion of the valve broken away and in its rearward position. Fig. 3 is a section on line 3—3 of Fig. 1. Fig. 4 is a section on line 4—4 of Fig. 1. Fig. 5 is a section on line 5—5 of Fig. 1. Fig. 6 is an elevation showing a modification of valve. Fig. 7 is a detail plan of the hose supporter which has a loop through which the work-tool passes. Fig. 8 is a detail view on an enlarged scale of a portion of the valve to show the chamfered end.

The tool comprises a cylinder A, an outer casing or jacket A′, a piston or hammer B which moves in the cylinder, a valve-block C at the rear end of the cylinder formed with a chamber C′, a valve D located and moving in said chamber, a head or plate E for the cylinder, a retaining-head F, for the valve-block, which is in threaded engagement with the jacket A′, and a jam nut G to prevent the retaining-head unscrewing from the jacket. The cylinder A is of smaller external diameter at its forward end, thereby forming an annular exhaust chamber between said diameter and the bore of the jacket.

The retaining-head is provided with a bore 1 of different diameters, transverse to the bore of the cylinder, the larger diameter being adapted to be connected with a source of fluid pressure supply (not shown). Passages 2, 2′, 2″, connect the bore 1 with an annular groove 3 in the rear end of the valve-block.

A throttle-valve H is mounted in the bore of the retaining-head; the small end H′ of the valve projects beyond the head and is engaged by the inclined surface 4 of the grasping-handle I. Said grasping-handle is movably mounted on the retaining-head and is retained thereon by the nipple J through which the motive fluid is supplied to the tool. Said nipple J passes loosely through a hole 5 in the side of the grasping-handle. Said hole 5 is made oblong in vertical section to allow the grasping-handle to move longitudinally on the retaining-head.

K, K′, K², are springs that normally hold the grasping-handle in a rearward position. The lower ends of said springs are seated in sockets K³, K⁴, K⁵, in the head. The parts are arranged so that the throttle-valve will be moved sufficiently to supply fluid to the tool before the grasping-handle reaches the forward limit of its movement, whereby the relative forward movement of the grasping-handle is cushioned by the springs and the jar and vibration of the tool is to a large extent absorbed by the springs without being transmitted to the hand of the operator.

The part H′ of the throttle-valve is a close working fit in the small bore of the retaining head to prevent the escape of motive fluid and keep the large end or head of the valve in alinement with the bore when the valve is unseated.

When the grasping-handle is pushed forward the inclined surface 4 moves the valve away from its seat, and the motive fluid passes through the passages 2, 2′ and 2″ to the annular groove 3 in the valve-block.

The valve-block is provided with a passage or series of holes 6 connecting the groove 3 with an internal annular groove or inlet-port 7 in the larger bore of the valve-block, and is also provided with a passage or

series of holes 8, leading from the internal annular groove 9 in the valve-block, which register with a passage or series of holes 10 through the plate E opening into the rear end of the piston-chamber. An exhaust-port or series of ports 11 connects the large bore of the valve-block with the exterior exhaust-groove 12 of the said block. The retaining-head is provided with an exhaust-port 13 which is threaded to receive an elbow or connection L to which is attached a flexible hose M.

The groove 3 is connected by a passage or passages 14 in the valve-block and is connected by a passage or passages 15 through the plate E with a passage 16 in the wall of the cylinder which opens into the interior of the cylinder through the port 17.

A passage 18 in the wall of the cylinder is provided with two ports 19 and 20 opening into the bore of the cylinder. Said passage is connected by a passage 21 in the plate E with the large bore of the valve-block. The passage 22 leads from the forward end of the piston-chamber and connects with passage 22^a in the valve-block. Ports 23, 24, open from passage 22^a into the bore of the valve-block. The port 24 is of larger capacity than the port 23, as shown in Fig. 2, the valve being broken away. The port 24, as shown, is formed by a series of holes and the passage 14, as shown in Fig. 4, is formed by two holes, but it will be understood that in each case a single passage or port of sufficient capacity may be provided. The exhaust-ports 11 in the valve-block may be connected together to form a single port, and I do not wish to limit myself in every instance to a plurality of ports. The valve D is of different diameters and is provided with an annular groove 25 formed between the large and small diameters which is always open to the inlet-port 7. The valve is provided with an annular groove 26 at its large diameter which is always open to the exhaust-ports 11 in the valve-block.

When the valve D is in a forward position, as shown in Fig. 1, and the grasping-handle is pushed forward, the motive fluid will pass around the head of the throttle-valve through the passages 2, 2′, 2″, to the annular groove 3, through passages 6 to the inlet-port 7, and the annular groove 25 in the valve. The fluid will pass from said groove 25 through the passages 8 and 10 to the rear end of the piston-chamber. When the piston is near the forward end of its stroke, the annular groove 27 in the piston will by ports 19 and 17 connect the passage 18 with the passage 16 which is always open to fluid prossure and the motive fluid will be supplied through passages 18 and 21 to the large area of the valve and move the latter rearward to the position shown in Fig. 2. The motive fluid will then pass from the groove 25 in the valve, through port 23 and passage 22^a to the forward end of the piston-chamber to drive the piston rearward. The forward end of the valve is preferably chamfered as shown at 41 in Fig. 8 to allow fluid pressure to pass through port 24 to maintain the valve in its rearward position. When the piston approaches the rear end of its stroke the port 20 is uncovered, or opened to the piston-chamber, by the large diameter of the piston and at the same time the small diameter B′ of the piston passes back out of the small bore of the cylinder, whereby the motive fluid in the forward end of the cylinder and valve-chamber will exhaust through a series of ports 28 in the wall of the cylinder and the ports 29 in the outer jacket A′. The area of the ports 28 and 29 is of much greater capacity than the port 23 through which the motive fluid is supplied to the forward end of the piston-chamber, and when the said end of the piston-chamber is open to said ports 28 and 29 the pressure is reduced sufficiently to allow the constantly acting pressure on the differential areas of the valve-groove 25 to move the valve forward.

When the piston is moving forward, the fluid in front of the same will pass out through the ports 28 and 29 until the small diameter of the piston enters the small bore of the cylinder. Then the fluid will pass through the passage 22 to the ports 24 and 23. The fluid from the port 24 passes through the groove 26 in the valve and the ports 11 in the valve-block to the exhaust-port 13. The fluid from the port 23 passes above the rear end of the valve to the valve-chamber.

I prefer to exhaust the fluid from the rear end of the valve-chamber through a passage 30 in the retaining-head as shown in Fig. 1, but I may omit said passage and exhaust the fluid through the interior of the valve and a small hole 31 in the wall of the latter opening into the groove 26 of the valve as shown in Fig. 6.

It is not essential that part of the fluid from the passage 22 be exhausted through the port 23. Said port may be located so that it is not open to the valve-chamber when the valve is in its forward position. The exhaust will in that event all pass through port 24. The object in providing the passage 30, or the hole 31, is to prevent any accumulation of fluid-pressure, which may leak through the joints or bearing surfaces of the valve from acting against the small diameter or end of the valve.

When the piston is moving rearward, the fluid from the rear end of the piston-chamber will pass through the passages 10 and 8 to the annular groove 9, thence through the groove 26 in the valve and ports 11 in the valve-block to the exhaust-port 13.

The cylinder A is provided at its rear end with an external flange A'' having ports therein which register with grooves cut in the outside of the cylinder forward of the flange. The outer jacket is forced on the cylinder so that its rear end will form a fluid tight joint with the forward side of the flange. The rear end of the jacket is in threaded engagement with the retaining-head which serves to prevent rearward displacement of the cylinder with relation to the jacket.

The elbow or connection L is provided with a projection or support 32, as shown in Fig. 3, said support having a bore into which the hose M fits snugly so that it will be retained in position and still can be easily drawn through the support.

The hose is passed through the support in such manner as to form a loop at the rear end of the cylinder, and the forward end of the hose is provided with a ring or loop 33 secured thereto through which the working-tool 34 passes as shown in Fig. 1. The hose is drawn through the support in one or the other direction, so that the end will be at the proper distance from the stone being drilled when working tools of varying lengths are employed.

What I claim is:—

1. In an impact-tool, a piston-chamber and piston, a valve for controlling the movements of the piston provided with an annular groove having opposing pressure surfaces of different areas to which the motive fluid is constantly admitted to press the valve in one direction, said valve having a pressure surface of still larger area to which the motive fluid is intermittently admitted to move the valve in the opposite direction, an external annular groove in the larger diameter of the valve and communication between said groove and the atmosphere externally to the valve which is constantly open.

2. In an impact-tool, a piston-chamber and piston, a valve for controlling the movements of the piston having an external annular groove which is always in communication with the atmosphere externally to the valve, said valve being provided with an annular groove having opposing pressure surfaces of different areas to which the motive fluid is constantly admitted to press the valve in one direction and a pressure surface of still larger area to which the motive fluid is intermittently admitted to move the valve in the opposite direction, said valve having one end constantly open to the atmosphere.

3. In an impact-tool, a piston-chamber and piston, a valve of different diameters for controlling the movements of the piston consisting of a tubular shell having its interior surface always open to the atmosphere and provided with opposing pressure surfaces of different areas to which the motive fluid is constantly admitted to press the valve in one direction, said valve having a pressure surface of still larger area to which the motive fluid is intermittently admitted to move the valve in the opposite direction, an external annular groove in the larger diameter of said valve, and communication between said groove and the atmosphere externally to the valve which is constantly open.

4. In an impact-tool, a piston-chamber and piston, a valve for controlling the movements of the piston consisting of a tubular shell having its interior surface always open to the atmosphere, said valve having two annular grooves, to one of which the motive fluid is constantly admitted and the other of said grooves having communication with the atmosphere externally to said valve which is constantly open.

5. In a fluid controlled impact-tool, a piston-chamber and piston, a valve provided with opposing pressure surfaces against which the motive fluid acts to move the valve in opposite directions, a valve-block having an inlet-port transverse to the bore of the block and to which the motive fluid is constantly admitted, exhaust-ports in the valve-block which are always open to the atmosphere, said valve being provided with two annular grooves, one of said grooves being always open to said inlet-port in the valve-block and the other of said grooves being always open to said exhaust-ports in the valve-block.

6. In a fluid controlled impact-tool, a piston-chamber and piston, a valve provided with opposing pressure surfaces against which the motive fluid acts to move the valve in opposite directions, a valve-block having an annular inlet-port to which the motive fluid is constantly admitted, exhaust-ports in the valve-block which are always open to the atmosphere, said valve being provided with two annular grooves, one of said grooves being always open to said annular inlet-port in the valve-block and the other of said grooves being always open to said exhaust-ports in the valve-block, said valve-block having ports and passages connected respectively with opposite ends of the piston-chamber and adapted to be brought alternately into communication with said inlet-port and exhaust-ports by the reciprocation of said valve.

7. In a fluid controlled impact-tool, a valve-block having an inlet-port and exhaust-ports, said exhaust-ports being always open to the atmosphere, a valve located in said valve-block provided with an annular groove having pressure surfaces of different areas to which the motive fluid is constantly admitted through said inlet-port to press the valve in one direction and an annular groove which is always open to said exhaust-ports

in the valve-block, said valve being provided with a pressure surface of still larger area to which the motive fluid is intermittently admitted to move the valve in the opposite direction.

8. In a fluid controlled impact-tool, a valve-block having a tubular valve therein, the interior of said valve being always open to the atmosphere, said valve-block being provided with exhaust-ports which are always open to the atmosphere, an annular groove in the valve to which the motive fluid is constantly supplied through an inlet-port in the valve-block and an annular groove in the valve which is always open to said exhaust-ports in the valve-block, said valve being provided with opposing pressure surfaces to which the motive fluid is admitted to shift the valve in opposite directions.

9. In a fluid controlled impact-tool, a valve-block having a bore of different diameters, the smaller bore being always open to the atmosphere, exhaust-ports in said valve-block opening into the bore of larger diameter, a valve located in the valve-block provided with opposing pressure surfaces of different areas to which the motive fluid is constantly admitted to press the valve in one direction and an annular groove which is always open to said exhaust-ports, said valve being provided with a pressure surface of still larger area to which the motive fluid is intermittently admitted to move the valve in an opposite direction.

10. In a fluid controlled impact-tool, a piston-chamber and piston, a valve-block having an interior annular inlet-port to which the motive fluid is constantly admitted and an interior annular groove connected by ports and passages to one end of the piston-chamber, exhaust-ports in the valve-block, ports in the valve-block in proximity to opposite ends of the valve-chamber and connected by passages with the opposite end of the piston-chamber, a valve for controlling the movements of the piston, said valve being provided with two annular grooves, one of said grooves being always open to fluid pressure and the other groove always open to said exhaust-ports, the ports connected respectively with the passages leading from opposite ends of the piston-chamber being adapted to be brought alternately into communication with said inlet-port and exhaust-ports by the reciprocation of the valve.

11. In a fluid controlled impact-tool, a piston-chamber and piston, a valve block provided with an interior annular inlet-port or groove to which the motive fluid is constantly admitted, exhaust-ports in the side walls of the valve-block, a valve adapted to control the admission of motive fluid to opposite ends of the piston-chamber and provided with two annular grooves, one of said grooves being located in the small diameter of the valve and always open to said inlet-port in the valve-block, and the other of said grooves being located in the large diameter of the valve and adapted to be alternately placed in communication with passages leading respectively to opposite ends of the piston-chamber and always open to said exhaust-ports externally to the valve.

12. In a fluid controlled impact-tool, a valve-block having a bore of different diameters, the smaller bore being always open to the atmosphere, said valve-block being provided with an interior annular inlet-port to which the motive fluid is constantly admitted and with exhaust-ports always open to the atmosphere, a valve in said valve-block provided with two annular grooves, one of said grooves being always open to said interior inlet port in the valve-block, and the other of said grooves being always open to said exhaust-ports.

13. In a fluid controlled impact-tool, a piston-chamber and piston, a valve-block provided with an inlet-port to which the motive fluid is constantly admitted and with exhaust-ports which are always open to the atmosphere, a valve for controlling the movements of the piston provided with an annular groove having opposing pressure surfaces of different areas against which the motive fluid constantly acts to press the valve in one direction, and an annular groove which is always open to said exhaust-ports, said valve being provided with a pressure surface of still larger area against which the motive fluid acts to move the valve in an opposite direction.

14. In a fluid controlled impact-tool, a piston-chamber and piston, a valve-block provided with an annular inlet-port to which the motive fluid is constantly admitted and with exhaust-ports in the side walls thereof which are always open to the atmosphere, a valve of different diameters adapted to control the admission and exhaust of motive fluid to and from opposite ends of the piston-chamber, said valve being provided with an annular groove which is always open to said annular inlet-port and an annular groove in the large diameter of the valve adapted to be alternately placed in communication with passages leading respectively to opposite ends of the piston-chamber, said groove being always open to said exhaust-ports externally to the valve.

15. In a fluid controlled impact-tool, a piston-chamber and piston, a valve-block provided with an inlet-port to which the motive fluid is constantly admitted and with exhaust-ports in the side walls thereof which are always open to the atmosphere, a valve for controlling the movements of the piston, said valve consisting of a tubular shell of different diameters having its small end and interior surface always open to the atmos-

phere and provided with an annular groove which is always open to said inlet-port and an annular groove which is always open to said exhaust-ports.

16. In a fluid controlled impact-tool, a valve-block having a bore of different diameters and an annular recess in its rearward face encircling the bore of the valve-block, an inlet-port in the valve-block located forward of said annular recess and connected by passages therewith, the smaller diameter of said bore being always open to the atmosphere, a head for the valve-block provided with a bore transverse to the bore of the valve-block to which the motive fluid is constantly admitted, said bore of the head being connected with passages which register with said recess in the valve-block whereby the motive fluid is supplied to said inlet-port.

17. In a fluid controlled impact-tool, a valve-block having a bore of different diameters, the smaller bore at its rearward end being always open to the atmosphere by an exhaust-port rearward of and exterior to the valve-block, an inlet-port opening into the larger bore and connected by passages with an annular recess in the valve-block to which the motive fluid is constantly admitted, said recess encircling the small bore of the valve-block rearward of said inlet-port.

18. In a pneumatic impact-tool, a cylinder having a flange at its rear end and provided externally with longitudinal grooves connected by port-holes with the interior of the cylinder, said flange having port-holes therein which register respectively with said grooves, said cylinder being provided with an outer jacket, said jacket being engaged at its rear end by said flange to prevent forward displacement of the cylinder with relation to the jacket.

19. In a pneumatic impact-tool, a cylinder having a flange at its rear end and provided externally with longitudinal grooves connected by port-holes with the interior of the cylinder, said flange having port-holes therein which register respectively with said grooves, said cylinder being provided with an outer jacket of greater length than the cylinder, said jacket being engaged at its rear end by said flange, said cylinder having a portion of smaller diameter at its forward end and provided with a series of holes through the walls at said forward end, said jacket having a series of holes opening into the space between said smaller end of the cylinder and the bore of the jacket.

20. In an impact-tool, a piston-chamber and piston, a valve-block provided with exhaust-ports in the side walls thereof, and with ports and passages leading respectively to opposite ends of the piston-chamber, a valve for controlling the movements of the piston, means controlled by the piston for actuating the valve, said valve being provided with two annular grooves, one of said grooves being always open to fluid pressure, the other of said grooves being always open to said exhaust-ports and adapted by the shifting of the valve to alternately connect said exhaust-ports externally to the valve, with opposite ends of the piston-chamber.

21. In an impact-tool, a piston-chamber and piston, a valve-block provided with exhaust-ports in the side walls thereof and with ports and passages leading respectively to opposite ends of the piston-chamber, a valve for controlling the movements of the piston, means controlled by the piston for actuating the valve, said valve being provided with two annular grooves, one of said grooves being always open to fluid pressure and adapted by the shifting of the valve to be alternately connected with opposite ends of the piston-chamber, the other of said grooves being always open to said exhaust-ports and adapted by the shifting of the valve to alternately connect said exhaust-ports, externally to the valve, with opposite ends of the piston-chamber.

22. In an impact-tool, a piston-chamber and piston, a valve-block provided with exhaust-ports in the side walls thereof, an inlet-port in the valve-block to which the motive fluid is constantly admitted, a valve for controlling the movements of the piston provided with two annular grooves, one of said grooves being always open to said inlet-port, the other of said grooves being always open to said exhaust-ports externally to the valve, said valve-block having ports and passages connected respectively with opposite ends of the piston-chamber which are adapted to be brought alternately by the shifting of the valve into communication with said inlet-port and with said exhaust-ports.

23. In an impact-tool, a piston-chamber and piston, a valve-block provided with exhaust-ports in the side walls thereof, an inlet-port in the valve-block to which the motive fluid is constantly admitted, a valve for controlling the movements of the piston provided with two annular grooves, one of said grooves being always open to said inlet-port, the other of said grooves being always open to said exhaust-ports externally to the valve, an annular groove in the valve-block connected by passages to one end of the piston-chamber, a passage leading from the opposite end of the piston-chamber provided with two ports, one of said ports being controlled by the valve to admit motive fluid to said opposite end of the piston-chamber and the other of said ports being controlled by the valve to exhaust fluid from said opposite end of the piston-chamber.

24. In an impact-tool, a piston-chamber and piston, a valve-block provided with an inlet-port transverse to the bore of the block

to which the motive fluid is constantly admitted and with exhaust-ports which are always open to the atmosphere, a valve for controlling the movements of the piston provided with opposing pressure surfaces of different areas and an external annular groove which is always open to said inlet-port and an external annular groove which is always open to said exhaust-ports externally to the valve, an annular groove in the valve-block connected by passages to one end of the piston-chamber, a passage leading from the opposite end of the piston-chamber provided with two ports opening into the bore of the valve-block, one of said ports being controlled by the valve to admit motive fluid to the opposite end of the piston-chamber and the other of said ports being controlled by the valve to exhaust fluid from said opposite end of the piston-chamber.

25. In an impact-tool, a piston-chamber and piston, a valve-block having a bore in alinement with the bore of the piston-chamber and provided with an inlet-port to which the motive fluid is constantly admitted, exhaust-ports in the valve-block located forward of said inlet-port, a valve provided with an annular groove which is always open to said inlet-port externally to the valve and an annular groove which is always open to said exhaust-ports externally to the valve and an interior annular groove in the valve-block located forward of said inlet-port which is connected by passages with one end of the piston-chamber.

26. In a pneumatic impact-tool, a piston-chamber and piston, a valve-block, a valve for controlling the movements of the piston provided with an external annular groove to which the motive fluid is constantly admitted, and an external annular groove which is always in communication with the atmosphere externally to the valve, a port in the valve-block connected by passages with one end of the piston-chamber, a passage leading from the opposite end of the piston-chamber provided with two ports opening into the bore of the valve-block, one of said last mentioned ports being controlled by the valve to admit motive fluid to said opposite end of the piston-chamber, and the other of said ports being controlled by the valve to exhaust fluid from said opposite end of the piston-chamber.

27. In a pneumatic impact-tool, a piston-chamber and piston, a valve-block, a valve for controlling the movements of the piston provided with an external annular groove to which the motive fluid is constantly admitted, and an external annular groove which is always in communication with the atmosphere externally to the valve, a port in the valve-block connected by passages with one end of the piston-chamber, a passage leading from the opposite end of the piston-chamber provided with two ports opening into the bore of the valve-block, one of said last mentioned ports being controlled by the valve to admit and exhaust motive fluid to and from said opposite end of the piston-chamber, and the other of said ports being controlled by the valve to exhaust fluid from said opposite end of the piston-chamber.

28. In an impact-tool, a piston-chamber and piston, a valve-block provided with exhaust-ports in the side walls thereof, an inlet-port in the valve-block to which the motive fluid is constantly admitted, a valve for controlling the movements of the piston provided with two annular grooves, one of said grooves being always open to said inlet-port, the other of said grooves being always open to said exhaust-ports externally to the valve, a port in the valve-block connected by passages with the rear end of the piston-chamber, a passage leading from the forward end of the piston-chamber provided with two ports, one of said ports being controlled by the valve to admit motive fluid to the forward end of the piston-chamber and the other of said ports being controlled by the valve to exhaust fluid from the forward end of the piston-chamber.

29. In a pneumatic impact-tool, a piston-chamber and piston, a valve-block, a valve for controlling the movements of the piston provided with an external annular groove to which the motive fluid is constantly admitted, and an external annular groove which is always in communication with the atmosphere externally to the valve, a port in the valve-block connected by passages with one end of the piston-chamber, a passage leading from the opposite end of the piston-chamber provided with two ports opening into the bore of the valve-block, one of said last mentioned ports being controlled by the valve to admit motive fluid to said opposite end of the piston-chamber, and through the other of said last mentioned ports to one end of the valve to retain it in the proper position when the motive fluid is supplied to said opposite end of the piston-chamber.

30. In an impact-tool, a solid valve-block having a bore of different diameters, the smaller bore being always open to the atmosphere, an interior annular inlet-port in the valve-block connected by passages in the block with an annular groove in the rear end of the valve-block to which the motive fluid is constantly admitted, said groove encircling the small bore of the valve-block forward of its rear end.

31. In an impact-tool, a piston-chamber and piston, a valve-block provided with exhaust-ports in the side walls thereof, an inlet-port in the valve-block to which the motive fluid is constantly admitted, a valve for controlling the movements of the piston

provided with two annular grooves, one of said grooves being always open to said inlet-port, the other of said grooves being always open to said exhaust-ports externally to the valve, a passage leading from one end of the piston-chamber to a port in the valve-block, said port being controlled by the valve to admit motive fluid to and exhaust fluid from said end of the piston-chamber, a port in the valve-block connected by passages with the opposite end of the piston-chamber, said port being controlled by the valve to admit and exhaust motive fluid to and from the said opposite end of the piston-chamber.

32. In an impact-tool, a piston-chamber and piston, a valve-block provided with exhaust-ports in the side walls thereof, an inlet-port in the valve-block to which the motive fluid is constantly admitted, a valve for controlling the movements of the piston provided with two annular grooves, one of said grooves being always open to said inlet-port, the other of said grooves being always open to said exhaust-ports externally to the valve, a passage leading from the forward end of the piston-chamber to a port in the valve-block, said port being controlled by the valve to admit motive fluid to said forward end of the piston-chamber and a port controlled by the valve adapted to admit motive fluid from said passage to one end of the valve to retain the latter in position.

33. In an impact-tool, a piston-chamber and piston, a valve-block provided with exhaust-ports in the side walls thereof, an inlet-port in the valve-block to which the motive fluid is constantly admitted, a valve for controlling the movements of the piston provided with two annular grooves, one of said grooves being always open to said inlet-port, the other of said grooves being always open to said exhaust-ports externally to the valve, said last mentioned groove being adapted by the shifting of the valve to alternately exhaust the motive fluid from opposite ends of the piston-chamber, and means controlled by the piston whereby the valve may be moved to alternately admit motive fluid to opposite ends of the piston-chamber.

34. In a fluid operated impact-tool, a valve provided with an annular groove to which the motive fluid is constantly supplied externally to the valve, and an annular groove which is constantly open to the atmosphere externally to the valve, said grooves acting in either position of the valve to supply motive fluid to one end of the piston-chamber and to exhaust fluid from the respective opposite end of the piston-chamber.

35. In a fluid operated impact-tool, a valve-block provided with an inlet-port, and with ports communicating respectively with opposite ends of the cylinder, adjacent to and on opposite sides of the inlet-port and further provided with exhaust-ports adjacent to the said cylinder ports, a valve provided with opposing pressure surfaces of different areas against which the motive fluid acts to move the valve in opposite directions and having an annular groove which is constantly open to said inlet-port, and through which motive fluid is alternately supplied to opposite ends of the cylinder by the reciprocations of the valve, said valve having bearing surfaces on either side of said groove which tend to prevent the motive fluid passing from the groove to the atmosphere and of such length that when the valve is in position to supply motive fluid to one end of the cylinder, the port leading to the respective opposite end of the cylinder is in communication with the exhaust ports adjacent thereto.

36. In a fluid operated impact-tool, a valve-block provided with an inlet-port, and with ports communicating respectively with opposite ends of the cylinder, adjacent to and on opposite sides of the inlet-port and further provided with exhaust ports adjacent to the said cylinder ports, a valve provided with opposing pressure surfaces of different areas against which the motive fluid acts to move the valve in opposite directions and having an annular groove which is constantly open to said inlet port, and through which motive fluid is alternately supplied to opposite ends of the cylinder by the reciprocation of the valve, said valve having bearing surfaces on either side of said groove which tend to prevent the motive fluid passing from the groove to the atmosphere and of such length that when the valve is in position to supply motive fluid to one end of the cylinder, the port leading to the respective opposite end of the cylinder is in communication with the exhaust ports adjacent thereto and the respective opposite exhaust ports are not covered or sealed by the bearing surface of the valve.

37. In a fluid operated impact tool, a valve-block provided with an inlet port, and with ports communicating respectively with opposite ends of the cylinder, adjacent to and on opposite sides of the inlet port, and further provided with exhaust ports adjacent to the said cylinder ports, a valve provided with opposing pressure surfaces of different areas against which the motive fluid acts to move the valve in opposite directions and having projections with bearing surfaces which pass over said cylinder ports during the travel of the valve and in the opposite positions of the valve present opposite sides of the projections to the said cylinder ports permitting alternately the admission of motive fluid to and the exhaust of fluid from respective ends of the cylinder.

38. In a fluid operated impact tool, a valve-block provided with an inlet port, and with ports communicating respectively with opposite ends of the cylinder, adjacent to and on opposite sides of the inlet port, and further provided with exhaust ports adjacent to the said cylinder ports, a valve provided with opposing pressure surfaces of different areas against which the motive fluid acts to move the valve in opposite directions and having projections with bearing surfaces which pass over said cylinder ports during the travel of the valve and in the opposite positions of the valve present opposite sides of the projections to the said cylinder ports permitting alternately the admission of motive fluid to and the exhaust of fluid from respective ends of the cylinder, said bearing surfaces tending when in either position to prevent the escape of motive fluid from the inlet port to the atmosphere.

39. In a fluid operated impact tool, a valve-block provided with an inlet port, and with ports communicating respectively with opposite ends of the cylinder, adjacent to and on opposite sides of the inlet port, and further provided with exhaust ports adjacent to the said cylinder ports, a valve provided with opposing pressure surfaces of different areas against which the motive fluid acts to move the valve in opposite directions and having bearing surfaces which in its opposite positions tend to prevent the escape of motive fluid from the inlet port to the atmosphere, permitting alternately the admission of motive fluid to and the exhaust from respective ends of the cylinder, said bearing surfaces not covering or sealing the exhaust ports to the atmosphere.

40. In a fluid operated impact-tool, a valve provided with an annular groove to which the motive fluid is constantly supplied externally to the valve and a pressure surface constantly subject to fluid pressure tending to press the valve in one direction, and a larger pressure surface to which motive fluid is intermittently admitted to move the valve in the opposite direction, and an annular groove which is constantly open to the atmosphere externally to the valve, said grooves acting in either position of the valve to supply motive fluid to one end of the piston-chamber and to exhaust fluid from the respective opposite end of the piston-chamber.

41. In a fluid operated impact-tool, a valve-block provided with an inlet-port, and with ports communicating respectively with opposite ends of the cylinder, adjacent to and on opposite sides of the inlet-port, and further provided with exhaust ports adjacent to the said cylinder ports, a valve having an annular groove which is constantly open to said inlet-port and a pressure surface constantly subject to fluid pressure tending to press the valve in one direction and a larger pressure surface to which the motive fluid is intermittently admitted to move the valve in the opposite direction, the motive fluid being supplied through said groove alternately to opposite ends of the cylinder by the reciprocations of the valve, said valve having bearing surfaces on either side of said groove which tend to prevent the motive fluid passing from the groove to the atmosphere and of such length that when the valve is in position to supply motive fluid to one end of the cylinder, the port leading to the respective opposite end of the cylinder is in communication with the exhaust ports adjacent thereto.

42. In a fluid operated impact-tool, a valve-block provided with an inlet-port and with ports communicating respectively with opposite ends of the cylinder which are located adjacent to and on opposite sides of said inlet-port, a valve provided with opposing pressure surfaces of different areas against which the motive fluid acts to move the valve in opposite directions and having an annular groove which is always subject to fluid pressure and which connects the inlet-port alternately with the ports leading to opposite ends of the cylinder, exhaust-ports in the valve-block adjacent to each of said last mentioned ports and in communication with one of said ports when the groove in the valve is in communication with the other of said ports.

43. In a fluid operated impact-tool, a valve having a pressure surface constantly subject to fluid pressure tending to press the valve in one direction and a larger pressure area to which the motive fluid is intermittently admitted to move the valve in the opposite direction, a valve-block provided with an inlet-port and with ports communicating respectively with opposite ends of the cylinder which are adjacent to and on opposite sides of the inlet-port, said valve having an annular groove which is always subject to fluid pressure and which connects the inlet-port alternately with the ports leading respectively to opposite ends of the cylinder, exhaust-ports in the valve-block adjacent to each of said last mentioned ports and in communication with one of said ports when the groove in the valve is in communication with the other of said ports.

44. In an impact-tool, a valve having an annular groove to which the motive fluid is constantly supplied and an annular groove which is always open to the atmosphere externally to the valve, a valve-block having a port communicating with one end of the cylinder and located between an inlet-port and an exhaust-port in the valve-block and alternately placed in communication therewith by

the reciprocations of the valve whereby motive fluid is supplied to and exhausted from the cylinder through said port, said valve-block having a port communicating with the opposite end of the cylinder which is located between inlet and exhaust-ports in the valve-block and alternately placed in communication therewith by said annular grooves in the valve.

45. In an impact-tool, a valve having an annular groove to which the motive fluid is constantly supplied and an annular groove which is always open to the atmosphere externally to the valve, a valve-block having a port communicating with the forward end of the cylinder and located between an inlet-port and an exhaust-port in the valve-block and alternately placed in communication therewith by the reciprocations of the valve whereby motive fluid is supplied to and exhausted from the cylinder through said port, said valve-block having a port communicating with the rear end of the cylinder which is located between inlet and exhaust-ports in the valve-block and alternately placed in communication therewith by said annular grooves in the valve.

46. In an impact-tool, a valve of different diameters having a pressure surface to which motive fluid is constantly admitted tending to press the valve in one direction, a larger pressure surface to which motive fluid is intermittently admitted to move the valve in the opposite direction, and an area equal to the difference in area between said pressure surfaces which is always in communication with the atmosphere to prevent any accumulation of pressure thereon acting in opposition to said larger area, said valve having an annular groove to which motive fluid is always supplied and another annular groove which is always open to the atmosphere externally to the valve.

47. In an impact tool, a piston chamber and piston, a valve for controlling the movements of the piston provided with an annular groove having opposing pressure surfaces of different areas to which the motive fluid is constantly admitted to press the valve in one direction, said valve having a pressure surface of still larger area to which the motive fluid is intermittently admitted to move the valve in the opposite direction, an external annular groove in the larger diameter of the valve, and communication between said groove and the atmosphere externally to the valve.

48. In an impact tool a piston chamber and piston, a valve block, a valve for controlling the movements of the piston provided with an annular groove having opposing pressure surfaces of different areas, an annular groove in the valve block communicating at all times with the said valve groove, a passage connecting the groove of the valve block with a source of pressure supply, said valve having an external annular groove in its larger diameter, and an exhaust port adapted to coöperate with said groove.

49. In an impact tool a piston chamber and piston, a valve block, a valve for controlling the movements of the piston provided with an annular groove having opposing surfaces of different areas, an annular groove in the valve block communicating at all times with the said valve groove, one or more longitudinal passages extending from said valve groove to the adjacent end of the valve block, an annular groove in the larger diameter of the valve, an exhaust port, and a cylinder port between the exhaust and inlet ports said cylinder port communicating with the cylinder by one or more longitudinal passages.

50. In a fluid operated impact tool a cylinder chamber, a valve block having a valve chamber at the rear of the cylinder chamber, an inlet port, a longitudinal passage leading rearwardly from the inlet port to a source of pressure supply, a cylinder port, a longitudinal passage leading forwardly from the cylinder port to the rear end of the cylinder, a valve provided with an annular groove constantly in communication with the inlet port, and an annular groove constantly open to the atmosphere, said groove in either position of the valve acting to supply motive fluid to one end of the piston chamber and to exhaust fluid from the respective opposite end of the piston chamber.

51. In a fluid controlled impact tool a valve block having a bore of different diameters, the smaller bore being always open to the atmosphere, an exhaust port in the valve block opening into the bore of larger diameter, a valve located in the valve block provided with opposing pressure surfaces of different areas to one of which motive fluid is constantly admitted to press the valve in one direction, and to the other of which pressure is intermittently admitted to press the valve in the opposite direction, an inlet port transverse to the bore of the valve block, a cylinder port also transverse thereto, a longitudinal passage extending in one direction from the inlet port and communicating with the source of pressure supply, and a longitudinal passage extending in the opposite direction from the cylinder port and communicating with one end of the cylinder.

52. In a fluid-controlled impact-tool, a piston-chamber and piston, a valve provided with opposing pressure surfaces against which the motive fluid acts to move the valve in opposite directions, a valve-block having an inlet-port transverse to the bore

of the block and to which the motive fluid is constantly admitted, an exhaust-port in the valve-block always open to the atmosphere, said valve being provided with two annular grooves, one of said grooves being always open to said inlet-port in the valve-block and the other of said grooves being always open to said exhaust-port in the valve-block and acting to exhaust motive fluid from both ends of the cylinder.

53. In an impact-tool, a piston-chamber and piston, a valve-block having a bore in alinement with the bore of the piston-chamber and provided with an inlet-port to which the motive fluid is constantly admitted, an exhaust-port in the valve-block located forward of said inlet-port, a valve provided with an annular groove which is always open to said inlet-port externally to the valve and and annular groove which is always open to said exhaust-port externally of the valve, the latter groove acting to exhaust motive fluid from both ends of the cylinder, and an interior annular groove in the valve-block located forward of said inlet-port which is connected by passages with one end of the piston-chamber.

54. In an impact-tool, a piston-chamber and piston, a valve-block provided with an exhaust-port in the side wall thereof, an inlet-port in the valve-block to which the motive fluid is constantly admitted, a valve for controlling the movements of the piston provided with two annular grooves, one of said grooves being always open to said inlet-port, the other of said grooves being always open to said exhaust-port externally to the valve and acting to exhaust motive fluid from both ends of the cylinder, a passage leading from one end of the piston-chamber to a port in the valve-block, said port being controlled by the valve to admit motive fluid to and exhaust fluid from said end of the piston-chamber, a port in the valve-block connected by passages with the opposite end of the piston-chamber, said port being controlled by the valve to admit and exhaust motive fluid to and from the said opposite end of the piston-chamber.

55. In a fluid operated impact tool, a valve-block provided with an inlet port, and with ports communicating respectively with opposite ends of the cylinder, and further provided with an exhaust port adjacent to the said cylinder ports, a valve having an annular groove constantly open to the exhaust and acting to exhaust motive fluid from both ends of the cylinder, and an annular groove which is constantly open to said inlet-port, a pressure surface constantly subject to fluid pressure tending to press the valve in one direction and a larger pressure surface to which the motive fluid is intermittently admitted to move the valve in the opposite direction, the motive fluid being supplied through said latter groove alternately to opposite ends of the cylinder by the reciprocations of the valve, said valve having bearing surfaces on either side of said groove which tend to prevent the motive fluid passing from the groove to the atmosphere and of such length that when the valve is in position to supply motive fluid to one end of the cylinder, the port leading to the respective opposite end of the cylinder is in communication with the said exhaust port.

56. In an impact-tool, a valve having an annular groove to which the motive fluid is constantly supplied and an annular groove which is always open to the atmosphere externally to the valve and acts to exhaust motive fluid from both ends of the cylinder, a valve-block having a port communicating with one end of the cylinder and located between an inlet-port and an exhaust-port in the valve-block and alternately placed in communication therewith by the reciprocations of the valve whereby motive fluid is supplied to and exhausted from the cylinder through said port, said valve-block having a port communicating with the opposite end of the cylinder which is located between inlet and exhaust ports in the valve-block and alternately placed in communication therewith by said annular grooves in the valve.

57. In an impact-tool, a valve having an annular groove to which the motive fluid is constantly supplied and an annular groove which is always open to the atmosphere externally to the valve and acts to exhaust pressure alternately from both ends of the cylinder, a valve-block having a port communicating with the forward end of the cylinder and located between an inlet-port and an exhaust-port in the valve-block and alternately placed in communication therewith by the reciprocations of the valve whereby motive fluid is supplied to and exhausted from the cylinder through said port, said valve-block having a port communicating with the rear end of the cylinder which is located between inlet and exhaust-ports in the valve-block and alternately placed in communication therewith by said annular grooves in the valve.

58. In a pneumatic impact tool a piston chamber and piston, a valve chamber and a differential pressure actuated valve therein, a pair of circumferential grooves on said valve, an inlet port in constant communication with one groove, an exhaust port in constant communication with the other groove, a cylinder port between the inlet and exhaust ports and communicating with one end of the cylinder, a cylinder port com-

munication with the opposite end of the cylinder and opening into the valve chamber on the opposite side of the inlet port from the first-named cylinder port, the opposite cylinder end also having a port opening into the valve chamber on the opposite side of the exhaust port from the first named cylinder port, and means for exhausting pressure from the opposite cylinder end through both of said port openings.

In testimony whereof I affix my signature, in presence of two witnesses.

GEORGE L. BADGER.

Witnesses:

THOMAS F. MCANARNEY,

CHARLES H. MCANARNEY.