D. S. WAUGH.

MOTIVE FLUID OPERATED TOOL.

APPLICATION FILED MAR. 24, 1908.

915,813.

Patented Mar. 23, 1909.

2 SHEETS—SHEET 1.

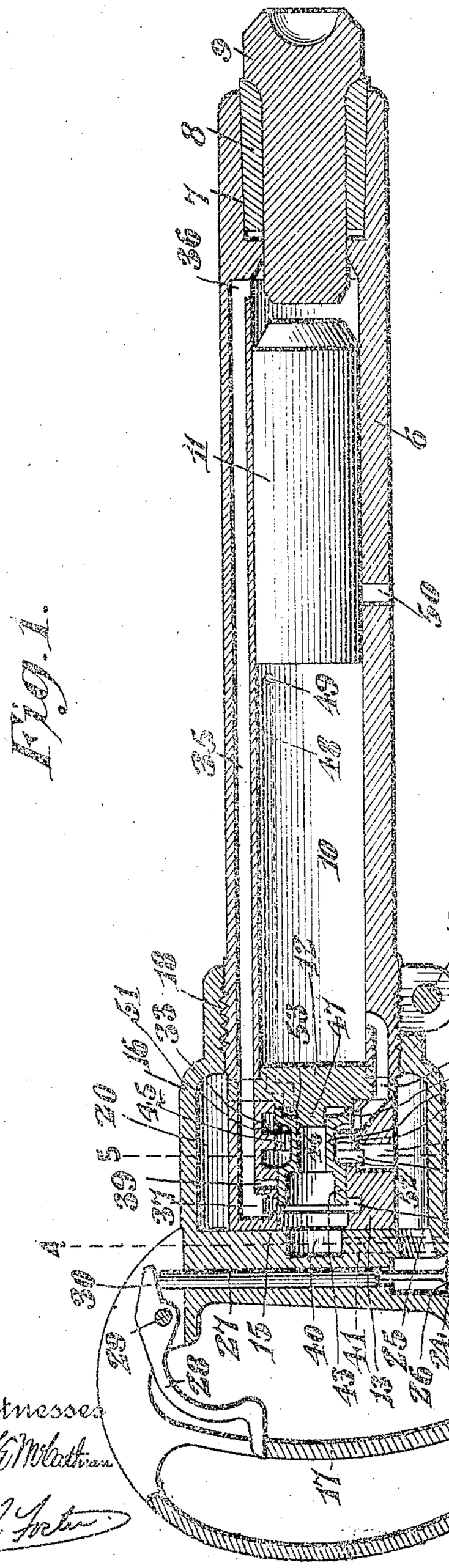

Fig. 1.

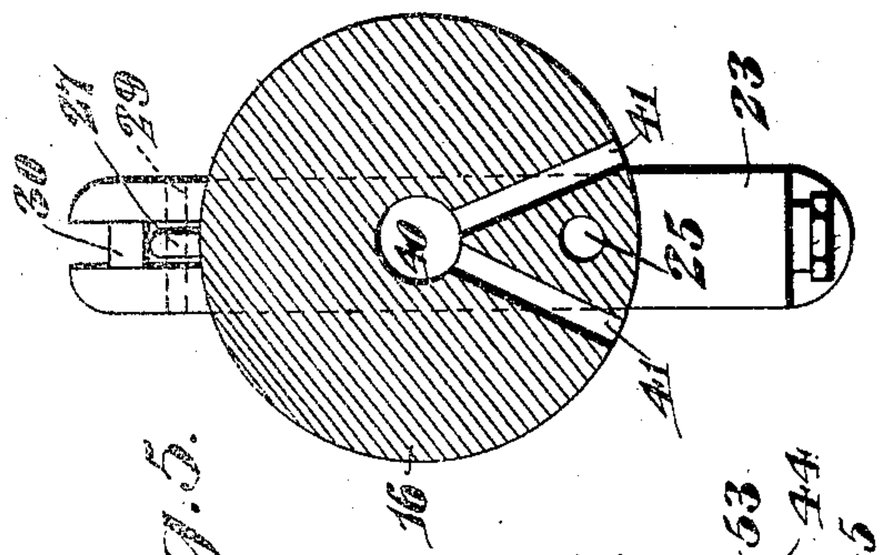

Fig. 5.

Fig. 6.

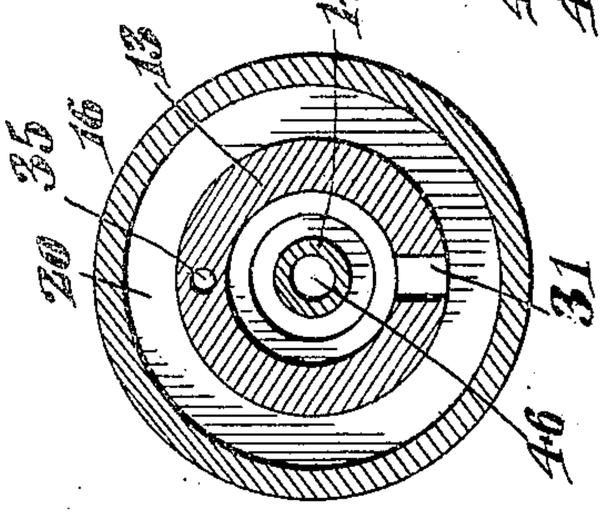

Fig. 4.

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2 SHEETS—SHEET 2.

Fig. 2.

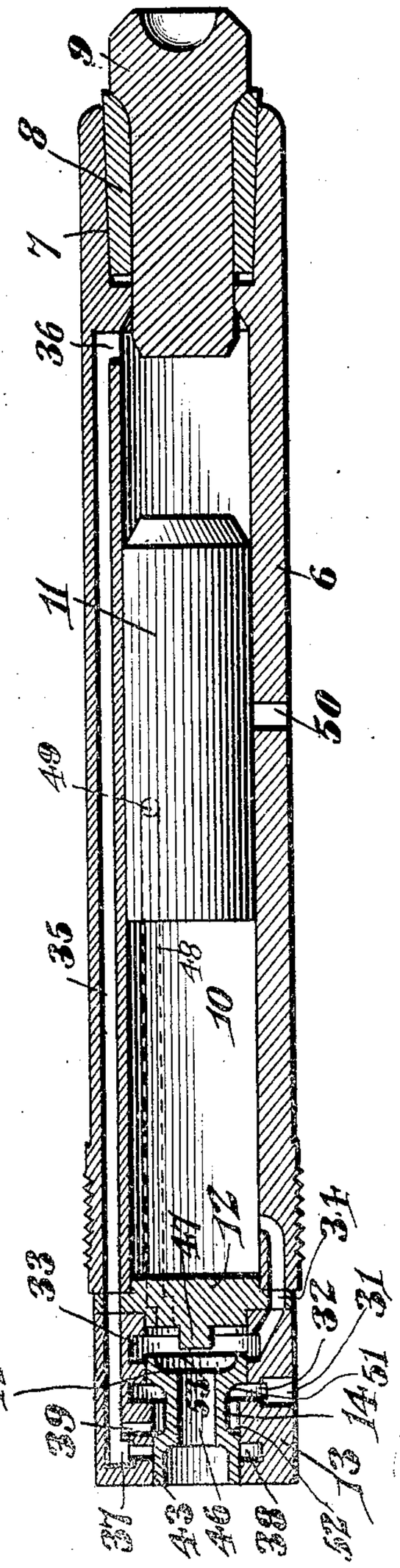
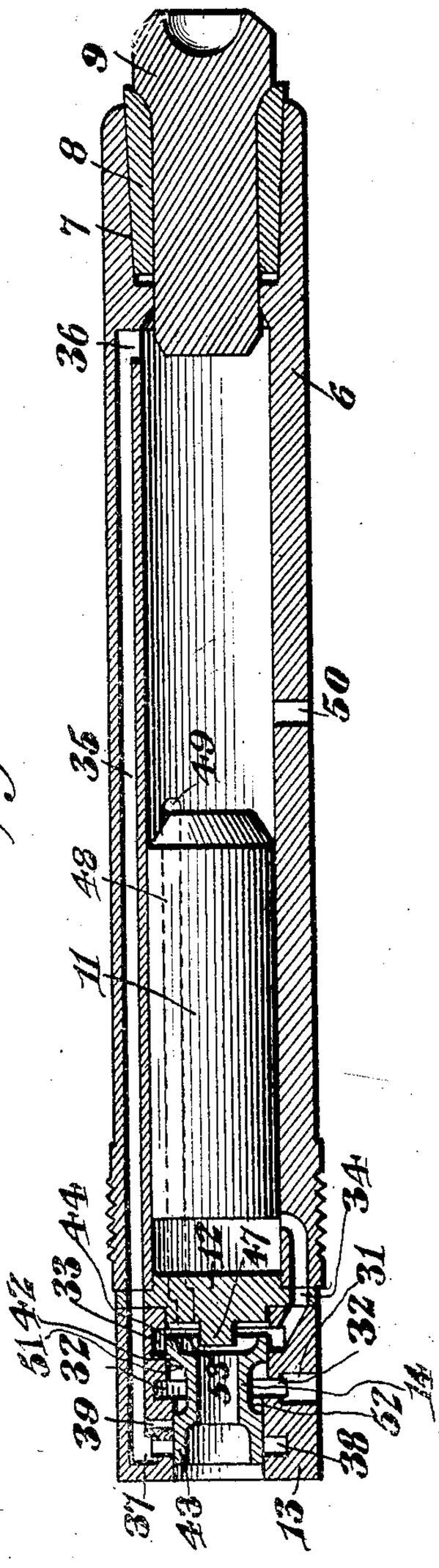


Fig. 3.



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UNITED STATES PATENT OFFICE.

DANIEL SHAW WAUGH, OF DENVER, COLORADO, ASSIGNOR TO THE DENVER ROCK DRILL & MACHINERY COMPANY, OF DENVER, COLORADO, A CORPORATION OF COLORADO.

MOTIVE-FLUID-OPERATED TOOL.

No. 915,813. Specification of Letters Patent. Patented March 23, 1909.

Application filed March 24, 1908. Serial No. 422,895.

To all whom it may concern:

Be it known that I, DANIEL SHAW WAUGH, a citizen of the United States, residing at Denver, in the county of Denver and State of Colorado, have invented a new and useful Motive-Fluid-Operated Tool, of which the following is a specification.

The present invention relates to motive fluid operated tools, and more particularly those of the type employing automatic controlling valves.

One of the primary objects of the present invention is to provide novel and effective means for securing a portion of the return stroke of the piston or hammer by the expansive force of the motive fluid, thereby effecting a saving in motive fluid and materially reducing the shocks and vibrations.

A further important object is to provide in the tool, a reservoir for motive fluid, to which reservoir a constant supply of motive fluid is directed and from which the working parts are supplied while the tool is in operation, the arrangement permitting the use of a comparatively small hose and decidedly increasing the working capacity of the machine.

One embodiment of the invention is illustrated in the accompanying drawings, wherein:—

Figure 1 is a longitudinal sectional view through an automatic riveter, showing the piston just about to complete its working stroke. Fig. 2 is a similar view showing the relation of the parts during the first portion of the return stroke. Fig. 3 is a sectional view illustrating the relation of the parts just prior to the completion of the return stroke. Figs. 4 and 5 are respectively cross sectional views on the lines 5—5 and 4—4 of Fig. 1. Fig. 6 is a side elevation of the valve.

Similar reference numerals designate corresponding parts in all the figures of the drawings.

In the embodiment illustrated, a cylinder member 6 is employed having a suitable socket 7 in one end that receives a chuck 8 or other holder for the tool to be operated, as 9. The cylinder member 6 is provided with a piston chamber 10, in which operates a reciprocatory piston 11 that engages the tool 9 at the end of its working stroke. The end of the chamber 10, opposite to that into which the tool 9 projects, is closed by a cap 12, and located against said cap, is a valve casing 13 having a central longitudinally disposed valve chamber 14, one end of which is closed by the cap 12, the other end being closed by the end wall 15 of a head 16 that is provided with a suitable handle 17. The head, as shown at 18, is threaded to the cylinder member, and secured against accidental movement or detachment by a suitable clamp 19. This head is provided with a chamber 20 that receives the valve casing 13, and being of greater diameter than said casing, forms about the same a reservoir for motive fluid. A nipple 21, located on the lower portion of the handle, is adapted to have a supply hose connected thereto, and the bore 22 of said nipple, communicates with the interior of a valve casing 23 having a valve seat 24 therein. A port 25 constitutes the means of communication with the interior of the valve casing, above the valve seat, and the reservoir or chamber 20. A reciprocatory valve 26, located in the casing, is movable into and out of coöperation with the valve seat 24, and has a stem 27 projecting from the upper portion of the end wall 15. A trigger 28, pivoted between its ends, as shown at 29, to the handle, has one end 30 operating against the upper end of the valve stem 27, the other end being in a position to be conveniently operated by a finger of the hand grasping the handle 17.

A supply port 31 constitutes the means of communication between the reservoir 20 and the valve chamber 14, said port opening into an annular groove 32 arranged in said chamber. Another annular groove 33, formed in the chamber in advance of the groove 32 communicates with a combined inlet and exhaust conduit 34 that leads into the rear end of the piston chamber 10 on one side of the piston. Another conduit 35 has a port 36 communicating with the opposite end of the cylinder, and consequently on the opposite side of the piston. This conduit 35 is provided at its rear end with a comparatively large exhaust port 37 communicating with an annular groove 38 in the valve chamber, and directly adjacent to said exhaust port, is an inlet or supply port 39. The end wall 15 of the head 16 is provided with an exhaust port 40 disposed centrally of the valve chamber 14 and of less diameter than the same, and leading from this port, are one or more exhaust channels 41 seen more particularly in Fig. 5.

The valve chamber 14 in the valve casing 13, has its rear portion of less diameter than its front portion, and operating in said chamber is a reciprocatory valve 42, the rear portion 43 of which is of less diameter than the front portion 44, said valve being provided between its ends with a single circumferential groove 45 that at all times is in communication with the supply port 31 and groove 32, and moves into and out of communication with the conduit 34 and the inlet port 39 of the conduit 35. The rear smaller portion 43 of the valve, located at one side of the groove 45, controls both the inlet port 39 and the exhaust port 37 of the conduit 35, as will be evident by reference to Figs. 1, 2 and 3. Said valve 42 furthermore has a central longitudinal open ended exhaust passage 46, the rear end of which is always open, the front end being open, when the valve is in its rearmost position, as shown in Fig. 2, and also when the same is in an intermediate position, as illustrated in Fig. 3. When the valve is in its advanced position, as shown in Fig. 1, the front end of the passage 46 is closed by a rearwardly extending plug 47 carried by the cap 12, and entering said passage. A third conduit 48 is formed in the cylinder member 6, and is provided with an inlet port 49 that opens in the piston chamber 10, said port being so located that it is uncovered by the piston 11, just prior to the completion of the working stroke of said piston. The conduit 48 has its outlet in the forward end of the valve chamber in advance of the valve. An exhaust port 50 is also preferably provided in one side of the cylinder element.

As preliminary to a description of the operation of the tool, it may be stated that the valve 42 has three distinct positions, namely, two opposite extremes, and an intermediate position, the latter of which varies slightly according to the difference in pressures, as hereinafter more fully appears, against the various pressure surfaces, 51, 52 and 53 of the valve. It will be noted that the surface 51, is greater in area than the surface 52, but less than the surface 53. If therefore the valve 26 is opened, motive fluid under pressure will be supplied to the reservoir 20, and passing through the port 31, will continuously operate against the surfaces 51 and 52. Under normal conditions, or when the port 49 of the conduit 48 is covered by the piston 11, during its working stroke, the pressure against the surface 51 will be sufficiently greater than the pressure against the surface 52 to maintain the valve in its foremost position, in which case the conduit 32 is in communication with the supply port 31 by means of the channel or groove 45 of the valve. Therefore air under pressure will be admitted to the piston chamber 10 in rear of said piston through the port 34, and will force the piston forwardly on its working stroke. As long as the piston is in rear of the exhaust port 50, the motive fluid in advance of said piston can exhaust freely through said port, and the exhaust port 37 of the conduit 35, being also uncovered, the motive fluid can pass freely through the port 36, the conduit 35, the port 37, through the rear portion of the valve chamber into the exhaust port 40 and through the exhaust conduits 41. When, however, the piston 11 reaches the position shown in Fig. 1, and the port 49 of the conduit 48 is uncovered, immediately a portion of the motive fluid utilized in effecting the working stroke of the piston enters the conduit 48, and produces a pressure against the end surface 53 of the valve 42.

Now it will be noted that the exhaust passage 46 is closed by the plug 47. The combined pressure therefore against the surfaces 52 through the port 31, and 53 through the conduit 48, being greater than the pressure against the surface 51, will cause a rearward movement of the valve sufficient to unseat the valve and cut off the conduit 34 from the annular groove 45, so that the supply of motive fluid to the piston chamber 10 in rear of the piston is stopped. At the same time, the rearward movement of the valve opens the exhaust passage 46, and brings it into communication with the conduit 34, so that the motive fluid in rear of the piston can exhaust through said conduit 34 into the front end of the valve chamber, and this exhaust of air operating against the valve completes the movement of the valve 42 to the position shown in Fig. 2. The exhaust of air through the conduit 34 thence passing through the passage 46, will escape through the exhaust port 40 and conduits 41. The rearward movement of the valve furthermore closes the exhaust port 37 of the conduit 35, and the annular groove or channel 45 of the valve is brought into communication with the inlet port 39 of said conduit 35. Therefore the motive fluid entering the port 39 from the port 31 by way of the channel 45, and flowing through the conduit 35 into the forward end of the piston chamber 10, will cause a rearward or return movement of the piston. But shortly after said piston starts on its return stroke, it covers the inlet port 49 of the conduit 48. The result is the cutting off of the passage of motive fluid between the rear portion of the piston chamber and the valve chamber, and the exhaust of the air through the passage 46 of the valve, reduces the pressure on the forward end of the valve, and therefore the valve will automatically move to an intermediate position, as illustrated in Fig. 3 because of the overbalancing pressure on the surface 51. It will, however, be prevented from entirely returning to its foremost position, because of the pressure of the exhaust through the conduit 34, due to the returning piston. It will now be noted that

when the valve is in said intermediate position, both the inlet and exhaust ports 39 and 37 of the conduit 35 are closed. Consequently the expansive force of the motive fluid behind the piston is utilized to complete the return stroke of said piston. As soon as the piston in its rearward movement passes beyond the port 34, this causes all pressure on the front of the valve 42 to be relieved and the valve is then forced forward to the extreme position shown in Fig. 1 by the pressure against the surface 51 of the valve, whereupon the exhaust port 37 of the conduit 35 will be opened, the exhaust passage 46 through the valve will be closed, the conduit 34 will be brought into communication with the supply port 31, through the annular groove or channel 45 in the valve, and a fresh supply of motive fluid will thus be admitted to effect a second working stroke of the piston. In this structure, the piston will start regardless of the position it may be in. For instance, if the parts are as shown in Fig. 1, as soon as air is admitted through the port 31, it will pass through the conduit 34 into the chamber 10 in rear of the piston 11. It will also enter the port 49, and passing through the conduit 48, will unseat the valve as above described, allowing air to rush through port 39, conduit 35, and port 36 in front of the piston. With this construction, two very important results are secured. In the first place, at no time are any of the exhaust channels directly or indirectly in communication with the motive fluid supply, and nearly three-fourths of the return stroke of the piston is secured by the expansive force of the motive fluid. It will thus be evident that a great saving of motive fluid is effected, and furthermore the vibration is reduced, for the piston is given a strong impulse at the commencement of its return stroke and gradually comes to a stop at the end of the same.

A further important feature is the provision of the reservoir 20, by means of which a small hose can be used to supply motive fluid to the machine, while experience has demonstrated that its capacity is increased. This will be evident when it is considered that there is a constant flow of the motive fluid to the air reservoir and an intermittent flow to the cylinder.

An addition advantage of the invention resides in the fact that when the piston strikes its blow, the exhaust through the port 36, conduit 35 and port 37, is entirely open so that there is no resistance to the forward movement of the piston at the end of the stroke, and the full force of the blow is secured. The piston immediately rebounds from said blow, and thus the return stroke is started, resulting in the automatic shifting of the valve, as above explained.

From the foregoing, it is thought that the construction, operation and many advantages of the herein described invention will be apparent to those skilled in the art, without further description, and it will be understood that various changes in the size, shape, proportion and minor details of construction, may be resorted to without departing from the spirit or sacrificing any of the advantages of the invention. For instance, while this invention is shown in connection with a riveter or short-stroke tool, it may be employed in connection with drilling machines, as disclosed in co-pending application, Serial No. 418,520, filed February 29, 1908. The claims in this application are therefore intended to cover the motor disclosed in said application.

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

1. In an instrument of the character set forth, the combination with a cylinder member, of a reciprocatory piston member operating therein, a valve casing connected to the cylinder member, a motive fluid supply reservoir surrounding the casing, means for supplying motive fluid to the reservoir, and a valve operating in the casing and controlling the passage of motive fluid from the reservoir to the cylinder member.

2. In an instrument of the character set forth, the combination with a cylinder member, of a reciprocatory piston member operating therein, a valve casing located at one end of the cylinder member in line therewith, a head fitted over the valve casing and secured to the cylinder member, said head having a chamber that receives and is of greater diameter than the valve casing, forming a motive fluid supply reservoir that surrounds said casing, means for supplying motive fluid to the reservoir, and a valve operating in the casing and controlling the passage of motive fluid from the reservoir to the cylinder member.

3. In an instrument of the character set forth, the combination with a cylinder member, of a reciprocatory piston member operating therein, a valve casing located at the rear end of the cylinder member and having a chamber disposed longitudinally thereof, said casing having a motive fluid supply port between its ends, and an exhaust port at its rear end, a combined supply and exhaust conduit communicating with the front end of the chamber and the rear end of the cylinder member, a combined supply and exhaust conduit communicating with the rear end of the chamber and the front end of the cylinder member, and a reciprocatory valve operating in the chamber longitudinally of the cylinder member, said valve having a groove that is in communication with the supply port and is movable alternately into communication with the conduits, said valve having an exhaust passage there-

through that has an inlet opening through the front end of the valve and moving into and out of communication with the first mentioned supply and exhaust conduit.

4. In an instrument of the character set forth, the combination with a cylinder member, of a reciprocatory piston operating therein, a valve located at the rear end of the cylinder member and having a chamber disposed longitudinally thereof, said casing having a motive fluid supply port between its ends and an exhaust port at its rear end, a combined supply and exhaust conduit communicating with the front end of the chamber and the rear end of the cylinder member, a combined supply and exhaust conduit communicating with the rear end of the chamber and the front end of the cylinder member, a reciprocatory valve operating in the chamber longitudinally of the cylinder member, said valve having a groove that is in communication with the supply port and is movable alternately into communication with the conduits, said valve also having an exhaust passage therethrough that has an inlet opening through its front end, said inlet being movable into and out of communication with the first mentioned supply and exhaust conduit, means for closing the inlet of the exhaust passage on the forward movement of the valve, and means for directing motive fluid against the front end of the valve when the inlet of said passage therethrough is closed, to move the valve to a position to open the inlet of the passage and bring it into communication with the said first mentioned supply and exhaust conduit.

5. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating in the cylinder member, a valve casing having a chamber, a valve operating in the chamber and having an internal exhaust passage having an inlet that opens through one end, a conduit communicating with the valve chamber and cylinder member, said conduit being covered and uncovered by the end of the valve through which the inlet of the exhaust passage opens, means for closing said end of the passage when the conduit is covered, and means for directing motive fluid against said end of the valve when the end of the passage therethrough is closed to move the valve to a position to uncover the conduit and effect the opening of the passage.

6. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, a valve casing having a chamber, a valve operating in the chamber and having an internal exhaust passage provided with an inlet that opens through one end, a combined inlet and exhaust conduit communicating with the valve chamber and cylinder member, said conduit being covered and uncovered by the end of the valve through which the inlet of the exhaust passage opens, the valve having a supply channel that communicates with the combined inlet and exhaust conduit when the same is covered by said valve, means for closing the inlet end of the passage through the valve when the conduit is covered, and means for directing motive fluid against said end of the valve when the end of the passage therethrough is closed in order to move the valve to a position to open the conduit, cut off communication between the channel and conduit, effect the opening of the inlet end of the passage through the valve, and permit the motive fluid from the cylinder member to flow through the conduit, through the valve chamber at the end of the valve and through said passage in the valve.

7. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, a valve casing having a chamber, a valve operating in the chamber and having an internal exhaust passage provided with an inlet that opens through one end, a conduit communicating with the valve chamber and cylinder member, said conduit being covered and uncovered by the end of the valve through which the inlet of the exhaust passage opens, means for closing said end of the passage when the conduit is covered, and a second conduit having a port in the cylinder member, said second conduit leading into the valve chamber for delivering motive fluid from the cylinder member to the chamber and against the end of the valve having the inlet of the exhaust passage therethrough, said piston uncovering the port when the inlet end of the passage through the valve is closed.

8. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, a valve casing having a chamber, a valve operating in the chamber and having an internal exhaust passage provided with an inlet that opens through one end, a combined inlet and exhaust conduit communicating with the valve chamber and cylinder member, said conduit being covered and uncovered by the end of the valve through which the inlet of the exhaust passage opens, the valve having a supply channel that communicates with the combined inlet and exhaust conduit when the same is covered by the valve, means for closing the end of the inlet end of the passage through the valve when the conduit is covered, and a second conduit having a port in the cylinder member, said conduit leading into the valve chamber for delivering motive fluid from the cylinder member to the chamber and against the end of the valve having the inlet end of the exhaust passage therethrough, said piston uncovering the port of

the second conduit when the inlet end of the exhaust passage is closed and when motive fluid is being delivered to the cylinder member through the combined inlet and exhaust conduit, the motive fluid supplied through the second conduit effecting the movement of the valve to a position to uncover the combined inlet and exhaust conduit, cut off communication between the channel in the valve and said conduit, effect the opening of the inlet end of the exhaust passage through the valve and permit the motive fluid from the cylinder member to enter the end of the valve chamber and exhaust through the passage in the valve.

9. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, a valve casing having a chamber, a valve operating in the chamber and having an internal exhaust passage provided with an inlet that opens through one end, a conduit communicating with the valve chamber and cylinder member, said conduit being covered and uncovered by the end of the valve through which the inlet end of the exhaust passage opens, a closure for the inlet end of the exhaust passage located in the end of the valve chamber, said valve moving into and out of communication with the closure, and means for effecting the movement of the valve.

10. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, a valve casing having a chamber, a reciprocatory valve operating in the chamber and having an internal exhaust passage that opens through both ends of said valve, a combined inlet and exhaust conduit communicating with the valve chamber and cylinder, said conduit being uncovered and covered by one end of the valve to cut the exhaust passage into and out of communication therewith, a closure plug projecting into one end of the valve chamber and engaging in the end of the exhaust passage when the valve is in one position, and means for effecting the reciprocation of the valve.

11. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, a valve casing having a valve chamber, an inlet and exhaust conduit for the cylinder member communicating with one end of the valve chamber, a reciprocatory valve operating in the chamber and having an internal exhaust passage, provided with an inlet end which opens through the end of the valve and communicates with the end of the chamber with which the conduit communicates, and a closure for said end of the exhaust passage, said valve having a supply channel moving into and out of communication with the inlet and exhaust conduit.

12. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, a controlling valve, means for automatically moving the valve to a position to admit motive fluid to the cylinder member on one side of the piston, means for automatically moving the valve to a different position to admit motive fluid to the cylinder member on the opposite side of the piston, and means for automatically moving the valve to and maintaining it in an intermediate position between the first two positions to cut off the supply of motive fluid to the cylinder member on both sides of the piston.

13. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, a reciprocatory controlling valve, means for automatically moving the valve to an extreme position in one direction to admit motive fluid to the cylinder on one side of the piston, means for automatically moving the valve to an extreme position in an opposite direction to admit motive fluid to the cylinder member on the opposite side of the piston, and means for automatically moving the valve to and maintaining it in an intermediate position between the two extreme positions to cut off the supply of motive fluid to the cylinder on both sides of the piston during a portion of the movement of said piston in one direction.

14. In an instrument of the character set forth, the combination with a cylinder member, of a reciprocatory piston operating therein, a controlling valve movable in opposite directions, means for automatically moving the valve to an extreme position in one direction to admit motive fluid to the cylinder member on one side of the piston and permit an exhaust from the cylinder member on the opposite side of the piston to effect a working stroke of said piston, means for automatically moving the valve in an opposite direction to an extreme position to admit motive fluid to the cylinder member on the opposite side of the piston and permit an exhaust from the first mentioned side to effect a return stroke of the piston, and means for automatically moving the valve to and maintaining it in an intermediate position between the two extreme positions during the return stroke to cut off the supply of motive fluid to the cylinder on both sides of the piston while still permitting the exhaust from the first mentioned side.

15. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, a controlling valve, means for automatically moving the valve to a position to admit motive fluid to the cylinder member on one side of the piston and permit an exhaust from the cylinder member on the opposite side of the piston, means for automatically moving the valve

to a different position to admit motive fluid to the cylinder member on the opposite side of the piston and permit the exhaust from the first mentioned side, and means for automatically moving the valve to and maintaining it in an intermediate position between the first two positions to cut off the supply of motive fluid to the cylinder on opposite sides of the piston and simultaneously constrict but still permit the exhaust from the first mentioned side.

16. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, means for supplying motive fluid to the cylinder member to effect the working stroke of the piston, means for exhausting said motive fluid and simultaneously supplying motive fluid to the cylinder member to effect the return stroke of the piston, and means for automatically cutting off the return supply prior to the completion of the return stroke while maintaining the exhaust open and preventing a second working stroke supply of motive fluid until the return stroke is completed.

17. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, a controlling valve, means for directing motive fluid against the valve to move it to a position to admit motive fluid to the cylinder member on one side of the piston, means for directing motive fluid against the valve to move it to a different position to admit motive fluid on the opposite side of the piston, and means for varying the motive fluid pressure against the valve to effect the automatic movement of the valve to an intermediate position between the first two positions to cut off the supply of motive fluid to the cylinder on both sides of the piston.

18. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, means for conducting motive fluid to and exhausting it from the cylinder member in advance of the piston, means for conducting motive fluid to and exhausting it from the cylinder member in rear of the piston, a valve controlling the admissions and exhausts, means for directing motive fluid against the valve to move it to a position to admit motive fluid to the cylinder member behind the piston, means for directing motive fluid against the valve to move it to a position to admit motive fluid to the cylinder member in advance of the piston, and means for varying the motive fluid pressure against the valve to effect an automatic movement of said valve to a position to cut off the admissions of motive fluid on both sides of the piston, cut off the exhaust in advance of said piston and leave the exhaust open in rear of the piston.

19. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, means for supplying motive fluid to the cylinder member to effect the working stroke of the piston, said means including a combined supply and exhaust conduit, a valve controlling the supply and exhaust and having an exhaust passage provided with an inlet that opens through one end of the valve, means for closing said inlet when the valve is in a position to admit a working supply of motive fluid to the cylinder member, and a conduit leading from the cylinder member for conveying a portion of the working supply of motive fluid against the end of the valve having the inlet to cause the valve to be moved to open said inlet and bring the same into communication with both conduits to permit the exhaust from the cylinder member through both of said conduits.

20. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, means for conducting motive fluid to and exhausting it from the cylinder in advance of the piston, means for conducting motive fluid to and exhausting it from the cylinder member in rear of the piston, a valve for controlling the admissions and exhausts, means for automatically moving the valve to a position to admit motive fluid to the cylinder member in advance of the piston and open the exhaust in rear of the same, and means for automatically moving the valve to a position to cut off such admission in advance of the piston and still leave the exhaust in rear of the piston open.

21. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, means for conducting motive fluid to and exhausting it from the cylinder member in advance of the piston, means for conducting motive fluid to and exhausting it from the cylinder member in rear of the piston, a valve controlling the admissions and exhausts, means for automatically moving the valve to admit motive fluid to the cylinder member in advance of the piston, cut off the exhaust in advance of the piston, and open the exhaust in rear of said piston, and means for automatically moving the valve to a position in which the admission in advance of the piston and the exhaust in advance of the piston are both cut off, while the exhaust in rear of the piston is maintained in open condition.

22. In an instrument of the character set forth, the combination with a cylinder member, of a piston operating therein, a conduit for admitting motive fluid to and exhausting it from the cylinder in advance of the piston, said conduit having separate inlet and exhaust ports, means for conducting motive fluid to and exhausting it from the cylinder

member in rear of the piston, a valve controlling the admissions and exhausts, means for automatically moving the valve to a position to open the inlet port of the conduit, close the exhaust port and open the exhaust in rear of the piston to effect a return stroke of said piston, and means for automatically moving the valve during the return stroke to a position to close the inlet port, maintain the exhaust port closed and maintain the exhaust in rear of the piston open.

23. In an instrument of the character set forth, the combination with a valve casing having an exhaust port at one end, the other end being closed and having a plug projecting longitudinally thereinto, said casing also having a motive fluid inlet port in one side between its ends, of an automatic reciprocatory valve operating in the casing and having an exhaust passage extending longitudinally therethrough and opening through both ends thereof, one end of the exhaust passage being always in communication with the exhaust port of the valve casing, the other end being closed and opened by the plug upon the reciprocation of the valve.

24. In an instrument of the character set forth, the combination with a motor cylinder, of a valve casing located longitudinally of and at one end of the cylinder, a cap interposed between the cylinder and casing and closing the adjacent ends of both, said cap having a plug projecting longitudinally into one end of the valve casing, the other end of said valve casing having an exhaust port, conduits constituting means of communication between the casing and cylinder, and an automatic reciprocatory valve operating in the valve casing and having an exhaust passage extending longitudinally through the same and opening through both ends thereof, one end of the exhaust passage being always in communication with the exhaust port of the valve casing, the other end of said exhaust passage being closed and opened by the plug upon the reciprocation of the valve and said valve constituting means for controlling the conduits.

In testimony, that I claim the foregoing as my own, I have hereto affixed my signature in the presence of two witnesses.

DANIEL SHAW WAUGH.

Witnesses:
W. H. LEONARD,
FRED HUMPHREY.