G. H. GILMAN.

PNEUMATIC TOOL.

APPLICATION FILED MAY 14, 1908.

995,593.

Patented June 20, 1911.

4 SHEETS—SHEET 1.

Fig. 1

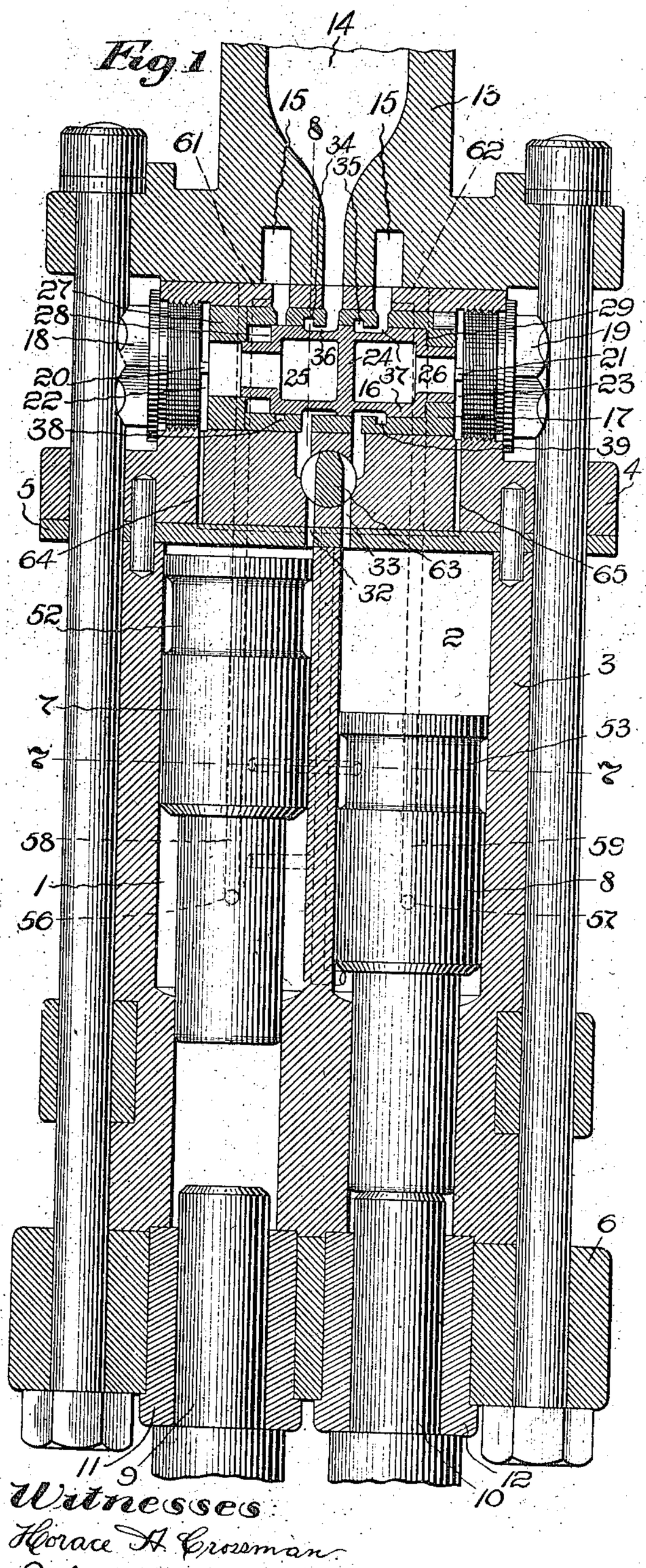
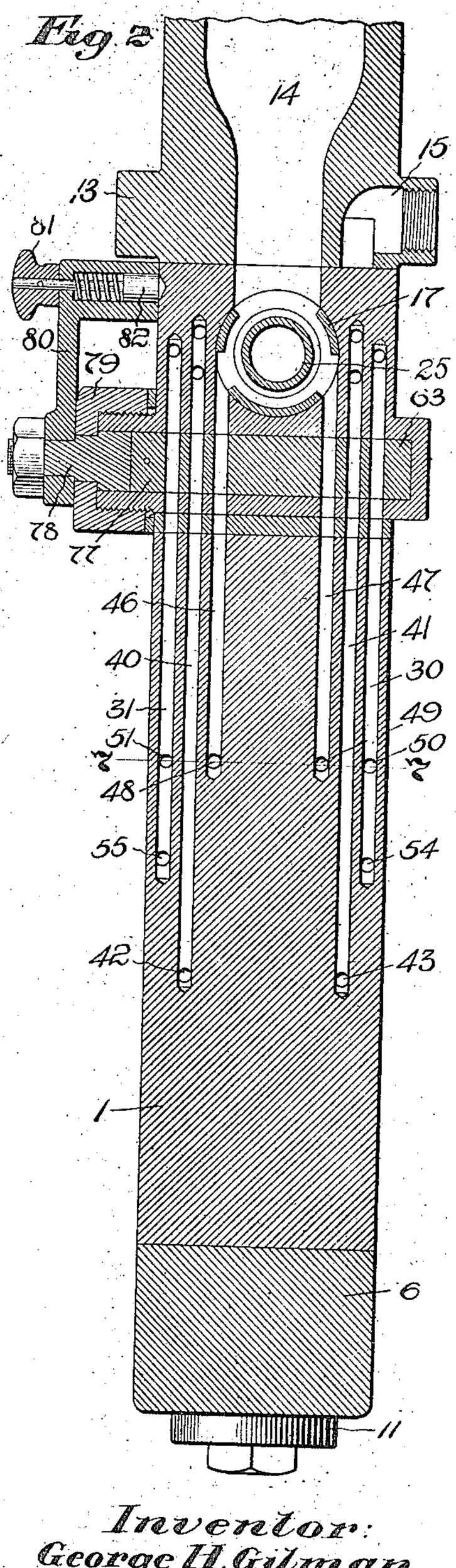


Fig. 2



Witnesses:

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Inventor:

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4 SHEETS—SHEET 2.

Fig. 3

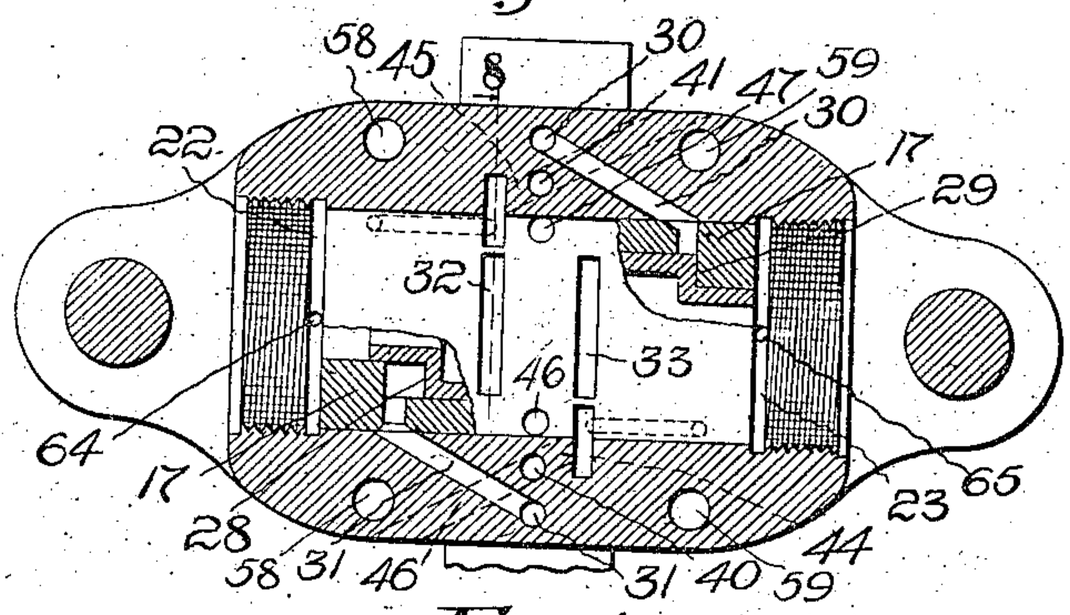


Fig. 4

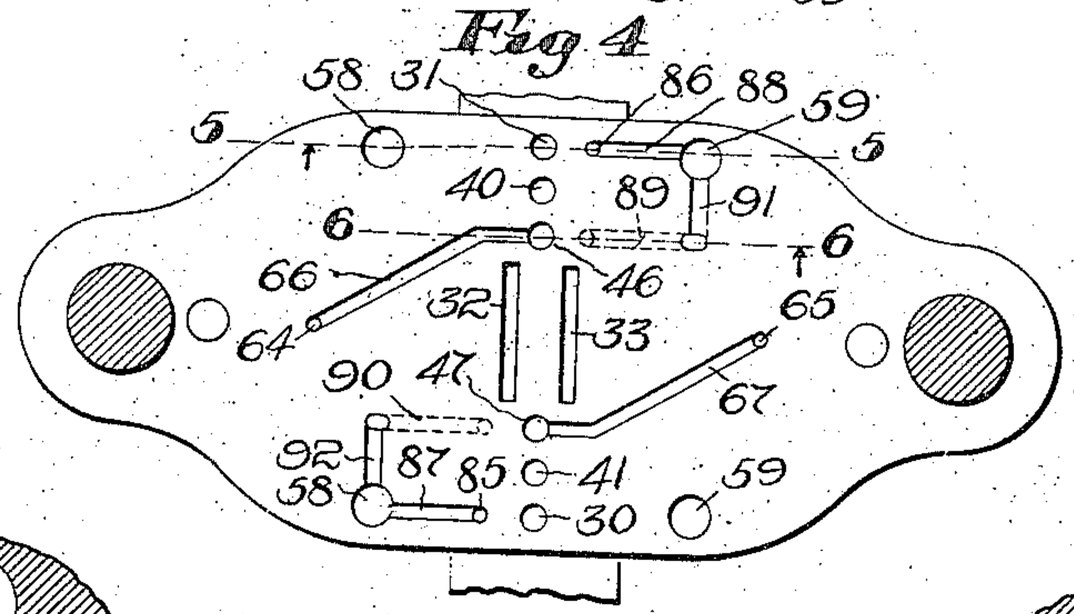


Fig. 5

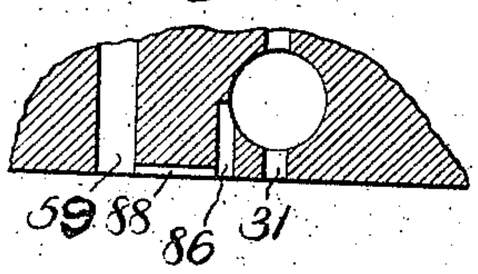


Fig. 6

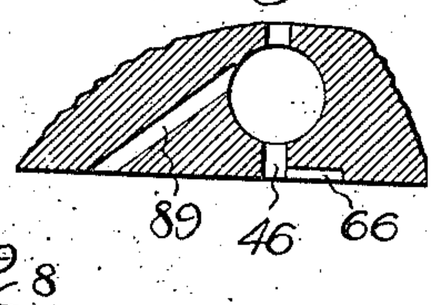


Fig. 2

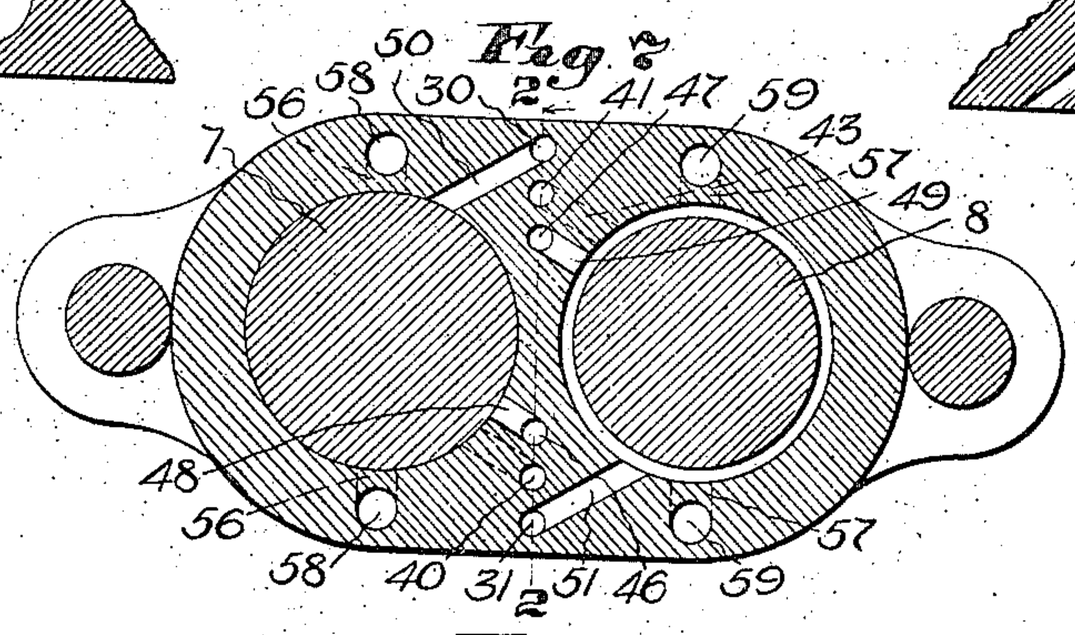
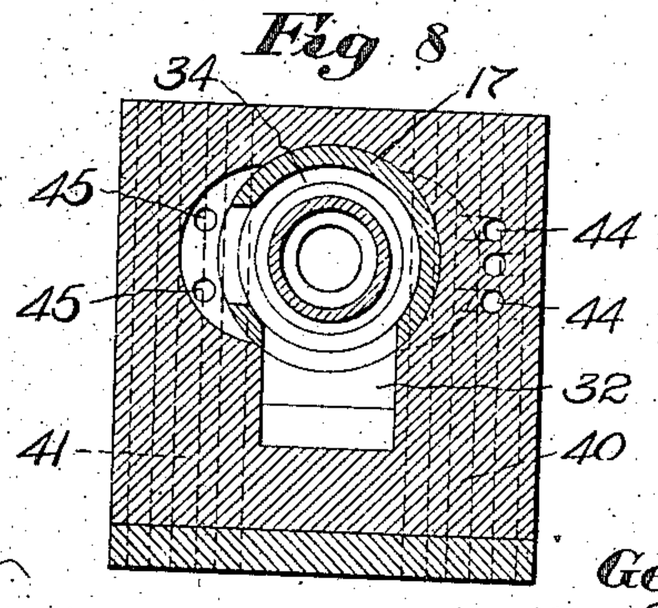


Fig. 8



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4 SHEETS—SHEET 3.

Fig. 9

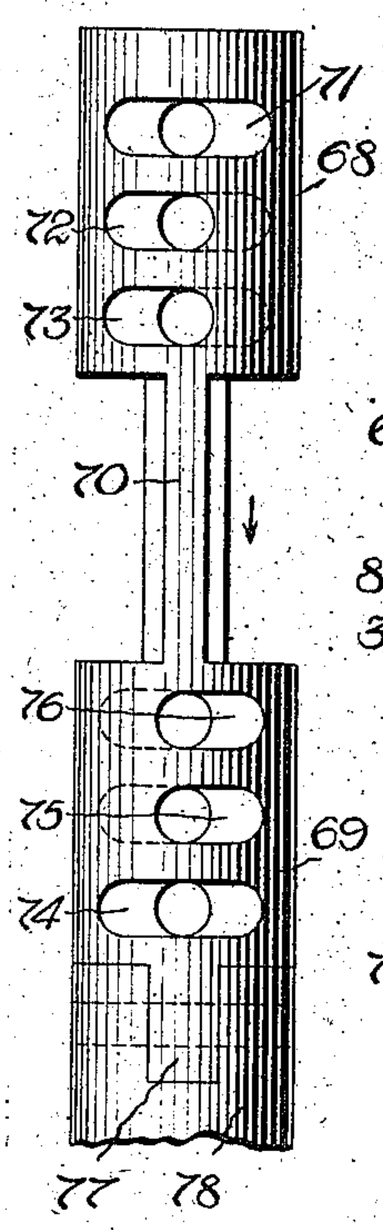


Fig. 10

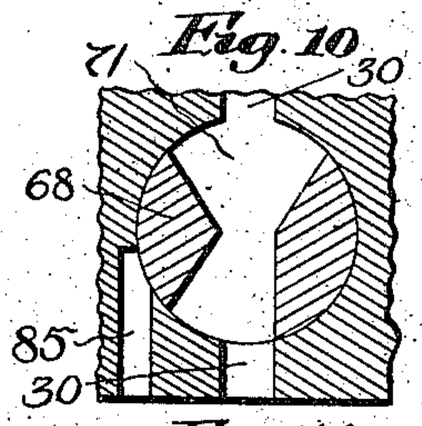


Fig. 11

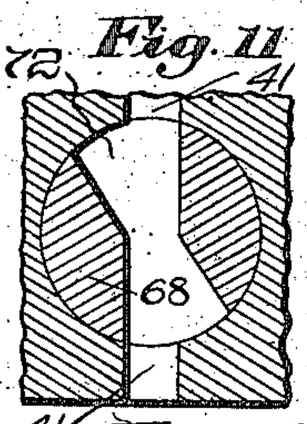


Fig. 12

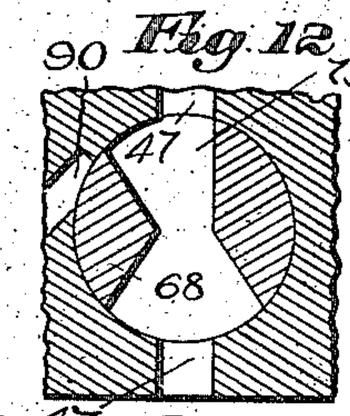


Fig. 13

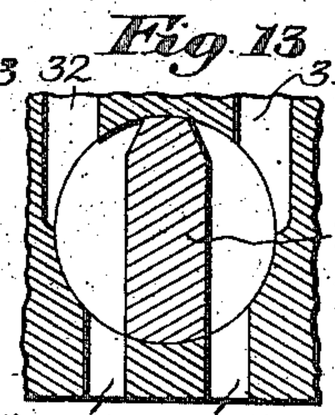


Fig. 14

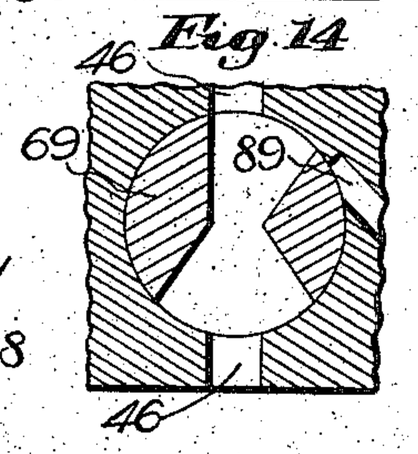


Fig. 15

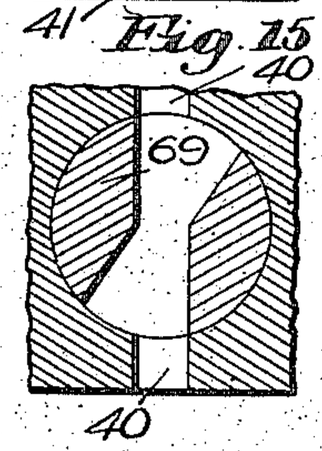


Fig. 16

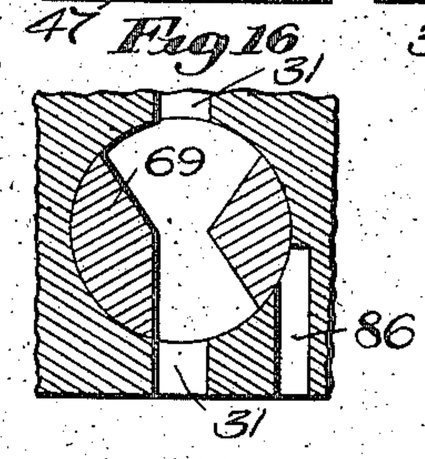


Fig. 17

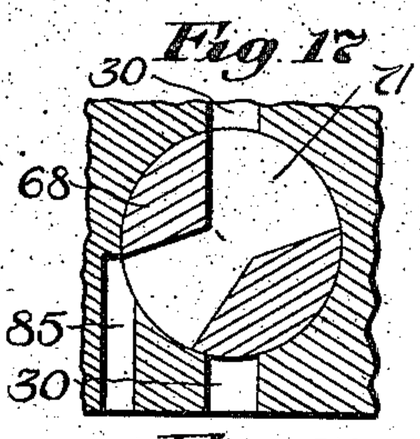


Fig. 18

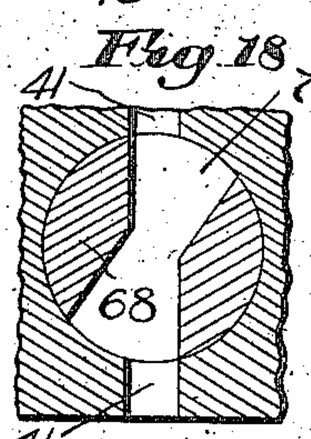


Fig. 19

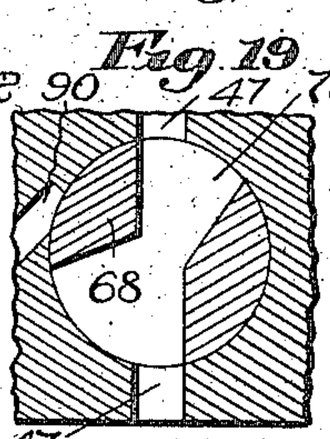


Fig. 20

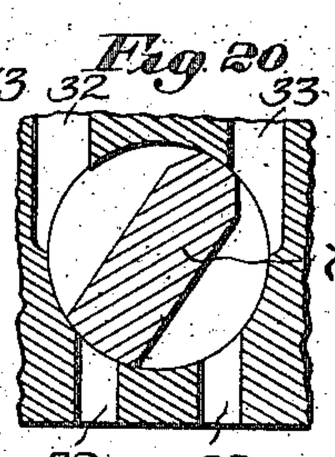


Fig. 21

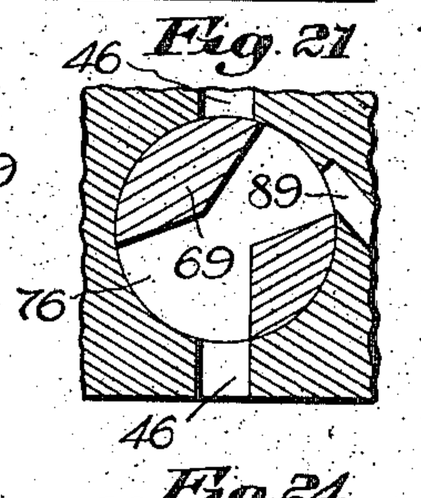


Fig. 22

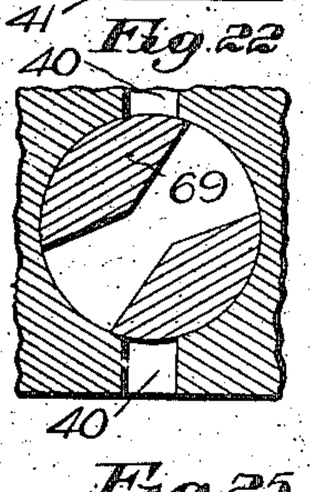


Fig. 23

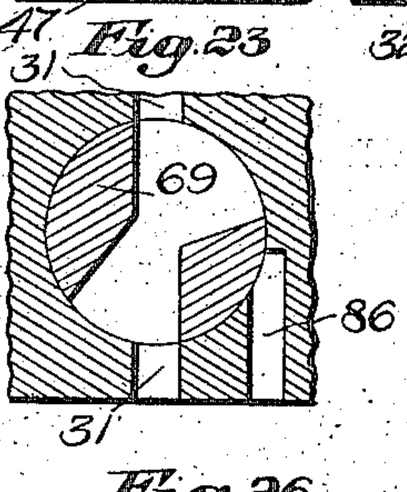


Fig. 24

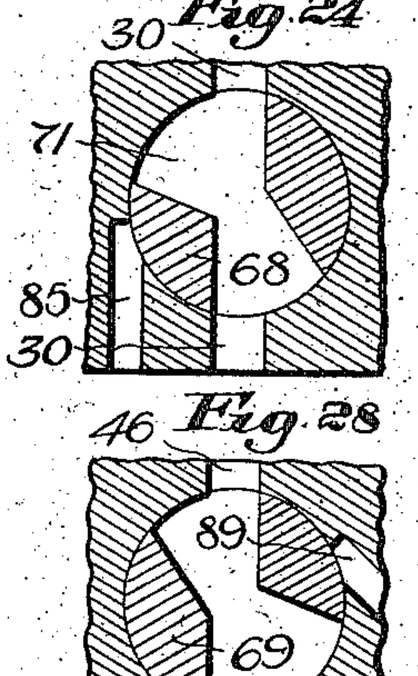


Fig. 25

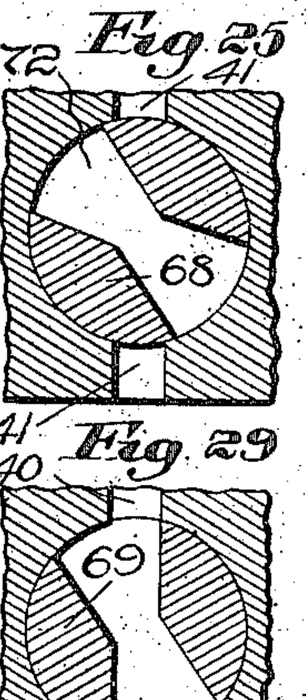


Fig. 26

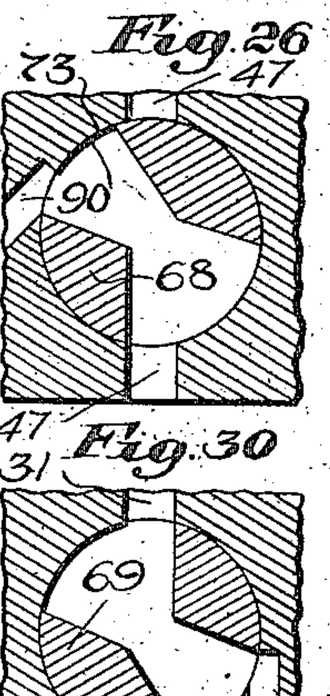


Fig. 27

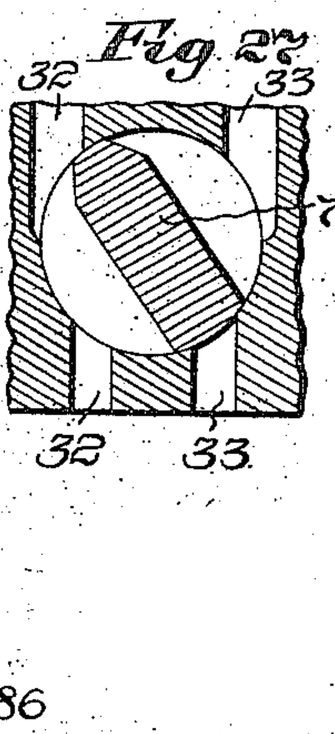


Fig. 28

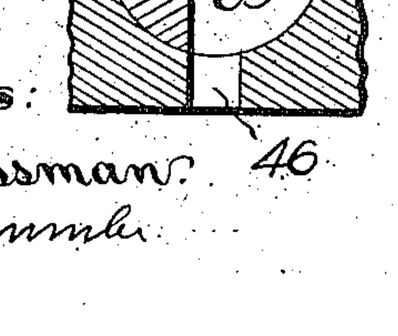


Fig. 29

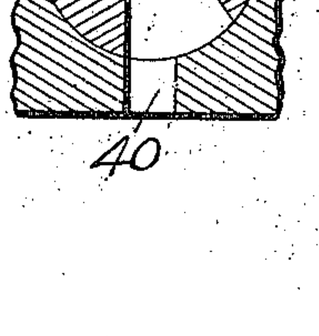
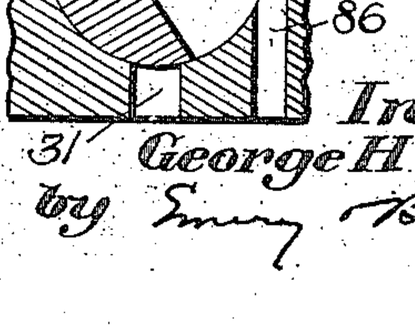


Fig. 30



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PNEUMATIC TOOL.

APPLICATION FILED MAY 14, 1908.

995,593.

Patented June 20, 1911.

4 SHEETS—SHEET 4.

Fig. 31

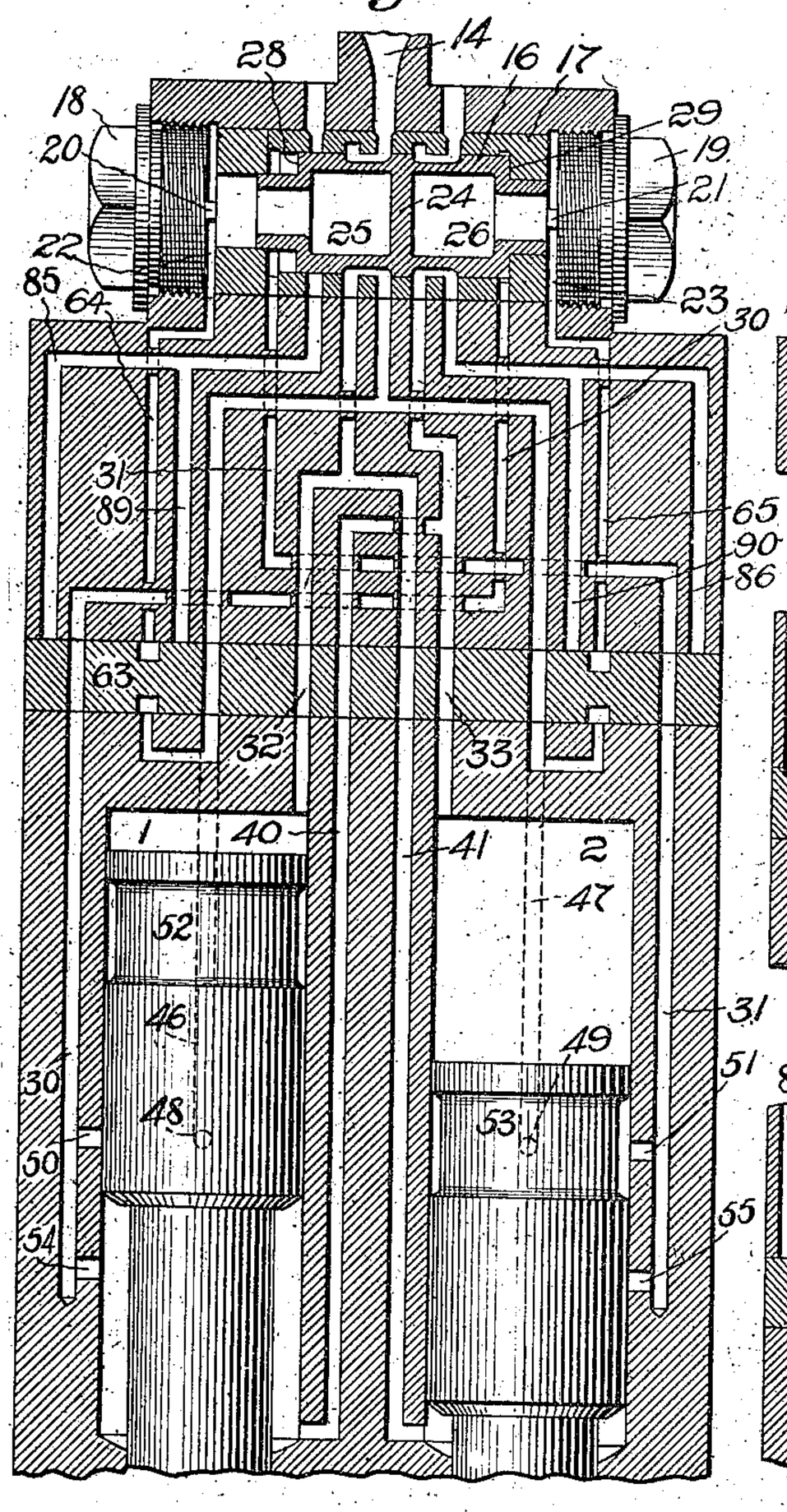


Fig. 32

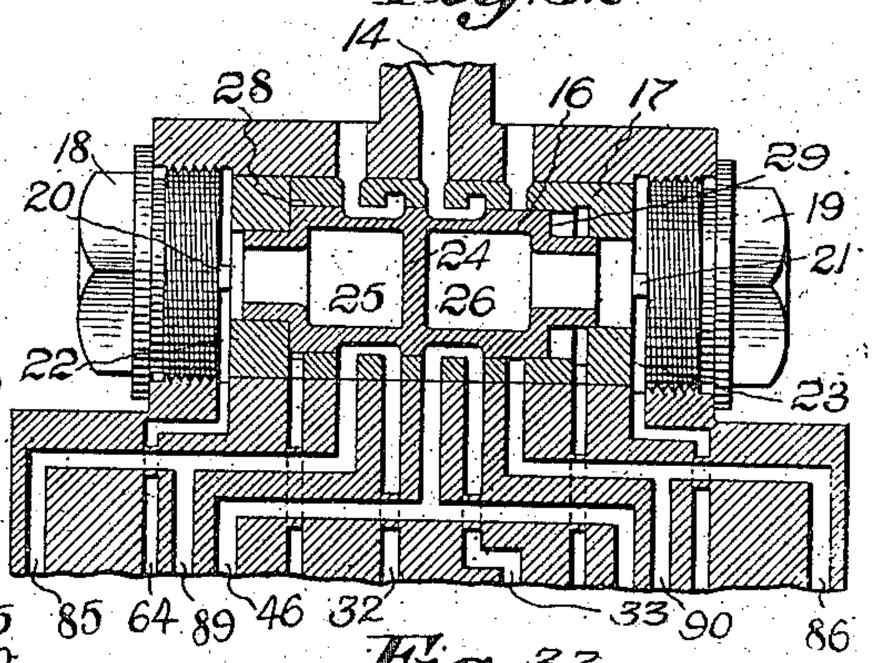


Fig. 33

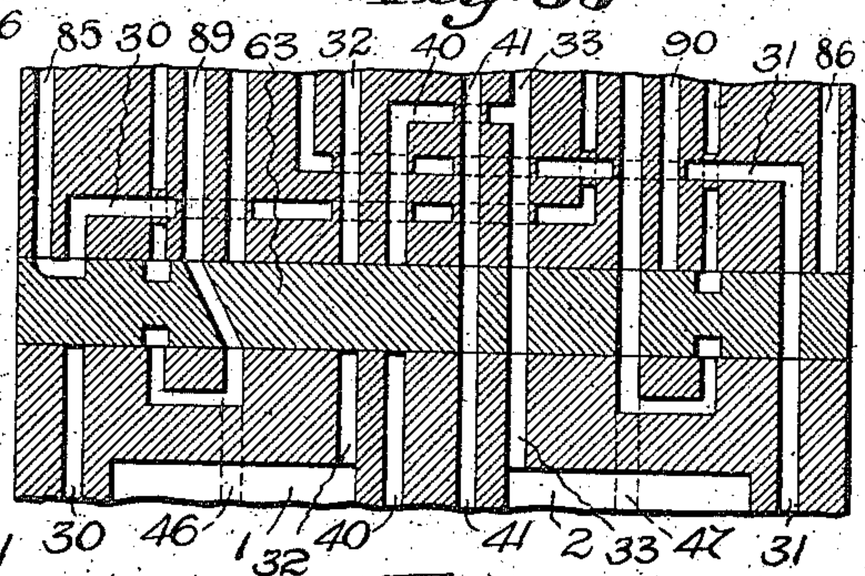


Fig. 34

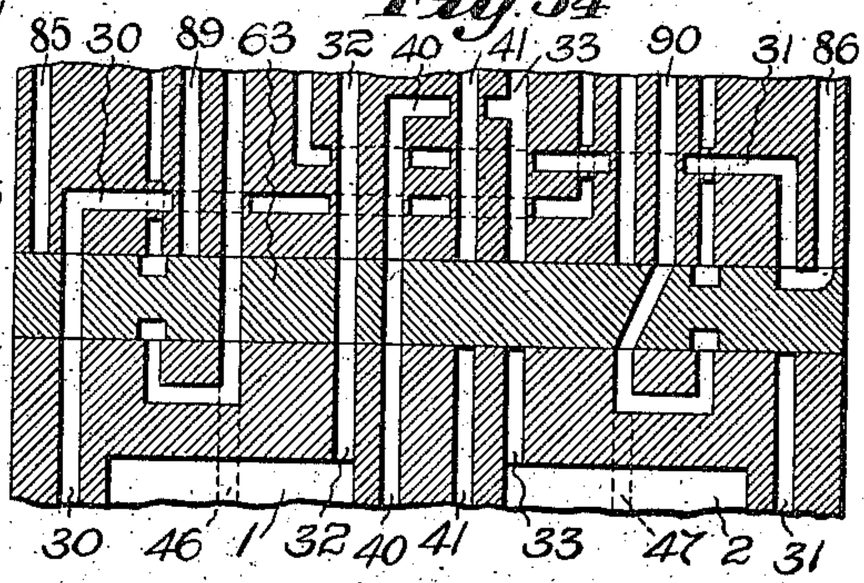


Fig. 35.

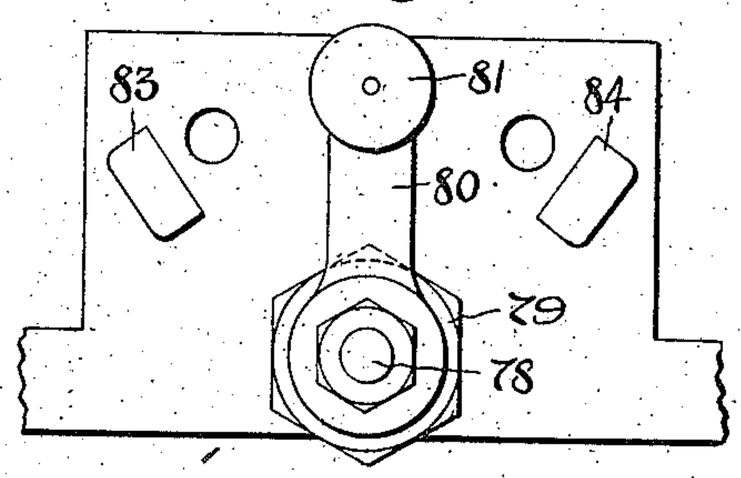
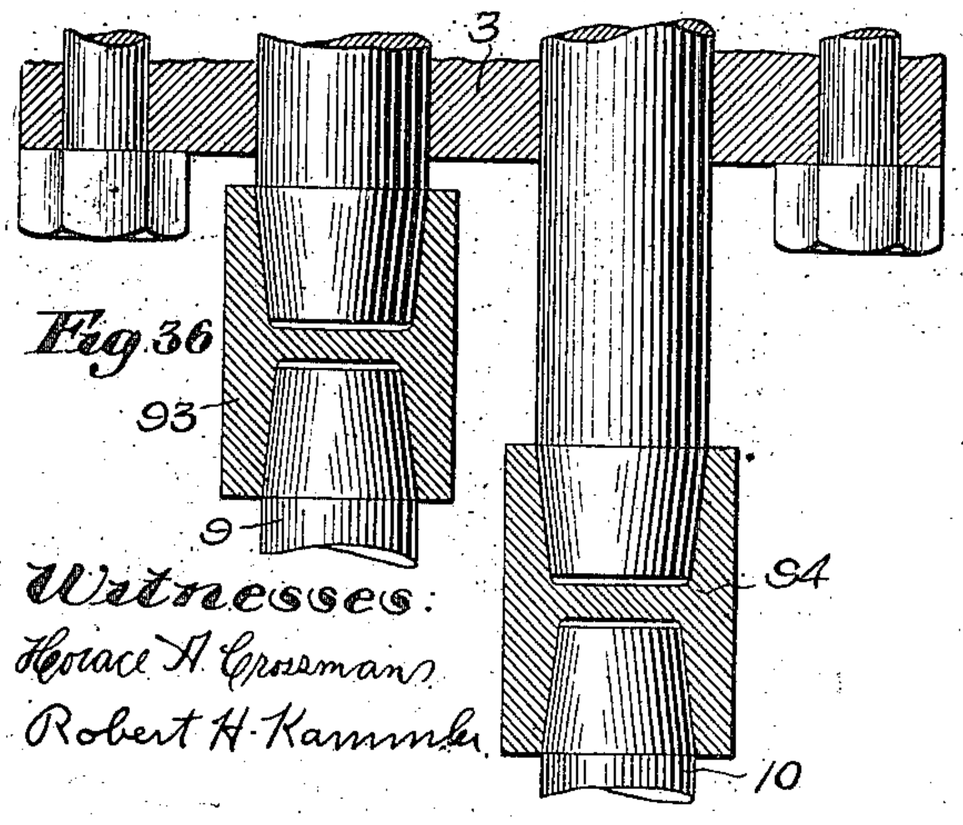


Fig. 36



Witnesses:

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Inventor:

George H. Gilman

by Emery Booth

Attys.

UNITED STATES PATENT OFFICE.

GEORGE H. GILMAN, OF CLAREMONT, NEW HAMPSHIRE, ASSIGNOR TO SULLIVAN MACHINERY COMPANY, OF CLAREMONT, NEW HAMPSHIRE, A CORPORATION OF MAINE.

PNEUMATIC TOOL.

995,593. Specification of Letters Patent. Patented June 20, 1911.

Application filed May 14, 1908. Serial No. 432,786.

To all whom it may concern:

Be it known that I, GEORGE H. GILMAN, a citizen of the United States, residing at Claremont, in the county of Sullivan, State of New Hampshire, have invented an Improvement in Pneumatic Tools, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

My invention relates to pneumatic or other pressure-fluid-actuated tools, being more particularly intended to provide a tool having two or more tool-actuated units together with suitable means for controlling or regulating the operation of said units.

While my invention in its broader aspects may be embodied in constructions other than the one herein shown, in the illustrated embodiment thereof the same is disclosed as applied to a duplex or double tool of the pneumatic piston-hammer impact type.

In the form of duplex tool shown, and herein submitted for illustrative purposes, there is provided a main controlling valve which controls the simultaneous operation of the two piston hammers. There is also provided means, such as a regulating valve, whereby either one of the pistons may be thrown out of operation and the operation of the tool continued with the remaining piston only, the latter being controlled by the same controlling valve. To facilitate this conversion of the machine from a duplex tool to a single acting tool, the valve construction is preferably such that the controlling valve may be converted at will by movement of the regulating valve from a balanced pressure-actuated valve to a differential pressure-actuated valve. When employed as a duplex tool, the controlling valve is operated as a balanced valve, and, when the tool units are operated singly, as a differential valve.

My invention will be best understood by reference to the following description when taken in connection with the accompanying illustration of one specific embodiment thereof, while its scope will be more particularly pointed out in the appended claims.

In the drawings: Figure 1 is a central sectional elevation, taken through the working cylinders and controlling valve, of a duplex hammer tool embodying one form of my invention; Fig. 2 is a similar section taken in a plane at right-angles to the plane of the section of Fig. 1 and looking toward the left in Fig. 1, or in the direction of the arrow shown on the section line 2—2 in Fig. 7; Fig. 3 is a section in plan, taken on a central plane through the valve block or head and showing a portion of the bushing and valve in position. Fig. 4 is a plan of the valve block shown in Fig. 3 looking at the bottom thereof; Fig. 5 is a partial section taken on the line 5—5 in Fig. 4, looking in the direction of the arrow but with the plate reversed from the position there shown; Fig. 6 is a similar section taken on the line 6—6 in Fig. 4, looking in the direction of the arrow but with the plate reversed from the position there shown; Fig. 7 is a section in plan taken through the working cylinders on the line 7—7 in Figs. 1 and 2; Fig. 8 is a central sectional elevation taken through the valve and the valve block on the line 8—8 in Figs. 1 and 3; Fig. 9 is a detail showing the regulating valve with a portion of the valve stem attached; Figs. 10 to 16 inclusive are sections taken transversely at different points lengthwise the regulating valve, showing the relation of the valve parts to the various registering ports in the head for the position of the valve corresponding to the simultaneous operation of both tool units; Figs. 17 to 23 inclusive are similar sections showing the relation of the regulating valve ports to the head ports in a different position of the valve, which position corresponds to the operation of one tool unit only; Figs. 24 to 30 inclusive are similar sections showing the port relations in a third position of the valve, which position corresponds to the operation of the remaining tool unit; Fig. 31 is a general and partly diagrammatic view showing a development of the pressure passages relatively to the controlling and regulating valves and showing the regulating valve in a position corresponding to Figs. 10 to 16; Fig. 32 shows the controlling valve in a reverse position from that shown in Fig. 31; Fig. 33 shows the

regulating valve in a different position from that shown in Fig. 31, and corresponding to Figs. 17 to 23; Fig. 34 shows the regulating valve in a third position and corresponding to the position shown in Figs. 24 to 30; Fig. 35 is a partial side elevation of the duplex tool shown in Fig. 1, illustrating the regulating valve handle, and Fig. 36 shows a partial section illustrating a modified construction employing a piston directly connected to the tool.

Referring to the drawings and to the illustrated embodiment of my invention, I have shown the same as applied to a pneumatic tool of the piston-hammer type provided with a pair of working cylinders with their coöperating and contained hammer pistons arranged side by side. Any desired arrangement or construction of the cylinders and pistons may be employed, but in the drawings (Fig. 1) the cylinder chambers 1 and 2 are shown as formed within a single cylinder casting 3, the latter being provided with the upper head 4 and the intervening head plate 5 closing the upper or head end of the cylinder, and also provided with the lower head 6 secured to the lower end thereof.

The pistons 7 and 8, which may be of any desired construction, are shown as provided with reduced striking or hammer ends which, as they reciprocate, are adapted to strike the ends of the independent or separate tools 9 and 10 loosely held within the bushings 11 and 12. In the construction disclosed the hammer pistons are arranged to reciprocate in out of step relation so as to reduce the shock and vibration of their combined tool action, the construction of the illustrated tool being such that they work in opposition, whereby shock due to the downward movement of one is largely neutralized by the upward movement of the other, and vice versa, so that the resultant operation of the duplex tool is accompanied by even less vibration and shock than the operation of a single tool.

While separate valves may be employed for the two tool units, or any other suitable arrangement of valve-controlling means utilized, as a simple and effective way of controlling the movements of the piston hammer, I preferably provide valve means common to the two working cylinders, the operation of such valve means providing for a movement of one hammer piston in one direction as the other simultaneously executes a movement in the opposite direction. Any suitable construction of valve may be used, but as shown in the drawings there is employed in the illustrative form a pressure-actuated valve located within the upper part of the head 4, which latter is in turn surmounted by the end piece 13, the latter containing the pressure-fluid admission passage 14 and the interconnecting exhaust passages 15 (Figs. 1 and 2).

The valve 16 may be of any suitable form, but herein the same is of the piston type consisting of a hollow cylindrical body having reduced end portions and alternating spaced grooves and shoulders or lips, the said grooves being adapted, according to the position of the valve, to connect the various desired pressure passages of the tool. The valve works within the suitably apertured valve bushing 17, the two ends of which are closed respectively by threaded cap pieces 18 and 19. The cap pieces are provided with inwardly facing projections or shoulders 20 and 21 acting as spacing members, so that when the cap pieces are screwed up tight there is still left, between their inner ends and the outer ends of the bushing, spaces which constitute respectively pressure chambers 22 and 23. These are kept in communication with the live pressure during the simultaneous operation of the two tools, so that the opposite interior ends of the valve 16, which are open to the said pressure chambers, are in communication with the live pressure. The valve is provided with a transverse interior wall or partition 24 which forms two chambers 25 and 26 respectively within the valve, pressure on opposite sides of the partition, which sides are of equal area, being balanced, as above described, during the normal operation of the tool. The right-hand end of the bushing (as viewed in Fig. 1) is contracted to receive the reduced open end of the valve, while the opposite end of the bushing is closed by a ring or washer 27, within which the opposite contracted end of the valve is adapted to slide. The shoulders between these contracted ends of the valve and the adjacent portions of larger diameter present external end pressure areas 28 and 29, respectively, preferably of equal area and exposed to the pressure in the chambers formed respectively in opposite ends of the valve bushing, to which pressure is alternately admitted and exhausted through the movements of the two pistons. As is best shown in Fig. 3, the end pressure area 28 is exposed to the pressure admitted thereagainst through the intermittent pressure passage 31, and the end area 29 to the pressure admitted through the intermittent pressure passage 30, the bushing being cut through laterally, as shown in Fig. 3, to open these passages to the external end pressure areas 28 and 29. In one position of the valve pressure is admitted to the head end of one cylinder and the forward end of the other, while, at the same time, the head end of the second cylinder and the forward end of the first are simultaneously opened to the

exhaust. On reverse movement of the valve, which is produced by connecting one of the intermittent pressure ports with the live pressure, and the other with the exhaust, reverse connections between the admission and exhaust and the respective ends of the cylinders are established to reverse the direction of movement of the two pistons.

For the admission of pressure to and its exhaust from the head end of the cylinder, the cylinder 1 is provided with the passage 32 leading to its head end and under the control of the valve 16. The cylinder 2 is provided with a like passage 33. The passage 32 leads to an annular groove 34 (see Figs. 1 and 8) in the valve bushing 17 and the passage 33 to a similar annular groove 35. The valve is also provided with coöperating circumferential grooves 36 and 37, through which the said passages 32 and 33 are adapted alternately to be placed in communication with the pressure admission passage 14 as the valve is alternately moved in its chamber from one position to the other. Next adjacent the grooves 34 and 35 the valve bushing is provided with grooves 38 and 39 which, as shown in Fig. 1, communicate directly and constantly with the exhaust passage 15, so that, with the valve in the position shown in Fig. 1, when pressure is being admitted to the head end of the cylinder 1, through the passage 32, it is being simultaneously exhausted from the head end of the cylinder 2 through the passage 33, valve groove 37, bushing groove 39 and exhaust passage 15. In the reverse position of the valve (Fig. 32) the head end of the cylinder 1 is connected with the exhaust through the passage 32, valve groove 36 and bushing groove 38.

The admission of pressure to and exhaust from the forward or tool end of the cylinders 1 and 2 is controlled through the tool-end pressure passages 40 and 41 respectively, which, as represented in Figs. 2, 3 and 7, extend longitudinally in the walls of the cylinder casting between the piston chambers and enter their respective cylinders through the ports 42 and 43 at the lower ends thereof. The tool-end pressure passages 40 and 41 extend upward through the cylinder head and valve block (see Figs. 2, 3 and 8), where they have direct connection with the annular grooves 35 and 34, respectively, by one or more horizontal passages 44 and 45 (see Figs. 3 and 8), so that, when the passage 32 is opened to the admission passage 14 by the valve 16, the tool-end pressure passage 41 for the tool end of the other cylinder is simultaneously opened to the admission, and, when the passage 32 is opened to the exhaust, pressure fluid is simultaneously exhausted from the tool-end of the opposite cylinder. In other words, the pressure controlling passage for the tool-end of each cylinder is so associated with the passage of the head end of the other cylinder that reverse conditions invariably prevail at the corresponding ends of the two cylinders during operation of the tool, thereby insuring movement of the two hammer pistons in opposed step.

For the control of the actuating or moving pressure for the valve, which is conducted through the reversing or intermittent pressure passages 30 and 31, I have provided constant pressure passages 46 and 47 for the cylinders 1 and 2, respectively. Each constant pressure passage (see Fig. 2) constantly communicates, through suitably cutaway portions in the bushing 17, with the pressure supply passage 14. The passage 14. The passage 46 opens into the cylinder 1 through the port 48 (see Figs. 2 and 7) and the passage 47 into the cylinder 2 through the port 49, the ports 48 and 49 being located, respectively, at or about the same position lengthwise the cylinders as the two ports 50 and 51, which open from the intermittent pressure passages 30 and 31, respectively, into the cylinders 1 and 2. The pistons 7 and 8, being provided with the respective contracted portions 52 and 53, the intermittent pressure port 50 will be opened to live pressure through the constant pressure passage 46, when the piston 7 approaches the limit of its downward movement in the cylinder 1, and, on the other hand, the intermittent pressure port 51 is placed in communication with the constant pressure port 49 when the other piston 8 approaches its limit of downward movement. The intermittent pressure passages, in addition to the ports 50 and 51, are also provided, respectively, with the ports 54 and 55 (see Fig. 2) opening into their respective cylinders at a point or level below or in advance of the ports 50 and 51.

Considering the simultaneous out-of-step operation of the two tools under the conditions referred to, pressure is admitted through the intermittent pressure port 51 near the close of the forward movement of the piston 8 (as represented in Fig. 1), thereby admitting pressure to the valve chamber to act against the left-hand (Fig. 1) end pressure area 28 of the valve. At the same time, the forward end of the cylinder 1, being opened to the exhaust (as will be explained) the intermittent pressure port 30 is also opened to the exhaust and pressure is thereby exhausted from the opposite end of the valve chamber and contiguous to the opposite end pressure area 29. This occasions the instant reversal of the valve and reverses the movement of the piston in each tool. On rearward movement of the piston 8 the port 55 in the intermit-

tent pressure passage 31 is soon uncovered and the forward end of the cylinder 2 opened to the exhaust (as will be explained) and pressure is there exhausted from the end pressure area 28 of the valve. At or about the same time forward movement of the piston 7 opens the intermittent pressure port 50 to the constant pressure port 48 and occasions admission of live pressure therethrough to the end pressure area 29 of the valve thereby again causing the reversal of the valve and a reversal of the piston movements.

The forward or tool ends of the cylinders may be exhausted in any suitable way, but herein, as is customary in this type of tool, the forward cylinder ends are first opened to the exhaust through the uncovering by their respective pistons of an appropriately located exhaust port or ports. The cylinder 1 is provided with a pair of exhaust ports 56 (Fig. 7) and the cylinder 2 with ports 57, the former connected to exhaust passages 58, and the latter to exhaust passages 59, which passages extend lengthwise the cylinder casting 3 and the valve block and are connected at their upper ends through grooves 61 and 62 of the valve block with the exhaust passages 15. This maintains the exhaust ports 56 and 57 permanently open to the exhaust and each, when uncovered by its respective piston, exhausts the pressure from the forward end of its cylinder, and, as above described, also, at the same time, from the corresponding end pressure area of the valve 16 to effect a reversal of the same.

Since the arrangement of the various pressure passages relative to the valve chamber and the clyinders, for obvious constructional reasons, are not shown in any of the constructional views, there is shown (Figs. 31–34) a diagrammatic arrangement of these passages in the form of a development thereof, without attempting to portray accurately the mechanical construction. The arrangement shown in Fig. 31, showing the valve in one position, and in Fig. 32, showing the valve in its reverse position, illustrates the arrangement of pressure passages when the tool is operated, as above described, with both units having simultaneous, but opposed, reciprocating movement.

In order to convert the duplex tool into a single acting tool a regulating valve 63 is employed located in the valve block transversely the controlling valve 16 and between the latter and the head plate 5. This regulating valve is so constructed and arranged with reference to suitable passages in the head that it may be turned to cut out of operation either cylinder at will, this being accompanied, at the same time in the illustrated form of my invention, by the conversion of the balanced pressure-actuated valve into a differential pressure-actuated valve controlling the movements of the particular cylinder and piston then in operation. The head end admission passages 32 and 33, the tool-end admission passages 40 and 41, the constant pressure passages 46 and 47 and the intermittent pressure passages 30 and 31 are all intercepted and controlled by the regulating valve 63. Before describing the construction of the regulating valve it may be stated that, in the form shown, when the valve is turned in a direction to cut off one of the cylinders, for example, the left-hand cylinder 1, it leaves the passages connecting with the right-hand cylinder unchanged from the relation shown in Fig. 31. At the same time, however, it acts not only to close the admission passage for the head end of the left-hand cylinder, the tool-end admission passage 40 and the left-hand intermittent pressure passage 30, but causes it to cut off live pressure from the left-hand interior valve chamber 25 at one side of the partition 24, opening the said chamber to the exhaust, while also opening the right-hand exterior, end pressure chamber 29 to the exhaust and cutting the same off from the intermittent pressure passage with which it had been previously connected. This leaves live pressure acting on the right-hand side of the partition 24 alone, pressure on the left-hand side thereof being exhausted, the valve, therefore, being constantly pressed in a left-hand direction, as viewed in Fig. 1. It also leaves the external end pressure area 29 exposed to the exhaust with the opposite exterior end area 28 connected with the right-hand intermittent pressure passage 31 and exposed to the pressure intermittently conducted therethrough. The end area 28 is greater in extent than the area of the interior partition 24, and the valve is accordingly moved to the right at each forward stroke of the piston 2, when the latter opens the intermittent pressure port 51 to the constant pressure port 49, but is moved in the opposite direction as soon as the said intermittent pressure port is opened to the exhaust. When the regulating valve is turned to a position to cut out the right-hand cylinder 2 reverse pressure conditions are caused to prevail, that is to say, the left-hand exterior end area 28 of the valve and the right-hand interior valve chamber 26 are open to the exhaust, thereby converting the valve into a differential valve controlled through the movement of the piston 1.

The valve chambers 22 and 23, into which the interior valve chambers 25 and 26 open, are placed in communication with the constant pressure passages 46 and 47 by passages or conduits 64 and 65 (Figs. 1, 3 and 4) which extends downward from the said chambers through the valve block to the bottom face thereof, where they are connect-

ed by surface grooves 66 and 67 (Fig. 4) with the constant pressure passages 46 and 47, respectively, below the regulating valve 63. When the regulating valve is turned to cut out one cylinder or the other, the constant pressure passage for that cylinder, as will more fully appear, is cut off from the pressure and placed in communication with the exhaust through the regulating valve, whereby the end chamber 22 or 23 is also opened to the exhaust.

Referring now to the regulating valve 63, the latter may be of any suitable construction and located in any selected position on the tool, but herein the same is constructed as represented in Figs. 9 to 30 and arranged transversely the tool beneath the valve 16, as represented in Figs. 1 and 2. The valve, as shown, is provided with two piston or barrel portions connected by an intermediate substantially flat portion 70. The latter lies adjacent the passages 32 and 33 in the valve block, as best shown in Figs. 1, 13, 20 and 27, so that in one position (Fig. 13) the said passages are both left free and open; in another position (Fig. 20) the passage 32 maintained closed, with the passage 33 open, and, in the third position (Fig. 27), the passage 33 closed and the passage 32 open. The barrel portion 68 is provided with apertures or ports 71, 72 and 73 which, with the valve in position, aline with the passages 30, 41 and 47, respectively. The barrel portion 69 likewise is provided with apertures or ports 74, 75 and 76 which, with the valve in position, aline with the passages 31, 40 and 46, respectively. The end of the barrel portion 69 of the valve is provided with a projection 77 (Figs. 2 and 9) which is embraced by the forked end of the valve stem 78, the latter passing through an aperture in the threaded cap 79 (Figs. 2 and 35), and provided with the external regulating lever 80. The lever is provided with a thumb or finger piece 81 carrying a sliding spring-pressed pin 82 adapted to engage with any one of three notches formed in the exterior face of the valve block (Fig. 35), whereby it may be moved to a central position, as represented in Figs. 2, 31 and 35, or to a position against the stop 83 to throw out of operation the cylinder 1 (Fig. 33), or against the oppositely disposed stop 84 to throw out of operation the cylinder 2 (Fig. 34), the spring-pressed pin acting at all times to retain it in its assigned position.

To understand the changes which the regulating valve effects in connections between the various ports and passages in the conversion of the balanced pressure valve into a differential pressure valve, attention is directed particularly to Figs. 3 to 7 inclusive. From this it will be observed that in the same plane with the intermittent pressure passages (see Fig. 5) there are also provided supplemental passages 85 and 86 opening into the regulating valve chamber (the former in line with the intermittent pressure passage 30 and the latter with the passage 31), which supplemental passages are permanently connected, as by the grooves 87 and 88, respectively, in the bottom of the valve block, each with an adjacent one of the exhaust passages 58 or 59. This makes it possible, by means of the regulating valve, to open up either intermittent pressure passage to the exhaust and thereby open up the corresponding exterior end pressure area to the exhaust. Furthermore, there is also provided (Fig. 6) in the planes of the constant pressure passages 46 and 47, respectively, additional supplemental passages 89 and 90 which lead from the bottom of the valve block and enter the regulating valve chamber on an incline, the said passages being also permanently connected each with an adjacent one of the exhaust passages 59 or 58 by means of the grooves 91 and 92, respectively, in the bottom of the valve block. This makes it possible by means of the regulating valve to shut off either one of the constant pressure passages from live pressure and open the same to the exhaust, thereby permanently exhausting pressure from the corresponding interior valve chambers 25 or 26.

The various connections made by the regulating valve will be best understood from an inspection of Figs. 31 to 34 inclusive in conjunction with the sections shown in Figs. 10 to 30 inclusive, the latter being taken transversely the regulating valve, and looking in the direction of the arrow in Fig. 9, *i. e.*, in the direction of the section of Fig. 1. When the regulating valve is set to the mid position the connections of the various ports are as shown in Figs. 10 to 16, both tools being simultaneously in operation. In this position all the cylinder passages for both cylinders are open, the supplementary exhaust passages 85, 86, 89 and 90 leading into the regulating valve chamber and adjacent to the ports 30, 31, 46 and 47, respectively, being closed, as will be seen from Figs. 10, 16, 14 and 12, respectively. In this position of the regulating valve the tool operates in the manner previously described, the valve 16 acting as a balanced pressure valve with pressure constantly admitted against the smaller effective areas thereof which are presented by the interior partition 24, and alternately admitted to and exhausted from the larger opposite and equal end pressure areas 28 and 29. This condition is represented by the diagrammatic view in Fig. 31. When the regulating valve handle 80 is turned to the right against the stop 84 it cuts out of operation the left-hand cylinder, changing the connections of the various passages, as represented in Figs. 17 to 23. In

this position of the valve the head end admission passages 32 (Fig. 20) for the cylinder 1 is closed, while the passage 33 for the cylinder 2 remains open. The tool end pressure port 41 (Fig. 18) for the right-hand cylinder 2 remains open, while the corresponding port 40 (Fig. 22) for the left-hand cylinder 1 is closed. The constant pressure passage 47 for the right-hand cylinder 2 (Fig. 19) remains open, while the constant pressure passage 46 (Fig. 21) for the left-hand cylinder 1 is cut off from communication with the pressure above and connected through the regulating valve port 76 with the supplementary exhaust passage 89, thereby exhausting from the interior valve chamber 25. The intermittent pressure passage 31 (Fig. 23) for the right-hand cylinder remains in communication with the external end pressure valve area 28, as before, while the intermittent pressure port 30 (Fig. 17) for the left-hand cylinder 1 is closed by the regulating valve and the upper portion of the passage which leads to the end pressure valve area 29 is placed in communication with the supplemental exhaust port 85 by means of the regulating valve port 71. This condition of affairs is represented diagrammatically in Fig. 33. In this position of the valve it will be seen that all the cylinder ports for the cylinder 1 except the constant pressure port 46 are shut off, while the constant pressure port is opened to the exhaust, thus exhausting pressure from the interior valve chamber 25. At the same time, the regulating valve has connected the exhaust passage with the external end pressure area 29 of the valve. The piston 2 will then operate in the following manner. The valve 16 being constantly pressed toward the left, as represented in Fig. 32, by pressure acting against one side of the partition 24 in the chamber 26, pressure is admitted through the head end admission passage 33 to drive the piston forward. At the same time, pressure is exhausted from the forward end of the cylinder through the tool end pressure passage 41. When the piston nears the forward end of its travel, it uncovers the intermittent pressure port 51 to the constant pressure port 49, thereby admitting pressure against the exterior end pressure area 28 of the valve. The area 28 being greater than the area of the partition 24, the valve is moved to the right, or to the position shown in Fig. 31. In the position shown in Fig. 31 pressure is exhausted from the head end of the cylinder through the passage 33 and admitted to the forward end of the cylinder through the passage 41; this condition obtaining until the piston uncovers the exhaust port 57 and the intermittent pressure port 55, whereupon the exhaustion of pressure from the end pressure area 28 permits the reversal of the valve to the position shown in Fig. 32, through the medium of the pressure fluid acting internally within the valve against the partition 24. When it is desired to operate the left-hand cylinder 1 alone, while cutting out of operation the right-hand cylinder, the regulating valve handle 80 is turned against the left-hand stop 83, effecting connections between the various ports and passages, substantially the same with reference to the left-hand cylinder as are those just described with reference to the right-hand cylinder. Such connections are represented in the sectional view shown in Figs. 24 to 30 and in the diagrammatic view shown in Fig. 34, which will be sufficiently clear without the need of further explanation, it being understood that under such conditions the left-hand cylinder operates while the right-hand cylinder is inoperative and the controlling valve 16 operates as a differential valve but with its effective areas reversed, that is to say, the larger area is now the external end area 29, and the smaller area the transverse wall 24 facing the chamber 25, pressure under these conditions being exhausted from the chamber 26 and the end area 28.

While I have described my invention as applied to a tool of the pneumatic impact hammer type, it is, of course, applicable also to direct connected tools, which, for some purposes, it may be advantageous to employ. In Fig. 36 I have shown such an application of the tool previously described, wherein the piston members 1 and 2 have their reduced ends fixedly attached to chuck or tool holders 93 and 94, which latter, in turn, have removably secured thereto the cutting bits or tools 9 and 10, respectively. It therefore follows that the tools reciprocate back and forth in alternation with the pistons, instead of receiving at each piston stroke the impact or blow thereof.

While I have shown for illustrative purposes one embodiment of my invention, it is to be understood that the same is not limited to the particular form herein disclosed or to the details of construction, which, for the sake of explicitness, are herein fully described and illustrated, but that extensive modifications and deviations from the illustrated construction may be made without departing from the true spirit of the invention.

Having thus described my invention, what I claim is:

1. A pressure fluid tool having a piston, a balanced valve for controlling the same, and means for converting the said balanced valve into a differential valve.

2. A pressure fluid tool having a piston, a valve controlling the same and presenting pairs of equal opposed pressure areas, means for admitting pressure constantly to one pair of areas, and means for alternately ad-

mitting pressure to one member of the other pair of pressure areas while exhausting pressure from the remaining one.

3. A pressure fluid tool having a controlling valve for controlling the admission of pressure to its cylinder, said valve presentpairs of equal opposed pressure areas, means for constantly admitting pressure against one pair of pressure areas, means for alternately admitting pressure to one member of the remaining pair of pressure areas while exhausting the same from the remaining one of said pair, thereby to operate said valve as a balanced valve and means to withdraw pressure from an area of one pair and the opposed area of the other pair, thereby to permit said valve to operate as a differential valve.

4. A pressure fluid tool having a valve provided with differential areas, to the smaller of which pressure may be constantly admitted to move the valve in one direction, and to the larger area of which pressure may be intermittently admitted to move the valve in the opposite direction, means for admitting at will constant pressure to another area, acting to balance said first-mentioned constant pressure, and means also to admit pressure intermittently to a fourth area of said valve in opposition to the first-mentioned intermittent pressure.

5. A pressure fluid tool having a controlling valve adapted to be moved constantly in one direction by constantly acting pressure fluid, and in the opposite direction by intermittently acting pressure fluid, and means at will also to move said valve in said first-mentioned direction by intermittently acting pressure fluid.

6. A pressure fluid tool having a pair of pistons and cylinders, a single controlling valve for controlling the movements of said pistons, said controlling valve operating as a balanced pressure-actuated valve, and means for converting said valve into a differential pressure-actuated valve.

7. A pressure fluid tool having a pair of cylinders each with its contained piston, a single controlling valve for controlling the movements of the pistons, means for causing said valve to operate as a balanced pressure-actuated valve during the simultaneous action of the two pistons, and means for cutting out of operation one of said cylinders while, at the same time, converting the said controlling valve into a differential pressure-actuated valve.

8. A pressure fluid tool having a plurality of cylinders, each with its contained piston, and a balanced pressure-actuated controlling valve for alternately admitting live pressure fluid from the valve chamber to opposite ends of each cylinder.

9. A pressure fluid tool having a plurality of cylinders, each with its contained piston, a balanced pressure-actuated valve, with its valve chamber controlling the movements of said pistons, each cylinder being provided with a passage leading to its forward end, through which passage is alternately opened to the live pressure fluid and the atmosphere through the movements of said valve.

10. A pressure fluid tool having a pair of cylinders, each with its contained piston, a balanced pressure-actuated valve passage connecting the opposite ends of each cylinder with the valve chamber, said valve being adapted on movement in one direction to place the rear end of one cylinder, and the forward end of the opposite cylinder, in communication with the live pressure fluid, and the forward end of the first cylinder and the rear end of the second in communication with the atmosphere.

11. A pressure fluid tool having a pair of cylinders, each with its contained piston, a controlling valve presenting equal opposed pressure areas, passages controlled by said valve for admitting live pressure fluid to opposite ends of each cylinder, pressure being admitted to the forward end of one cylinder simultaneously with its admission to the rear end of the other cylinder, means for admitting pressure to one of said pressure areas on the forward movement of one piston and for exhausting pressure therefrom on the rearward movement thereof, and means also for admitting pressure to said other area on the forward movement of the remaining piston and for exhausting pressure therefrom on the rearward movement thereof.

12. A pressure fluid tool having a plurality of cylinders, each with its contained piston, valve controlling means for causing the simultaneous operation of said pistons, and a regulating valve for throwing any one of said pistons out of operation.

13. A pressure fluid tool having a plurality of cylinders, each with its contained pistons, means for operating the same simultaneously, a single controlling valve, and a regulating valve for throwing one or another of said pistons out of operation.

14. A pressure fluid tool having a pair of cylinders, each with its contained piston, means for causing the same to operate simultaneously in opposed step, and a regulating valve for throwing either one of said pistons out of operation.

15. A pressure fluid tool having a pair of cylinders, each with its contained piston, a balanced pressure-actuated controlling valve for the same, and a regulating valve for converting said balanced valve into a differential pressure-actuated valve, and, at the same time, cutting out of operation one of said pistons.

16. A pressure fluid tool having a pair of cylinders, each with its contained piston, a

balanced pressure-actuated valve for causing the simultaneous operation of said pistons, means for converting said valve into a differential pressure-actuated valve, pressed in one direction by constantly acting pressure and in the opposite direction by intermittently acting pressure for the sole operation of one piston, and means also for converting the controlling valve into a differential valve, pressed in the other direction by constantly acting pressure and in the opposite direction by intermittently acting pressure for the sole operation of the remaining piston.

17. A pressure fluid tool having a piston, a valve controlling the same and presenting sets of equally opposed pressure areas, means for alternately reversing the pressure conditions on the opposed sets of pressure areas to cause the valve to move reversely as a balanced valve and means to operate said valve as a differential valve by intermittently changing the pressure conditions at one end of the valve.

18. A pressure fluid tool having a piston, a valve controlling the same, the latter having a plurality of pressure receiving areas, means for moving valve in opposite directions through the change in pressure conditions upon a given combination of pressure areas and means also to move the valve when desired in opposite directions through the alteration of pressure conditions upon a different combination of pressure areas.

19. A pressure fluid tool having a piston, a valve controlling the same and presenting pairs of equally opposed pressure areas, means for maintaining constant pressure conditions upon one pair of areas, and means for alternately reversing pressure conditions upon the members of the other pair of pressure areas.

20. A pressure fluid tool having a pair of pistons and cylinders, a single controlling valve for controlling the movements of said pistons; said valve presenting a plurality of pressure areas and serving to control said tool through a certain combination of pressure areas, and means for operating said valve under a different combination of pressure areas.

21. A pressure fluid tool having pistons 7 and 8 and the valve 16 the latter provided with equal opposed pressure areas 25 and 26 and also with the equal opposed pressure areas 28 and 29.

22. A pressure fluid tool having a plurality of cylinders each with its free hammer piston, means for operating said pistons together and means also to place any one out of operation at will.

23. A pneumatic tool having a plurality of free hammer pistons, pressure fluid means to cause the same to operate jointly in opposed step, and means also to throw either one of said pistons out of operation at will while continuing the operation of the remaining piston.

24. A pressure fluid tool having a plurality of cylinders, each with its contained piston, pressure actuated valve means for operating said pistons together, and means also to place any one out of operation at will.

25. A pneumatic tool having a plurality of mechanically disconnected pistons, means to cause the same to operate jointly in opposed step, and means to throw either one of said pistons out of operation at will while continuing the operation of the remaining piston or pistons.

26. In a pneumatic tool the combination with the hammer pistons 7 and 8 of the controlling valve means 16 and the regulating valve 63.

27. A pressure fluid tool having a plurality of cylinders, each with its free hammer piston, means for operating the same simultaneously, and controlling means for throwing either one of said pistons out of operation.

28. A pressure-fluid tool having a plurality of cylinders, each with its free hammer piston, means for operating the same in out of step relation, and controlling means for throwing either one of said pistons out of operation.

29. A pressure-fluid tool having a plurality of cylinders, each with its free hammer piston, means for operating the same simultaneously, and a regulating valve located to control the passages between the main valve and the cylinders for throwing either one of said pistons out of operation.

30. A pressure-fluid tool having a plurality of cylinders, each with its free hammer piston, means for operating the same in out of step relation, and a regulating valve located to control the passages between the main valve and the cylinders for throwing either one of said pistons out of operation.

31. A pressure-fluid tool having a plurality of cylinders, each with its contained piston, a single controlling valve for causing the operation of said pistons simultaneously, and means for throwing either one of said pistons out of operation.

32. A pressure-fluid tool having a plurality of cylinders, each with its contained piston, a single controlling valve for causing the operation of said pistons in out of step relation, and means for throwing either one of said pistons out of operation.

33. A pressure-fluid tool having a plurality of cylinders, each with its contained piston, a single controlling valve for causing the operation of the same in opposed step and a regulating valve for throwing either one of said pistons out of operation.

34. A pressure-fluid tool having a plurality of cylinders, each with its contained

piston, a single controlling valve for causing the operation of the same simultaneously, and a regulating valve for throwing either one of said pistons out of operation.

35. A pressure-fluid tool having a plurality of cylinders, each with its contained piston, pressure-actuated controlling valve means controlled by ports actuated through piston controlled ports for causing the operation of the said pistons simultaneously, and means for throwing either one of said pistons out of operation.

36. A pressure-fluid tool having a plurality of cylinders, each with its contained piston, pressure-actuated controlling valve means controlled by ports actuated through piston controlled ports for causing the operation of the said pistons simultaneously, and a regulating valve for throwing either one of said pistons out of operation.

37. A pressure-fluid tool having a plurality of cylinders, each with its contained piston, pressure-actuated controlling valve means controlled by ports actuated through piston controlled ports for causing the operation of the said pistons in out of step relation, and means for throwing either one of said pistons out of operation.

38. A pressure-fluid tool having a plurality of cylinders, each with its contained piston, pressure-actuated controlling valve means controlled by ports actuated through piston controlled ports for causing the operation of the said pistons in out of step relation, and a regulating valve for throwing either one of said pistons out of operation.

39. A pressure-fluid tool having a plurality of cylinders, each with its contained piston, valve means for operating the same simultaneously, and a regulating valve located to control passages between the main valve and said cylinders for throwing either one of said pistons out of operation.

40. A pressure-fluid tool having a plurality of cylinders, each with its contained piston, valve means for operating the same in opposed step, and a regulating valve located to control passages between the main valve and said cylinders for throwing either one of said pistons out of operation.

In testimony whereof, I have signed my name to this specification, in the presence of two subscribing witnesses.

GEORGE H. GILMAN.

Witnesses:

E. J. BURCHARD,

J. A. BRUCE.