C. O. PALMER.

COMPRESSED AIR APPARATUS FOR OPERATING PNEUMATIC TOOLS.

APPLICATION FILED AUG. 21, 1909.

1,154,796.

Patented Sept. 28, 1915.

3 SHEETS—SHEET 1.

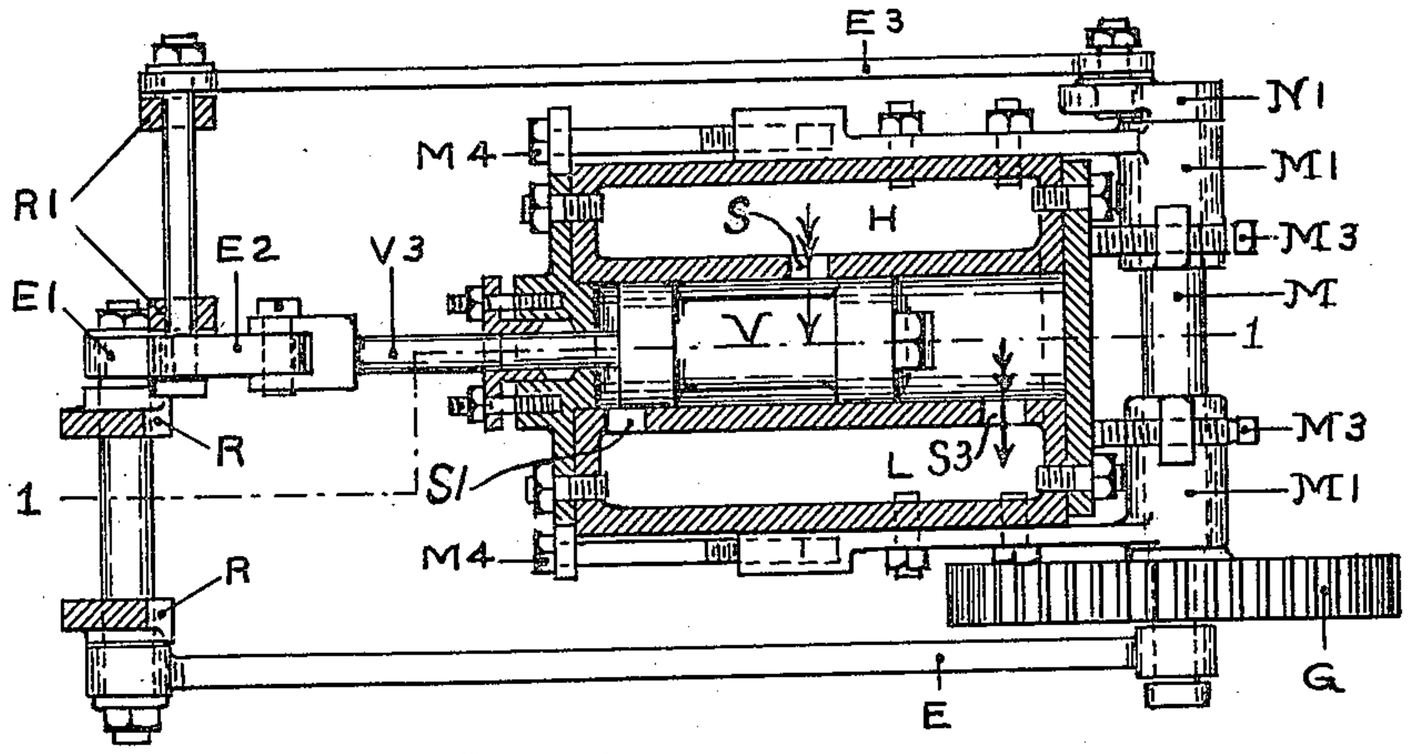

Fig. 2.

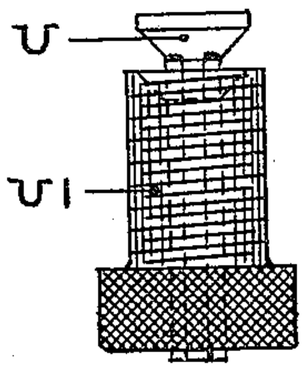

Fig. 5.

Fig. 1.

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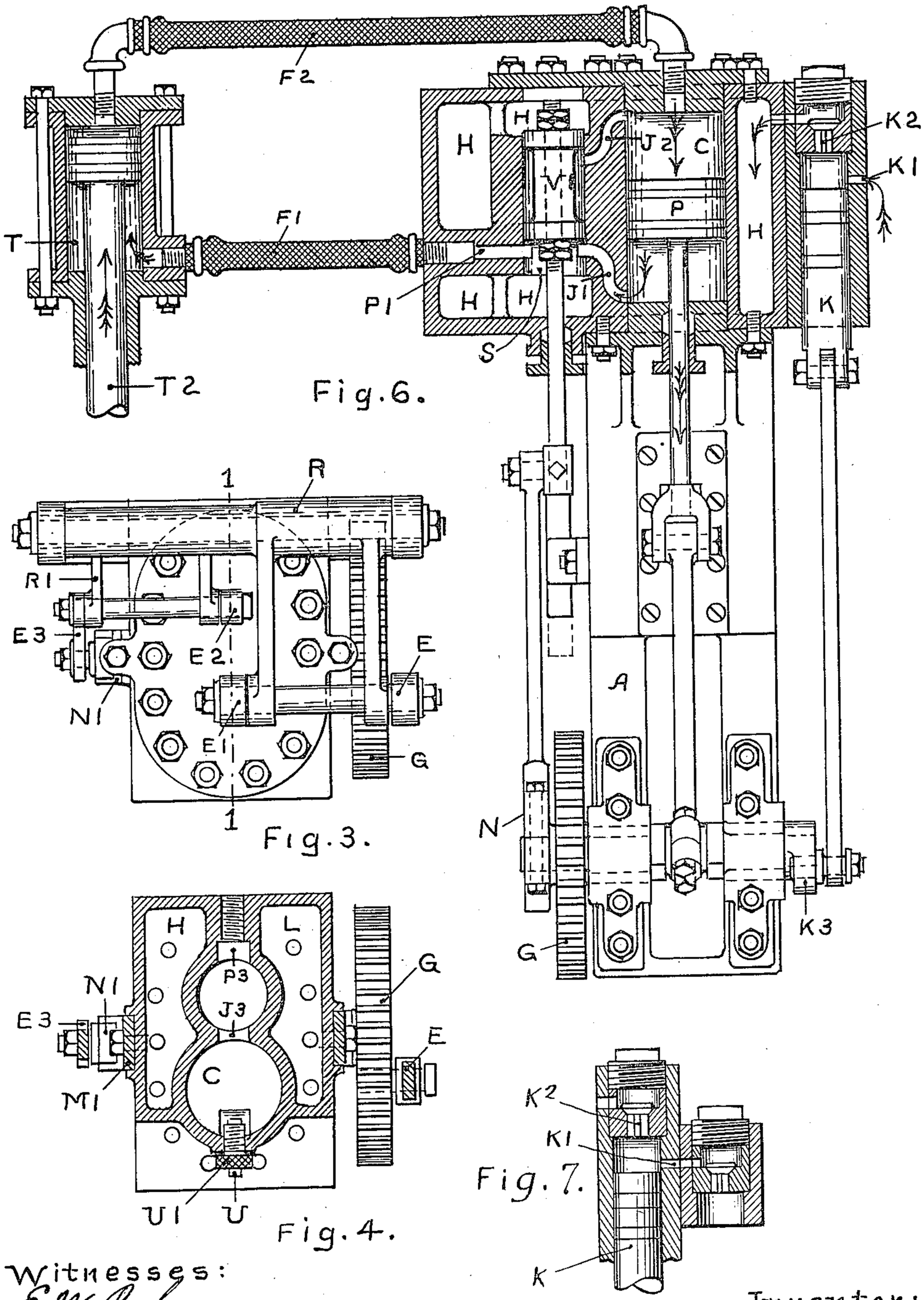

Fig. 6.

Fig. 3.

Fig. 4.

Fig. 7.

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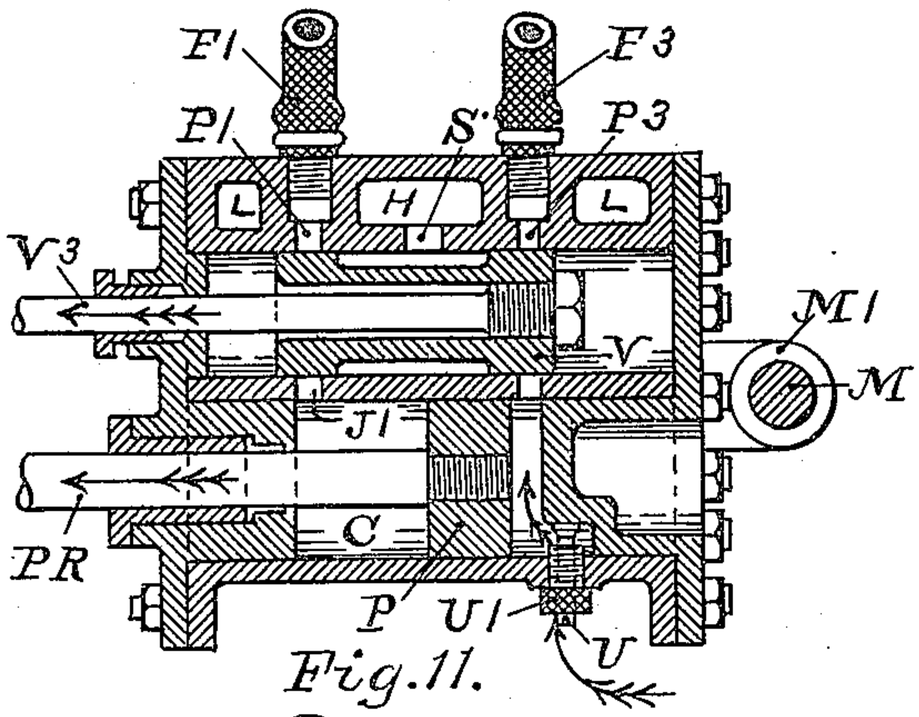

Fig. 11.

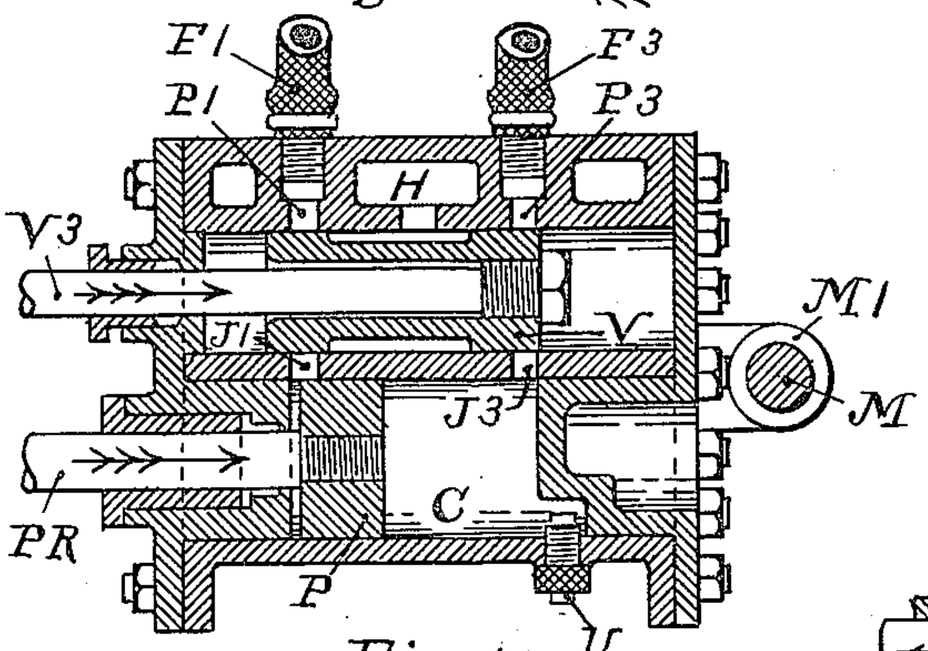

Fig. 10.

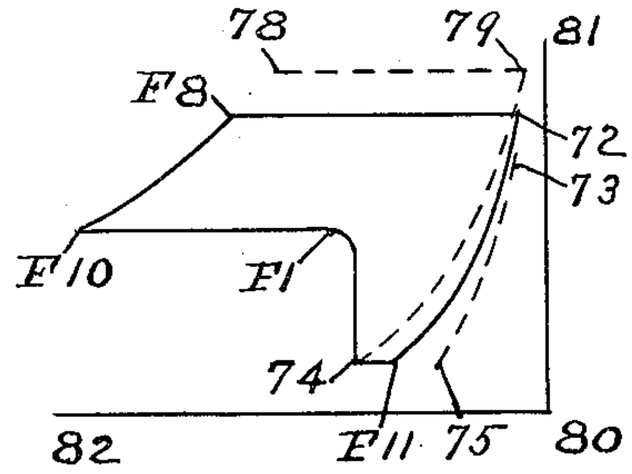

Fig. 9.

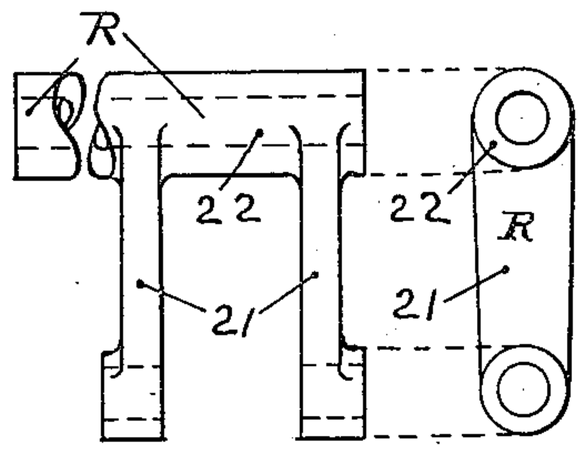

Fig. 12

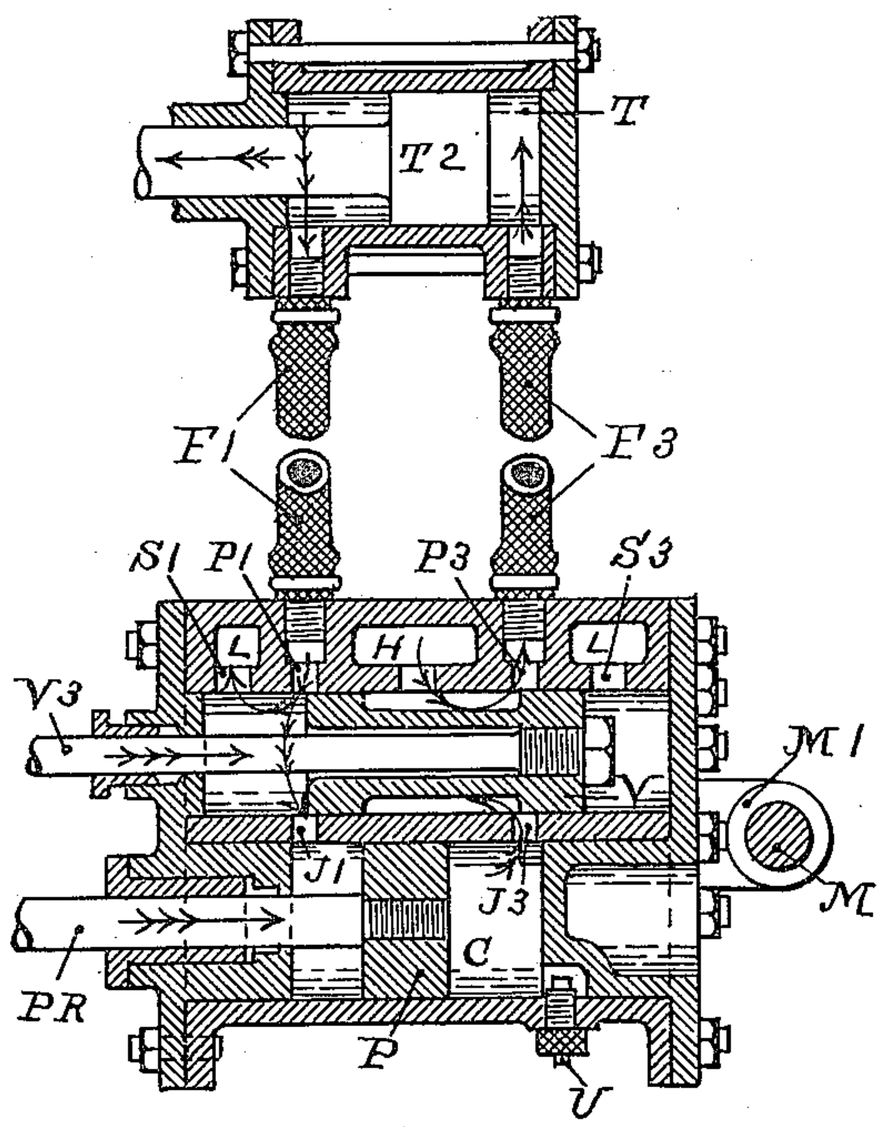

Fig. 8.

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UNITED STATES PATENT OFFICE.

CHARLES OTIS PALMER, OF CLEVELAND, OHIO.

COMPRESSED-AIR APPARATUS FOR OPERATING PNEUMATIC TOOLS.

1,154,796. Specification of Letters Patent. Patented Sept. 28, 1915.

Application filed August 21, 1909. Serial No. 514,029.

To all whom it may concern:

Be it known that I, CHARLES OTIS PALMER, a citizen of the United States of America, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Compressed-Air Apparatus for Operating Pneumatic Tools; and I hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it pertains to make and use the same.

My invention relates to closed air apparatus for operating pneumatic tools such as power picks, rock drills, power hammers, etc. Especially to the class in which the tool is operated by reciprocatory columns of compressed air from the pressor through passageways which connect the ends of the tool and pressor or compressor cylinders. And is in the nature of a modification of the system shown in my application for a "compressed air system, etc., Serial No. 369,258, filed April 20, 1907" and my application for a "compressed air apparatus, Serial No. 393,386, filed September 17, 1907."

Among the objects herein sought are, to keep the pneumatic balance between the two compartments of the pneumatic system; to raise the pressure in the tool cylinder in the beginning of its stroke; to provide a simple means for introducing air into the closed system; to simplify the compressor valve mechanism and means for operating the compressor piston and valve.

I will now describe my invention as applied to a power pick, and from which its application to rock drills and other reciprocating tools will be understood.

In the accompanying drawings, Figure 1 is a vertical longitudinal section through any improved air pressor or compressor (it is really both) on line 1—1 of Fig. 2 showing the valve mechanism and connection with the reciprocatory tool; Fig. 2 is a horizontal section on line 2—2 of Fig. 1; Fig. 3 is a view of the front end of the air compressor shown in Fig. 1; Fig. 4 is a vertical section on line 4—4 of Fig. 1; Fig. 5 is a view of the inlet valve of the compressor cylinder when detached and open; Fig. 6 is a diagram showing the compressor and tool cylinders in which my improved passageway is shown connecting the lower ends of the cylinders and the ordinary passageway connects the upper ends of the cylinders; Fig. 7 is a section of a check valve that may be used to admit air to the auxiliary compressor at the point K1 of Fig. 6 if so desired; Fig. 8 is the same section as Fig. 1 with the piston near the middle of the return stroke; Fig. 9 is an indicator diagram of the rear end of the compressor cylinder shown in Fig. 1; Fig. 10 is a vertical section through the compressor cylinder showing the piston at the front end of the cylinder; Fig. 11 is a section through the compressor cylinder showing the position of the equalizer valve and piston when the check valve U is open; Fig. 12 is a detail drawing of the rocker R.

The same characters denote the same parts throughout the several views. The arrows on the parts show the direction of motion of the parts themselves, and the arrows in the air passages indicate the direction the air is moving at the time shown and described.

Roughly stated my invention consists in taking a pneumatic apparatus comprising air compressor and tool cylinders, reciprocatory pistons in said cylinders, passageways connecting the ends of the cylinders, and adding a pneumatic balance consisting of one or preferably two, equalizer chambers with ports connecting the chambers with said passageways, a positively driven valve controlling said ports and preferably also said passageways, and adapted to interchange said chambers with said passageways reversely at each stroke of the compressor piston. Also in means of introducing air into the closed pneumatic apparatus, consisting of placing a check valve opening inwardly near the end of the compressor cylinder so that when operated in connection with the said power driven valve it will admit outside air to the cylinder when the cylinder pressure falls below the atmosphere, as will be described later. Also in a "double channeled valve" which simplifies the valve mechanism necessary. Also in a system of rockers and link connections by which the compressor frame is shortened, a small angular movement of the connecting rod secured, and the mechanism for converting the rotary motion of the crank shaft into the reciprocating motion of both the

piston and the equalizer valve is cheapened and otherwise improved as will be explained later. Also in certain combinations and arrangements of parts which will be hereafter set forth and pointed out in the claims.

As shown in Fig. 1, the compressor cylinder C is connected with the tool cylinder T at one end, by the passageway composed of tube F1 and air channels P1 and J1, and at the other end by the passageway composed of tube F3 and air channels P3 and J3. In the compressor cylinder C the piston P reciprocates, and in the tool cylinder T the piston T2.

Apparatus of this character used in mining requires to be transported frequently. It also has to work in dirty, dark and confined places, so it should be compact and simple in construction and readily accessible for attention and repairs. The connection of the crank with the piston is therefore made outside the cylinder where it is readily accessible for oiling and repairs. (See Fig. 1.) The crank shaft is journaled at the back end of the compressor cylinder and is provided with a piston crank on one end which is combined with the crank gear G, and with a valve crank N1 on the other end. (See Fig. 2.) To complete the connection between the crank gear and the piston P the stresses received from the main crank by the side connecting rod E are transferred half across the front end of the machine by means of the rocker R which consists of two widely separated rocker arms 21 (see Fig. 12) that are connected at one end by a rocker shaft 22 that is journaled on the front end of the compressor. A short link E1 from the rocker to the piston rod PR completes the connection that transforms the rotary motion of the crank gear G to the reciprocatory motion of the piston P. In a similar manner the equalizer valve V receives its motion through the crank shaft and the valve crank N1, the valve rod E3, a similar but smaller valve rocker R1, valve link E2 and valve stem V3. The double armed rockers with their short connecting links eliminate the ordinary cross head and greasy guides shown in Fig. 6 that are sure to catch the dust and grit in the air. Besides being much cheaper to make and repair, as the vertical alinement takes care of itself. Also by forming the piston crank on the side of gear G the crank shaft M is relieved of the torsional stress due to driving the cylinder piston P, thereby allowing a considerably smaller shaft than if it had to transmit this torsional stress. Also by cutting teeth on the periphery of the main crank disk almost all the weight and cost of a separate gear is saved.

To decrease the clearance in the back end of the cylinder so the check valve U shall open as early in the stroke as possible, the piston P should approach as near the end of the cylinder as practicable. To accomplish this the bearings M1 of the crank shaft M are made adjustable and are held in place longitudinally by the screws M3 and M4. Now eliminate the chamber L by closing the ports S1 and S3 of Figs. 1 and 2 (either by casting the cylinder with these ports closed as shown in Figs. 10 and 11 or by closing them in any well known manner). There will then be only the one air chamber H the same as the air chamber H in Fig. 6 which will be described later.

As shown in Fig. 1, the compression of the air in the front end of the compressor cylinder C by the piston P is transmitted through the front end passageway composed of the channels J1 and P1 and the tube F1 to the front end of the tool piston T2. And at the same time the air in the back end of the tool cylinder T is escaping by the tube F3 and channels P3 and J3 to the rear end of the compressor cylinder and the tool piston T2 is pushed to the rear end of the tool cylinder. After reaching the front end of the cylinder the direction of the piston, and of the air is reversed, also the relative pressures in the ends of the tool cylinder are reversed, and the tool piston T2 is pushed toward the forward end (see Fig. 8) and the action on the tool is that of a pressor. A bit or chisel (not shown) of the required form is held by the end of the tool piston T2 and operates on the coal or other material. The proper working of the system however is dependent on an approximate balance of pressure being maintained on the opposite sides of the tool piston. When this balance is not maintained, the tool piston stays nearer to the end of the cylinder having the least pressure and does not have a long free stroke as it should. This loss of pneumatic balance may be produced by leakage of air to the atmosphere from one of the compartments, by air slipping by the piston, and other ways. To preserve the pneumatic balance several methods have been resorted to. In my improved pneumatic apparatus as shown in Fig. 1 the equalizer valve V connects the high pressure compartment with the equalizer chamber H. On the return stroke of the compressor piston P the valve V is moved to its backward position shown in Fig. 8 and the air chamber H is connected with the back end which has now become the high pressure end of the compressor cylinder.

The equalizer chamber H is thus alternately connected, first with one passageway and then with the other, but always with the high pressure end of the cylinder or high pressure compartment. As each compartment is connected with the air chamber H it assumes the same pressure as said chamber H. Hence if each compartment has the

same pressure as the chamber H then each compartment has approximately the same pressure as the other compartment and the apparatus is balanced pneumatically.

The above described method of pneumatic balancing which consists in placing the air chamber alternately in connection with each compartment is especially set forth and claimed in my application Serial No. 369,258 previously mentioned and for that reason is not claimed in this application.

It is distinctive of this application however that the ports leading from the air chambers H and L connect into the passageways that join the compressor and tool cylinders and that both of the passageways connecting the ends of the cylinders are controlled by a positively driven valve. The object of having a valve in said passageways is to keep the passageways closed until the pressure in the high pressure end of the compressor reaches its maximum, which is about the pressure of the air chamber H. The valve V then opens the passageways communicating with the tool cylinder at the maximum pressure of the compressor cylinder instead of at the beginning of its stroke when the pressure in the compressor cylinder is lower. The time of opening the passageways is perhaps best understood by referring to the indicator diagram shown in Fig. 9 of the rear end of the compressor cylinder shown in Fig. 1 as will be explained later.

As already described, the equalizer chamber H was connected only with the compartment on the high pressure side of the compressor. There are however several ways in which the air chamber may be connected to the low pressure instead of the high pressure compartment. By reversing the direction of rotation of the gear G, but the following are preferable: by setting the valve crank N1 half around on the shaft, by closing the ports S instead of the ports S1 and S3 as in the above description.

By leaving all ports S, S1 and S3 open as shown in Fig. 1 I secure the advantages of two air chambers, one connected to the high and one connected to the low pressure compartment.

When working, the density of the air in the high pressure chamber H is being increased because the compressor draws air from the low pressure chamber L and the low pressure end of the tool and compresses it into the high pressure chamber and the high pressure end of the tool. At the same time, the tool cylinder is receiving air from the high pressure chamber H and the high pressure end of the compressor, to operate the tool piston. The tool also discharges its exhaust air into the low pressure chamber L and low pressure end of the compressor. The effective pressure is thus being built up by the compressor and pulled down by the tool. Stop the tool and there is a definite circulation of air that raises the pressure in chamber H and lowers the pressure in chamber L. Both of which increase the effective pressure in the tool cylinder. The tool is therefore operated by a combination pressor and compressor in one machine. The height to which the effective pressure rises is limited by the clearance in the compressor when not otherwise limited.

As herein described the term "passageway" refers to the whole pressure connection from cylinder to cylinder that joins the ends of the pressor and tool cylinders. The same term being used for the connection at both ends of the cylinders. Thus the front passageway is composed of the channels J1 and P1 and the tube F1 and the rear passageway is composed of the channels P3 and J3 and the tube F3. The term "compartment" refers to the space inclosed by one passageway plus the space between the piston and cylinder head in both of the connecting cylinder ends at the ends of said passageway. The term "ports" refers to the pressure connections that join the equalizer chamber with the said compartments and is lettered S for chamber H and S1 and S3 for chamber L. These terms are used somewhat arbitrarily as above stated in order to aid the reader to understand the various valvular and other pressure connections referred to in the specification and claims, and partly to make them uniform with the terms required by the office action Mar. 6, 1914 in my other application No. 393,386 before mentioned.

To stiffen the air (or other elastic medium) in the two compartments through which the motion of the compressor piston is transmitted to the tool piston, and also to take the place of the air that leaks out through stuffing boxes and other unavoidable leaks, and thus to more effectively transmit the reciprocations of the compressor piston to the tool piston, air is taken into the closed system in the following manner. Starting with the compressor piston in the rear end of its cylinder the equalizer valve V is so timed as to keep the end of the compressor cylinder closed until the piston P has progressed to the left so far that the pressure in the rear end of the cylinder has fallen below the atmosphere when the check valve U opens (by pressure from outside) see Fig. 11 and air is admitted into the cylinder C. When the piston has progressed a little farther to the left to about the point shown in Fig. 1, then the valve V opens and air from the low pressure end of the tool cylinder rushes into the cylinder space behind the piston, which continually grows larger as the compressor piston P advances to the left. On the return stroke of

the piston P, and after the valve V has opened all the ports and passageways as shown in Fig. 8, all the air in the right end of the pressor cylinder is forced partly into the tool cylinder and partly into the connecting high pressure chamber.

The timing of the valves will be best understood by referring to the indicator diagram of the rear end of the compressor cylinder which is shown in Fig. 9. In this diagram the horizontal distances from line 80—81 indicate the volume of contained air in the cylinder. The vertical distance above line 81—82 indicates the pressure corresponding to that volume. Starting with the compressor piston at the rear end of the cylinder at point 72 of Fig. 9 the valves are all closed, the piston advances to the left and the pressure falls until it reaches atmospheric pressure at point F11. The check valve U then opens to the atmosphere from point F11 to point 74 and outside air rushes in as shown in Fig. 11. At point 74 the valve V opens the channels P3 and J3 and air from the low pressure end of the tool cylinder rushes into the compressor cylinder and the pressure rises to point F1 and the check valve U in the meantime closes. The piston continues to the left until it has completed its stroke at point F10. Then it commences on the compression stroke. The ports and passageways are again all closed at point F10 see Fig. 10 and the pressure in the right end of the cylinder again gradually rises from point F10 to point F8 which is about the same pressure as the high pressure chamber H. The valve V again opens all its pressure connections, at point F8 see Fig. 8 and the pressure in the compressor cylinder remains approximately constant from point F8 to the end of the stroke at point 72 at which we started. As the apparatus continues to work, and if the connections are pretty tight the pressure may rise above the line F8—72 to nearer the line 78—79 and the initial pressure at the beginning of the stroke starts about the point 79 of Fig. 9. Then the expansion will follow nearer the dotted line 79—74 of said Fig. 9 and strike the atmospheric line nearer the point 74 and less outside air will be admitted because the atmospheric pressure has been reached more nearly the point that the valve V opens, consequently there is a shorter time for the inlet valve to remain open. Conversely, if the initial pressure at which the piston starts its stroke is nearer the point 73, the expansion line will strike the atmospheric line F11—74 about the point 75 and more outside air will be admitted by the inlet valve U because it will be open longer. In this way the amount of air admitted, hence the maximum pressure obtainable, is automatically limited.

In case no inlet valve is used air may be forced into the system by means of an auxiliary compressor as shown in Fig. 6 where a small piston K is shown driven from a moving part of the compressor.

If there were no valves in the passageways joining the ends of the cylinders, as shown in the rear end passageway of Fig. 6 the pressure in the tool cylinder in starting would be the same as at point F10 and would gradually rise as the pressure in the compressor cylinder raised (depending on the relative movements of the tool and compressor pistons) until it reached that of line F8—72. The pressure on the tool piston at starting would therefore be less than here shown and described which starts at point F8.

The nature of my pneumatic improvement as regards the placing of a power operated valve in the passageway is best illustrated in Fig. 6. Here the back ends of the tool cylinder T and compressor cylinder C are connected by the passageway composed of the tube F2 in the ordinary manner, while their front ends are connected by the passageway composed of tube F1 and the channels P1 and J1. The compressor piston P is here operated through a pitman from a crank on the crank shaft that is driven by the gear G the same as the gear G in Fig. 1 is driven.

To thicken the inclosed air a secondary compressor K operated from the crank K3 on the crank shaft as shown, or in any other convenient manner. The system is kept in balance by the equalizer valve V1 which first opens the port S and so connects the chamber H with the front compartment as shown in Fig. 6 and on the reverse stroke of the compressor piston connects the chamber H with the rear compartment through port J2.

The object of having the channels P1 and J1 of Fig. 6 closed by the valve is the same as before explained in connection with passages P1 and J1 of Fig. 1.

The construction shown in Fig. 6 is made the subject of a separate application for compressed air apparatus for operating pneumatic tools Serial No. 832,920 filed Apr. 18, 1914 where it is claimed and for that reason is not claimed in this application.

As previously stated the tool cylinder is only diagrammatically represented, in practice it is usually advisable in power picks to cushion the piston at both ends of its stroke. The effective pressure area on the opposite sides of the tool piston are preferably nearly equal. This may be accomplished by having a tail rod on the tool piston to counterbalance the piston-rod: or the piston-rod may be made of such ratio to the diameter of the cylinder as necessary, which would be considerably smaller in proportion to the diameter of the cylinder than here shown. But as my invention involves only the same

principles in the solution of these problems as in machines already on the market, no further instructions are required for utilizing my invention.

Having thus described my invention I claim:

1. In apparatus of the class described the combination of a gas compressor cylinder and piston therein, of a tool cylinder and piston therein, passageways connecting the ends of said cylinders forming thereby two closed compartments, an equalizer air chamber, ports connecting said air chamber with both of said compartments, an equalizer valve controlling said ports, means to reciprocate said piston and valve comprising two rockers journaled on the front end of the compressor cylinder, links connecting the inside ends of the rockers with the piston rod and valve stem respectively, a crankshaft journaled on the rear end of the cylinder, a piston crank on one end of the crankshaft and a valve crank on the other end, a valve rod and a connecting rod joining the outside ends of the said rockers with their respective cranks.

2. The combination with a gas compressor cylinder and piston therein, of a tool cylinder and piston therein, passageways connecting the ends of said cylinders forming thereby two closed compartments, a high pressure equalizer chamber, a low pressure equalizer chamber, ports connecting both of said equalizer chambers with both of said compartments, an equalizer valve controlling said ports, means for reciprocating the compressor piston and valve consisting of two rockers journaled on the front end of the compressor cylinder, links connecting the rockers with the piston and valve stems respectively, a crank shaft journaled on the back end of the cylinder, piston and valve cranks on said shaft, a valve rod and a connecting rod connecting the said cranks with their respective rockers.

3. In apparatus of the class described the combination of an air compressor cylinder and piston therein, of a tool cylinder and piston therein, passageways connecting the ends of said cylinders forming thereby two closed compartments, an equalizer chamber, ports connecting the equalizer chamber with both of said passageways, an equalizer valve controlling said ports, means to reciprocate the compressor piston, and means operatively timed with the compressor piston to first close said valve at the end of each stroke and then to open said valve to establish communication between said equalizer chamber and each of the passageways alternately at each stroke of the compressor piston.

4. In apparatus of the class described the combination of an air compressor cylinder and piston therein, of a tool cylinder and piston therein, passageways connecting the ends of the compressor and tool cylinders forming thereby two closed compartments, an equalizer chamber, ports connecting the equalizer chamber with both of said passageways, an equalizer valve controlling said ports and passageways, means to reciprocate the compressor piston, and means for operating said valve in coöperative conjunction with the compressor piston to close the valve at the end of each stroke and to again open the valve when the pressure in the compartment reaches that of the equalizer chamber.

5. The combination with an air-compressor cylinder and piston therein, of a tool cylinder and piston therein, passageways connecting the ends of said cylinders forming thereby two closed compartments, a high pressure equalizer chamber, a low pressure equalizer chamber, ports connecting both of said chambers with both of said passageways, an equalizer valve controlling said ports, means for reciprocating the compressor piston, and means for positively operating said equalizer valve from a moving part of the compressor to close said valve at the end of the piston stroke, and then to open said valve to interchange said chambers with said passageways reversely at each stroke of the compressor piston.

6. In a pneumatic apparatus of the class described, the combination of air compressor cylinder and piston therein, of a tool cylinder and piston therein, passageways connecting the ends of said cylinders, forming thereby two closed compartments, an equalizer chamber, ports connecting the equalizer chamber with both of said passageways, a check valve opening inwardly in the end of the compressor cylinder, a positively driven equalizer valve controlling both of said ports and passageways, and adapted to connect said equalizer chamber with said passageways alternately, means to reciprocate said compressor piston, and means to positively operate said equalizer valve in coöperative conjunction with the compressor piston to close the equalizer valve at the end of each stroke and to again open same after the pressure in the cylinder has fallen below the atmosphere and air has been admitted through said check valve.

7. The combination with an air compressor cylinder and piston therein, of a tool cylinder and piston therein, passageways connecting the ends of said cylinders forming thereby two closed compartments, a high pressure equalizer air chamber, a low pressure equalizer air chamber, ports connecting both of said air chambers with both of said passageways, a check valve in the end of the compressor cylinder opening inwardly, a positively driven equalizer valve controlling all of said ports and passageways and adapt-

ed to interchange said equalizer chambers in said passageways reversely at each stroke of the piston, driving mechanism comprising a crank shaft, piston and valve cranks on said shaft, and driving connections from said cranks to said compressor piston and equalizer valve that are adapted to close said ports and passageways at the end of the stroke and to again open said ports and passageways after air has been admitted through said check valve.

In testimony whereof, I sign the foregoing specification, in the presence of two witnesses.

CHARLES OTIS PALMER.

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B. C. BROWN.