F. D. HOLDSWORTH.

PULSATING APPARATUS.

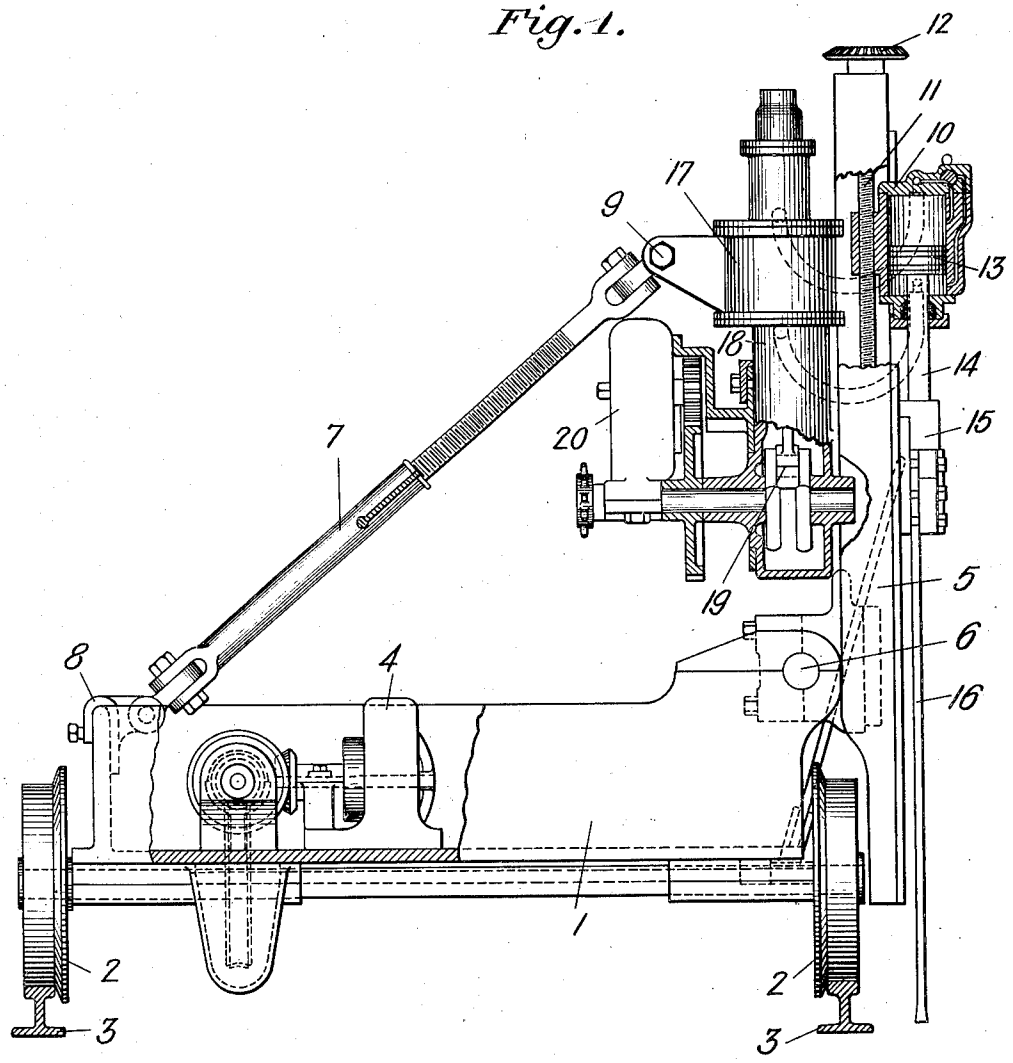
APPLICATION FILED APR. 22, 1907.

1,025,467.

Patented May 7, 1912.

3 SHEETS—SHEET 1.

Fig. 1.



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3 SHEETS—SHEET 2.

Fig. 2.

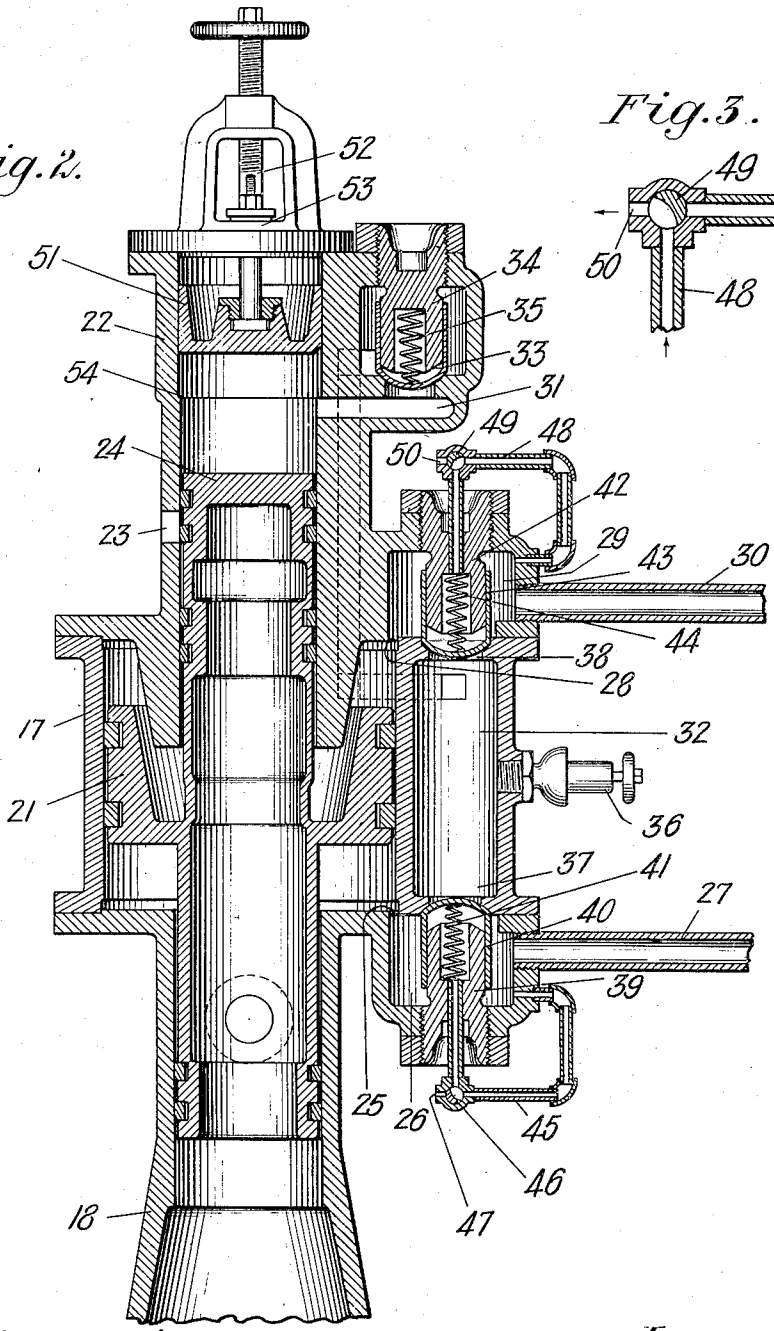

Fig. 3.

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3 SHEETS—SHEET 3.

Fig. 4.

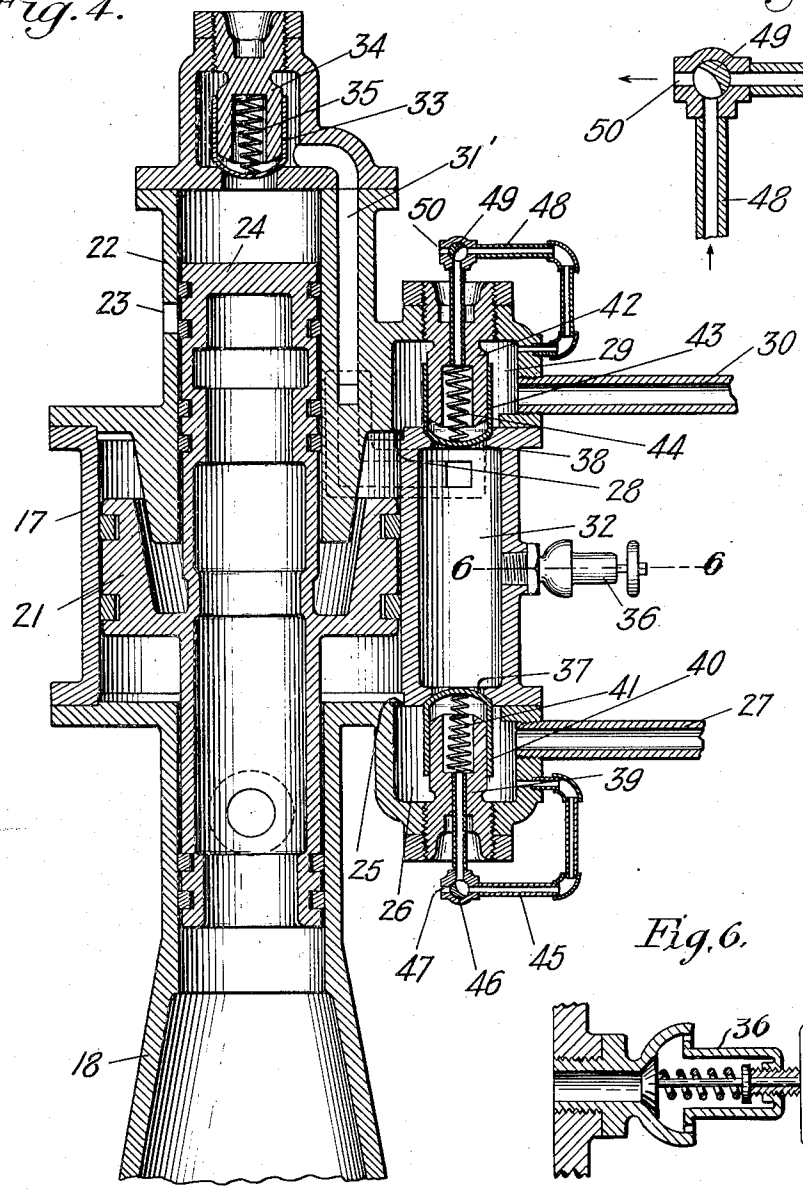

Fig. 5.

Fig. 6.

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UNITED STATES PATENT OFFICE.

FRED D. HOLDSWORTH, OF CLAREMONT, NEW HAMPSHIRE, ASSIGNOR TO SULLIVAN MACHINERY COMPANY, OF CLAREMONT, NEW HAMPSHIRE, A CORPORATION OF NEW HAMPSHIRE.

PULSATING APPARATUS.

1,025,467. Specification of Letters Patent. Patented May 7, 1912.

Application filed April 22, 1907. Serial No. 369,418.

To all whom it may concern:

Be it known that I, FRED D. HOLDSWORTH, a citizen of the United States, residing at Claremont, in the county of Sullivan and State of New Hampshire, have invented an Improvement in Pulsating Apparatus, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

This invention relates to pulsators preferably of the reciprocating type and herein represented as specifically applied to tool actuating motors and associated with improvements in quarrying machines, herein typified as of the channeler type.

In order that the principles of the invention may be fully apparent, I have disclosed a single type or embodiment thereof in the accompanying drawings, wherein—

Figure 1 is an end elevation of a quarrying machine to which my invention may be applied, portions of the invention being represented in vertical section; Fig. 2 is a vertical central section upon an enlarged scale of a form of pulsator embodying my invention, together with the parts associated therewith; Fig. 3 is a vertical central section of a detail representing an exhaust valve oppositely disposed from the position shown in Fig. 2; Fig. 4 is a vertical central section upon an enlarged scale of a pulsator and associated parts embodying my invention and representing a slightly different construction from that shown in Fig. 2; Fig. 5 is a detail in vertical section of the exhaust valve shown in Fig. 4 but oppositely disposed; and Fig. 6 is a section on the line 6—6 in Fig. 4.

Having reference to that single type or embodiment of the invention herein indicated, it is noted that my invention is in no wise restricted to that particular type of mechanism wherewith it is shown associated, such mechanism being merely selected as a convenient embodiment of means with which the pulsator may be operatively connected. The pulsator is adapted for use in many different types of apparatus and for widely varying purposes. Herein the pulsator, is shown as applied to a quarrying machine of the channeler type which, being merely illustrative, need not be specifically described.

Referring briefly to Fig. 1, the body or frame of the machine to which the invention is herein shown as applied is indicated at 1, it preferably having wheels 2 supported upon tracks 3, said wheels being herein indicated as driven from a motor 4. Upon the body or frame is supported an upright standard 5, preferably mounted in any suitable manner for movement longitudinally of the machine and also for rocking or tilting movement. To that end, the standard may be supported upon a longitudinally disposed trunnion shaft 6, said standard being disposed in any position of rocking movement by means of a two part brace 7, one end thereof being attached to the frame or body at 8 for movement longitudinally of the latter and the other member being attached to the standard or a part supported thereon as indicated at 9. The channeler or working cylinder is indicated at 10, it being herein represented as supported for longitudinal or vertical movement by means of a vertically disposed screw 11 having a gear 12 at the upper end thereof to which power may be applied in any suitable manner to rotate the screw and hence to elevate or depress said cylinder. Disposed within the cylinder is a piston 13, the piston rod 14 whereof is connected to a cross head 15 to which drills 16 may be connected in any desired manner.

I employ a pulsator which, in the present embodiment of the invention, is employed to operate the working piston 13, the pulsator being to that end operatively connected to opposite ends of the working cylinder as indicated in dotted lines in Fig. 1. In the operation of the pulsator, air or other fluid is maintained under desired pressure in the system and is pulsated first from one side of the piston of the pulsator to one side of the piston of the working cylinder and then from the opposite side of the piston of the pulsator to the opposite side of the piston of the working cylinder.

The cylinder of the pulsator is indicated at 17, it being secured in any suitable manner, directly or otherwise, to the standard 5 and herein shown as having extended downwardly therefrom a frame or housing 18 to receive a crank mechanism 19, preferably actuated from a motor 20 herein sus-

tained upon the standard 5 in any suitable manner. The pulsator piston 21 (Figs. 2 and 4) is operatively connected to the crank mechanism 19, whereby in the operation of the motor 20 the said piston is reciprocated and the air or other fluid is forced alternately to opposite ends of the working cylinder.

Operatively connected to and herein mounted directly upon the upper end of the pulsator cylinder 17 is a compressor or charging cylinder 22 having an opening 23 therein for the entrance of air and having its piston 24 preferably formed as a continuation of the piston 21 of the pulsator and preferably, as indicated, of reduced diameter.

The lower end of the pulsator cylinder is in communication by a passage 25 with a chamber 26 herein shown as provided by an extension of the pulsator cylinder, it being apparent, however, that said chamber may be disposed as found desirable. Leading from said chamber 26 is a passage 27 preferably provided by flexible tubing, that is connected as indicated in dotted lines in Fig. 1 to the lower portion of the working cylinder 10. Similarly by a passage 28 the upper portion of the pulsator cylinder 17 is connected to a chamber 29 communicating by passage 30 provided by a preferably flexible tubing to the upper portion of the working cylinder as indicated in dotted lines in Fig. 1. The chamber 29 is herein shown as formed with or laterally extended from the pulsator cylinder 17, but it is apparent that it may be disposed in any suitable manner with respect thereto.

As apparent from Figs. 2 and 4, the downward movement of the piston 21 compresses the air beneath it and forces the same through the passage 25 into the chamber 26 and thence by the passage 27 to the under side of the piston in the working or channeler cylinder. Similarly in the upward movement of the piston 21 the air above the same is compressed and forced through the passage 28 into the chamber 29 and thence by means of the passage 30 to the upper end of the channeler piston.

When the piston 21 is at the lower end of its stroke the inlet port 23 is uncovered and air may pass into the space above the piston 24 of the compressor or charging cylinder. Upon the upward movement of the pistons 21 and 24 the inlet port 23 is closed and the air in the compressor or charging cylinder 22 is compressed by the piston thereof and is forced into a passage 31 communicating with a reservoir 32 herein shown as formed in an extension of the pulsator cylinder 17, it being apparent, however, that such reservoir may be disposed at any suitable point and formed in any suitable manner. At any desired point in the passage 31 is disposed a valve 33 of suitable type. Herein said valve is shown as having a closed end and sleeved upon a plug 34, preferably screw threaded into the upper portion of an enlargement of the passage 31. The plug 34 is axially bored for a portion of its extent to receive a light spiral spring 35 engaging the inner face of the end of the valve, thereby pressing it to its seat.

The reservoir 32 is preferably provided with a relief valve 36 which may be adjusted so that the excess pressure above a predetermined point may be allowed to escape.

Each of the chambers 26 and 29 is in communication with the reservoir 32 as by openings 37 and 38 respectively. Preferably screw threaded into a wall of the chamber 26 is a plug 39 having sleeved thereon a valve 40 adapted to be pressed by a preferably light spring 41 to its seat in the opening 37, a similar plug 42 being mounted in a wall of the chamber 29 and having sleeved thereon a valve 43 pressed by a preferably light spring 44 to its seat in the opening 38. The space between the plug 39 and the valve 40 is in communication by a passage 45 with the chamber 26, a valve 46 being disposed within said passage and controlling the same, an outlet 47 being afforded to the atmosphere and likewise controlled by said valve. In a similar manner the space between the plug 42 and valve 43 is in communication by a passage 48 with the chamber 29, a valve 49 being disposed in said passage. An outlet 50 is afforded in said passage 48 to the atmosphere, said outlet being controlled by the valve 49.

As the piston 21 moves upward the air confined in the space beneath the same, the chamber 26 and the passage 27 and the under side of the channeler piston is rarefied. If this rarefaction, considering the air that is received in said parts from the lower portion of the working or channeler cylinder, reduces the pressure in said parts below that in the reservoir 32, the valve 40, which is normally spring pressed to its seat, will open and allow an additional supply of air to pass to the parts mentioned. The valve 43 performs a similar function with respect to the space above the piston 21, the chamber 29 and the passage 30, and thus maintains the proper supply of air upon the upper side of the piston. Thus, the pressure is kept equal at the two sides of the piston and any leakage from the system is automatically supplied from the reservoir 32 to either face of the pulsator piston and that part of the system controlled thereby as is necessary.

In the position of the parts indicated in Fig. 2 the same condition of pressure will exist within the valves 40 and 43, that is be-

tween the same and their plugs, as exists upon the exterior of said valves and hence each valve will be held to its seat so long as the lowest pressure in its chamber 26 or 29 is not less than the pressure in the reservoir 32. If the pressure in either chamber 26 or 29 falls or tends to fall below that in the reservoir the valve associated with such chamber is forced open admitting air to the proper side of the piston 21.

In Fig. 3, the valve 49 is shown as closing that portion of the passage 48 that communicates with the chamber 29, so that the air in the interior of the valve 43 may escape, the pressure in the interior of the valve thereby falling to that of the outside atmosphere. When this occurs, the valve 43 will be elevated until it strikes the inner end of the screw threaded portion of the plug. This prevents any leakage and hence any escape of air from the chamber 29 to the atmosphere. If the valve 46 be turned to correspond with the position of the valve 49 shown in Fig. 3, both valves 40 and 43 will be pressed from their seats. The effect of this is to equalize throughout the stroke the pressure upon the opposite faces of the piston 4, thus equalizing the pressure on both sides of the channeler piston through the passages 27 and 30 and thereby interrupting the operation of the channeler.

The upper end of the compressor or charging cylinder 23 is provided with a movable head 51 adapted to be elevated or depressed by means of a screw 52 passing through a suitable stuffing box 53. Preferably, means are provided to prevent the head 51 from being moved downward to such an extent as to contact with the upper face of the piston 24 at the upward limit of its stroke. While this may be accomplished in different ways, herein the charging or compressor cylinder 22 is shown as being of an increased diameter at the upper end thereof to receive the head 51, a shoulder 54 being thereby afforded to limit the downward movement of the head. When said head is moved downward against the shoulder 54, the compressor or charging cylinder 22 will furnish its maximum quantity of air to the reservoir 32. If the head 51 be moved upward, a less quantity of air will be discharged by means of the passage 31 into the reservoir 32 for the reason that the air confined in such additional space as is afforded by such upward movement of the head 51 will expand and occupy a portion of the interior of the cylinder 22 that otherwise would be filled with air taken from the outside atmosphere through the port 23 when the same is placed in communication with the interior of the cylinder 22 upon the downward movement of the piston 24. That is to say by the described positioning the head 51 the quantity of air received into the cylinder 22 through the opening 23 upon each stroke of the piston may be adjusted. The head 51 should be so adjusted that just the right quantity of air will be furnished to the reservoir 32 to compensate for leakage losses that may occur without discharging any air through the relief valve 36. In this manner a saving of power is effected. If the leakage losses should increase due to any cause such as the wear of the piston rod packing of the channeler or working cylinder so that pressure in the reservoir 32 would fall, the head 51 may be moved downwardly to compensate therefor. It will be observed that this arrangement is automatic in its action at all times, assuming that the leakage is a constant quantity.

I will assume for purposes of explanation that it is desirable to maintain a pressure of 30 pounds in the reservoir 32. The head 51 will therefore be placed in such position that the pressure in the space above the piston 24 of the charging or compressor cylinder 22 is exactly 30 pounds when such piston 24 is at the upper end of its stroke. The pressure in the enlargement in the passage 31 wherein the valve 33 is located will also be 30 pounds as it is in open communication with the reservoir 32. It is apparent that the valve 33 will not rise from its seat to allow the escape of any air from the cylinder 22 as the pressure is equal upon opposite sides of the valve. If leakage should reduce the pressure in the reservoir 32, as, for instance, by five pounds, the pressure in the charging cylinder 22 being 30 pounds at the end of the upward stroke of the piston 24, the valve 33 will be lifted from its seat and air will be forced into the reservoir 32 to restore the pressure to 30 pounds. If the leakage increases so that the quantity of air discharged in the manner described will not maintain the desired pressure, the operator lowers the head 51 thereby reducing the clearance volume and causing more air to be received at each stroke in the charging or compressor cylinder and forced into the reservoir 32.

The construction shown in Fig. 4 differs from that shown in Fig. 2 only in that the movable head 51 is omitted, and the valve 33 is placed above and alined with the piston 24, the passage 31′ leading from the exterior of said valve to the reservoir 32 as indicated.

Having thus described one type or embodiment of my invention, I desire it to be understood that although specific terms are employed they are used in a descriptive and generic sense and not for purposes of limitation, the scope of the invention being set forth in the following claims:

1. The combination with a working cylinder and piston, the latter exposed to confined working fluid, of pulsating means for alternately raising and lowering the pres-

sure of the confined fluid against said piston; a pressure fluid reservoir; means for supplying fluid from said reservoir to the side of said working piston; and means for automatically maintaining the pressure of said reservoir at a predetermined point.

2. In combination, a pulsator cylinder, a piston therein, means for operating said piston, a reservoir, operative connections between said reservoir and the opposite ends of said pulsator cylinder, means for supplying pressure fluid to said reservoir and automatically acting valves controlling the connections between said reservoir and said pulsator.

3. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a working cylinder having a piston exposed to working fluid confined in said pulsator, working cylinder and connections, operative connections between said pulsator cylinder and said working cylinder, a charging cylinder, a reservoir, operative connections between said charging cylinder and said reservoir and between said reservoir and said pulsator cylinder, and automatic provisions for maintaining a predetermined fluid pressure in said reservoir and in said pulsator cylinder.

4. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a working cylinder having a piston, operative connections between said pulsator cylinder and said working cylinder, a charging cylinder, a reservoir, operative connections between said charging cylinder and said reservoir and between said reservoir and said pulsator cylinder, and fluid pressure actuated valves controlling said connections whereby a predetermined fluid pressure is maintained in said reservoir and in said pulsator cylinder.

5. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a working cylinder having a piston, operative connections between said pulsator cylinder and said working cylinder, a charging cylinder, a reservoir, operative connections between said charging cylinder and said reservoir and between said reservoir and said pulsator cylinder, and fluid pressure actuated valves controlling said connections, said valves being normally spring pressed to their seats, said valves maintaining a predetermined fluid pressure in said reservoir and in said pulsator cylinder.

6. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a charging cylinder, a piston therein, a reservoir, operative connections between the reservoir and said charging cylinder and pulsator cylinder respectively, and a valve interposed in said connection between the reservoir and the pulsator cylinder, said valve being sleeved upon a support and longitudinally movable thereon and acting in one position thereof to close communication between the reservoir and the pulsator cylinder and in the opposite position thereof to open such communication.

7. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a charging cylinder, a piston therein, a reservoir, operative connections between the reservoir and said charging cylinder and pulsator cylinder respectively, a hollow valve in said connection between the reservoir and pulsator cylinder and controlling the passage of pressure fluid to said pulsator cylinder, and means for admitting pressure fluid to the interior of said valve, an outer face of said valve being subjected to the fluid pressure in said reservoir.

8. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a charging cylinder, a piston therein, a reservoir, operative connections between the reservoir and said charging cylinder and pulsator cylinder respectively, a hollow valve mounted in said connection between said reservoir and said pulsator cylinder, means for admitting pressure fluid to the interior of said valve and a spring mounted interiorly of said valve, such supply of pressure fluid and said spring tending to maintain said valve seated, an outer face of said valve being subjected to the fluid pressure in said reservoir.

9. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a charging cylinder, a piston therein, a reservoir, operative connections between the reservoir and said charging cylinder and pulsator cylinder respectively, a hollow valve in said connection between said reservoir and said pulsator cylinder, means to equalize fluid pressure upon the interior of said valve and upon the lateral face thereof, another face of said valve being subjected to the fluid pressure within said reservoir, whereby when the fluid pressure in said reservoir exceeds the forces tending to maintain the valve seated, the valve is unseated and pressure fluid is supplied to said pulsator cylinder.

10. In combination, a pulsator cylinder, a piston therein, a charging cylinder, a piston therein, means to actuate said piston, a reservoir, operative connections between said reservoir and opposite ends of said pulsator cylinder and between said reservoir and said charging cylinder, a pressure fluid actuated valve controlling the connection between said reservoir and opposite ends of said pulsator cylinder, each of said valves being normally subjected to equalize fluid pressure upon opposite faces and supplemental yielding means to hold said valves to their seats, whereby if the fluid pressure upon that face of either of said valves that is opposed

the fluid pressure within said cylinder, falls below said cylinder fluid pressure, said supplemental holding means may be overcome and said valves opened to equalize the fluid pressure.

11. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a working cylinder having a piston, operative connections between said pulsator cylinder and said working cylinder, a reservoir and means for supplying the same with pressure fluid, a valve interposed between said reservoir and said pulsator cylinder and exposed to the fluid pressure in said reservoir, said valve being normally subjected to equalize fluid pressure upon opposite faces, supplemental yielding means to hold said valve to its seat, whereby if pressure upon that face of the valve that is opposed to the reservoir fluid pressure, falls below the reservoir fluid pressure such supplemental holding means may be overcome and the valve opened to equalize the fluid pressure and means to exhaust pressure fluid from that face of the valve that is opposite to that exposed to reservoir fluid pressure.

12. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a working cylinder having a piston, operative connections between said pulsator cylinder and said working cylinder, a reservoir, and means to supply the same with pressure fluid, operative connections between said reservoir and said pulsator cylinder, a hollow valve disposed in said last mentioned operative connection and exposed to reservoir fluid pressure, said valve being normally subjected to equalize fluid pressure upon the interior thereof and upon that face that is subjected to reservoir fluid pressure, and means to exhaust the pressure fluid upon the interior thereof.

13. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a working cylinder having a piston, operative connections between said pulsator cylinder and said working cylinder, a reservoir, and means to supply the same with pressure fluid, operative connections between said reservoir and said pulsator cylinder, a hollow valve disposed in said last mentioned operative connection and exposed to reserve fluid pressure, said valve being normally subjected to equalize fluid pressure upon the interior thereof and upon that face that is subjected to reservoir fluid pressure, and means to exhaust the pressure fluid upon the interior thereof, said valve being mounted for actual movement.

14. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a working cylinder having a piston, operative connections between said pulsator cylinder and said working cylinder, a reservoir. and means to supply the same with pressure fluid, operative connections between said reservoir and said pulsator cylinder, a hollow valve disposed in said last-mentioned operative connection and exposed to reservoir fluid pressure, said valve being normally subjected to equalize fluid pressure upon the interior thereof and upon that face that is subjected to reservoir fluid pressure, and means to exhaust the pressure fluid upon the interior thereof, said valve being mounted for axial movement, and supplemental yielding means to hold said valve to its seat, whereby if the reservoir fluid pressure exceeds the fluid pressure in the pulsator cylinder, said supplemental holding means may be overcome and the valve opened to equalize said fluid pressures.

15. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a charging cylinder, operative connections therefrom to said pulsator cylinder, a piston in said charging cylinder, and means to actuate the same, and means for regulating the amount of air discharged from said charging cylinder upon each stroke of the piston thereof.

16. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a charging cylinder, operative connections therefrom to said pulsator cylinder, a piston in said charging cylinder, and means to actuate the same, and means to vary the amount of air discharged by the piston of the charging cylinder.

17. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a charging cylinder, operative connections therefrom to said pulsator cylinder, a piston in said charging cylinder, and means to regulate the quantity of air received into the charging cylinder upon each stroke of the piston thereof.

18. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a charging cylinder, operative connections therefrom to said pulsator cylinder, a piston in said charging cylinder, and a movable head for said charging cylinder opposed to the compressing stroke of the charging cylinder piston.

19. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a charging cylinder, operative connections therefrom to said pulsator cylinder, a piston in said charging cylinder, and a movable barrier in said charging cylinder opposed to the compressing stroke of said charging cylinder piston, whereby the amount of air discharged from said charging cylinder may be regulated.

20. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a charging cylinder, operative connections, a piston in said charging cylinder, that portion of said charging cylinder that is op-

posed to the compressing stroke of the charging cylinder piston being of a diameter other than that of the portion of the cylinder wherein the piston reciprocates, and a movable barrier interposed in such portion of said cylinder that is of a different diameter.

21. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a charging cylinder, operative connections therefrom to said pulsator cylinder, a piston in said charging cylinder, that portion of said charging cylinder that is opposed to the compressing stroke of the charging cylinder piston being of a diameter other than that of the portion of the cylinder wherein the piston reciprocates, and a movable barrier interposed in such portion of said cylinder that is of different diameter, and hand controlled means for moving said barrier.

22. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a charging cylinder, a reservoir, operative connections between said reservoir and said pulsator cylinder and charging cylinder respectively, a piston in said charging cylinder, a movable barrier in said charging cylinder opposed to the compressing stroke of the piston therein, and means to move said barrier.

23. In combination, a pulsator cylinder, a piston therein, means to actuate said piston, a charging cylinder, a reservoir, operative connections between said reservoir and said pulsator cylinder and charging cylinder respectively, a piston in said charging cylinder, a movable barrier in said charging cylinder opposed to the compressing stroke of the piston therein and hand controlled means to move the barrier.

24. The combination with a working cylinder and its piston, means for alternately raising and lowering the pressure of fluid on opposite sides of said piston to cause the same to pulsate, a pressure fluid reservoir and separate simultaneously effective connections from said reservoir to both sides of said working piston.

25. The combination with a working cylinder and its piston, means for alternately raising and lowering the pressure of fluid on opposite sides of said piston to cause the same to pulsate, a pressure fluid reservoir, and separate connections automatically to augment the pressure fluid on either side of said piston from the pressure fluid of said reservoir.

26. The combination with a working cylinder and piston therein, means for alternately raising and lowering the pressure of fluid on opposite sides of said piston to cause the same to pulsate, a pressure fluid reservoir comprising means for supplying said reservoir with fluid under compression, and means for automatically augmenting the pressure fluid simultaneously effective on either side of said working piston from said reservoir.

27. The combination with a working cylinder and piston the latter exposed to confined working fluid of pulsating means for alternately raising and lowering the pressure of the confined fluid working against said piston, a pressure fluid reservoir, means for supplying fluid from said reservoir to the side of said working piston, and a regulating valve for automatically maintaining the pressure of said reservoir at a predetermined point.

28. The combination with a cylinder and piston therein, of means for alternately raising and lowering the pressure of fluid on each side of said piston and means for automatically augmenting the pressure fluid simultaneously on each side of said piston from stored pressure fluid.

29. The combination with a working cylinder with its piston therein, the latter being exposed to confined working fluid of pulsating means for alternately raising and lowering the pressure of the confined working fluid against the same to cause the same to pulsate, a pressure fluid reservoir, and automatic valve between said reservoir and the working pressure fluid of said piston, and means to control said valve.

30. The combination with a working cylinder and piston the latter being exposed to confined working fluid, of pulsating means for alternately raising and lowering the pressure of the confined working fluid against opposite sides of said piston to cause the same to pulsate, a pressure fluid reservoir, normally having valved communication with both sides of the piston and means to place the pressure fluid on one side of said piston in free communication with said reservoir.

31. The combination with a working cylinder and piston, of means alternately to raise and lower the pressure of working fluid on opposite sides of said piston to cause the same to pulsate, a pressure fluid reservoir, and means to place opposite sides of said piston simultaneously in free communication through said reservoir.

32. The combination with a working cylinder and its piston therein, of means for alternately raising and lowering the pressure of the working fluid on opposite sides of said piston to cause the same to pulsate, a pressure fluid reservoir, having separate connections to opposite sides of the piston and means for automatically equalizing the pressure on opposite sides of said working piston.

33. The combination with a working cylinder and piston, of means for alternately raising and lowering the pressure of the working fluid on opposite sides thereof, a

source of pressure fluid supply to augment the pressure fluid for said working piston, a valve controlling said supply and automatically actuated by the difference in the pressure of the working and the supplied fluid, and means for varying the pressure difference at which said valve will operate.

34. The combination with a working cylinder and piston, of means for alternately raising and lowering the pressure of the working fluid on opposite sides thereof, a source of pressure fluid supply to augment the pressure fluid for said working piston, a valve controlling said supply and adapted to be opened by the excess of pressure of the supply fluid over the working fluid acting against the said valve, and means for varying the pressure of the working fluid effective against the said valve.

35. In a pressure-fluid compressor the combination with a cylinder having an inlet passage alternately opened and closed, a piston, an outwardly opening discharge check valve, and an adjustable clearance wall for the cylinder.

36. The combination with a working cylinder and piston, the latter exposed to confined working fluid, of pulsating means for alternately raising and lowering the pressure of the confined fluid working on either side of said piston to cause the same to pulsate; a pressure fluid reservoir; communicating passages between said reservoir and each side of the working piston; and means for automatically maintaining the pressure of said reservoir at a predetermined point.

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

FRED D. HOLDSWORTH.

Witnesses:
G. W. BATEMAN,
E. J. BURCHARD.