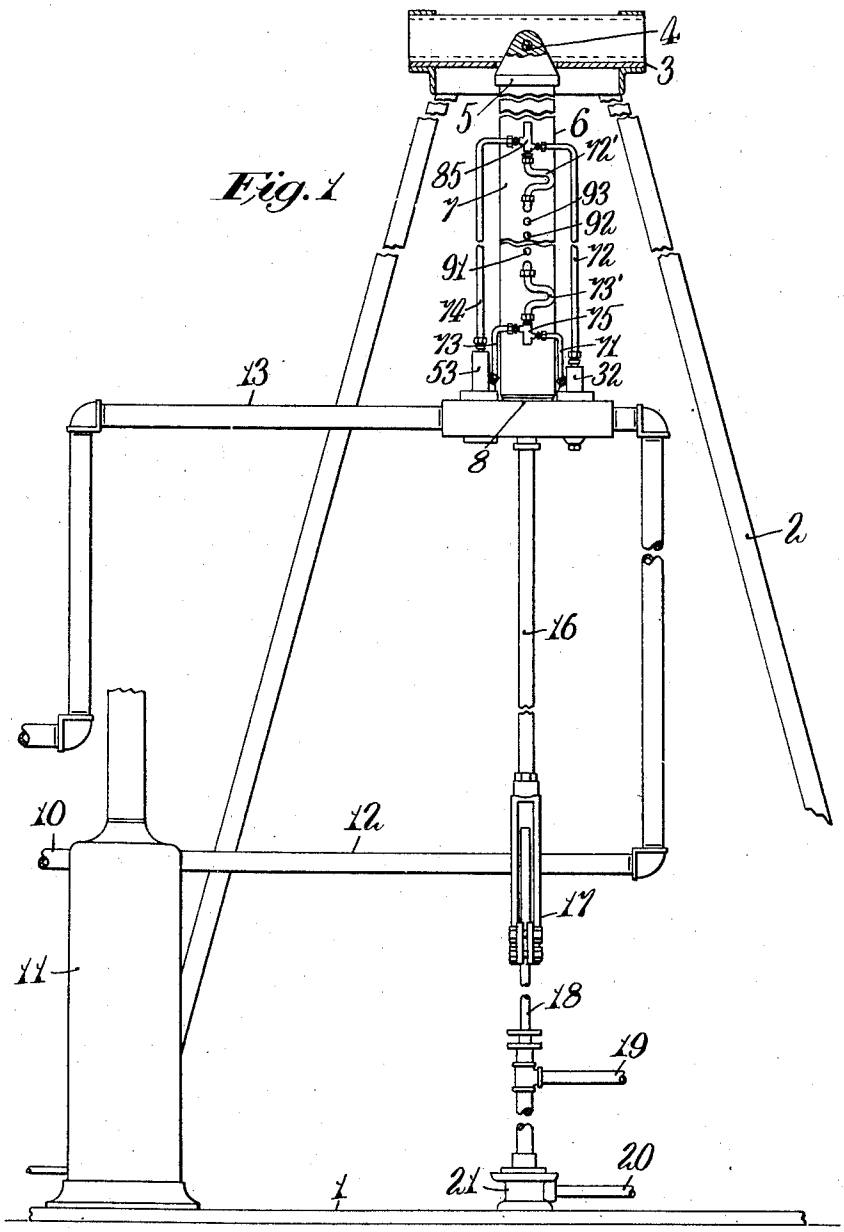
June 11, 1935. W. H. WINEMAN 2,004,146

MOTOR FOR PUMPING MECHANISMS

Filed May 20, 1932 3 Sheets-Sheet 1

Fig. 1



Inventor:
Wade H. Wineman.
by Louis A. Maxson.
atty.

June 11, 1935. W. H. WINEMAN 2,004,146

MOTOR FOR PUMPING MECHANISMS

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Fig. 3.

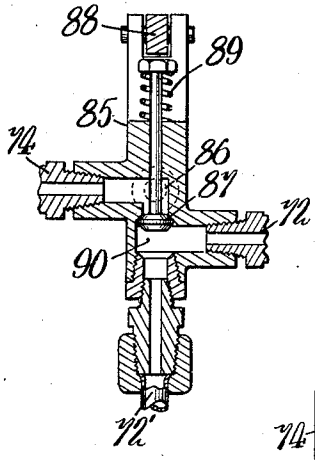
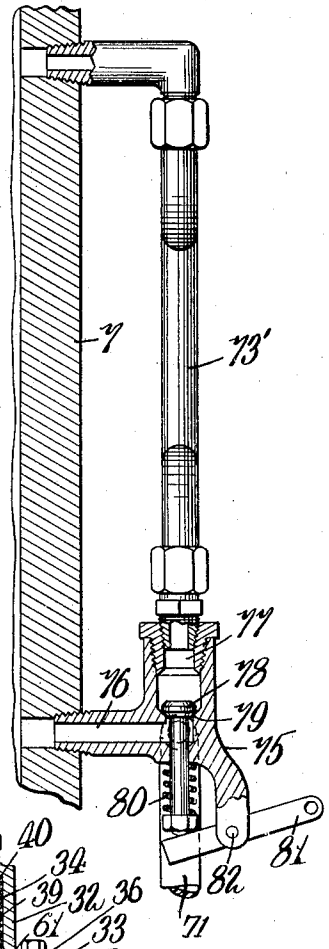


Fig. 2.

Fig. 4.



Inventor:
Wade H. Wineman.
by Louis A. Maxson.
Atty.

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Fig. 5.

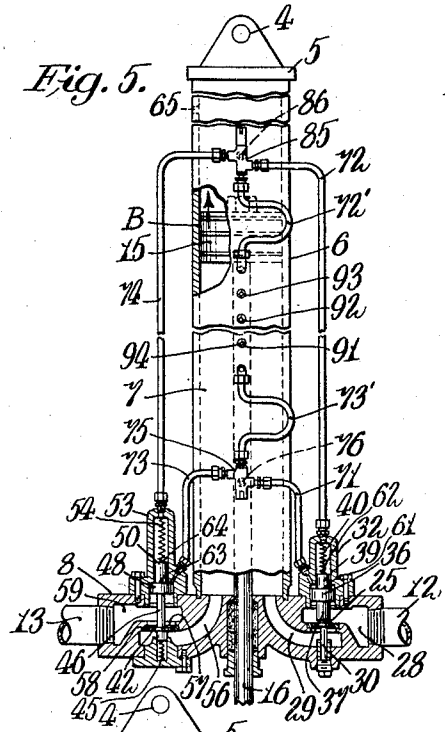


Fig. 6.

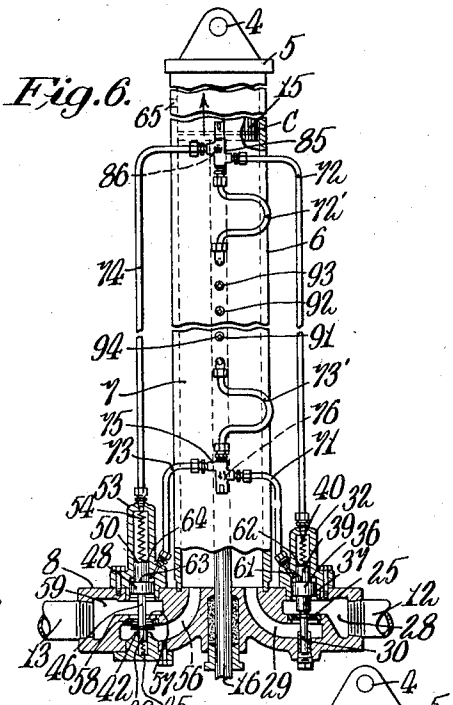


Fig. 7.

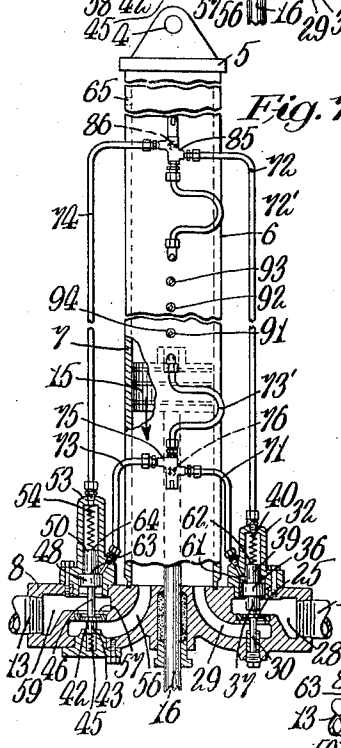


Fig. 8.

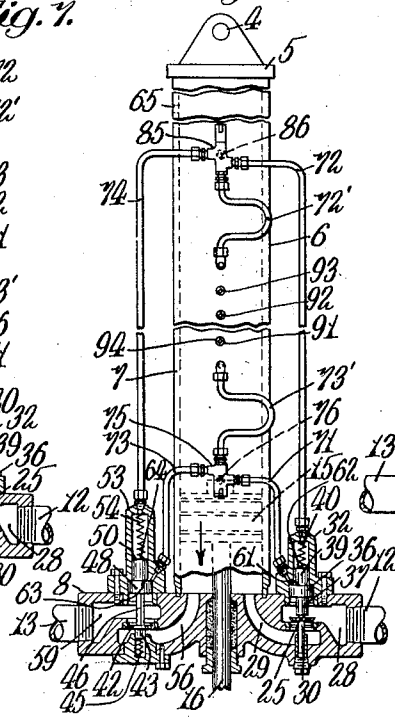
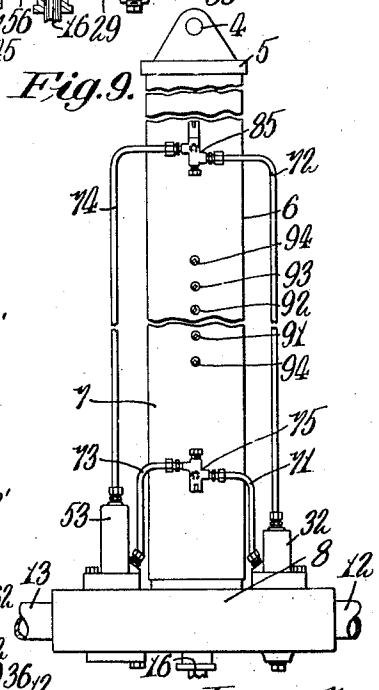


Fig. 9.



Inventor:
Wade H. Wineman.
by Louis A. Mapson
Atty.

Patented June 11, 1935

2,004,146

UNITED STATES PATENT OFFICE

2,004,146

MOTOR FOR PUMPING MECHANISMS

Wade H. Wineman, Michigan City, Ind., assignor to Sullivan Machinery Company, a corporation of Massachusetts

Application May 20, 1932, Serial No. 612,538

48 Claims. (Cl. 121—126)

My invention relates to pumping mechanisms, and more especially to expansible chamber motors which may be used for various purposes, but which find a special application in the operation of pumps for raising oil from wells.

In some oil fields there is a considerable quantity of oil available, but there is not a sufficient pressure to cause the oil to rise to the surface, and under such conditions, devices for pumping the oil must be resorted to. A very satisfactory system includes a number of pumping units arranged within a reasonable area and all supplied with power operating medium from a central air compressor having pipes leading out therefrom to the pumping units. In a preferred form of such apparatus, the unit at each well includes a pump head in the form of an expansible chamber motor connected with a piston type pump in the well. To effect economy, the air is customarily supplied to the pump heads after pre-heating at the well, and is exhausted from the motor cylinders with considerable residual pressure and returned through the intake of the compressor plant for re-compression. As, for reasons of economy, it is not practicable to have an operator at each well, it is highly important that the pumping apparatus at each well be of a rugged and positive type, and since it is desirable, under some circumstances and in some fields, to operate the motor with expansion and compression, and, perhaps in a different location, to use fundamentally the same motor with practically a rectangular cycle, it is desirable that the motor be provided with means permitting its adaptation to various conditions. Also, since derangements may occur, so that pumping has to be re-started after a test, it is also important that provision be made to permit the ready adjusting of the motor, though it may be desired normally to operate it with expansion and compression, to permit test on the rectangular cycle.

An object of the present invention is to provide an improved pumping motor, particularly adapted for the use described, but of general application, where relatively long and comparatively slow strokes are desired. Another object of the invention is to provide an improved single acting motor of the expansible chamber type. A further object of my invention is to provide an improved fluid operated valve gear for an expansible chamber motor. A still further object of my invention is to provide an improved fluid operated valve gear of the poppet type for an expansible chamber motor. Yet another object of my invention is to provide an improved expansible chamber motor having means whereby its cycle of operations may be readily varied. Other objects and advantages of the invention will hereinafter more fully appear.

In the accompanying drawings, in which one illustrative embodiment of the invention and a modification thereof have been shown for purposes of illustration,—

Fig. 1 is a side elevation, with parts broken away, showing a portion of a pumping mechanism arranged at a well which is to be pumped.

Fig. 2 is a view on an enlarged scale and with parts broken away, to show a central section through the illustrative embodiment of the improved expansible chamber motor, herein described in detail.

Fig. 3 is a fragmentary detail section through a portion of the motor.

Fig. 4 is a detail section through another portion of the motor, the section being at right angles to that of the section of Fig. 3.

Figs. 5, 6, 7 and 8 are diagrammatic views showing the parts in different operative positions.

Fig. 9 is a view on a small scale showing a modification.

Referring first to Fig. 1, it will be noted that a platform or derrick floor 1 has mounted upon it a suitable frame 2 of structural steel or the like. This frame at its top has a cross member 3 on which is pivotally supported at 4 the upper head member 5 of an expansible chamber motor 6. This motor includes, in addition to the upper head 5, a cylinder 7 and a lower cylinder head 8. The parts may be held together by threading the parts, or by side rods, not shown, extending between the upper and lower heads and clamping the cylinder between these heads. Associated with the lower head are the admission and discharge valve mechanisms of the motor, which I shall shortly describe in detail; and these control the flow of air under pressure from a compressor, not shown, through a supply pipe 10, pre-heater 11, and delivery pipe 12, to the motor and the exhaust from the motor through a discharge line 13 back to the intake of the compressor. The motor 6 has a piston 15 reciprocable within the cylinder 7 and having a piston rod 16 which is connected through a suitable adjustable connection 17 with a pump rod 18 leading to a pump of the reciprocatory type, not shown, disposed within the well. A discharge line 19 discharges the pumped oil, and a line 20 leads away gas from the well head 21. The lower cylinder head of the motor has

associated with it and directly supports the admission and exhaust valves of the motor.

The admission valve is of the poppet type and is illustrated at 25. This valve is adapted to seat upon a seat 26 formed in a partition 27 lying between a chamber 28 with which the pipe 12 communicates and a passage 29 leading into the bottom of the cylinder. The admission valve 25 has a depending stem 30 guided at 31, and its movements are controlled with the aid of a controlling mechanism arranged, in the main, in a housing 32. Within this housing is a pair of bores 33 and 34. The upper bore 34 is considerably smaller than the bore 33, and it will be understood that the relative areas of these bores and the proportions of the other parts will be varied, depending upon the pressures to be controlled. As best illustrating the mode of operation of the apparatus, certain values of pressures and areas will be assumed, but it will be appreciated by those familiar with this art that modifications may be made in the areas and values which will be described, even with the pressures assumed, without departing from the scope of the present invention, and that variations in the operating pressures will obviously call for modifications in proportions etc. Assuming now, for example, that the supply pressure is to be 300 pounds per square inch, and that the exhaust or back pressure is to be 100 pounds per square inch, it may be assumed that the cross-sectional area of the bore 34 will be one-third of the cross-sectional area of the bore 33. Reciprocable within the bore 33 is a piston 36 having a depending portion 37 having an interlocking laterally flexible connection with a head 38 fixed to the valve 25, and having also a reduced upward extension 39 which constitutes a piston reciprocable within the bore 34. A spring 40 is also housed within the bore 34 and exerts upon the upper end of the piston 39, when the valve 25 is seated, a pressure equal to approximately one-half the per-inch supply pressure; and when the valve 25 is open, a pressure materially greater than one-half the pressure per square inch of the supply pressure. Specifically, let it be assumed that the cross-sectional area of the valve 25 is three square inches, the cross-sectional area of the cylinder 33 is three square inches, the exposed upwardly facing area of the piston 36 surrounding the piston 39 is two square inches, the top area of the piston 39 is one square inch, and the spring pressure 150 pounds when the valve 25 is closed. The spring pressure will obviously be greater than 150 pounds when valve 25 is open.

Now turning to the exhaust valve, it will be observed that an exhaust valve 42 is provided with a depending stem 43 guided in the bore 44, and that a spring 45 exerts continuously a small pressure tending to seat this valve. This pressure may be assumed, for purposes of illustration, to be, with the admission and discharge pressures described, 15 pounds. The exhaust valve 42 has an upwardly extending stem 46 seated within a bore 47 in a differential piston 48 whose effective lower area is substantially equal to the effective top area of the valve 42. The differential piston comprises a head 49 and a smaller head 50, and these are reciprocable in bores 51 and 52, respectively, in a cylinder member 53. The area of the piston 50 is approximately one-third the area of the piston 49. A spring 54 housed within the member 53 exerts a pressure of approximately 150 pounds on the upper end of the piston 50 when the valve 42 is closed. It will be observed that this spring pressure is approximately equal to one-half the inch line pressure, and as in the case of the inlet valve, we may assume an exhaust valve area of three square inches, a cross-sectional area of the piston 48 of three square inches, an area on the piston 49 surrounding the piston 50 of two square inches, an area on the piston 50 of one square inch, and a spring pressure of 150 pounds with the exhaust valve closed. It will be noted that the exhaust valve controls communication between a passage 56, through a port 57 surrounded by valve seat 58, to a discharge chamber 59, with which the exhaust pipe 13 communicates. For greater convenience in further description, I shall designate the upwardly facing area on the piston 36 as 61, the end area of the piston 39 as 62, the upwardly facing area on the piston 49 as 63, and the end area of the piston 50 as 64.

The upper end of the cylinder 6 is in constant communication with the atmosphere through a vent passage 65. The bore of the cylinder is communicable with the surface 61 through a connection 71. The bore of the cylinder is normally communicable with the area 63 through a connection 73, 73'. The area 62 is normally communicable with the bore of the cylinder through a connection 72, 72', and the area 64 is communicable with the bore of the cylinder through a connection 74. It will be observed that the connection 71 opens into a fitting 75 which communicates through a passage 76 with the bore of the cylinder, and which also provides a connection 77 between the connections 73 and 73'. A valve 78, normally seated upon a valve seat 79, normally prevents communication between the passage 76 and the connection 73, and a spring 80 normally holds the valve in seated position. Upon reversal of its position, the valve 78 will close communication between 73' and 73 and cause 73, as well as 71, to communicate with the cylinder bore through 76. A lever 81, pivoted at 82 on the fitting 75, is manually operable to move the valve 78 and to cause connections 71 and 73 to have free communication with the cylinder bore through 76, as described above. Another fitting 85 is arranged at a point near the upper end of the desired piston travel, and communicates with the cylinder bore through a connection 86. This connection 86 communicates directly with the connection 74 and may communicate, when a valve 87 is opened by a manual operating means 88 and against the pressure of the spring 89, with the connection 72, which, however, normally communicates with the connection 72' through the chamber 90 formed in the fitting 85. When the valve 87 is in bottom position, 72 and 74 both communicate with the cylinder bore only through 86. With the description given, the mode of operation of this device will now be readily understood.

With the parts in the position shown in Fig. 2, it will be noted that the piston 15 is at approximately the bottom of its travel, that the admission valve 25 is open, and that the exhaust valve 42 is closed. It will be noted that the connections 71, 72, 73 and 74 are establishing free communication between the surfaces 61, 62, 63 and 64, with the atmosphere through the interior of the cylinder above piston 15, and the passage 65. It will therefore be evident that the admission valve is pressed towards open position, with the areas and pressures assumed, by a pneumatic pressure of approximately 900 pounds acting upwardly. The

spring 40 opposes the 900-pound pressure, but exerts a much smaller pressure in view of the fact that, even though this spring has been compressed, it exercises, in the open position of the valve, say, not over a couple of hundred pounds of downward pressure. The exhaust valve is maintained closed by a pneumatic pressure of approximately 900 pounds acting upwardly, which is opposed by the pressure of only 150 pounds exerted by the spring 54. Of course, the spring 45 is also pressing upwardly, but it is, as will be remembered, quite light. The piston 15 therefore moves upwardly, and when it passes beyond the mouth of the passage 76, the 300 pounds of pressure within the cylinder is transmitted to the surface 61. The valve 25 still stays open, however, as the total downward pressure does not exceed, say, 600 plus, say, 200, or 800 pounds. When the piston 15 passes above the port communicating with the upper end of the connection 73', pressure is admitted to act on the surface 63, but the exhaust valve is not opened, as the pressure of 750 pounds then exerted downwardly will not overcome the larger pressure acting upwardly. The piston 15 therefore continues to rise and passes above the mouth of the passage 72', as indicated at B. Thereupon, pressure passes through 72', and chamber 90, and the connection 72 to act upon the surface 62. Under these circumstances, there is an upwardly facing area subjected to pressure equal to the downwardly facing area subjected to pressure, and the spring 40 will operate to close the admission valve 25. Fig. 5 shows this relative position of the various parts. As pressure will not be admitted to the connection 74, however, until the piston has moved still further upwardly, to the position C, the pressure within the cylinder will not be exhausted, and accordingly, the piston 15 will rise still higher under the expanding force of the motive fluid, which will operate expansively until the lower edge of the piston overruns the port 86 (at C). Then air admitted through the connection 74 will act upon the surface 64 and equalize the oppositely facing areas associated with the exhaust mechanism and permit the pressure of the spring 54 to open the exhaust valve. Fig. 6 shows this position of the parts. With the opening of the exhaust valve, the pressure below the piston 15 will be vented to approximately 100 pounds per square inch; and the weight of the rod line, etc. will begin to move the piston downwardly. As soon as the piston has moved down a short distance, the pressure acting on the surface 64 will be vented, but will not cause closing of the exhaust valve 42, for the exhaust valve will be still held open by, say, 125 pounds pressure exerted by the somewhat expanded spring 54, the 200-pound pressure exerted by the pressure of 100 pounds on the two-inch area of 63, and the force tending to close the exhaust valve will be equal to but, say, 315 pounds, due to the pressure on the upwardly acting unbalanced area of three square inches, plus the 15 pounds pressure of the spring 45. When the upper edge of the piston opens the mouth of the connection 72', the pressure acting on the surface 62 will be vented, but the 300 pounds pressure (three inches times 100 pounds) acting upwardly on the bottom of the valve 25 will not overcome the 200 pounds pressure (100 pounds times two inches) on the surface 61 plus the 150 pounds pressure exerted by spring 40. When the upper edge of the piston 15 overruns the mouth of the connection 73', the surface 63 will also be vented to atmosphere. There will then be only the 125 pounds exerted by spring 54 to oppose the much larger upward pressure (equal to approximately 300 pounds) exerted by the back pressure on the lower side of the piston 48 or valve 42, and accordingly, the spring 54 will be overcome and the valve 42 seated by the spring 45. Fig. 7 shows this position of the parts. Thereafter, the piston will move downwardly against compression, for the exhaust valve will be closed. Preferably, the parts will be so proportioned that before the compression pressure acting on the lower side of the valve 25 would be sufficient to open the valve against the opposing pressure of 100 pounds per square inch on area 61 plus the pressure of the spring 40, the upper edge of the piston will overrun the mouth of the passage 76 and vent the area 61 to the atmosphere. This relative position of the parts is shown in Fig. 8. However, obviously, even if the valve 25 were to be opened before this occurred, the motor would operate in a satisfactory manner. Of course, as soon as the pressure acting on the surface 61 is vented, the total pneumatic pressure of upwards of 300 pounds acting to open the valve 25 will be effective to overcome the pressure of the spring 40. It will be clear that as soon as the valve 25 is opened it will be held open in the manner described above. The complete cycle has now been traced and the continued operation of the motor will simply be made up of repetitions of the events described.

At times it is desirable to operate some wells at a very slow speed, approximately one stroke per minute. When operating at such speeds, the expansion and compression of the pumping fluid cannot well be availed of, and under those circumstances, connections 72' and 73' are rendered inoperative by movements of the valves 78 and 87 to their positions opposite those shown in Figs. 3 and 4, thereby sealing all communication between the valve controlling areas and the bore of the cylinder, except through the passages 76 and 86. Moreover, after any work has been done on the well, such as pulling sucker rods or tubing, it is customary to operate the pump slowly for the full stroke to determine whether the pump plunger is traveling with sufficient clearance at the top and at the bottom, and that everything is clear. To do this on a pump that is set for speeds high enough to take advantage of expansion and compression, the levers 81 and 88 are actuated to move the valves 78 and 87 as just described, thereby causing the pump to operate as last mentioned. Where the pump is to operate continuously on the slow stroke, the connections 72' and 73' may also be entirely eliminated and plugs or caps inserted to close their cylinder connections and their ends. This feature is shown in Fig. 9. A number of different points for the connections 72' and 73' are provided along the length of the cylinder, as at 91, 92 and 93, these being normally closed by plugs 94 when not in use. The ratio of expansion could obviously be increased by moving downwardly the point of communication of connection 72' with the cylinder bore. The duration of compression may, within limits, be increased by moving upwardly the communication of the upper end of the connection 73' with the cylinder bore.

When the pump is being operated without expansion or compression, closing of the admission valve before opening of the exhaust valve will be assured by reason of the fact that the spring 40 is exerting a greater pressure than the spring 54, and the spring 45, though of comparatively small strength, also must be overcome to effect opening of the exhaust valve. Likewise, on the down stroke it will be observed that a higher pressure on the

area 63 is needed to keep the exhaust valve open than is required on the area 61 to prevent valve 25 from opening, for the valve 25 is pressed toward closed position by a spring pressure of 150 pounds, while the valve 42 is pressed toward closed position by the light spring 45 which detracts from the pressure of spring 54, which is already less than 150 pounds, by reason of its being in relatively expanded condition.

From the foregoing description, it will be clear that the apparatus described is simple, readily lends itself to the needed adjustments in use, is certain in operation, has a minimum number of moving parts, is not apt to severe derangement in the event of impurities in the air, and is very reliable.

While I have in this application specifically described one embodiment which my invention may assume in practice, and a modified embodiment, it will be understood that these forms are shown for purposes of illustration only and that the invention may be further modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:—

1. In a motor, in combination, a cylinder, a piston reciprocable therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction and means for supplying pressure to said areas during one pass of the piston, from a space within said cylinder at the same side of said piston, in a predetermined order to cause said valve to perform one of its functions after both areas are supplied with pressure and venting the pressure from said areas in a reverse order during the opposite pass of the piston to cause reverse movement of the valve after venting of both areas.

2. In a motor, in combination, a cylinder, a piston reciprocable therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction and means for supplying pressure to said areas during one pass of the piston in a predetermined order to cause said valve to perform one of its functions after both areas are supplied with pressure and venting the pressure from said areas in a reverse order during the opposite pass of the piston to cause reverse movement of the valve after venting of both areas.

3. In a motor, in combination, a cylinder, a piston therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas each acting to move said valve in one direction and means for supplying pressure to said areas, during the relative movement in one direction between the cylinder and the piston, in a predetermined order to cause said valve to perform one of its functions after both areas are supplied with pressure and venting the pressure from said areas in a reverse order during the opposite relative movement between the cylinder and the piston to cause reverse movement of the valve after venting of both areas.

4. In a motor, in combination, a cylinder, a piston reciprocable therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction and means for supplying pressure to said areas during one pass of the piston from a space within said cylinder at the same side of said piston, in a predetermined order to cause said valve to perform one of its functions after both areas are supplied with pressure and venting the pressure from said areas in a reverse order during the opposite pass of the piston to cause reverse movement of the valve after venting of both areas, said supplying and venting means including means for varying the relation between the points in the motor cycle at which admission to said areas occurs.

5. In a motor, in combination, a cylinder, a piston reciprocable therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction and means for supplying pressure to said areas during one pass of the piston in a predetermined order to cause said valve to perform one of its functions after both areas are supplied with pressure and venting the pressure from said areas in a reverse order during the opposite pass of the piston to cause reverse movement of the valve after venting of both areas, said supplying and venting means including means for varying the relation between the points in the motor cycle at which admission to said areas occurs.

6. In a motor, in combination, a cylinder, a piston therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas each acting to move said valve in one direction and means for supplying pressure to said areas, during the relative movement in one direction between the cylinder and the piston, in a predetermined order to cause said valve to perform one of its functions after both areas are supplied with pressure and venting the pressure from said areas in a reverse order during the opposite relative movement between the cylinder and the piston to cause reverse movement of the valve after venting of both areas, said supplying and venting means including means for varying the relation between the points in the motor cycle at which admission to said areas occurs.

7. In a motor, in combination, a cylinder, a piston reciprocable therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction and means for supplying pressure to said areas during one pass of the piston, from a space within said cylinder at the same side of said piston, in a predetermined order to cause said valve to perform one of its functions after both areas are supplied with pressure and venting the pressure from said areas in a reverse order during the opposite pass of the piston to cause reverse movement of the valve after venting of both areas, said supplying and venting means including means for varying the relation between the points in the motor cycle at which venting of said areas occurs.

8. In a motor, in combination, a cylinder, a piston reciprocable therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction and means for supplying pressure to said areas during one pass of the piston in a predetermined order to cause said valve to perform one of its functions after both areas are supplied with pressure and venting the pressure from said areas in a reverse order during the opposite pass of the piston to cause reverse movement of the valve after venting of both areas, said supplying and venting means including means for varying the relation between

the points in the motor cycle at which venting of said areas occurs.

9. In a motor, in combination, a cylinder, a piston therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas each acting to move said valve in one direction and means for supplying pressure to said areas, during the relative movement in one direction between the cylinder and the piston, in a predetermined order to cause said valve to perform one of its functions after both areas are supplied with pressure and venting the pressure from said areas in a reverse order during the opposite relative movement between the cylinder and the piston to cause reverse movement of the valve after venting of both areas, said supplying and venting means including means for varying the relation between the points in the motor cycle at which venting of said areas occurs.

10. In a motor, in combination, a cylinder, a piston reciprocable therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction and means for supplying pressure to said areas during one pass of the piston, from a space within said cylinder at the same side of said piston, in a predetermined order to cause said valve to perform one of its functions after both areas are supplied with pressure and venting the pressure from said areas in a reverse order during the opposite pass of the piston to cause reverse movement of the valve after venting of both areas, said supplying and venting means including means for varying the relation between the points in the motor cycle at which admission to said areas occurs and the relation between the points in the cycle at which venting of said areas occurs.

11. In a motor, in combination, a cylinder, a piston reciprocable therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction and means for supplying pressure to said areas during one pass of the piston in a predetermined order to cause said valve to perform one of its functions after both areas are supplied with pressure and venting the pressure from said areas in a reverse order during the opposite pass of the piston to cause reverse movement of the valve after venting of both areas, said supplying and venting means including means for varying the relation between the points in the motor cycle at which admission to said areas occurs and the relation between the points in the cycle at which venting of said areas occurs.

12. In a motor, in combination, a cylinder, a piston therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas each acting to move said valve in one direction and means for supplying pressure to said areas, during the relative movement in one direction between the cylinder and the piston, in a predetermined order to cause said valve to perform one of its functions after both areas are supplied with pressure and venting the pressure from said areas in a reverse order during the opposite relative movement between the cylinder and the piston to cause reverse movement of the valve after venting of both areas, said supplying and venting means including means for varying the relation between the points in the motor cycle at which admission to said areas occurs and the relation between the points in the cycle at which venting of said areas occurs.

13. In a motor, in combination, a cylinder, a piston therein, a valve mechanism for said motor including an admission valve and an exhaust valve and controlling means for each of said valves, each of said valve controlling means having a plurality of pressure areas acting in the same direction, and means for supplying pressure to said areas during one stroke of the motor in a predetermined order to cause the respective valve to perform one of its functions after both areas are supplied with pressure, and for venting the pressure from said areas in a reverse order during the opposite stroke of the motor to cause reverse movement of the respective valve after venting of both areas.

14. In a motor, in combination, a cylinder, a piston reciprocable therein, a valve mechanism for said motor including an admission valve and an exhaust valve and controlling means for each of said valves, each of said valve controlling means having a plurality of pressure areas acting in the same direction, and means for supplying pressure to said areas from a space within said cylinder at the same side of said piston during one pass of the piston in a predetermined order to cause the respective valve to perform one of its functions after both areas are supplied with pressure, and for venting the pressure from said areas in a reverse order during the opposite pass of the piston to cause reverse movement of the respective valve after venting of both areas.

15. In a motor, in combination, a cylinder, a piston reciprocable therein, a valve mechanism for said motor including an admission valve and an exhaust valve and controlling means for each of said valves, each of said valve controlling means having a plurality of pressure areas each acting to move its respective valve in one direction, and means for supplying pressure to said areas during one pass of the piston in a predetermined order to cause the respective valve to perform one of its functions after both areas are supplied with pressure, and for venting the pressure from said areas in a reverse order during the opposite pass of the piston to cause reverse movement of the respective valve after venting of both areas.

16. In a motor, in combination, a cylinder, a piston reciprocable therein, a valve mechanism for said motor including an admission valve and an exhaust valve and controlling means for each of said valves, each of said valve controlling means having a plurality of pressure areas acting in the same direction, and means for supplying pressure to said areas during one pass of the piston in a predetermined order to cause the respective valve to perform one of its functions after both areas are supplied with pressure, and for venting the pressure from said areas in a reverse order during the opposite pass of the piston to cause reverse movement of the respective valve after venting of both areas, said admission and exhaust valves also having associated therewith additional means exerting pressures in the same direction as said pressure areas, the pressures exerted by said additional means being different in the case of one valve from the other.

17. In a motor, in combination, a cylinder, a piston reciprocable therein, a valve mechanism for said motor including an admission valve and an exhaust valve and controlling means for each of said valves, each of said valve controlling means having a plurality of pressure areas acting

in the same direction, and means for supplying pressure to said areas from a space within said cylinder at the same side of said piston during one pass of the piston in a predetermined order to cause the respective valve to perform one of its functions after both areas are supplied with pressure, and for venting the pressure from said areas in a reverse order during the opposite pass of the piston to cause reverse movement of the respective valve after venting of both areas, said admission and exhaust valves also having associated therewith additional means exerting pressures in the same direction as said pressure areas, the pressures exerted by said additional means being different in the case of one valve from the other.

18. In a motor, in combination, a cylinder, a piston reciprocable therein, a valve mechanism for said motor including an admission valve and an exhaust valve and controlling means for each of said valves, each of said valve controlling means having a plurality of pressure areas each acting to move its respective valve in one direction, and means for supplying pressure to said areas during one pass of the piston in a predetermined order to cause the respective valve to perform one of its functions after both areas are supplied with pressure, and for venting the pressure from said areas in a reverse order during the opposite pass of the piston to cause reverse movement of the respective valve after venting of both areas, said admission and exhaust valves also having associated therewith additional means exerting pressures in the same direction as said pressure areas, the pressures exerted by said additional means being different in the case of one valve from the other.

19. In a motor, in combination, a cylinder, a piston reciprocable therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas acting to move said valve in one direction and means for supplying pressure to said areas during one pass of the piston in a predetermined order to cause, only when both said areas are supplied with pressure, movement of said valve in the aforesaid direction, and venting the pressure from said areas in the reverse order during the opposite pass of the piston to cause reverse movement of the valve only after venting of both areas.

20. In a motor, in combination, a cylinder, a piston reciprocable therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas acting to move said valve in one direction and means for supplying pressure to said areas during one pass of the piston in a predetermined order to cause, only when both said areas are supplied with pressure, movement of said valve in the aforesaid direction, and venting the pressure from said areas in the reverse order during the opposite pass of the piston to cause reverse movement of the valve only after venting of both areas, said valve controlling means also including means for opposing movement of said valve by said pressure areas including an area subjected to the fluid controlled by said valve and acting in opposition to said first mentioned areas.

21. In a motor, in combination, a cylinder, a piston reciprocable therein, and valve mechanism for said motor including a valve and controlling means therefor having a plurality of pressure areas acting to move said valve in one direction and means for supplying pressure to said areas during one pass of the piston in a predetermined order to cause, only when both said areas are supplied with pressure, movement of said valve in the aforesaid direction, and venting the pressure from said areas in the reverse order during the opposite pass of the piston to cause reverse movement of the valve only after venting of both areas, said valve controlling means also including means for opposing movement of said valve by said pressure areas including an area subjected to the fluid controlled by said valve and acting in opposition to said first mentioned areas, and said valve controlling means further including supplemental means for exerting a continuous pressure tending to move said valve in the same direction as said first mentioned pressure areas.

22. In a motor, in combination, a cylinder, a piston reciprocable therein, means for continuously venting one end of said cylinder, and means for controlling admission and exhaust with respect to the opposite end of said cylinder including an admission valve opened by motor back pressure and an end-seating exhaust valve moving on closure in the direction of flow of the discharging exhaust fluid and whose closing is controlled by motor back pressure, said exhaust valve when closed subjected to exhaust line pressure acting in a direction to open the same.

23. In a motor, in combination, a cylinder, a piston reciprocable therein, means for continuously venting one end of said cylinder, and means for controlling admission and exhaust with respect to the opposite end of said cylinder including an admission valve opened by motor back pressure and an independently movable exhaust valve whose closing is controlled by motor back pressure, said exhaust valve provided with and controlling a flow port which both serves as the main motor exhaust and conducts fluid to effect exhaust valve closure.

24. In a motor, in combination, a cylinder, a piston therein, means for continuously venting one end of said cylinder, and means for controlling admission and exhaust with respect to the opposite end of said cylinder including an admission valve opened by motor back pressure and an exhaust valve having but a single flow connection with the extremity of the unvented end of the cylinder bore and through which exhaust occurs.

25. In a motor, in combination, a cylinder, a piston reciprocable therein, means for continuously venting one end of said cylinder, and means for controlling admission and exhaust with respect to the opposite end of said cylinder including an admission valve opened by motor back pressure and an exhaust valve whose closing is controlled by motor back pressure and means for effecting opposite movements of said valves by working pressure from the cylinder including passage means for each valve sequentially uncovered by the piston on each pass thereof and each cooperating to vary the valve-positioning effecting forces each time it is uncovered.

26. In a motor, in combination, a cylinder, a piston therein, means for continuously venting one end of said cylinder, and means for controlling admission and exhaust with respect to the opposite end of said cylinder including an admission valve opened by motor back pressure and an exhaust valve whose closing is controlled by motor back pressure and means for effecting opposite movements of said valves by working pressure from the cylinder having plural supply con-

nections for each valve controlled by piston movement at widely separated points in such movement.

27. In a motor, in combination, a cylinder, a piston reciprocable therein, means for continuously venting one end of said cylinder, and means for controlling admission and exhaust with respect to the opposite end of said cylinder including an admission valve opened solely by motor back pressure and an exhaust valve whose closing is controlled by motor back pressure and means for effecting the respectively opposite movements of said valves by working pressure from the cylinder having supply connections communicating with the cylinder bore and overrun by said piston on both passes of the latter.

28. In a motor, in combination, a cylinder, a piston therein, admission and exhaust valves, and means for effecting functionally opposite movements of said valves including connections with the cylinder bore at spaced points one individual to each valve, and means for rendering one of said connections ineffective and the other operative for both valves at will.

29. In a motor, in combination, a cylinder, a piston therein, admission and exhaust valves, and means for effecting functionally opposite movements of said valves including a plurality of spaced connections with the cylinder bore for one of said valves, a plurality of spaced connections with the cylinder bore for the other of said valves, and means for rendering one half of said connections ineffective and the remainder operative for both valves at will.

30. In a motor, in combination, a cylinder, a piston therein, admission and exhaust valves, and means for effecting functionally opposite movements of said valves including a plurality of spaced connections with the cylinder bore for one of said valves, a plurality of spaced connections with the cylinder bore for the other of said valves, and means for making one of the connections individual to each valve operative for the other at will.

31. In a motor, in combination, a cylinder, a piston therein, admission and exhaust valves, and means for effecting functionally opposite movement of said valves including a connection for one of said valves with the cylinder bore in one longitudinal half of said cylinder, a connection with the cylinder bore for the other of said valves in the same longitudinal half of said cylinder, a connection for one of said valves with the bore of said cylinder in the other longitudinal half of the latter, a connection for the other of said valves with the cylinder bore in the last mentioned longitudinal half of the cylinder, and means for rendering the connection for one of said valves at one end of the cylinder operative for both at will and for rendering the connection for the other of said valves at the other end of the cylinder operative for both valves at will.

32. In a motor, in combination, a cylinder, a piston therein, admission and exhaust valves, and means for governing closure of the exhaust valve and opening of the admission valve including connections with the cylinder bore at spaced points one individual to each valve, and means for rendering one of said connections ineffective and the other operative for both valves at will.

33. In a motor, in combination, a cylinder, a piston therein, admission and exhaust valves, and means for effecting closure of the admission valve and opening of the exhaust valve including connections with the cylinder bore at spaced points one individual to each valve, and means for rendering one of said connections ineffective and the other operative for both valves at will.

34. In a motor, in combination, a cylinder, a piston therein, and distributing valve mechanism including a valve and actuating means therefor including a pressure fluid actuated element, and means for subjecting the same cumulatively to cylinder pressure through communications established at widely different times in one direction of the piston travel including a connection communicable with the cylinder at a plurality of different points along the length of the latter and means for delaying reverse valve movement until said cumulative pressures are all released.

35. In a motor, a cylinder, a piston reciprocable therein, a valve mechanism for said motor including a valve, and actuating means therefor including means continuously pressing said valve in one direction, a plurality of means for intermittently pressing said valve in the same direction by pressure fluid both effective during a single pass of the piston, and means whereby said valve is pressed in an opposite direction alternatively by motor back pressure and line pressure respectively to open the same and to maintain the same open.

36. In a motor, a cylinder, a piston reciprocable therein, a valve mechanism for said motor including a valve, and actuating means therefor including means continuously pressing said valve in one direction, a plurality of means for intermittently pressing said valve in the same direction by pressure fluid, said plurality of means being operative for different portions of the motor cycle but acting cumulatively and both effective during a single piston pass, and means whereby said valve is pressed in an opposite direction alternatively by motor back pressure and line pressure respectively to open the same and to maintain the same open.

37. In a motor, a cylinder, a piston reciprocable therein, a valve, and actuating means therefor including means continuously pressing said valve in one direction, a plurality of mutually cumulative means for intermittently pressing said valve in the same direction by pressure fluid, each of which is effective during a single pass of the piston, and means whereby said valve is pressed in an opposite direction alternatively by motor back pressure and by the live pressure in the cylinder respectively to close the same and to maintain the same closed.

38. In a motor, a cylinder, a piston reciprocable therein, a valve, and actuating means therefor including means continuously pressing said valve in one direction, a plurality of means for intermittently pressing the valve in the same direction by pressing fluid, said plurality of means being operative for different portions of the motor cycle but acting cumulatively and both effective during a single piston pass, and means whereby said valve is pressed in an opposite direction alternatively by motor back pressure and by the working pressure in said cylinder respectively to close said valve and to maintain the same closed.

39. In a motor, in combination, a cylinder vented at one end, a piston therein, independent admission and exhaust valves for the unvented end of said cylinder, each having associated therewith and controlling a port communicating directly with the unvented end of the cylinder at

the extreme end thereof, and fluid operated valve controlling means adjustable to vary the degree of compression including means for automatically effecting closure of said exhaust valve prior to opening of said admission valve irrespective of such adjustment.

40. In a motor, in combination, a cylinder vented at one end, a piston reciprocable therein, independent admission and exhaust valves for the unvented end of said cylinder each having associated therewith and controlling a port communicating directly with the unvented end of the cylinder at the extreme end thereof, and fluid operated valve controlling means including substantially identical pressure fluid actuated devices associated one with each valve and each having motor piston controlled communication with the cylinder bore, each of said devices having supplemental means associated therewith for pressing the same in the direction said device is movable by fluid pressure transmitted thereto from the motor cylinder, and said supplemental means exerting unequal pressures.

41. In a motor, in combination, a cylinder vented at one end, a piston therein, independent admission and exhaust valves for the unvented end of said cylinder respectively controlled as to opening and closing by compression pressure, and fluid operated valve controlling means adjustable to vary the degree of compression including means operative to render said exhaust valve more responsive to compression pressure for automatically effecting closure of said exhaust valve prior to opening of said admission valve irrespective of such adjustment.

42. In a motor, in combination, a cylinder vented at one end, a piston reciprocable therein, independent admission and exhaust valves for the unvented end of said cylinder, and fluid operated valve controlling means adjustable to vary the degree of compression including resilient means for automatically effecting closure of said exhaust valve prior to opening of said admission valve irrespective of such adjustment.

43. In a motor, in combination, a cylinder, a piston therein, means for continuously venting one end of said cylinder, and means for controlling admission and exhaust with respect to the opposite end of said cylinder including an admission valve opened by motor back pressure and an exhaust valve having an exhaust port controlled thereby and opening to the cylinder bore at the extreme end of the latter and whose closing is controlled by motor back pressure.

44. In a motor, in combination, a cylinder, a piston reciprocable therein, means for continuously venting one end of said cylinder, and means for controlling admission and exhaust with respect to the opposite end of said cylinder including an admission valve opened by motor back pressure and an exhaust valve having an exhaust port controlled thereby and opening to the cylinder bore at the extreme end of the latter and whose closing is controlled by motor back pressure, and means for effecting opposite movements of said valves by working pressure from the cylinder.

45. In a motor, in combination, a cylinder, a piston reciprocable therein, means for continuously venting one end of said cylinder, and means for controlling admission and exhaust with respect to the opposite end of said cylinder including an admission valve opened by motor back pressure and an exhaust valve having an exhaust port controlled thereby and opening to the cylinder bore at the extreme end of the latter and whose closing is controlled by motor back pressure, and means for effecting opposite movements of said valves by working pressure from the cylinder having supply connections controlled by piston movement.

46. In a motor, in combination, a cylinder, a piston reciprocable therein, means for continuously venting one end of said cylinder, and means for controlling admission and exhaust with respect to the opposite end of said cylinder including an admission valve opened by motor back pressure and an exhaust valve having an exhaust port controlled thereby and opening to the cylinder bore at the extreme end of the latter and whose closing is controlled by motor back pressure, and means for effecting opposite movements of said valves by working pressure from the cylinder having supply connections communicating with the cylinder bore and overrun by said piston.

47. In a motor, in combination, a cylinder, a piston therein, means for continuously venting one end of said cylinder, and means for controlling admission and exhaust with respect to the opposite end of said cylinder including an admission valve opened by motor back pressure, and an exhaust valve whose closing is controlled by motor back pressure, said exhaust valve when closed subjected to exhaust line pressure acting in a direction to open the same.

48. In a motor, in combination, a cylinder, a piston therein, means for continuously venting one end of the cylinder, a supply line for the other end of the cylinder, an exhaust line for the last mentioned end of the cylinder constantly maintained under a substantial pressure, and means for controlling connection of said supply and exhaust lines alternatively with the last mentioned end of said cylinder including an admission valve opened by motor back pressure and an independently movable exhaust valve constantly subjected on one end to the pressure conditions at the extreme end of the second mentioned end of the cylinder and subjected when closed to exhaust line pressure on its other end.

WADE H. WINEMAN.