Dec. 28, 1937. W. H. WINEMAN 2,103,965

MOTOR FOR PUMPING MECHANISMS

Filed Oct. 10, 1934 3 Sheets-Sheet 1

Fig.1.

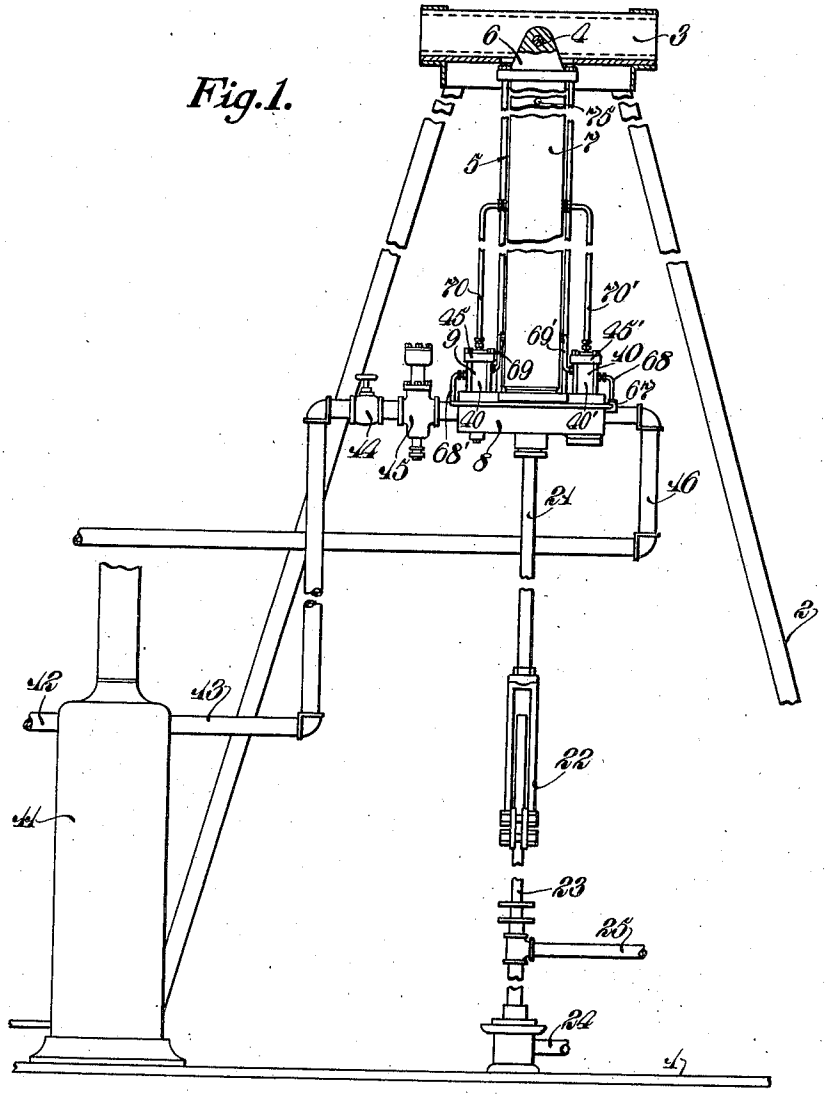
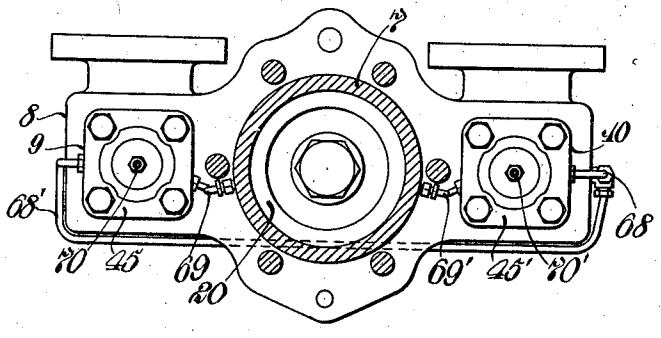



Fig.3.




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Dec. 28, 1937. W. H. WINEMAN 2,103,965

MOTOR FOR PUMPING MECHANISMS

Filed Oct. 10, 1934 3 Sheets-Sheet 2

Fig. 4.

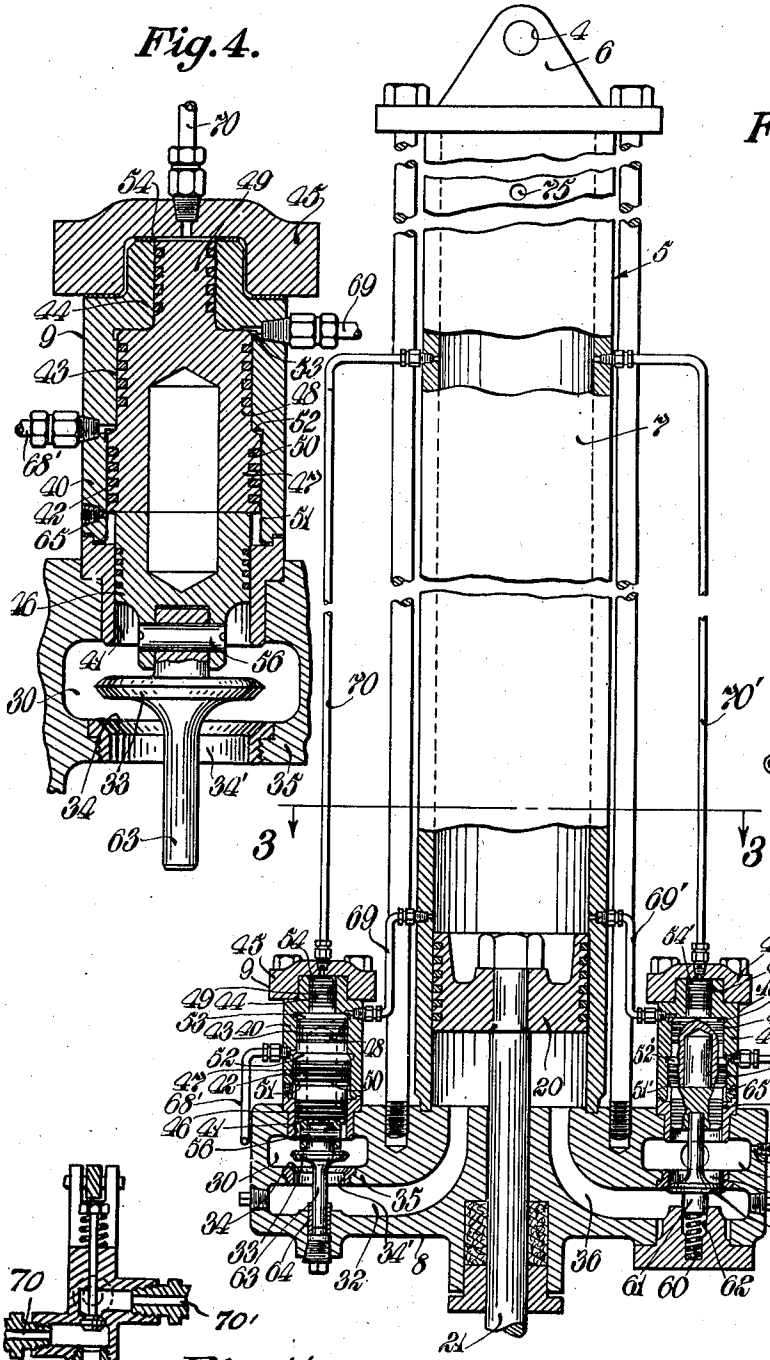



Fig. 2.

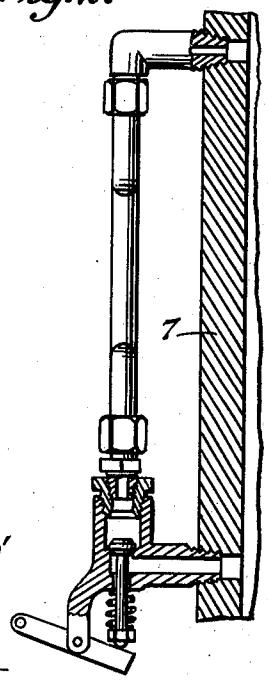



Fig. 10.

Fig. 11.

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Dec. 28, 1937. W. H. WINEMAN 2,103,965

MOTOR FOR PUMPING MECHANISMS

Filed Oct. 10, 1934 3 Sheets-Sheet 3

Fig.5.

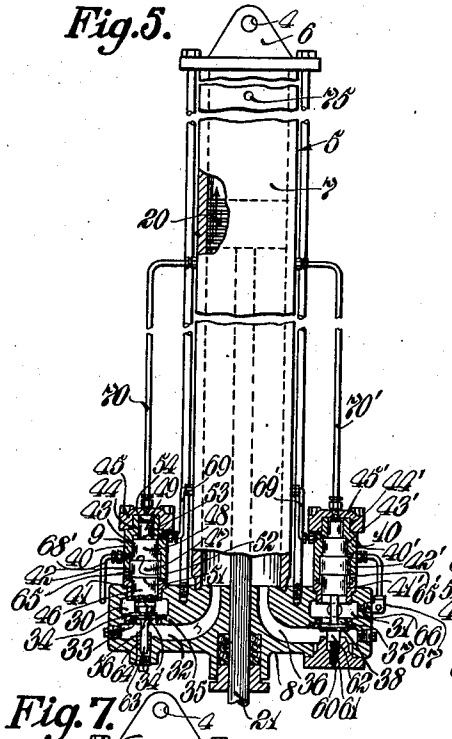


Fig.6.

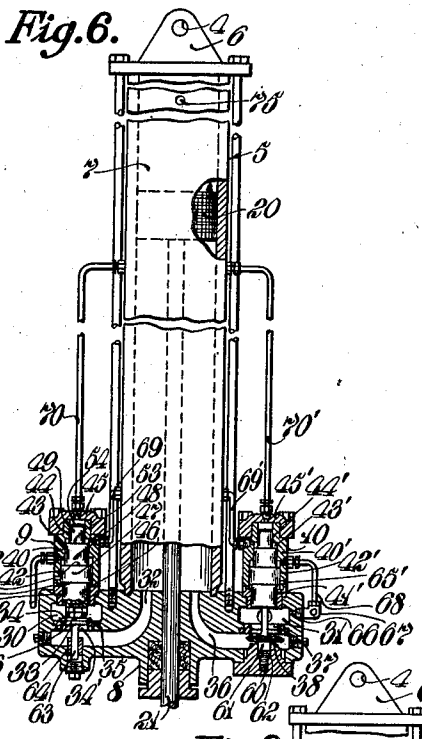


Fig.7.

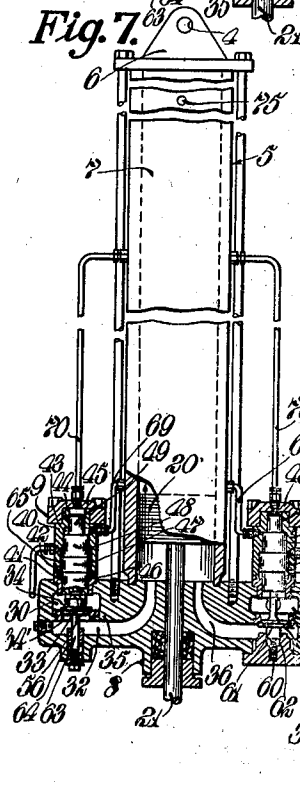


Fig.8.

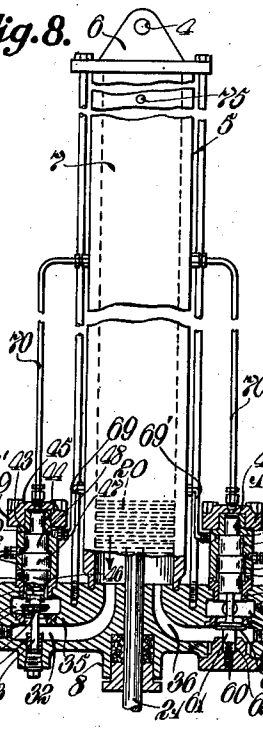
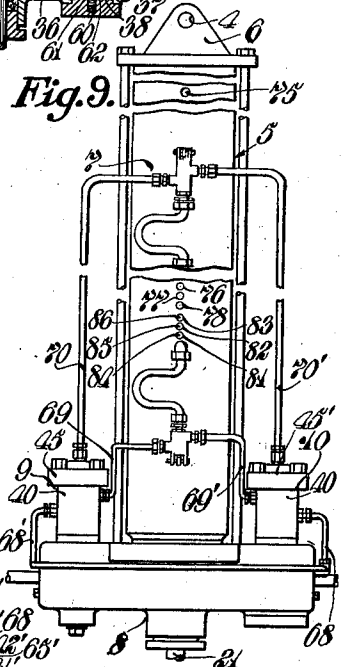


Fig.9.



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Patented Dec. 28, 1937 2,103,965

# UNITED STATES PATENT OFFICE

2,103,965

## MOTOR FOR PUMPING MECHANISMS

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

Application October 10, 1934, Serial No. 747,677

23 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 particular applicability to the pumping of oil wells.

There are oil fields in which there is considerable oil available, but not an adequate subterranean pressure to raise the oil to the surface without pumping, and various means of pumping the oil from wells in these fields have been resorted to. A very satisfactory form of pumping apparatus includes a central source of pressure fluid for the operation of the pumps, such as a compressor, a series of single acting pumping motors, one at each well connected with the central source of fluid supply, and having their pistons displace, on the non-pumping movements thereof, the actuating fluid which has caused the pistons to perform their working strokes, under a substantial back pressure, so that weight of the rod line, etc., is sufficiently counter-balanced to prevent danger of breakage, hammering and other difficulties.

The pumping motors for such a system must be very simple, must have no parts liable to easy derangement, and must be durable and completely automatic in operation; and it is an object of this invention to provide a motor especially adapted for use in such a system. It is another object of the invention to provide a motor having an improved valve gear of simple and efficient construction, and in which variation in points of cut-off and compression may easily be obtained by resort to an arrangement of the type described in my co-pending application Serial No. 612,538, now Patent No. 2,004,146. It is another object of my invention to provide a very efficient pumping motor operating on a rectangular cycle. Further objects and advantages of the invention will hereinafter appear.

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

Fig. 1 is a side elevation, with parts broken away, of a pumping mechanism located at an oil well and provided with an illustrative embodiment of my improved pumping motor,

Fig. 2 is a view on an enlarged scale, with parts in section, showing the pumping motor per se,

Fig. 3 is a horizontal section on the line 3—3 of Fig. 2,

Fig. 4 is a section on an enlarged scale taken through the axis of the admission valve mechanism of the pumping motor,

Figs. 5, 6, 7 and 8 are views partially in section and partially in elevation showing the relative positions of the motor parts at cut-off, release, compression and admission,

Fig. 9 is a view of a modified form of the invention, showing in side elevation the arrangement employed when it is desired to work with substantial variations in point of cut-off and in point of compression,

Figs. 10 and 11 are fragmentary views showing details of construction of the modification of Fig. 9.

Referring to the drawings, and first to Fig. 1, it will be observed that a platform or derrick floor 1 supports a suitable frame of structural steel 2. At its top this frame has a cross member 3 on which there is pivotally supported at 4 a pumping motor generally designated 5. This pumping motor comprises an upper head 6, which is the part directly connected to the cross member 3, a cylinder 7 and a lower head 8 which also supports an admission valve mechanism 9 and an exhaust valve mechanism 10. For the purpose of obtaining maximum efficiency, a preheater 11 is used for preheating the air, which is supplied from a central station (not shown) through a pipe line 12; and after preheating, the air passes through a pipe line 13 past a hand-operable stop valve 14 and an automatic stop valve 15 to enter the admission space of the motor 5. After the air has done its work in the motor it is discharged to a return line 16 through which it passes back to the intake side of a compressor at the central station, and suitable means not shown are employed for maintaining a substantial back pressure in the line 16. The cylinder 7 contains a piston 20 which is connected by a piston rod 21 and an adjustable connector device 22 to a sucker rod line 23. Gas from the well is led away through a connection 24, and oil, pumped from the well by a suitable lift type pump not shown but operated by the sucker rod line 23, is discharged through a connection 25.

Referring to the species of Figs. 1 to 8, inclusive, it will be observed that the lower head 8 of the motor contains a supply space 30 to which the supply line 13 leads, and an exhaust chamber 31 with which the exhaust line 16 directly communicates. The admission port 32 opens into the lower end of the motor cylinder, and its communication with the supply chamber 30 is controlled by an admission valve 33 which is adapted to cooperate with a seat 34 surrounding a port 34' provided in a septum 35 separating the

chamber 30 and the port 32. A discharge port 36 is communicable through a seat-surrounded port 37 controlled by an exhaust valve 38 with the exhaust space 31. It will be observed that the admission valve 33 seats in the direction of flow of fluid from the source of supply to the cylinder, while the exhaust valve 38 seats in the direction of flow of exhausting fluid from the cylinder to the exhaust line 16.

The admission and exhaust valves are controlled by similar mechanisms. Each of these controlling mechanisms includes a composite cylinder structure designated 40 in the case of the admission valve, and 40' in the case of the exhaust valve. These composite cylinder structures each provide a plurality of bores and the same reference characters will be used, with primes in the case of the exhaust valve mechanism, for designating corresponding parts in the admission and exhaust valve controlling mechanisms. Referring to the bores provided by the cylinders 40, 40' and beginning first with the lower ends of the latter, it will be noted that each comprises a lower bore of the same cross sectional area as the port opening through the seat for the valve which is actuated by the controlling mechanism, these bores being designated 41, 41'. Next comes a larger bore having a cross sectional area approximately one and one-quarter times the cross sectional area of the bores 41 and 41'. These larger bores are designated 42 and 42'. Next comes another bore of the same size as the bore first described, these third bores being designated 43 and 43', and last comes a small bore approximately one-fifth the cross sectional area of the bottom and third bores 41, 41', and 43, 43'. These last and smallest bores are designated 44 and 44'. Heads 45, 45' close these upper bores. Within each of the composite cylinder mechanisms 40, 40' there is reciprocable a composite piston structure. Each of these comprises four heads. The admission valve controlling piston comprises a lower head 46 fitting the bore 41, a large intermediate head 47 fitting the bore 42, a second intermediate head 48 fitting the bore 43 and a small upper portion 49 fitting the small bore 44. Each of these various portions of the piston is provided with suitable means for reducing leakage, herein with piston rings 50. The exhaust valve controlling piston is of like construction. It will be observed that a shoulder 51 is provided at the lower end of piston 47, a shoulder 52 at the upper end of piston portion 47 and a shoulder 53 at the upper end of piston portion 48. A head 54 is provided by the piston portion 49. These shoulders and heads provide pressure areas and the area of 54 is approximately one-fourth the area of 53. The area of 52 is larger than the area of 54, being approximately one-fourth the cross sectional area of the bore 43. The area 51 is of course the same as the area 52. The piston portion 46 is connected by a pin 56 with the admission valve 33. The area of the latter exposed to admission chamber pressure when closed somewhat exceeds the area of the latter exposed to pressure within the cylinder through the opening 34' surrounded by the valve seat 34.

The parts of the composite piston structure cooperating with the exhaust valve 38 are designated by like reference characters, primed, to those used in connection with the composite piston structure which cooperates with the admission valve 33. The exhaust valve 38 is not pinned to its controlling piston structure, as this is unnecessary. It is, however, maintained in continuous contact therewith by the action of a spring 60 which acts upon a guiding portion 61 formed upon the lower end of the exhaust valve 38. This guiding portion fits freely in a bore 62, so that the fluid below the exhaust valve 38 acts freely upon the lower end of the guiding portion 62. The admission valve 33 is provided with a guide stem 63 which freely fits in a guide bushing 64 in line with the admission valve seat.

Free venting of the shoulders 51, 51' to atmosphere is provided through suitable port connections 65, 65'. The shoulders 52, 52' are constantly subjected to a reduced pressure, herein the back pressure in the exhaust line 16, a passage 66 connecting a double elbow 67 with the exhaust space 31; and pipe lines 68 and 68' respectively connect the double elbow with the spaces at the upper ends of the bores 42', 42. Obviously suitably reduced line pressure might be used instead. The spaces at the upper ends of the bores 43, 43' are connected with the bore of the cylinder 7, in the first species of the invention disclosed, at points in approximately the same transverse plane and in such position that they are uncovered by the upper end of the piston 20 as the latter approaches the lower end of the cylinder 7 in its downward travel. The connections for effecting these communications are respectively numbered 69, 69'. The upper ends of the bores 44 and 44' are respectively connected by tubes or pipes 70 and 70' with the bore of the cylinder 7 at points where they are uncovered by the lower end of the piston 20 as the latter approaches the desired upper limit of its working stroke. The pressure exerted by the spring 60 may be chosen within fairly wide limits, but a satisfactory pressure would be perhaps one eighth of the per-square inch back pressure in the exhaust line 16.

The mode of operation of this apparatus will be readily understood from the description which has been given. Fig. 2 shows the parts in the position they occupy with admission taking place. The fluid is then flowing from the line 12 through the preheater 11 through the line 13 past the manual and automatic stop valves 14 and 15 and into the chamber 30, through the port 34', beneath the lifted valve 33, through the port 32, and into the lower end of the cylinder 7 where it acts on the lower side of the piston 20 to move the latter upwardly. The valve 33 will naturally remain in its open position as it is held up by a pressure equivalent to the product of the supply line pressure multiplied by the cross-sectional area of the bore 41 minus the product of the discharge line back pressure multiplied by the area of the shoulder 52. Supply line pressure may advantageously be perhaps three or four times the exhaust pressure, and accordingly, it is obvious that the admission valve is firmly held in open position.

As the piston 20 moves upwardly in the cylinder its lower edge uncovers the points of communication of the passage 69, 69' with the cylinder bore, and this admits cylinder pressure to the shoulders 53, 53', but obviously this is not sufficient to counter-balance the pressure which is holding the inlet valve open or the pressure which is maintaining the exhaust valve closed. With reference to the exhaust valve, it is to be noted that this is held in closed position by full cylinder pressure acting on its lower surface and also by the action of the spring 60.

The piston 20 continues upwardly and its lower edge uncovers the points of communication of

connections 70 and 70' with the cylinder bore. When the mouth of connection 70 is uncovered by the lower edge of the piston 20, pressure passes from the cylinder to the surface 54, and there is then provided a cumulative downward pressure sufficient to close the admission valve 33, for the cumulative areas of shoulder 53 and head 54 offset the effective exposed area at the lower end of the composite piston construction, and the exhaust line pressure acting on the shoulder 52 provides and causes downward pressure which positively and firmly closes the admission valve. The exhaust valve also opens soon after the mouth of ports 70' is exposed to the pressure within the cylinder bore by passage of the lower end of the piston 20 upwardly past the mouth of connection 70', but it does not open until after the admission valve has closed, first because the area of the exhaust valve 38 exposed to pressure within the cylinder bore (that is its lower surface) is slightly larger than the cumulative area of the shoulder 53' and head 54', so that the exhaust valve for that reason delays its movement slightly longer than the admission valve, and in the second place because the spring 60 also provides a slight time delay as it necessitates the building up to a slightly higher degree of the pressure acting upon 53' and 54' before the exhaust valve will open.

Conditions when the admission valve has closed and the exhaust valve has not yet opened, are shown in Fig. 5; and conditions which exist when the exhaust valve first opens are illustrated in Fig. 6.

When the exhaust valve opens, the pressure below the piston 20 practically immediately reduces to exhaust line back-pressure, and accordingly the exhaust valve will remain open notwithstanding the venting of the pressure above the piston portion 54' when the pipe connection 70' is connected to atmosphere (as occurs when the top edge of the piston 20 passes below the mouth of the port 70', due to the fact that the upper end of the cylinder 7 is vented to atmosphere, as shown at 75). It will be noted that there is still an excess downward pressure exceeding the upward pressure of spring 60. Similarly, the placing of the passage 70 in communication with the atmosphere will not result in unseating of the admission valve. These facts may readily be seen from the following: During exhaust the upward pressure on the exhaust valve with the proportions specified and the pressure ratios mentioned is equal to the pressure exerted by the spring 60 and the product of exhaust line pressure multiplied by the area of the lower end of the piston 46'. The downward pressure is equal to exhaust line pressure multiplied by the sum of the areas of shoulder 53' and shoulder 52'. It will be observed that there is an excess downward pressure holding the exhaust valve open, of a small but adequate amount. In the case of the admission valve, the preponderance of downward pressure is even greater, for the upper surface of the valve 33 is slightly larger than the lower surface, and accordingly, there is a certain amount of downward pressure due to this difference in area multiplied by line pressure. Moreover, the admission valve is not subjected to the force of any spring corresponding to the spring 60.

When the piston 20 approaches the lower end of its travel, it uncovers the mouths of passages 69 and 69' and places these in communication with the atmosphere. Almost immediately then the exhaust valve will close, for the only pressure tending to maintain it open will be the pressure exerted by exhaust line pressure upon the shoulder 52', which is entirely inadequate to offset the sum of the small pressure exerted by the spring 60 and the force of exhaust line pressure on an area equal to the full cross sectional area of the bore 41'. The exhaust valve therefore closes promptly on uncovering of the mouth of 69' by the top of the piston. The inlet valve opens slightly later, for the opening pressure upon the inlet valve is equal to compression pressure acting upon an area equal to the cross sectional area of the bore 41, opposed by exhaust line pressure on the shoulder 52 and full line pressure acting upon an area equal to the difference between the area of the top of the seated admission valve 33 and the cross sectional area of the bore 41. The admission valve will, however, open soon after the exhaust valve closes, as compression pressure builds up, and thereafter the cycle described will be repeated as long as fluid is supplied to the motor.

In Figs. 9, 10, and 11, the possibility of connecting the pipe 70 to the cylinder at different places below the point of connection employed for the rectangular cycle, so as to use the fluid expansively, is shown. A number of openings 76, 77 and 78 are provided, these being closed by plugs, and the connection 70 may be made to any one of these, as desired, all the unused connections being kept closed with plugs. Similarly, a number of connections 81, 82, and 83 provided with plugs 84, 85, and 86, respectively, are provided to permit the connection of 69' with the cylinder bore at different earlier points in the downward stroke of the piston, thereby to work with different degrees of compression. For further description of the mode of operation of the variably positionable connections with the cylinder bore, if this be desired, reference may be had to Letters Patent No. 2,004,146.

From the foregoing portions of this specification, it will be evident that I have provided a very simple, positive, efficient and durable valve mechanism, and a motor well directed to the particular function described, and also for any purpose where a single acting motor is needed. The valve mechanism is easily manufactured, positive in connection, has only a single spring, and the whole may be manufactured with a minimum of difficulty and of machining operations.

While I have in this application specifically described one form and a modification which my invention may assume in practice, it will be understood that these are shown for purposes of illustration, 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.

I claim:

1. In a motor, in combination, a cylinder, a piston reciprocable therein, and fluid distribution means for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction, means for constantly supplying pressure fluid to one of said areas, and means for supplying pressure to two others of 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 said last mentioned areas are supplied with pressure and venting the pressure from said last mentioned areas in a reverse

order during the opposite pass of the piston to cause reverse movement of the valve after venting of both said last mentioned areas.

2. In a motor, in combination, a cylinder, a piston reciprocable therein, and fluid distribution means for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction, means for constantly supplying pressure less than line pressure to one of said areas, and means for supplying pressure to two others of 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 said last mentioned areas are supplied with pressure and venting the pressure from said last mentioned areas in a reverse order during the opposite pass of the piston to cause reverse movement of the valve after venting of both said last mentioned areas.

3. In a motor, in combination, a cylinder, a piston reciprocable therein, said motor exhausting against a substantial back pressure, and fluid distribution means for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction, means for constantly supplying motor back pressure to one of said areas, and means for supplying pressure to two others of 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 said last mentioned areas are supplied with pressure and venting the pressure from said last mentioned areas in a reverse order during the opposite pass of the piston to cause reverse movement of the valve after venting of both said last mentioned areas.

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

5. In a motor, in combination, a cylinder, a piston reciprocable therein, and fluid distribution means for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction, means for constantly supplying pressure less than line pressure to one of said areas, and means for supplying pressure to two others of said areas during one pass of the piston in a predetermined order to cause said valve to perform one of its functions after both said last mentioned areas are supplied with pressure and venting the pressure from said last mentioned areas in a reverse order during the opposite pass of the piston to cause reverse movement of the valve after venting of both such areas.

6. In a motor, in combination, a cylinder, a piston reciprocable therein, said motor exhausting against a substantial back pressure, and fluid distribution means for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction, means for constantly supplying motor back pressure to one of said areas, and means for supplying pressure to two others of said areas during one pass of the piston in a predetermined order to cause said valve to perform one of its functions after both said last mentioned areas are supplied with pressure and venting the pressure from said last mentioned areas in a reverse order during the opposite pass of the piston to cause reverse movement of the valve after venting of both such areas.

7. In a motor, in combination, a cylinder, a piston reciprocable therein, and fluid distribution means for said motor including a valve and controlling means therefor having a plurality of pressure areas acting in the same direction, means for continuously supplying pressure fluid to one of said areas, and means for supplying pressure to two others of 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 said last mentioned areas are supplied with pressure and venting the pressure from said last mentioned areas in a reverse order during the opposite pass of the piston to cause reverse movement of the valve after venting of both such 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.

8. In a motor, in combination, a cylinder, a piston reciprocable therein, and fluid distribution means 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 including a plurality of pressure areas acting in the same direction, means for constantly supplying pressure to one of said areas, and means for supplying pressure to others of said areas during one pass of the piston in a predetermined order to cause its respective valve to perform one of its functions after said last mentioned areas are supplied with pressure, and for venting the pressure from said last mentioned areas in a reverse order during the opposite pass of the piston to cause reverse movement of its respective valve after venting of said last mentioned areas.

9. In a motor, in combination, a cylinder, a piston reciprocable therein, and fluid distribution means 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 including a plurality of pressure areas acting in the same direction, means for constantly supplying pressure less than line pressure to one of said areas, and means for supplying pressure to others of said areas during one pass of the piston in a predetermined order to cause its respective valve to perform one of its functions after said last mentioned areas are supplied with pressure, and for venting the pressure from said last mentioned areas in a reverse order during the opposite pass of the piston to cause reverse movement of its respective valve after venting of said last mentioned areas.

10. In a motor, in combination, a cylinder, a piston reciprocable therein, said motor exhausting against a substantial back pressure, and fluid distribution means for said motor including an admission valve and an exhaust valve and con-

trolling means for each of said valves, each of said valve controlling means including a plurality of pressure areas acting in the same direction, means for constantly supplying motor back pressure to one of said areas, and means for supplying pressure to others of said areas during one pass of the piston in a predetermined order to cause its respective valve to perform one of its functions after said last mentioned areas are supplied with pressure, and for venting the pressure from said last mentioned areas in a reverse order during the opposite pass of the piston to cause reverse movement of its respective valve after venting of said last mentioned areas.

11. In a motor, in combination, a cylinder, a piston reciprocable therein, and fluid distribution means 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 including a plurality of pressure areas acting in the same direction, means for supplying pressure fluid constantly to one of said areas, and means for supplying pressure to others of 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 its respective valve to perform one of its functions after said other areas are supplied with pressure, and for venting the pressure from said other areas in a reverse order during the opposite pass of the piston to cause reverse movement of its respective valve after venting of said other areas.

12. In a motor, in combination, a cylinder, a piston reciprocable therein, and fluid distribution means 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 including a plurality of pressure areas acting in the same direction, means for supplying pressure less than line pressure constantly to one of said areas, and means for supplying pressure to others of 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 its respective valve to perform one of its functions after said other areas are supplied with pressure, and for venting the pressure from said other areas in a reverse order during the opposite pass of the piston to cause reverse movement of its respective valve after venting of said other areas.

13. In a motor, in combination, a cylinder, a piston reciprocable therein, said motor exhausting against a substantial back pressure, and fluid distribution means 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 including a plurality of pressure areas acting in the same direction, means for supplying motor back pressure constantly to one of said areas, and means for supplying pressure to others of 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 its respective valve to perform one of its functions after said other areas are supplied with pressure, and for venting the pressure from said other areas in a reverse order during the opposite pass of the piston to cause reverse movement of its respective valve after venting of said other areas.

14. In a motor, in combination, a cylinder, a piston reciprocable therein, and fluid distribution means 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 including two 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 its 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 its respective valve after venting of both areas, said admission and exhaust valves also respectively having associated therewith additional means exerting pressures in the same direction as said pressure areas, the pressures exerted by said additional means being the same in the case of both valves.

15. In a motor, in combination, a cylinder, a piston reciprocable therein, and fluid distribution means 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 including a pair 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 its 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 its respective valve after venting of both areas, said admission and exhaust valves also respectively having associated therewith additional means exerting pressures in the same direction as said pressure areas, the pressures exerted by said additional means being the same in the case of both valves.

16. In a motor, in combination, a cylinder, a piston reciprocable therein, and fluid distribution means 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 including a pair 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 its 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 its respective valve after venting of both areas, said admission and exhaust valves also respectively having associated therewith additional means exerting pressures in the same direction as said pressure areas, the pressures exerted by said additional means being the same in the case of both valves.

17. 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 the pressure prevailing in the working end of the cylinder just prior to admission 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, and means for effecting opposite movements of said valves by pressure fluid including for each valve means providing at least three pressure receiving areas facing in the same direction, and means for supplying fluid at above atmos-

pheric pressure continuously to part of said areas and intermittently to others.

18. 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 the pressure prevailing in the working end of the cylinder just prior to admission 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, and means for effecting opposite movements of said valves by pressure fluid including for each valve means providing a plurality of pressure receiving areas facing in the same direction, and means for supplying fluid from the motor exhaust continuously to part of said areas and from the motor cylinder intermittently to others.

19. 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 the pressure prevailing in the working end of the cylinder just prior to admission 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, and means for effecting opposite movements of said valves by pressure fluid including for each valve means providing a plurality of pressure receiving areas facing in the same direction, and means for supplying fluid at less than line pressure and above atmospheric pressure continuously to part of said areas and at cylinder working pressure intermittently to others.

20. 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 the pressure prevailing in the working end of the cylinder just prior to admission and an exhaust valve whose closing is controlled by motor back pressure and means for effecting opposite movements of said valves including constant pressure areas and areas subjected to working pressure from the cylinder, and supply means for the latter areas including a plurality of passage means for each valve, each distinct throughout its length from the remainder of said passage means for said valve, sequentially uncovered by the piston on each pass thereof.

21. In a single-acting motor, in combination, a cylinder vented to atmosphere at one end, a piston reciprocable in said cylinder, and means for supplying and exhausting fluid relative to the other end of said cylinder including means forming a motive fluid supply port leading to said other end of the cylinder, an admission valve controlling said supply port, controlling means for said valve providing a plurality of pressure areas acting in the same direction, means for constantly supplying pressure fluid at above atmospheric pressure to one of said areas, means forming a passage for connecting another of said areas with a point in the cylinder bore uncovered by one end of the piston when the latter is at the end of the cylinder with which said supply port communicates and by the other end of the piston relatively early in the working stroke, and means forming a completely distinct passage for connecting another of said pressure areas with the cylinder bore at a point beyond which the last mentioned end of the piston passes at a point comparatively late in the working stroke of said piston.

22. In a single-acting motor, in combination, a cylinder vented to atmosphere at one end, a piston reciprocable in said cylinder, and means for supplying and exhausting fluid relative to the other end of said cylinder including means forming an exhaust port leading from said other end of the cylinder, an exhaust valve controlling said exhaust port, controlling means for said valve providing a plurality of pressure areas acting in the same direction, means for constantly supplying pressure fluid at above atmospheric pressure to one of said areas, means forming a passage for connecting another of said areas with a point in the cylinder bore uncovered by one end of the piston when the latter is at the end of the cylinder with which said exhaust port communicates and by the other end of the piston relatively early in the working stroke, and means forming a completely distinct passage for connecting another of said pressure areas with the cylinder bore at a point beyond which the last mentioned end of the piston passes at a point comparatively late in the working stroke of said piston.

23. In a single-acting motor, in combination, a cylinder vented to atmosphere at one end, a piston reciprocable in said cylinder, and means for supplying and exhausting fluid relative to the other end of said cylinder including means forming a motive fluid supply port leading to said other end of the cylinder, means forming an exhaust port leading from the last mentioned end of the cylinder, separate relatively movable valves respectively controlling said supply and exhaust ports, controlling means for each of said valves respectively individual thereto and each providing a plurality of pressure areas acting in the same direction, means for constantly supplying pressure fluid at above atmospheric pressure to one of said areas on each of said controlling means, means for connecting another of said pressure areas on each of said controlling means with the cylinder bore at a zone therein uncovered by one end of the piston when the latter is at the end of the cylinder with which said ports communicate and by the other end of the piston relatively early in the working stroke, means distinct from said last mentioned means for connecting another of said pressure areas on each of said controlling means with a zone in the cylinder bore at a point beyond which the last mentioned end of the piston passes at a point comparatively late in the working stroke of the piston, and means associated with the exhaust valve providing a pressure in opposition to the pressure exerted on said valve by said controlling means.

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