

Nov. 19, 1940.

J. M. BARTHOLOMEW

2,221,855

PUMPING APPARATUS

Filed Dec. 2, 1935

3 Sheets-Sheet 1

Fig. 1.

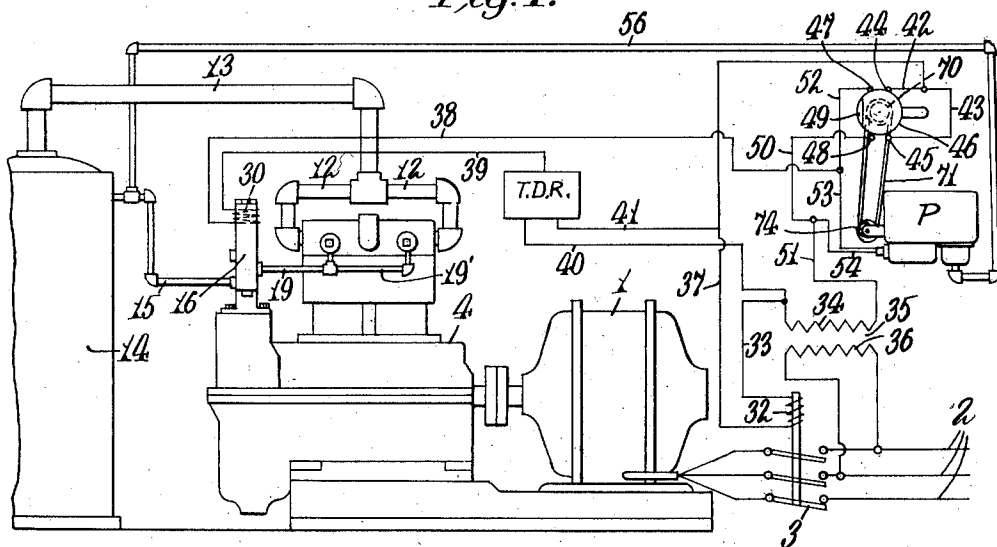


Fig. 2.

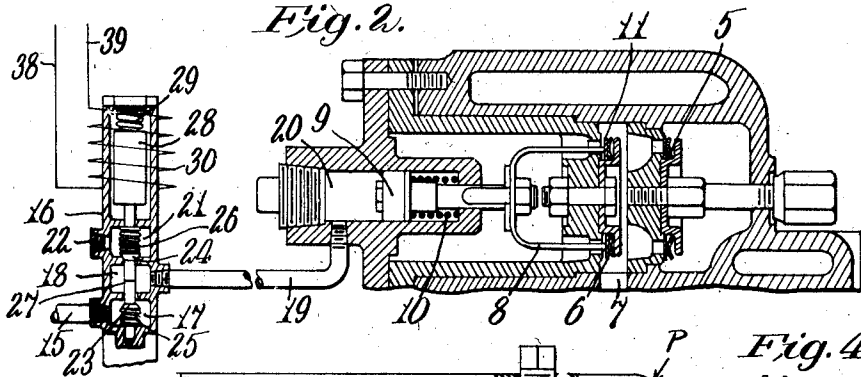


Fig. 3.

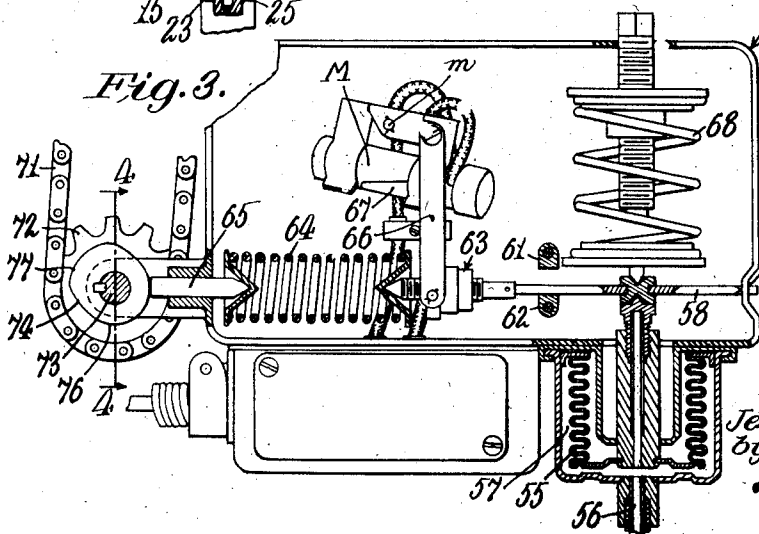


Fig. 4.

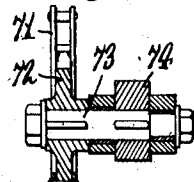
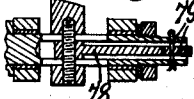


Fig. 2^a.



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Fig. 5.

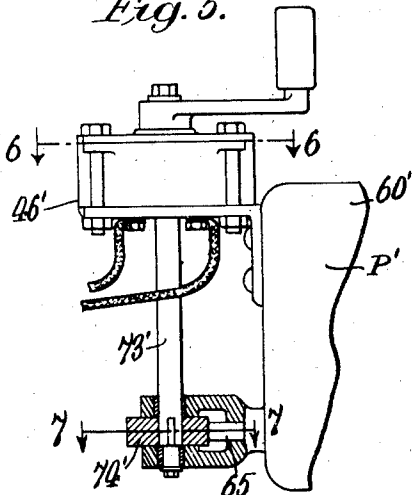


Fig. 6.

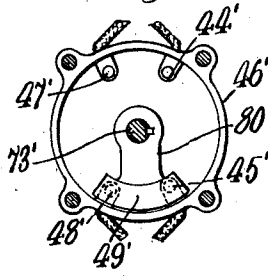


Fig. 7.

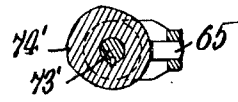


Fig. 8.

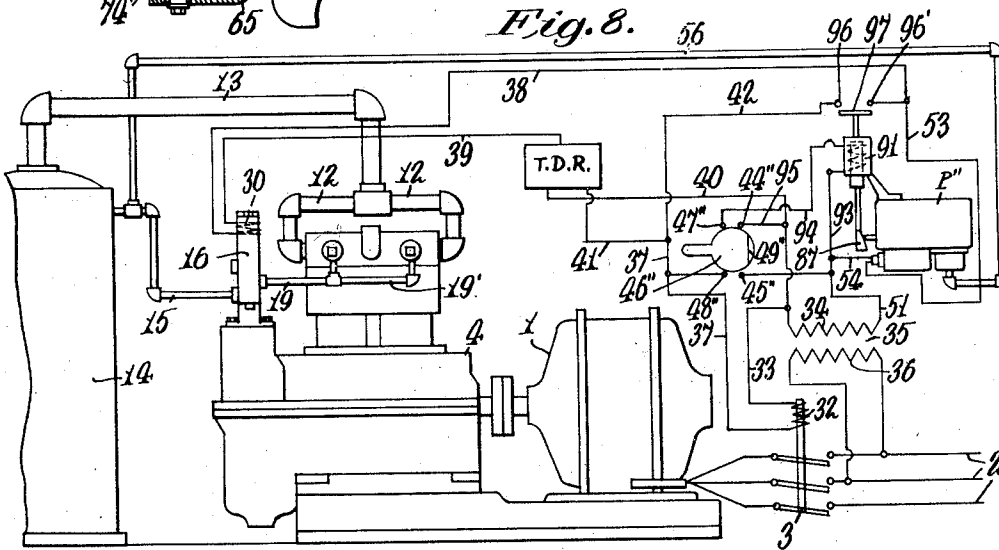


Fig. 9.

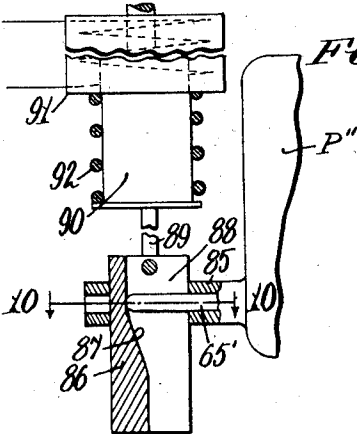
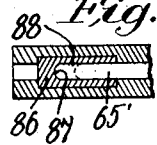


Fig. 10.



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Fig. 11.

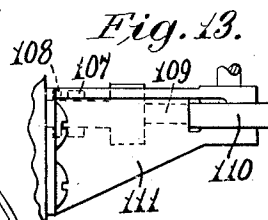
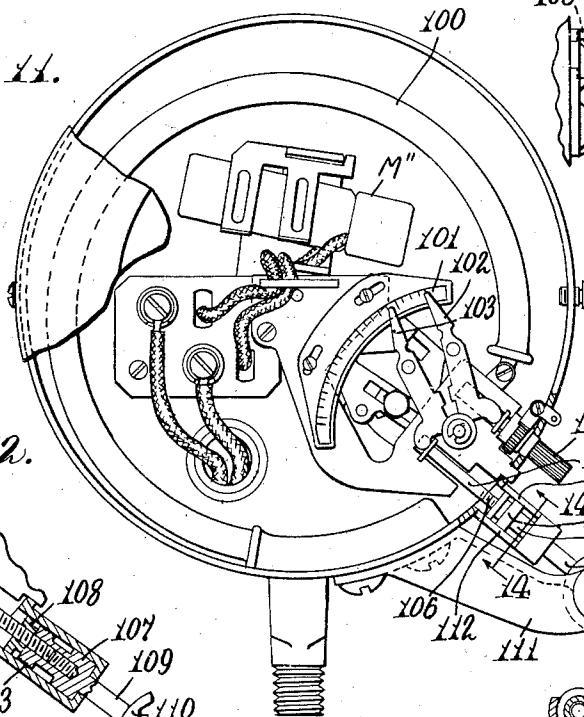


Fig. 12.

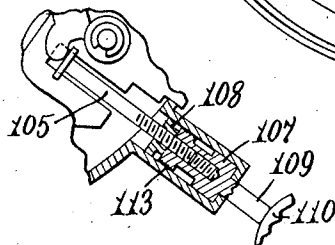
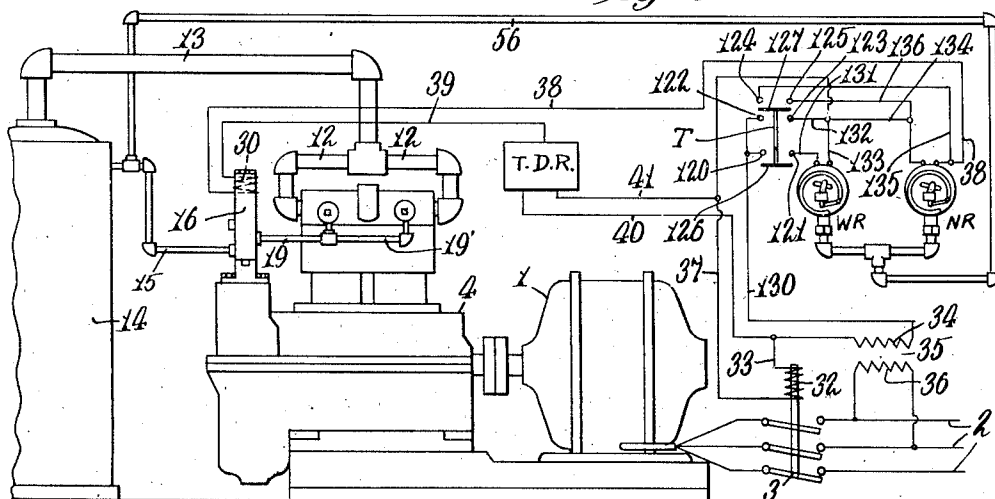


Fig. 14.



Fig. 15.



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UNITED STATES PATENT OFFICE

2,221,855

PUMPING APPARATUS

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Application December 2, 1935, Serial No. 52,552

19 Claims. (Cl. 230-4)

My invention relates to pumping apparatus, and more particularly to pumping apparatus having special controlling means whereby the same may be caused to operate with maximum efficiency irrespective of the mode employed for maintaining its output within the desired limits. From another aspect, it relates to improved pilot mechanism especially adapted to, but not exclusively limited to, pump control.

Under certain conditions, where a relatively uniform and high demand prevails (near the maximum pumping capacity), it is desirable to operate pumping apparatus—and particularly, though not exclusively, reference is here had to compressors—upon a system in which there is no stopping of the compressor drive, but instead an interruption of the delivery of fluid by the continuously driven pumping apparatus for so long a time as may be requisite to reduce the quantity of previously pumped fluid to the desired minimum value.

Under other circumstances, where the demand for pumped fluid is relatively low and accordingly the quantity of fluid pumped within a unit of operating time is likely to suffice for a considerably longer period of demand, it is desirable, to reduce wear and to economize on operating medium, to interrupt the drive of the pumping apparatus completely and to bring the same to a stop until such time as the consumption of the pumped fluid again makes necessary further pumping to preclude the reduction of the available pumped fluid to less than a desired minimum.

When operating upon the first system, it is considered good practice to effect interruption and resumption of the pumping apparatus upon comparatively small changes in the available quantity of pumped fluid. For example, in the case where the pumped fluid is air and the pumping apparatus is an air compressor, and the maximum desired value is, let us say, 100 pounds per square inch—at which point unloading would be resorted to, to preclude further delivery of fluid—it would be desirable to effect re-loading and a resumption of the delivery of pumped fluid after a reduction of perhaps five pounds. This is true both because the rate of consumption of pumped fluid is rapid and because it is desirable to provide as nearly a uniform pressure, ordinarily, at the pumped-fluid-utilizing devices as possible.

Under other circumstances, where—for example during a night shift—there might be comparatively little demand for pumped fluid and a compressor adequate to supply the daytime needs would, if operated on the load-and-unload sys-

tem, operate for long periods unloaded and use considerable quantities of operating medium without benefit, the stop-and-start system of operation is obviously the more economical; and, further, very material economy can be effected if re-starting is deferred for a maximum possible period. If the pumped fluid be air and the maximum desired operating pressure is 100 pounds per square inch, it is possible, without undue loss of efficiency and with sound economy for the entire system, to allow the pressure to drop perhaps to 80 pounds per square inch before re-starting the compressor.

Now it will be evident that it may be highly desirable to operate the same plant selectively on either of the two systems specified, employing the one during day shifts and the other at night or on holidays; and it will be noted that it would be desirable to change the minimum pressure limit although not the maximum pressure limit, in making the change from the one system to the other.

It is an object of my invention to provide an improved apparatus in which the change-over from one system to the other is automatically accompanied by a change in the minimum pressure limit. It is a further object of my invention to provide in such an apparatus improved means whereby the change in the minimum pressure limit does not appreciably affect the maximum pressure limit. It is a still further object of my invention to provide an improved pumping apparatus in which a single "pilot apparatus" may be automatically adjusted, in making the change-over from the one operating system to the other, to perform its function produced on attainment of a predetermined minimum pressure at distinctly different minimum pressures, without altering materially the point of functioning at a maximum pressure. It is another object of my invention to provide an improved apparatus of the character set forth, in which devices having substantially the same maximum control pressures and widely differing minimum control pressures may be selectively connected into controlling relation to the system when a change in basic type of control of the system is effected. A still further object of the invention is to provide an improved, adjustable pressure-responsive pilot mechanism. Still another object of my invention is to provide an improved snap action pilot mechanism having associated therewith means for varying the lower snap joint while leaving the higher snap point unchanged, and providing for said improved pilot mechanism means

for automatically varying the snap point when the basic system of control of the apparatus as a whole is changed. Still another object of the invention is to provide an improved pilot means having provision for various maximum and minimum values and having control mechanism associated therewith operative to alter the minimum value without varying the maximum value, when the system of which said pilot mechanism forms a part is shifted from one of the operating systems previously mentioned to the other. Other objects and advantages of the invention will hereinafter more fully appear.

In the accompanying drawings, in which several illustrative embodiments of my invention, from various aspects, have been shown for purposes of illustration—

Fig. 1 is a somewhat diagrammatic view of a pumping apparatus in which one illustrative embodiment of the invention is incorporated.

Fig. 2 is an enlarged, somewhat diagrammatic view showing a portion of the unloading mechanism of the compressor and a portion of the controlling apparatus therefor.

Fig. 3 is a view, also on an enlarged scale, and in vertical section, showing a portion of the adjustable pilot means employed in the system of Fig. 1.

Fig. 4 is a vertical, fragmentary section on the plane of the line 4—4 of Fig. 3.

Fig. 4^a is a detail showing a possible modification.

Fig. 5 is a fragmentary view showing details of a modified apparatus for effecting a transfer from one operating system to another.

Fig. 6 is a horizontal section on the plane of the line 6—6 of Fig. 5, but with the switch arm in a different position.

Fig. 7 is a fragmentary horizontal section on the plane of the line 7—7 of Fig. 5 and with the cam shown in the position corresponding to the position of the switch arm in Fig. 6.

Fig. 8 is a view, partially in side elevation and partially diagrammatic, of a system similar to that with which the apparatus of Figs. 3 to 7 inclusive is employed, but employing a still different type of control for the pilot means.

Fig. 9 is a fragmentary view showing a detail of construction of the apparatus of Fig. 8.

Fig. 10 is a fragmentary horizontal section on the plane of the line 10—10 of Fig. 9.

Fig. 11 is an enlarged view, partially in section and with parts broken away, showing details of another form of pilot apparatus.

Fig. 12 is a fragmentary section on a plane parallel to the view in Fig. 11, showing details of construction.

Fig. 13 is a fragmentary view from below, showing a detail of construction.

Fig. 14 is a small transverse view on the plane of the line 14—14 of Fig. 11, showing a detail of construction.

Fig. 15 is a partially diagrammatic and partially side elevational view of a system employing a pilot apparatus of the character shown in Figs. 11 to 14, inclusive.

Referring first to the apparatus illustrated in Fig. 1, it will be observed that a suitable driving motor 1 arranged to receive current from power lines 2 upon the closure of a main line switch 3, is connected in driving relation with a compressor 4, herein of the multi-cylinder type. This compressor is provided, for each cylinder thereof, with intake and discharge mechanism as illustrated in Fig. 2. This mechanism includes a

discharge valve 5 and an inlet valve 6, the space between the valves being placed in communication with a cylinder bore through a passage 7. To effect unloading of the cylinder, a fork 8 having an operating piston 9 normally held in loading position by a spring 10, is arranged to engage and unseat the inlet valve proper, 11. The compressor cylinders deliver, through connections 12, 12, to a common discharge connection 13, which leads herein to a receiver 14, the pressure from within which is conducted through a pipe 15 to a controlling valve mechanism 16 including a lower receiver-pressure-filled chamber 17, an intermediate chamber 18 connected by a pipe 19 with a cylinder 20 in which the plunger 9 reciprocates, and an upper, vented chamber 21 having an atmospheric or other suitable vent connection 22. Oppositely facing valves 23 and 24 are adapted, in the position of the parts shown in Fig. 2, to open communication between the line 15 and the pipe 19, and in the reversed (raised) position of the valves 23 and 24, to interrupt communication between pipes 15 and 19 and open communication between pipe 19 and the vent 22. Springs 25 and 26 are provided at opposite sides of the valves, and these valves may be separately formed and have stems abutting each other, as at 27. An operating plunger 28 having a heavy spring 29 normally maintaining the valve 24 seated and the valve 23 open, is adapted to control the position of the valves. This plunger constitutes the core of an electromagnetic device, and is surrounded by a solenoid or magnet winding 30; and upon energization of this winding, valve 24 is unseated and valve 23 is allowed to close. When, however, the winding 30 is not energized, the spring 29, the weight of the plunger 28, etc. seat the valve 24 and hold it closed, and unseat the valve 23, and thereby place the unloading plungers 9, since both are supplied through the connection 19 and its extension 19', with receiver pressure substantially simultaneously, under pressure, and so hold the compressor unloaded.

Now, from the description so far given, it will be evident that the compressor 4 is adapted to be driven when its driving motor 1 is supplied with current, but that it will not be loaded until the winding 30 is energized; and so, unless the winding 30 be energized before the compressor is started, the compressor will start unloaded, which is a very desirable condition.

The switch 3 is of the normally open type and is adapted to be closed by a solenoid 32. The solenoid 32 is connected at one end by a conductor 33 with the secondary 34 of a transformer 35 whose primary 36 is connected across two of the power lines 2. The other end of the solenoid 32 is connected to a conductor 37.

The magnet winding 30 is connected at one end to a conductor 38 and at its other end to a conductor 39. The conductor 39 leads from a time delay relay of well known commercial construction, marked TDR in the drawings, and the conductor 39 is adapted to be connected, upon the circuit-closing operation of the time delay relay, with a conductor 40 leading to the end of the transformer secondary 34 to which the conductor 33 is also connected. The time delay relay is also connected by a conductor 41 to the conductor 37, and when a circuit is established between the conductor 41 and the end of the transformer secondary 34 to which the conductor 40 is not connected, the time delay relay is set in operation, and after a predetermined

time interval closes a circuit between the conductors 40 and 39. As this function and the structure of these devices are well known, and this time delay relay mechanism may assume many forms and is a standard article of manufacture which can be bought in the open market, further description of its mode of operation is unnecessary. Beyond its point of connection with the conductor 41, the conductor 37 is connected to other conductors 42 and 43 respectively. These lead respectively to contacts 44 and 45 in a so-called transfer switch 46, and this transfer switch also is provided with other contacts 47 and 48 and with a movable contact 49, which may be caused, in one position of the switch, to connect the contacts 44 and 47, and in an opposite position to connect the contacts 45 and 48. The contact 48 is connected by a conductor 50 and a further conductor 51 to the end of the transformer secondary 34 to which conductors 33 and 40 are not connected. The contact 47 has a conductor 52 connected thereto, to which the conductor 38 leads, and also is connected, by a conductor 53, to one of the contacts of a "Mercoïd" switch M whose other contact is connected by a conductor 54 to the conductor 51. The "Mercoïd" switch forms a portion of a pilot mechanism, generally designated P. This pilot mechanism, best illustrated in Fig. 3, comprises a diaphragm 55 which is subjected, upon its exterior, to receive pressure through a connection 56, which opens into a chamber 57 surrounding the diaphragm 55. It will be noted that the diaphragm 55 is operatively connected to and tends to effect a swinging movement of an arm 58 about a pivot 59 provided by a casing 60 housing the component elements of the pilot mechanism P. The range of movement of the arm 58 is limited by stops 61 and 62. The arm 58 forms a portion of a trigger or snap mechanism, generally designated 63, and is subjected to the endwise pressure of a spring 64 whose compression may be varied by varying the projection within the casing 60 of a plunger 65, which provides a reaction point for the end of the spring 64 remote from the arm 58. A link 66 connects the free end of the arm 58 with the switch M, which is of the so-called Mercoïd type and contains mercury, as at 67, which in the tilted position of the switch shown in Fig. 3 establishes an electric circuit between the conductors 53 and 54. The plunger 65 is disposed substantially in alignment with the pivot 59, and accordingly the spring 64 exercises little effect upon the movement of the arm 58 when said arm is in depressed position, i. e. as shown in Fig. 3. A primary control spring 68 acting in opposition to the diaphragm 55, provides substantially exclusive control of the movement of the arm 58 upwardly, and provides a major load thereon; and the adjustment of the compression of the spring 68 varies the maximum pressure limit of operation of the apparatus P. When the arm 58 is in its upwardly tilted position, which it assumes upon the attainment of the maximum desired receiver pressure (in which position the switch M is swung about the pivot m and the mercury 67 flows away from the conductors 53 and 54 and opens the circuit between said conductors), the spring 64 exercises a very substantial force and plays a very material part in determining the pressure at which movement of the arm 58 in the downward direction shall take place. It will be found that the pressure range between the opening and closing of the switch M can be markedly varied simply

by varying the compression of the spring 64, without materially varying the pressure at which opening of the switch will occur; and the plunger 65, upon being variously projected longitudinally, will provide for the necessary variation in the compression of the spring 64 to secure a large or small pressure difference, as may be desired, in the pressure at which the spring 68 will be effective to cause re-closing of the switch M.

Many ways of varying the projection of the plunger 65 may be employed. In Figs. 1, 3 and 4, one simple and somewhat diagrammatic mode of accomplishing this function is illustrated. It will be noted that the transfer switch 46 is provided with a sprocket 70 turning therewith and connected by a chain 71 with a sprocket 72 mounted upon a shaft 73 whose axis is at right angles to the axis of the plunger 65. The shaft 73 carries a cam 74 which, in the "off" position (the intermediate position) of the transfer switch 46, simply holds the plunger 65 in the position shown in Fig. 3. Upon movement of the transfer switch 46 to connect the contacts 44 and 47, the cam 74 will project the plunger 65 substantially to the right in Fig. 3, and then hold it there. Upon movement of the transfer switch from the position shown in Fig. 1 to a position connecting the contacts 45 and 48, no movement of the cam 74 affecting the position of the plunger 65 will take place. It will be noted that the cam 74 has a long, low arcuate portion 76 and a quadrantal high operating portion 77.

If it be desired to vary the pressure difference produced by moving the cam 74 into pin-projecting position, this may be easily accomplished by providing a cam of varying radial dimension and sliding the cam longitudinally along its shaft, of course providing suitable holding means to maintain it in desired position. Such an arrangement is shown in Fig. 4^a, in which the cam portion 77' is sloping and the cam is movable by the adjusting mechanism 78, held in different positions by the pin devices 79, to provide different movements, as may be desired, of the plunger 65. This mechanism is merely illustrative of a wide variety of devices which may be employed.

The mode of operation of the apparatus so far described will be readily understood from what has been said. In Fig. 1 the apparatus is shown with the parts in the relative positions they would occupy before the motor is started. The switch 46 is in neutral position and must be moved in one direction or the other to place the system in operation. It will be borne in mind that in the position of the parts shown, the solenoid 30 is de-energized and accordingly the compressor is unloaded. Depending upon which direction the switch mechanism 46 is turned, the system will operate either with continuous running of the compressor and periodic loading and unloading, or with intermittent running of the compressor and starting each time unloaded. Continuous running of the compressor will take place when switch 46 is moved counter-clockwise from the position shown in Fig. 1. Intermittent running of the compressor will be the mode of operation upon movement of the switch 46 clockwise in Fig. 1. It should be borne in mind that in the position of the plunger 65 shown in Fig. 3 the pilot mechanism will effect opening of the switch at a maximum pressure, let us say, of 100 pounds, and closing of the switch again when the pressure falls off, let us say, to 95 pounds; while with the plunger 65 projected into the casing 60, as would

occur when the cam portion 77 contacts the end of the plunger, the switch will open still at approximately 100 pounds, but will not close again until the pressure falls off perhaps to 80 pounds.

5 Now let us consider that the operator wishes to start up the system and to cause the same to operate on the continuous running, loading-and-unloading system. He will therefore turn the switch 46 through 90° counter-clockwise in Fig. 1
10 and cause the contact 49 thereon to connect the contacts 45 and 48. Immediately, current will flow from the transformer secondary 34 through the circuit including the conductor 51, conductor 50, contact 48, contact 49, contact 45, conductor 43, conductor 37, solenoid 32 and conductor 33;
15 and the switch 3 will close and the motor will start. Simultaneously with the establishment of the circuit through the switch operating solenoid 32, a circuit will be established including the transformer secondary 34, conductor 51, conductor 50, contacts 48, 49 and 45, conductor 43, conductor 37, conductor 41, the time delay relay operating circuit, and conductor 40; and the time
20 delay relay will close its internal contactor after a predetermined time interval. When the time delay relay for which the time delay relay is set, has elapsed, current will likewise flow through a circuit including the transformer secondary 34, the conductor 51, conductor 54, switch M if the latter
25 be closed, conductor 53, conductor 38, solenoid 30, conductor 39, time delay relay TDR, and conductor 40. It will therefore be evident that only when the switch M is closed will the compressor load; and it will further be evident that the compressor will load and unload under the control of the movements of the switch M as long as the
30 system is set to operate in the manner mentioned, that is, as long as the switch 46 remains in the position last described. During this operation, loading and unloading will be brought about as a result of the pressure changes, loading occurring when the pressure drops to, say, 95 pounds, and unloading occurring when the pressure rises to 100 pounds.

35 When it is desired to operate on the stop-and-start system, the operator, instead of positioning the switch 46 with the contact 49 in lower position, will move the switch 46 to cause the contact 49 to connect the contacts 47 and 44. Then the following operations will occur. Only when the switch M is closed will anything take place. When the switch M is closed, however, a circuit will be established including transformer secondary 34, conductor 51, conductor 54, mercury
40 67, conductor 53, conductor 52, contacts 47, 49 and 44, conductor 42, conductor 37, solenoid 32, and conductor 33; and the motor switch 3 will then be closed. This will start the motor. Concurrently with the establishment of the circuit just described, there will also be established a circuit including transformer secondary 34, conductor 51, conductor 54, mercury 67, conductor
45 53, conductor 52, contacts 47, 49 and 44, conductor 42, conductor 37, conductor 41, the operating device of the time delay relay, and conductor 40. Accordingly, the time delay relay will be set in operation concurrently with the closing of the motor circuit. Then, after the time lapse compelled by the time delay relay, a further circuit
50 will be established including the transformer secondary 34, conductor 51, conductor 54, mercury 67, conductor 53, conductor 38, winding 30, conductor 39, the time delay relay, and conductor 40; and the compressor will be loaded due to the
55 movement of the valves 23 and 24 respectively to

shut off further fluid supply to the unloading plungers and to vent the latter to atmosphere.

Now it is important to note that as the switch 46 was moved to position the contact 49 in engagement with contacts 47 and 44, the sprocket 70, chain 71, and sprocket 72 moved the cam 74 and brought its high point 77 into engagement with the plunger 65, and forced that plunger inwardly, thereby increasing the compression of the spring 64 and making necessary a much greater
10 receiver pressure drop before the switch M would move from open to closed position. Accordingly, when rising receiver pressure has once caused opening of the switch M and stopping of the compressor through the breaking of the circuit through the solenoid 32, a much more marked
15 pressure drop will be necessary before the switch M will reclose, say, a drop from 100 to 80 pounds. However, due to the special relation of the parts, this result, which follows upon the protrusion of the plunger 65 into the casing 60, will not materially affect the upper pressure limit of 100 pounds.

From the description given, it will be obvious that I have provided an apparatus adapted effectively to control the output of a pumping system, either by loading or unloading upon the occurrence of close pressure differentials, or starting and stopping upon marked pressure differentials, using the same general pilot mechanism in each case and varying the responsiveness of the pilot mechanism to dropping pressures while maintaining its operating value substantially unchanged for maximum pressures. This apparatus automatically effects a change in responsiveness of the pilot mechanism with the change in system, in the desired manner and with great simplicity and absolute certainty.

It will be evident that instead of employing a mechanism utilizing the chain and sprockets of the species of the invention shown in Figs. 1 to 4, the transfer switch 46 may be arranged coaxial with the cam; and such an arrangement is shown in Figs. 5, 6 and 7. In these figures it will be observed that a transfer switch mechanism, generally designated 46', is arranged in a generally vertical position and mounted at the left-hand end of the casing 60' of the pilot mechanism P'. The plunger 65 is shown in the same relative position as in Fig. 3, but instead of employing a cam rotating upon a horizontal shaft, as in Figs. 1 and 3, the cam 74' is mounted upon a vertical shaft 73' which is coaxial with the switch arm 80 which carries the movable contact 49' and moves it selectively into engagement with the stationary contacts 47', 44' and 48', 45'. In Fig. 6, the switch arm 80 is in the position for load-and-unload operation, and accordingly the cam, which is shown in the corresponding position in Fig. 7, is not effecting protrusion of the plunger 65. Further description of this simplified and more compact arrangement of the parts is unnecessary, as how it works will be obvious.

In Figs. 8, 9 and 10 a further modification is shown, in which the transfer switch does not manually shift the cam, but in which instead a circuit is established through a solenoid which moves the cam for actuating the plunger 65' when the transfer switch is moved to "stop and start" operating position. In this form of the of the invention there is arranged adjacent the plunger 65' a guide 85, in which there is reciprocable a cam-providing member 86 providing a cam surface 87 at the bottom of a slot 88 into which the plunger 65' projects. A connection 89 75

attaches the cam-providing member 86 to the core or plunger 90 of an operating solenoid 91, and a spring 92 normally maintains, except when said solenoid is energized, the cam in position so that the pilot device P'' operates on relatively small pressure changes. The solenoid 91 is connected at one end, by a conductor 93, to a conductor 51 which leads to one end of the transformer secondary 34; and the other end of the solenoid is connected, by a conductor 94, to the contact element 47'' of a switch 46''. The contact element 44'' is connected by a conductor 95 to a conductor 40 which connects the time delay relay with the end of the transformer secondary 34 to which the conductor 51 does not lead. The same end of the transformer secondary 34 which is connected to the time delay relay by the conductor 40 is connected by a conductor 33 to the switch operating solenoid 32, and the other end of the latter is connected by a conductor 37 through a conductor 41 with the time delay relay, and through a conductor 42 to a contact 96 which is connectable, in the closed position of a switch 97, with a second contact 96' electrically connected with the conductor 38 leading to the solenoid 30, and also connected by the conductor 53 to the switch M. The contact 48'' is connected with the conductor 37, and the contact 45'' with the conductor 51. Further description of the connections is unnecessary in view of similarity to the system illustrated in Fig. 1.

The mode of operation of this device can now be readily understood. When the switch mechanism 46'' is operated to position the swingable contact element 49'' in the position to connect contacts 48'' and 45'', the motor will operate continuously and the compressor load and unload in accordance with the receiver pressure variations. It will be evident that circuits will be established connecting the transformer secondary 34, through the conductor 51, contact 45'', contact 49'', contact 48'', conductor 37, motor switch operating solenoid 32, and conductor 33, to close and hold closed the motor starting switch; and also the time delay relay operating circuit will be energized as soon as the switch 46'' is actuated to effect the positioning specified, as a conductor 40 leads to one end of the transformer secondary 34 while the other end of the transformer secondary is connected, through conductor 51, contacts 45'', 49'' and 48'', conductor 37, and conductor 41, to the time delay relay. The solenoid 30 will be energized and de-energized, depending upon the operation of the pilot mechanism P''. After the time delay relay operates, it will be evident that a circuit will be established from the left-hand end of the transformer secondary 34 through conductor 40, through the time delay relay, through conductor 39, through the solenoid 30, through conductor 38, through conductor 53, and, when the switch M is closed, through that, and through conductors 54 and 51 back to the transformer secondary, so that whenever the switch M is closed the compressor will be loaded, and whenever the switch M opens, the compressor will be unloaded. Accordingly, this system will operate on the load-and-unload principle with relatively small pressure changes between loading and unloading.

When the switch mechanism 46'' is actuated to position the contact element 49'' to connect contacts 47'' and 44'', the solenoid 91 will be energized continuously through a circuit including transformer secondary 34, conductor 51, conductor 93, the solenoid, conductor 94, contacts

47'', 49'' and 44'', and conductor 40. This will move the cam 87 to increase the pressure range of the pilot mechanism P'' and to make the same effective to move in switch-opening direction at the same maximum pressure, but to effect switch closure only at a considerably reduced pressure, say, opening the switch M at 100 pounds and closing it again at 80 pounds. The upward movement of the cam will be accompanied by upward movement of the contact 97, which will then connect contacts 96 and 96'. As a result of this, there will be provided controlling circuits controlled by the switch M for the motor starting magnet 32, the time delay relay and the solenoid 30. Accordingly, when the receiver pressure becomes low enough, and the switch M is closed, the transformer secondary 34 will deliver current to the motor starting switch solenoid 32 through a circuit including conductor 51, conductor 54, switch M, conductor 53, contacts 96', 97, and 96, conductor 42, conductor 37, magnet 32 and conductor 33. Also, since conductor 41 connects to conductor 42 and conductor 40 connects to the left-hand end of the transformer secondary 34, operating current will be supplied to the time delay relay TDR simultaneously with current supply to the operating magnet 32. Current cannot be supplied to the solenoid 30 until the time delay relay operates to establish a circuit, and so, in spite of the fact that a circuit is otherwise completely established through the solenoid 30 upon closure of the switch M, through conductors 51, 54, switch M, conductors 53, 38, solenoid 30, conductor 39 and conductor 40, the compressor will not be loaded until the time delay relay operates. Accordingly, with this form of connection there will be stopping of the motor and of the compressor each time the compressor builds up, let us say, 100 pounds pressure in the receiver, and thereafter the compressor will remain out of operation until the receiver pressure drops to the lower level caused by the action of the cam 87, for example, 80 pounds.

It is obviously unnecessary to employ, in making avail of the broadest aspects of my invention, a single pilot mechanism having provision for the effecting of a radical modification of its operating range; and accordingly in Fig. 15 I have illustrated another embodiment of the invention in which a pair of pilot devices selectively placed in control of the operation of the system are employed, these pilot devices being arranged to effect unloading upon the attainment of substantially identical upper receiver pressure limits but to effect re-loading at markedly different lower receiver pressure limits. In this system I may use pilot switches of the type generally illustrated in Figs. 11 to 14, but without the special lower limit adjustment of that switch.

In Fig. 11 there is shown a pilot mechanism which is essentially the well known commercial apparatus known as a Mercoid pressure control switch. This device includes a Bourdon tube 100 which is adapted to operate, through mechanism not shown, the switch M'' in opposite directions upon the attainment of upper and lower critical pressures. This apparatus is provided with a graduated scale 101 over which pivoted fingers 102 and 103 are adjustable, and these fingers are adapted to indicate the pressure settings of the mechanism. In the commercial device, a pair of adjusting elements like the element 104 are provided, and by manipulation of these elements the internal mechanism of the switch apparatus may be adjusted to vary the operating points.

For example, adjustment of the element marked 104 on the drawings changes the upper pressure limit and also changes the position of the finger 102 so that the upper working pressure limit may be continuously known. Similar mechanism is provided in the standard "Mercoid" switch for adjusting the lower pressure limit and the index finger 103. According to my invention, however, as illustrated in Figs. 11 to 14, the adjusting mechanism on the standard "Mercoid" switch associated with the low pressure limit control is replaced by a plunger 105 having a threaded portion 106 entering a nut 107, and provided also with a lock nut 108. The nut 107 has a projecting pin 109 which may be actuated by an appropriately formed cam 110 supported on a bracket 111 when it is desired to use a single Mercoid switch of this type, in a system such as is illustrated in Fig. 1, for example. It will be evident that it is possible, since guides 112 are provided for the stem 109 in a form to permit access to the knurled periphery 113 of the nut 107, to effect adjustment of the position of the screw 105 and so of the lower pressure limit; and by rotating the cam 110 at the same time that the transfer switch is moved, the lower pressure limit may be increased or diminished as the control system changes from stop-and-start to load-and-unload, and vice versa. Since it will be obvious how the cam 110 may be rotated in conjunction with the transfer switch, from what has been previously illustrated, this arrangement needs no further description.

In Fig. 15 two such Mercoid switches are illustrated at WR and NR. In this case, however, the Mercoid switches are of the standard commercial type and are not provided with the special attachment shown in Figs. 11, 12, 13 and 14. Switch WR is set to provide an upper operating pressure of 100 pounds, let us say, and a lower operating pressure of 80 pounds; while switch NR is set to provide an upper operating pressure of 100 pounds and a lower operating pressure of 95 pounds. Each of the switches WR and NR is simply shown with diagrammatically represented connections, and it will be understood that upon the attainment of the upper pressure limits for which the switch mechanisms are adjusted, the switches will open, and upon the lower pressure limits being attained, the switches will close.

Now referring to the circuits of Fig. 15, it will be observed that a transformer 35 has a primary 36 connected across two of the power lines and a secondary 34 connected to the motor starting switch winding 32 by a conductor 33 and to a time delay relay TDR by a conductor 40, as well as by a part of the conductor 33. A transfer switch is diagrammatically illustrated in Fig. 15 at T and comprises a series of stationary contacts 120, 121, 122, 123, 124, 125 and a pair of spaced movable contacts 126 and 127 connected for movement together. Any suitable operating means for this switch may be provided, and in the upper position thereof contact 126 connects stationary contacts 120 and 121, while the contact 127 connects stationary contacts 124 and 125. In the other position of the switch, contact 126 becomes inactive, but contact 127 connects contacts 122 and 123. A conductor 130 connects the end of the transformer secondary 34 not previously referred to, to contacts 120 and 122. A conductor 131 connects contact 121 to pilot mechanism WR, and the other side of this pilot mechanism is connected by a conductor 133 and

a conductor 132 to contact 123. A conductor 134 connects one side of the switch NR also to contact 123, and a conductor 135 connects the other side of switch NR to contact 124. A conductor 136 connects the first mentioned side of switch NR to contact 125. Conductor 38 is connected to the same side of switch NR as conductor 135. Conductor 37 is connected to contact 123.

The mode of operation of this apparatus may now be readily understood. Let it be assumed 10 that the switch mechanism T is moved upwardly. This establishes connection between contacts 120 and 121 and between contacts 124 and 125. Accordingly, transformer secondary current will traverse a circuit including the conductor 130, 15 contact 120, movable contact 126, contact 121, conductor 131, the switch of WR when the latter is closed, conductor 133, conductor 37, motor switch winding 32, and conductor 33, and therefore obviously switch mechanism WR will, when 20 closed, effect closing of the motor switch. Obviously, since the time delay relay is connected by conductor 41 to conductor 37 and by conductor 40 to conductor 33, opening and closing of the switch WR will also open and close the circuit of the time delay relay operating mechanism. When switch WR is closed and the time delay relay operating mechanism is operated, a circuit will also be established through the winding 30 of the unloading-mechanism-controlled 25 switch, including transformer secondary 34, conductor 130, contacts 120, 126 and 121, conductor 131, conductor 133, conductor 134, conductor 136, contact 125, movable contact 127, contact 124, conductor 135, conductor 38, the winding 30, 35 conductor 39, the time delay relay switch mechanism, and conductor 40; and the compressor will be loaded at the appropriate time after the motor has come up to speed.

With this arrangement, since the mechanism 40 WR is set for a wide pressure range, the system will operate to start the compressor and, after the same has had an opportunity to come up to speed, to load the latter upon the attainment of the desired relatively low minimum pressure, say 80 pounds per square inch; and will stop the compressor and cause unloading thereof at the desired upper pressure value, say 100 pounds.

Now, when it is desired to run the compressor continuously with loading and unloading to 50 maintain the receiver pressure within the desired limits, this may be accomplished by moving the switch mechanism T to its lower operating position. This will cause contact 127 to connect contacts 122 and 123 and place pressure switch 55 mechanism NR in control. The motor switch will be closed and maintained closed by energization of the magnet 32 through a circuit including conductor 33, transformer secondary 34, conductor 130, contact 122, contact 127, contact 123, and 60 conductor 37. The time delay relay operating circuit will also be energized since conductors 41 and 40 are arranged as shown and previously described.

The pilot valve controlling magnet 30 will be 65 energized only when switch NR is closed, however, since the conductor 38 is connected through the conductor 134, conductor 132, contact 123, contact 127, contact 122, and conductor 130, with the transformer secondary only when the 70 switch mechanism NR is in closed position.

In this illustrative embodiment of the invention, it will be evident that I have illustrated a system using a pair of pressure-responsive switch mechanisms having similar upper operating 75

limits but radically different lower operating limits, to accomplish the same generic results accomplished in the other species of the invention heretofore described.

5 In all the embodiments of the invention herein illustrated and described, it will be evident that I have provided a simple, effective, automatic means for changing the operating pressure range of a pump control system to increase the pressure
10 range between interruption and resumption of pumping when delivery is to be controlled by stopping and starting the compressor, and reducing the pressure range between interrupting and resuming pressure delivery when loading-and-unloading is the method of control used. In
15 all the forms illustrated, means is provided whereby the upper pressure limit may be maintained substantially constant if desired, notwithstanding the wide range of adjustment possible
20 in the lower pressure limit.

While I have in this application specifically described several forms which my invention may assume in practice, and modifications thereof, it will be understood that these various forms
25 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.

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

1. In combination, a pump, a driving motor therefor, means for stopping and starting pump drive by the motor, means operative while the
35 pump is continuously operated for interrupting or causing pumping, means for rendering either of said means effective to control fluid delivery, and means common to both of said first two means for effecting control of the pumping system
40 by the pumped fluid in either case, providing for interruption of fluid delivery when the same quantity of fluid is available, irrespective of which control means is effective, and for initiation of fluid delivery upon a less reduction in
45 the available quantity thereof when control is by said second mentioned means than when control is by said first mentioned means, including means for automatically varying the critical quantity when the control system is changed.

50 2. In combination, a pump, a driving motor therefor, means for stopping and starting pump drive by the motor, means operative while the pump is continuously operated for interrupting
55 or causing pumping, means for rendering either of said means effective to control fluid delivery, and means common to both of said first two means for effecting control of the pumping system by the pressure of the pumped fluid in either
60 case, providing for interruption of fluid delivery at the same maximum delivered pressure, irrespective of which control means is effective, and for initiation of fluid delivery upon a less reduction in the delivered pressure when control
65 is by said second mentioned means than when control is by said first mentioned means, said means including elements movable in predetermined relation to each other for changing controls and delivered pressure minima.

70 3. In combination, a pump, a driving motor therefor, means for stopping and starting pump drive by the motor, means operative while the pump is continuously operated for interrupting
75 or causing pumping, means for rendering either of said means effective to control fluid delivery, and means for effecting control of the pumping

system by the pumped fluid in either case, providing for initiation of fluid delivery upon a less reduction in the available quantity thereof when control is by said second mentioned means than
5 when control is by said first mentioned means and interruption of delivery for the same available quantity during control by either means, said fourth mentioned means comprising a pumped-fluid controlled device having provision
10 for varying the value of its lower operating limit.

4. In combination, a pump, a driving motor therefor, means for stopping and starting pump drive by the motor, means operative while the pump is continuously operated for interrupting
15 or causing pumping, means for rendering either of said means effective to control fluid delivery, and means for effecting control of the pumping system by the pumped fluid in either case, providing for initiation of fluid delivery upon a less
20 reduction in the available quantity thereof when control is by said second mentioned means than when control is by said first mentioned means and for discontinuation of fluid delivery at the same maximum available quantity irrespective of
25 which of said first two control means is effective, said means fourth mentioned comprising a pair of pumped-fluid responsive devices having like upper settings and materially different lower settings.

5. In combination, a pump, a driving motor therefor, means for stopping and starting pump drive by the motor, means operative while the pump is continuously operated for interrupting
30 or causing pumping, means for rendering either of said means effective to control fluid delivery, and means for effecting control of the pumping system by the pumped fluid in either case, providing for initiation of fluid delivery upon a less
35 reduction in the available quantity thereof when control is by said second mentioned means than when control is by said first mentioned means but interruption of delivery at the same available quantity, said fourth mentioned means including
40 a pressure responsive device whose adjustment is automatically varied by the operation of said third mentioned means.

6. In combination, a compressor, a driving motor therefor, means for starting and stopping the motor, means for loading the compressor and unloading the same, means for rendering either of
50 said means operative to control the output of the compressor, and pressure-responsive means having an adjustment controlled by said third mentioned means for providing like limits for stopping
55 the motor and for unloading the compressor and unlike limits for starting the motor and loading the compressor.

7. In combination, a compressor, a driving motor therefor, means for starting and stopping the motor, means for loading the compressor and unloading the same, means for rendering either of
60 said means operative to control the output of the compressor, and a single pressure-responsive means having regulating means controlled by said third mentioned means for providing like
65 limits for stopping the motor and for unloading the compressor and unlike limits for starting the motor and loading the compressor.

8. In combination, a compressor, a driving motor therefor, means for starting and stopping the motor, means for loading the compressor and unloading the same, means for rendering either
70 of said means operative to control the output of the compressor, and selectively operative pressure-responsive means providing like limits for
75

stopping the motor and for unloading the compressor and unlike limits for starting the motor and loading the compressor.

9. In combination, a compressor, a driving motor therefor, unloading means for said compressor, means for effecting stopping and starting of the driving motor, means for effecting operation of the unloading means to effect compressor unloading and loading, pressure-responsive means for governing both loading and unloading and motor stopping and starting, means for rendering said pressure-responsive means selectively operative to control either loading and unloading or motor stopping and starting, and means for automatically varying the operating characteristics of said pressure-responsive means with the change from one control to the other.

10. In combination, a compressor, a driving motor therefor, unloading means for said compressor, means for effecting stopping and starting of the driving motor, means for effecting operation of the unloading means to effect compressor unloading and loading, pressure-responsive means for governing both loading and unloading and motor stopping and starting, a rotatable switch for rendering said pressure-responsive means selectively operative to control either loading and unloading or motor stopping and starting, and means rotatable with said switch for automatically varying the operating characteristics of said pressure-responsive means with the change from one control to the other, to reduce the lower operating limit thereof when said pressure-responsive means is controlling said second mentioned means.

11. In combination, a compressor, a driving motor therefor, unloading means for said compressor, means for effecting stopping and starting of the driving motor, means for effecting operation of the unloading means to effect compressor unloading and loading, pressure-responsive means for governing both loading and unloading and motor stopping and starting, a switch for rendering said pressure-responsive means selectively operative to control either loading and unloading or motor stopping and starting, and cam means movable with said switch for automatically varying the operating characteristics of said pressure-responsive means with the change from one control to the other to increase the differential between the operating limits of said pressure-responsive means while maintaining one of them constant, when control by driving motor stop and start is effected.

12. In combination, a compressor, a driving motor therefor, unloading means for said compressor, means for effecting stopping and starting of the driving motor, means for effecting operation of the unloading means to effect compressor unloading and loading, pressure-responsive means for governing both loading and unloading and motor stopping and starting, means for rendering said pressure-responsive means selectively operative to control either loading and unloading or motor stopping and starting, and reciprocable cam means for automatically varying the operating characteristics of said pressure-responsive means with the change from one control to the other.

13. In combination, a compressor, a driving motor therefor, unloading means for said compressor, means for effecting stopping and starting of the driving motor, means for effecting operation of the unloading means to effect com-

pressor unloading and loading, pressure-responsive means for governing both loading and unloading and motor stopping and starting, means for rendering said pressure-responsive means selectively operative to control either loading and unloading or motor stopping and starting, and electromagnetically operated means for automatically varying the operating characteristics of said pressure-responsive means with the change from one control to the other.

14. In combination, a compressor, a driving motor therefor, unloading means for said compressor, means for effecting stopping and starting of the driving motor, means for effecting operation of the unloading means to effect compressor unloading and loading, pressure-responsive means for governing both loading and unloading and motor stopping and starting, means for rendering said pressure-responsive means selectively operative to control either loading and unloading or motor stopping and starting, and electromagnetically operated cam means for automatically varying the operating characteristics of said pressure-responsive means with the change from one control to the other.

15. In combination, a compressor, a driving motor therefor, unloading means for the compressor, a motor switch, operating means for the compressor unloading means and the motor switch respectively, pressure-responsive means controlling both of said operating means and providing the same upper operating limit and different lower operating limits, and means for selectively causing control of the output of the compressor through said unloading means by said pressure-responsive means providing the higher of the lower operating limits and by said motor switch through said pressure-responsive means providing the lower of the lower operating limits.

16. In combination, a compressor, a driving motor therefor, unloading means for the compressor, a motor switch, operating means for the compressor unloading means and the motor switch respectively, pressure-responsive means controlling both of said operating means and providing the same upper operating limit and different lower operating limits, and switch means for selectively causing control of the output of the compressor through said unloading means by said pressure-responsive means providing the higher of the lower operating limits and by said motor switch through said pressure-responsive means providing the lower of the lower operating limits.

17. In combination, in a system to be controlled, a device whose operation creates one critical condition in such system, and interruption of whose operation permits the development in said system of a lower critical condition, and means for effecting the operation of said device to produce said first mentioned critical condition having controlling means providing for the selective rendering of said device operative to produce said first mentioned critical condition upon the attainment of different lower critical conditions and effective to interrupt operation of said device on attainment of the same upper critical condition.

18. In combination, a compressor, a driving motor therefor, means for starting and stopping said motor, means for unloading and effecting reloading of said compressor, a pressure responsive element having relatively adjustable operating limits, means for rendering it selectively effective to control both of said first men-

tioned means or the second only in accordance with compressor discharge pressure, and means for automatically increasing the lower operating limit of said element when it is made effective
5 to control said second mentioned means only, while maintaining its upper operating limit substantially unchanged.

19. In combination, a compressor, a driving motor therefor, means for starting and stopping
10 said motor, means for unloading and effecting reloading of said compressor, a time delay device associated with said second mentioned

means, a pressure responsive element having relatively adjustable operating limits, means for rendering it selectively effective to control each of said first two means and said device or said
second mentioned means only, in accordance with
compressor discharge pressure, and means for
automatically increasing the lower operating
limit of said element when it is made effective to
control said second mentioned means only, while
maintaining its upper operating limit substan-
tially unchanged. 10

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CERTIFICATE OF CORRECTION.

Patent No. 2,221,855.

November 19, 1940.

JESS M. BARTHOLOMEW.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, second column, line 53, for the word "joint" read --point--; page 3, first column, line 8, for "conection" read --connection--; line 31, for "receive" read --receiver--; page 8, first column, line 11, claim 9, strike out "pressor, means for effecting stopping and starting" and insert instead --unloading and motor stopping and starting,--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 31st day of December, A. D. 1940.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)