Nov. 1, 1938. J. M. BARTHOLOMEW 2,134,693

PUMPING MECHANISM

Filed July 16, 1936

Fig. 1.

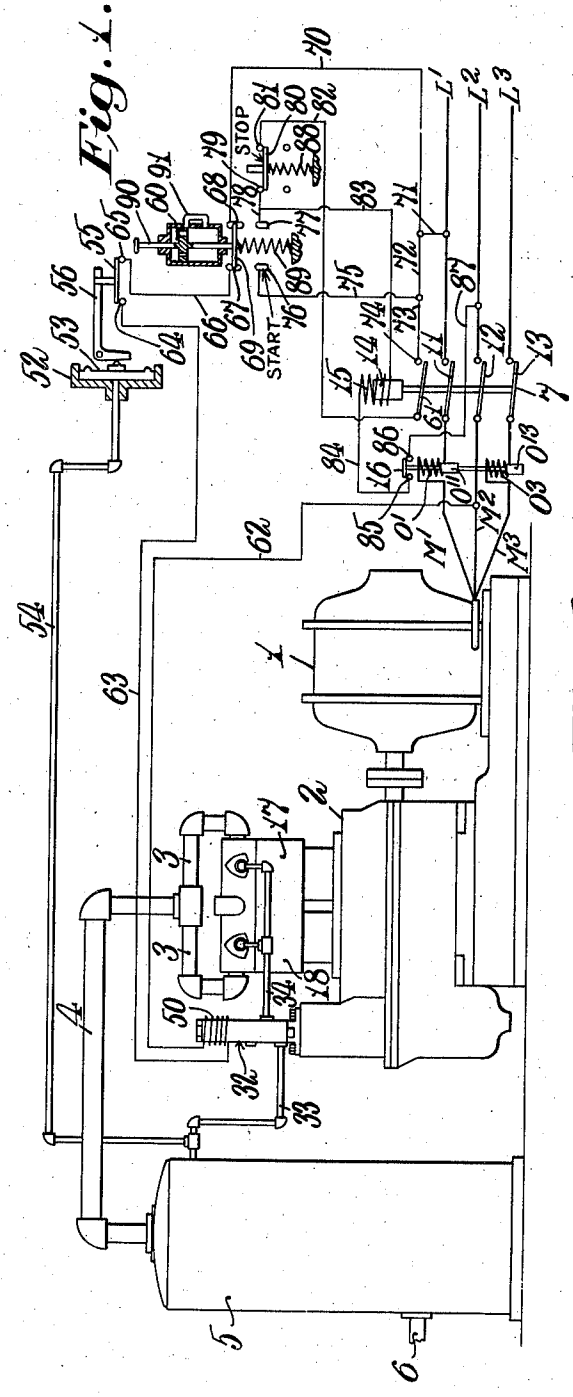
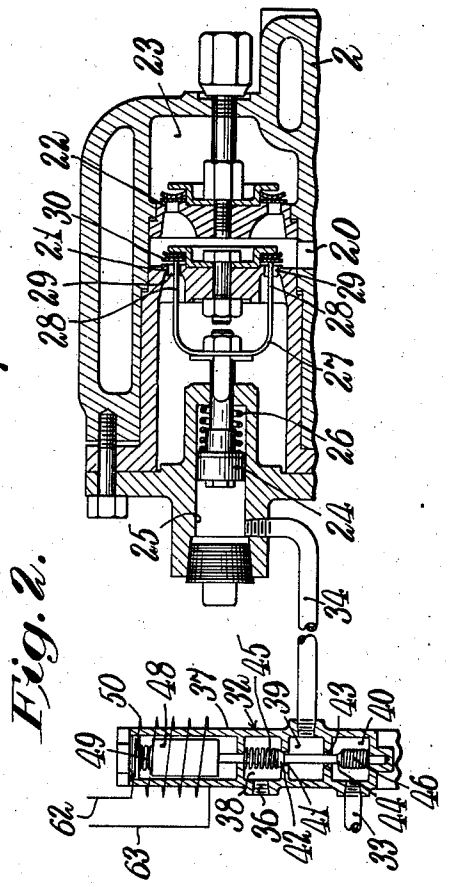


Fig. 2.



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2,134,693

PUMPING MECHANISM

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15 Claims. (Cl. 230—24)

My invention relates to an improved automatic system for controlling the starting and operation of a motor driven compressor.

It is desirable in the operation of motor driven compressors, particularly where a fairly constant and high demand for air exists, to operate the compressor on the continuous-drive, load-and-unload system of output control. It is also desirable to control the compressor during starting in such manner that the compressor shall start unloaded. It is further desirable to use the simplest possible controlling equipment to accomplish the functions mentioned. These same principles of course apply to pumps handling other fluids than air where the conditions are generally the same, and it is perhaps even more important to provide for starting of a hydraulic pump unloaded than is the case with compressors for gaseous fluids.

It is an object of my invention to provide an improved compressor controlling apparatus. It is another object of my invention to provide an improved compressor controlling apparatus operating to control the volume of fluid pumped by loading and unloading, while drive is maintained. It is a further object of my invention to provide an improved pumping system having improved means for effecting unloading during starting, as well as unloaded operation when a predetermined excess of fluid is pumped. Other objects and advantages of the invention will hereinafter more fully appear.

In the accompanying drawing I have shown for purposes of illustration one embodiment which my invention may assume in practice.

In this drawing,

Fig. 1 is a diagrammatic view of a compressor outfit having associated therewith an illustrative embodiment of my improved controlling mechanism.

Fig. 2 is a fragmentary view showing a section through an electrically controlled pilot mechanism and through the valve mechanism and associated unloading device for a compressor cylinder.

Referring first to Fig. 1, it will be noted that a motor 1 drives a compressor 2, herein of the vertical two-cylinder type. The compressor discharges fluid through the branch lines 3, 3 to a discharge line 4 which delivers to a receiver 5, from which the pumped fluid may be led away to a point of use through a connection 6. Current for operating the motor 1 is supplied from lines L^1, L^2 and L^3, and the motor 1 is herein of the three-phase type. A multi-pole switch 7 having concurrently movable contact elements 11, 12, and 13 respectively controlling current flow from the lines L^1, L^2 and L^3, is arranged to control the supply to the motor leads M^1, M^2 and M^3, and overload coils O^1 and O^3 are arranged in the motor leads M^1 and M^3.

A plunger 14 is arranged in position to be raised by a solenoid 15 upon energization of the latter to close the multi-pole switch 7 and effect motor starting. The overload coils O^1 and O^3 have respectively associated with them plungers O^{11} and O^{13} arranged so that either or both may actuate an appropriate overload controlled switch 16.

The compressor cylinders 17 and 18 are each provided with individual inlet and discharge valves, and Fig. 2 shows the inlet and discharge valve mechanism and associated unloading mechanism for one of the compressor cylinders. A passage 20 opens into the outer end of one of the compressor cylinders. An inlet valve mechanism 21 controls the admission of air to the cylinder through the port 20. A discharge valve mechanism 22 controls the discharge of air through the port 20 and to a space 23 communicating with one of the branch discharge lines 3. A plunger 24 movable in a cylinder 25, and normally maintained in its outer position by a spring 26, actuates a fork-like member 27 whose prongs 28 pass through the port openings 29 in the inlet valve mechanism into engagement with the inlet valve proper 30, and open the latter and hold the latter unseated, that is, in unloading position, when air is admitted to the outer end of the cylinder 25. Supply of air to the cylinder 25 is controlled by an electrically operated pilot mechanism 32, which receives a supply of operating pressure through a line 33 leading from the receiver 5 and controls the delivery of that operating pressure through a line 34 to the cylinders 25. This pilot mechanism also controls the venting of pressure from the line 34 and cylinders 25 to a point of escape, as at 36.

The pilot mechanism comprises a casing 37 having a vent chamber 38, a chamber 39 communicating with the cylinder 25, and a supply chamber 40. Chambers 38 and 39 are connectible through a valve-seat-surrounded port 41 controlled by a valve 42, and chambers 39 and 40 are connectible through a valve-seat-surrounded port 43 controllable by a valve 44. Valves 42 and 44 are so related that but one can be seated at a time. Springs 45 and 46 normally tend to close each of the valves whenever its closure is possible. By the provision of a relatively heavy plunger 48 operatively connected with the valves

42 and 44, the valve 44 may be maintained open and the valve 42 closed in the normal position of the parts, and a suitable relatively powerful spring 49 may provide a bias of the plunger 48 in the direction mentioned, thereby reducing the weight of the plunger necessary.

When the valve 44 is open and the valve 42 closed, as shown in Fig. 2, the compressor is unloaded by virtue of the passage of receiver pressure through pipe 33, chamber 40, passage 43, chamber 39 and pipe 34 into cylinder 25. When, on the other hand, plunger 48 is raised, valve 44 closes port 43 and valve 42 opens port 41, and accordingly no more air is supplied to the cylinder 25, but instead the latter is vented through connection 34, chamber 39, passage 41, chamber 38 and port 36 to the atmosphere. To raise the plunger 48 when desired, a magnet winding 50 is arranged in proper relation to the plunger so that upon the supply of current to the magnet winding 50, the same will be energized and effective to lift the plunger 48 and cause a reversal of the position of the valves shown in Fig. 2.

It will be noted that the pilot mechanism 32 will effect unloading when the solenoid or magnet 50 is de-energized, and loading when it is energized, and so that energization and de-energization of the magnet 50 may be caused to take place in proper dependence upon the receiver pressure, means is provided including a pressure responsive switch 52 having herein a pressure responsive element 53 subjected at one side to receiver pressure through a connection 54 and having its other side adapted to transmit motion to a switch element 55 through a suitable mechanism, herein a bell crank mechanism 56.

Before further describing the circuits of the illustrative embodiment of the invention, I may state that I provide a starting switch mechanism, generally designated START, and a stopping switch mechanism, generally designated STOP, and that with the starting switch mechanism there is herein associated a time delay device 60 whose purpose and structure will later be described. It may be noted also that at 61 there is provided an auxiliary switch element of the so-called interlock type whose purpose will shortly be apparent, this switch element being moved to closed position concurrently with the closure of the starting switch 7.

Now it will be noted that a conductor 62 leads from the motor lead M^2 to one end of the magnet winding 50, and that the other end of this magnet winding is connected by a conductor 63 to one of the stationary contact elements 64 associated with the receiver-pressure-operated switch element 55. The other stationary contact 65, with which the switch element 55 coacts, is connected by a conductor 66 to a contact 67 forming one of an upper pair (the other numbered 68) of contacts of the START switch apparatus. A movable contact member 69 in its upper position is adapted to connect the contacts 67, 68. Contact 68 is connected by a conductor 70 and a conductor 71 to line L^1, and by a conductor 72 is connected both to a conductor 73 leading to a stationary contact 74 with which the interlock switch element 61 coacts in establishing a circuit later more fully described, and also by a conductor 75 to a lower stationary contact 76 forming one of a pair (the other element is numbered 77) of lower contacts of the START switch mechanism. Contact element 77 is connected by a conductor 78 to an upper contact 79 engageable in its closed position by the switch element 80 of the STOP switch mechanism. The other stationary contact of the STOP switch mechanism, designated 81, is connected by a conductor 82 to the pivot end of the interlock switch 61. From the conductor 78 there branches a conductor 83 which leads to one end of the main operating coil 15 for the starting switch, and the other end of said operating magnet coil is connected by a conductor 84 to a stationary contact 85 with which switch element 16 coacts. The other stationary contact 86 with which switch element 16 contacts is connected by a conductor 87 to line L^2. A spring 88 normally maintains the STOP switch element 80 in contact with stationary contacts 79, 81. A spring 89 normally maintains the switch element 69 in contact with the contacts 67, 68. A manually operable plunger 90 may be moved downward through means including the dashpot mechanism 60 against the pressure of the spring 89 with substantially no retardation, and cause 69 to connect contact elements 76, 77. The dashpot device 60 provides a slow, retarded, upward movement of the switch element 69 with a substantial time delay after pressure is removed from the plunger 90 before contact will be broken between the element 69 and the contacts 76 and 77. The by-pass 91 permits a sharp upward movement of the switch element 69 just as it approaches the point of leaving contact with the stationary switch elements 76, 77, so that arcing is minimized.

Now, the mode of operation of this device will be readily understood, but as a preliminary, it should be said that the time delay created by the dashpot device 60 will be made such that the motor 1 will have had abundant time to bring the compressor 2 up to full operating speed before, even following an immediate release of pressure from the plunger 90, the switch element 69 will be able to leave contact with the stationary switch elements 76 and 77.

To start the compressor, the operator will depress the plunger 90 and move the contact element 69 into contact with the elements 76 and 77. This will establish a circuit from line L^2 through conductor 87, switch 86, 16, 85, conductor 84, magnet winding 15, conductor 83, conductor 78, switch 77, 69, 76, and conductor 75, conductor 72 and conductor 71 to line L^1. This will energize the magnet winding 15, and the plunger 14 will close the switch 7 and move the interlock switch element 61 into contact with the stationary contact element 74. Closure of the switch element 61 will result in a circuit from line L^2 through conductor 87, switch 86, 16, 85, conductor 84, magnet 15, conductor 83, the stop switch 79, 80, 81, conductor 82, switch element 61, stationary switch contact 74, and conductors 73, 72, 71 to line L^1, this being in parallel to the circuit originally established; and accordingly, even through the spring 89, after a few seconds of initial supply of motor starting current, moves the contact 69 to break the circuit between contacts 76, 77, there will be maintained an energization of the solenoid 15 and a maintenance of the switch 7 in closed position. It will be noted that this holding circuit includes the STOP switch mechanism, and that by depressing the member 80 out of contact with the contacts 79, 81, the solenoid 15 can be readily de-energized and the motor caused to stop by the opening of the starting switch 7. It will be noted, moreover, that upon an overload of the motor, the excessive flow of current through either coil O^1

or O^3, or both, will be effective to cause opening of the switch 16, and this also will break the circuit through the main motor switch operating coil 15, and accordingly result in a stopping of the motor. As soon as the switch 7 drops open, interlock switch element 61 also moves to open position, and so manual closure of the starting switch mechanism, including the downward movement of the plunger 90 and the switch element 69, the latter into contact with the contacts 76 and 77, is necessary to restart the motor.

It will be observed that the depressing of the element 69 out of engagement with the contacts 67 and 68 prevents the establishment of a circuit, which would otherwise have been made on closure of the switch element 12, if the pressure was low enough to cause switch 55 to close, from line L^2 through switch element 12, motor lead M^2, conductor 62, magnet winding 50, conductor 63, contact 64, switch element 55, contact 65, conductor 66, contact 67, switch element 69, contact 68, conductor 70, conductor 71, and line L^1. Accordingly, energization of the winding 50 is impossible until switch element 69 moves back into contact with the contacts 67, 68, and therefore, because of the time delay device, loading will be impossible until the motor has come up to speed, the time lapse occasioned by the dashpot mechanism 60 giving time enough for this to result. Obviously, the dashpot 60 could be omitted if it were desired to hold the element 69 manually out of contact with the contacts 67, 68 long enough to permit the motor to come up to speed before establishment of the circuit by the switch parts 67, 68 and 69. Of course, if the switch 55 is open, as will be the case if the receiver pressure is greater than the predetermined minimum for which the switch mechanism 52 is set, the compressor will not load, even on the upward movement to the position shown in Fig. 1 of the contact element 69.

It will be appreciated that I have provided an exceedingly simple and very effective arrangement for maintaining a compressor unloaded during the time when the latter is coming up to speed. Moreover, with a minimum of mechanism, this function is accomplished, and the compressor system enabled to operate under the load-and-unload system of output control.

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

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

1. In combination, a pump having unloading means, pressure responsive controlling means for said unloading means, a driving motor for said pump, motor controlling means including a member movable from one predetermined position to another to start said motor and out of the latter position while said motor continues to operate, and means operative in the second predetermined position of said member but not in the position occupied thereby during normal motor operation to render said pressure responsive controlling means ineffective to render said unloading means inactive.

2. In combination, a pump having unloading means, pressure responsive controlling means for said unloading means, a member having to be in a predetermined position to make said unloading means inoperative, a driving motor for said pump, and means for starting said motor connected with said member and moving the latter out of said predetermined position when actuated to start said motor, and means for maintaining said motor in operation when said member is returned to said predetermined position.

3. In combination, a pump having unloading means, an electric control for the latter including a pressure responsive switch, a solenoid, and a further switch, both said pressure responsive switch and said further switch having to be closed to effect loading, a pump driving motor having a starting switch, and controlling means for the latter necessitating opening of said second mentioned switch during starting of the pump driving motor.

4. In combination, a pump having unloading means, an electric control for the latter including a pressure responsive switch, a solenoid, and a further switch, both said pressure responsive switch and said further switch having to be closed to effect loading, a pump driving motor having an electrically actuated starting switch, an operating magnet for the latter having a control circuit established by said further switch when the latter is moved to open the circuit of said unload'ng means control, and means for maintaining sa'd magnet energized independently of said further switch, whereby reclosing of said further switch after motor starting is possible.

5. In combination, a pump having unloading means, an electric control for the latter including a pressure responsive switch, a solenoid, and a further switch, both said pressure responsive switch and said further switch having to be closed to effect loading, means for automatically moving said further switch from open to closed position, a pump driving motor having an electrically actuated starting switch, an operating magnet for the latter having a control circuit established by said further switch when the latter is moved to open the circuit of said unloading means control, means operative on closing of said starting switch due to movement of said further switch into said magnet circuit to establish a circuit in parallel with said further switch for maintaining said operating magnet energized, and means operable to open said parallel circuit and deenergize said operating magnet.

6. In combination, a pump having unloading means, a driving motor for said pump, a starting switch for said motor having an operating magnet, controlling means for said unloading means including an operating solenoid energized to effect loading, separate circuits for said magnet and solenoid, a switch element operative in different positions thereof to establish said separate circuits, and means operable by said magnet for maintaining a holding circuit through said magnet.

7. In combination, a pump having unloading means, a driving motor for said pump, a starting switch for said motor having an operating magnet, controlling means for said unloading means including an operating solenoid energized to effect loading, separate circuits for said magnet and solenoid respectively, a switch element operative in different positions thereof to form an element of said separate circuits, means for automatically restoring said switch element, when moved therefrom, to a position to form an element of the solenoid controlling circuit, means operative on closure of said starting switch due

to movement of said switch element into said magnet circuit to create a holding circuit around said switch element for said magnet, and means operable to open said holding circuit and deenergize said magnet.

8. In combination, a pump having unloading means, a driving motor for said pump, a starting switch for said motor having an operating magnet, controlling means for said unloading means including an operating solenoid energized to effect loading, separate circuits for said magnet and solenoid respectively, the circuit for said solenoid containing a pump-discharge-pressure responsive switch, a switch element operative in different positions thereof to form an element of said separate circuits, means for automatically restoring said switch element, when moved therefrom, to a position to form an element of the solenoid controlling circuit, means operative on closure of said starting switch due to movement of said switch element into said magnet circuit to create a holding circuit around said switch element for said magnet, and means operable to open said holding circuit and deenergize said magnet.

9. In combination, a pump having unloading means, a driving motor for said pump, a starting switch for said motor having an operating magnet, controlling means for said unloading means including an operating solenoid energized to effect loading, separate circuits for said magnet and solenoid respectively, a switch element operative in different positions thereof to form an element of said separate circuits, means for automatically restoring, after a predetermined time lapse, said switch element, when moved therefrom, to a position to form an element of the solenoid controlling circuit, and means operative on closure of said starting switch due to movement of said switch element into said magnet circuit to create a holding circuit around said switch element for said magnet.

10. In combination, a pump having unloading means, a driving motor for said pump, a starting switch for said motor having an operating magnet, controlling means for said unloading means including an operating solenoid energized to effect loading, separate circuits for said magnet and solenoid respectively, the latter circuit containing a pump discharge pressure responsive switch, a switch element operative in different positions thereof to establish said separate circuits, means for normally maintaining said switch element in the solenoid circuit and for automatically returning it thereto after movement to establish the magnet circuit, and means operative on energization of said magnet due to movement of said switch element into said magnet circuit to shunt said switch element in the magnet circuit and maintain said magnet circuit closed after said switch element has been returned to said solenoid circuit.

11. In combination, a pump having unloading means, a driving motor for said pump, a starting switch for said motor having an operating magnet, controlling means for said unloading means including an operating solenoid energized to effect loading, separate circuits for said magnet and solenoid respectively, the latter circuit containing a pump discharge pressure responsive switch, a switch element operative in different positions thereof to establish said separate circuits, means for normally maintaining said switch element in the solenoid circuit and for automatically returning it thereto after movement to establish the magnet circuit, means operative on energization of said magnet due to movement of said switch element into said magnet circuit to shunt said switch element in the magnet circuit, and dashpot means retarding movement of said switch element out of the magnet circuit.

12. In combination, a pump having unloading means, a driving motor for said pump, motor starting and stopping means including a member movable to a predetermined position to effect motor starting and thereafter movable out of said position without stopping said motor, pressure responsive controlling means for said unloading means requiring the positioning of said member out of said predetermined position thereof to enable loading, and controlling means for the positioning of said member.

13. In combination, a pump having unloading means, pressure responsive controlling means for said unloading means including an operating system in which the operating medium is controlled both in response to pump discharge pressure and through the position of a control element, a driving motor for said pump, and controlling means for said driving motor requiring the positioning of said control element in a position to preclude pump loading to effect motor starting, but not subsequent thereto for continued motor operation, and means for controlling the position of said controlling element.

14. In combination, a pump having unloading means, pressure responsive controlling means for said unloading means including an operating system in which the operating medium is controlled both in response to pump discharge pressure and through the position of a control element, a driving motor for said pump, and controlling means for said driving motor requiring the positioning of said control element in a position to preclude pump loading to effect motor starting, but not subsequent thereto for continued motor operation, and means for controlling the position of said controlling element automatically, normally maintaining the same in a position enabling the effecting of loading.

15. In combination, a pump having unloading means, a controlling system for the latter including a pressure responsive element movable to control the flow of an operating medium and a second element also movable to control the flow of such operating medium, a pump driving motor, and controlling means for said motor including devices for effecting motor starting rendered operative on movement of said second element to interrupt operating medium flow in said system, means for maintaining said motor in operation after starting thereof, independently of the position of said second element, and a further element movable to effect motor stopping.

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