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COMPRESSOR CONTROL SYSTEM

2,646,919

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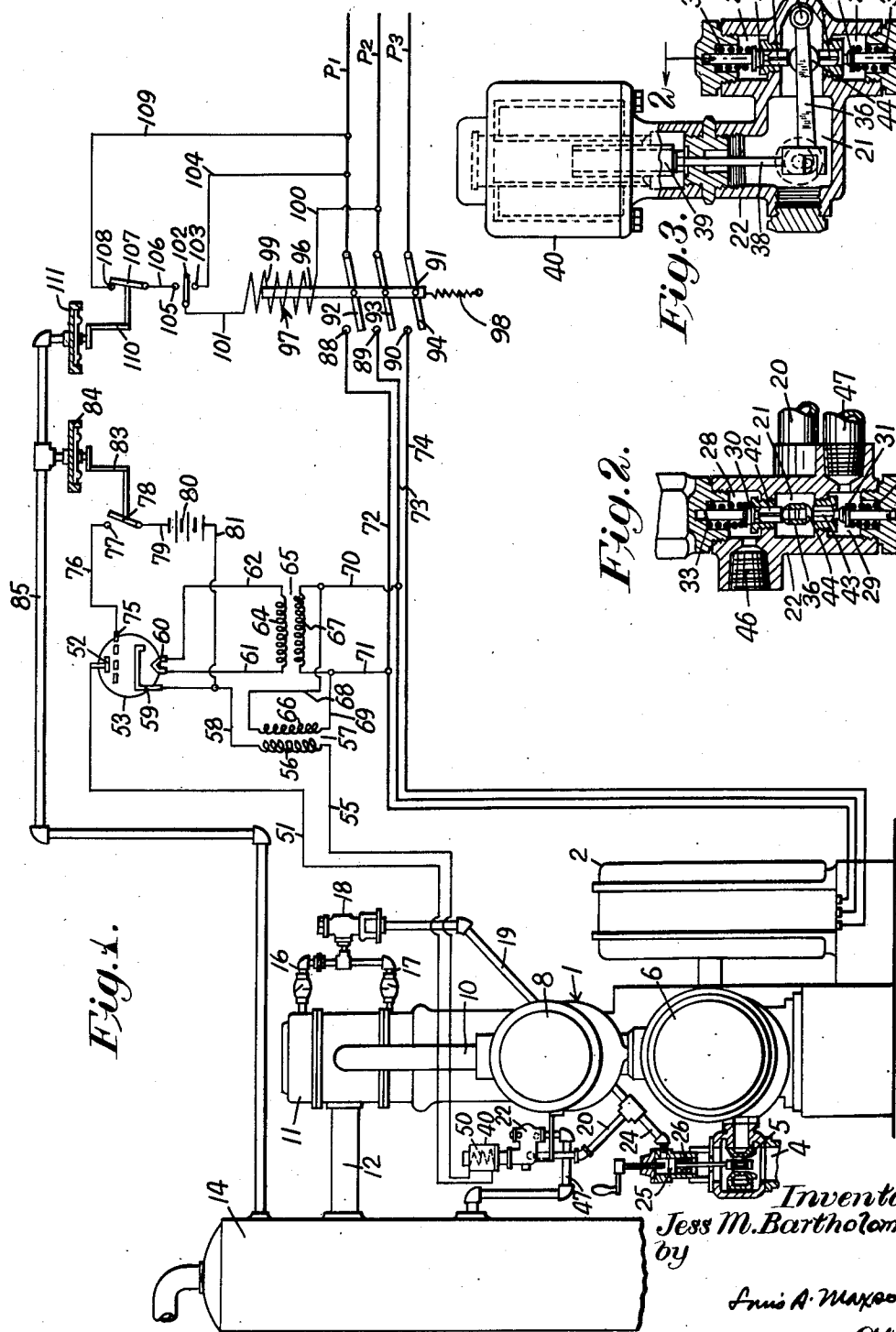


Fig. 1.

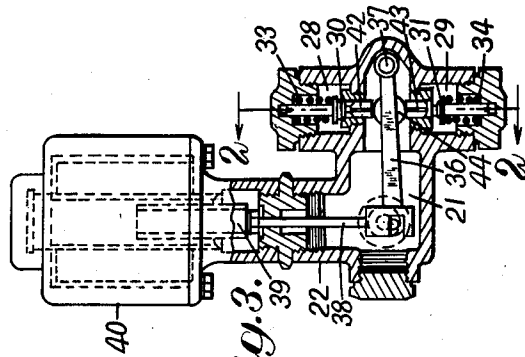
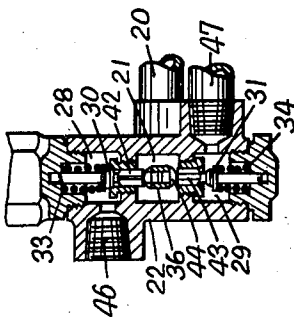


Fig. 3.

Fig. 2.



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COMPRESSOR CONTROL SYSTEM

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1 Claim. (Cl. 230—26)

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My invention relates to control systems for compressors, and more particularly to control apparatus for electrically driven compressors.

It is necessary that a compressor be provided with some means for effecting its unloading when a predetermined maximum discharge pressure is reached. After the compressor has been unloaded it may either be stopped or driven unloaded, until the pressure in a receiver to which the fluid is delivered has dropped to a predetermined low value. If the demand for fluid is low, it is desirable that the compressor be stopped when unloading takes place, whereas, if the demand is high, it is desirable that the compressor be driven until it is reloaded. When the compressor is started, either at the time of initial starting or while operating under the stop and start type of control, it should be held unloaded until it is brought up to speed.

In a preferred form of my invention I have shown a motor driven compressor having unloading means to which pressure fluid is supplied for effecting its unloading operation. The flow of fluid relative to the unloading means is controlled by a solenoid, the winding of which forms part of a circuit connected to the cathode and anode of an electronic tube. When the solenoid is de-energized, pressure fluid is delivered to the unloading means to effect unloading, and when it is energized, the unloading means is vented to atmosphere. Instead of controlling the flow of fluid relative to the unloading means, the solenoid may be connected directly to the unloading means for effecting its operation, if desired. A heating element for the electronic tube is connected to the secondary winding of a transformer which has its primary winding connected in the motor circuit at the motor side of a line switch. Since a short time is required after the heating element is first energized before electrons pass from the cathode to the anode in sufficient quantity to energize the solenoid and effect a loading operation of the unloading means, it will be seen that the motor will be started and brought up to speed while the compressor is unloaded. The electronic tube is provided with a grid circuit containing a switch which is actuated by a device responsive to pressures in the receiver. This switch is closed to energize the grid circuit and cut off the flow of electrons between the cathode and anode when the receiver pressure reaches the maximum desired value. If desired, the switch in the grid circuit may be so arranged as normally to provide a positive grid polarity, and to change the polarity of the grid from a

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positive to a negative at the time unloading is to be effected, thus providing a greater variation of current in the unloading solenoid. The line switch is provided with a solenoid which operates to effect its closing when energized. The winding of this solenoid is connected to a switch element which is adapted to be connected either directly or through another switch controlled by a device responsive to the receiver pressure, to the power line. Instead of providing separate pressure responsive devices for the latter switch and the switch in the grid circuit, there may be provided a single pressure responsive device for controlling both switches. In this case, however, the starting and stopping of the motor and the loading and unloading of the compressor would take place at the same pressure limits when operating under the different types of control, whereas with two pressure switches a larger pressure drop before restarting can be provided during stop and start control than takes place before reloading when the compressor is continuously driven and has its output controlled by unloading and reloading.

An object of my invention is to provide an improved control system for a compressor. Another object is to provide an improved electrical control circuit for a motor driven compressor. Still another object is to provide an improved circuit for controlling the loading and unloading of a compressor, said circuit operating to effect loading a predetermined time after the compressor is started. Yet another object is to provide for a compressor improved control circuits which are selectively operative to effect loading and unloading with continuous operation of the compressor or to effect starting and stopping of the compressor, the loading of the compressor then taking place a predetermined time after it is started. Another object is to provide an improved control circuit for controlling the loading and unloading of a motor driven compressor, the control circuit including an electronic tube which is energized from the motor circuit. Yet another object is to provide an improved control circuit including an electronic tube having its cathode and anode connected to a solenoid which controls the loading of a motor driven compressor, and also having a heating element which is energized by the motor circuit. These and other objects will appear more fully during the course of the following description.

In the accompanying drawing in which there is shown for purposes of illustration one form which my invention may assume in practice:

Fig. 1 is an elevational view of a compressor

having my improved control circuit associated therewith.

Fig. 2 is a cross-sectional view taken on the plane of the line 2—2 of Fig. 3.

Fig. 3 is an enlarged view of the unloading control means, part of the control means being shown in vertical section and part in elevation.

In the illustrative embodiment of the invention there is shown a two-stage compressor, generally designated 1, driven by an electric motor 2. Air is taken through an intake passage 4 under the control of an intake closure valve 5 and inlet valves, not shown, into a low pressure cylinder 6 where it is compressed and then discharged to an intercooler 8. A conduit 10 conducts fluid from the intercooler to a high pressure cylinder 11 under the control of inlet valves, not shown; and the fluid is compressed further in the cylinder 11 and then discharged to a conduit 12 leading to a receiver 14. Associated with the high pressure cylinder is means operative on the supply of pressure fluid thereto to permit the venting of the opposite ends of the high pressure cylinder to atmosphere. This means includes conduits 16 and 17 which constitute check valve controlled venting connections for the opposite ends of the high pressure cylinder and a pressure fluid controlled relief valve mechanism 18 which controls venting of the conduits 16 and 17 and is connected for control, by a conduit 19 and a further conduit 20, to a chamber 21 in a control device 22. The structure of the high pressure cylinder venting mechanism is disclosed and described in the patent to Hughes 1,786,114, granted December 23, 1930. Other types of compressors, either single stage or multi-stage, could be used in place of the compressor shown, if desired.

A conduit 24 is also connected in communication with the conduit 20 for delivering fluid to or venting fluid from a piston 25 connected to the intake closure valve 5. A spring 26 acting against the piston 25 tends normally to hold the intake closure valve in its open, loading position. On supply of pressure fluid to the piston 25, the valve 5 is closed, cutting off the admission of air to the low pressure cylinder.

The chamber 21 of the control device 22 is adapted to be connected with chambers 28 and 29 under the control of valves 30 and 31 which are urged toward their closed positions by springs 33 and 34. Extending through the chamber 21 between the chambers 28 and 29 is a lever 36 having one of its ends pivotally connected at 37 to a wall of the chamber 21, and having its other end connected by a rod 38 to a plunger 39 of a solenoid 40. Carried by the valves 30 and 31 are ribbed portions 42 and 43 projecting into the chamber 21 and engaging a member 44 fixed to the lever 36. The chamber 28 is connected to atmosphere by a port 46, and the chamber 29 is connected to a conduit 47 which communicates with the receiver 14. When the lever 36 is swung upwardly about its pivot 37 by energizing the solenoid 40, the valve 30 is unseated connecting the chamber 21 to atmosphere and venting fluid from the unloading devices to effect loading of the compressor. When the solenoid is de-energized, the plunger 39 drops and swings the lever 36 about its pivot to unseat the valve 31 and supply pressure fluid from the receiver to the unloading devices for unloading the compressor.

The winding 50 of the solenoid 40 is connected at one end to a conductor 51 leading to the anode 52 of an electronic tube 53 and is connected at its other end to a conductor 55 leading to the sec-

ondary winding 56 of a transformer 57. The other end of the winding 56 is connected by a conductor 58 to the cathode 59 of the electronic tube. A heater element 60 of the electronic tube is connected by conductors 61 and 62 across the secondary winding 64 of a transformer 65. Primary windings 66 and 67 of the transformers 57 and 65 are connected by conductors 68, 69, 70 and 71 to two of the conductors 72, 73 and 74 leading to the motor 2. A grid 75 of the electronic tube is connected by a conductor 76 to a switch contact 77 which is adapted to be engaged by a contactor 78. A conductor 79 connects the contactor 78 to the negative terminal of a battery 80, and the positive terminal of the battery is connected by a conductor 81 to the conductor 58 leading to the cathode. The contactor 78 is connected by a lever mechanism 83 to a pressure responsive device 84 to which pressure fluid is supplied from the receiver by a conduit 85. When the receiver pressure reaches a predetermined maximum value, the pressure responsive device 84 operates to move the contactor 78 into engagement with the contact 77 and place a negative potential upon the grid 75 so as to oppose the flow of electrons from the cathode to the anode. At a predetermined lower pressure in the receiver, the pressure responsive device 84 operates to open the contactor 78 and break the grid circuit. It will thus be seen that when the switch or contactor 78 is open the compressor is loaded and when it is closed the compressor is unloaded.

The motor conductors 72, 73 and 74 lead to contacts 88, 89 and 90 of a line switch 91, and contactors 92, 93 and 94 of this switch are adapted to connect the contacts 88, 89 and 90 to conductors P₁, P₂ and P₃ of a power line. The contactors are operatively connected to a plunger 96 of a solenoid, generally designated 97, which operates when energized to move the contactors to their closed positions against the action of a spring 98. The winding 99 of the solenoid 97 is connected at one end by a conductor 100 to the power line P₂, and is connected at its other end to a conductor 101 which connects to a switch element 102. The switch element 102 is adapted to engage either a contact 103 which is connected by a conductor 104 to the power line P₁ or a contact 105 which is connected by a conductor 106 to a switch contactor 107. A contact 108 is engageable by the contactor 107 and is connected by a conductor 109 to the power line P₁. A lever mechanism 110 operatively connects the contactor 107 to a pressure responsive device 111 to which pressure fluid is supplied from the receiver through the conduit 85. The pressure responsive device 111 operates at predetermined maximum and minimum pressures in the receiver for effecting opening and closing movements, respectively, of the contactor 107. The maximum pressure at which the device 111 operates may be the same as, or slightly lower than, the pressure at which the device 84 operates. In order that it may be certain that the line switch is opened during start and stop operation of the compressor, the pressure responsive device 111 should be made to operate at a high pressure slightly below that at which the device 84 operates. It will be seen that an operation of the device 84 when operating on start and stop control is unnecessary since an opening of the line switch results in a de-energizing of the electronic tube and an unloading of the compressor. The low pressure at which the device 111 operates must

either be the same as, or lower than, the low pressure at which the device 84 operates. It is usually desirable that the compressor be restarted, when operating on the start and stop control, at pressures lower than those at which reloading takes place when operating on the load and unload control. In this case the device 111 must operate at low receiver pressures somewhat below those at which the device 84 operates. If it were desirable that both the load and unload, and the start and stop controls operate at the same low and high pressures, a single pressure responsive device may be used in place of the devices 84 and 111 for controlling the contactors 79 and 107.

The operation of the control system described is as follows: If it is desired that the compressor operate under the load and unload control while it is driven continuously, the contactor 102 is moved to a position engaging the contact 103. Current then flows through a circuit including the power line P₁, the conductor 104, the contactor 102, the conductor 101, the winding 99 of the solenoid 97, the conductor 100 and the power line P₂. As soon as current passes through the solenoid winding 99, the plunger 96 is actuated to move the contactors 92, 93 and 94 into engagement with the contacts 88, 89 and 90. Current is then supplied from the power line through the conductors 72, 73 and 74 to the motor 2 for starting the latter. At the same time, current is delivered to the primary windings of the transformers 65 and 57. The voltage induced in the secondary winding 64 of the transformer 65 causes current to flow through the element 60 of the electronic tube for heating the cathode 59. The voltage induced in the secondary winding 56 of the transformer 57 causes current to flow in the circuit including the winding 50 of the solenoid 40 as soon as the cathode becomes sufficiently heated. The energizing of the solenoid winding 50 causes the plunger 39 to move upwardly and swing the lever 36 about its pivot unseating the valve 30 and venting the unloading devices to atmosphere to effect loading of the compressor. The compressor then delivers fluid to the receiver 14 until a predetermined maximum pressure is reached. At this time, the pressure acting through the conduit 85 on the pressure responsive device 84 causes the latter to operate and move the contactor 78 into a position engaging the contact 77. The grid 75 is then given a negative potential with respect to the cathode by reason of its connection through the conductor 76 and the contactor 78 to the negative terminal of the battery 80, and the connection of the positive terminal of the battery to the cathode by the conductor 81. The flow of electrons from the cathode to the anode is then cut off by the grid, and the circuit including the solenoid winding 50 is de-energized. The plunger 39 of the solenoid then drops and causes the lever 36 to swing about its pivot unseating the valve 31 and permitting pressure fluid to flow from the receiver to the unloading devices for effecting an unloading of the compressor. The compressor is held unloaded until the pressure in the receiver drops to a value at which the pressure responsive device 84 operates to move the contactor 78 out of engagement with the contact 77. The potential on the grid 75 is then removed and electrons again pass from the cathode to the anode so as to effect an energizing of the solenoid 40 and an actuation of the lever 36 to effect a loading of the compressor.

If it is desired to operate the compressor under the start and stop control, the contactor 102 is moved into engagement with the contact 105. If the pressure in the receiver is sufficiently low, the pressure responsive device 111 will be in a position to cause the contactor 107 to engage the contact 108 and complete a circuit from the power line P₁ through the conductor 109, the contactor 107, the conductor 106, the contactor 102, the conductor 101, the winding 99 of the solenoid 97, the conductor 100 and the power line P₂. The switch 91 will then close and cause current to flow from the supply line to the motor and to the transformers 57 and 65. The motor is started immediately, but loading of the compressor is delayed due to the time required for heating the cathode of the electronic tube. No heating commences until the switch 91 is closed. When the pressure reaches a predetermined maximum value, the pressure responsive device 111 operates to move the contactor 107 out of engagement with the contact 108. The circuit through the winding 99 of the solenoid 97 is then broken and the switch 91 opens to cut off the flow of current to the motor and to the transformers 57 and 65. When the receiver pressure drops to the low value at which the pressure responsive device 111 operates to move the contactor 107 into engagement with the contactor 108, the solenoid winding 99 is again energized and causes the switch 91 to be closed so as to supply current to the motor and to the transformers 57 and 65.

As a result of my invention there is provided an improved control system which is operative to effect either a loading and unloading or a starting and stopping of a compressor in response to the pressures in a receiver. The compressor will always be unloaded when it is stopped and will not be loaded until it is started and brought up to speed.

While there is in this application specifically described one form which the invention may assume in practice, it will be understood that this form 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 claim.

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

In combination, a compressor, a driving motor for said compressor, a starting switch for said motor, magnetically controlled unloading means for said compressor, an electronic tube including an anode, cathode, heater and grid, a control circuit for said magnetically controlled unloading means including the cathode and anode of said electronic tube, means controlled by opening and closing of said starting switch for energizing said heater upon closure of said starting switch, and means governed by compressor discharge pressure for energizing said grid upon the attainment of compressor discharge pressure to a predetermined value.

JESS M. BARTHOLOMEW.

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