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COMPRESSOR SYSTEM

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Fig. 1.

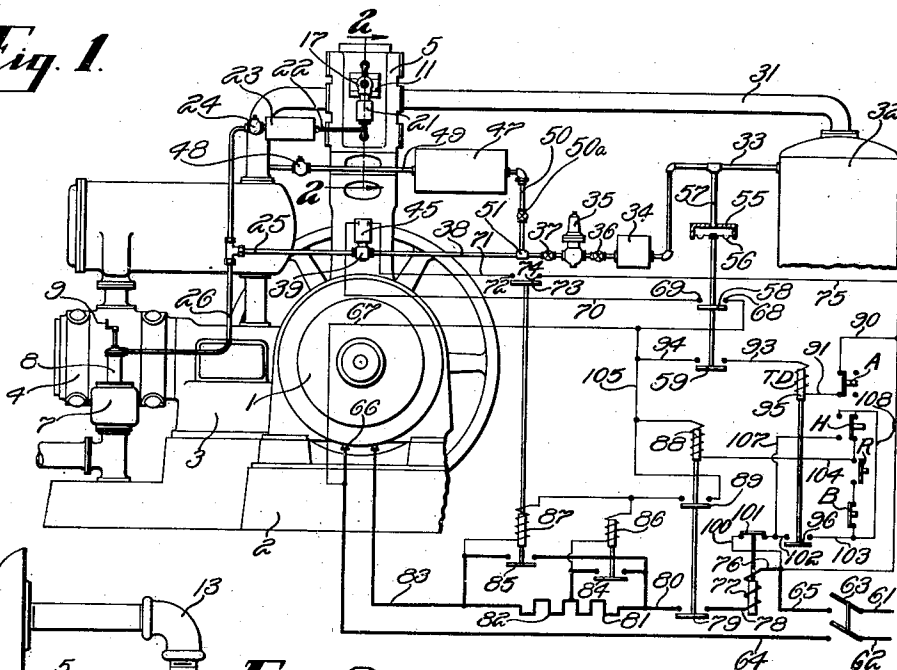


Fig. 2.

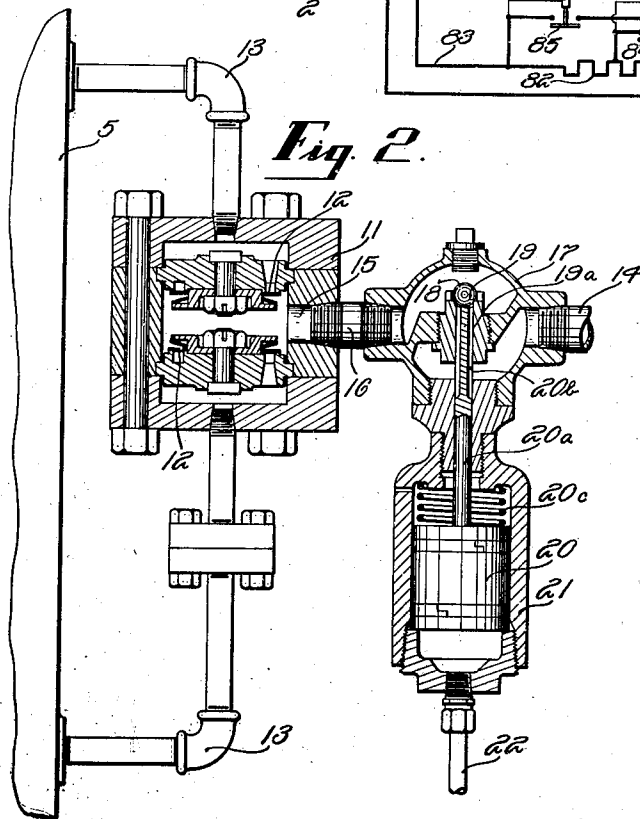


Fig. 3.

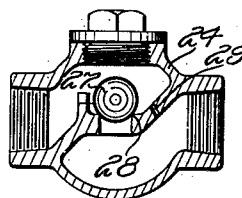
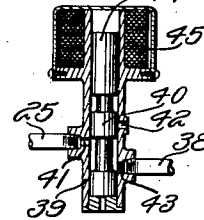


Fig. 4.



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COMPRESSOR SYSTEM

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My invention relates to compressor systems, and more particularly to systems for the control of compression of air to high pressures.

jects and advantages of the invention will subsequently appear.

In the accompanying drawing, in which for purposes of illustration one illustrative embodiment of my invention is shown,—

Fig. 1 is a diagrammatic view of a compound compressor system in which the invention is embodied.

Fig. 2 is an enlarged vertical sectional view on the line 2—2 of Fig. 1.

Fig. 3 is a section through a check valve employed in connection with the high pressure unloading means.

Fig. 4 is a sectional view of an electrically operated three-way controlling valve.

Referring to the drawing, it will be noted that a motor 1 mounted upon a base 2, which also supports a compressor 3, drives through direct connection the compressor 3. This compressor is of the compound type and comprises a low pressure cylinder 4 and a high pressure cylinder 5. The low pressure cylinder is provided with a usual intake closure type unloading valve mechanism 7 whose construction is so well known that detailed illustration is unnecessary. It will suffice to say that this mechanism includes a cylinder 8 to which air is admitted at appropriate times to effect the closure of a valve which when closed cuts off the admission of air through the intake of the low pressure cylinder 4. A manual device 9 is provided to permit manual unloading if desired, as is common practice with unloading devices of this character. The high pressure cylinder 5 is provided with a controlling mechanism which permits the venting of any pressure which might leak past the intake closure valve mechanism 7 of the low pressure cylinder. Were such a mechanism not provided, a very high range of compression would take place in the high pressure cylinder, with resultant damage due to the excessive generation of heat. This protective mechanism consists of a valve casing 11 in which a pair of spring loaded check valves 12 are arranged to control the flow through passages 13 opening into the high pressure cylinder adjacent the ends thereof to an atmospheric discharge 14. The check valves permit flow of air from the

5 It is frequently desirable to compress air or other gaseous media to quite high pressures, and by the appropriate design of compressors even a two-stage machine can be used for this purpose. It is also desirable to control compressors, even when working at these high terminal pressures, by unloading devices, and it is preferable not to have to supply unloading devices of any different type from those which are commonly used in lower pressure ranges. In other words, for example, in the case of a compound compressor it is desirable to provide perhaps an intake unloader for the low pressure cylinder and automatic venting means for the high pressure cylinder operative when the intake closure valve mentioned has been closed; but were these unloading devices to be subjected to the full terminal discharge pressure of the compressor, breakage would almost certainly result, and it is therefore desirable to provide means for supplying a reduced pressure for the actual operation of the unloading devices while making the supply directly responsive to the flow of terminal pressure against which the compressor is operated.

An object of my invention is to provide an improved compressor system. Another object of my invention is to provide an improved pumping system adapted to operate against and discharge at high terminal pressures. A further object of my invention is to provide an improved compressor system having associated therewith unloading means operable by pressure fluid at a lower pressure than that at the discharge side of the compressor, which forms an element of the system. A still further object of the invention is to provide an improved compressor system adapted to discharge at high pressures and having improved unloading means controllable by fluid pressure and adapted to be supplied with operating pressure from different sources all of which are at pressures below the terminal compressor discharge pressure. Other ob-

ends of the high pressure cylinder under conditions which will shortly be described, but prevent opposite flow. The casing 11 is provided with a vent connection 15 opening into the same between the check valves 12, and the vent connection is connected by a pipe 16 with a vent controlling valve mechanism 17, herein including a ball valve 18 which may be moved off of its seat 19 by a piston 20 reciprocable in a cylinder 21. The piston 20 carries a piston rod or stem 20^a which passes through an opening 19^a in the valve seat, and the stem is grooved, as at 20^b, to permit the ready flow of fluid from above the valve seat to an atmospheric discharge 14 when the valve 18 is unseated. A spring 20^c normally maintains the piston 20 in a position to permit seating of the valve 18.

It will be evident that when the valve 18 is seated no air can discharge from the interior of the casing 11, and accordingly pressure which passes the check valves 12 will build up and, because the backs of these check valves are of larger area than the surfaces thereof exposed to pressure through the ports in the valve seats, the check valves will close, very quickly after the closure of the valve 18, and remain closed. When, however, the valve 18 is unseated, the check valves will be free to open, due to the discharge of pressure which has been acting on their backs, and accordingly, as soon as the pressure builds up to slightly above atmospheric pressure in the high pressure cylinder, it will be vented.

The supply of operating medium to the cylinder 21 is through a connection 22 which leads from a storage tank 23 having a check valve 24 controlling communication thereof with a line 25, which also supplies controlling fluid to a line 26 leading to the cylinder 8 of the intake closure unloading valve of the low pressure cylinder. The check valve 24 is illustrated in section and on an enlarged scale in Fig. 3, and will be noted to comprise a ball valve 27 seated upon a seat 28, and also has a small port 29 opening through the web which supports the seat 28, so that some air may pass the check valve even though the valve is seated. The purpose of this arrangement is to insure upon unloading, a time delay in the unloading of the high pressure cylinder, while upon reloading, effecting simultaneous loading of the low and high pressure cylinders. It will be evident that when air is admitted through the pipe 25 it will immediately act to unload the low pressure cylinder, but that it will be able to pass to the piston 20 only through the leak port 29, and accordingly the high pressure cylinder will be somewhat delayed in being unloaded and will discharge to the receiver the air within the intercooler, thus effecting economy. When, however, the air is vented from the pipe 25, discharge from the cylinder

8 and from the cylinder 21 will occur at similar rates, for the air within the cylinder 21 will be able to unseat the ball valve 27 and effect reloading very promptly. Of course a small delay taking place for one or two strokes of the high pressure cylinder piston may be necessary before the pressure acting upon the backs of the check valves 12 will be sufficient to maintain them closed.

The control of operating fluid to the high and low pressure unloading mechanisms through the pipe 25, and the source of that fluid, will now be described. The compressor high pressure cylinder 5 discharges through a connection 31 to a receiver 32, and the receiver pressure may be as high as one thousand pounds, whereas it may be desired to maintain the operating pressure for the unloading mechanism as low as one hundred pounds, or slightly above. Two ways of accomplishing this result are illustrated. The receiver 32 is connected with a pipe 33 leading to a storage tank 34, whose function is merely to eliminate pressure fluctuations. This tank 34 is connected to a discharge side pressure governed pressure reducing valve 35, which is mounted between stop valves 36 and 37 in a passage 38 leading to a valve casing 39. The valve casing 39 contains a three-way valve, shown for simplicity as a piston valve 40, which controls the connection of a port 41, with which the pipe 25 communicates, alternatively with an atmospheric vent 42 and a port 43 to which the pipe 38 leads. An armature or plunger 44 is connected to the piston valve 40, and a solenoid 45 when energized moves the piston valve to a position to vent the pressure supplied previously to the pipe 25, and thereby to effect loading. The pressure reducing valve 35 is set to maintain any desired pressure in the line 38, and may be set, for example, to maintain a pressure of 100# or 110#, or any other desired pressure which is suitable for the direct operation of the unloading mechanisms.

Another source of operating pressure for the compressor unloading mechanisms is intercooler pressure. To make this available, a storage tank 47 is connected through a check valve 48 and a line 49 with the air space of the intercooler; the check valve 48 permitting passage of air to the reservoir 47 but preventing reverse flow. A valved connection 50 extends from the reservoir 47 to a T 51 between the stop valve 37 and the passage 38. By opening the valve 50^a in the valve connection 50 and closing the valve 37, intercooler pressure may be used as the operating medium for the unloading mechanisms associated with the low and high pressure cylinders.

It is desirable that the unloading mechanisms be made directly responsive to the pressure in the compressor discharge line, and to effect this result means are provided for energizing and de-energizing the solenoid 45 in

direct accordance with the pressure in the receiver 32. A pressure responsive mechanism 55 including a diaphragm 56 is connected through a passage 57 with the line 33. The diaphragm 56 operates a pair of switch elements 58 and 59, and the movement of the switch element 58 controls a circuit leading to the solenoid 45.

As it is desirable to effect starting of the motor 1 unloaded, and also to be able selectively to control the output of the compressor either by loading and unloading or starting and stopping, depending upon the conditions under which the compressor is working, I have illustrated an improved control system for the compressor driving motor and for the solenoid 45. Power lines 61 and 62 are connectible through a double pole main line switch 63 with conductors 64 and 65. The conductor 64 leads directly to one of the motor connections 66, and a conductor 67 leads from the conductor 66 to a contact 68 which is connectible through the switch element 58 with a second contact 69, which is in turn connected by a conductor 70 with the solenoid 45. The other end of the solenoid is connected by a conductor 71 to a contact 72, which may be connected by a switch element 73 with a second contact 74. The last mentioned contact is connected by a conductor 75 to the conductor 65. The conductor 65 is connected, through the overload coil 77, by a conductor 78 to one side of the primary contactor 79. The other side of this contactor is connectible by a conductor 80 through resistances 81, 82 to a conductor 83 leading to the other side of the motor. Resistance cut-out contactors 84 and 85 are arranged to effect successive cutting out of the resistances 81 and 82, and are provided with operating coils 86 and 87, respectively. The main contactor 79 is provided with an operating coil 88 and with a switch element 89 which moves to closed position on closure of the contactor 79. Switch devices are provided to permit what is known as automatic and hand controls. The switch marked A when closed, i. e. in the position shown in Fig. 1, causes the compressor to run and to stop dependent upon the variations in receiver pressure. The switch marked H, when in the opposite position from that shown in Fig. 1, causes the compressor to operate continuously but to load and unload to maintain the receiver pressure within the desired limits. It will be understood that the switches A and H are provided with arrangements which preclude both of them being in depressed position at the same time. The switch marked R is a starting switch, and that marked B is a stopping switch. The connections may best be described in connection with the operation of the device.

It will be noted that the switch A is connected between a conductor 90 leading from the line 75 and a conductor 91 leading to a

solenoid TD whose other end is connected by a conductor 93 to one of the contacts with which the switch member 59 cooperates. The other side of the switch 59 is connected by a conductor 94 with the line 67. The solenoid TD forms a part of a time delay relay, and this relay may be of any well known type which operates immediately upon supply of current thereto to effect actuation of the device controlled thereby, but which delays appreciably after interruption of current supply to it the reverse operation of the device which it controls. Herein, the solenoid TD controls a core 95 which actuates a switch 96, and on energization of the solenoid the switch 96 is immediately closed, whereas on de-energization a small delay occurs before the switch 96 opens. What is known as a copper jacketed type of coil may be conveniently used for the solenoid TD. The pressure responsive device 55 is shown in a position such that the switches 58 and 59 are open. Upon reduction in receiver pressure to the desired minimum, the diaphragm 56 will operate to close the switches 58 and 59. Closure of the switch 58 will not result in immediate energization of the solenoid 45 because the switch 73 will still be open. Closure of the switch 59 will result in energizing the solenoid TD through the conductors 64, 67, 94, switch 59, conductor 93, solenoid TD, conductor 91, automatic switch A, conductor 90, and conductors 75 and 65. The switch 96 will then close. Current will then flow in a circuit including conductor 65, conductor 100, overload switch 101, conductor 102, switch 96, conductor 103, conductor 108, switch H, conductor 104, solenoid 88, conductor 105, conductor 67, and conductor 64. Energizing of the solenoid 88 will close the main contactor 79 and the connected switch 89. The motor will then be supplied with current through a circuit including conductor 65, conductor 76, overload coil 77, conductor 78, contactor 79, resistances 81, 82, conductor 83, motor 1, and conductor 64. The closure of the switch 89 will result in the coils 86 and 87 successively closing their contactors 84 and 85 as the counter electro-motive force of the motor builds up; these solenoids operating in a well known manner, it being noted that the coils 86 and 87 are so connected that the voltage of the current applied to them depends on the counter electro-motive force of the motor. When the contactor 85 is closed, the motor will be on the line and the compressor will be driven at full speed until the receiver pressure builds up to the desired maximum limit. It will be noted that the solenoid 45 will not be energized until the switch 73 is closed, and this occurs only when the motor has been brought up to full speed. Accordingly, the compressor is started unloaded. Obviously, any other com-

mon form of automatic resistance cut-out devices might be employed if desired.

Now, when the receiver pressure reaches the desired maximum value, the diaphragm 56 will open the switches 58 and 59, and when this occurs, the solenoid 45 will be immediately de-energized, resulting in immediate unloading of the compressor. The opening of the circuit by the switch 59 through the time delay coil TD will, however, not result in the opening of the switch 96 for a predetermined time after the switch 59 is opened, and accordingly the compressor will be unloaded before the motor current supply is interrupted, and so the compressor driving motor will coast smoothly to a stop. When the receiver pressure again drops, the cycle described will be reinitiated.

If the switch H is depressed and the switch A moved to its opposite position from that shown, the motor will be started, provided the switch R is also closed, through a circuit including conductors 65, 100, overload switch 101, conductor 107, hand switch H, conductor 108, switches B and R, conductor 104, coil 88, and conductors 105, 67 and 64. It will be noted that the position of the switch 96 will then be immaterial, and that because the switch A is in open position the coil TD will not be energized and de-energized as the switch 59 opens and closes. Energization of the coil 88 will result in the starting of the motor just as previously described, and the motor will then continue to run, the receiver pressure variations controlling the operation of the motor by varying the position of the switch 58, closing this switch when the pressure gets to the desired minimum value, and thereby energizing the solenoid 45 and moving the valve 40 to its loading position; and when the receiver pressure reaches the maximum value, breaking the circuit through the solenoid 45. Obviously, in this case also the compressor starts unloaded when it is first set in operation by movements of the hand switch H and the starting switch R. The compressor can be stopped by moving the switch B to open position.

From the foregoing description it will be apparent that I have provided an improved system permitting either the loading and unloading or the starting and stopping methods of control of compressor output with a compressor discharging at a very high pressure and while effecting the control of the unloading devices by pressure fluid at a much reduced pressure. Two sources of pressure appropriate for the operation of the unloading devices are provided, either receiver pressure delivered through a reducing valve, or inter-cooler pressure. In every case the compressor is started unloaded, and whenever it is operating on the start and stop principle, it is always brought to a stop unloaded.

While I have in this application specifically described one form which my invention may assume in practice, it will be understood that this form is shown for illustrative purposes only 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 a pumping system, a compressor, unloading devices therefor, operating means for said devices operable by pressure fluid, a source of fluid under a pressure less than compressor discharge pressure, and means for controlling operation of said operating means by fluid from said source including a valve controlling communication between said source of fluid under pressure and said operating means, and means for controlling said valve governed by compressor discharge pressure.

2. In a pumping system, a compound compressor having an intercooler, unloading devices for said compressor, operating means for said devices operable by fluid pressure, means for supplying intercooler pressure to said operating means and venting it therefrom including a controlling valve, and means for controlling said valve governed by compressor discharge pressure.

3. In a pumping system, a compressor, unloading devices therefor, operating means for said devices operable by pressure fluid, a source of fluid under a pressure less than compressor discharge pressure including a pressure reducing valve connected with the compressor discharge, and means for controlling operation of said operating means by fluid from said source including a valve controlling communication between said source of fluid under pressure and said operating means, and means for controlling said valve governed by compressor discharge pressure.

4. In a pumping system, a compressor, unloading devices therefor, operating means for said devices operable by pressure fluid, a source of fluid under a pressure less than compressor discharge pressure, and means for controlling operation of said operating means by fluid from said source including a valve controlling communication between said source of fluid under pressure and said operating means, and electromagnetic means for controlling said valve governed by compressor discharge pressure.

5. In a pumping system, a compressor, an electric driving motor therefor having starting control devices, unloading devices for said compressor, operating means for said devices operable by pressure fluid, a source of fluid under a pressure less than compressor discharge pressure, and means for controlling operation of said operating means by fluid from said source including a valve controlling communication between said

source of fluid under pressure and said operating means, and electromagnetic means for controlling said valve governed by compressor discharge pressure and by said starting control devices.

In testimony whereof I affix my signature.

FRANK A. HALLECK.

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