F. D. HOLDSWORTH

APPARATUS FOR CONTROLLING COMPRESSORS

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2 Sheets-Sheet 2

Inventor:
Fred D. Holdsworth

by Henry J.风景

Attys.
APPARATUS FOR CONTROLLING COMPRESSORS.


To all whom it may concern:

Be it known that I, Fred D. Holdsworth, a citizen of the United States, and a resident of Claremont, county of Sullivan, and State of New Hampshire, have invented an Improvement in Apparatus for Controlling Compressors, of which the following description, in connection with the accompanying drawings, is a specification, like characters on the drawings representing like parts.

This invention relates to pressure systems, being more particularly intended to provide improved means for unloading motor-driven compressors during such times as they are being driven below certain predetermined speed limits for the purpose of permitting the driving motor to bring the compressor from rest up to a predetermined speed unloaded.

The invention will be best understood by reference to the following description when taken in connection with the accompanying illustration of one specific embodiment thereof, while its scope will be more particularly pointed out in the appended claims.

In the drawings:

Fig. 1 is an elevation partly broken away showing a compressor to which is applied one form of my invention, the said compressor being shown in conjunction with its driving motor and controlling devices, the latter being represented partly in diagrammatic form.

Fig. 2 is an elevation taken in longitudinal section showing a speed responsive valve controller which is utilized in the apparatus shown in Fig. 1; and

Fig. 3 shows a portion of the valve controller with the valve in a different position from that shown in Fig. 2.

Referring to the drawings and to the illustrated embodiment of the invention therein, I have shown in Fig. 1 a single stage motor-driven compressor which may be of any ordinary or usual type. Herein this embodies the compressor cylinder 1 containing the usual piston (not shown) which is driven from the crank shaft 2, the latter being in turn driven from any suitable motor.

An electric motor 3 is herein diagrammatically represented, there being also diagrammatically indicated the belt connection 4 from the driving pulley 5 on the motor to the driven pulley 6 on the crank shaft 2 of the compressor. The inlet chamber 7 of the compressor is connected through the inlet pipe 8 to the atmosphere. The discharge pipe 9 is connected to any suitable receiver 10 from which compressed air is delivered to the pressure system.

In order to unload the compressor and maintain it in that condition until the driving motor and the compressor have obtained nearly full speed, a speed responsive device indicated at 11 in Fig. 1 is provided which so applies the receiver pressure to the inlet valves 12 (one of which is indicated in Fig. 1) that the latter are lifted from their seats when the motor speed drops below a predetermined limit and are held open until the speed again rises above that limit. For this purpose adjacent the end of the stem of each inlet valve there is provided a small pressure-controlled piston or plunger 13 working in the small cylinder 14 formed in the valve cap. The end of each cylinder 14 is connected through pipes 15 to a common pipe 16 by means of which the end of the plunger 13 may be exposed either to atmospheric pressure on the one hand or a relatively high pressure on the other hand, according to the speed of the motor and compressor. When receiver pressure is admitted to the cylinder 14 the valve 12 is held open and the compressor remains completely unloaded, but when atmospheric pressure is admitted thereto, the unloading device is ineffective and the valve operates in the usual manner.

The control of pressure to the pipe 16 may be effected through any suitable speed responsive means, but herein a centrifugal governor is employed which is driven from a pulley 17 on the compressor shaft 2 connected by a belt 18 to a pulley 19 on the low shaft 20 of the speed responsive member 11.

Referring to the details of the centrifugal governor shown in Figs. 2 and 3, air is conveyed from the storage receiver 10 through the pipe 21 to a chamber in the valve casing 22. The control of the pressure is effected through suitable valve means, which herein for convenience of manufacture comprises two separate valves 23 and 24 with the ends of their stems in abutment. When the valve 23 is lifted from its seat and the valve 24
seated, as represented in Fig. 2, high pressure air is admitted from the pipe 21 through the valve chamber to the pipe 16. On the other hand, when the valve 23 is seated and the valve 24 lifted from its seat (as represented in Fig. 3), communication from the pipe 16 to the pipe 21 is cut off, but is opened from the pipe 16 through the valve chamber to the atmospheric vent 25. Movement of the valves 23 and 24 from one position to the other is controlled by the weights 26 attached to thin spring ribbons 27 and adapted to be rotated through the hollow shaft 20 and pulley 19. The ends of the flat steel springs 27 are securely attached at one end to the head 28 fixed on the shaft 20 and at the opposite end to the head 29 which is telescopically mounted on the end of the shaft and free to slide longitudinally thereon. The sliding head 29 is pinned or otherwise fastened to a pin or plunger 30 the outer end of which has the head 31 abutting against the head 22 of the valve 24.

When the weights move outward, due to centrifugal action, the springs are bent outwardly, as indicated in dotted lines in Fig. 2 and full lines in Fig. 3, and pull the head 29 toward the right, as viewed in Fig. 2. The corresponding movement of the pin 30 allows the valve 24 to leave its seat under the pressure of the spring 33 which is seated against the end of the valve 23. The sliding movement of the head 29 may be limited by the fixed collar 31 on the shaft 20.

The operation of the device is as follows: With the motor at rest the parts stand in the position shown in full lines in Fig. 2, and receiver pressure passes through the valve casing 21 to the pipe 16, holding the inlet valves at each end of the cylinder off from their seats. If the motor is then started, the outward movement of the weights will finally be sufficient to draw the head 29 toward the right, allowing the valve 24 to leave its seat and the valve 23 which is always in contact with it to move to its seat under the influence of the spring 33 and the air pressure back of it. This cuts off the air pressure from beneath the unloading plunger 13, opening the pipe 16 to the atmosphere through the vent 25. This exhausts the air from beneath the plungers and allows the inlet valves to take their normal working position and the work of compression to begin.

If the supply circuit for the motor be opened to stop the compressor, as the speed dies down it reaches a point where the weights assume a position where the valve 24 is seated and the valve 23 lifted. This will permit air from the receiver to pass to the unloading plungers, leaving the compressor in a completely unloaded condition until the motor is again started and reaches the required speed.

The centrifugal weights 26 may be made of such mass and the springs 27 of such a degree of flexibility and the pulley 19 of such size as to give any desired speed before they will act to render the unloading device effective or ineffective, thereby making it possible to adjust the compressor so that it will remain unloaded up to sixty, seventy, eighty, ninety or any other per cent of its full rated speed as required.

To provide adjustment for the speed limit at which the unloading device will act, other than that secured by changing the centrifugal weights, the springs or the pulley, I have provided an additional spring in the form of a coil spring 35 located within the hollow shaft 20. This spring acts at one end against an adjusting screw 36 by means of which its compression may be regulated and at the opposite end against a sliding pin 37 which bears against the end of the plunger 30. By compressing the spring 35 through the adjusting screw 36, the speed limit at which the unloading device will act may be raised and by relaxing the spring through the adjusting screw the speed limit may be lowered.

The centrifugal governor is contained within the casing 38 which provides journals for the rotating elements and is enclosed by the cover 39. The casing 38 is bolted to the framework of the compressor, as indicated in Fig. 1.

The speed-responsive controller for the unloading devices is particularly effective in connection with automatic pressure controlled starting and stopping device by the motor will be stopped when the pressure of the system rises to a predetermined maximum, and again started when such pressure arrives at a predetermined minimum. Such automatic control of the motor, and particularly where an electric motor is employed, imposes a severe duty thereon unless the compressor is completely unloaded and kept unloaded until the motor has attained nearly its full speed.

To automatically control the operation of the compressor responsive to the pressure of the system, the following arrangement is provided: The main terminals 40 and 41 are connected through the switch 42 to the motor leads 43 and 44. The motor circuit 43 is interrupted by the contact switch 45, which latter is normally held open, but may be closed by the energization of the solenoid 46. The solenoid 46 is controlled by a common type Bourdon pressure gauge represented generally at 47, having the pressure controlled pointer 48, the position of which is varied by the receiver pressure admitted through the pipe connection 49. As the pressure falls, the needle or pointer 48...
moves toward the right (represented in Fig. 1) and when it reaches a predetermined point comes into electrical contact with the stop 50. This closes the circuit through the solenoid 46, the connections being from the terminal 41 through the switch 42, the wire 51, contact 50, pointer 48 and wire 52. This closes the switch 45 and starts the motor.

The closing of the switch 45 puts the solenoid into circuit independent of the pointer 48 by causing the bridging switch 53 to bridge the contacts 54 and 55, thereby connecting the circuit 51 with the solenoid independent of the position of the pointer 48.

The motor and the compressor thereupon continue to run until the receiver pressure reaches a predetermined maximum, whereupon the pointer 48 which has been moved toward the left (as viewed in Fig. 1) by the increasing pressure, comes in contact with the stop 56. This acts to short circuit the solenoid and the contact switch 45 springs open, opening the motor circuit and stopping the motor. When the pointer touches the contact 56, the circuit 51 is directly connected with the opposite side of the supply circuit 40 through the contacts 55 and 54, the pointer 48, the contact 56, the connecting wire 57 and the resistance 58 therein.

The result is that as the pressure rises above the required limit, the motor circuit is opened and the motor gradually comes to rest. As soon as its speed drops below the predetermined limit, the unloading devices are rendered effective. When the receiver pressure drops below what is required, the motor circuit is again closed and the motor starts. The compressor, however, remains in its unloaded condition until the predetermined speed limit is reached, at which it may safely take the full load of the compressor. At this point the speed-responsive device renders the unloading devices ineffective. It will be observed that the unloading device operates and continues effective at all times, except when the motor is operating at the required speed.

While I have herein shown and described for purposes of illustration one specific form of the invention and one preferred mode of carrying it into effect, it is to be understood that the same is not limited to immaterial details of construction or procedure herein referred to, but that extensive deviations may be made therefrom without departing from the spirit hereof.

Claims:

1. The combination with an electric motor, of a compressor driven thereby, a receiver, unloading means for the compressor, the same comprising inlet valves with pressure-controlled means for holding the same open, switching devices to automatically start the motor when the receiver pressure drops to a predetermined minimum and to stop the same when said pressure reaches a predetermined maximum, means responsive to the speed of the motor to render the unloading means effective below a predetermined speed limit and ineffective above a predetermined speed limit, said means comprising valve means acting in one position to admit receiver pressure to said pressure-controlled means and in another position acting to open the same to atmospheric pressure, and a centrifugal governor for moving said valve means.

2. The combination with an electric motor, of a compressor driven thereby, a receiver, unloading means for the compressor, switching devices to automatically start the motor when the receiver pressure drops to a predetermined minimum and to stop the same when the said pressure reaches a predetermined maximum, and means responsive to the speed of the motor to render the unloading means effective below and ineffective above a predetermined speed limit.

3. The combination with an electric motor, of a compressor driven thereby, a receiver, pressure-controlled unloading means for the compressor, switching devices to automatically start the motor when the receiver pressure drops to a predetermined minimum and to stop the same when said pressure reaches a predetermined maximum, and means responsive to the speed of the motor to apply pressure to render the unloading means effective below a predetermined speed limit and ineffective above a predetermined speed limit.

4. In a compressor system, the combination of a compressor, a receiver connected therewith, a motor, automatic switching devices controlled by receiver pressure for starting and stopping the motor, compressor driving mechanism actuated by the motor, and compressor unloading mechanism controlled by the speed of the compressor driving mechanism for varying the pressure in the receiver.

5. The combination with a compressor having inlet valves, of driving means therefor, unloading means for said compressor comprising pressure controlled devices for holding the inlet valves of said compressor open, valve means including a plurality of oppositely disposed valve seats and oppositely disposed valve members adapted to contact alternately with said seats controlling said devices, and a governor responsive to compressor speed for controlling the valve means to unloading the compressor during the starting period and to load the same when it reaches a predetermined speed.

6. The combination with an electric motor, of a compressor driven thereby, unloading means for the compressor, automatic
pressure-controlled means to start and stop the motor, and a centrifugal governor to control the unloading means to unload the compressor during the starting period.

7. In a compressor system, the combination of a compressor, a receiver connected therewith, an unloading means, a motor; automatic switching devices to automatically start the motor when the receiver pressure drops to a predetermined minimum and to stop the motor when the pressure reaches a predetermined maximum, compressor driving mechanism actuated by the motor, and means responsive to the speed of the compressor driving mechanism to render the unloading means effective to vary the output of the compressor.

8. In a pressure system the combination of a motor, a compressor driven thereby and supplying pressure to said system, unloading means, means responsive to the pressure of the system to start and stop the motor, and means responsive to motor speed to control the unloading means to unload the compressor during the starting period.

9. The combination with an electric motor, of a compressor driven thereby, pressure responsive means to automatically start the motor when the delivery pressure drops to a predetermined minimum and to stop the same when said pressure reaches a predetermined maximum, a speed-responsive governor, and valve means controlled thereby to apply pressure to open the inlet valves of the compressor when the motor speed drops below a predetermined minimum.

10. The combination with a compressor, of unloading means therefor including a rotatable element, connections to drive the same at a speed proportionate to that of the compressor, centrifugal weights driven by said element, and a plurality of mutually engageable alternately operative valves moved by said weights adapted through their movement to apply pressure to unload the compressor or to relieve pressure to load the same.

11. In a pressure system, the combination of a motor, a compressor driven thereby and supplying pressure to said system, unloading means, pressure responsive means to control the motor, and mechanically operated means responsive to motor speed to control the unloading means, said mechanically operated means including a plurality of valves, part of which controls the flow of fluid pressure to the unloading means and another part of which controls the flow of fluid pressure from the unloading means to the atmosphere.

12. In a pressure system, the combination of a motor, a compressor driven thereby and supplying pressure to said system, unloading means, pressure responsive means to control the motor, and mechanically operated means responsive to motor speed to control the unloading means, said mechanically operated means including a valve adapted to be opened upon an increase in motor speed and closed upon a decrease in motor speed and a second valve adapted to be opened upon a decrease in motor speed and to be closed by spring pressure upon an increase in motor speed.

13. In a pressure system, the combination of a motor, a compressor driven thereby and supplying pressure to said system, unloading means, pressure responsive means to control the motor, a motor driven governor mechanism, and mechanically operated means responsive to said governor mechanism to control the unloading means, said mechanically operated means including a valve member actuated in one direction by the governor mechanism, and resilient means for actuating said valve in the other direction.

14. In a compressor mechanism, the combination with a centrifugal governor, of a casing having receiver and atmospheric connections and a chamber provided with an unloader connection, and means automatically controlled by said governor and including a plurality of mutually engageable and seating valves for establishing communication between said chamber and said receiver connection while interrupting communication between said chamber and the other of said first named connections when the speed of rotation of the governor is below a predetermined minimum.

15. In a compressor mechanism, the combination with a centrifugal governor, of a casing having receiver and atmospheric connections and a chamber provided with an unloader connection, and means automatically controlled by said governor and including a plurality of mutually engageable and seating valves for establishing communication between said chamber and said receiver connection while interrupting communication between said chamber and the other of said first named connections when the speed of rotation of the governor is below a predetermined minimum.

16. In a compressor controlling mechanism, the combination with a centrifugal governor, of a casing having receiver and atmospheric connections and a chamber provided with an unloader connection, and means automatically controlled by said governor and including a plurality of cooperatively operable relatively movable valves operative when the speed of rotation of the governor is above a predetermined rate to establish communication between said chamber and the atmosphere while interrupting communication between said chamber and said connection with the receiver.

17. In a compressor controlling mechanism, the combination with a centrifugal governor, of a casing having receiver and
atmospheric connections and a chamber provided with an unloader connection, and means automatically controlled by said governor and including a plurality of mutually engageable and relatively movable valves for establishing communication between said chamber and said first mentioned connection and simultaneously interrupting communication between said chamber and said second mentioned one of said first named connections when the speed of said governor is below a predetermined speed and for effecting the reversal of said connections when said predetermined speed is exceeded, and means for varying the speed limit at which said reversal of connections is effected.

18. In a compressor controlling mechanism, the combination with a centrifugal governor, of a casing having receiver and atmospheric connections and a chamber provided with an unloader connection, and means automatically controlled by said governor at predetermined speeds and including a plurality of relatively movable end seating valves for alternately establishing communication between said chamber and one of said first named connections while interrupting communication between said chamber and the other of said first mentioned connections, said mechanism operating to connect said chamber with the receiver connection when the governor speed is below a predetermined minimum and with the atmospheric connection when said governor speed is above a predetermined rate.

19. In a compressor controlling mechanism, the combination with a support, a centrifugal governor thereon including a shaft journaled on the support and a member movable longitudinally relative to the shaft as the governor is rotated, of a casing having receiver and atmospheric connections and a chamber provided with an unloader connection, and means automatically controlled by said governor at predetermined speeds and including a plurality of mutually engageable end seating valves for alternately establishing communication between said chamber and one of said first mentioned connections while interrupting communication between said chamber and the other of said first mentioned connections, the connection of said chamber with said receiver connection being made at speeds below a predetermined rate and that with the atmospheric connection at speeds above such rate.

20. In a compressor controlling mechanism, the combination with a support, a centrifugal governor thereon including a shaft journaled on the support and a member movable longitudinally relative to the shaft as the governor is rotated, of a casing having receiver and atmospheric connections and a chamber provided with an unloader connection, and means automatically controlled by said governor at predetermined speeds and including a plurality of mutually engageable end seating valves for alternately establishing communication between said chamber and one of said first mentioned connections while interrupting communication between said chamber and the other of said first mentioned connections, the connection of said chamber with said receiver connection being made at speeds below a predetermined rate and that with the atmospheric connection at speeds above such rate.

21. In a compressor controlling mechanism, the combination with a support, a centrifugal governor thereon including a shaft journaled on the support and a member movable longitudinally relative to the shaft as the governor is rotated, of a casing having receiver and atmospheric connections and a chamber provided with an unloader connection, and means automatically controlled by said governor at predetermined speeds and including a plurality of mutually engageable valves actuated by engagement of said movable member with one of the same, for alternately establishing communication between said chamber and one of said first mentioned connections while interrupting communication between said chamber and the other of said first mentioned connections, the connection of said chamber with said receiver connection being made at speeds below a predetermined rate and that with the atmospheric connection at speeds above such rate.
until said compressor speed falls back to said desired minimum and including a plurality of valves for establishing communication between said chamber and the receiver and interrupting communication between said chamber and the atmospheric connection during the period from the beginning of resumption of compressor running until said predetermined minimum speed is reached.

23. In a compressor system including a receiver, a compressor provided with unloading means, a driving motor for said compressor, and means for interrupting the driving of said compressor by said motor when the receiver pressure reaches a desired limit and for effecting a resumption of the driving of the compressor when said pressure has fallen to a predetermined lower limit, means for causing said unloading means to unload said compressor prior to the resumption of compressor drive and to maintain it unloaded until the speed of the compressor has been brought up to a desired minimum and then reload it including, in combination, a centrifugal governor whose speed is proportional to compressor speed, and a casing having receiver and atmospheric connections and a chamber provided with an unloader connection, and means automatically controlled by said governor until the speed of the compressor reaches the desired minimum but thereafter freed from governor control until said compressor speed falls back to said desired minimum and including a plurality of valves operative during the period from the beginning of resumed compressor running until said predetermined minimum speed is reached to-establish communication between said chamber and the receiver connection and to interrupt communication between said chamber and said atmospheric connection and operative after said predetermined minimum speed has been reached to reverse said connections.

25. In a compressor system including a receiver, a compressor provided with unloading means, a driving motor for said compressor, and means for interrupting the driving of said compressor by said motor when the receiver pressure reaches a desired limit and for effecting a resumption of the driving of the compressor when said pressure has fallen a predetermined amount, means for causing said unloading means to unload said compressor prior to the resumption of compressor drive and to maintain it unloaded until the speed of the compressor has been brought up to a desired minimum and thereupon to reload it including, in combination, a support, a centrifugal governor thereon including a shaft journalied on the support and a member movable longitudinally relative to the shaft as the governor is rotated, a casing having receiver and atmospheric connections and a chamber provided with an unloader connection, and means automatically controlled by said governor and including a plurality of separate mutually engageable valves one of which is engaged by said movable member for alternately establishing communication between said chamber and said first mentioned connections while interrupting communication between said chamber and the other of said first mentioned connections and reversing said connections, said movable member being controlled by said governor to cause said valves to operate to connect said chamber with the receiver connection and to interrupt communication between said chamber and the atmospheric connection at speeds below said predetermined minimum and said member being movable out of contact with the one of said valves which it engages after said predetermined minimum speed is attained to permit interruption of the connection of said chamber with the receiver and its connection to the atmosphere.

26. In a compressor system including a receiver, a compressor provided with unloading means, a driving motor for said compressor, and means for interrupting the driving of said compressor by said motor when the receiver pressure reaches a desired limit and for effecting a resumption of the driving of the compressor when said pressure has fallen a predetermined amount,
means for causing said unloading means to unload said compressor prior to the resumption of compressor drive and to maintain it unloaded until the speed of the compressor has been brought up to a desired minimum and thereupon to reload it including, in combination, a support, a centrifugal governor thereon including a shaft journaled on the support and a member movable longitudinally relative to the shaft as the governor is rotated, a casing having receiver and atmospheric connections and a chamber provided with an unloader connection, and means automatically controlled by said governor and including a plurality of separate mutually engageable valves one of which is engaged by said movable member for alternately establishing communication between said chamber and one of said first mentioned connections while interrupting communication between said chamber and the other of said first mentioned connections and reversing said connections, said movable member being controlled by said governor to cause said valves to operate to connect said chamber with the receiver connection and to interrupt communication between said chamber and the atmospheric connection at speeds below said predetermined minimum and said member being movable out of contact with the one of said valves which it engages after said predetermined minimum speed is attained to permit interruption of the connection of said chamber with the receiver and its connection to the atmosphere, and an adjustable resilient connection between said member and said shaft for varying said minimum speed.

In testimony whereof, I have signed my name to this specification, in the presence of two subscribing witnesses.

FRED D. HOLDSWORTH.

Witnesses:

W. ALEX RICE,

SARAH B. FITCH.