Dec. 31, 1935. W. H. WINEMAN 2,026,293

COMPRESSOR

Filed Jan. 25, 1934

Fig. 1.

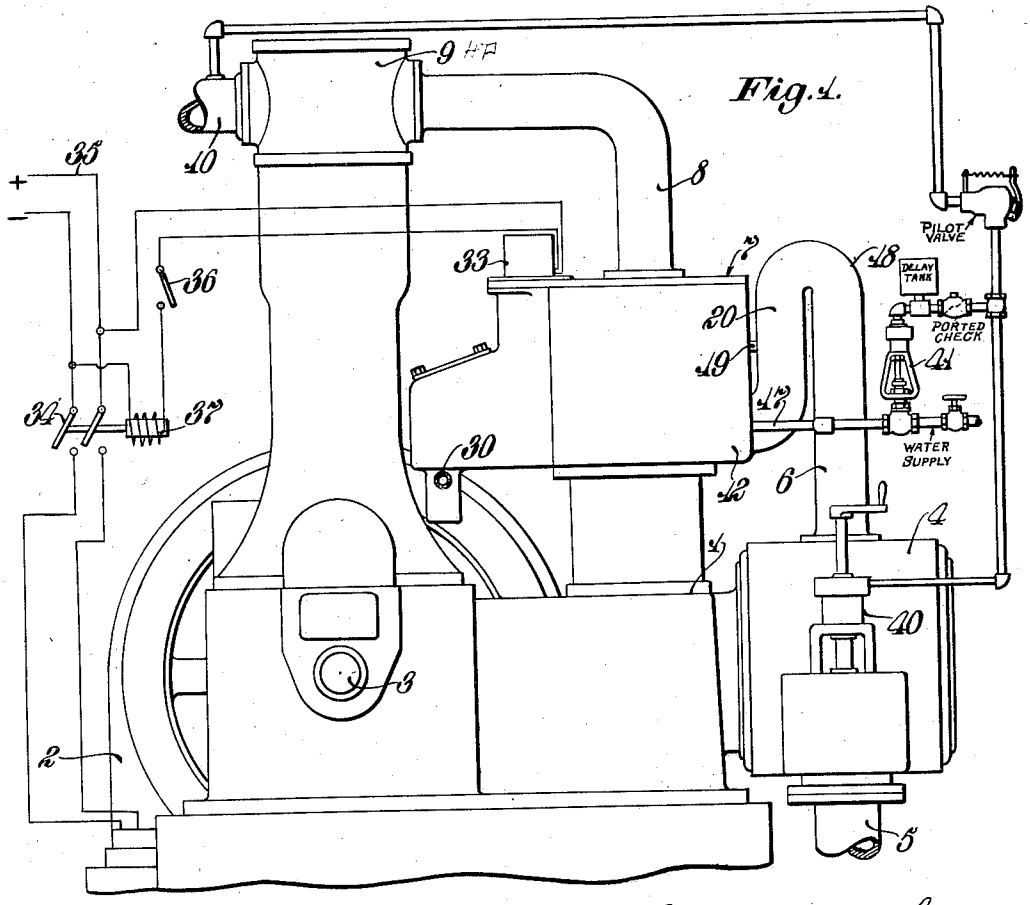


Fig. 2.

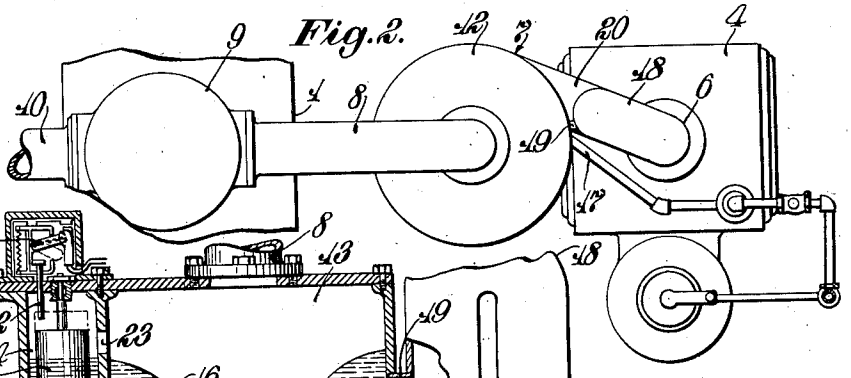
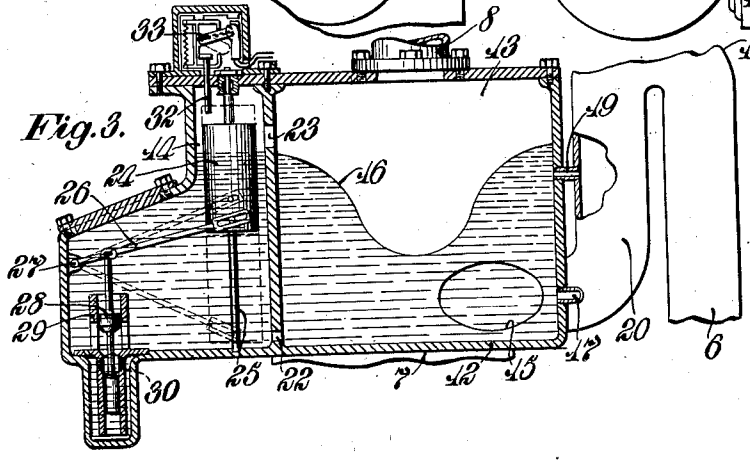


Fig. 3.



Inventor:
Wade H. Wineman.
by
Louis A. Maxon.
Att'y.

Patented Dec. 31, 1935

2,026,293

UNITED STATES PATENT OFFICE

2,026,293

COMPRESSOR

Wade H. Wineman, Michigan City, Ind., assignor to Sullivan Machinery Company, a corporation of Massachusetts

Application January 25, 1934, Serial No. 708,261

14 Claims. (Cl. 230—182)

My invention relates to compressors, and more particularly to heat exchange and liquid removal devices for compressors.

As is well known in compound compressors, it is the best practice to employ an intercooler between stages for the purpose of removing moisture from the air discharged by the lower pressure cylinder, and removing, at least in part, the heat of compression from the partially compressed air. By directly mingling the air discharged by the lower pressure cylinder with a relatively large quantity of cooling liquid, by insuring thorough contact of the air from the low pressure stage with the cooling liquid, by discharging the air below the surface of the liquid and providing other suitable arrangements for effecting intimate contact between the air and the cooling liquid, and by subjecting the mingled fluids to a rapid whirling action, it is possible to obtain a very effectual cooling, and a very substantial reduction in the amount of moisture in the air drawn into the intake to the high pressure cylinder.

One object of my invention is to provide an improved compound compressor. Another object of my invention is to provide an improved compound compressor having an improved intercooler. A further object of my invention is to provide an improved compound compressor having an improved intercooler effecting direct contact between the cooling liquid and the air to be cooled. Still a further object of my invention is to provide an improved compound compressor having an improved intercooler in which direct contact between the air to be cooled and the cooling liquid is effected, and in which automatic protective devices are provided for the purpose of maintaining the desired quantity of cooling liquid in the system. Still another object of my invention is to provide an improved compound compressor having an improved intercooler in which direct contact between the air to be cooled and the cooling liquid is effected, and in which automatic protective devices are provided for the purpose of maintaining the desired quantity of cooling liquid in the system and for shutting down the compressor should the quantity of liquid in the system exceed a safe and desired maximum. Other objects and advantages of the invention will subsequently appear.

In the accompanying drawing, in which one form which the invention may assume is shown for purposes of illustration—

Fig. 1 is a side elevation of a two-stage compressor constructed in accordance with the invention.

Fig. 2 is a fragmentary plan view of the compressor shown in Fig. 1.

Fig. 3 is a vertical sectional view through the intercooling mechanism proper.

In the accompanying drawing, I have shown a compressor, generally designated 1, driven by a motor 2 whose rotor is herein directly connected to the crank shaft 3 of the compressor. While my invention is applicable, of course, to compressors having more than two stages, for simplicity I have shown only a compound compressor, having a low pressure cylinder 4 provided with an intake 5 and having a discharge conduit 6 leading to improved intercooling mechanism, generally designated 7. From the latter a connection 8 leads to the intake side of a high pressure cylinder 9, and after compression to a higher pressure in the high pressure cylinder the air is discharged to any suitable point of use or storage, not shown, through a connection 10.

Now referring more particularly to the construction of the intercooling mechanism 7, it will be observed that this, in the illustrative form, includes a relatively large casing 12 providing a cooling and separating chamber 13 and a float and control chamber 14. The discharge line 6 from the low pressure cylinder opens into the cooling chamber 13 tangentially, as shown at 15. It will be evident that as fluid is discharged into the chamber 13 from the low pressure cylinder, there will be a rapid whirling motion imparted to the contents of the chamber 13. This chamber contains a cooling liquid 16, which even at the relatively high rate of rotation which it assumes during the operation of the compressor, always has a depth at its lowest point greater than the height of the top of the air inlet from the bottom of the casing. During operation, cooling liquid is constantly admitted at a suitable rate through a water conduit 17 which also opens into the chamber 13 more or less tangentially, and in the direction of rotation of the material within the chamber. The water supply passage is reached by the whirling liquid slightly before the mouth 15 of the air delivery passage. The conduit 6, through which the air enters the cooling chamber, is provided with a rebent portion 18 of such height as absolutely to preclude the possibility of any liquid running over into the low pressure cylinder discharge space, and a connection of small diameter 19 is made between the downwardly directed leg 20 of the reverse bend and the chamber 13 to permit equalization of pressure, during un-

loaded operation of the compressor, between the interior of the chamber 13 and the interior of the connection 6. The float chamber 14 communicates with the cooling chamber 13 through a pair of openings, a lower opening 22 and a higher opening 23, so that the pressure in the upper and lower parts of the float chamber may always be the same as in the cooling chamber 13. A float 24 in the float chamber is guided for vertical movement upon a rod 25 and is connected with an arm 26 pivoted at 27 and adapted to move a valve 28 in its casing 29 to control discharge through a port 30 from the float chamber, and accordingly from the cooling chamber. It will be observed that the valve 28 and casing 29 are of such construction that end seating is provided, but that no great pressure is required to lift the valve from its seat. The valve, moreover, opens progressively as the liquid level rises, and accordingly is calculated to regulate the quantity of liquid which is in the chamber 13 and preclude an excessive level being reached. When the float 24 reaches a vertical position higher than that which corresponds to the maximum desired height of liquid in the chamber 13, it is adapted to engage a plunger 32 and actuate to open position a normally closed snap switch 33 which controls a suitable electrically actuated main line switch 34 which delivers current to the motor 2.

From the foregoing description, the mode of operation of the invention as so far described, will be readily understood. The main line switch is connected with a source of power 35 by closing a manually operated starting pilot switch 36 which energizes a solenoid 37 which draws the main line switch to closed position. Of course a more complicated starting system may be used if desired, particularly with larger sized motors, but the one illustrated and described is to be understood as merely a simplified disclosure of the intended mode of control.

When the motor is driving the compressor, air is drawn in through the intake 5 and compressed in the low pressure cylinder 4. It is then discharged through the pipe 6 and its return bend 18, through the port 15, into the chamber 13 below the level of the liquid therein, where it imparts a very rapid rotation to the liquid. The unloading means 40 for the low pressure cylinder and the water supply control valve 41 are so constructed and arranged that, preferably after a small time lag after reloading takes place, the control valve is opened to permit initiation of further liquid supply through the connection 17. Correspondingly, it will be noted that the liquid supply may be cut off each time the compressor unloads to economize on the amount of liquid used. The entering liquid stream through the connection 17, and the relatively large volume of air from the low pressure cylinder discharge, and the liquid already in the chamber 13, are intimately commingled and every particle of the air will be cooled, and the moisture carried over with the discharged air and condensed during the first stage of compression will be separated out of the air during and through the whirling action in the chamber 13; and accordingly when the air separates in the chamber prior to its discharge through the top thereof to the passage 8, there will be both a cooling and a removal of substantially all the excess liquid which was in the air discharged from the low pressure cylinder, and there will be delivered to the high pressure cylinder air in a suitably cooled condition and with a humidity of practically one hundred percent, it being impractical to reduce the amount of moisture in the air below that point. Should there be, for any reason, a more rapid supply of liquid through the passage 17, or slower escape of liquid through the passage 30, than is desired for the purpose of maintaining the proper liquid height in the chamber 13, the float valve 24 which, by raising the valve member 28, increases the discharge area as the liquid height rises, will finally engage the plunger 32 and move the switch 33 to open the circuit at the main line switch 34 and shut down the entire system. When unloading occurs, the compressed fluid will no longer be supplied to the chamber 13, and the liquid will assume a level at a point below the equalizing passage 19, though above the top of the opening 15, and accordingly there will be a continuous communication directly from a point in the discharge space of the low pressure cylinder through to the inlet space of the high pressure cylinder. The passage 19, by virtue of its small size and its submergence during pumping, will not interfere with the effective intercooler action.

From the foregoing description, it will be apparent that I have disclosed an improved compressor having improved intercooling means of great simplicity, without the need for the packing of many joints, with a very effectual cooling and separation of the compressed air from the cooling liquid, with an automatic control of the liquid level to protect the compressor from any possibility of access of the liquid to places that would be damaged thereby, and with economy of cooling liquid.

While I have in this application specifically described one form which the invention may assume in practice, it will be understood that this form is shown for purposes of illustration 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 combination, in a compressor, a low pressure cylinder, a high pressure cylinder, and an intercooler between said cylinders having provision for the direct mingling of the air passing between said cylinders with a cooling liquid and for the separation of the liquid from the cooled air.

2. In combination, in a compressor, a low pressure cylinder, a high pressure cylinder, and an intercooler between said cylinders having provision for the direct mingling of the air passing between said cylinders with a cooling liquid and for the separation of the liquid from the cooled air including a centrifugal air and liquid mixing and separating device.

3. In combination, in a compressor, a low pressure cylinder, a high pressure cylinder, and an intercooler between said cylinders having provision for the mingling of the air flowing between the cylinders directly with a liquid, comprising a chamber containing a liquid, and means for discharging the entering air beneath the level of the liquid.

4. In combination, in a compressor, a low pressure cylinder, a high pressure cylinder, and an intercooler between said cylinders having provision for the mingling of the air flowing between the cylinders directly with a liquid, comprising a chamber containing a liquid, and means for discharging the entering air beneath the level of the liquid in a tangential direction.

5. In combination, in a compressor, a low pres-

sure cylinder, a high pressure cylinder, and an intercooler between said cylinders having provision for the mingling of the air flowing between the cylinders directly with a liquid, comprising a chamber containing a liquid, and means for discharging the entering air beneath the level of the liquid in a tangential direction and having provision for admitting replacement cooling liquid also tangentially.

6. In combination, in a compressor, a low pressure cylinder, a high pressure cylinder, and an intercooler between the same having provision for the direct mingling of the air flowing between the cylinders with a liquid, comprising means providing a circular chamber having means for supplying cooling liquid thereto, and means for providing a regulated discharge of liquid therefrom under control of the height assumed by the liquid therein.

7. In combination, in a compressor system, a compound compressor having an intercooler providing for direct intermingling of the air and a cooling liquid, means for controlling the quantity of liquid in said intercooler, and means controlled by the liquid level for stopping said compressor upon too high a liquid level.

8. In combination, in a compressor system, a compound compressor having an intercooler providing for direct intermingling of the air and a cooling liquid in a centrifugal-type separating chamber, means for controlling the quantity of liquid in said intercooler chamber, and means controlled by the liquid level for stopping said compressor upon too high a liquid level.

9. In combination, in a compressor system, a compound compressor having an intercooler providing a substantial quantity of liquid beneath whose surface air flowing between the cylinders enters the intercooler, means for changing the liquid relatively continuously during pumping operation of the compressor, and means for discontinuing liquid changing automatically when pumping operation ceases.

10. In combination, in a compressor system, a compound compressor equipped with unloading means and having an intercooler providing a substantial quantity of liquid beneath whose surface air flowing between the cylinders enters the intercooler, means for changing the liquid relatively continuously during pumping operation of the compressor, and means for discontinuing liquid changing automatically when the compressor is operating unloaded.

11. In combination, in a compressor system, a compound compressor having an intercooler providing a substantial quantity of liquid beneath whose surface air flowing between the cylinders enters the intercooler, means including a liquid supply effective substantially continuously during pumping operation of the compressor, for changing the liquid in the intercooler, means for discontinuing liquid changing automatically when pumping operation ceases, and means for automatically stopping the compressor in the event of excessively high liquid level in the intercooler.

12. In combination, in a compressor system having unloading means, a compound compressor having an intercooler providing a substantial quantity of liquid beneath whose surface air flowing between the cylinders enters the intercooler, means including a liquid supply effective substantially continuously during loaded compressor operation, for changing the liquid in the intercooler, means for discontinuing liquid changing automatically when the compressor is operating unloaded, and means for stopping the compressor automatically in the event of excessively high liquid level in the intercooler.

13. In combination, in a compressor system, a compound compressor having a low pressure cylinder and an intercooler containing a substantial quantity of liquid maintained during pumping operation of the compressor in rotation at such a rate that the surface of said liquid at the periphery of the intercooler is at a higher level during pumping operation than upon the interrupting of pumping operation, a connection for the air flowing between the cylinders entering the intercooler at a point below the static liquid level in the latter, every point in one vertical section through said connection, at at least one point in the latter, being higher than the maximum peripheral height of the liquid in the intercooler at any time, and means for establishing communication between said connection and the interior of said intercooler at a point in the latter submerged during pumping operation of the compressor but uncovered when pumping operation ceases.

14. In combination, in a compressor system, a compound compressor having a low pressure cylinder equipped with a total closure intake-type unloader, having further an intercooler containing a substantial quantity of liquid maintained during pumping operation of the compressor in rotation at such a rate that the surface of said liquid at the periphery of the intercooler is at a higher level during pumping operation than upon the interrupting of pumping operation, a connection for the air flowing between the cylinders entering the intercooler at a point below the static liquid level in the latter, every point in one vertical section through said connection, at at least one point in the latter, being higher than the maximum peripheral height of the liquid in the intercooler at any time, and means for establishing communication between said connection and the interior of said intercooler at a point in the latter submerged during pumping operation of the compressor but uncovered when pumping operation ceases.

WADE H. WINEMAN.