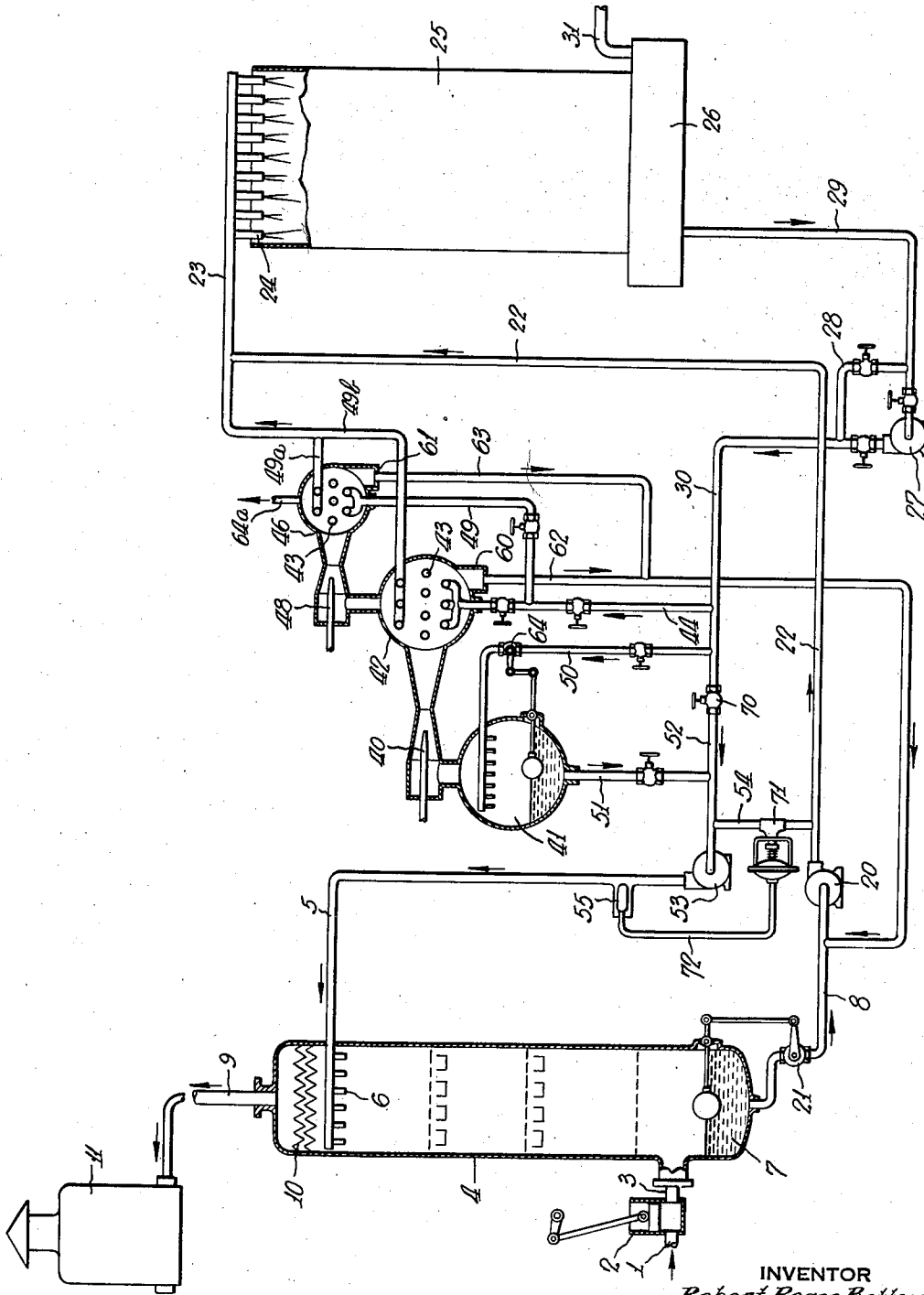


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R. R. BOTTOMS
AIR CONDITIONING METHOD

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INVENTOR
Robert Roger Bottoms
BY
Dean T. Hirsch
ATTORNEYS

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AIR CONDITIONING METHOD

Robert Roger Bottoms, Louisville, Ky., assignor
to The Girdler Corporation, Louisville, Ky., a
corporation of Delaware

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This invention relates generally to a process for conditioning air or other gases or gaseous mixtures wherein the moisture content, temperature and pressure must be closely regulated and in an economical manner. In a more limited sense the invention has application to the conditioning of the large quantities of air such as used in blast furnaces and other metallurgical apparatus. In an installation of this nature wherein extremely large quantities of air must be treated and wherein the condition of the treated air entering the furnace or other apparatus is preferably constant regardless of the external atmospheric conditions, a number of difficult problems are encountered.

In the first place such air as taken from the atmosphere varies in its moisture content and temperature continuously with the atmospheric conditions. For example, it has been found that the quantity of moisture in the air may vary from less than 1 grain per cubic foot of air during certain winter conditions to more than ten grains per cubic foot of air during summer conditions. In the latter case it has been calculated that more than 70 tons of unnecessary water vapor would be fed into a blast furnace during a 24 hour period if untreated atmospheric air of this nature were used. The presence of this large amount of undesirable water vapor reduces the efficiency of the furnace and involves a waste of fuel and a lowering of the useful charge capacity of the furnace.

While the elimination of excess water vapor is highly desirable in standard blast furnace practice the elimination of all moisture is undesirable, and unless the atmosphere happens to contain the right amount of water vapor, it is desirable either to add moisture thereto or to extract moisture therefrom. The optimum moisture content has been found to be about 3 grains of water vapor per cubic foot at standard conditions. In the past various methods and various means for regulating and controlling the amount of water vapor introduced to or extracted from blast furnace air has been proposed, but due to the initial cost of the same and/or the operating costs of the same they have not been brought in commercial use.

In the usual case in such methods, it has been found necessary to employ some type of commercial refrigeration in order to lower the temperature of the air sufficiently to regulate the moisture content thereof.

In view of the customary lack of adequate water supply or lack of a water supply at a suffi-

cient low temperature, and also in view of the excessive cost of the necessary refrigerating equipment for the air and operation of the same, the conditioning of blast furnace air has proven to be very high in cost and prohibitive as a practical proposition.

The present invention relates to a simple and efficient method of so conditioning large quantities of air without entailing a large amount of apparatus and without requiring expensive refrigeration. As a result of my invention it is now possible to provide an invariable and constant supply of conditioned air merely by utilizing a dual evaporative cooling stage requiring no separate refrigerating medium. Based upon the well known physical fact that the moisture content of a cubic foot of any gas when saturated is practically independent of the pressure at which this cubic foot of gas exists, I propose, in my improved air conditioning system, to draw the air in from the atmosphere regardless of the atmospheric conditions, and to compress and then treat the air in such a compressed condition as hereinafter set forth. Following this treatment the air may then be led to a point of utilization and have the exact amount of moisture content and the exact pressure required in that utilization.

For example, if such air is to be used under certain standard conditions, it will have 3.1 grains of moisture per cubic foot at these conditions, after being expanded from a saturated condition of 8.4 grains of moisture per cubic foot of gas at 71° F. and 25 pounds gauge pressure.

In the accompanying drawing the single figure shows diagrammatically one application of my invention. As illustrated air is taken from the atmosphere through inlet 1 and compressed by compressor 2 to a pressure in the neighborhood of 25 pounds per square inch. During this compression the temperature of the air is appreciably raised. As a consequence the air enters pipe 3 leading into tower 4 at a pressure of 25 pounds and a temperature of about 235° F. Based upon the assumption that the air to be used in the blast furnace should have a moisture content of 3.1 grains per cubic foot at standard conditions it will then become necessary to lower the temperature of the air from 235° F. to 71° F. provided the 25 pounds pressure is maintained. At this 25 pounds pressure and 71° F. a cubic foot of air can hold a maximum of 8.4 grains of moisture and under these conditions the air is completely saturated. Therefore, by deliberately saturating the air at these conditions it becomes

possible to provide an invariable and constant amount of moisture in the air leaving the process. Since the saturation of air and the removal of excess free water therefrom is a simple matter it follows that it is immaterial whether the air entering the process originally has an excess or deficiency of moisture, since the process can either add or extract moisture during the saturation phase.

The above method of conditioning air has long been known, but due to the problem of providing a cooling medium which will bring such enormous quantities of air down to the temperature commensurate with the saturation temperature required, the practical application of this knowledge has been greatly impaired. Tremendous quantities of water having a temperature lower than 71° F. would be required if water alone were used as a cooling medium. Since such a water supply is rarely, if ever available, it has been necessary to have recourse to commercial refrigeration, but in view of the large quantities of air being treated this has involved such a high cost that the blast furnace operators have been compelled to forego the benefits of the use of conditioned air.

In my process the air entering the tower 4 at a temperature of 235° F. is brought into intimate contact with large quantities of water at 70° F. entering the tower through pipe 5 and being sprayed into the tower through jets 6. By virtue of the intimate contact of these large quantities of cooled water flowing countercurrent to the gases the latter are reduced in temperature to about 71° F. while maintaining the pressure of 25 pounds per square inch. The spraying by means of the jets is merely a diagrammatic showing of means for effecting the desired intimate contact, and the term "sprayed" is used to include any trickling, dropping, or other means for effecting the desired intimate contact.

In the event that the gases originally contained more than 8.4 grains of moisture per cubic foot under these conditions they will precipitate out such excess moisture which will then pass with the cooling water into the base 7 of the tower for removal through pipe 8. On the other hand, if the moisture originally contained is not sufficient to give the compressed gases as much as 8.4 grains of water per cubic foot, the gases will absorb the necessary amount of water to establish this saturated condition. In either event the gases will pass in a saturated condition from the top of the tower across baffles 10 serving to remove free liquid and then through pipe 9 at the required temperature, pressure and moisture content to any point of utilization, as for example, a conventional type hot blast stove 11 of a standard blast furnace.

From the foregoing it will be obvious that the successful application of this desirable result depends entirely upon a continuous and reliable source of large quantities of cooling water maintained at an invariable temperature of 70° F. and constantly available for introduction through pipe 5.

One method of securing this desirable result will now be described, although it will be apparent to those skilled in the art that variations and modifications thereof may be adapted without departing from the scope or intent of this invention.

Pump 20 serves to withdraw a continuous supply of recirculating water and moisture taken from the gas under treatment from the tower

through pipe 8 and under control of a conventional float control valve 21. Merely as one example, it may be assumed that the water withdrawn through pipe 8 will be at approximately 126° F. and that the pump 20 may have a capacity of about 600 gallons per minute. From pump 20 all or a part of the water leaving tower 4 may be directed through pipe 22 into pipe 23 terminating in sprays 24 above a conventional atmospheric cooling tower 25. Since the water thus sprayed into tower 25 at 126° F. will be much hotter than the surrounding atmosphere it follows that substantial quantities of this water will be evaporated and will be carried away by natural or induced air currents. It is significant to note that tower 25 provides the sole exit from the system of all moisture. Reference to this point will be made hereafter.

From tower 25 the cooled water may pass into a basin 26 and may have a temperature approximating 85° F. Make-up water supplied from any suitable source and of any desired temperature may be added to the process by introduction through pipe 31 into basin 26 and is there mixed with the cooled water coming from tower 25. A large pump 27, having a valve control bypass 28 therearound, serves to withdraw the water from basin 26 through a pipe 29 and direct it into pipe 30. At this point it will be noted the water in pipe 30 will ordinarily be at a temperature in excess of that required for spraying into tower 4, but on a cold winter day it might be too cold. An important feature of the present invention is the provision of means for insuring a supply of water to pipe 5 which will always be at the desired temperature.

In order to obtain this result without the use of a special refrigerating medium, I employ a complementary evaporative cooling step which may be in one or more stages. In the normal operation of the usual blast furnace there is a large amount of waste steam available at low pressure ranging from 0 to 15 pounds gauge which is ideally adapted for use in the operation of my invention. I utilize a jet of this steam to form a partial vacuum, and utilize such vacuum to partially evaporate and thereby cool water delivered by the pump 27. As shown I provide an evaporator 41 into which water is sprayed from a pipe 50 leading from the pipe 30. The cooled water returns to the pipe 30 through a pipe 51. I direct a suitable quantity of the low pressure steam through a conventional jet 40 serving to lower the vapor pressure in a cooling vessel 41. Such exhaust steam together with entrained water vapor may pass into a condenser 42 of any suitable construction.

For convenience, I have shown a surface condenser having a series of condensing tubes 43 through which is circulated a portion of the relatively cooled liquid received from pipe 30 through a connecting pipe 44. A supplementary ejector 48 may receive a portion of waste steam and may serve to maintain a high vacuum in condenser 42 by withdrawing entrained air and water vapor from condenser 42 and deliver them to a second condenser 46 having condenser tubes 43 and a vent 64a to the atmosphere. Cooled condensing liquid may be supplied to the tubes of condensers 42 and 46 in parallel, by a pipe 49 having branches leading from the pipe 30. These may have valves whereby the flow to each branch may be controlled or shut off. The heated condensing waters leaving the tubes of the two condensers may be brought together and conducted by pipes

49a and 49b into the spray pipe 23 for subsequent cooling. Any suitable condensate traps 60 and 61 in condensers 42 and 46 may be provided with outlet pipes 62 and 63 for removal of the condensed steam. This condensate may then be conducted back into pipe 8 ahead of pump 20 under control of any suitable control valves (not shown).

It is contemplated that a barometric type of condenser could be used in lieu of either or both of the surface condensers 42 and 46 when such a substitution is found to be more desirable. The rate of flow of water through the pipe 50 may be controlled by a valve 64 operated by a float in the chamber 41.

By means of the system thus disclosed it becomes possible to direct a necessary portion of the water in pipe 30 through a spray pipe 50 controlled by the necessary valves and float control mechanism and to spray this water at a temperature of about 85° F. into the cooling vessel 41 in which a lower vapor pressure is being maintained by the action of ejector 40. Within the vessel 41 the water thus sprayed may be reduced in temperature to approximately 70° F. through vaporization of a portion of the same and may then be delivered through a pipe 51 into a pipe 52 leading to pump 53, which forces the water through the pipe 5 into the spray 6 of the high pressure chamber 4. This pump then forces the water having a temperature of 70° F. back into spray pipe 5 serving to spray the water into the conditioning tower 4. The pipes 52 and 30 may be directly connected by a valve 70 so that when the valve is open the evaporator 41 may be bypassed, and by controlling the valve any desired portion of the water delivered by the pump 27 may be led to the evaporator and further cooled.

In order to take care of conditions in which a higher temperature than 70° F. may be desired in pipe 5 or in which the water from pipe 51 and/or pipe 30 may then be lower than 70° F., I provide a bypass 54 between the pipes 22 and 52 and having a valve 71 controlled by any conventional thermostatic element 55 responsive to the temperature of water in pipe 5. The diaphragm of the valve may be connected to the bulb of the thermostatic element by a pressure fluid tube 72. By means of this arrangement it is possible to bypass any desired quantity of the high temperature water in pipe 8 back into the lines leading to spray pipe 5. Any suitable type of thermostat control may be used upon the various valves indicated generally in pipes 51, 30, 50 and 44 in order to provide an automatic control of the system when such appears to be desirable.

As a result of this system and this sequence of condensing and cooling steps for compressed air, it is possible to achieve the desirable objectives set forth hereinabove. Although the operation of this process may require the use of many tons of water per day when conditioning large quantities of air, nevertheless it enables the user to employ the efficient and economical evaporative cooling process in lieu of the relatively expensive refrigeration process heretofore considered necessary and to use external water sources which may be at temperatures appreciably above the 70° F. required by the process. The process permits water at a predetermined temperature to be employed regardless of variations in the temperature of the source of water supply and the outside atmosphere.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. The method of cooling and dehydrating compressed gas at elevated temperature, which involves circulating water in a closed cycle, including a spray in contact with the compressed gas, an evaporative action at atmospheric pressure and in finely divided condition, and an evaporative action under subatmospheric pressure and in finely divided condition, creating said subatmospheric pressure by the action of a steam jet, condensing the steam from said jet and adding at least a portion of it to said closed cycle, and controlling the temperature of the water delivered to said spray by varying the portion of the water delivered to said evaporative action under subatmospheric pressure.

2. The method of cooling and dehydrating compressed gas at elevated temperature, which involves circulating water in a closed cycle, including a spray in contact with the compressed gas, an evaporative action at atmospheric pressure and in finely divided condition, and an evaporative action under subatmospheric pressure and in finely divided condition, creating said subatmospheric pressure by the action of a steam jet, condensing the steam from said jet and adding at least a portion of it to said closed cycle, and controlling the temperature of the water delivered to said spray by bypassing a portion of the water without passing through said evaporative action at atmospheric pressure.

3. The method of cooling and dehydrating compressed gas at elevated temperature, which involves circulating water in a closed cycle, including a spray in contact with the compressed gas, an evaporative action at atmospheric pressure and in finely divided condition, and an evaporative action under subatmospheric pressure and in finely divided condition, creating said subatmospheric pressure by the action of a steam jet, condensing the steam from said jet and adding at least a portion of it to said closed cycle, and controlling the temperature of the water delivered to said spray by bypassing a portion of the water without passing through said evaporative action at subatmospheric pressure.

4. In the cooling and dehydrating of large volumes of compressed gas at an elevated temperature by the action of a spray of cooled water, and in which the water is heated and increased in volume by the absorption of moisture from the gas, the method of providing the required volume of cooled water from a limited supply source, and independent of the temperature of said source, which method consists in withdrawing the heated water after contact with the heated, compressed gas, subjecting at least a portion of the heated water to a cooling evaporative action at atmospheric pressure, creating a subatmospheric pressure by the action of a steam jet, subjecting at least a portion of this cooled water to a cooling evaporative action at said subatmospheric pressure, mixing at least a part of the liquid resulting from the condensation of said steam jet with the water to be evaporated at atmospheric pressure, and then returning the cooled water for further heating in contact with said gas.

5. The method of providing a circulating body of cooled water from a limited source, and for use in cooling large volumes of heated, compressed gas, which method includes withdrawing the heated water after contact with the

- gas, and then subjecting at least a portion of the heated water to a cooling evaporative action at atmospheric pressure, creating a subatmospheric pressure by the action of a steam jet, 5
5 subjecting at least a portion of this cooled water to a cooling evaporative action at said subatmospheric pressure, mixing at least a part of the liquid resulting from the condensation of said steam jet with the water to be evaporated at at- 10
10 mospheric pressure, and then returning the cooled water for further heating in contact with said gas.
6. The method of providing a circulating body of cooled water from a limited source, to be 15
15 sprayed into large volumes of heated, compressed gas to cool the latter, which method includes withdrawing the heated water after contact with the gas, subjecting at least a portion of the heated water to a cooling evaporative action at 20
20 atmospheric pressure, subjecting at least a portion of this cooled water to a cooling evaporative

action at subatmospheric pressure, returning all of the unevaporated water for further heating in contact with said gas, and varying the relative proportions of the water subjected to said evaporative actions to control the temperature of the returned water. 5

7. The method of cooling and dehydrating compressed gas at elevated temperature, which involves circulating water in a closed cycle, including a spray in contact with the compressed gas, an evaporative action at atmospheric pressure and in finely divided condition, and an evaporative action under subatmospheric pressure and in finely divided condition, creating said subatmospheric pressure by the action of a steam jet, condensing the steam from said jet by the action of a portion of the water cooled by the first evaporative action, and returning the water used to effect said condensation to said cycle for further evaporative action and cooling. 10
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ROBERT ROGER BOTTOMS.