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METHOD AND APPARATUS FOR DEHUMIDIFYING AND COOLING THE AIR OF MINES

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Fig. 1.

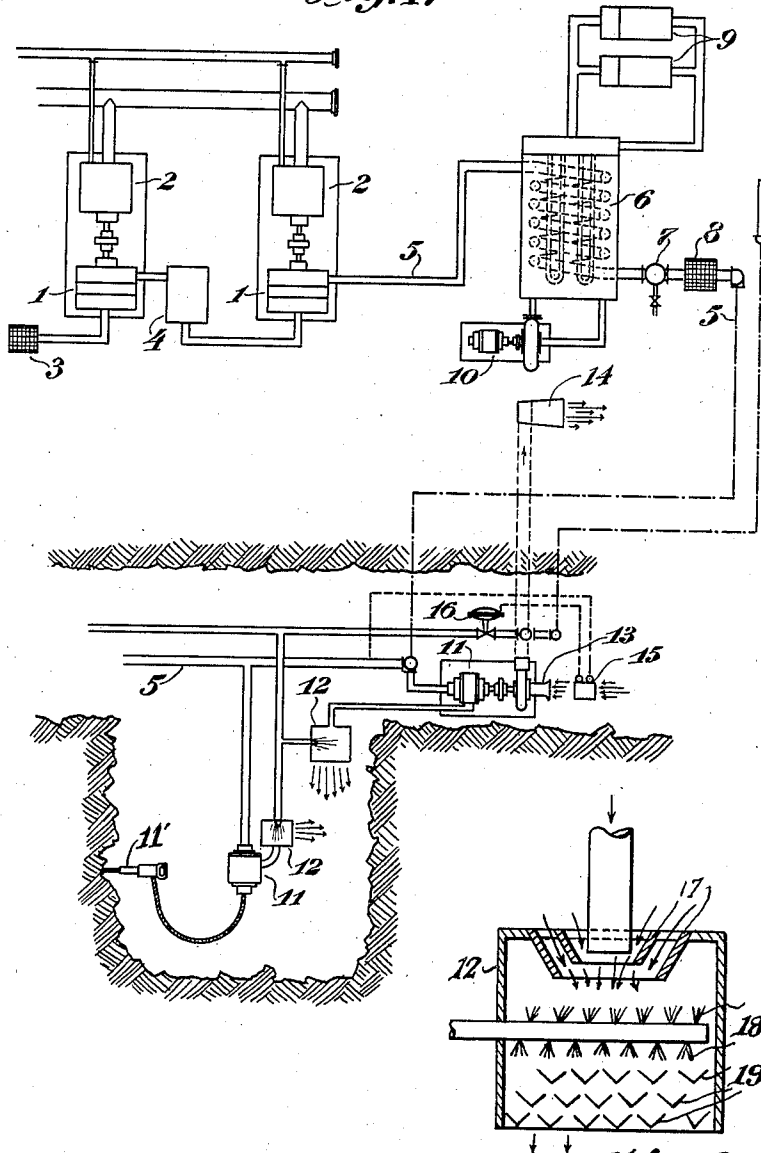


Fig. 2.

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METHOD AND APPARATUS FOR DEHUMIDIFYING AND COOLING THE AIR OF MINES

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11 Claims. (Cl. 62-138)

My invention relates to methods of, and means for conditioning air, and is especially suited for deep mines and long tunnels.

One object of my invention is to provide an ample supply of cool, fresh air in chambers that are far distant from the source of supply.

Another object of my invention is to provide an efficient method of refrigerating the workings of deep mines that, as is well known, become unendurably hot on account of the heat absorbed from the rock walls, from the workers, and from the power tools used in working the mines.

A further object of my invention is to provide means for lowering the humidity of the air in the mines. This is generally excessive, especially where seepage occurs in large quantities. The workers also steadily contribute moisture from their perspiration and respiration. This must be absorbed by and carried away in the air stream if work is to proceed without interruption.

A further object of my invention is to provide a supply of fresh air to deep mines in such a manner that the minimum amount suffices for the purposes of respiration and lowering the temperature and humidity for proper ventilation. These and such other objects of my invention as may hereinafter appear from the drawing and description are intended to be claimed in the appended claims.

In the drawing, Figure 1 represents a diagrammatic view of the equipment at the surface for supplying air to the mine, one level of which is shown in horizontal section; and

Figure 2 is a plan, in section, of a detail.

At the surface, I provide compressors 1 driven by turbines 2 and drawing air from the atmosphere through a filter 3. Intercooler 4 is inserted between the compressors 1 in the customary manner. The air is carried from the compressors by the pipe 5 through the direct-expansion brine cooler 6 and then through water trap 7 and final filter 8 down into the mine. Refrigerating machines 9 supply refrigerant to the brine cooler 6 that is provided with the brine circulating pump 10.

In the mine, I provide the main conduit 5 with a number of branch outlets, each consisting of turbine-expander 11, or other suitable means for effecting cooling of the compressed air by expansion while doing useful work. After passing through such means the cold dry air is led to a mixing box 12 where it is mixed with a portion of the air drawn into the box through inductor cones 17 (see Figure 2). The mixture of air then passes through a water spray 18 and thence past

eliminators 19 into the atmosphere of the mine. I also provide an exhaust fan 13, preferably actuated by one of the turbines 11, for removing the used air from the mine through exhaust conduit 14 to the surface. Humidistat 15 is surrounded by the air being exhausted by blower 13 and connected to a valve 16 for the water supplied to sprays 18 to control the amount supplied thereto in inverse proportion to the relative humidity of the exhaust air.

The operation of my preferred embodiment, above-described, is as follows: The air is drawn from the atmosphere through a filter 3 that removes any dust or other non-gaseous impurities. The turbines 2 drive the multistage turbo- or centrifugal-compressors 1 that take the filtered air at atmospheric pressure and raise it to that in the main discharge conduit 5, say 125 pounds per square inch gauge. Intercooler 4 between compression stages refrigerates the air in the well known manner to produce efficient compression. This intercooler is provided with a drain so that the moisture is removed from the air. Following the last stage of compression, the brine cooler 6 removes practically all of the remaining moisture from the air; a final water trap 7 and filter 8 being provided.

By the use of turbo-compressors, I avoid introducing lubricating oil into the fresh air supply. This makes it more suitable for breathing day after day by the miners. While I ordinarily use a brine cooler 6 for dehumidifying the air, this may be alternatively done, as by absorbers of the silica-gel type, in certain cases.

This supply of compressed, fresh, dry air then flows through main conduit 5 into the depths of the mine. Since this air is highly compressed, it requires only a relatively small pipe to carry the requisite quantity to the considerable distances involved in a mine of 10,000 feet depth, for example. Further in such mines there is a considerable "barometric" effect of the dense air descending and the warm, light air ascending, while being exhausted, that assists materially in the efficient transportation of the ventilating air according to my invention.

The compressed air is cool as it leaves the brine cooler 6 at the surface. This cool air becomes warmer at it flows down the descending pipe 5, rapidly reaching the mine temperature. There is an appreciable cooling effect exerted by the air during its journey, although this is only incidental.

The air is expanded at the level of the workings through turbines 11, driving the exhaust blower

13 and an electrical generator (not shown) for examples, drilling machines 11', etc. It is preferable to take out energy from the compressed air in the form of necessary work and thus obtain the maximum lowering of air temperature from that of the mine to a condition of, say, 0 degrees Fahrenheit and practically 0 percent relative humidity. This air thus has a large capacity for absorbing both heat and moisture. Consequently this dry air mixes with that in the workings and improves its condition both as to temperature and humidity.

Prior to final discharge into the atmosphere of the mines the expanded and very cold air leaving the turbines 11 is first led to mixing boxes 12 into which a portion of the hot mine air is also admitted. The resulting mixture is of much higher temperature than that of the expanded compressed air and somewhat lower than that of the portion of mine air brought into the mixing box, and the mixture is very dry. The water sprays 18 furnish a finely divided liquid fog that rapidly evaporates into the dry air mixture and produces a considerable additional refrigerating effect. In other words, the latent heat of vaporization of this water is used so that it, in effect, acts as a refrigerant. Water has the great advantage over other refrigerants for this use in that leakage is entirely harmless, non-toxic and incombustible. The humidified mixture which is necessarily cold, passes through the eliminators 19 which remove any free water, and thence into the mine chamber. Being cold the discharge mixture lowers the temperature of the mine atmosphere. As the cold mixture warms up, it becomes capable of absorbing more moisture and thus by evaporative action the relative humidity of the mine atmosphere is reduced. Humidistat 15 responds to the relative humidity of the used air being exhausted by blower 13 through conduit 14 to the surface. The humidistat 15 so controls the amount of water fed to sprays 12 as to maintain a relative humidity of 40 percent, for example, and thus obtain the largest amount of refrigeration from evaporation consistent with the decrease of comfort with humidity.

For example, where 90 degrees Fahrenheit is the maximum permissible temperature of the air leaving the workings, it requires approximately 50 percent more dry air to effect the necessary cooling than it does where the seepage and/or water otherwise supplied brings the relative humidity up to 40 percent, which is a conservatively low humidity.

There is no difficulty in carrying the water to the sprays 18 since it will flow readily by gravity. Then it forms a vapor that decreases the density of the air being exhausted so that it tends to rise more easily to the surface than it would if it were dry.

My system of ventilation reduces the air and water conduit dimensions to a minimum and may save the great expense of sinking a separate ventilating shaft in deep mines. Further, a reduction in the conduit sizes means a worthwhile reduction in the cost of the conduits themselves in mines of a depth of more than one mile since miles of piping are required for the adequate ventilation of the workings.

The used air passes back through the galleries of the deep level, becoming more heated and so cooling the mine there. Since this air is expanding constantly as it passes outward to the main shaft, its relative humidity is not unduly increased. In deep mines where the air pressure

sustains about 40 inches of mercury in a barometer as compared with 30 inches at sea level, my improved method of combining the necessary ventilation and cooling in a single uninsulated pipe (for air) of moderate dimensions permits an adequate supply of fresh air to be supplied so that miners can work a full shift with unimpaired efficiency, an object long sought and rarely achieved before.

While my invention has been described for a mine it may also be used for long tunnels, and for skyscraper ventilation where ordinary air conditioning systems have proven expensive and troublesome due to the amount of valuable space required for ducts carrying air at low pressure, and to the infiltration problems caused by high wind-pressures acting upon tall buildings.

Although I have shown and described the preferred embodiment of my invention, I do not wish to be limited thereto in the appended claims which I intend to have cover whatever is new and useful.

I claim:

1. In a mine ventilating system, the method of supplying the minimum amount of air to accomplish a given amount of cooling of said mine that comprises compressing, and dehumidifying said air at the entrance of said mine, transporting it at considerably more than one atmosphere pressure to the deep workings of said mine, there expanding it to the atmospheric pressure therein, mixing it with the hot air of the mine and evaporating water in said mixed air to further lower its temperature.

2. In a mine ventilating system, the combination of a conduit for air under pressure, an expansion nozzle connected to said conduit, a mixing box connected to said expansion nozzle and adapted to mix air from the mine with that from the nozzle, a conduit for water under pressure and a spray nozzle connected to said water conduit and said mixing box and arranged to spray said water into said mixed air streaming from said expansion nozzle, whereby said mixed air is cooled.

3. In a mine ventilating system, an air compressor, an air cooler, an expansion means in the deep workings of said mine, a conduit connecting said compressor, cooler and expansion means, a spray nozzle adjacent to said expansion means and means to supply water to said spray nozzle.

4. In a mine ventilating system, as in claim 3, in which said expansion means comprises an engine acting to remove energy from said air and so lower its final temperature.

5. In a mine ventilating system as in claim 3, in which said expansion means comprises an expansion turbine, whereby the air stream therefrom is free from oil.

6. In a mine ventilating system as in claim 3, in which said air compressor is of a type, as centrifugal, not introducing oil into the air stream.

7. In a mine ventilating system, a source of dry air under pressure, expansion means for liberating said air in the deep workings of said mine, a spray nozzle for spraying finely divided water into the stream of air from said expansion means, a valve for controlling the supply of water for said nozzle, a humidistat exposed to the air in said deep workings and responsive to the relative humidity of said air therein, and means for operatively connecting said humidistat and said valve to maintain a predetermined relative humidity.

8. The method of cooling and dehumidifying the atmosphere in the depths of a mine or the like, which comprises delivering dry compressed air to the said depths, there cooling said delivered
5 air by expansion while doing useful work, then mixing the resulting cold air with a portion of the air of the mine, followed by evaporation of water by the air mixture and subsequent discharge of the cold humidified air into the mine
10 atmosphere.

9. The method of cooling and dehumidifying the atmosphere in the depths of a mine or the like, which comprises delivering dry compressed air to the said depths, there cooling said delivered
15 air by controlled expansion, conducting the resulting cold air to a mixer for mixture therein with a portion of the mine air, followed by the evaporation of water by the air in said mixer and subsequent discharge of the cold humidified air
20 into the mine atmosphere.

10. Apparatus for cooling and dehumidifying the atmosphere in the depths of a mine or the like which comprises, in combination, means for

drying and compressing air; means for conducting said dry compressed air to the depths of the mine; means at said depths for cooling the said conducted air by expansion while doing useful
5 work; means for mixing said expanded air with a portion of the mine air; and means for supplying water to said mixture to be evaporated thereby, before discharge into the mine atmosphere.

11. Apparatus for cooling and dehumidifying
10 the atmosphere in the depths of a mine or the like which comprises, in combination, means for drying and compressing air; means for conducting said dry compressed air to the depths of the mine; means at said depths for cooling the said
15 conducted air by expansion while doing useful work; means providing a chamber in which said cold expanded air is mixed with a portion of the air from the mine; and means supplying water in said chamber for evaporation by said mixture
20 before discharge into the mine atmosphere.

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