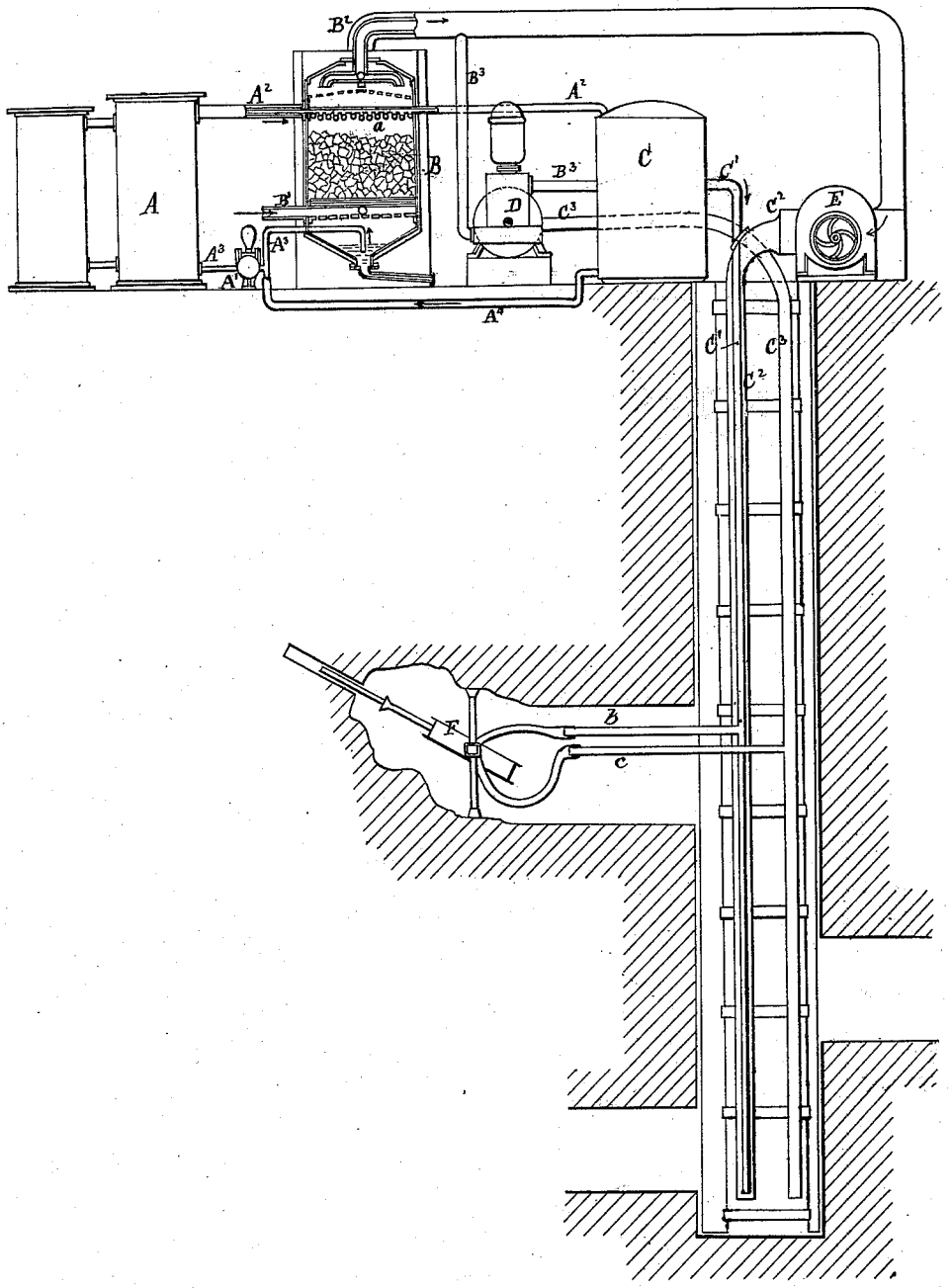
2 Sheets—Sheet 1.

C. M. TESSIE du MOTAY & L. F. BECKWITH.

Method and Means of Ventilating Mines, &c., and Operating Machinery therein.

No. 219,037. Fig 1 **Patented Aug. 26, 1879.**



Witnesses:

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their attorney

2 Sheets—Sheet 2.

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Fig. 2.

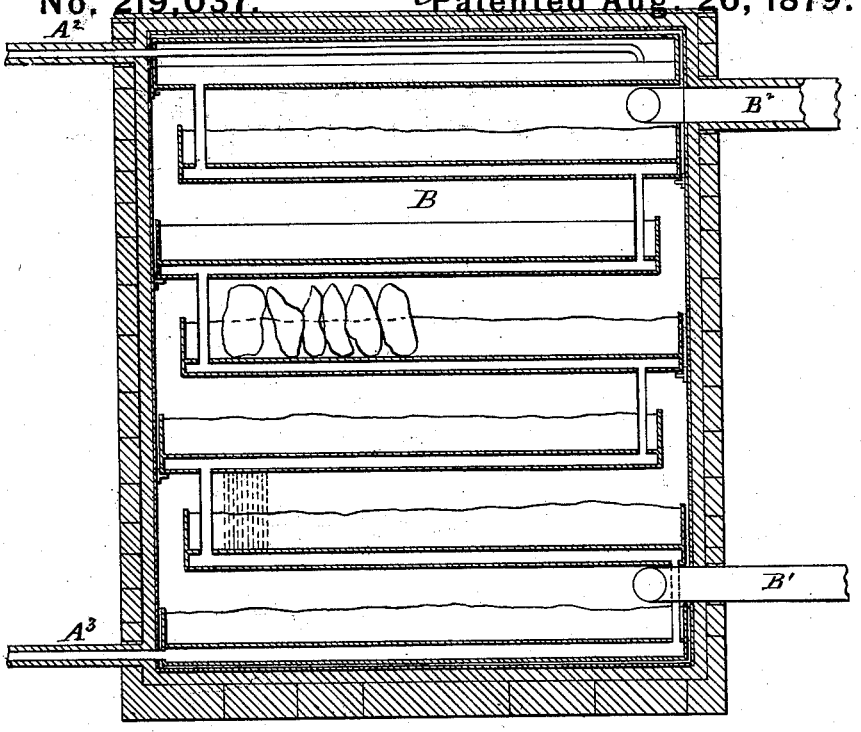


Fig. 3.

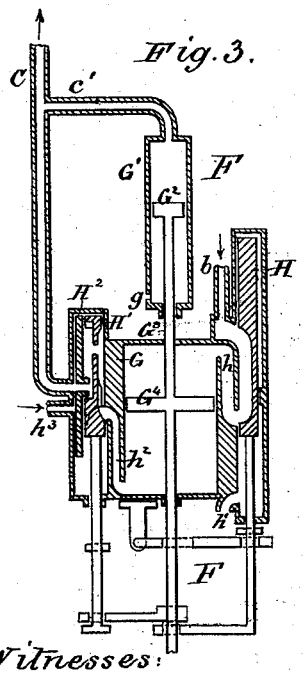
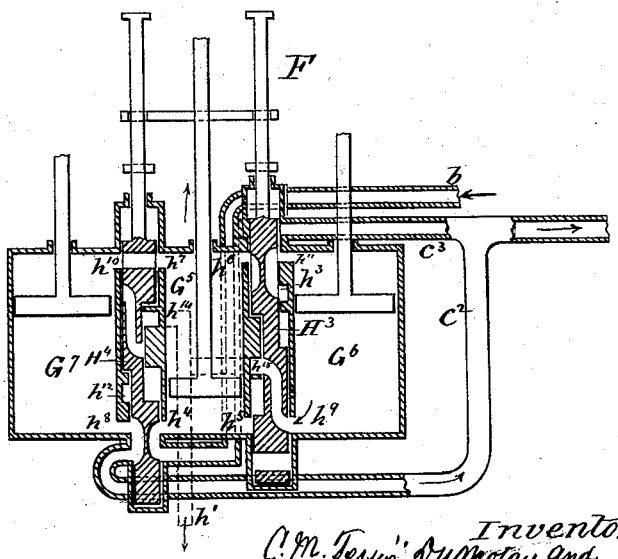


Fig. 4.



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UNITED STATES PATENT OFFICE.

CYPRIEN M. TESSIÉ DU MOTAY, OF PARIS, FRANCE, AND LEONARD F. BECKWITH, OF NEW YORK, N. Y.

IMPROVEMENT IN METHODS AND MEANS OF VENTILATING MINES, &c., AND OPERATING MACHINERY THEREIN.

Specification forming part of Letters Patent No. **219,037**, dated August 26, 1879; application filed April 26, 1879.

To all whom it may concern:

Be it known that we, CYPRIEN M. TESSIÉ DU MOTAY, of Paris, in the Republic of France, and LEONARD F. BECKWITH, of New York, in the county and State of New York, have invented a new and useful improvement in ventilating and cooling mines, tunnels, vessels, houses, &c., and operating machinery therein, which improvement is fully set forth in the following specification.

In mining, tunneling, and similar engineering and underground work, the drills are usually or often operated by compressed air, cooled by means of water, and conveyed to the drilling machinery by pipes. The air, as it expands, operates the machinery, and also as it escapes cools and ventilates the mine.

The air being cooled simply to the temperature of cold water, and conveyed in exposed pipes, is apt to become warm before it is used, and, the machinery itself being operated against the pressure of the surrounding atmosphere, considerable pressure is required. Ordinarily the air escapes from the mine by the shaft.

The object of this invention is to ventilate and cool the mine or other chamber more thoroughly and perfectly and to operate machinery therein more efficiently, with less expenditure of force; and the invention consists in ventilating by means of dry cold compressed air; in supplying compressed and cooled air through pipes inclosed in larger ones, through which cooled air is forced; in the method and means for obtaining the cooled and compressed cold air at a suitably reduced temperature; in the use of a vacuum to aid the operation of the machinery, and in the withdrawing of the vitiated air by the operation of such machinery; in the general system, and also in the apparatus and the construction and combination of parts thereof.

The air (mixed or not with additional oxygen or other gases) is cooled and dried by passing through a box or compartment through which circulates an uncongealable liquid previously cooled to a low temperature, and part of this air is then compressed and cooled by means of the cold liquid in a reservoir. The compressed cold air is forced through a pipe of suitable diameter, and delivered to the drills or other machinery by suitable branch pipes, and the air which is or may be simply cooled being forced through larger pipes inclosing the compressed-air pipes, both maintains the compressed air at a temperature constantly below that of the exterior air, and also serves to ventilate, cool, and purify the inclosures to which the pipes lead.

The compressed air, as it acts to drive the direct-acting or rotary drill or other machinery, is aided by a vacuum maintained by means of a return-pipe. The fresh cooled air, after acting to drive the machinery, is allowed to escape into the atmosphere of the mine, and the air vitiated by the breathing of workmen or deleterious gases, and heated by terrestrial heat, is drawn into the cylinder by the retreat of the piston, and on its next forward movement is carried off through the return-pipe.

Referring to the drawings, Figure 1 is a section of a mine showing the air-pipes and a single drill in operating position, with the air cooling, compressing, and forcing apparatus located at the mouth of the shaft; Fig. 2, an enlarged view in section of a modification of the air-cooling apparatus; and Figs. 3 and 4, enlarged sectional views, showing the construction of the apparatus employed for operating respectively a direct-acting and a rotary drill by the aid of a vacuum.

The same letters refer to like parts on all the figures where they occur.

A represents a refrigerating apparatus of any ordinary or suitable kind, operating to produce cold by the use of anhydrous sulphurous oxide, ammonia, ether, &c. The cold produced by the volatilization of the agent is transmitted in the usual way to an uncongealable liquid, which is caused to constantly circulate through the refrigerator of the machine by means of a small pump, A^1. This liquid may be a brine or solution of water and chloride of magnesium or other soluble salt, in such proportions as not to freeze in the refrigerator of the machine; or it may be a mixture of glycerine and water. By means of this liquid the air is effectually cooled in the

air-cooling chamber B and compressed-air reservoir C. To effect this, the following disposition may be adopted, referring to Fig. 1:

The air-cooling chamber is an insulated box, B, with funnel-shaped top and bottom. A perforated floor or screen placed across the lower portion supports a mass of fragments of porous materials—such as pumice-stone, iron-sponge, &c. A pipe, A^2, conducts the cold uncongealable liquid to the top of this box, and distributes it equally by numerous apertures *a* over the area of porous material, through which it percolates gradually to the bottom, where it is collected by the funnel and returns by a pipe, A^3, to the refrigerator of the machine to be cooled, to be taken again by the circulating pump and returned to the cooling-box.

The air introduced below by the pipe B^1 under sufficient pressure to produce circulation ascends through the mass of porous material permeated with the cold fluid, and, being brought into direct contact with the extended cooling-surface thus produced, is cooled in its passage. The pipe B^1 is perforated underneath to permit the escape of the air and to prevent the inflow of the refrigerating liquid. The air on arriving at the top makes its exit by the pipe or flue B^2.

In the modification of the cooling-chamber shown in Fig. 2, the insulated compartment or box B is provided with a suitable number of hollow-bottomed metallic shelves, with upwardly-extended sides, forming shallow basins on their upper surfaces, and extending alternately almost across the box. The hollow bottoms of the shelves communicate by means of vertical tubes connecting them with each other. In these basins separate masses or lumps of porous material—such as pumice-stone, iron-sponge, or any other material—are placed. Instead of those materials, successive screens of fine metallic wire, preferably brass, closely set together, may be used. The basins are filled with a moderate depth of water.

The uncongealable solution coming from the refrigerating apparatus A is introduced by the pipe A^2, at the top of the compartment, into the bottom of the first shelf, through which it circulates, freezing into ice the water in the basin over it; thence it passes by the vertical tube to the next inferior shelf, and so on until it reaches the lower shelf, and returns through the pipe A^3, by the circulating-pump, to the refrigerating-machine, to be again cooled therein and returned to the top of the compartment. In its entire circuit it does not come once in contact directly with the air to be cooled, as it does in the apparatus represented in Fig. 1. The air to be cooled is first allowed to pass through a box containing chloride of calcium, for the purpose of depriving it of its humidity. Two boxes of chloride of calcium are provided with the apparatus, each one of suitable size for twenty-four hours use. These are used alternately, the one not in use being heated meanwhile to deprive it of its absorbed moisture. The dry air enters at the bottom of the cooling-compartment, and meets with a very extended refrigerating-surface, consisting of the masses of cold porous material, which, being bedded in ice, are constantly kept at a very low temperature; or if the wire screens are used the air passes through them, and is cooled by contact. The bottoms of the shelves also assist the cooling.

The air under sufficient pressure to produce circulation passes from the pipe B^1 upward to the top of the compartment, whence it takes its exit by the pipe B^2. Any humidity not deposited in the chloride-of-calcium boxes is deposited as frost on the cold porous materials, and the cold air is perfectly dry. In either disposition, when it is desired to mix oxygen with the cooled air for the purpose of purifying the atmosphere of the mine or facilitating the working of the miners, a small pipe connecting with the reservoir of oxygen supplies the latter to the air-current, either immediately after or before the cooling.

From the pipe B^2, referring to Fig. 1, a portion of the cold air is taken by the pipe B^3, and compressed into the reservoir C by the pump D. A continuation of the pipe A^2 conducts the refrigerating liquid or solution to the reservoir C, around the walls of which it circulates, cooling the compressed air therein.

A pipe, A^4, conducts the solution back to the circulating-pump A^1. From the reservoir C the compressed cold air is conducted by a distributer-pipe, C^1, into the mine, and this pipe, by smaller ones, supplies the drills F or other machinery in the different workings.

For the purpose of keeping cool the compressed air, the distributer-pipe is surrounded by a larger one, C^2, in which cold air from the cooling-compartment B, but uncompressed, is circulated by an ordinary fan, E, or other suitable ventilating apparatus, and supplied to the workings as judged necessary. The cold air is expanded by the drills in working, and ejected into the mine, lowering the temperature. These drills aspirate the vitiated air from the workings, and, being connected by a second series of small pipes with a collector return-pipe, C^3, itself connected with the apparatus producing a vacuum, the vitiated air is expelled from the mine. This vacuum apparatus is arranged at the side of the pump D, and operated by the same power thereas.

The manner of constructing and operating the drills by aid of a vacuum will now be described.

In the ordinary drills worked by air a direct pressure of about two to two and a half atmospheres is used, with a corresponding friction in the conducting pipes. Now if the air is aspirated from the other side of the piston, it is clear that less direct pressure will be required, power saved and made uniform, and a pressure of one to one and a half atmosphere becomes sufficient, with a corresponding decrease of friction in the pipes. Therefore the compressor will have a double pur-

pose to perform. It must compress, on one hand, the cold air to the diminished pressure above stated, and, on the other hand, the machinery must aspirate the air from the drills.

In direct-acting drills which are single acting, referring to Fig. 3, there is a small cylinder, G^1, on the extension of the main cylinder G, the piston G^2 of which is worked by the rod G^3 of the main cylinder. On the direct stroke the compressed air is introduced from the pipe *b* by means of the slide-valve H on one side of the piston G^4 during half the stroke, expands during the balance of the stroke, and performs its work in driving the drill. This work is facilitated by the cylinder on other side of the piston being put in communication with the vacuum-pipe *c* through the port h^3 by a slide-valve, H^1 H^2. The part H^2 of this slide-valve is operated by projections on the side of the part H^1 at the end of each stroke. The small cylinder G^1 being always in communication with the vacuum-pipe by a branch pipe, c^1, its piston, in following the motion of the piston of the large cylinder while driving the drill, is simply exhausting on a vacuum which does not present much resistance.

On the return stroke, the communication of the compressed air in one half of the cylinder being made with the mine through the outlet *h* by the movement of the valve H, the cold air, additionally cooled by the expansion, is released and driven into the mine, and cools the latter. On the other hand, the other side of the cylinder G is shut off from the communication with the vacuum-pipe *c* by the movement of the part H^2 of the slide-valve, and put into communication with the air of the mine through the opening h^3 and port h^2. The air is drawn into the cylinder upon the retreat of the piston. The small cylinder being in constant communication with the vacuum or return pipe *c*, the small piston is caused, by the pressure of the air in the mine entering the cylinder G^1 by an aperture, *g*, or other suitable opening, to return to the end of the stroke, carrying the large piston with it, the latter driving the cold air into the mine and drawing the vitiated air of the mine into the cylinder, to be expelled at the next stroke into the vacuum-pipe, and thence by the vacuum-pump on the surface into the air outside. Thus the compressed air drives the drill by direct action, the vacuum on the other side assisting this action by diminishing the resistance and expelling the vitiated air; and the return stroke is effected by the action of the little vacuum-cylinder G^1 when the cold air enters the mine.

In operating with rotary drills it is preferred to use three cylinders, on the principle of the system of Woolf's steam-engine.

Referring to Fig. 4, the compressed air enters the central cylinder, G^5, through the port h^4, and acts on the piston during either the whole or a portion of the stroke, according as it may be thought advantageous. The compressed air on the opposite side of the piston passes through the ports h^7 and h^{10} into the left-hand cylinder G^7, and there expands, completing its action. At the advance of the piston of the left-hand cylinder G^7 the vitiated air from the mine, which filled the cylinder at the preceding stroke, is driven before it through the port h^4 and pipe c^2 into the vacuum-pipe *c*, with which it has been put in communication by the slide-valve H^4, the communication being through the port h^8 and pipe c^2. Meanwhile the cylinder G^6 has become filled with vitiated air from the mine, with the atmosphere of which communication is opened by the slide-valve H^3 through the ports h^{11} and h^{13}, and the cold air remaining from the previous stroke is expelled into the mine through the ports h^9 and h^{15} and outlet h^1. (Shown in dotted lines.) On the return stroke of the piston of the central cylinder, G^5, the compressed air is let in below the piston and drives it upward, and the cold air from the previous stroke expands into the cylinder G^6 through ports h^5 and h^9, connected through the slide-valve H^3, and the vitiated air therein is carried off into the vacuum-pipe through the port h^{11} and pipe c^3. The cold air with which the left-hand cylinder G^7 is filled is driven into the mine, and the vitiated air from the mine enters the cylinder on the opposite side of the piston through the ports h^{12} and h^8, to be expelled into the vacuum-pipe at the next stroke. The cold air in the right-hand cylinder is at the next forward stroke carried off into the vacuum-pipe.

From the above description it will be seen that in the central cylinder the compressed air from the pipe *b* acts during both forward and return strokes. In the left-hand cylinder during the forward stroke the compressed air from the central cylinder acts expansively, being aided by the vacuum upon the opposite side of the piston, and during the return stroke the pure cold air is expelled into the mine and the cylinder filled with vitiated air. The right-hand cylinder, conversely, is filled with vitiated air on the forward stroke, and the air from the central cylinder, aided by the vacuum, acts expansively during the return stroke.

It is obvious, however, that instead of using the air expansively in the side cylinders the slide-valves might be readily arranged to allow the compressed air from the distributer-pipe to act directly upon the piston of the right and left handed cylinders on alternate strokes; and also, that instead of using three cylinders a larger number might be employed.

Other machinery might be operated in the same way as I have before described with reference to direct-acting and rotary drills, and in cases where a direct double-acting motor is required two cylinders in line, if desired, may be used.

The system above described has the advantages of utilizing the expansive force of the compressed air and of using a very uniform power. It removes from the workings the air

which has become vitiated by the respiration of the workmen, by the burning of lamps, or from the many causes of impurity arising from deleterious gases issuing from fissures in the rocks, fire-damp, &c.

The terrestrial heat, which grows so rapidly with the increasing depth of mines as to render the working of many of them almost impossible, is controlled and diminished by the introduction of cold air in combination with a perfect ventilation, and mines which have been abandoned from any of the preceding causes can once more be worked.

With regard to the use of the compressed air which forms the power for the drills, it is not only used at half the former pressure, which is a very desirable economy, but it is used expansively, and produces by its expansion a considerable additional cold.

Although the system complete in all its details as set forth is preferred, as yielding the best and most perfect result, it is evident that modifications might be made without departing from the spirit of the invention, and also that many advantages over systems now in use might be obtained by the use of parts of the invention without the others. For example, changes might be introduced in the manner of drying and cooling the air, or in the valve mechanism of the motors for operating the drills or other machinery.

The arrangements for cooling and conveying the compressed cold air might be employed simply for ventilation and cooling, or to drive ordinary drills or machinery; or the drills described might be run by compressed air supplied in the usual way, a return-pipe being used to assist the operation by a vacuum and to draw out the vitiated air. Many other modifications will readily suggest themselves.

The invention is not confined to tunnels and mines, although especially adapted thereto, but may be used in houses or ships or inclosures which it is desired to ventilate and cool, and at the same time operate machinery therein; nor is it confined to air for ventilating and operating machinery, as it may be used with any desired gas or gases.

Having described our invention, what we claim, and desire to secure by Letters Patent, is—

1. The method of ventilating and cooling mines and other inclosures, the same consisting in cooling and drying air by reducing the same to a suitably low temperature, compressing this cold air, and again cooling the same and supplying the compressed cold air by suitable pipes, whereby drills or other machinery may be operated by said compressed cold air, which also by its expansion cools, and by its inflow ventilates, the inclosure, substantially as described.

2. The method herein described for ventilating and cooling mines and other inclosures, and allowing the compressed cold air to escape into the atmosphere of the inclosure, the same consisting in supplying compressed cold air by suitable pipes inclosed in larger pipes, through which a circulation of cold dry air is maintained, substantially as set forth.

3. The method of supplying mines and other inclosures with cold and compressed cold air, for the purposes specified, the same consisting in cooling and drying the air by passing the same in contact with pumice or similar material reduced to a low temperature by the circulation of an uncongealable liquid, in compressing a part of said cold air, and cooling the same when compressed by the aforesaid uncongealable liquid, and in conveying the compressed cold air in pipes surrounded by the cold air, made to circulate by suitable means in larger inclosing-pipes, substantially as described.

4. The method of ventilating mines and other inclosures, and operating drills and other machinery therein, the same consisting in operating the machinery by compressed air aided by a vacuum; the air after expanding to drive the machinery being ejected into the inclosure, and air from said inclosure being withdrawn and carried off by the means for maintaining a vacuum, substantially as described.

5. The herein-described system or method of ventilating and cooling mines and other inclosures, and operating drills or other machinery therein, the same consisting in cooling and drying air, compressing and cooling a portion of the dry cold air thus obtained, supplying to the motor or engine of the drills or other machinery the compressed cold air by suitable pipes inclosed in larger pipes, through which cold dry air obtained by the first operation is circulated, and aiding by means of a vacuum the driving of the drills or other machinery, substantially as specified, the compressed air being allowed to escape into the atmosphere of the inclosure, and air from said inclosure being drawn into the motor and carried off by the apparatus for maintaining the vacuum, substantially as set forth.

6. The combination, with an air-cooling chamber, means for causing a circulation of air therethrough, an air-reservoir, and pump for compressing air thereinto, of means for refrigerating and circulating a non-congealable liquid through said cooling-chamber and compressed-air reservoir, the aforesaid pump being supplied with air cooled in the cooling-chamber, substantially as described.

7. The combination, with air cooling and forcing apparatus, a compressing-pump, and reservoir provided with means for cooling the air compressed thereinto, of a distributer-pipe for delivering the cold compressed air from the reservoir to the inclosure to be ventilated, and a larger pipe inclosing said distributer-pipe connected with the first-named air cooling and forcing apparatus, substantially as described.

8. The combination, with a distributer-pipe

receiving compressed air from a reservoir or forcing apparatus, and a collector or return pipe connected with vacuum apparatus, of a drill or other machinery having one or more piston-cylinders provided with valve mechanism, arranged substantially as specified, to permit the inflow of the compressed air into said cylinder or cylinders and its exhaust into the atmosphere of the inclosure, and to cause air from the inclosure to be drawn into the cylinder or cylinders and carried off by the vacuum apparatus through the return-pipe, the operation of the compressed air in driving the machinery being assisted by the vacuum, substantially as set forth.

9. The combination of the following elements: first, an air cooling and forcing apparatus; second, a compressing-pump and reservoir, the latter provided with means for cooling the air compressed thereinto by said pump; third, a distributer-pipe connected with said reservoir, and inclosed by, fourth, a larger pipe connected with the first-named air cooling and forcing apparatus; fifth, a conveyer or return pipe connected with, sixth, a vacuum apparatus; and, seventh, a drill or machine provided with valve mechanism and connected with said distributer and return-pipes, substantially as described.

In testimony whereof we have signed this specification in the presence of two subscribing witnesses.

CYPRIEN M. TESSIÉ DU MOTAY.
LEONARD F. BECKWITH.

Witnesses:
E. GILLET,
ARTHUR BECKWITH.