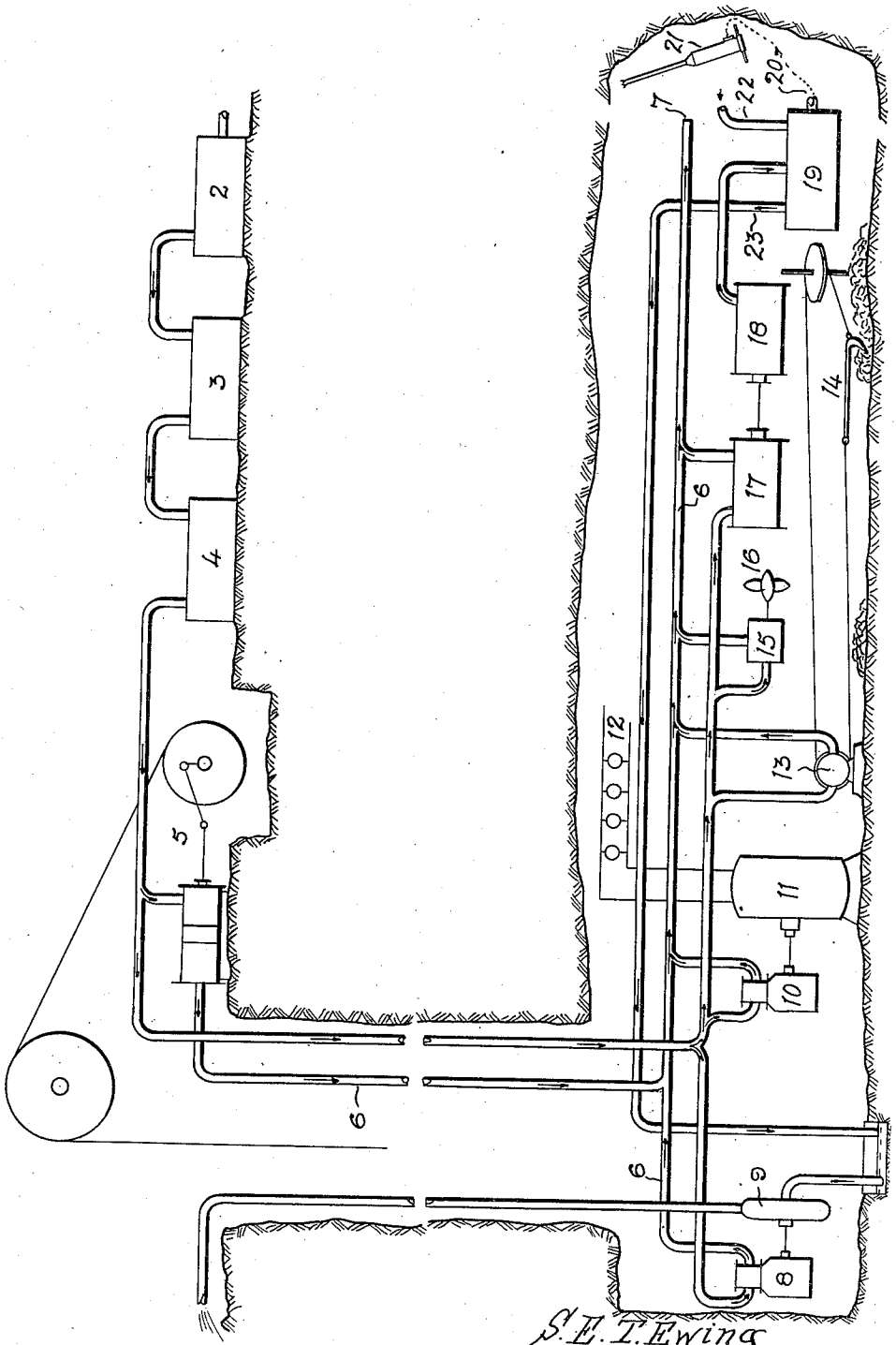
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CONDITIONING MINE AIR

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CONDITIONING MINE AIR

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This invention relates to systems of conditioning mine air, in which compressed air is caused to do work by expanding against a load, being thereby cooled and dried, and is then used to reduce the temperature of the mine air.

Heretofore, in systems of this kind, it has been the practice to deliver the compressed air from the compressor plant to the pipe line by which it is conveyed to the compressed air motors, in the conditions of temperature and humidity under which it is normally delivered by a compressor plant having the usual water-cooled after-cooler. These conditions are that it is delivered at the temperature to which it can in practice be cooled by water, that is, approximately the prevailing atmospheric temperature; and at that temperature is fully saturated with water vapour, besides containing some surplus moisture in the form of minute globules of water which have been condensed in the after-cooler. Even if the surplus moisture be removed, the presence of this large amount of water vapour in the compressed air prevents the latter from attaining, by its expansion, the very low air temperatures which are possible and which are desirable in order that the expanded air may most effectively cool the mine air, because expansion causes the condensation of much of its contained water vapour. If compressed air as normally delivered with contained water vapour, is expanded in motors of the piston type, it must be exhausted at a temperature not much below the freezing point of water in order to avoid mechanical difficulties resulting from the congelation of its condensed water vapour. With reasonably high initial pressure of the compressed air, this means that the air must be exhausted at approximately two to three atmospheres pressure so that not only is much of its energy wasted, but it is substantially warmer than it would be if expanded to about atmospheric pressure. The presence of congealed condensed vapour does not raise the same mechanical difficulties in the case of compressed air turbine motors, and in them lower expansion pressures can be attained; but such motors necessarily comprise narrow passages through which the air flows at high speed. Frictional heating of the air results and the attainment of low temperatures is thereby defeated.

Another reason why water vapour in the compressed air limits the coldness of the expanded exhaust air is the fact that it condenses and liberates its latent heat in the form of sensible heat which is added to the mine atmosphere.

It has now been shown that there are two objections to expanding ordinary saturated compressed air for use in cooling a mine, (*a*) the formation in the expansion machines of ice from the condensed water vapour, (*b*) the liberation of latent heat from the condensed vapour and its appearance as sensible heat.

Heretofore also, it has been proposed to devaporize saturated surface-compressed air at a point underground in the mine, near to the point where the mine air is to be reconditioned, and to expand the devaporized compressed air to drive a generator of electric power to be applied to various purposes. The devaporizing of compressed air underground is open to the following objections:—

(*c*) the latent heat of the condensed water vapour appears as sensible heat in the mine itself, which is opposed to the primary purpose of cooling the mine;

(*d*) the power lost or used in the devaporizing process also appears as heat in the mine;

(*e*) certain most efficient known devaporizing processes, involving the compression of noxious secondary vapours, cannot be utilized underground.

The present invention overcomes both the objections (*a*) and (*b*) to the use of ordinary saturated compressed air and also overcomes the objections (*c*), (*d*) and (*e*) to devaporizing compressed air underground. The invention consists in producing compressed air so devaporized at the surface of the mine, that its vapour content and total heat content are substantially below those of saturated air at the same pressure and the prevailing atmospheric temperature, working the compressed air so treated expansively against a load, and utilizing the cold expanded air to cool the mine atmosphere. Also according to the invention, such compressed air devaporized on the surface is utilized in the several manners hereafter described.

The invention is illustrated in the accompanying drawing which is a diagrammatic representation of a mine compressed air installation according to the invention.

2 indicates the usual kind of air compressor situated at the surface of a mine and fitted with an after-cooler 3, which reduces the compressed air to about the normal prevailing temperature. The after-cooling causes the usual precipitation of some of the water vapour from the air and the air is delivered from the after-cooler as saturated compressed air. Such saturated compressed air is then devaporized in a high degree by a devaporizer 4, situated on the surface of the mine,

various types of which are readily available. The resulting devaporized compressed air is then worked expansively in a compressed air motor driving a load whereby it is reduced to a low temperature when exhausted from the motor; and the cold exhaust air is utilized to cool the atmosphere of the mine or a working place in the mine.

The removal of water vapour from the compressed air permits it to be expanded to substantially lower pressures and temperatures than is possible with the normal saturated compressed air; and if the devaporization is substantially complete the expansion may be carried to an indefinite extent without freezing trouble. It is accordingly preferred to expand the air to approximately atmospheric pressure and thereby obtain the maximum lowering of its temperature.

Among the loads to which the devaporized compressed air can usefully be applied in and about a mine, are those involving work against gravity. Since in such cases the heat energy abstracted from the compressed air disappears as such and appears as potential energy in the raised material, it is effectively disposed of from the point of view of cooling the mine.

One example of this type of load is the use of devaporized compressed air for operating the surface or underground winding plant 5 of the mine. The cold air exhausted from the winder is utilized in any desired manner for cooling the mine air. As shown it is led to the mine workings it is desired to cool, by a light insulated pipe 6. It is discharged as free air into the mine atmosphere at convenient points indicated generally by 7; and by diluting the hot moist atmosphere, improves the condition thereof.

Another similar use of the devaporized compressed air is in the motor 8 driving the pump 9 for raising water out of the mine. In this case also the exhaust air is shown as discharged into the mine atmosphere.

A load of another type is that which dissipates the energy of the motive air as heat in the mine. Two instances of this type of load are illustrated, one consisting in the driving by the air motor 10 of a generator 11 supplying electric current for the mine illuminating system 12. The whole of the heat energy withdrawn from the compressed air and delivered to the generator appears as heat in the lamps and otherwise, which heat goes into the mine atmosphere. By discharging the exhaust air from the motor 10 into the mine atmosphere, the heating due to the lamps and generator is exactly counterbalanced by the cooling due to the exhaust air; so that the beneficial result of the invention in this case is that of preventing the addition of heat to the mine atmosphere.

A second instance of the type of load in which the air energy is dissipated as heat in the mine, is the driving of horizontal rope haulages, ore scrapers, belt conveyors, ventilating fans, winches and the like in the mine. In these operations potential energy is not usually produced, but the work done by the air motors is converted into friction heat in the mine. The drawing shows a motor 13 driven by the devaporized compressed air and driving a scraper 14; also a motor 15 similarly driven and driving a ventilating fan 16. Both motors exhaust into pipe 6. In this case the loss of heat from the expanded air balances the friction heat from the machines and results, as in the case of the electric lighting, in no net addition of heat to the mine atmosphere. When electrical energy is used for driving the machine just mentioned above, the whole of it appears as heat in the mine atmosphere.

A third type of load is the compression of mine air which is utilized for the purposes for which compressed air is ordinarily used in the mine.

17 indicates a compressed air motor supplied with the devaporized primary compressed air from the compressor 2 and devaporizer 4; and delivering its cold exhaust air at 6. It drives the compressor 18 which takes in air from the mine atmosphere. The secondary compressed air is cooled as by means of the after-cooler 19 and is then delivered to the regular underground compressed air main 20; being ultimately used for operating drills 21, and other small mining appliances. The after-cooler 19 is cooled by mine water supplied at 22, and discharged at 23 to be added to the mine drainage water.

In this application of the invention the disposal of the heat withdrawn from the primary compressed air by its expansive working is somewhat different from that in the other cases, since said heat reappears as the heat of compression of the secondary air. It is, however, collected in the cooling water and withdrawn from the mine by pumping such water to the surface.

We claim:

1. The process of conditioning mine air which consists in producing compressed air which is at substantially the temperature prevailing at the surface and which is so devaporized at the surface of the mine that its vapor content and total heat content are substantially below those of saturated air at the same pressure and the prevailing atmospheric temperature, working the compressed air so treated expansively and causing the energy thereby given out to do work principally against gravity, and utilizing the cold expanded air to cool the mine atmosphere.

2. The process of conditioning mine air which consists in producing substantially completely devaporized compressed air at the surface of the mine and at approximately the temperature prevailing at the surface, expanding the compressed air so devaporized substantially to atmospheric pressure and against a lod consisting of work principally against gravity, and exhausting the expanded air into the mine atmosphere.

3. The process of conditioning mine air which consists in producing compressed air which is at substantially the temperature prevailing at the surface and which is so devaporized at the surface of the mine that its vapor content and total heat content are substantially below those of saturated air at the same pressure and the prevailing atmospheric temperature, working the compressed air so treated expansively and thereby compressing secondary air in the mine, collecting the heat of compression of the secondary air and disposing of such heat in a manner which does not materially heat the mine atmosphere and utilizing the cold expanded air to cool the mine atmosphere.

4. The process of conditioning mine air, which consists in producing substantially completely devaporized compressed air at the surface of the mine and at approximately the temperature prevailing at the surface, working the compressed air so treated expansively and thereby compressing secondary air in the mine, exhausting the expanded air into the mine, collecting the heat of compression of the secondary air, disposing of such heat in a manner which does not materially heat the mine atmosphere, and utilizing the cold expanded air to cool the mine atmosphere.

5. The process of conditioning mine air, which consists in producing compressed air which is at substantially the temperature prevailing at the surface and which is so devaporized at the surface of the mine that its vapor content and total heat content are substantially below those of saturated air at the same pressure and the prevailing atmospheric temperature, working the compressed air so treated expansively and thereby compressing secondary air in the mine, employing such secondary compressed air to drive small machines such as rock drills, collecting the heat of compression of the secondary air and disposing of such heat in a manner which does not materially heat the mine atmosphere, and utiltizing the cold expanded air to cool the mine atmosphere.

6. Apparatus for conditioning mine air comprising a source of compressed air, means for cooling such air only to approximately atmospheric temperature, means at the surface of the mine to devaporize the cooled compressed air, an expansion motor arranged to be driven by the devaporized compressed air, a load for the motor, and means whereby the exhaust air from the motor is used to cool the mine atmosphere.

7. Apparatus for conditioning mine air comprising a source of compressed air, means for cooling such air only to approximately atmospheric temperature, means at the surface of a mine to devaporize the cooled compressed air, machinery for raising material from the mine and comprising an expansion motor arranged to be driven by the devaporized compressed air, and means whereby the exhaust air from the motor is used to cool the mine atmosphere.

8. Apparatus for conditioning mine air comprising a source of compressed air, means for cooling such air only to approximately atmospheric temperature, means at the surface of a mine to devaporize the cooled compressed air, an expansion motor arranged to be driven by the devaporized compressed air, a secondary compressor situated in the mine and driven by said expansion motor, means to supply cooling water to the secondary compressor, means to convey the resulting cooled water to the mine draining system, and means whereby the exhaust air from the motor is used to cool the mine atmosphere.

9. In a combined air conditioning and work performing device for mines, an air compressor, an after cooler, an expansion engine communicating with said cooler for doing work at the surface, means for passing cooled air from the exhaust of said expansion engine into the mine, means for passing non-expanded air at atmospheric temperature into the mine, an expansion engine receiving said non-expanded air beneath the surface and doing work in the mine, and means for combining air from the expansion engine at the surface with air from the expansion engine beneath the surface and discharging it in the interior of the mine.

10. A device as claimed in claim 9 in which the after cooler is of heat conducting material and is directly exposed to the atmosphere and a devaporizer is interposed between the after cooler and the piping leading to the mine.

11. The process of conditioning mine air and performing work in a mine which comprises compressing air, placing said compressed air in heat exchanging relation with the atmosphere to cool said compressed air to the prevailing atmospheric temperature, expanding a portion of the compressed air in an air engine to cool it further and piping said cool air to the interior of the mine, piping the remainder of said compressed air at atmospheric temperature down into the mine, expanding said remainder air in an expansion engine to do work in the mine, combining said portions of air and discharging the same into the mine.

12. The process of conditioning mine air, which consists in producing compressed air which is at substantially the temperature prevailing at the surface and which is so devaporized at the surface of the mine that its vapor content and total heat content are substantially below those of saturated air at the same pressure and the prevailing atmospheric temperature, working the compressed air so treated expansively against a load, and utilizing the cold expanded air to cool the mine atmosphere.

13. The process of conditioning mine air which consists in producing substantially completely devaporized compressed air at the surface of the mine, and at approximately the temperature prevailing at the surface, working the compressed air so treated expansively against a load, and utilizing the cold expanded air to cool the mine atmosphere.

14. The process of conditioning mine air which consists in producing compressed air which is at substantially the temperature prevailing at the surface and which is so devaporized at the surface of the mine that its vapor content and total heat content are substantially below those of saturated air at the same pressure and the prevailing atmospheric temperature, expanding the compressed air so devaporized against a load and to substantially atmospheric pressure, and utilizing the cold expanded air to cool the mine atmosphere.

15. The process of conditioning mine air which consists in producing substantially completely devaporized compressed air at the surface of the mine and at approximately the temperature prevailing at the surface, expanding the compressed air so devaporized against a load and to substantially atmospheric pressure, and utilizing the cold expanded air to cool the mine atmosphere.

16. The process of conditioning mine air, which consists in producing compressed air which is at substantially the temperature prevailing at the surface and which is so devaporized at the surface of the mine that its vapor content and total heat content are substantially below those of saturated air at the same pressure and the prevailing atmospheric temperature, working the compressed air so treated expansively against a load and exhausting the expanded air into the mine atmosphere.

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