Oct. 9, 1945. W. R. F. LUNT 2,386,560

METHOD OF COOLING THE AIR IN UNDERGROUND MINE WORKINGS AND LIKE PLACES

Filed Feb. 12, 1940 3 Sheets-Sheet 1

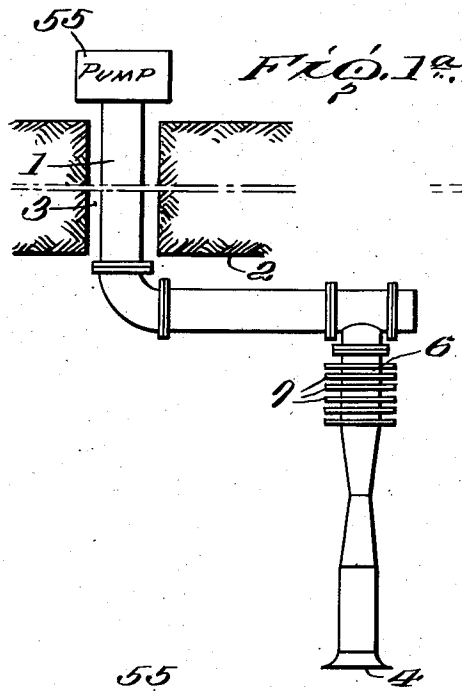


FIG. 1a.

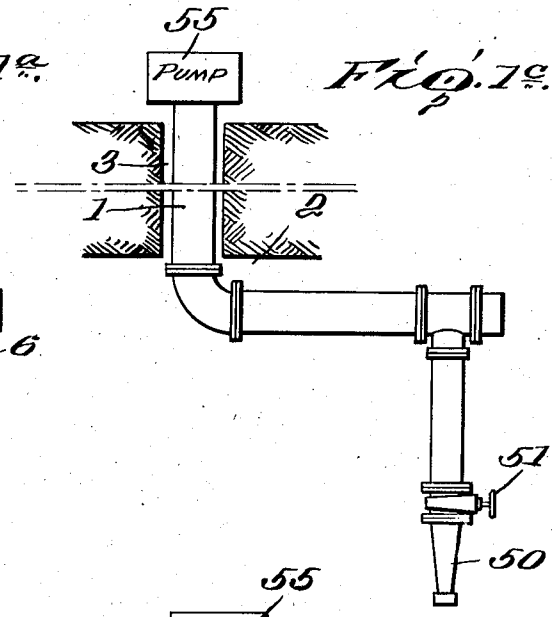


FIG. 1c.

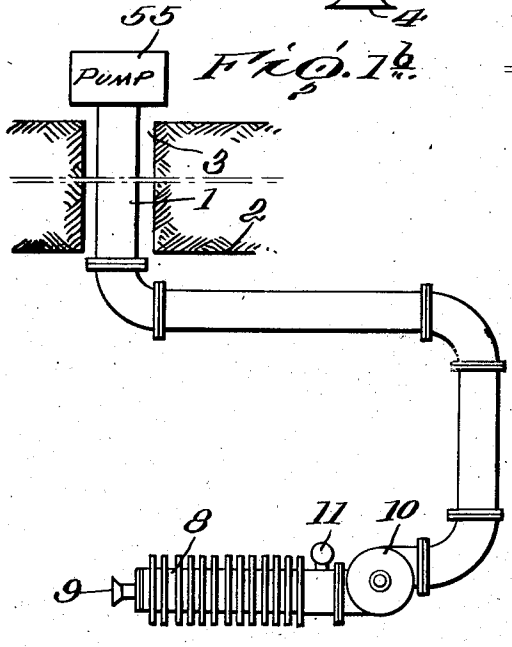


FIG. 1b.

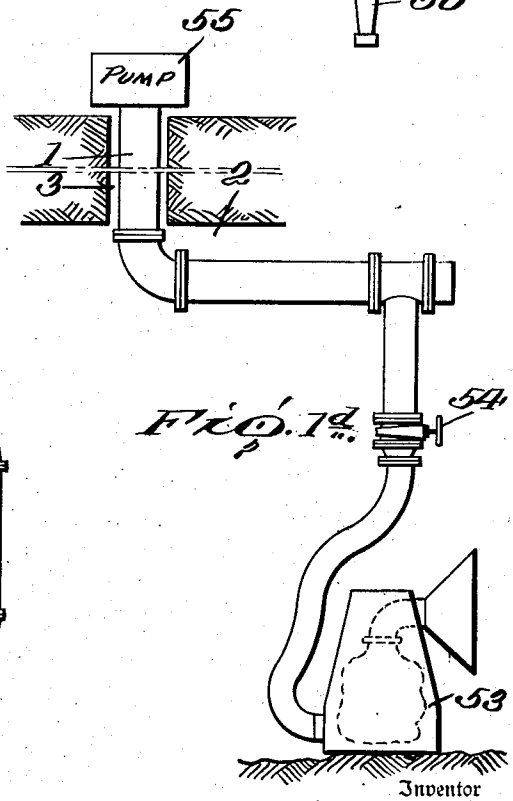


FIG. 1d.

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Fig. 2.

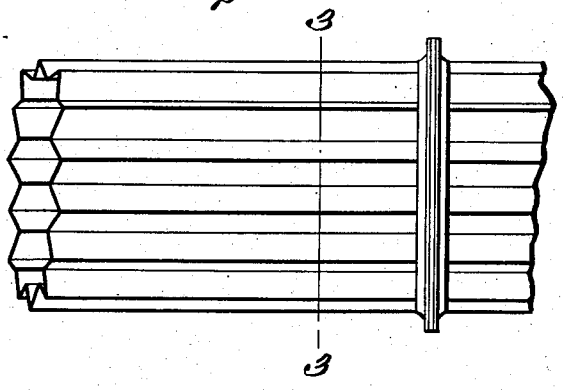


Fig. 3.

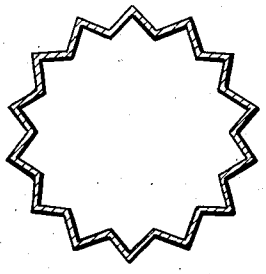


Fig. 6.

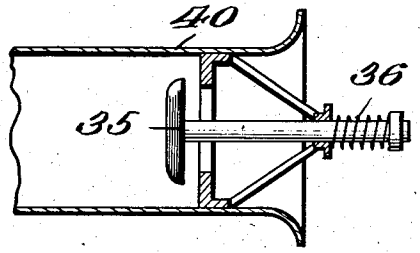


Fig. 7.

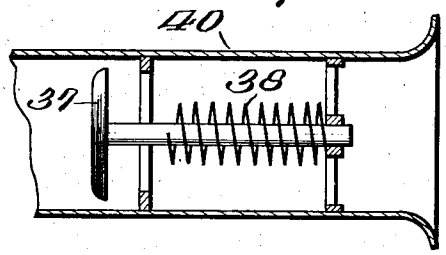
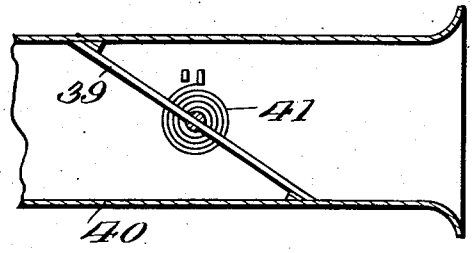


Fig. 8.



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METHOD OF COOLING THE AIR IN UNDERGROUND MINE WORKINGS AND LIKE PLACES

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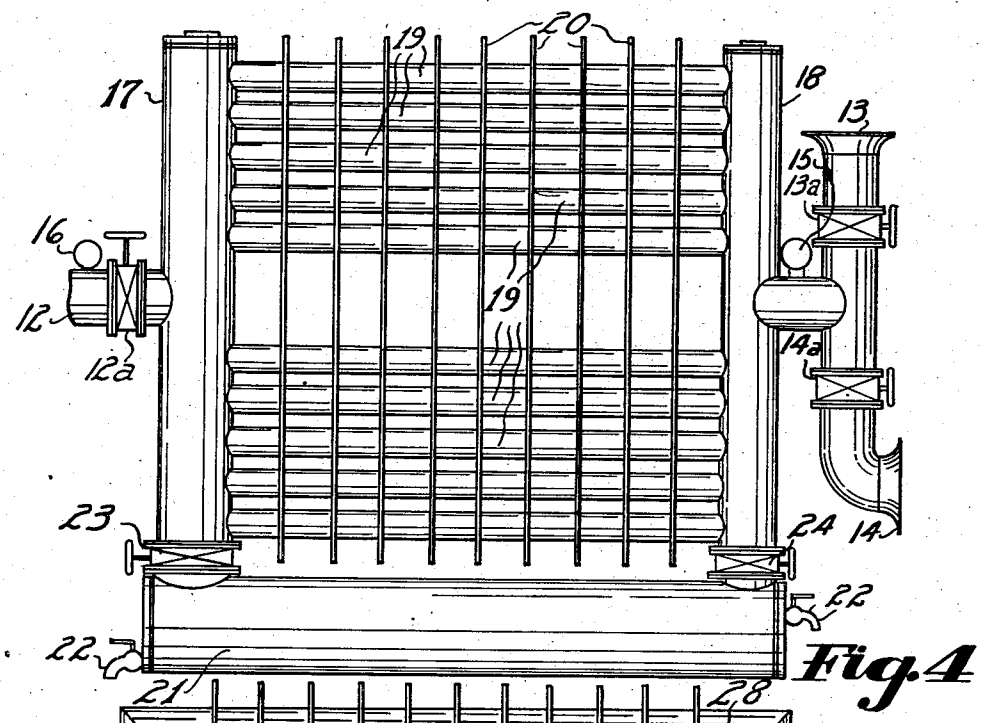


Fig. 4

Fig. 5

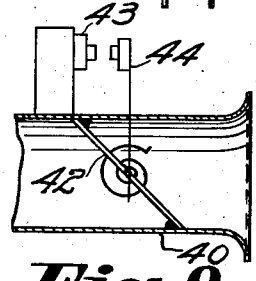


Fig. 9

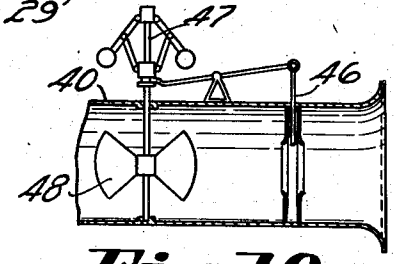


Fig. 10

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2,386,560

METHOD OF COOLING THE AIR IN UNDERGROUND MINE WORKINGS AND LIKE PLACES

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Application February 12, 1940, Serial No. 318,613
In the Union of South Africa February 17, 1939

12 Claims. (Cl. 62—170)

This invention relates to an improved method of cooling the air in underground mine workings and is particularly applicable to deep mines where high temperatures are the rule.

According to an earlier application it is proposed positively to evacuate dust-laden air from mine workings by means of a suction conduit system arranged to extend from the surface to the underground shafts and working places. The said conduit system branches in all directions throughout the mine and each branch is provided at spaced intervals with valve-controlled openings which openings are arranged at the lower points or depressions in the workings towards which the dust particles normally tend to gravitate. The means at the surface for creating a partial vacuum in the conduit system may comprise an evacuating pump or the like.

Accordingly the present invention consists in the provision of a suction conduit system extending from the surface to the underground shafts and working places, means at the surface for evacuating air from said conduit system so as to create a partial vacuum therein, means in the form of restricted resistance-creating inlet apertures to cause controlled adiabatic expansion of the constant entropy or isentropic process type, of the mine air into the conduit system to cool it and utilising the conduit system as heat exchanging means to extract heat from the mine air in contact therewith, whereby the workings are cooled by air drawn from the bottom or lower levels upwardly. By mine air is meant the air in the shaft or drives surrounding the conduit system, and which is available to the workers. By exhaust air, as the term is hereinafter employed in the specification and claims, I mean the vitiated mine air as it is drawn from the mine exteriorly of the conduit system, into the conduit system and is there subjected to a sequence of thermal processes.

More particularly it is proposed to insert in the conduit system large expansion chambers whereby, due to the drop in temperature caused by the adiabatic expansion of the air entering the chambers, cooling of the mine air surrounding and passing in contact with said expansion chambers is effected by a transfer of heat from the mine air to the air being evacuated.

These expansion chambers are provided at intervals throughout the conduit system and at positions in the mine workings where they will be most effective in cooling the mine air. The said chambers are provided with large cooling surfaces to ensure the maximum transfer of heat.

It will be understood that the drop in temperature through adiabatic expansion, will also take place in the ducting forming the conduit system, and this ducting will be constructed and arranged in such a manner that it acts effectively to assist cooling the mine air. According to the method of the present invention air in the underground workings of a mine is cooled by heat exchange with air drawn from the bottom or lower levels upwardly in contradistinction to known methods where cooling is effected by heat exchange with air drawn from the surface downwardly.

In applying the invention it is proposed that, where a series of pipes converge, incoming air is arranged to pass around the piping for purposes of being cooled.

According to present practice dust-laden air is withdrawn from mine workings by means of exhaust trunking which terminates in the mine workings in dust-collecting chambers.

According to the present invention control valves and heat exchangers are suitably interspersed on all exhaust trunking extending from these dust-collecting chambers so that the adiabatic expansion of the mine air as it passes through these passages will give a degree of cooling which is thus communicated to the mine air.

On all exisiting mine ventilation systems of the suction type, control valves, Venturi ducts and like means for reducing or throttling the air flow are employed to cause a slight degree of expansion and so give a cooling effect. Suction heads or filtering heads may or may not be contained in a suction exhaust system, in cases where valves are in existence for controlling the air inflow.

On all existing exhaust conduits effective heat extraction may be increased by painting such conduits black and providing them with fins.

The exhaust trunking is further provided with reducing air intake apertures where required for controlling air expansion. Such apertures are preferably in the form of replaceable nozzles having a streamlined interior shape to reduce friction losses.

Air resistance by means of filtering and suction heads may be created in the suction system so as intentionally to restrict the flow of air for expansion purposes.

The air expansion chambers or heat exchangers included in a suction system are provided with means for extracting condensed moisture which is liable to collect therein. Such means may consist of water-collecting chambers provided

with the necessary stop cocks or valves for isolating such chambers for drainage purposes.

In order to increase the degree of suction in the dust-collecting chambers air ejectors operating from the existing compressed air conduit may be employed. Fans may be embodied in the exhaust conduit not so much as boosters but as means to localise the vacuum effect or sub-atmospheric pressure for air expansion purposes.

The invention also includes the provision in existing or new ducting of a valve or valves arranged for automatic opening or closing whereby intermittent expansion of air is obtained. The said valve or valves may be arranged to be controlled thermostatically or their opening and closing may be arranged to depend upon the degree of suction or velocity of the air entering the ducting. In the first mentioned arrangement a thermostatic device such as a bimetallic strip may be employed, while in latter case spring tension or the speed of a wind vane located in the duct may be used.

When thermostatically operated, full opening of the valve or valves may be arranged to take place when the mine temperature rises to a certain degree, which will cause a decrease in temperature in the mine air and the removal of a larger quantity of air with little expansion, or alternatively a rise in mine temperature may be arranged to cause a partial opening of the valve or valves whereby the expansion will be greater but the removal of air lessened. In this latter case, owing to the volume of air removed being reduced, the British thermal units extracted will of course be lessened and the temperature of the workings will rise.

In an alternative embodiment an electrically operated vibrator valve governed by an electrically operated governor of the ball type may be employed in such a manner that its speed would control the valve for opening and closing the duct as desired.

It is to be understood that the present invention is applicable to existing ventilation systems as well as to new installations.

To enable the invention to be more clearly understood and carried into practice, reference is now made to the accompanying drawings in which like reference numerals denote like parts throughout the several views.

Figs. 1*a*–1*d* illustrate diagrammatically applications of the invention to the underground workings of a mine.

Fig. 2 is an elevation of an improved construction for the ventilation ducting.

Fig. 3 is an end section taken on line III—III of Fig. 2.

Fig. 4 is an elevation of an expansion chamber or heat exchanger.

Fig. 5 is an elevation of a modified construction of expansion chamber or heat exchanger.

Fig. 6 shows a spring-regulated control valve.

Fig. 7 shows a thermostatically-controlled valve.

Fig. 8 shows a modified form of thermostatically controlled valve.

Fig. 9 shows a valve controlled for intermittent opening and closing by electrical means, and

Fig. 10 shows a valve controlled by the degree of suction or velocity of inflow of mine air.

Referring to the drawings, Fig. 1*a*, reference **1** denotes a branch of the suction ducting extending down a shaft **3** into an underground working **2**. One inlet for mine air is shown at **4**. A suction is created by pump **55** disposed on the surface of the ground. The mine air entering by this opening is restricted or throttled by the Venturi throat **5** whereafter it expands into the expansion chamber or heat exchanger **6**, provided with fins **7** to increase its efficiency.

In Figure 1*b* a slightly different form of heat exchanger is shown at **8**. In this case the opening **9** causes throttling of the inflowing mine air by being made relatively smaller than the chamber **8**. To provide means for controlling the degree of partial vacuum in the chamber **8**, a booster fan or blower **10** is arranged in series with the ducting **1**. A vacuum gauge **11** indicates the degree of vacuum being obtained.

In Figure 1*c* alternatively a nozzle **50** controlled by a valve or cock **51** may be used to control expansion of mine air into the suction conduit **1** which will itself then act as heat exchanging means.

In another embodiment shown in Figure 1*d* a filtering head **53** controlled by a valve **54** may be arranged so that the filtering medium provides sufficient resistance to inflow to cause the entering mine air to expand for purposes of cooling the suction conduit **1**.

To facilitate the transfer of heat, the suction ducting may be constructed in the manner shown in Figs. 2 and 3, in which the walls are corrugated or fluted in a longitudinal direction to increase their effective area.

Fig. 4 illustrates one form which an expansion chamber or heat exchanger may take. As shown it is connected to the suction ducting by the pipe **12** while the inlet apertures for the mine air are shown at **13** and **14**. Valves **12***a*, **13***a* and **14***a* are provided to regulate the rate of inflow and outflow and consequently the degree of cooling obtained. Vacuum gauges **15** and **16** indicate the actual degree of vacuum at the inlet and outlet sides respectively. The vertical pipes **17** and **18** are connected by a series of horizontal smaller bore cross pipes **19** provided with fins **20**. The lower ends of the pipes **17** and **18** lead into a duct and moisture-collecting chamber **21** supplied with drain cocks **22**. The isolating valves **23** and **24** are provided to enable the chamber to be drained when necessary.

Fig. 5 illustrates another form which a heat exchanger may take. In this case vertical pipes **25** and **26** are connected by small bore cross pipes **27** and top and bottom pipes **28** and **29**. The bottom pipe **29** constitutes the dust- and moisture-collecting chamber and for this purpose is provided with the drain cocks **30**. Mine air enters by the aperture **31** and the apparatus is connected to the suction ducting by the pipe **32** controlled by the valve **33**. A valve **34** controls the inlet aperture **31**.

Figs. 6 to 10 illustrate various constructions to provide for the automatic opening and closing of valves controlling the inflow of mine air to the suction ducting **40**. In Fig. 6 a valve **35** is arranged to be opened against the action of a compression spring **36**. In Fig. 7 a valve **37** is arranged to be opened thermostatically by expansion of the heat sensitive coil **38**. In Fig. 8 a butter-fly valve **39** is controlled thermostatically by a heat sensitive spiral **41**. In Fig. 9 a butterfly valve **42** is arranged to be opened intermittently by an electrically operated vibrator coil **43**, co-operating with a contact **44** fixed to an arm **45** actuating the valve **42**. And lastly, Fig. 10 shows a gate valve **46** controlled by a governor **47** actuated by a wind vane **48** located in the

ducting 40. These constructions are given by way of example and are not intended to limit the invention to these particular methods of valve control.

What I claim is:—

1. In localizing the cooling of air prevailing at selected places in the drives in a mine working which working includes a main shaft and drives extending therefrom, the method which comprises, in combination, the steps of drawing a stream of exhaust air from the drives into a principal zone of lower pressure through branch zones located in said drives and discharging the air from said principal zone outside of the said working, transferring heat from and reducing the temperature of the air prevailing in said selected places by causing the stream of exhaust air in each branch zone to undergo a controlled adiabatic expansion adjacent each selected place, and causing heat exchange, while said exhaust air is cooled as a result of such expansion, between the air prevailing in such selected place and the cooled and expanded exhaust air in the particular branch zone associated therewith.

2. An improved method of cooling the air in an underground working, comprising drawing, through a suction ventilating conduit system disposed in said working, a partial vacuum from the region of the outlet of said working and thereby, at selected points in the working, and by said vacuum, drawing the air into said conduit system, and expanding it, in a controlled adiabatic process, thereby reducing the temperature of the air, and, at selected points within said working, facilitating heat transfer from the air exteriorly of the conduit system to the expanded and cooled air within the latter, to cool said exterior air.

3. An improved method of cooling the air in an underground working having an opening or outlet to the surface, comprising drawing, through a suction ventilating conduit system disposed in said working and having one or more heat exchange zones disposed at desired points therein, a partial vacuum from the region of said outlet, thereby at selected points in the working, and by said vacuum, drawing the air into said conduit system, and expanding it, in a controlled adiabatic process, through restricted stream-lined openings, in said conduit system on the up-stream side of said zone or zones, and, at said one or more heat-exchange zones, facilitating heat transfer from the air exteriorly of the conduit system to the expanded and cooled air within the latter, to cool said exterior air.

4. Apparatus for cooling the air in an underground working, having an opening or outlet to the surface of the ground, comprising a conduit system extending from said outlet into said working; air-evacuating means connected thereto near said outlet for evacuating exhaust air from the system so as to create a partial vacuum in the system; one or more heat-exchange means provided in said conduit system at a point or points within the working where it is desired to localize the cooling of the air in said working exterior to said conduit system; and means, having stream-lined interiors, and providing openings on the up-stream side of said heat exchange means, for causing a controlled adiabatic expansion of the air drawn therethrough into the said heat exchange means, thereby appreciably lowering the temperature of the air which is being exhausted, the heat-exchange means serving to transfer the heat of the air exterior thereto, and which contacts them, to the expanded and cooled air being exhausted.

5. Apparatus for cooling the air in an underground working, having an opening or outlet to the surface of the ground, comprising a conduit system extending from said outlet into said working; air-evacuating means connected thereto near said outlet for evacuating exhaust air from the system, so as to create a partial vacuum therein; one or more heat-exchange means provided in said conduit system at a point or points within the working where it is desired to localize the cooling of the air in said working exterior to said conduit system, said heat-exchange means having total cross-sectional areas substantially increased over that of the remainder of the conduit system, and having large surface areas, for active heat transfer; and means, having stream-lined interiors, and providing openings on the up-stream side of said heat-exchange means, for causing a controlled adiabatic expansion of the air drawn therethrough into the said heat-exchange means, thereby appreciably lowering the temperature of the air which is being exhausted, the heat-exchange means serving to transfer the heat of the air exterior thereto, and which contacts them, to the expanded and cooled air being exhausted.

6. Apparatus for cooling the air in an underground working, having an opening or outlet to the surface of the ground, comprising a conduit system extending from said outlet into said working; air-evacuating means connected thereto near said outlet for evacuating exhaust air from the system, so as to create a partial vacuum in the system; one or more heat-exchange means provided in said conduit system at a point or points within the working where it is desired to localize the cooling of the air in said working exterior to the conduit system, said heat-exchange means having total cross-sectional areas substantially increased over that of the remainder of the conduit system, and having large surface areas, for active heat transfer; water-collecting chambers connected to said heat-exchange means for collecting condensed moisture; means for isolating said chambers from the rest of the system, to permit drainage; and means, having stream-lined interiors, and providing openings on the up-stream side of said heat-exchange means, for causing a controlled adiabatic expansion of the air drawn therethrough into the said heat-exchange means, thereby appreciably lowering the temperature of the air which is being exhausted, the heat-exchange means serving to transfer the heat of the air exterior thereto, and which contacts them, to the expanded and cooled air being exhausted.

7. Apparatus for cooling the air in an underground working, having an opening or outlet to the surface of the ground, comprising a conduit system extending from said outlet into said working; air-evacuating means connected thereto near said outlet for evacuating exhaust air from the system, so as to create a partial vacuum in the system; one or more heat-exchange means provided in said conduit system at a point or points within the working where it is desired to localize the cooling of the air in said working exterior to said conduit system; means, having stream-lined interiors, and providing openings on the up-stream side of said heat-exchange means, for causing a controlled adiabatic expansion of the air drawn therethrough into the said heat-exchange means, thereby ap-

preciably lowering the temperature of the air which is being exhausted, the heat-exchange means serving to transfer the heat of the air exterior thereto, and which contacts them, to the expanded and cooled air being exhausted, and booster fans in the conduit system for substantially localizing the vacuum effect at desired points.

8. Apparatus for cooling the air in an underground working, having an opening or outlet to the surface of the ground, comprising a conduit system extending from said outlet into said working; air evacuating means connected thereto near said outlet for evacuating exhaust air from the system, so as to create a partial vacuum in the system, said conduit system being externally modified at one or more points along its length within the working substantially to localize the heat transfer from the neighboring air in said working exterior to said system; and means, having streamlined interiors, providing openings on the up-stream side of the modified portion or portions of said conduit system, for causing a controlled adiabatic expansion of the air drawn therethrough into the said modified portion or portions of the conduit system, thereby appreciably lowering the temperature of the air which is being exhausted, the modified portion or portions of the conduit system serving to transfer the heat of the air exterior thereto, and which contacts it, to the expanded and cooled air being exhausted.

9. Apparatus for cooling the air in an underground working, having an opening or outlet to the surface of the ground, comprising a conduit system extending from said outlet into said working; air-evacuating means connected thereto near said outlet for evacuating exhaust air from the system, so as to create a partial vacuum therein, one or more heat-exchange means having exteriorly disposed heat-absorbing fins provided in said conduit system at point or points within the working where it is desired to localize the cooling of the air in said working exterior to said conduit system; and means, having streamlined interiors, and providing openings on the up-stream side of said heat-exchange means, for causing a controlled adiabatic expansion of the air drawn therethrough into said heat-exchange means, thereby appreciably lowering the temperature of the air which is being exhausted, the heat-exchange means serving to transfer the heat of the air exterior thereto, and which contacts them, to the expanded and cooled air being exhausted.

10. Apparatus for cooling the air in an underground working, having an opening or outlet to the surface of the ground, comprising a conduit system extending from said outlet into said working; air-evacuating means connected thereto near said outlet for evacuating exhaust air from the system, so as to create a partial vacuum therein; one or more heat-exchange means exteriorly black in color provided in said conduit system at point or points within the working where it is desired to localize the cooling of the air in said working exterior to said conduit system; and means, having stream-lined interiors, and providing openings on the up-stream side of said heat exchange means, for causing a controlled adiabatic expansion of the air drawn therethrough into the said heat-exchange means, thereby appreciably lowering the temperature of the air which is being exhausted, the heat-exchange means serving to transfer the heat of the air exterior thereto, and which contacts them, to the expanded and cooled air being exhausted.

11. An improved method of cooling the air in an underground mine working comprising drawing, through a suction ventilating conduit system disposed in said working, a partial vacuum from the region of the outlet of said working and thereby, at selected points in the working, and by said vacuum, drawing the atmospheric air and its existing water vapour content into said conduit system, and expanding said air, in a controlled adiabatic process, thereby reducing the temperature of the air, and at selected points within said working, facilitating heat transfer from the air exteriorly of the conduit system, to the expanded and cooled air within the latter, to cool said exterior air.

12. Apparatus for cooling the air in an underground working, having an opening or outlet to the surface of the ground, comprising a conduit system extending from said outlet into said working; air-evacuating means connected thereto near said outlet for evacuating exhaust air from the system so as to create a partial vacuum in the system; one or more heat-exchange means provided in said conduit system at a point or points where it is desired to localize the cooling of the air in said working exterior to said conduit system; and means for causing a controlled adiabatic expansion of the air drawn therethrough into said heat exchange means, thereby appreciably lowering the temperature of the air which is being exhausted, the heat-exchange means serving to transfer the heat of the air exterior thereto, and which contacts them, to the expanded and cooled air being exhausted.

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