May 23, 1967 R. S. CHAPPLE ET AL 3,320,765

MINE COOLING UNIT

Filed Feb. 18, 1966 2 Sheets-Sheet 1

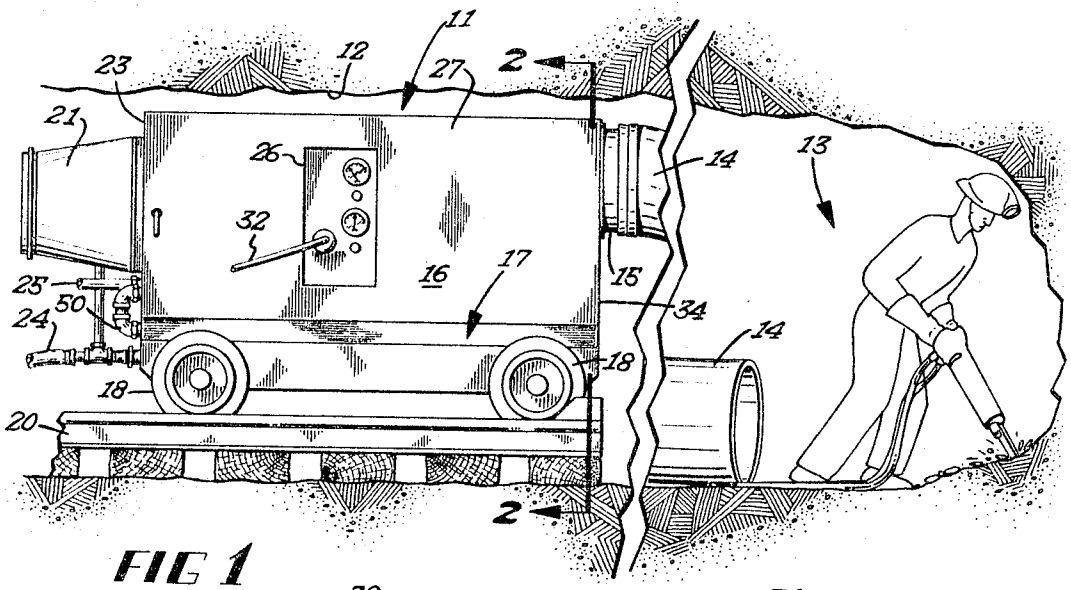


FIG 1

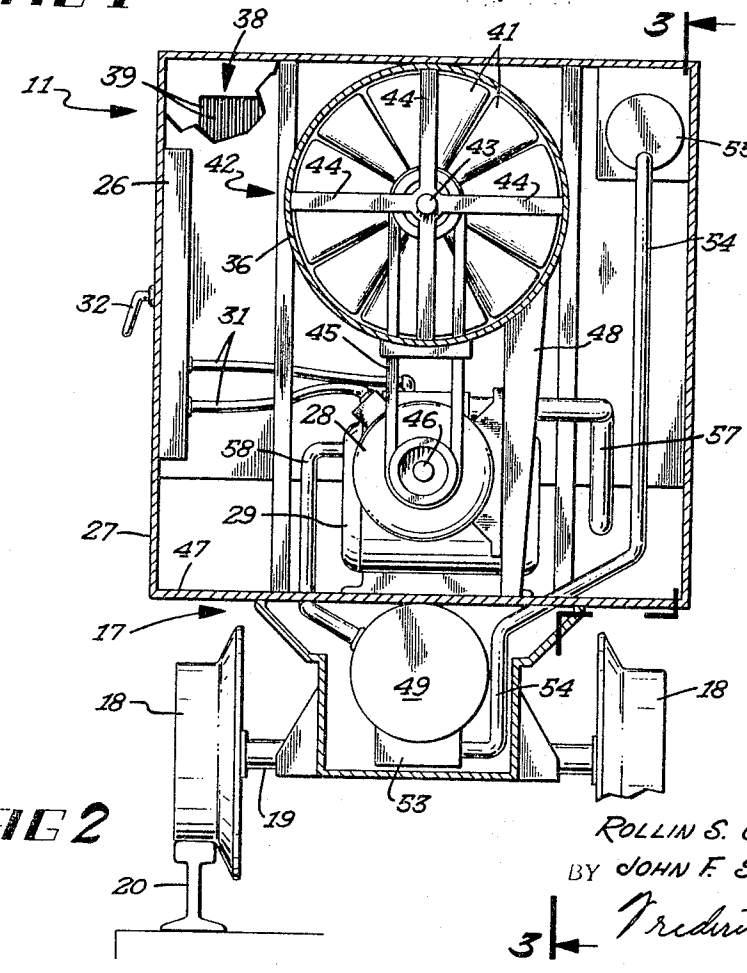


FIG 2

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MINE COOLING UNIT

Filed Feb. 18, 1966 2 Sheets-Sheet 2

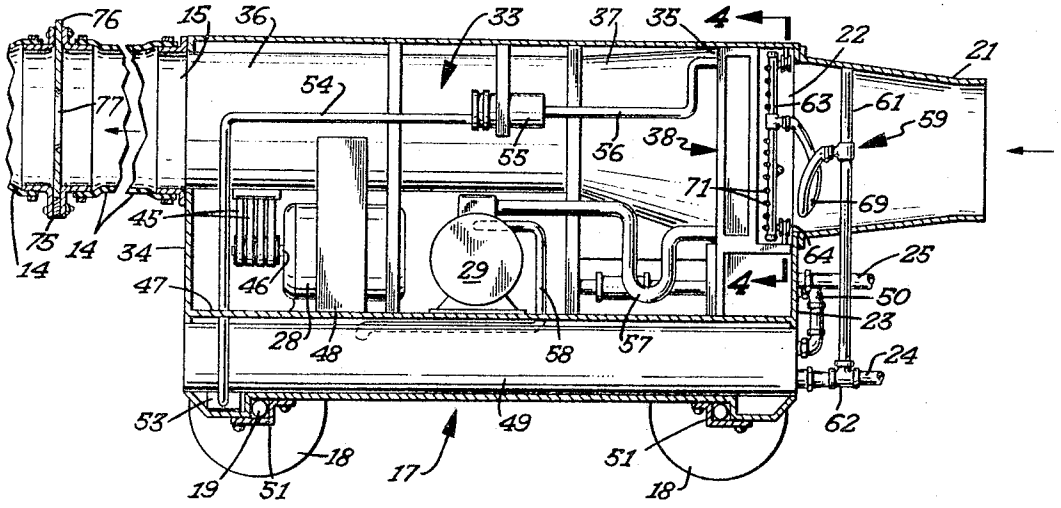


FIG 3

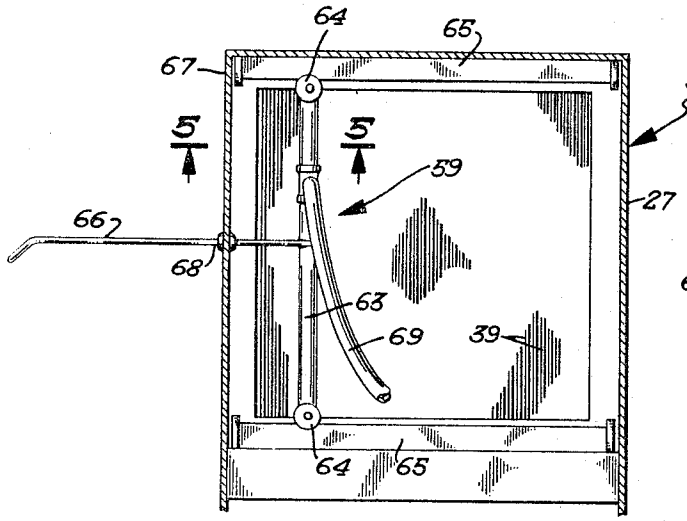


FIG 4

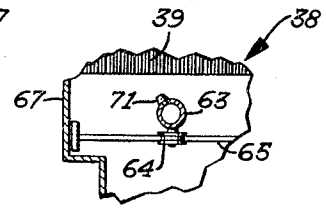


FIG 5

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MINE COOLING UNIT

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11 Claims. (Cl. 62—239)

ABSTRACT OF THE DISCLOSURE

A portable mine cooling unit for introducing cool air into heated mine passages in which the evaporator coils of the unit extend completely across the air passageway in the unit and are positioned in the entrance of the air passageway upstream from the fan in the air passageway; which is utilized to force air through the unit. The air passageway is located in the upper portion of the unit and the condenser, fan motor, compressor and other heavy components of the unit are located adjacent the bottom of the unit so as to improve the stability of the unit.

This invention relates to an improved cooling unit for use in mines, and more specifically, to an improved mobile mine cooling unit having a unique, compact arrangement of the components of the air cooling system whereby the unit may provide maximum cooling capacity within the practical size limitations imposed by the dimension of the mine passages.

As is well known, the extreme heat in many mines, and particularly in those mines which are located in areas of volcanic origin or extend far below the earth's surface, severely limits the efficient working of such mines. In some cases, the heat is so intolerable that the miners are unable to work for more than a few minutes at a time. Heretofore, various types of cooling units have been proposed and used to alleviate the heat in mines, but these units have not proved to be entirely satisfactory because of a number of problems.

One problem is that to enable a cooling unit to be moved within a mine passage and particularly within a passage near the working area, the over-all height and width of the unit obviously must be less than the corresponding dimensions of the mine passage which are often quite small. Additionally, the permissible length of the unit is limited by the radius of curvature of the abrupt curves in the passage.

Another problem is that mines have a notoriously dirty and dusty atmosphere. Thus a successful mine cooling unit must be able to operate under extremely adverse conditions and in vew of the often critical nature of the heat problem involved, with minimum of maintenance and malfunctioning. As a result of the dirty environment of a mine, the air drawn or sucked into the inlet of the unit often has small particles of dirt and other debris entrained therein and these particles tend to damage the blades of the large, high-speed fans utilized in the units heretofore used. Furthermore, to achieve what was believed to be increased cooling effectiveness, the evaporator coils in prior units were positioned downstream of the fan, and this arrangement hindered cleaning and removal of dirt and other debris from the upstream side of the coils.

Furthermore, in addition to being able to function in an extremely dirty environment, the cooling units must be of rugged construction so as to withstand shocks from blasting in the mine passages since it is impractical to move the unit every time blasting occurs.

Briefly, the present invention contemplates the use of an improved mobile, rugged cooling unit in which the components of the cooling system of the unit are arranged in a novel manner whereby the size of the components

may be maximized within the size limitations imposed by the dimensions of the mine passage, thereby miximizing the cooling capacity of the unit. In this novel arrangement, an air passageway extends through the upper portion of the unit, and the fan, which moves the air through the unit, is positioned in a reduced portion of the air passageway adjacent the air outlet. The coils of the evaporator extend substantially across the relatively larger air intake end of the air passageway thereby permitting maximum air intake flow and heat transfer. The fins of the coil, together with the coils themselves, are effective to filter or screen the particles of dirt or other debris entrained in the incoming air thereby preventing the particles from hitting and damaging the blades of the fan. Furthermore, because of the difference in cross-sectional area between inlet and outlet portions of the air passageway, the velocity of the air passing through the evaporator coils is relatively low. This minimizes the number of particles of dirt or debris that will be entrained in the incoming air and also of course minimizes the chances that the particles will damage or clog the evaporator coils. Moreover, the converging tube or nozzle arrangement of the air passageway of the unit permits a smaller fan to be utilized, without reducing the volmue of air flow and also provides additional space for the other components of the air cooling system.

A water cooled condenser for the cooling system is centrally positioned between the wheels of the unit and extends from one end of the unit to the other. In this manner, not only may a larger condenser be utilized but also the cooling unit is made more stable as the center of gravity of the entire unit is lowered. The compressor, fan motor and other heavy components of the cooling system are substantially positioned in the space between the reduced portion of the air passageway and the condenser.

As noted above, this unique arrangement of the components of the cooling system permits maximum utilization of the available space for obtaining optimum cooling capacity and effectiveness. Moreover, this novel arrangement permits use of sturdy, commercially available components which may satisfactorily withstand the extremely adverse conditions present in mines and provide long-lasting dependable service.

Accordingly, a principal object of this invention is to provide an improved mobile cooling unit for mines.

Another object of this invention is to provide an improved mine cooling unit wherein the components of the unit are uniquely arranged, within the size restrictions imposed by the dimensions of a mine passage, so as to afford maximum cooling capacity and effectiveness.

Another object of the present invention is to provide an improved mine cooling unit wherein the evaporator coils of the air cooling system are positioned in the air inlet of the unit, upstream of the air fan so that the coils screen or filter the small particles of dirt or debris entrained in the air and prevent the particles from damaging the blades of the fan. A related object of this invention is to provide a mine cooling unit wherein the cross-sectional area of the air passageway adjacent the evaporator coils is relatively large as compared to the cross-sectional area of the passageway adjacent the fan whereby a large volume of air may be drawn or sucked into the unit at a relatively low velocity and expelled therefrom at a higher velocity.

Another object of the present invention is to provide an improved mine cooling unit, wherein the water-cooled condenser of the cooling system is positioned between the wheels of the unit and extends from one end of the unit to the other. This arrangement permits the size and capacity of the condenser to be significantly increased with respect to the permissible over-all size of the unit, as dictated by the dimensions of the mine passage, with a con-

omitant increase in cooling capacity and efficiency of ıe unit. This arrangement also significantly increases the tability of the unit and this facilitates movement of the nit in mine passages.

Another object of the present invention is to provide an nproved, compact mine cooling unit wherein evaporator oils are positioned adjacent the air inlet of the unit and xtend substantially across the air passageway, a conden- er is positioned between the wheels of the unit and ex- ends from one end of the unit to the other, and the fan notor, compressor and other components of the unit are ositioned between the air passageway and the condenser, enerally beneath the fan portion of the passageway. This ompact arrangement permits the above-described compo- ients of the unit and the unit itself, to be designed for ptimum capacity and effectiveness within the over-all size imitations imposed by the dimensions of the mine passage.

Another object of the present invention is to provide ın improved mine cooling unit including readily accessible neans attached to the unit for quickly and easily clean- ng the evaporator coils.

Still another object of the present invention is to pro- vide an improved mine cooling unit which may be rela- ively inexpensively manufactured from commercially available components, which is relatively easy to main- tain and repair "on the job" and which is sturdy and com- pletely dependable even under the severe operating con- ditions found in mines.

Other objects and features of this invention will become apparent from the following descriptions of the preferred embodiment of the invention, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is an elevational view of the improved mine cooling unit of this invention shown in a mine passage as when in use;

FIGURE 2 is a vertical cross-sectional view taken along line 2—2 in FIGURE 1 with a portion broken away to show a portion of the evaporator coil;

FIGURE 3 is a vertical cross-sectional view taken along line 3—3 in FIGURE 2;

FIGURE 4 is a partial vertical cross-sectional view taken along line 4—4 in FIGURE 3; and

FIGURE 5 is a partial horizontal cross-sectional view taken along line 5—5 of FIGURE 4.

Referring now to FIGURE 1, the improved mine cooling unit **11** of this invention is shown positioned in a mine passage **12**. The right-hand side of FIGURE 1 shows the working area **13** of the mine passage and the terminal end of the conduit **14** which is used to convey cooled air from the unit **11** to the working area. As shown in the left-hand portion of FIGURE 1, the conduit **14** is connected at its other end to the air outlet **15** of the unit.

The cooling unit **11** includes a generally rectangular body **16** formed of heavy gauge metal sheet which protects the components of the unit from falling rocks and other debris encountered in a mine passage also from the force of blasting which frequently occurs in mines. As shown in FIGURE 1, the height of the unit **11** is limited by the ceiling height of the passage **12**. Furthermore, the width and the length of the unit are likewise limited by the width and the radius of curvature of the sharp, abrupt curves in the mine passage, respectively. This spatial limitation presents a real problem as it is impractical to enlarge the mine passage in order to accommodate a large mine cooling unit.

The body **16** of the unit **11** is supported and carried by an undercarriage or frame **17**. Standard flanged railroad type wheels **18** are mounted on axles **19** and are designed to ride on the conventional railroad tracks **20** normally used in mine passages. The unit **11** may be moved within the mine on the tracks **20** as any other type of mine car. Thus, the unit may always be positioned relatively close to the working area of the mine and be moved freely from one passage to another.

As shown in FIGURE 1, the unit **11** has a generally truncated conical cowling or protecting hood **21** which surrounds the air inlet **22** and is detachably secured to and extends rearwardly from the rear end **23** of the unit. Supply water hose **24** is connected with a source of water to supply condensing and cleaning water to the unit and outlet water hose **25** conveys the used water away from the unit.

A conventional electrical control box **26** is mounted on the side wall **27** of the unit and is designed to permit the operator of the unit to control the operation of the unit from alongside the unit. More specifically, the control box **26** controls the operation of the fan motor **28** and compressor **29** which are connected to the box by the conduits **31** Current is supplied to the unit from an external source (not shown) through a conduit **32** removably connected to the box **26**.

Referring now to FIGURES 2 and 3, an air passage **33** extends from the rear end wall **23** to the front end wall **34** of the unit and is centrally disposed, with respect to the side walls of the unit, in the upper portion of the unit. Adjacent the rear wall **23**, the air inlet portion **35** of the passage has a generally rectangular cross-section as shown in FIGURE 4, and from approximately the middle of the unit to adjacent the front wall **34**, the outlet portion **36** of the passageway has a generally circular cross-section. The total cross-sectional area of the outlet portion **36** is substantially smaller than the cross-sectional area of the inlet portion **35**. This permits a large volume of air to be drawn into the unit at a low velocity relative to the velocity of the air in the outlet portion **36** and the conduit **14**, and thus reduces the number and size of the particles of dirt or debris which will be entrained in the incoming air. The intermediate portion **37** of the air passageway is generally shaped in the form of a converging tube or nozzle and provides a smooth interconnection between the inlet and outlet portions **35** and **36**.

A rather large, high performance evaporator coil **38** is positioned in the inlet portion **35** of the passageway adjacent the rear wall and the coil **38** extends completely across the air passageway so that all air flowing into the unit and through the passageway must pass through the coil. The coil **38** may be a conventional cooling coil of the type usable with direct expansion refrigerants such as Type "F" refrigerant coils manufactured by the Trane Company of La Crosse, Wis. The coils include continuous curved metal fins **39** which are designed to achieve improved turbulent air flow through and around the coils and thus superior heat exchange characteristics. These fins **39** are positioned closely adjacent each other and therefore also act as a filter or screen for the incoming air. In other words, the fins **39** are so positioned that particles, particularly the larger particles, of dirt and like debris which may be sucked up and entrained in the air being drawn into the unit, are filtered or screened by the fins and thereby prevented from passing into the rest of the air and damaging the rotating blades **41** of the high speed fan **42**.

The fan **42** is positioned in the outlet portion **36** of the air passageway adjacent the outlet **15** of the unit. As noted above and as shown in FIGURE 2, the outlet portion **36** of the air passageway has a circular cross-section and blades **41** of the fan **42** have an outer diameter substantially equal to the inner diameter of the air passageway. The fan shaft **43** is mounted and supported in the air passageway by means of cross members **44** and is driven by a plurality of belts **45** which interconnect, in driving relationship, the shaft **43** and the output shaft **46** of the electrical motor **28**. The motor **28**, as shown in FIGURE 2, is positioned directly below the fan and the air passageway in the unit and is securely mounted on the floor **47** of the body unit. The fan and outlet portion **36** are supported and braced by the vertical member **48**. As noted above, the operation of the motor is con-

trolled from the electrical contact box **26** mounted in the side **27** of the unit.

The arrangement and construction of the air passageway permits the utilization of a smaller diameter fan without unduly impairing the flow rate through the unit. Because of the screening or filtering effect of the fins **39** on the evaporator coils **38**, the fan **42** may be safely operated at high speed without fear of having the blades **41** damaged by particles of dirt or debris which would otherwise be entrained in the air flowing through the unit. Furthermore, utilization of the smaller fan not only permits more economical operation, but it also provides more available space for the other components of the coiling system. This is particularly important in an environment where space is at a premium, as in a mine passage.

Immediately rearwardly and adjacent to the motor **28** (to the right in FIGURE 3) a reciprocating compressor **29** is positioned. As noted in FIGURE 3, the compressor is securely mounted on the floor **47** in the space adjacent the intermediate portion **37** of the air passageway. Thus, the motor **28** and compressor **29** are both positioned in the increased space made available by the utilization of the reduced cross-sectional area portion of the air passageway in the unit. Thus, other than what might be expected, the reduction of the size of a portion of the air passageway does not adversely affect the capacity or effectiveness of the unit. Rather, as pointed out above, the capacity and effectiveness is increased due to the fact that larger components may be used in the system.

A water cooled condenser **49** is positioned between the floor **47** of the unit and the axles **19** of the wheels **18**. As shown in FIGURES 2 and 3, the condenser **49** is generally cylindrical in shape, extends from one end of the unit to the other and is positioned midway between the wheels **18**. Condenser **49** is supported by the undercarriage **17** which is in turn supported by the axles **19**. Bearings are mounted between the undercarriage **17** and the axles and are held in place by clamps **51**.

This positioning of the condenser **49** is particularly advantageous in that the condenser is one of the heaviest and bulkiest components of the cooling system. Moreover, the space between the tracks **20** in mines is always maintained free of debris and rock to permit passage of the conventional material handling mine cars. Not only does this arrangement provide a significant amount of additional space in the body **16** of the unit, which as noted above, permits the size of compressor, fan and motor and evaporator coils but also greatly increases the stability of the mine cooling unit in that it significantly lowers the center of gravity of the unit. This increased stability aids in the ease of moving the unit from one position to another and, of course, reduces the possibility of the unit accidentally tipping over.

As noted above, the condenser **49** is water cooled and may be connected, through hose **24**, to a source of water remote from the unit. Water from the condenser passes through an elbow assembly **50** to a conventional flow regulator, not shown, located on the floor **47** of the unit and thereafter out through the hose **25** to a sump. The coolant or refrigerant used in the cooling system is introduced into the top of the condenser and passes through baffle chambers to a lower collecting sump **53** at the bottom portion of the condenser.

The liquefied coolant or refrigerant from the condenser is conveyer from the sump **53** thereof through tubing **54** to a dryer **55**. From this dryer the coolant passes through tubing **56** to the expansion valve, not shown, and then to the evaporator coil **38**. After passing through the evaporator coil **38** the coolant is returned to the compressor **29** through tubing **57** and is again compressed. From the compressor the coolant is returned to the top of the condenser through tubing **58**.

As noted above, all the components of the cooling system are of conventional design and the design and functional interrelationship of the components, per se, does not form a part of this invention. Rather, it is the specific spatial relationship and location of these components within the limited, restricted space dictated by the dimensions of the mine passage that constitutes the invention.

For best efficiency, the coils and fins of the evaporating coil **39** must be periodically cleaned to remove the dirt which naturally accumulates thereon because of the dirty atmosphere in mines. Furthermore, the filtering or screening effect of the fins **39** and the small air flow passages through the coils necessitate that the coils be cleaned regularly. For this reason, and because of the often critical nature of the heat problem in the mine, cleaning apparatus **59** is incorporated into the unit to facilitate the cleaning of these coils and particularly the cleaning of the upstream side of the coils. As shown in FIGURES 3, 4 and 5, the cleaning apparatus **59** includes a standpipe **61** which is interconnected by means of a T fitting and three-way valve **62** to the inlet water hose **24** adjacent the condenser. If desired, standpipe **61** may instead be connected to the outlet side of the water system adjacent hose **25**. This pipe **61** extends upwardly from the hose **24** into the cowling **21** which, as noted above, surrounds the inlet **22** of the air passageway. A second vertically extending pipe **63** is positioned immediately adjacent the upstream side of the coils **38** and between the coils and wall **23**. This pipe **63** has rollers **64** rotatably attached to each end thereof. The rollers engage and are guided by the tracks **65** which extend across the unit at the top and bottom of the passageway. This roller and track arrangement permits the pipe **63** to be reciprocally moved across the upstream face of the cooling coils by means of a handle **66** which extends through the side wall **67** of the unit. A gasket **68** journals the handle **66** in the side wall. The pipe **63** is connected with the standpipe **61** by means of a flexible hose **69** and includes a plurality of nozzles **71** which are vertically arranged along the pipe as shown in FIGURE 5. These nozzles **71** are offset slightly from a plane perpendicular between the pipe and the face of the coils so as to provide better cleaning characteristics. In operation, the valve **62** is opened, cleaning pipe **63** is manually moved back and forth across the upstream face of the evaporator coils until the dirt is washed therefrom by the relatively high velocity water jets from the nozzles **71**.

As noted above, the cooling unit of this invention is generally positioned as close to the working area in the mine as possible. The general practice is to build a short siding off of the main track in the passage and position the cooling unit thereon while in use so as not to block the main track which, of course, is needed to convey the mined material from the working area. The conduit **14** extends from the outlet **15** of the unit to the working area and provides a steady, relatively large volume stream of cooled air to the working area and the miners working therein as shown in FIGURE 1.

The length of the conduit **14** will vary with different mine situations. In some cases, it is possible to place the cooling unit fairly close to the place of work. In others, it is necessary to place it a substantial distance away. In order to have a uniform flow of air to the working area, it is desirable to provide some means for compensating for the varying pressure drops through the conduit **14** depending upon the length of the conduit. This may be accomplished by the use of variable size orifice plates. Referring to FIGURE 3, it will be noted that there is shown a holder **75** interposed in the hose **14**. This holder is preferably located a substantial distance from the mine cooler, for example five feet away. The holder **75** is designed to receive a disc **76** having a central aperture **77** therein. If the distance from the cooling unit to the working area is relatively short, the

perture 77 will be relatively small to create a substantial pressure drop. As it is necessary to use longer conuits 14, a different plate 76 is substituted. This plate ;ill have a larger aperture 77. Where the hose is exremely long, the aperture plate 76 may be omitted enirely. By the use of such aperture plates 76 with diferent size orifices, it is possible to have reasonably contant rates of flow through hose 14 regardless of the ength thereof.

As noted hereinabove, the arrangement of the cooling ystem components of the mine cooling unit of this invenion permits maximum utilization of the available space n a mine passage. Thus, the cooling capacity of this nine unit may be optimized since larger components may)e used than heretofore possible. The specific design)f the mine cooling unit permits air to be drawn into he unit at a relatively low velocity thereby substantially :liminating entrainment in the incoming air of large)articles of dirt or other debris. Furthermore, the ar-angement of the fins on the evaporator coils, positioned n the inlet of the unit, prevents substantially all of the arger particles of dirt and debris which are entrained n the air from hitting the rotating blades of the high speed air fan, thereby preventing damage to the blades of the fan.

Furthermore, the novel arrangement of the components permits construction of a sturdy, stable unit which can withstand the conditions found in mines, such as falling debris, the concussive forces from blasting, and the dirty atmosphere.

Accordingly, it is seen that the mine cooling unit of the present invention solves a longstanding problem in that it provides a high capacity and extremely effective means for cooling the air within a mine passage. Not only does this unit provide a highly advantageous cooling capacity and effectiveness, but also it is relatively inexpensive to manufacture and maintain in that it utilizes standard commercially available components.

It will be understood that the various changes may be made in the arrangement and details of construction of the cooling unit described hereinabove. Therefore, it is desired that the above described embodiment be considered in all respects as illustrative and not restrictive, reference being made to the appended claims rather than the foregoing description to indicate the scope of the invention.

We claim:

1. A mine cooling unit comprising a carriage; a housing carried by said carriage; said carriage and housing being of a size capable of being positioned in and moved along a mine passage; said housing including an air intake, an air outlet and an air passageway extending between said air intake and said air outlet; a fan positioned in said air passageway for drawing air therethrough; a motor located adjacent said air passageway and operatively connected with said fan; refrigeration apparatus located substantially in said housing, said refrigeration apparatus comprising a compressor, a condenser and an evaporator coil; said coil being located within said air passageway between said air intake and said fan and having sufficiently small air passages therethrough to prevent debris of any substantial size from engaging said fan; said condenser being located adjacent to the bottom of said housing and said motor and said compressor being located below said air passageway and adjacent said condenser.

2. The mine cooling unit of claim 1 in which the condenser is a water cooled condenser and extends substantially the full length of said air passageway in said housing.

3. The mine cooling unit of claim 1 in which the carriage is a wheeled carriage adapted to be supported upon and moved along the tracks in a mine passage and in which the condenser extends between the wheels of said wheeled carriage.

4. The mine cooling unit of claim 1 in which adjustable air directing means are connected with said air outlet and adapted to direct the cooled air leaving said air outlet to a selected remote work area in the mine.

5. The mine cooling unit of claim 1 in which said evaporator coil is located in said air passageway adjacent said air intake and extends completely across said air passageway.

6. The mine cooling unit of claim 5 in which said fan is positioned within said air passageway adjacent said air outlet and said fan is substantially the same size as the air passageway adjacent said air outlet.

7. The mine cooling unit of claim 6 in which the cross-sectional area of said air passageway adjacent said air intake is relatively larger than the cross-sectional area of said air passageway adjacent said air outlet and said air passageway also includes a substantially converging nozzle portion extending between the portions of said air passageway adjacent said air intake and said air outlet.

8. The mine cooling unit of claim 7 in which said air passageway extends through the upper portion of said housing and in which said motor is located between said air passageway and said condenser substantially under said fan.

9. The mine cooling unit of claim 8 in which said compressor is located between said converging nozzle portion of said air passageway and said condenser adjacent said motor.

10. The mine cooling unit of claim 1 which includes means disposed on the intake side of said condenser for cleaning dirt and the like from said small passages through said evaporator coil.

11. The mine cooling unit of claim 1 in which a conduit extends from said air outlet to a selected work area and in which an orifice plate is located in said conduit, said orifice plate having an orifice therein of a size dependent upon the length of said conduit.

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