Jan. 7, 1969 H. O. KIRKPATRICK 3,420,294

ROOF MOUNTED AUTOMOBILE HEAT EXCHANGER

Filed Dec. 19, 1966 Sheet 1 of 2

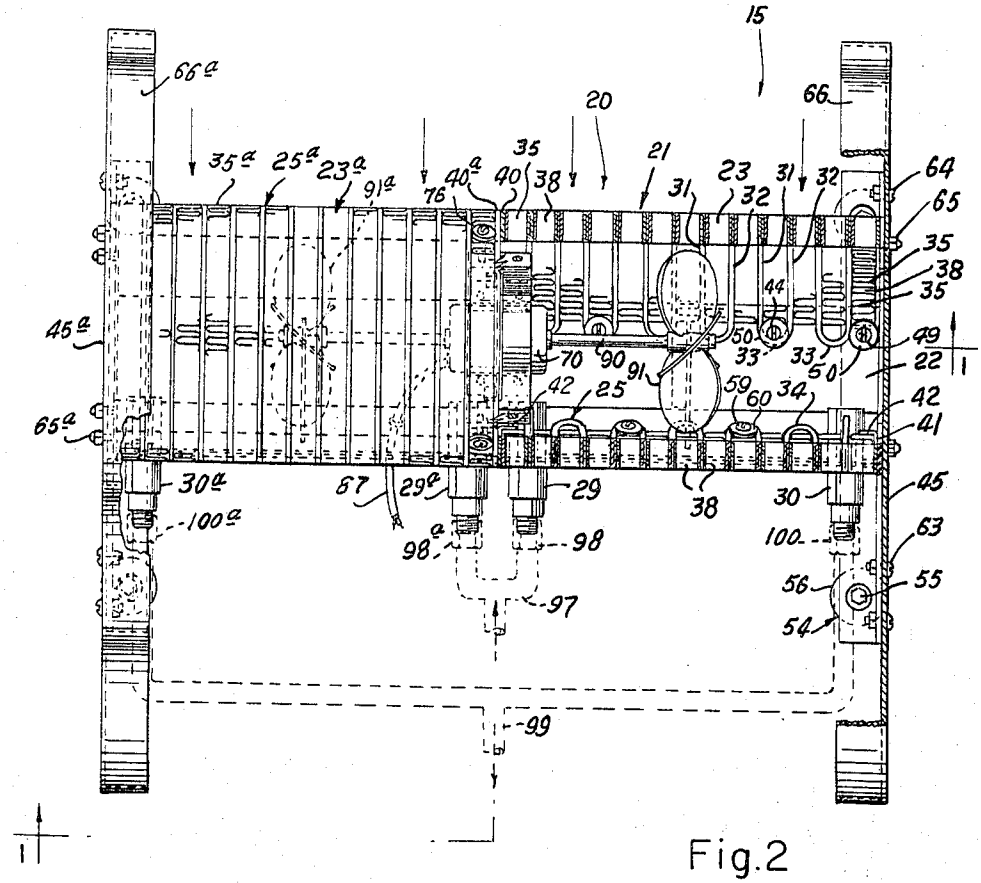


Fig.2

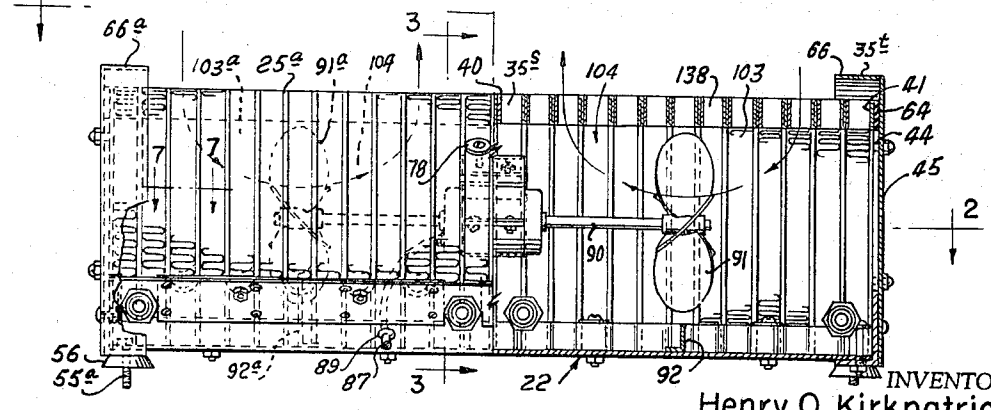


Fig.1

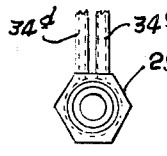


Fig.9

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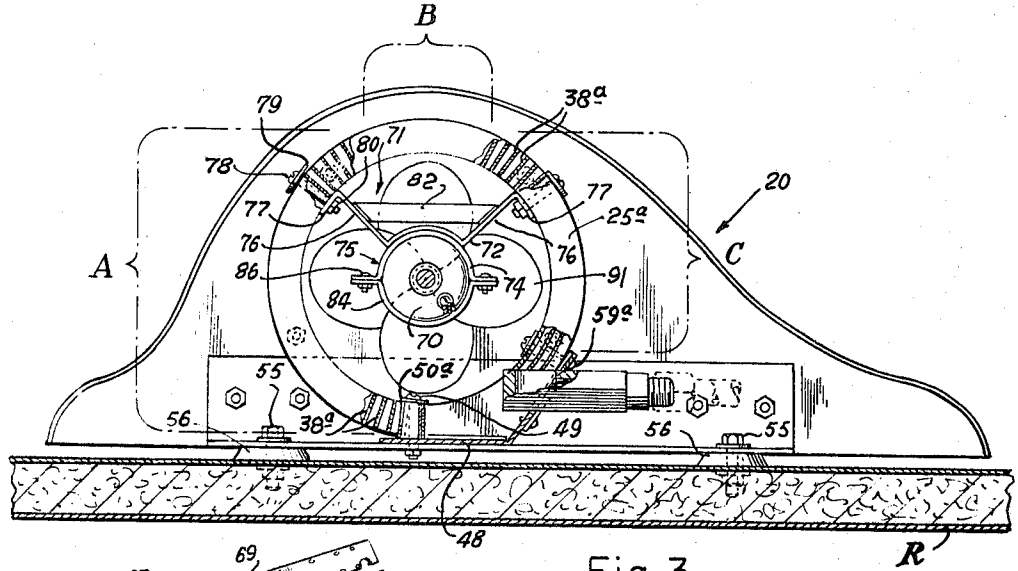


Fig. 3

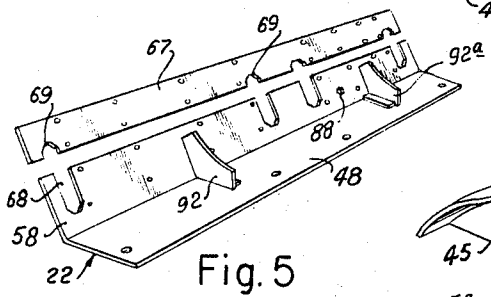


Fig. 5

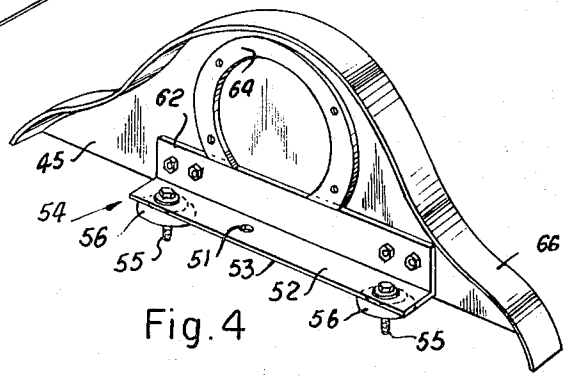


Fig. 4

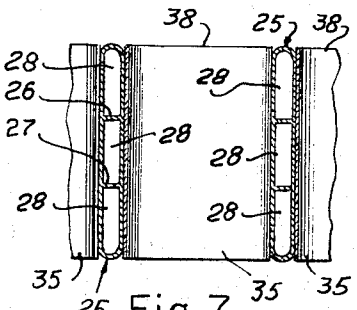


Fig. 7

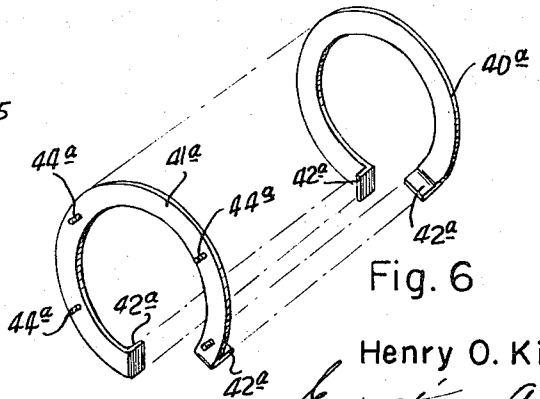


Fig. 6

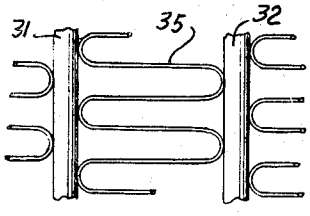


Fig. 8

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ROOF MOUNTED AUTOMOBILE HEAT EXCHANGER

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U.S. Cl. 165—41 6 Claims
Int. Cl. F28b *1/06*

ABSTRACT OF THE DISCLOSURE

A heat exchanger having a coil assembly through which a heat transfer fluid may be circulated. The coil assembly being in the form of a section of a cylinder and including a coil whose convolutions are spaced longitudinally of the cylinder and convoluted heat transfer means between adjacent spaced sections of the coil. End plates close opposite ends of the coil assembly, and air moving means are disposed in the coil for moving air inwardly through opposite end portions of the coil assembly and outwardly through a middle portion thereof.

This invention relates to heat exchangers and more particularly to a heat exchanger for a refrigeration apparatus.

An object of this invention is to provide a new and improved heat exchanger through which air may be circulated to transfer heat between the circulated air and a refrigerant fluid flowing through a coil of the heat exchanger.

Another object is to provide a heat exchanger of simple structure and of relatively small dimensions for a given heat transfer capability.

Another object of this invention is to provide a heat exchanger which is mountable on a vehicle through which air flow takes place due to the movement of the vehicle on which it is mounted, the heat exchanger having means for circulating air therethrough when the vehicle is not moving or very slowly.

A further object is to provide a heat exchanger having a coil through which a refrigerant fluid is circulated which provides for efficient transfer of heat between the refrigerant fluid and air being circulated through the heat exchanger.

Another object is to provide a heat exchanger having a coil assembly arranged to constitute a section of a cylinder, the coil assembly having a coil whose convolutions are spaced longitudinally of the cylinder and convoluted heat transfer means between adjacent spaced sections of the coil.

A still further object is to provide a heat exchanger of the type described having end plates which close opposite ends of the coil assembly and air moving means disposed in the coil for moving air inwardly through opposite end portions of the coil assembly and outwardly through a middle portion of the coil assembly.

Another object is to provide a coil assembly of the type described having air circulation passages through substantially 340 degrees of a cylinder whereby the circulation of air therethrough when the vehicle on which it is mounted is moving is faciliated due not only to ram effect but also to the pressure differential created between the interior of the coil assembly and the exterior thereof due to the decrease in pressure above and rearwardly of the coil assembly.

Still another object is to provide a coil assembly wherein the flow of the refrigerant through the coil of the coil assembly is in reverse direction to the flow of air through the end and middle portions of the coil when the

air moving means is in operation to provide an optimum substantially uniform temperature gradient at all locations of the coil between the air circulating through the coil assembly and the refrigerant fluid circulating through the coil.

Additional objects and advantages of the invention will be readily apparent from the reading of the following description of a device constructed in accordance with the invention, and reference to the accompanying drawings thereof, wherein:

FIGURE 1 is a rear partly sectional view of a heat exchanger embodying the invention taken on line 1—1 of FIGURE 2;

FIGURE 2 is a partly sectional view taken on line 2—2 of FIGURE 1;

FIGURE 3 is a sectional view taken on line 3—3 of FIGURE 1;

FIGURE 4 is a perspective view of one of the end mount assemblies of the heat exchanger;

FIGURE 5 is a perspective view of a bottom closure plate of heat exchanger;

FIGURE 6 is a perspective view showing the end reinforcing plates of one of the sections of the coil assembly;

FIGURE 7 is a fragmentary enlarged sectional view of the coil assembly;

FIGURE 8 is a fragmentary enlarged front view of the coil assembly; and,

FIGURE 9 is a fragmentary view of a modified form of the coil assembly.

Referring now particularly to FIGURES 1 through 8 of the drawings, the heat exchanger **15** embodying the invention is shown mounted on the roof R of a vehicle for use as the condenser of a refrigerating apparatus employed to cool and condense refrigerant fluid compressed by a compresser of the apparatus prior to its transmission to an evapartor of the apparatus disposed in a compartment of the vehicle wherein the condensed refrigerant fluid evaporates and expands to cool such compartment.

The heat exchanger **15** includes a coil assembly **20** having a coil **21** which constitutes a section of approximately 340 degrees of a cylinder and a closure plate **22** which extends between the longitudinal adjacent ends of the coil to close the gap of approximately 20 degrees therebetween. The coil may be formed of two sections **23** and **23***a* secured together in longitudinal alignment. The section **23** has a flattened tube **25** divided by longitudinal partitions **26** and **27** into three longitudinal passages **28** which open at their inlet ends to the inner end of the tube inlet coupling **29** and at their outlet ends **29** to a similar outlet coupling **30**. The tube is arranged in a plurality of arcuate convolutions about a central longitudinal axis, the convolutions being defined by pairs of adjacent parallel arcuate portions **31** and **32** connected at their forward bottoms ends by arcuate front end portions **33** and at their rear ends by arcuate end portions **34**. Convoluted heat exchanger fins or vane strips **35** are disposed between adjacent parallel portions of the convolutions of the tube with opposite bight portions of the strips being secured, as by welding, bonding or the like, in good heat conductive relationship to the tube. The strips **35** impart great rigidity and strength to the coil section and also provide for a good heat transfer between a refrigerant fluid which is circulated through the passages of the tube and air which flows through the passages **38** defined by the strips **35** and the tube. The passages **38** extend radially relative to the central longitudinal axis of the coil assembly.

The inner and outer end strips **35***s* and **35***t*, respectively, of the coil section **23** extend outwardly of the end arcuate portions of the tube and inner and outer arcuate end reinforcing plates **40** and **41**, respectively, and are secured thereto. The reinforcing plates having inturned flanges **42**

to which opposite ends of the end strips are secured. The outer reinforcing plate **41** is provided with a plurality of threaded studs **44** by means of which the reinforcing plate may be secured to an end plate **45** which closes the outer end of the coil section **23**.

The closure plate **22** of the coil assembly **20** has a bottom horizontal portion **48** over which extends, in tangential relationship, the forward bottom end portion of the coil section **23** which is secured thereto by bolts **49** and suitable washers **50**. The bolts extend through spaces between the end portions **33** of the tube convolutions and the ends of the strips.

The outermost bolt also extends through a suitable aperture **51** in the horizontal flange **52** of the angle bracket **53** of a mount assembly **54**. The mount assembly is secured to the roof R of a vehicle by any suitable manner, as by bolts **55** which extend through suitable apertures of the horizontal flange of the angle bracket. Suitable resilient spacers **56** are interposed between the horizontal flange and the vehicle roof.

The rearwardly and upwardly extending portion **58** of the closure plate abuts the rear portion of the coil section and is rigidly secured there by bolts **59** and washers **60**, the bolts extending through the spaces between the end portions **34** of the tube and adjacent ends of the cooling strips **35**. The vertical flange **62** of the angle bracket of the end mount assembly **54** is rigidly secured to the end plate **45** in any suitable manner, as by bolts **63**, and to the outer reinforcing plate **41** of the coil section **22** by means of the studs **44**, which extend outwardly through aligned apertures in the end plate and in a gasket **64** which is interposed between the end plate and the reinforcing plate, and cap nuts **65** threaded on the studs. The end plate may have a desired ornamental configuration and be provided with an inwardly extending peripheral flange **66** which serves to conceal the angle bracket.

The coil section **23***a* and the mount assembly **54***a* are similar in structure to the coil section **23** and the mount assembly **54**, and, accordingly, their elements have been provided with the same reference numerals, to which the subscript "*a*" has been added, as the corresponding elements of the coil section **23** and the mount assembly **54**.

The inner reinforcing plates **40** and **40***a* of the two coil sections **23** and **23***a*, respectively, abut one another and are rigidly secured to one another in any suitable manner, as by bonding or the like so that the two coil sections are rigid with one another.

A plate **67** may be secured, as by screws, to the rear upwardly inclined portion **58** of the closure plate to close the upper portions of the slots **68** of the closure plate through which the couplings of the two coil sections extend. The plate **67** has slots **69** in which the upper portions of the couplings are received. Suitable gaskets, not shown, may be disposed about the couplings to prevent flow of air between the couplings and the plates **22** and **67**.

A motor **70** is mounted in the coil assembly by means of a motor mount **71** whose bracket **72** has an arcuate middle portion rigidly secured, as by welding, to an arcuate top motor clamp strap **75**. The bracket has upwardly and outwardly divergent arms **76** provided with downwardly extending flanges **77** which are secured to the coil by means of bolts **78** which extend through the passages **38** of the coil and suitable apertures in the end flange. The bolts, of course, are provided with the usual washers **79** and nuts **80**. A brace bar **82** extends between and is rigidly secured to the arms **76**, as by welding. A bottom clamp strap **84** extends below the motor and the two clamp straps are secured by bolts **86** which extend through suitable apertures in their abutting end flanges. The electric cable **87** through whose conductors electric current is supplied to the motor extends outwardly to an input circuit through an aperture **88** of the closure plate. A grommet **89** prevents contact between the insulation of the cable and the edges of the closure plate defining the aperture.

The drive shaft **90** of the motor has end portions extending outwardly of the motor to which are secured fans **91** and **91***a*. The fans are disposed at the middles of the two coil sections and in alignment with the baffle plates **92** and **92***a* rigidly secured to the closure plate and which extend between the adjacent end portions of the coil sections to prevent air from bypassing the fans between the ends of the coil sections. The pitches of the blades of the fans are such that when the motor is energized, the fans draw air inwardly into the end passages through the radial passages **38** and **38***a* of the coil **21** at the end portions of the coil and then into the middle passage from where the air flows outwardly through the radial passages at the middle portion of the coil.

Hot compressed gas from the compressor of a refrigeration apparatus is delivered simultaneously by means of a branched conduit **97** and couplings **98** and **98***a* connected to the inlet couplings **29** and **29***a*, respectively, of the coil **21**, and thus to the inner inlet ends of the tubes **25** and **25***a*, respectively. The liquified and cooled refrigerant fluid is withdrawn from the outer ends of the tubes **25** and **25***a* by means of a branched conduit **99** and couplings **100** and **100***a* which are connected to the other couplings **30** and **30***a*, respectively.

The coil assembly and the end plates define a chamber **102** divided into outer end passages **103** and **103***a* and a middle passage **104** by the fans and the baffle plates. The middle passage of the chamber is approximately twice as long as the end passages so that the rate of outward flow of the air from the middle passage through the radial passages which open thereto is essentially equal to the rate of inward flow of air into the end passages through the radial pasages which open to the end passages.

In use, when the vehicle on which the condenser **20** is mounted is traveling forwardly, the air pressure along the front portion A of the coil increases and simultaneously the pressure of the air along the upper and rear portions B and C, respectively, of the coil decreases. The air pressure forwardly of the coil is thus greater than the pressure within the passages **103**, **103***a* and **104** of the coil assembly and simultaneously the pressure rearwardly and upwardly of the coil is less than the pressure within these passages of the coil. As a result, due to this pressure differential, as well as the ram effect created by the forward movement of the vehicle, air flows inwardly into the passages **103**, **103***a* and **104** of the coil assembly through the radial passages along the potrion A and flows outwardly from the passages **103**, **103***a* and **104** rearwardly through the radial passages along the rear portion C of the coil and also upwardly through its radial passages along the portion B. Large volumes of air thus flow through the heat exchanger past very large areas of the tubes and of the cooling fins or strips **35** and **35***a* so that the air absorbs large amounts of heat from the hot compressed refrigerant fluid flowing through the tubes as the air circulates through the coil assembly.

When the vehicle is stopped for a short period of time, as for a traffic signal light, it may not be necessary to energize the motor since some of the radial passages along the lower forward portion of the coil open upwardly into the passages **103**, **103***a* and **104** of the heat exchanger and other radial passages at the top portion thereof open upwardly from the passages and convective flow of air takes place through the heat exchanger as the air in the passages of the coil heats and rises.

If the vehicle remains stationary a long period of time, however, it is necessary that forced circulation of air take place through the heat exchanger. The motor is then energized and, since the pitches of the blades of the two fans are reversed, as the fans are rotated in a counterclockwise manner, FIGURE 3, air is drawn inwardly through the radial passages of the portions of the coil located longitudinally outwardly of the fans into the end passages **103** and **103***a*, thence into the middle passage **104** and then outwardly through the radial passages of the coil

which open to the middle passage. Since the hot compressed refrigerant fluid is introduced into the inner ends of the tubes **25** and **25***a* of the coil **21** at the inlet couplings **29** and **29***a* and then flows through the tubes to the outlet couplings **30** and **30***a*, the temperature gradient between the refrigerant fluid flowing through the tubes at the location of the middle passage and the air flowing outwardly from the middle passage of the coil through the radial passages which open to the middle passage is substantially equal to the temperature gradient between the refrigerant fluid flowing through the portions of the tubes at the locations of the end passages and the air flowing inwardly through the radial passages which open into the end passages. It will be apparent that the air flowing inwardly into the end passages is cooler than the air flowing outwardly from the middle passage since the air in flowing into the end passages is warmed due to the absorption thereby of heat from the refrigerant fluid flowing through the tubes at the locations of the end passages which has been somewhat cooled during its passage through the portions of the tubes at the location of the middle passage due to the absorption of air heat therefrom by the air flowing outwardly through the radial passages which open to the middle passage.

It will now be seen that since the coil **21** is substantially tubular and extends transversely of the direction of movement of a vehicle on which the heat exchanger is mounted and since it is in substantially the form of a section of approximately 340 degrees of a cylinder, the cooling fins or strips and the tubes have very great areas of surface exposed to the air which flows through the heat exchanger whether due to the movement of the vehicle on which the heat exchanger is mounted or due to the operation of the fans.

It will further be seen that the heat exchanger may be of relatively small overall dimensions for a given rate or capacity of heat exchange between the fluid being circulated through its tubes and the air which flows therethrough.

While the heat exchanger has been illustrated as being formed of two sections **23** and **23***a*, the heat exchanger may be formed of a coil having a single tube whose middle rear arcuate portion is cut and the adjacent portion **34***d* and **34***e* thereof are connected to a single inlet conduit **29***d*, FIGURE 9, so that in effect the tube is separated into two sections extending from a middle vertical plane of such long coil and that the refrigerant fluid will then flow through such tube sections from their inner ends outwardly to the outer ends thereof.

The foregoing description of the invention is explanatory only, and changes in the details of the construction illustrated may be made by those skilled in the art, within the scope of the appended claims, without departing from the spirit of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. A heat exchanger including: a tubular coil assembly, said coil assembly including a coil having a tube through which a heat transporting fluid may flow, said tube having convolutions, said convolutions being provided by parallel arcuate spaced portions of the tube and end connector portions connecting adjacent ends of adjacent parallel portions, and convoluted heat transfer strips disposed between adjacent parallel portions of the tube and providing with the tube a plurality of air passages which extend between the exterior and the interior of said coil assembly; a pair of air moving means in said coil assembly dividing the interior of said coil assembly into a pair of end passages and a middle passage; means in said coil for driving said air moving means, said air moving means moving air inwardly into one of said middle passage and said end passages through those of said air passages which open to one of said middle passage and said end passages and moving air outwardly from the other of said middle passage and said end passages through those of said air passages which open to said other of said middle passage and said end passages; and means for closing outer ends of said end passages, said tube and said convoluted strips of said coil lying in a section of a cylindrical plane of at least 180 degrees; said coil assembly including a closure plate closing the space between adjacent ends of said coil whereby air may move into and out of said end and middle passages only through said air passages.

2. The heat exchanger of claim **1**, and means for introducing heat transporting fluid into said tube at a midpoint thereof and for withdrawing fluid from said tube at opposite ends thereof.

3. The heat exchanger of claim **2**, and means for mounting said heat exchanger on a vehicle in position wherein the axis of said cylindrical plane extends transversely to the direction of forward movement of the vehicle and forward movement thereof will cause air to flow inwardly into the end and middle passages through air passages at the front potrion of said coil assembly and outwardly from the end and middle passages through air passages at the rear and upper portions of said coil assembly.

4. A heat exchanger adapted to be mounted on a vehicle for use as a condenser of a refrigerator apparatus, said heat exchanger including: a substantially tubular, elongated coil assembly having an elongated chamber closed at its ends and extending transversely to the direction of movement of a vehicle on which the heat exchanger is mounted, said coil assembly including a convoluted tube through which refrigerant fluid may flow, and a plurality of heat transfer fins between convolutions of the tube, said tube and said fins constituting an arcuate coil and said coil being in the form of a section of a cylinder greater than 180 degrees, said coil having transversely extending sides, said coil assembly including a closure plate extending between said spaced sides and closing the space therebetween, said tube and said fins defining a plurality of spaced air passages opening from such chamber forwardly at the front portion of the coil assembly, upwardly at the upper portion of the assembly and rearwardly at the rear portion of the coil assembly whereby when a vehicle on which the heat exchanger is mounted is moving forwardly, air flows inwardly into said chamber through air passages of said assembly at the front portion of said assembly and outwardly from the interior of said assembly through air passages along another portion of said assembly and air moving means for moving air inwardly into the interior of said assembly through air passages along one portion of said assembly and outwardly from the interior of said assembly through air passages along another portion of said assembly.

5. The heat exchanger of claim **4**, and end mount assemblies secured to said coil assembly at opposite ends thereof for mounting said heat exchanger on a vehicle.

6. The heat exchanger of claim **5**, wherein said air moving means comprises a pair of spaced fans in said chamber for moving aid in opposite transverse directions in said chamber.

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