(54) Title: ELECTRIC VEHICLE WITH AIR COOLING SYSTEM

(57) Abstract: A vehicle (100) has a propulsion system operable for propelling the vehicle. The propulsion system includes a heat dissipating component that generates heat when the propulsion system is operated. An air cooling system is configured for flowing air across the heat dissipating component to extract heat therefrom and has an intake portion that includes a snorkel (36). The snorkel has an elongated channel open to the atmosphere at a snorkel intake (38) for drawing in cooling air and is associated with the heat dissipating member to deliver cooling air thereto at a location that is preferably lower than the intake. Also, intake and exhaust plenums can be provided on upstream and downstream sides of the heat dissipating components, respectively, to control and direct the flow of air.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
ELECTRIC VEHICLE WITH AIR COOLING SYSTEM

FIELD OF THE INVENTION

The present invention relates to an air-cooling system for a vehicle, and more particularly, to a vehicle with an air-cooling system configured for flowing air across a heat-dissipating component of a propulsion system.

BACKGROUND OF THE INVENTION

Vehicles are known to use air cooling or in which a component of the cooling relies on air flow. In some vehicles, fans are provided in front or behind a radiator, such as in a liquid cooled engine. Some electric scooters, for example, have vented battery compartments, some which have a fan to exhaust the vented air.

A vehicle cooling system is needed which can provide improved air cooling of a heat generating component, such as of a power source of a vehicle.

SUMMARY OF THE INVENTION

The present invention relates to a vehicle with an improved air cooling system. A preferred embodiment of the vehicle includes a propulsion system that is operable for propelling the vehicle. The propulsion system has a heat dissipating component that generates heat when the propulsion system is operated. An air cooling system of the vehicle is configured for flowing air across the heat dissipating component to extract heat therefrom. The air cooling system has an intake portion that includes a snorkel with an elongated snorkel channel that is open to the atmosphere at a snorkel intake for drawing in cooling air. The snorkel channel is associated with the heat dissipating member for delivering the cooling air thereto at a location that is preferably located lower than the intake. This arrangement allows the cooling air to be fed into or near the bottom of the heat generating component, while the intake is kept high, such as out of road debris that may be kicked up by a tire, dust, or water.

The heat dissipating component can be a vehicle battery, and preferably a plurality of batteries. The cooling system can be configured for flowing the cooling air in parallel across various batteries, such as through cooling air passages that are defined through the batteries to direct the cooling air thereacross. The snorkel is preferably configured to direct the cooling air to a bottom side of the batteries or in general to a lower side thereof in common with the air passages oriented to direct air upwards from the batteries, although in
alternative embodiments, the cooling air can be directed to a different part of the batteries and made to flow in a different direction. A plenum is used in the preferred embodiment, which is disposed downstream of the heat generating component from the snorkel. The plenum is preferably configured to receive the cooling air from the heat generating component and for exhausting the cooling air to the atmosphere. The exhaust plenum can define separate exhaust channels for air entering from different locations on the heat generating component, such as from separate heat generating components, for example, from different groups of batteries. One or more air movers, such as fans or blowers, are associated with the plenum for moving the cooling air through the plenum and the exhaust channels, and preferably separate air movers are associated with each channel for moving the cooling air therethrough.

The preferred plenum is provided as a frame portion of the vehicle body, and the plenum and another frame portion cooperatively define an interior cavity in which the heat generating component is housed. The plenum preferably has sufficient strength and stiffness to significantly increase the stiffness of the vehicle body, and preferably sufficient strength for supporting a vehicle seat on which a rider is to be seated, such as disclosed in U.S. Patent Application No. 10/697,871. In one embodiment, a plurality of air movers are provided within the plenum or along another part of the path of the cooling air through the vehicle body. One of the air movers can be disposed ahead of the other, and in a scooter, for example, in which a step-through is to be provided, the various air movers can be disposed behind the forward most of the heat generating components.

The plenum can define a ramp that separates forward and rear, or upper and lower, exhaust channels from each other, such as with one exhaust channel extending forward of and above the other at the location of the ramp. These exhaust channels preferably lead to the air movers, but can alternatively lead from the air movers. In other locations, or alternatively, the exhaust channels can be offset laterally with respect to each other. The preferred plenum has a rear portion, which can house the air movers, for example, and a forward portion that is disposed lower than the rear portion, which allows a step through to be provided above the lower front portion.

The snorkel can include first and second snorkels, such as with the intake openings disposed on an upper side of a wheel space that is configured for placement of a vehicle wheel, such as a front wheel. The preferred vehicle has handle bars that are in steering association with a steerable front wheel for steering the vehicle. Also, in the preferred
embodiment, some or all of the exhaust cooling-air can be redirected over a heat sink, such as for a power source controller, to provide increased cooling over the heat sink.

Consequently, an improved cooling system is provided, which is especially useful for cooling batteries that provide motive energy for an electric-vehicle propulsion-system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of a preferred embodiment of a scooter constructed according to the present invention;

FIG. 2 is a perspective view of a scooter frame, shown semi-transparently to show the components housed internally within the frame;

FIG. 3 is a cut-away side view of the frame;

FIG. 4 is a top view of the plenum thereof; and

FIG. 5 is a perspective view of an intake plate with snorkel connectors.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. 1, a preferred embodiment of a vehicle constructed according to the invention is a scooter 100, which includes a frame 10 on which a plurality of components are mounted. These components include fairings 102, that cover the structural components of the underlying frame 10. Seat 104 is mounted on the frame 10, and is preferably directly mounted to and supported by an upper portion of the frame, which in this embodiment is preferably an exhaust plenum 44. A swing-arm 106 is pivotally connected to the frame 10, and shocks between the swing-arm 106 and frame 10 are absorbed by shock absorber/spring 108. A propulsion system is provided that includes a motor or an engine, and the preferred embodiment includes a motor 110, which can be housed in the swing-arm 106 or elsewhere on the vehicle. The propulsion system also includes batteries 20, which are housed within a closed interior cavity of the frame, which cavity is preferably defined cooperatively between upper and lower frame portions. The upper portion of the frame 10, which in the preferred embodiment is plenum 44, can be removed from the lower frame portion to open the interior space and provide access to the batteries, such as for removing the batteries therefrom.

At a front end of the frame, a steering tube 110 is preferably received within a head tube 14 for rotation to steer front wheel 112. In alternative embodiments, other steering arrangements can be employed. The preferred embodiment is a land or road vehicle, having
two wheels, three wheels, or more. In one embodiment, the vehicle is driven by a component other than wheels.

Referring to Figs. 1-4, vehicle frame 10 includes a framework of welded elongated struts 12, and is preferably constructed as disclosed in U.S. Patent Application No. 10/697,871. The struts are preferably configured to provide a lower frame portion. The lower frame portion preferably includes the head tube 14, configured for rotatably receiving steering tube 110, which preferably has a wheel fork 112, and which is steered by handle bars 114, on which a twist throttle 116 can be mounted. The openings on the outside of the lower frame portion are sealed by skins 16, preferably structural skins that are welded or bolted to the struts 12. The lower frame portion defines a lower side of an interior cavity 18 within the framework that is configured to house a portion of a propulsion system, which preferably includes batteries 20, or another energy storage component, such as capacitors. Footrest supports 22 are welded, or otherwise mounted or fixed to the lower frame portion, preferably to the struts 12. While the skins 16 are preferably secured to the struts 12 to stiffen the lower frame portion, particularly in longitudinal torsion about a longitudinal axis extending from front to back of the vehicle, alternative embodiments can have other skins that close, and preferably seal, the sides of the interior cavity 18, but which can be non-structural.

A bottom tray portion 24 closes off a bottom side of the bottom frame portion, and is configured for supporting the batteries 20. An internal battery tray 26 is spaced from the external tray 24 to provide an intake air plenum 28 therebetween to allow air to flow underneath the batteries 20.

At the front of the lower frame portion, frame skin 16 preferably closes off an upper portion of the front side of the interior cavity 18. On a bottom portion of the front side is preferably a front plate 30, shown in detail in Fig. 5, which includes one or more intake conduits connectors 32. Connectors 32 define an open channel 34 therein, which is connected to the intake air plenum 28 to feed cooling air thereto. In the preferred embodiment, two intake connectors 32 are provided, which are placed on lateral left and right sides of the front plate 30. Fig. 3 shows an example of an alternate position for the intake connectors 39, which are shown in phantom lines, and are placed on the lateral sidewalls of the exterior battery tray 24.

Snorkels 36 are connected to the connectors 32, and define an elongated, interior snorkel-channel that is open to the atmosphere at snorkel intakes 38. The intakes 38 are preferably oriented in alignment with the local airflow to take advantage of ram air
pressure when the vehicle is moving in a forward direction, although other orientations can be used. As shown in Fig. 1, the intakes 38 can be disposed in the wheel space 118 for the front, steerable wheel 112, preferably above mud guard 120 to receive clean air, with the mud guard deflecting any road debris or dust. The intakes 38 are also preferably concealed from view by a head fairing 122, being disposed therebeneath. The snorkels 36 draw in cooling air 78 from the atmosphere and direct the air 78 into the intake plenum 28. The snorkels 36 can be made of a rigid material, and in the embodiment shown are made of flexible tubing which is attached to the connectors 32 and to the lower frame portion, such as by clamps or wraps 40. The snorkels 36 preferably extend adjacent the front tire of the vehicle, and are preferably disposed to permit the front tire to rotate left and right without interfering with the snorkels. Similarly, the connectors 32 have angled surfaces 42 to enable the tire to be turned without bumping up against the connectors 32. In alternative embodiments, the connectors have other shapes, but are disposed far enough back, vertically, and/or to the lateral sides to avoid interference with the tire in any steering position.

The batteries 20 are arranged with cooling channels 42 that are open to the intake plenum 28. The cooling channels 42 preferably extend in a generally vertical direction and are open and top and bottom ends of the batteries 20. In one embodiment, the batteries themselves are configured with channels 42, and in another embodiment the batteries 20 include a plurality of batteries, preferably arranged in groups such as stacks and arranged with respect to each other such that air passages 42 extend therebetween or therethrough.

The plenum 44 is preferably made of a material and a configuration selected to provide sufficient strength and rigidity to substantially increase the stiffness of the lower frame portion, especially the torsional stiffness thereof, and to prevent the horizontally extending struts 12 at the top of the lower frame portion from buckling, since these upper horizontal struts 12 are in compression when the vehicle is supported on front and rear wheels.

The preferred plenum is bolted with bolts 46 or other fasteners to couple the plenum with the lower frame portion. A forward portion 48 of the plenum is disposed at a lower height that a rear portion 50 of the plenum to provide a step-through, such as in the case that the vehicle is a scooter. In a motorcycle or other vehicle embodiment, the forward portion of the plenum can be as high or higher than the rear portion 50.

Referring to Figs. 2-4, preferably in the rear portion 50, one or more blowers, fans 52,54, or other device to move the cooling air through the plenum are housed. Baffling 56 is preferably provided to capture the air 78 separately from forward and rear batteries 20 to
direct the air from the forward batteries to the forward fan 52 and the air 78 from the rear batteries to the rear fan 54. Exit baffling 58 can also be provided to maintain separate the air flowing from each fan 52,54 and to direct the air towards an exit 60, which is preferably open to the atmosphere. The preferred fans are centrifugal fans that have an intake 62 on a bottom side thereof, and a tangential exit 64, which is aligned with the baffling. As shown in Fig. 1, the forward batteries are preferably disposed partially or entirely forward of the forward fan 52.

As seen in Fig. 3, the upstream side of the plenum baffling includes a substantially vertical wall 66, which leads to an inclined wall, for example forming a ramp 68, to define a first plenum portion 70. The first plenum portion leads the cooling air from the forward batteries 20 to the forward fan 52. This baffling portion separates the forward plenum portion 70 from the rear plenum portion 72, which thus preferably operates as a separate plenum. In an alternative embodiment, a common plenum can be employed for additional portions of the batteries or all of the batteries. On the exit side of the plenum, downstream from the fans 52,54, plenum channels are defined by additional baffling 72, which is configured to provide separate exit channels for air 78 coming from the forward fan 52 and the rear fan 54. In the preferred embodiment, the baffling 72 in the plenum 44 is integrally and unitarily formed with the rest of the plenum, but alternative forms of baffling can be used, and the channels, both upstream and downstream of the fans 52,54 are separated only by the baffles, which form walls between the adjacent channels.

Seals 74 are preferably used to seal the exit area of the plenum from the intake area of the plenum 44. The fans 52,54 and the exhaust channels downstream from the fans 52,54, preferably direct the cooling air generally horizontally or substantially parallel to the seat 104. The exit area of the plenum is configured to provide the two exit channels laterally displaced with respect to each other, i.e., one to the left and one to the right, and the exit channel from the fan 52 is configured to extend laterally and/or vertically around the side of the space occupied by fan 54. As seen in Fig. 3, the plenum exit opening 60 is preferably angled downwards, although other orientations can be used. In the preferred embodiment the exit air is aimed and blown over heat sinks 76 of another heat generating component, such as a controller that controls the power to the motor 110.

With reference to Fig. 3, cooling air 78 is drawn into snorkels 36 and is directed to the intake plenum 28. From here, the cooling air 78 is drawn in parallel upwards across the batteries, preferably by passing through cooling channels 42, into the intake.
portions 70 and 72 of the plenum 44. Fans 52,54, which are drawing the air through the intake side of the system, then blow the air through the exit portion of the plenum and out the exit 60, at which point the cooling air can further be used to increase the air flow and increase cooling over heat sink 76, which can comprise a plurality of cooling fins and is preferably located at a back wall of the frame. To assist the proper pathway that the cooling air 78 follows in the intake plenum, a seal 80, shown in dashed lines in Fig. 2, can be used to seal the intake plenum to the batteries. Additionally, or alternatively, an exhaust plenum seal can be provided to seal the upper plenum to the batteries, such as at dashed line 82, to prevent or reduce cooling air spillage around the batteries or around another area that is desired to be cooled. The cooling air preferably flows along two parallel paths from where it comes into contact with the batteries 20 until it reaches the fans 52,54, and also preferably downstream of the fans 52,54.

Suitable propulsion systems for electric and hybrid embodiments of the inventive vehicle are disclosed in the copending application filed on June 14, 2006, entitled, “Vehicle With Contactless Throttle Control”. The entire contents of said copending application and of U.S. Patent Application No. 10/697,871 are hereby incorporated herein by reference thereto.

While illustrative embodiments of the invention are disclosed herein, it will be appreciated that numerous modifications and other embodiments can be devised by those skilled in the art. Features of the embodiments described herein, can be combined, separated, interchanged, and/or rearranged to generate other embodiments. Therefore, it will be understood that the appended claims are intended to cover all such modifications and embodiments that come within the spirit and scope of the present invention.
THE CLAIMS

What is claimed is:

1. A vehicle, comprising:
   a propulsion system operable for propelling the vehicle and comprising a heat
   dissipating component that generates heat when the propulsion system is operated;
   an air cooling system configured for flowing air across the heat dissipating
   component to extract heat therefrom, the air cooling system comprising an intake portion
   including a snorkel that includes an elongated snorkel channel open to the atmosphere at a
   snorkel intake for drawing in cooling air, the snorkel channel being associated with the heat
   dissipating member for delivering the cooling air thereto at a location lower than the first
   location.

2. The vehicle of claim 1, wherein the heat dissipating component is a
   vehicle battery.

3. The vehicle of claim 2, wherein the battery comprises a plurality of
   batteries, and the cooling system is configured for flowing the cooling air in parallel across the
   batteries.

4. The vehicle of claim 3, wherein each battery defines cooling air
   passages therethrough for directing the cooling air across the batteries for extracting heat
   therefrom, the air passages being oriented to direct air upwards from a bottom of the batteries,
   wherein the snorkel is configured to direct the cooling air to the bottom of the batteries.

5. The vehicle of claim 1, wherein the air cooling system comprises an
   exhaust plenum disposed on a downstream side of the heat generating component from the
   snorkel, the plenum being configured for receiving the cooling air from the heat generating
   component and exhausting the cooling air to the atmosphere.

6. The vehicle of claim 5, further comprising a vehicle body comprising a
   frame portion, wherein the plenum and frame portion cooperatively define an interior cavity in
which the heat generating component is housed, wherein the plenum has sufficient strength and stiffness to significantly increase the stiffness of the vehicle body.

7. The vehicle of claim 5, wherein the plenum supports a vehicle seat for a rider mounted thereon.

8. The vehicle of claim 5, wherein the plenum defines separate exhaust channels for air exiting from different locations on the heat generating component.

9. The vehicle of claim 7, wherein plenum defines separate exhaust channels for different locations on the heat generating component, the cooling system comprising an air mover associated with each of the exhaust channels for moving the cooling air therethrough, wherein a first of the air movers is disposed longitudinally forward of the other of the air movers, and one of said locations on the heat generating component is disposed forward of the air mover associated therewith.

10. The vehicle of claim 9, wherein the exhaust channels are offset laterally with respect to each other downstream of the fans.

11. The vehicle of claim 5, wherein the plenum has a forward portion and a rear portion, the rear portion being vertically taller than the forward portion and is disposed under a seat area of the vehicle configured for placement of a seat, wherein the front portion is sufficiently lower to define a step-through of a scooter.

12. The vehicle of claim 5, further comprising an intake plenum connected to direct the cooling air from the snorkel to the heat dissipating component.

13. The vehicle of claim 1, wherein the snorkel comprises first and second snorkels, and the intake opening is disposed on an upper side of a wheel space that is configured for placement of a vehicle wheel.

14. The vehicle of claim 13, wherein the vehicle wheel is a steerable front wheel.
15. The vehicle of claim 14, further comprising handle bars in steering association with the steerable front wheel for steering the vehicle.

16. A vehicle, comprising:

5 a propulsion system operable for propelling the vehicle and comprising a heat dissipating component that generates heat when the propulsion system is operated;

an air cooling system configured for flowing air across the heat dissipating component to extract heat therefrom, the air cooling system comprising an exhaust plenum disposed on a downstream side of the heat dissipating component and to receive the cooling air from the component and direct the cooling air to the atmosphere, wherein the plenum defines separate exhaust channels for different locations on the heat dissipating component; and

separate fans associated with each exhaust channel for moving the cooling air therethrough.
B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F01P B61C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 3 827 523 A (WILLIAMS D) 6 August 1974 (1974-08-06) figures</td>
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<td>WO 2006/121426 A (MACK TRUCKS [US]; MCPHERSON ROBERT HARRY [AU]; HOLLENBECK BRUCE PHELPS) 16 November 2006 (2006-11-16) abstract; figures 1,2b,3</td>
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<td>FR 2 735 076 A (PEUGEOT MOTOCYCLES SA [FR]) 13 December 1996 (1996-12-13) abstract; figures</td>
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Further documents are listed in the continuation of Box C.

| X       | See patent family annex. |

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* Special categories of cited documents:

* A* document defining the general state of the art which is not considered to be of particular relevance

* E* earlier document but published on or after the international filing date

* L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

* O* document referring to an oral disclosure, use, exhibition or other means

* P* document published prior to the international filing date but later than the priority date claimed

* I* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

* X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

* Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

* S* document member of the same patent family

Date of the actual completion of the international search

13 November 2007

Date of mailing of the international search report

19/11/2007

Name and mailing address of the ISA

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Authorized officer

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<td>A</td>
<td>GB 696 849 A (MORRIS LTD) 9 September 1953 (1953-09-09) figures</td>
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### Box No. II  Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. □ Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. □ Claims Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. □ Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box No. III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple Inventions in this International application, as follows:

**see additional sheet**

1. □ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. □ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. □ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. □ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

- □ The additional search fees were accompanied by the applicant’s protest and, where applicable, the payment of a protest fee.
- □ The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- □ No protest accompanied the payment of additional search fees.
This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-15

   Vehicle according to claim 1, provided with an air cooling system comprising an air intake in form of snorkel.

2. claim: 16

   Vehicle according to claim 16, provided with an air cooling system comprising a plenum placed on a downstream side of the component to be cooled and defining separate channels with associated separate fans.
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